

DEER: A NEW SOURCE OF *ESCHERICHIA COLI* O157:H7 INFECTIONS

IN NOVEMBER 1995, a three-year-old Corvallis boy was hospitalized with bloody diarrhea. *Escherichia coli* O157:H7 ("O157") was isolated from a stool culture, and the case was reported to the Benton County Health Department. As part of the routine follow-up, questions were posed about any concurrent diarrheal illness in the household, and, in fact, several household members and friends reported mild symptoms. Additional stool specimens were eagerly solicited. Of interest was the story that two days before the first illness, family members had begun to eat jerky prepared from a deer killed the week before.

O157 is an important cause of infectious diarrhea and the hemolytic uremic syndrome. Although an increasing variety of food sources and other vehicles for O157 transmission have been documented in recent years, direct or indirect exposure to bovine or human feces explains almost all cases where a source is identified. O157 has occasionally been isolated from animals other than cattle, including sheep, goats, and a dog, and from retail meats other than beef, including pork, lamb, and poultry. To date, however, only cattle had been unambiguously implicated as zoonotic sources of human infection. The hunt was on.

THE CASES

We identified six culture-confirmed and five presumptive cases, ranging from nine months to 54 years old (median, 22 years). These included 9 of 11 persons in three households (an extended family) and two hapless friends who visited for a weekend. As is common with O157 infections, most were not very sick; only two cases (both confirmed) reported bloody stools, and only one (the index) sought medical attention.

With almost everyone ill in these families, we could not do a case-control or cohort study (no controls). The two visitors shared relatively few exposures, however, and venison jerky was the only food item identified that could readily

explain the outbreak. All but one of the cases (an infant, presumably infected by person-to-person transmission) began eating the jerky on November 11.

WHENCE THE JERKY?

The deer was shot on November 4; the chest wound allegedly did not result in intestinal rupture. The deer was gutted in the woods, dragged to a truck, and hung outdoors at ambient temperatures for five days. After skinning, the carcass was dismembered with the band saw in the garage and further trimmed by hand. Some 10 kg were cut into thin strips and marinated in a refrigerator. The meat was dried in several batches in a food dehydrator set at 52-57°C (125-135°F) for 12-14 hours per batch. The drier consisted of a set of plastic racks stacked over a thermostatically-controlled heating element.

Leftover jerky and uncooked frozen venison from the same carcass were tested; both were positive for O157. (After storage at room temperature, some of the jerky was *still* positive one year later.) Thus, it seemed clear that the jerky had been the source of the first infections in the household (some later ones could be the result of person-to-person transmission). But was the deer actually infected at the time it went to its great reward—or was this another example of cross-contamination?

On November 28, we were guided to the site where the deer had been field dressed, but as expected, there were no traces of intestines (or anything else) worth culturing. At the house where the animal had been butchered, we swabbed kitchen counters, freezer shelves, and the band saw. The deer skin had been discarded, but a few slimy fragments teeming with maggots were collected from the remains found nearby.

To our surprise, O157 was cultured from both a gout of dried gore in the band saw and from the rotting deer skin. By pulsed-field gel electrophoresis (PFGE), these isolates were an exact match to those from the six stool-positive cases, as

well as those from the meat. The significance of the positive skin lies in the fact that it was removed before the animal was cut up on the band saw—effectively ruling out cross-contamination from earlier mayhem as a source.

SO WHAT ABOUT DEER?

One month after the hunt, we enlisted the help of OSU foresters and local health department sanitarians to collect deer and elk fecal pellets from the vicinity. Single pellets were collected from each fresh-appearing pile found. O157 was cultured from 3 (9%) of 32 deer pellets and none of 9 elk pellets collected. By PFGE, these isolates appeared unrelated to the outbreak strain.

Meanwhile, back at the literature, there was a single report of O157 culture-positive deer pellets on a cattle ranch in Texas,¹ and a report of a positive water sample from a Pennsylvania pond around which deer were abundant (and cattle were absent).² Although not discussed in their report, investigators had considered deer a possible source of the apple contamination that led to a 1991 outbreak of O157 infections traced to unpasteurized apple cider.³ None of the ~10 deer pellets cultured from the implicated orchard were positive. O157 was cultured from caribou meat collected during an outbreak investigation in a remote Canadian village,⁴ but caribou consumption was not associated with illness, and opportunities for post-slaughter contamination were rife.⁵

DRIED MEAT: IS IT SAFE?

So what about jerky? As Dustin Hoffman ponders in *Marathon Man*, "is it safe?" Drying meat is a time-honored method of preserving it, known since the time of the Pharaohs.* But is it safe? We enlisted food microbiologists at the University of Georgia to address this question. In laboratory experiments, they assessed the fate of O157 during jerky preparation, using procedures similar to those used by the Oregon family.

* and what was their life expectancy?

Venison strips were inoculated with measured amounts of O157, covered with either an acidic marinade or a neutral buffer (PBS), and refrigerated for 15 hours. The meat was then dried for 10 hours at 52° and 63°C (125° and 145°F), with sampling at 2-hour intervals.[†] At the lower temperature, bacterial counts for the PBS-steeped venison were essentially unchanged over the 10-hour period, while counts declined slowly for the marinated specimens, reaching levels too low to be quantified after 10 hours. At the higher temperature, O157 levels fell within 6-8 hours to levels that were undetectable by direct plating. With enrichment, however, O157 could still be cultured after 10 hours at the dehydrator's hottest temperature (63°C/145°F). Given O157's probably very low infectious dose, this is not good news.

DISCUSSION

This investigation implicated both a novel species (black-tailed deer) and a novel food vehicle (jerky) as sources of human infections with O157. In fact, this is the first time that animals other than cattle have been confirmed to be a source of this disease. Culturing O157 with a different PFGE pattern from fresh droppings a month later suggests that colonization of deer may not be a fluke occurrence.

Following this outbreak, in fact, the Health Division added venison consumption and deer hunting to the list of possible exposures asked of every reported O157 case. In 1996, a Linn County resident developed bloody diarrhea after killing and butchering a deer; O157 isolates with identical PFGE patterns

[†] no, not *per os*.

were cultured from both the hunter and frozen cuts of the venison. In just the last few months, O157 was isolated from deer pellets collected near a certain California apple orchard, and two or three human cases in Illinois have been linked to consumption of contaminated venison.

Collectively, these observations raise new questions about the role of deer and other wild ruminants in the maintenance and transmission of O157. Many humans have direct exposure to cervids, and deer in particular often range freely through cattle rangeland and other agricultural land. Deer thus have the opportunity both to contaminate produce and to transport O157 among otherwise segregated cattle herds.

Game processing poses several challenges for the control of foodborne disease. Venison can be heavily contaminated with fecal bacteria,⁶ the degree varying with the hunter's skill, wound location, and other factors. While fresh beef is usually rapidly chilled, deer carcasses are typically held at ambient temperatures for several days, potentially allowing bacterial multiplication.

Home preserving procedures are probably quite variable in practice. Some time-honored recipes may be inadequate. These experiments indicate that low-temperature (≤62.8°C/145°F) dehydration is an unreliable means of eradicating O157 from contaminated meat. More work is needed to characterize safe methods of drying potentially contaminated meat. In the absence of more specific data, we recommend that meat to be dehydrated should be pre-cooked to at least the same internal temperature (74°C/165°F) that the FDA recommends

for commercially cooked wild game. Lower temperature processes—including many recommended in cookbooks and other references—are potentially unsafe.

An estimated 10 million Americans go deer hunting annually,^{7*} and worldwide, many people process or eat venison. Hunters and other consumers should understand that wild game deserves the same careful handling and thorough cooking recommended for other meats. Venison, contact with deer, and contamination with deer feces should be considered potential sources of O157.

And by the way, thanks for reporting. You never know where it may lead.

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