Supershedders' Role in Spreading *E. coli* Scrutinized


TERRY ARTHUR (D3139-1)

About 2 percent of cattle are supershedders of *E. coli* O157:H7 bacteria. Just one supershedder in a pen can spread the bacteria to the hides of most of the other animals in the pen.

Though you can't tell just by looking at them, some of the cattle grazing in a pasture, or noshing high-energy rations in a feedlot pen, may be "supershedders"—meaning they shed high levels of pathogenic *Escherichia coli*—such as *E. coli* O157:H7—in their manure.

Supershedding could increase the amount of *E. coli* O157 that makes its way from pasture or feedlot pen into packinghouses where steaks, roasts, ground round, or other in-demand beef products are prepared.

Often referred to simply as "O157," this bacterium is apparently harmless to cattle. But in people, it can cause vomiting, severe stomach cramps, diarrhea, or other illness, such as hemolytic uremic syndrome—a sometimes deadly form of kidney failure.

In the United States, O157 is associated with about 95,000 infections every year, according to estimates from the U.S. Centers for Disease Control and Prevention. Some of these infections are attributed to eating O157-contaminated ground beef that was not properly cooked. Findings from studies led by Agricultural Research Service microbiologist Terry Arthur may help keep beef safe to eat by adding to our knowledge of supershedding. Arthur is with the agency's Roman L. Hruska U.S. Meat Animal Research Center in Clay Center, Nebraska.

The investigations may provide a scientifically sound basis for new and effective strategies to curb supershedding. What's more, the studies are a step toward a longer term goal—shared by public health officials, food safety researchers, and beef producers, processors, and purveyors alike—of ensuring that no harmful *E. coli* occurs in any link of the beef-production chain—from ranch to fork.

What Defines a Supershedder?

Scientists generally agree that a supershedder is any animal that sheds 10,000 pathogenic organisms per gram of manure. "It isn't the amount of manure that's shed," Arthur emphasizes. "It's the amount of the pathogen in the manure."

Supershedding is a transitory condition that researchers currently think lasts less than a month. Regardless of duration, the basic problem with supershedding is the same: the copious amounts of O157 in the manure don't necessarily stay where the manure was deposited.

Instead, shedding may lead to spreading.

An animal that takes a soothing dust bath, for instance, may inadvertently roll over some *E. coli*-contaminated manure on the feedlot floor and end up with O157 cells stuck to its hide. Later, some of that manure-borne *E. coli* may spread to pen mates during the usual milling about. Or the microbes could be ingested during mutual grooming, another normal, everyday behavior of pastured or penned cattle.

E. coli O157 that's swallowed might then colonize a previously uninfected animal's gastrointestinal tract, and that animal's manure could later become a new source of infection in other cattle.

From Feedlot to Packinghouse

Understandably, high levels of O157 on cattle hides could stress packinghouse sanitation systems designed to prevent the spread of the pathogen.

To discover more about supershedding, Arthur and colleagues designed and conducted studies of 6,000 head of feedlot cattle and more than 13,000 manure, hide, and carcass samples. Some of their investigations are among the most detailed of their kind, to date.

The team was the first to gather data—representative of the entire U.S. cattle population—to estimate incidence of supershedding. Their analysis showed that supershedders may make up approximately 2 percent of a herd, on average.

In other work, the researchers monitored O157 contamination on hides of cattle in 10 feedlot pens and determined that supershedders were responsible for the majority of contamination.

There's more. Arthur and team showed that, in supershedders, *E. coli* colonization may occur throughout the digestive system, from mouth to tail-end. "If you are operating a packinghouse sanitation system with the expectation that O157 occurs primarily in the lower digestive tract, it's important to know that a supershedder is apparently an exception to that generalization," Arthur says.


A sponge rubbed on a cow's hide to sample contaminants, including soil, manure, and microorganisms.

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Microbiologists Terry Arthur (left) and Norasak Kalchayanand analyze molecular fingerprint patterns for *E. coli* O157:H7 in studies of supershedding cattle.

One Strain To Blame?

In another "first," the researchers showed that supershedding was not restricted to any particular O157 strain. "Our work rules out the idea that a strategy should target a specific strain or strains to reduce supershedding," Arthur says. "The O157 in the manure samples collected for our research was mostly a mixture of strains in which no single *E. coli* predominated."

The research has also yielded criteria to gauge the success of candidate strategies for reducing or eliminating supershedding. Such interventions might include treating cattle with an O157 vaccine or adding an ingredient to their feed that helps suppress the pathogen. For an intervention to be deemed successful, the scientists say, two criteria must be met. First, none of the cattle in the pasture or pen would be supershedders. Second, the rate of fecal contamination (the number of cattle in a pen that are shedding O157 in their manure) would be kept below 20 percent. Though preliminary, these criteria are apparently the first statistically sound targets for the development and testing of a feedlot intervention.

"When you have a supershedder or more than 20 percent of the animals shedding O157 in their manure," Arthur says, "you have a dramatic increase in the number of hides contaminated with manure-borne *E. coli* O157. Hide contamination is typically 80 percent or higher in those pens.

"It may seem surprising that having 20 percent of the herd shedding O157 at low levels, or one animal supershedding, could lead to having 80 percent of the hides contaminated with O157. But cattle tend to congregate, and that promotes contamination.

"Right now, it's difficult to say what's 'normal' in terms of the number of cattle in a pen that shed O157. We've seen anywhere from 0 to 100 percent, and we're trying to define factors that are responsible for the differences."

Arthur's group of current and former ARS scientists, including Clay Center researchers Mick Bosilevac, Jim Bono, Dayna Brichta-Harhay, Norasak Kalchayanand, Mohammad Koohmaraie, John Schmidt, Steven Shackelford, and Tommy Wheeler, has documented these findings in peer-reviewed scientific articles published in 2009 and 2013 in *Applied and Environmental Microbiology*. ARS and the Beef Checkoff helped fund the research.

In Clay Center, Nebraska, technician Frank Reno collects swab samples from cattle hides to test for *E. coli* O157:H7.

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Other Aspects Also Probed

Related work at Clay Center, conducted by researchers Jim Bono and Jim Wells, along with colleague Andy Benson of the University of Nebraska-Lincoln and others, may fill in other pieces of the supershedder puzzle. In particular, their research may help answer the question of why some cattle are supershedders while others are not.

In one set of studies, these scientists are inventorying and comparing the microbes that live in the gastrointestinal tract of supershedders with those dwelling in non-supershedders. This work may provide clues about whether some microbial species and strains help O157 flourish or, conversely, whether some "beneficial" species outcompete and suppress it. Such data may be useful in developing approaches to help the beneficial strains proliferate in cattle.

In another line of inquiry, geneticists Larry Kuehn and Warren Snelling are scrutinizing the genetic makeup of supershedders to determine whether supershedding is a gene-controlled trait. If it is, it may be possible to breed the trait out of tomorrow's beef cattle herds and help end this troublesome phenomenon.—By **Marcia Wood,** ARS.

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