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Coping with Deer in Connecticut

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Deer produce a mixed reaction in Connecticut

It is hard to be neutral about white-tailed deer.

These bashful creatures can spellbind us with their graceful bounds across open meadows or as they graze in pastoral landscapes reminiscent of an earlier age. Deer also provide recreation opportunities for hunters and photographers who track and stalk them for the perfect shot. And who can resist the appealing look of a fawn still with the spots which, together with its size, reveal its tender age.

But there is another side to deer.

Deer may spring without warning into the path of an oncoming vehicle and cause an accident. They often extend their grazing into suburban yards, nurseries, orchards, and farms. They harbor the ticks that transmit pathogens that cause diseases such as Lyme disease. Even their meat has been identified as a potential source of *E. coli* infection.

Considering how ubiquitous they are, it is hard to imagine a time when deer were rare. In 1900, the number of deer in the entire state was thought to be a dozen. Now, the population is estimated by the Department of Environmental Protection at 76,000 and growing. Deer can sometimes be observed feeding in herds of a dozen or more alongside horses and cows in a pasture. Under the cover of darkness, deer may also steal into yards or nurseries and consume large quantities of desirable and valuable plants such as tulips, hostas, rhododendrons, and yews. Also, wherever deer are active, it is usually easy to find black-legged ticks, potential carriers of the spirochete that causes Lyme disease, in abundance.

Because deer are so important as pests in our gardens and nurseries and the role they have in the transmission and spread of tick-borne diseases, we have chosen to devote this issue of *Frontiers of Plant Science* to white-tailed deer and the research being conducted on the species at the Experiment Station.

- Kirby C. Stafford III writes about the relationship of deer to Lyme disease and efforts to control ticks.
- Jeffrey S. Ward writes about a survey of their favorite landscape plants and about possible ways to protect small trees in the forest from deer browsing.
- Uma Ramakrishnan writes about research into deer abundance and habits and experiments getting underway to control deer through non-lethal means.
- Douglas W. Dingman writes about *E. coli* and deer browsing and deer meat as a potential source of *E. coli.*

I hope you find this issue useful and informative.

John F. Anderson

Director

An increasing deer population is linked to the rising incidence of Lyme disease

By Kirby C. Stafford III

A major problem related to the increasing population of white-tailed deer is Lyme disease, which is caused by the spirochete (a type of bacterium) *Borrelia burgdorferi*. The blacklegged tick (*Ixodes scapularis*), which is commonly known as the deer tick, transmits the Lyme disease spirochete in the Northeast and upper Midwest. White-tailed deer are the primary host for the adult stage of the blacklegged tick, although adults also feed on medium-sized mammals such as dogs, cats, and raccoons. Each blood-fed engorged female tick from deer can lay 1,000-2,000 eggs.

Accumulating evidence from Experiment Station scientists and others indicates that the abundance and distribution of the tick is correlated with deer density, and the increase in Lyme disease is related to the resurging deer population. According to the Connecticut Department of Environmental Protection, the highest deer densities in Connecticut are in Fairfield County. According to the Connecticut Department of Public Health, this county accounted for over one-third of the reported cases of Lyme disease in the state in 2000.

Maintenance of the Lyme disease spirochete, however, is dependent upon cyclic transmission between the immature stages of the tick and certain small animal hosts, particularly the white-footed mouse (*Peromyscus leucopus*).

Lyme disease was first recognized from a cluster of cases in Lyme, CT, in 1975. The spirochete which causes it was finally identified in 1982. The number of reported human cases in Connecticut has steadily increased since the disease was made reportable to the Department of Public Health in 1987 (224 cases) to 3,772 cases in 2000.

Lyme disease is the leading arthropod-associated disease in the United States, with nearly 130,000 cases reported nationally for the 11-year period from 1989-1999. Over 90% of the cases are still reported from the Northeast, Mid-Atlantic, and upper Midwest. The pathogens of two other diseases, human babesiosis (caused by *Babesia microti*), and human granulocytic ehrlichiosis (HGE), are also transmitted by *I. scapularis* in Connecticut.

Engorged female deer tick laying eggs (enlarged 3 times).

The highest deer densities in Connecticut are in Fairfield County

Drs. John F. Anderson and Louis A. Magnarelli and colleagues examined the presence of *B. burgdorferi* and *B. microti* and ticks on several islands in Narragansett Bay, RI; two islands inhabited by deer and mice and four islands without deer. Both *B. burgdorferi* and *B. microti* were isolated from tick-infested white-footed mice and meadow voles (*Microtus pennsylvanicus*) on the two deer-inhabited islands. Neither of the pathogens nor the blacklegged tick was detected in mice on the four islands that had no deer. This suggested that, in the absence of deer, other mammalian hosts couldn't sustain the tick in sufficient numbers to transmit the Lyme disease or babesiosis agents. This raised the question whether a reduction in a deer population could reduce tick numbers sufficiently to prevent human infection.

I initially approached this question by examining the impact of excluding white-tailed deer through the use of electric deer fencing. Host-seeking ticks were sampled both within and outside two fenced enclosures (ca. 8 acres and 15 acres) and at nearby unfenced properties in Lyme. Tick numbers declined significantly the farther inside the fence one went, with a 74% reduction in adult tick abundance and a 84% reduction in nymphal ticks, in plots >70 meters within the fenced property. No larval ticks were recovered in these plots. Twice as many mice near the fence line were infested with ticks compared with those captured in woods well within the fenced area. Most of the larval ticks (86% of only 22) recovered from the mice far within the fenced properties were taken from a single male mouse, illustrating that small mammals can infest a protected area with ticks.

In another study, I examined the impact of steady and transient deer reductions on tick populations over an 8-year period from 1992-2000. Deer populations at two sites in Connecticut initially exceeded 200 animals per square mile, but were reduced through contraceptive studies or controlled hunts to less than 40 deer per square mile. These geographically isolated sites, the Bluff Point Coastal Reserve in Groton and a privately-owned, forested, fenced tract in Bridgeport, had high deer densities and superabundant tick populations. Although with the decline in deer population tick abundance was reduced, it had only declined to levels comparable to what I have recorded in the towns of Lyme, Old Lyme, Westport, and Weston, where deer densities also range 30-40 deer per square mile. Ticks infected with *B. burgdorferi* remained abundant. Incidentally, I discovered that a minute wasp killed up to nearly 30% of the *I. scapularis* ticks at both sites. With the decline in the deer population, parasitism rates by the wasp have also declined to very low levels (<1.0%). This suggests that tick densities

A computer model suggests that the population of blacklegged ticks could be reduced to low levels over a period of 3-5 years if 95% of the ticks could be killed on 90% of the local deer.

on the mainland are too low for the wasp to adequately find and parasitize its tick hosts. All the Station's studies and those conducted elsewhere indicate that the deer population would have to be reduced to very low levels to reduce tick levels sufficiently to impact the transmission of either *B. burgdorferi* or *B. microti*.

An alternative approach would be to treat the deer, either orally or topically, with a chemical to kill female ticks and reduce tick reproduction. The use of the broad spectrum anti-parasite drug ivermectin has been shown to effectively kill ticks on treated animals. Its use in deer is precluded by a 48-day withdrawal period between treatment and slaughter of an animal for human consumption. Treatment of deer during the peak period of adult blacklegged tick activity would correspond with the fall hunting season. The USDA developed another approach, a self-application system for treating deer with a topical pesticide using a patented bait system termed the '4-poster'. The device consists of a central bin that holds whole kernel corn as an attractant and two feeding troughs on either side of the bin. Deer have to angle their heads to reach the corn in the trough and, consequently, contact one of two vertical foam paint rollers, which deliver the pesticide as the the animals press against the rollers when feeding. In Texas, 92 and 97% control of adult and nymphal lone star ticks (*Amblyomma americanum*), respectively, on treated deer was obtained.

A computer model suggests that the population of blacklegged ticks could be reduced to low levels over a period of 3-5 years if 95% of the ticks could be killed on 90% of the local deer. Consequently, a regional tick control project was begun in the Northeast with experimental sites in Connecticut, Rhode Island, New York, New Jersey, and Maryland. Each site has up to 24 of the 4-poster devices distributed over a 2 square mile area, mainly in residential

Deer visiting a 4-poster in a photograph taken at night by a motion-sensing camera.

Scott Williams fits a captured deer with cattle tags to aid in future identification.

communities. Another community serves as a control. The devices are operated during the fall and spring when adult *I. scapularis* are primarily active, although summer stages of lone star ticks on deer are also targeted in New Jersey and Maryland.

In Connecticut, associates at White Buffalo Inc. and the Experiment Station and I first placed the devices in Old Lyme in fall 1997. With the exception of the second adult tick season, over 90% of the local deer have been visiting the devices. Because a large production of acorns during fall 1998 provided a preferred alternative food source, little usage of the 4-posters was noted.

Some additional adjustments to the 4-posters were found necessary to ensure delivery of sufficient chemical to kill the ticks within the winter hair coat of the large number of deer visiting the devices.

Concurrently, my assistants and I have sampled host-seeking larval and nymphal ticks at residential sites in the treated area in Old Lyme and in an untreated area of Old Saybrook each year. Although tick numbers in Old Lyme were up slightly in summer 2000 compared with numbers during the drought of 1999, preliminary calculations indicate an overall decline of over 70% in larvae and nymphs from 1998 to 2000 in comparison with tick populations in the untreated control area in Old Saybrook. It cannot yet be substantiated whether this reduction is due to the treatment of the deer. Reductions in tick numbers on deer comparable to the Texas studies have been observed in the one state (New York) where deer were tranquilized and inspected for ticks at both the treated and control communities.

Treating deer to control tick populations remains an experimental approach and the exclusion of deer by fencing is expensive and limited in many areas. With the exception of some islands, it is unlikely deer numbers can be reduced and maintained at a level sufficient to impact the rate of tick-borne disease. It is clear that with rising deer populations in the Northeast and in the absence of an effective natural enemy or a tick control and Lyme disease vaccine program, the number of ticks and tick-associated illnesses will continue to increase.

Limiting deer browse damage in yards and forests through plant selection and protection

By Jeffrey S. Ward

Many Nutmeggers, especially those near forests, have witnessed the damage that visiting deer cause to their vegetable and flower gardens. Large deer herds have also caused many commercial nurseries and farms to adjust their planting practices by applying repellents, constructing fences, or planting browse-susceptible species near high traffic areas.

Until there is public consensus on both the necessity and method of reducing deer populations, gardeners will have to adopt landscape design and management techniques that minimize the amount of damage caused by deer browsing. If scare tactics, repellents, or fences have failed to deter deer from feeding on your landscape plants, then the only probable remaining alternative is to choose plants that are resistant to deer browse. Over the past 2 years, I conducted a survey on deer browse damage with 269 Connecticut gardeners and landscapers in 63 towns participating. The Federated Garden Clubs of Connecticut, the Wilton Garden Club, and Margaret Boehm greatly assisted in the dissemination and collection of the surveys.

As part of the survey, gardeners noted which species had, and had not, been browsed in their gardens. This provided an estimate of the frequency of browse damage. Gardeners also reported the amount of browse damage, or severity, to plants that had been browsed. Severity was noted on a scale from 0 (no damage) to 5 (extreme, cannot grow species). Most gardeners (97%) who completed the survey have had some browse damage to their landscape plants.

Browse damage has caused a shift in the type and number of landscape species in some parts of Connecticut. Nearly 60% of the gardeners who participated in the survey have stopped growing at least one (average 5.6) species because of deer browse damage. Over half the gardeners who completed the survey have stopped growing tulips (Tulipa) because of browse damage. Other common species that gardeners reported they no long grow include yew (Taxus), arborvitae (Thuja), hosta (Hosta), daylily (Hemerocallis), and impatiens (Impatiens).

This survey of browse damage susceptibility is unique because it is state-wide and because it provides an index value of the relative browse damage susceptibility of each species. Browse damage depends on local deer density, their feeding habits, and availability of food in the neighborhood and the surrounding woods. Which species are browsed, and the amount of browse damage, will vary from year to year, and from neighborhood to neighborhood.

Damage severity is also dependent on an individual gardener's tolerance of browse. Damage that a casual gardener might rate as light might be rated as extreme by a gardener growing a special cultivar. Thus, this comprehensive survey not only integrates town-to-town and neighborhood-to-neighborhood variation, but also incorporates the sensitivity of individual gardeners to browse damage.

Choosing resistant plants will increase the odds that deer will not cause extensive damage to the shrubs and flowers in your landscape.

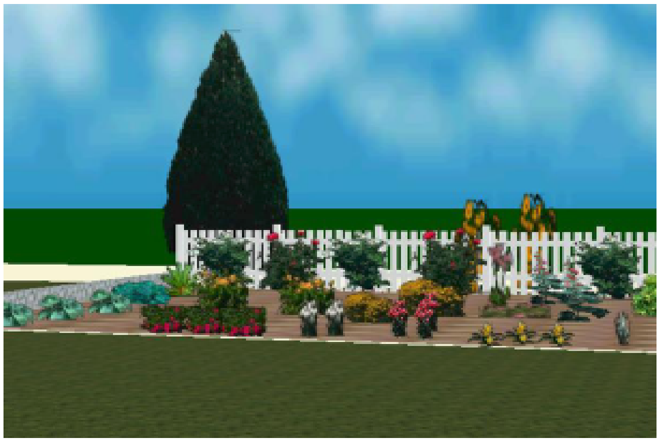
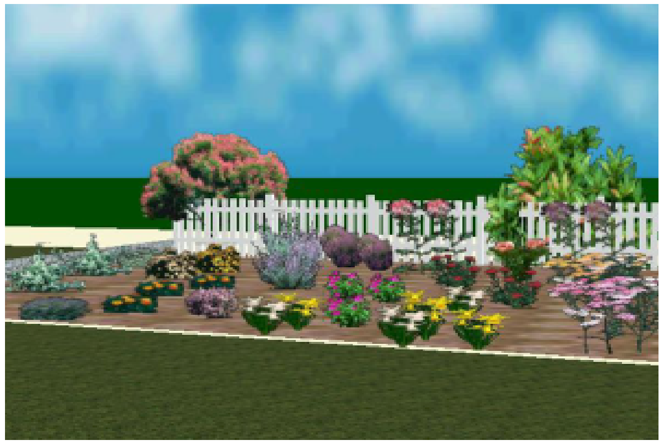
The index value for a given species incorporates both the frequency and average severity of browse damage. Index values ranged from <50 (highly resistant) to >200 (highly susceptible). The advantage of an index value for each species is that it allows homeowners more flexibility in selecting plants, especially in areas with low to moderate browse damage.

The index of browse damage susceptibility was calculated for 256 species. These values are published in Bulletin 968 "Limiting deer browse damage to landscape plants." (available on the Station's website at www.caes.state.ct.us or from Publications: The Connecticut Agricultural Experiment Station, P.O. Box 1106; New Haven, CT 06504-1106). In addition, the Bulletin provides an in-depth description of the survey methodology and lists the frequency and average severity of browse and the number of respondents for each species.

No species was completely resistant to browse damage. This is exemplified by daffodils (*Narcissus* spp.). Daffodils are usually listed as completely or highly resistant to deer browse damage. However, 15% of gardeners in our survey reported at least some browse damage, albeit light, to their daffodils. This damage was probably caused by fawns that had not yet learned to avoid daffodils because they contain calcium oxylate crystals and toxic alkaloids.

There are no guarantees against browse damage (deer are unpredictable), but choosing resistant plants will increase the odds that deer will not cause extensive damage to the shrubs and flowers in your landscape. One possible design would include snowdrops (*Galanthus*), Star of Bethlehem (*Ornithogalum*), and daffodils (*Narcissus*) for early spring color. Shrubs such as andromeda (*Pieris*), beautybush (*Kolkwitzia*), heather (*Calluna*), and bluebeard (*Caryopteris*) can be used as foundation plants or focal anchors in the garden. For summer color, annuals such as marigolds (*Tagetes*), spiderflowers (*Cleome*), and vinca (*Catharanthus*) could be used. Additional diversity can be added to the garden's palette by incorporating perennials such as poppies (*Papaver*), Russian sage (*Perovskia*), Lamb's ears (*Stachys*), yarrow (*Achillea*), and silvermound (*Artemisia*). A browse-resistant garden would not be complete without a section of aromatic herbs including lavender (*Lavandula*), mint (*Mentha*), oregano (*Origanum*), and thyme (*Thymus*).

A different suite of plants, those that are very susceptible

Colorful gardens can be grown in areas with and without high densities of deer. A susceptible garden and a resistant garden are illustrated. The browse-susceptible garden, left, has yews, sunflowers, roses, hosta, impatiens, tulips, crocus, daylilies, yucca, phlox, lobelia, black-eyed Susans, and purple coneflowers. The browse-resistant garden, right, has butterfly bush, beautybush, marigolds, poppies, daffodils, spiderflowers, vinca, Russian sage, yarrow, Artemisia, mints, and lavender.

to deer browse damage, can be grown where browse damage is minimal, or in gardens that are fenced to exclude deer. Massed plantings of tulips, crocus (*Crocus*), and lilies (*Lilium*) herald the arrival of spring. Azaleas (*Rhododendron*) and mountain laurels (*Kalmia*) form walls of color in the juncture between spring and summer. Yews, cedars (*Juniperus*), and arborvitae frame the summer garden alive with a rainbow of colors provided by annuals such as impatiens, sunflowers (*Helianthus*), dahlias (*Dahlia*), and begonias (*Begonia*). Against a border of hosta are many of the perennial favorites including: daylilies, garden phlox (*P. paniculata*), hollyhocks (*Alcea*), black-eyed Susans (*Rudbeckia*), Shasta daisies (*Leucanthemum*), coneflowers (*Echinacea*), and cardinal flowers (*Lobelia*). Where deer browse damage is minimal, the centerpiece of many gardens is the kaleidoscope of whites, yellows, pinks, and reds found in a rose (*Rosa*) collection.

Although not as visible to most as damage occurring in gardens, deer browsing is causing long-term changes in forest ecosystems in many parts of the state. In some forests, severe deer browse has fostered groundcovers dominated by ferns, grasses, and alien invasive species. Severe browsing has also reduced natural regeneration of species (e.g., oak, maple, pine) needed to replace harvested or dead trees. Because hophornbeam, blue beech, striped maple, and barberry are unpalatable species, understories dominated by these species are good indicators of severe browse pressure.

Maintaining a diverse forest is an important element of responsible forest management. Browsing by large deer herds has prevented successful regeneration of important species such as oak, pine, and hemlock. Concern over the impact of deer browsing in forest ecosystems stimulated research on reducing damage that began in the late 1980s. Tree planting is a method of forest regeneration that allows both maintenance of these species and introduction of other species. However, planting requires an investment of both time and material. In areas with large deer herds, entire plantings can be destroyed by browsing unless the seedlings are protected. Replanting would be futile without protecting the replacement seedlings.

George R. Stephens, Martin P.N. Gent, Todd Mervosh, and I began experiments examining different methods of limiting deer browse damage in 1989. These studies would not be possible without the cooperation of the Connecticut Department of Environmental Protection, Division of Forestry; Regional Water Authority; Northeast Utilities; Great Mountain Forest; Ferrucci and Walicki, LLC; and Hull Forest Products. In addition to providing study sites, these organizations donated personnel and material to plant the 3,920 seedlings used in the experiments.

These studies have evaluated the effectiveness of seven devices to reduce browse damage: 2 ft tall plastic mesh sleeves, 2 ft tall spunbonded polypropylene sleeves, 4 and 6 ft tall tan treeshelters, 4 ft tall white treeshelters, 2 ft tall rigid mesh tubes (Vexlar), and bud caps. Five tree species were included in the study: northern red oak, eastern white pine, Norway spruce, eastern hemlock, and black walnut.

Our results have shown that the combination of rigid mesh tubes and bud caps is a promising, cost-effective method of protecting eastern white pine and Norway spruce from browse damage. The rigid mesh tubes are placed over the seedlings immediately after planting and provide protection for 2 years. When the growing seedlings emerge from the tubes after the second growing season, the terminal leaders are then protected with bud caps. Bud caps are 6-inch long tubes of spunbonded polypropylene that are placed directly over terminal leaders and stapled to the needles. They have an open top to allow normal expansion of the developing bud during the spring. Bud caps disintegrate within several years.

Deer have demonstrated a remarkable ability to adapt and thrive in the presence of increasing numbers of humans. Today, and for the foreseeable future, deer are a part of both suburban and natural landscapes in Connecticut. Where reducing the deer herd is not a viable option, we will also need to continue to adapt by planting browse-resistant landscape species and protecting valuable tree species in reforestation projects.

Methods of controlling white-tailed deer

By Uma Ramakrishnan

Residential areas at forest fringes are attractive to white-tailed deer because there is year-round access to food within a small area. Hunting is often problematic or prohibited in such suburban areas. Therefore I have begun to explore non-lethal control methods to manage deer in the urban forest.

Live capture and relocation is expensive, and mortality is often high. Contraception has been used to remove individuals from the reproductive pool, but a major problem is that use of contraceptives requires multiple treatments of the same female each year.

The option of male sterilization is often brought up in discussions, but it has not been investigated. Hunting records have shown that removing males does not adversely affect the reproductive rate because the males that remain will mate with the females. However, by sterilizing large males and retaining them in the population, the number of fawns born might be reduced. This is feasible because white-tailed deer exhibit a distinct hierarchy in which dominant males monopolize most mating.

A promising method of male sterilization involves the injection of chemicals such as carbolic acid directly into the vas deferens, which are a set of tubes that transport sperm. The chemicals cause scarring which blocks the tubes, thus

A bald eagle feeding on a deer killed by coyotes.

By sterilizing large males and retaining them in the population, the number of fawns born might be reduced

preventing reproduction while not affecting reproductive behavior. This sterilization method has been tried successfully on other species, including humans, and I will try it on white-tailed deer.

I am studying deer on South Central Regional Water Authority property at Lake Gaillard in North Branford, where residential communities border the southern edge. As part of my study, I am collecting information on population, movements, and behavior.

Based on numbers recorded since September 1999, I estimate densities in the northern part of the study site at 25 deer/sq. mile. Densities adjacent to residences are significantly higher, at 120 deer/sq. mile. I have captured over 50 deer and fitted them with cattle tags to allow identification of individuals. To record their movements, some have been fitted with GPS (global positioning system) collars and radio collars. The GPS collars use satellites to record the exact location of the deer as many as 24 times daily. The radio collars allow us to locate the deer on the ground when we need to.

In Connecticut, the only predator capable of taking down adult white-tailed deer is the coyote. Although smaller than mountain lions and wolves, coyotes contribute to deer mortality, especially fawns. I am recording all deer mortality at the site and determining the cause when possible. Examination of hair found in droppings revealed a high proportion of deer in coyote diets. Using motion-activated cameras focused on deer carcasses, I have also found that the carcasses provide food to a host of species, including gray and red fox, raccoons, martins, skunks, and birds of prey, including eagles.

Sterilization must be viewed only as a long-term solution. While this technique is unlikely to be more effective than hunting, where 11,000 deer are harvested each year, it may provide a control alternative, especially in areas where residential densities preclude hunting as an option.

E. coli and deer in orchards and deer meat

By Douglas W. Dingman

Escherichia coli O157:H7, which can cause a fatal disease in humans, has been identified in apple cider manufactured in Connecticut. Because white-tailed deer are often observed in apple orchards and have been suggested as a source for this microbe, I monitored several orchards and the surrounding wooded areas for the presence of *E. coli* O157:H7 for 2 years.

Deer feces were collected from four apple orchards and near a cattle farm in New Haven County, primarily during the

These findings also indicate that deer meat must be prepared with the same care as commercially-available meats to minimize the likelihood of infection

summer (June to September) and in the late fall (November). *E. coli* O157:H7 was not identified in 196 fecal samples collected from the ground in the apple orchards and farm. Likewise, the testing of 38 rectal swab samples obtained from deer killed during the hunting season (November to December) in 1997 and 10 cattle feces samples from 1998 was also negative.

However, health authorities found that *E. coli* O157:H7 had a role in the 1998 illness of a 7-year-old boy who had eaten barbecued white-tailed deer meat. Using an immunomagnetic enrichment technique, I isolated *E. coli* O157:H7 from frozen meat of the deer suspected as the cause of the infection. PFGE DNA-fingerprinting comparisons showed identical patterns between the *E. coli* O157:H7 culture obtained from the frozen deer meat and a clinical *E. coli* O157:H7 culture isolated from the child.

I also found genes for verotoxin production in approximately 50% of all the *E. coli* isolates (non-O157:H7) obtained from the deer feces. Verotoxins (also called Shiga toxins) are a family of toxins that inhibit protein synthesis and destroy cells. These toxins have been attributed to the cause of bloody diarrhea, and, once absorbed into the bloodstream, can cause extensive damage to kidney cells and lead to the condition called hemolytic uremic syndrome (HUS).

My investigations have shown that deer are an incidental host and are not likely a long-term carrier for *E. coli* O157:H7. However, these findings also indicate that deer meat must be prepared with the same care as commercially-available meats to minimize the likelihood of infection.

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