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Chronic Wasting Disease Management Through Culling, Baiting, and Vaccination Methods

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Abstract

Chronic wasting disease (CWD) is a lethal, progressive, and highly infectious disease that targets cervid populations through transmission by prions. There are currently no treatment options that are highly effective at stopping CWD, but the scientific community has great knowledge on CWD’s transmission and effects. In this literature review: culling, baiting and vaccination techniques are analyzed and compared to view which method could potentially work the best to control CWD. Long term effects of CWD could result in cervid population extermination and enormous economic losses for areas that are inhabited by cervids.

Keywords

Chronic wasting disease, CWD, prion, cervid, culling, baiting, mineral licks, vaccination, transmission, disease management

Introduction

Chronic wasting disease is an infectious prion disease with detrimental effects on cervid populations. Cervid populations are members of the deer family, including white tail deer, mule deer, elk, and moose. CWD has been very effective at infecting and killing cervid populations due to no known effective vaccine or treatment options available (Joly et al., 2006). CWD is a contagious neurological disease that spreads in the form of prions. Prions are three-dimensional misfolded proteins with no known reason on why they misfold. CWD attacks the central nervous system of cervid populations, specifically the cortex of the brain. The cortex of the brain processes sensory information and when prions attack the cortex the senses are dulled, motor functions decline, and memory loss occurs. The disease is progressive and deteriorates mental and physical abilities in infected cervids over time. Microscopic holes develop in the cortex of the brain as the disease advances, further worsening the health condition of the infected individual. This is known as transmissible spongiform encephalopathies also known as TSE. TSE's get this name due to the sponge like appearance of the brain under a microscope. CWD is transmitted in bodily fluids such as feces, urine, and saliva. When a non-infected cervid ingests bodily fluids from an infected cervid, it is then infected (Williams, 2005). It is believed that CWD originated from sheep in the Rocky Mountain range in the 1900s. The disease mutated and was then able to infect the cervid family (Salman, 2003). CWD is very similar to mad cow disease in how it spreads and affects the infected. CWD is now in twenty-three states of the United States ("CWD," 2018). CWD used to be a rare phenomenon but now it is becoming more prevalent and spreading into new populations. CWD is a species-specific disease that only infects similar species. This explains its success across the cervid family. CWD relies on the PrP gene in cervids which encodes a protein folding gene that allows for infection (Salman, 2003). The PrP gene can have polymorphism which are many different forms of the original gene. One of these different forms of the gene leads to the folding of a protein into a prion instead of a normal protein. CWD is currently unable to jump species because, not every species has the correct PrP coding sequence. Without the correct PrP sequence more prions can't be created. This brings up great concern when looking into the possibilities of CWD being able to mutate again and infect other wildlife species or humans. CWD infected deer are safe to consume due to the species barrier but, if this barrier was removed CWD would be of great concern for people's health.

CWD management is being taken very serious due to the possible long term effects it could cause. If CWD was able to clear out whole cervid populations this would cause large economic consequences for those areas that practice hunting (Joly et al., 2006).

In the state of Missouri in 2017 there were a total of 500,686 deer hunters (Flinn, 2017). Every year thousands of people come to Missouri to hunt white-tailed deer. If the white-tailed populations were removed due to CWD then deer hunting would no longer be practiced. This would cause an enormous loss of revenue for the Missouri Department of Conservation and the state's economy as well. It is estimated deer hunting brings in a billion dollars into state and local economies throughout Missouri ("Chronic Wasting Disease (CWD)," n.d.). Overall the scientific community has a well understood basis of CWD but, it lacks effective methods to stop CWD.

In this review, various models for stopping CWD will be reviewed and their efficacy compared against each other. The models discussed include density and culling efforts, mineral and baiting control, and vaccination. Scientific studies have been completed looking into these models but gaps in the literature still exist. The goal of the discussion is to make note of these gaps and analyze scientific writings that could fill them.

Density and Culling Methods to Control CWD

Prevalence of chronic wasting disease is influenced by the density of the population

Chronic wasting disease is more susceptible to infect cervid populations in areas that are more densely populated. Researchers explored modeling examples that show if population reduction occurs then contacts between infected and healthy white-tailed deer drops (Joly et al., 2006). If transmission cannot occur, then the disease cannot spread, and the disease will not exist. There is no former research that proves that density and transmission rates have any correlation. However, the research team examined deer populations in south-central Wisconsin and discovered that healthy white-tailed deer that live in close presence to infected deer are more likely to become infected (Joly et al., 2006). The goal of their research was to examine factors that can lead to CWD management and explain the connection between CWD distribution and deer density.

The research team performed tissue collections and analysis from deer within the range of their study. The deer samples were collected from September 2002 until March 2004. The deer were acquired from deer harvests and government sharpshooters (Joly et al., 2006). They broke the study into two segments to compare if CWD prevalence would change after culling efforts took place. The first section of the study was conducted from September 1, 2002 until March 31, 2003. During this time frame they analyzed 6,436 white-tail deer; of the deer they analyzed 152 were infected which is a 2.3% infection rate. The second section of the study was conducted from April 1, 2003 until March 1, 2004. They collected 4,242 deer in this sample set and 94 were infected. The second sample had an infection rate of 2.2%. The data they collected showed no seasonal differences in the infection rate of the white-tailed deer under normal conditions.

They mapped out the locations of the infected deer and found that there are hot spots present near the location where CWD is believed to have originated, in this area of Wisconsin. The research team then analyzed the habitat in the areas they studied. The research team found that if the habitat was more suitable to sustain larger deer populations in higher density, then chronic wasting disease was more likely to be present. The area in which is believed to be the originating location of CWD in the study area had a very suitable habitat for the large deer population that inhabited the area. The paper concludes with, the prevalence of chronic wasting disease is influenced by both the history of the disease in the area and density of the population within the area of its occurrence (Joly et al., 2006).

The paper was clear at demonstrating the connection between density of the population and infection rate but failed to present a method on how to stop CWD. Experimentation to follow up the modeling might come up with a value of how low of a density is needed to stop CWD transmission. The population would need to be low enough to stop CWD infection but high enough that the deer are still able to reproduce and be successful.

Density-dependent Vs. Frequency-dependent Disease Culling

Another modeling study was performed in Wisconsin to examine if CWD is a density-dependent or frequency-dependent transmission disease (Wasserberg, Osnas, Rolley, & Samuel, 2009). Density-dependent transmission diseases are more successful in higher density populations, and frequency-dependent diseases are density independent. To eliminate a density-dependent disease, the host population must be reduced to below a threshold amount, so the disease is unable to be passed on. This coincides with what Joly et al. (2016) presented as a method to control CWD. If CWD is a frequency-dependent disease, then the host population must be eliminated to stop the disease. Lowering the population will not stop the transmission of the disease (Wasserberg et al., 2009). To stop CWD from infecting and killing healthy populations, first an analysis to see if CWD is density-dependent or frequency-dependent needs to be completed. The research team created matrix models that examined: age, sex, infection stage, and seasonal heterogeneity with respect to demographic and epidemiologic parameters, to simulate the effect of different culling strategies on disease and white-tail deer dynamics in the Wisconsin study area (Wasserberg et al., 2009). Through the creation of these models, culling efforts can be performed with a greater likelihood of success, because the model is the closest representation of what would happen if culling was implemented directly to natural deer populations.

The research group was not able to conclude if CWD is density-dependent or frequency-dependent. The two disease variants for spreading are very difficult to differentiate unless you perform aggressive culling and analyze the results. Naturally, if a disease is density-dependent and there is no alteration to its infection route, then the infection rate and death will increase until an equilibrium is found that keeps the population steady (Wasserberg et al., 2009). If CWD is frequency-dependent, then the disease will naturally eradicate deer below the threshold required in order to maintain a healthy population. If CWD is frequency-dependent, then culling in the hot spots of CWD will cause the disease transmission rate to drop. If CWD is density-dependent, then culling evenly across all deer populations will cause the transmission rates to lower (Wasserberg et al., 2009). Once a label can be placed on CWD as being density-dependent or frequency-dependent then the appropriate culling effort needs to be implemented. It is estimated that it will take approximately 13-15 years to get rid of CWD if it is density-dependent, with aggressive culling efforts. For a frequency-dependent CWD it is estimated 31-33 years of aggressive culling would be needed to eradicate CWD. If no culling efforts are implemented, then CWD has the potential to overtake and kill all cervid populations.

Further research and experimentation are required to determine if CWD is density-dependent or frequency-dependent. Joly et al. (2016) and Wasserberg et al. (2009) presented culling efforts as a possibility to manage CWD spread, however neither article presented a procedure to follow but, if further research was completed, then the scientific community's knowledge on CWD management will be greater and possibly give an answer to the CWD endemic.

Cervid Feeding and Mineral Licks Cause CWD Transmission

Baiting and Supplemental Feeding of Wildlife

The human dispersal of artificial or natural food sources is used worldwide to control wildlife populations. Feeding of wildlife has a wide range of uses across the globe. These uses can include: helping wildlife populations survive through tough winter conditions, control crop destruction, reduce vehicle and wildlife collisions, and controlling hunting and tourism opportunities (Sorensen, van Beest, & Brook, 2014). At these man-made food sources, populations come into close proximately of each other and disease transmission rates increase (Lavelle et al., 2014). Feeding of wildlife populations can be broken into two main categories: baiting and supplemental feeding of wildlife. The baiting of wildlife is used to bring wild populations into an area and keep them there. Baiting is often utilized by hunters to keep populations in a pattern-based rotation to increase the likelihood of a successful harvest. Supplemental feeding of wildlife is used to enhance the populations' health directly or indirectly. Feeding deer populations can increase birth rate and survival rate from the increased nutrients available, but also keep populations from crossing heavily trafficked highways due to a food source being on the same side of the highway as their water source and bedding habitat (Sorensen et al., 2014).

CWD is not the first disease that effects cervid populations to be examined at the site of baiting and supplemental feeding locations. There is a history of bovine tuberculosis, bovine brucellosis, scrapie, skin papilloma, and fibroma growth being present at food sources (Sorensen et al., 2014). Chronic wasting disease is currently in the spotlight for possibly transmitting at an increased rate in high traffic baiting and feeding locations due to deer from vast ranges coming together to consume easily accessible food sources. In Missouri, baiting has become illegal due to the fear of CWD spread. By eliminating baiting techniques, CWD transmission should decrease due to a lower cervid contact rate and a more spread out feeding pattern of cervids.

Mineral Licks are a Source of CWD Transmission

Mineral licks are like baiting and supplemental feeding locations when examining CWD transmission. Mineral licks can be both natural and artificial. Cervid populations can visit mineral deposits to get vital nutrients that are essential to survive that were not obtained from daily diet intake. Magnesium and sodium are the most common minerals cervid populations lack and will consume mineral-rich soil and water as a way to take up these nutrients (Lavelle et al., 2014). Mineral licks are often visited by cervids which leads to higher concentration and interaction rates in small areas. Cervids who visit the mineral lick will leave feces, saliva, and urine behind; these bodily fluids can transmit CWD, continuing its cycle.

Lavelle et. al. (2014) examined cervid populations and mineral lick usage from June 1, 2006 until October 2, 2006 in northern Colorado, with various terrains from wet meadows to tundra in the 529 square kilometer study site (Lavelle et al., 2014). Game cameras documented still image photographs of 1,563 elk and 328 deer visits at the mineral licks. An elk or deer was labeled as consuming minerals if their naso-oral region was in contact with the soil (Lavelle et al., 2014). Twenty-eight percent of elk and seventy percent of deer that visited the mineral site were believed to have eaten mineralized soil. The research team was able to conclude that if a cervid is visiting the mineral licks, it is likely doing so out of mineral consumption needs (Lavelle et al., 2014).

Johnson et al. (2006) analyzed scrapie prion attachment to quartz, montmorillonite, and kaolinite, to evaluate if prions can stay in a dormant stage between hosts. Quartz is the most abundant natural mineral on earth and accounts for ten percent of earth's crust. Montmorillonite and kaolinite are minerals commonly found in clay soils. The research team obtained soil samples from West Lafayette, Indiana. They combined scrapie prion proteins with the soils and suspended them in an aqueous solution for two hours, followed by centrifugation to remove the unbound prion proteins (Johnson et al., 2006).

Scrapie prions were able to bind to all the soil minerals, but with montmorillonite at a rate of nearly 100-fold stronger than the other two minerals (Johnson et al., 2006).

Montmorillonite had approximately 200 µg of protein per mg of montmorillonite, whereas the other minerals had ~2 µg of protein per mg of mineral. They performed inoculation on the mice with resuspended scrapie prions from the montmorillonite. The scrapie prions were able to infect the mice proving that they were not denatured during the binding and unbinding from the mineral. This study proved that prions can be infectious after binding to common minerals present in soil and then being inserted into another animal.

CWD can transmit through cervid bodily fluids which are present around food sources and mineral licks. It does not matter the intent upon feeding cervid populations, CWD can transmit if an infected individual is in the presence of uninfected cervids and bodily fluid trade off occurs. Cervids require trace elements which can be obtained from mineral licks. These mineral licks may be CWD hot spots due to cervids traveling to them frequently and consuming minerals from the same location. Cervids do not need direct contact to spread CWD. CWD can be transmitted through infectious prions bound to soil minerals after the previous infected cervid has left the area.

Vaccination to Control CWD Transmission

Synthetic Peptide Vaccine

Vaccination against CWD could be the best route to control its infection rate because, if the disease could no longer infect cervids then it would not be a threat to their populations. There is currently no vaccine that stops CWD from infecting cervid populations, but creation of a vaccine is under research. In 2007 a research team created a synthetic peptide vaccine that effects peptide four and six in cervid populations. When peptide four and six of the immune system are activated, it causes the release of antibodies from B-cells. These released antibodies recognize the CWD molecules and induce an immune attack. Through the activation of peptide four and six there is a two month delay in disease onset (Pilon et al., 2013). In the study, thirteen mule deer were used to test the vaccine. Seven were injected with the vaccine serum and six were used as controls. Three weeks after vaccination the study groups were released into an infectious CWD environment. The control group was infected at a faster rate than the vaccine group (Pilon et al., 2013). At month fifteen of the study, fifty percent of the control group was infected and only forty-three percent of the vaccinated were infected. In both the control group and the vaccinated group, all the deer were infected with CWD by month twenty-one. When the deer became very sick from the CWD infection or at month twenty-one, they were euthanized and examined. Peptide four and six antibody levels were examined; the vaccination group had levels approximately twenty times higher than the control group (Pilon et al., 2013).

This vaccination study shows that CWD can be slowed down but not stopped. All the deer in the two groups eventually perished or were euthanized at the end of the study, but those which received the vaccine were able to live longer before becoming infected. The vaccine administered is believed to have been of too little dosage. The research team believes a higher concentration vaccine or larger dosage may allow better immune protection against CWD.

Mucosal Immunization Against Chronic Wasting Disease

Goñi et al. (2015) orally administered the vaccine to deer with the help of attenuated salmonella as a delivery mechanism. Six deer were used as a control and five received the experimental vaccine. The vaccine was administered by feeding tube and syringe methods. Vaccinations occurred eight times over an eleven-month study period. The vaccinations led to systemic immune responses that created partial protection from chronic wasting disease. After the vaccinations all the deer were released into a den with CWD infected deer and evaluated them for 1,310 days after. All the deer except one became infected. One out of the five deer administered the vaccine did not contract CWD despite being in proximity with infected deer (Goñi et al., 2015). The reason for one of the deer being immune to CWD was not deeply examined but will in future research. This is the first documented time, a CWD vaccine has ever protected a cervid from getting infected. The research team believes that the vaccine was overall a success because it was orally administered. CWD usually infects cervids by being consumed and the vaccine was consumed as well. One possibility of the deer not being infected could be a polymorphism of codon 96 in the deer's DNA. Codon 96 is believed to control immune system sensitivity to CWD (Goñi et al., 2015). In this study the vaccinated deer were able to stay uninfected for approximately one hundred and fifty days longer than the nonvaccinated control group.

Conclusion

Chronic wasting disease is an infectious disease that needs to be stopped. The possibilities of CWD wiping out cervid populations and the chance of CWD mutating across the species barrier are serious threats, to both cervids and all other organisms. I believe the correlation between higher density and increased infection rate is a factor to examine when looking to control CWD transmission. The density-dependent method of reducing population size below the threshold for infection would be more effective than the frequency-dependent method of a total population elimination. If the entire population was culled, then culling would not be protecting the cervid family. The larger cervid populations should be culled into smaller groups that way infected and healthy interaction rates for cervids would decrease.

The idea of slowing down CWD transmission by eliminating feeding methods and mineral licks is another important aspect to consider. If all baiting, supplemental feeding, and artificial mineral lick practices were abolished, then CWD transmission would slow down. These heavily visited cervid locations are just potential cesspools for CWD. When cervid populations graze for food naturally the chances of transmission are much lower than when they are eating from the same feeder or licking the same mineral rich soil. Prions can adhere to minerals and food. If the chance of eating the same nutrients source is reduced, then transmission chance will as well.

Vaccinations for CWD could potentially be the most successful method to stop CWD, but there is currently no vaccine that can constrain CWD. The synthetic peptide vaccine and mucosal vaccination techniques are a strong start towards a vaccine, but more research and development must be completed. The one white-tail deer that survived CWD free after receiving the mucosal vaccine is a great achievement. I believe the focus for future studies should be on the mucosal vaccine. Mucosal vaccination is easier to administer due to cervids just being able to consume treated food, this would be very easy to implement in wild populations. Overall, we have a deep understanding of chronic wasting disease but, something needs to be done to eliminate CWD before it is too late. A combination of culling, baiting, and vaccination methods appears to be the best route of action that coincides with our current knowledge of CWD.

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