Transmittance of Chronic Wasting Disease in White-Tailed Deer through the Courtship Ritual

By

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Abstract

Chronic Wasting Disease is a transmissible spongiform encephalopathy specific to Cervidae, and there has been increasing concern for the white-tailed deer of Wisconsin since 2001. The Department of Natural Resources and other scientists have been studying how the disease is transferred through the white-tailed deer population in efforts to determine potential ways to reduce its spread. Transmissible spongiform encephalopthies are diseases that affect the nervous system of humans, bovine and particular species of Cervidae. The illness is caused by the mis-folding of proteins; the prions cause masses to form within the tissue creating a sponge-like appearance. The clinical symptoms generally include dementia, lack of coordination, and eventual loss of brain function. Visible signs of Chronic Wasting Disease are apparent only in the last stages of the disease, and include an abnormal pelt, lack of muscle mass and fat storage and the individual carrying head and torso lower than spine. Studies of relatable diseases suggest that urine, feces, blood by transfusion, and saliva can all be possible factors of transmittance. Many forms of deer behavior can be under-lying factors for CWD contraction. For example, white-tailed bucks will slurp urine of females in rutting season to determine if a doe has entered estrus and is viable to mate, and this might increase CWD transmission if it is transferred via urine. Also if urine is the mechanism of transfer, populations with lower male to female ratios are expected to have higher infection rates among males because males will be mating with more females, increasing risk of contraction through the mating ritual. This hypothesis is supported by the fact that the prevalence of CWD from the years 2002 to 2008 indicates that males are infected almost double the amount than female deer are infected despite the consistently closer proximity of females throughout the year. Using data from the 2009 Wisconsin deer hunting season sex ratios and population densities of CWD infected deer were compared between two locations. The two locations spanned over three counties; Iowa, Dane, and Rock county where a total of 1,620 deer were tested for CWD. While studying these forms of transmittance it was expected to find male CWD infection rates to be higher than females; which was found to be true in both sites; CWD-MZ 77A and CWD-MZ 70A.

Introduction

Chronic Wasting Disease, CWD, was discovered in Wisconsin white-tailed deer in 2001 when hunters brought in sick-looking deer. Wisconsin immediately put an effort together with hunters to test white-tailed deer during the hunting season, being part of the process hunters would participate in when their deer is registered and tagged. The prevalence of CWD has increased over the last nine years bringing concern to how healthy the Wisconsin deer population is. This study will investigate the literature on CWD and related diseases to apply to Wisconsin's 2009 white-tailed deer hunting data.

Though the exact mode of transfer remains unknown, experiments from organisms affected by other TSEs suggest that the disease is spread by body fluids, including blood, feces, and urine. In deer, this could be enhanced by the unique mating behavior of deer, in which male deer sniff the urine of multiple females to determine if the female is in estrus, and then mate multiple times. It is crucial to evaluate the potential importance of this mating behavior in the transmission of chronic wasting disease in white-tailed deer. Further, understanding the forms of transmittance will allow for better forms of management.

Transmissible Spongiform Encephalopathies

Transmissible spongiform encephalopathies are diseases caused by the mis-folding of proteins within an infected individual. In a TSE infected individual, a normal protein will refold into an abnormal shape, and then this protein is not useful to the cell, the prions will accumulate in nerve cells. The accumulated prions within the nerve cells will begin to damage and eventually destroy the tissue with holes, taking the appearance much like Swiss cheese.

The clinical symptoms of TSEs vary in each disease, but generally they include dementia, lack of coordination, eventual loss of brain function, and ultimately death. Transmissible spongiform encephalopathies are present in humans, bovine, and other organisms. Although the clinical symptoms may be similar, the forms of TSEs vary in symptoms and transmittance. The human form of TSEs is Creutzfeldt-Jakob disease (CJD); the affected age is usually over 60 years of age. The age of onset depends on the type of Creutzfeldt-Jakob disease; CJD can be contracted either by exposure to beef in the form of vCJD or can be genetically present in humans called sCJD (Johnson, 2003). The bovine form of Transmissible spongiform encephalopathies (TSE) is subcategorized as Bovine spongiform encephalopathies (BSE), and is

present in many bovine species. This BSE is commonly known as Mad Cow Disease, where the first appearance was found in Great Britain. Scrapie, another TSE, is found in sheep and goats; the name being derived from the symptom where affected animals will compulsively scrape off their fur or fleece against rocks or trees (Prusiner, The Prion Disease). While Chronic Wasting Disease is found in white-tailed deer, it can also affect other ungulates, or hoofed mammals of the family Cervidae. Cervidae have distinguishing characteristics such as forked antlers, a four-part stomach, and no gall bladder that separates them from other hoofed mammals. There are currently no cases of Chronic Wasting Disease being passed to humans for the reason that the connection of similarity has been made to the Mad Cow transmittance to humans as the form of vCreutzfeldt-Jakob disease.

Diseased animals can be CWD carriers for years without showing any symptoms. Symptoms of deterioration, abnormal coats, and problems with movement can show 14 to 30 months after contraction. Infected individuals can pass CWD along to the population without showing signs of CWD. The first news of CWD originated in northeastern Colorado and southeastern Wyoming in the 1960s. Due to the fact that deer do not migrate long distances, usually moving only within a one square mile area, CWD would have to reach Wisconsin by other means. States between Wyoming and Wisconsin have not seen signs of infected Cervidae within their borders. A likely transfer of the disease may have happened in 1999 when a deer farm transferred deer to Wisconsin. There were reports of infected deer in the herd shortly after the transfer.

Prions

Cervidae have proteins similar to those in the human body. Like the human proteins, Cervidae proteins can become misshapen, folding abnormally into a protease resistant form

known as a prion, or PrP^sc which is the prion susceptible to CWD contraction. The protease resistant form can then infect and transform normal proteins. These abnormal proteins build up in normal tissue, causing damage and deterioration. In the case of CWD and other TSEs spongiform holes will form in the brain and nervous tissue.

Prions detectable in urine

Prions, the infectious agent of TSEs, are detectable at excretion sites long before clinical symptoms appear if chronic inflammation is present (Seeger, 2005). Inflammatory kidney conditions onset by bacteria, viruses, or disease are frequent, a study was conducted to determine whether chronic inflammatory kidney disorders would trigger excretion of prion infectivity into urine (Seeger, 2005). A strain of the Rocky Mountain Laboratory (RML) scrapie was administered to rats. The rats' kidneys progressively accumulated PrP^sc and prion infectivity at 60 to 90 days after administration. Scrapie-infected hamsters and CJD patients were reported to excrete urinary PrP^sc (Shaked, 2001). It is likely that prions are produced locally and excreted during leukocyturia because prionuria is associated with local prion replication within kidneys (Seeger, 2005). Leukocyturia is a combination of the words leukocytosis and uria, where leukocytosis is defined as an increased level of white blood cells in the circulating blood which can be normal but is abnormal when infection exists; uria means there is a presence of a specific substance in urine. This study concluded that inflammation associated prionuria, prions present in urine, may be a transmission factor among sheep, deer, and elk (Seeger, 2005). Providing support to how effectively prions can transfer when white-tailed male deer conduct behavior rituals of slurping urine from females to determine the onset of an estrus cycle. Viably predicting that male infection rates will spike after the rutting season of October through

December when a chronic inflammatory kidney disorder causes excretion of prion infectivity into urine.

Prions related to CWD

The positive CWD pattern of codon 96 in white-tailed deer is specific to white-tailed deer but the affected prions may be transmissible to other Cervidae. Research of *PrnP* implies 86-96% of white tailed deer in the region have *PrnP* specific combinations that will support CWD infection (Johnson, 2003). This study suggested that both white tailed deer and mule deer were polymorphic in certain codon regions; meaning if the code changes within this codon region the function of the protein will not change. While the study also suggested white tailed deer were heterogeneous at codon 96, while mule deer were not. This heterogeneity at codon 96 in white-tailed deer was correlated to CWD-positive white tailed deer. The prion may affect other codons specific to those Cervidae. Prion research is still underway, concerning how prions function to interfere with normal proteins and the transmissible qualities of these prions within a taxonomic family, like Cervidae.

Chronic Wasting Disease

The form of CWD transfer is not well known, although passing of prions is a hypothesized cause of disease transfer. Sheep spread scrapie by eating the dropped placentas of infected ewes, and cows spread Mad Cow disease by eating feed made from infected cows (Blakeslee, 2002). Studies suggest urine, feces, blood (by transfusion), and saliva can all be possible factors of transmittance for CWD. The soil and vegetation is thought to hold infected prions affectively enough to be passed along to other individuals foraging in the area. Animals will consume soil on a regular basis to meet mineral needs, the infected soil and vegetation then

acts as transmitters of Chronic Wasting Disease (Basu, 2006). With so many forms of transmission and the potential to spread CWD, it will be hard to slow the spread of CWD within an infected population. Chronic Wasting Disease is set apart from other prion diseases by the high transmittance rate in cervids (Mathiason CK, 2009).

A study in Wisconsin aimed to find if CWD prions were present in body fluids during the pre-clinical phase of the disease and if repeated animal exposure versus animal to animal contact was enough to transmit CWD (Mathiason CK, 2009). The study consisted of four different test groups of deer each receiving a different substance to determine if the substance was a form of transmittance. These substances of transmittance concern were whole blood, saliva, urine and fecal samples, environmental contact, and brain tissue. Each substance varied by exposure dosages and rates, but each test group was tested every three months for a total of fifteen months in observation (Figure 1). The whole blood test group was given an IV of infected blood one time and each of the three deer tested were infected. The saliva test group was given 10 ml/day for five days; two of the three test deer were infected. The transmittance of saliva seems the most common in animals that have grooming interactions, shared resources, and highly dense populations; such as deer (Mathiason CK, 2009). In another test group brain tissue matter was fed to four individual deer and each of them contracted CWD. Two deer were exposed to bedding, water and feed buckets from pens that housed infected individuals on a daily basis; each individual was contracted CWD by these form of transmittance. The test groups receiving urine and fecal samples for 90 days; were not infected by this form of transmittance (Mathiason CK, 2009). Although this form of transmittance was the only form not to cause positive contractions of CWD, it cannot be dismissed for several reasons. First, fawns are not able to show signs of being CWD positive because they have not accumulated high enough concentrations of the

infected prions. Another reason may be that fawns are not sexually mature, and so the urine excreted may not be the same as mature does. Other researchers suggest that very low concentrations of prions are present in urine and feces (Mathiason CK, 2009). A longer incubation time may be needed to build up a higher level of CWD+ prions within the individual deer. A consideration of the individuals used in this study is necessary; fawns were used in the research and may not be as susceptible to urine and fecal transmittance. The urine from these fawns may have lower concentrations of infected prions to urine of females in estrus. Finally, the behavior of deer within a social group may differ in important ways, including increased interactions among males and females, and increased exposure to key modes of transmission.

Cervidae Behavior

The white-tailed deer, *Odocoileus virginianus,* disperses through favorable habitats in Wisconsin. The preferred habitat is woodland, though some deer prefer agricultural areas as a more open aired environment. Deer prefer the edge effect; where two vegetation types merge; this preference is explained as a defense response (Hiller, 1938). A deer may use the edge of two habitats to either be able to view its surroundings when eating but also relying on the ability to run back into the cover of another habitat when danger approaches; two habitats used for defensive purposes. Habitat preferences tend to change with the seasons, likely due to the change in food resources or availability of resources varying in accordance with population densities. Jackson suggests that deer living in a hardwood evergreen forest will disperse ten deer per square mile, while deer living in oak-maple forest will disperse only 20 to 50 deer per square mile (Jackson, 1961). White-tailed deer will travel to feeding grounds daily; sometimes this is to meet in small groups of other white-tailed deer, yet adults will still stay within a range of one

square mile (CWD Alliance, 2009). Does will travel together throughout the year, while adult bucks can be seen with other bucks only in the spring when their antlers are still in velvet. Bucks traveling together are called "fraternal groups", the group will break apart when the velvet sheds and the antlers harden. Antlers begin to harden before the rutting season, allowing bucks to spar with each other for possession of a doe.

The rutting season begins different social tendencies, the bucks will begin to court does, following the scent of estrus, which will determine which females are viable to mate. White-tailed bucks generally follow an individual doe for 2-3 days, mating with them before looking for a new mate (Whitehead, 1971). A buck will proceed to mate with multiple does throughout the rutting season, which lasts from October to early December (Whitehead, 1971). Typically a male will mate with less than ten does, however, one buck was able to breed 32 does in a season (Hiller, 1938). Does have an estrus cycle of 28 days; if copulation is unsuccessful in this first cycle, a second rut, or estrus cycle, will be reached in another 28 days (Hiller, 1938). A doe will rarely be overlooked by a rutting but within the breeding season so, a sexually mature doe will almost always give birth to a fawn or a pair of fawns (Hiller, 1938). It has also been observed that when deer range conditions are poor or crowded, the rut will produce a higher percentage of male fawns. When range conditions are good and spread out the rut will produce a higher percentage of female fawns (Hiller, 1938).

In addition to these mating rituals, other deer behaviors may also contribute for CWD contraction. Grooming, for instance, is a common social activity within all Cervidae groups, both male and female alike (Hiller, 1938). The fact that a deer has the ability to reach every portion of its own body with its mouth or hooves, self-grooming is not a problem (Hiller, 1938). Social grooming behaviors can be a direct form of transmitting CWD through saliva, especially

if the deer actively grooms itself and others. Scent is the dominant form of communication between white-tailed deer. Visual communication does not provide as much information and cannot be given to many individuals due to the population's dispersion (Rue, 2000). White-tailed deer communicate through urine, feces, and secretions of external glands. In this form, individuals never have to come into direct contact and the message continues to be sent for weeks; for example, a buck's age, health and fertility can be expressed in the urine (Rue, 2000). These communication devices attract other individuals to learn about surroundings and other deer; this would allow CWD positive prions to transfer to individuals, assuming prions can be transferred through urine, feces, and other secretions.

Objective

The objective of this study is to determine if the white-tailed deer mating ritual could contribute to the spread of Chronic Wasting Disease among male deer in a population. If transmittance of CWD is directly related to the female interaction with many males, then populations with lower male to female ratios are expected to have higher infection rates among males because individual males will be mating with more females, increasing risk of contraction through the mating ritual. This is the likely reason males are infected almost double the amount that female deer are infected despite the closer proximity of females throughout the year.

Females are also predicted to be infected at a steady rate over time, while male infection rates should spike after the rutting season of October through December. If males are contracting the disease as a response to the change in proximity to females during the rutting season, then the number of CWD-positive males should spike after December, although the incubation rate varies by age and severity.

Methods

To address how Chronic Wasting Disease spreads, two locations were chosen for comparison. The first site chosen was a Chronic Wasting Disease Management Zone, or CWD-MZ; this site spans a portion of both Dane County and Iowa County, WI. Dane and Iowa Counties are the oldest known sites in Wisconsin to contain CWD, first discovered in 2002. The CWD-MZ of Dane County does have the oldest data for comparison providing a good site choice. The second site spans Rock County, covering a larger square mileage and contained a smaller population of deer per square mile in comparison to Dane and Iowa Counties. The active collection of deer samples during the hunting season provided samples of deer lymph nodes, spinal cords and tonsil samples retrieved with deer-hunter cooperation at deer registration stations. The data was collected for the whole deer hunting season of 2009 at all registration locations within the three counties. In 2008 and 2009 the Wisconsin DNR focused on two core zones, referenced as 77A-CWD Monitoring Area (Site 2) and 70A-CWD Monitoring Area (Site 1), refer to Figure 3.

Each site provided test results and these test results can be compared to the number of deer tested, giving the percentage of positive deer within that monitoring area. This leads to a comparison of the prevalence of Chronic Wasting Disease within the site. The test results can be compared by age and by sex of the tested individual giving the data to understand how males are affected by the disease in comparison to females and how age is a factor to the incubation period. These two sites have different population densities so the results are important in determining a transmittance factor.

Data from the 2009 deer hunting season was received from each location with the Department of Natural Resources cooperation. Data sets were provided of individuals found CWD positive out of each areas population. The data provided can be viewed in categories of age, females versus males, county, directional coordinates within the range and township. The fawn data, or what are considered antlerless deer, cannot provide a proportion of infected individuals, since the fawns are too young to accumulate enough prions for the disease to show up in the testing process. The fawn data is not distinguished in the DNR data for this reason.

Geographic Information Systems

Geographic Information Systems is a computer software system used to combine databases with computer generated maps. GIS creates a visual aid to understand, interpret data relative to relationships, patterns and trends in the forms of maps, globes, reports and charts. In the aspect of CWD research, the data received from the DNR in the 2009 deer hunting season will be linked to a geographic database. The data will be mapped to see patterns and areas of interest, specifically analyzed by population density in reference to the deer testing CWD postitive within the management zones.

Results

The data from adult deer represents the proportion of CWD infected males and females within a population, comparing the sex ratios to each other. Further comparison of these sex ratios was compared between the two sites and can be seen in Figure 1. The results showed that the infected male populations were greater than the infected female populations at each individual site. Comparing the data between the two sites, site 1 (Dane and Iowa County) had a greater infection overall than site 2(Rock County). This overall infection rate is due to lower

population density of deer in Rock County in comparison to Dane/Iowa County's high population of deer. Site 2, 77A, had a 4% CWD prevalance while Site 1, 70A, had a 6.9% CWD prevalance of those tested in 2009. In Rock County, 77A-CWD MZ, there are areas where CWD was not found where as CWD is found throughout 70A-CWD MZ. Figure 1 represents the number of infected divided by the number of tested individuals expressed for each sex at both sites. Site 1: 70 A CWD-MZ presented a 8.1% of males and 6.17% of females in the population were infected with CWD, approximately 24% more males are infected by CWD than females. In site 2: 77A CWD-MZ presented a 5.7% of males and 2.6% of females in the population tested were infected by CWD, approximately 55% more males are infected by CWD than females. These results show how white-tailed bucks are more susceptable to CWD than females.

Discussion

Working with hunter data has created issues with testing my hypothesis. It would be ideal to create two test populations to know each population's size, the number of individuals infected within the population, and the ratio of females to males. Because these animals are live test subjects it is not ideal to herd a population and keep them within the territory until the testing is done. Since the research is young in development, anesteshia will have to be used on each individual to determine if the individual is infected with CWD. The procedure is too invasive for an individual to be awake. Once it has been determined if the animal is CWD+, it would be ideal to release the animals into the population and overtime calculcate the rate of infection and ultimately determine the form of transmittance. Benefits to using the hunting data are how thoroughly the testing is recorded, how many samples can be collected at one time giving an

accurate estimate of the infected population at that period of time and the support for data collection is encouraging.

In order to have a viable sample, the collection period should be over a period of several years. Due to the fact that the data used is from previous years of the DNR collection process it may be difficult to interpret the data. This is because it was not specifically geared toward the transfer of CWD, but focused on how fast the disease is spreading and preventative forms of control. The DNR also relies on active collection during hunting, but receiving samples only once a year can cause incomplete data. It would be ideal for collection to continue year round. An assumption must be made that infected animals are spread evenly through the area to allow for equal opportunity of contraction, but the data suggests that the infection appears in clusters.

Knowing the parameters of experimentation available to scientists it is not probable to eliminate infected males from the test population to hypothesize whether females are infecting males by the courtship ritual. Also by knowing how behavior can cause under-lying factors for disease transfer and how transmissible spongiform encephalopathies diseases with similar symptoms would pass through similar excretions, scientists can expect more research in the future to fully understand the dynamics of transmission through white-tailed deer. For future studies Stella modeling should be implemented in an effort to understand the behavioral dynamics. Stella modeling will allow the white-tailed deer behaviors and known forms of TSE transfer to be modeled to see a predicted outcome. Stella modeling will use known data to weigh the important factors over less important factors giving researchers a viable research tool to implement programs for slowing down transmission.

Working with live specimen, there are many factors that need to be taken into consideration, so a model of behavior used to analyze the numbers should be implemented in

future research. In the end the proportion of CWD infected males is our concern to support the theory of the courtship ritual being a transmittance factor. To measure this proportion of CWD+ males, a behavior ratio of how many females courted by each male will be factor (A), a proportion of infected females (B) will need to be known, and a density of the population will be factor (C). Factor A will rely on the two assumptions that males take urine into the mouth of all the females they court and that prions are transmitted through urine. Females tend to share regular feeding locations with other females, so when a mating buck is present the male will lead him around with her, causing him to come into contact with other females in the area at these familiar feeding sites. High population densities cause females to stay clustered, allowing males to move from female to female to perform the courtship ritual more frequently.

Figure 3 and Figure 4 shows our area of interest in detail and a refence to where these three areas are located in Wisconsin. In Figure 4, Dane, Iowa, and Rock counties are outlined in yellow; the area outlined in red identifies the CWD management zones 70A and 77A. Each square box outlined in black indicates a township and an area of a square mile. Comparing the CWD management zones one can see the likelyhood of frequence within the area. Referring to the GIS map, Figure 4, the highlighted areas indicate a ratio of CWD+ males and CWD+ females. The map does not indicate the differential amount of deer tested in each site. In site 77A, Rock County, there were 297 deer tested for CWD and out of that total only 12 deer tested positive. Each of these 12-CWD positive deer had a kill zone which was located and coordinated with the GIS mapping database to distribute accordingly, and given a grade scale. Site 2, 77A does not compare with site 1; 70A which had a total of 1323 deer tested for CWD with 92 CWD+ deer. Site 1, 70A has a significantly higher population than Rock County. Despite this difference in populations, the ratios of males to females tested at each site were

relatively equal. With this relatively equal ratio of deer tested and the results of Figure 1, the significance can be seen. Since the ratio of males to females tested is equal, the prevalence of CWD+ males over CWD+ females is important only to the forms of transmittance and not to population tested.

Earn-A-Buck is a program requiring a hunter to tag, harvest, an antlerless deer (doe or fawn) prior to being authorized to harvest an antlered deer (buck). Earn-a-buck is an effective population control measure which increases harvest pressure on antlerless deer. Otherwise prize bucks would be overharvested leaving a very unhealthy deer population. In 2009, CWD Deer Management Units located within the specific CWD Management Zone had unlimited earn-a-buck regulations. Both CWD-MZ 77A and 70A, the locations used in this study, had unlimited earn-a-buck regulations. This regulation specifically cause more antlerless deer to be harvested; the data supported this at fourteen more antlerless deer were harvest then antlered deer in Site 2 and 235 more antlerless deer were harvested then antlered deer in Site 1. The greater number of antlerless (female) deer at each site is not a true representation of males and females harvested due to the inclusion of doe fawns and buck fawns considered in the antlerless deer number. During the hunting season fawns, or yearlings, are undistinguishable from does at great distances. Buck fawns are categorized as antlerless deer for their inability to grow antlers the first winter and undistinguishable features compared to females; therefore the ratio of harvested males to females is an inaccurate model of the ratios occurring in nature.

Many seasons of white-tailed deer fawns have shown nearly even ratios of buck fawns to doe fawns. A theoretical 50:50 sex ratio has been recognized in vertebrates, leaving scientists to wonder if this equality is evolutionary or adaptive (Verme, 1981). The length of time a doe has been in estrus when a fawn is conceived influences the sex of her progeny (Verme, 1981).

Movement of 67 does, were monitored through individual pens, until every doe had bred or until the trials ended in early winter (Verme, 1981). Based on observations the does would increase their movements significantly which signaled the start of estrus (Verme, 1981). In this particular study the interval between estrus onset and breeding was prolonged to determine the effect the estrus cycle has on the sex of fawn produced. In this study the sex ratio was 62 males: 63 females overall.

The research of CWD transmission must continue to give Wisconsin a better understanding of how CWD is affecting the deer populations in the state. The state of Colorado has reviewed CWD in their state to be a result of overpopulation. If CWD infections are a direct correlation to deer behavior, then CWD could be a sign of an overpopulated area, but relating back to the other TSEs it cannot be concluded that TSEs in general act as indicators for over populated areas. Overpopulation can lead to an increased infection rate by raw fact that the individual is exposed more to infection when inhabiting a densely population area. With the lack of information Wisconsin has obtained over the last seven years, it is not safe to say how CWD has affected the white-tailed deer populations.

In conclusion, an infected individual can transmit prions to another individual without showings visible signs of CWD or other TSEs. Prions were found to be detectable in urine when chronic inflammatory kidney disorders were present; supporting how effective prion infectivity transfers when sheep have instincts to eat the placenta of their offspring or when white-tailed deer have behavior rituals during the rutting season. Essentially CWD prevalence is a not limited to the transfer of bodily fluids, such as blood, saliva, urine, but extended to environmental exposure. Transmittance of CWD in white-tailed deer is enhanced by behavior rituals, high population densities and other key modes of transmittance. Based on the behavior

ritual predictions were made, that the prevalence of CWD in males would be twice the prevalence of CWD in females. Although, the data did not support the prediction, the ratio of infected males was significantly higher than the ratio of infected females. Despite different densities between the test sites a higher ratio of infected males was present at both sites, suggesting density is not a prominent factor in CWD transmission. It is important to understand how CWD transfers from individual to individual to sustain a healthy deer population. Understanding how CWD and other TSEs transfer within a species can provide understanding to how transfers are made between species. Future work should incorporate how CWD transmits in relation to how transmission is enhanced by behavior of white-tailed deer, *Odocoileus virginianus.*

Figure 1: Represents the number of CWD infected individuals in comparison to the sex of the individual. Site 1: 70A CWD-MZ is Dane and Iowa County. Site 2: 77A CWD-MZ is Rock County.

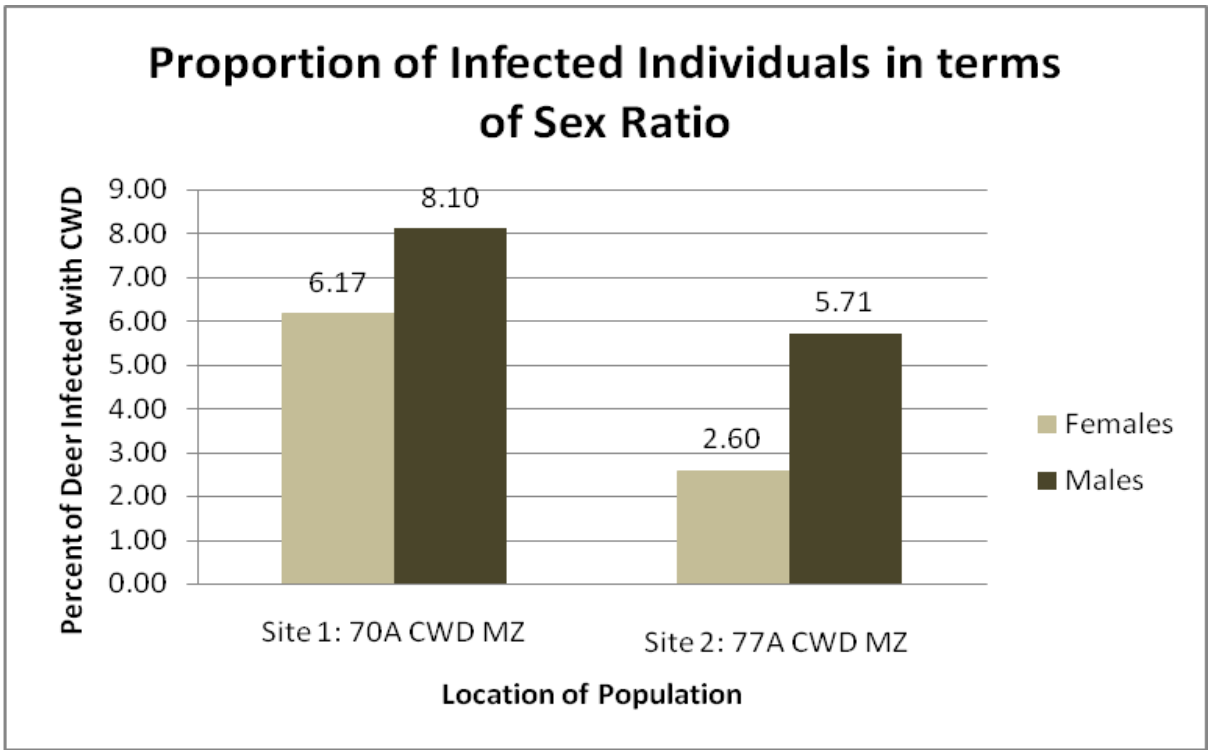
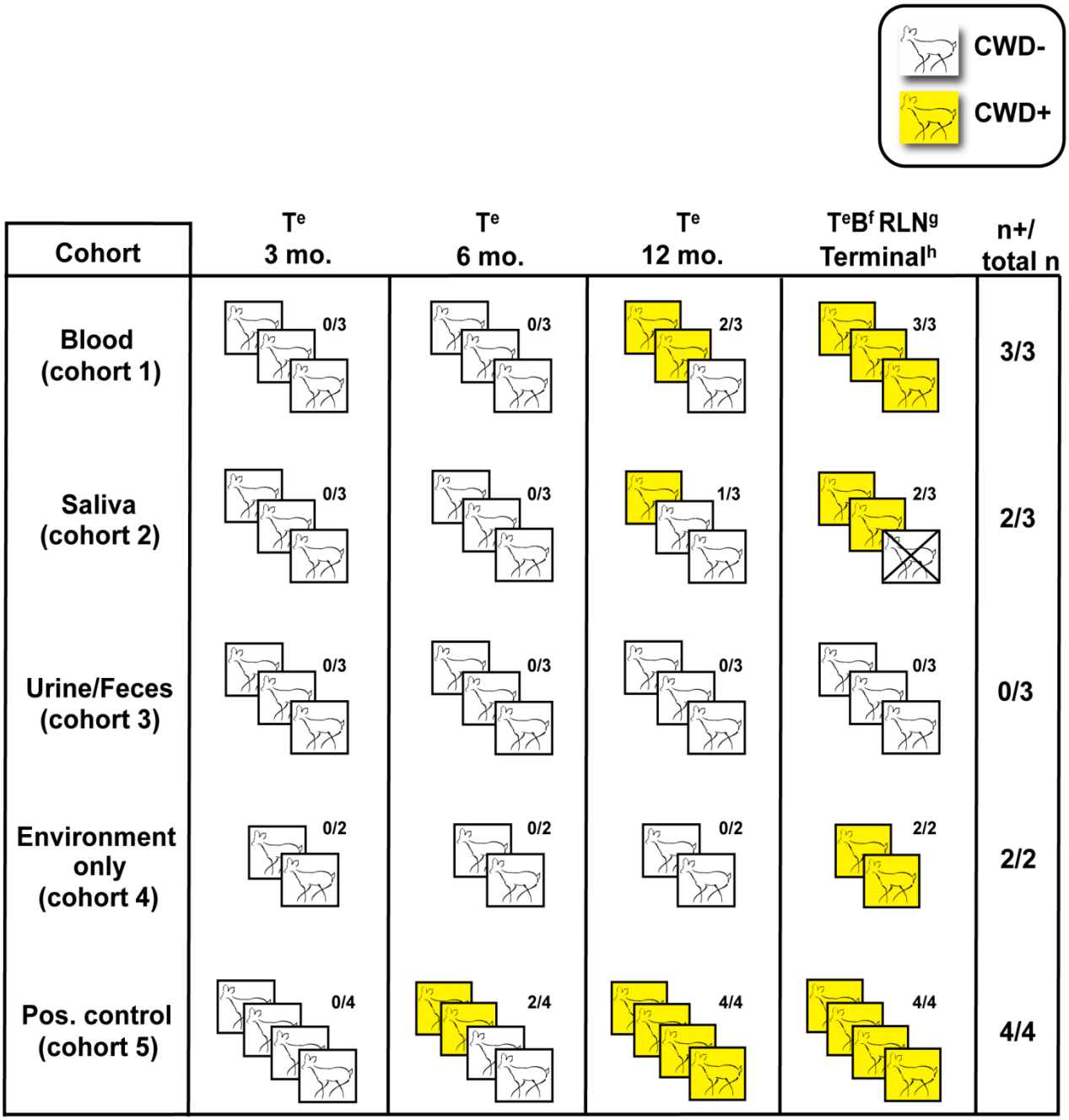


Figure 2: PrP^{CWD} detection by longitudinal tonsil biopsy and terminal necropsy. Five cohorts were tested on white-tailed deer fawns to determine possible CWD transmission modes (Mathiason, 2009).



Te=tonsil, Bf=Brain at obex, RLNg=Retropharyngeal lymph node, h= euthanasia dependent upon clinical disease progression or space availability, X= animal euthanized for reason other than CWD.