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The Relationship of the Characteristics of Feedlot Pens to the Percentage of Cattle Shedding *Escherichia coli* O157:H7 Within the Pen

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The food-borne pathogen *Escherichia coli* O157:H7 was commonly found in pens of feedlot cattle, and the percentage of cattle shedding the organism may have been influenced by the pen environment.

Summary

This study was designed to discover relationships between characteristics of feedlot pens and the percentage of cattle shedding Escherichia coli O157:H7. Twenty-nine pens from five Midwestern feedlots were each sampled once between June and September, 1999. Feces were collected from all cattle in each pen. E. coli O157:H7 was isolated from the feces of 714 of 3162 cattle tested (23%), including at least one animal from each of the 29 pens. Pen prevalence did not differ between feedyards, but did vary widely within feedyards. Muddy pens were more likely to have a higher pen prevalence than normal pens.

Introduction

Escherichia coli bacteria are commonly found as normal inhabitants of the intestinal tracts of humans and animals. Unfortunately, some strains including *E. coli* O157:H7, though generally harmless for cattle, carry traits that allow them to cause serious food-borne disease in humans.

Many segments of the food industry have adopted the principles of hazard-analysis-critical-control-points (HACCP) to minimize the likelihood that food will be contaminated with potentially dangerous pathogens. Unfortunately, there is insufficient knowledge of the epidemiology and

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ecology of *E. coli* O157:H7 to design and implement HACCP-based food safety programs in cattle feedyards.

Cattle in feedlots rarely are handled as individuals. Most conceivable control points for reducing human food-borne pathogens in feedlot cattle would be directed towards pens of cattle. Therefore, epidemiologic studies with the objective of identifying manageable factors (control points) to reduce human food-borne pathogens in the feedlot should relate the characteristics and pathogen status of managed groups of cattle (pens), rather than characteristics of cattle as individuals. The objective of this study was to describe the percentage of cattle shedding *E. coli* O157:H7 in feces within Midwestern feedlot pens and to identify potential risk factors for pen prevalence.

Procedure

Study design

The study design was cross-sectional observational at the level of the feedyard pen. The percentage of cattle within a pen shedding detectable levels of E. coli O157:H7 was described and compared to concurrent characteristics of the feedlot pen relating to the cattle and the pen environment. Approximately 30 g of feces was collected from the rectums of all cattle within each pen while they were restrained in a handling chute for routine management procedures (re-implanting). Concurrent samples were collected of water from water tanks, and partially consumed feed from feedbunks of the same pens. Concurrent information was collected about characteristics of the pen that may be risk factors for the prevalence of cattle shedding *E. coli* O157:H7. These factors included number of cattle, days on feed, average body weight, class and sex of cattle, culture results from water or feed, water-tank temperature and pH, and subjective assessments of pen condition and water-tank cleanliness.

Source of cattle

Five feedyards, typical of commercial feedlots in the region, were asked to voluntarily participate in the study. The one time cattle capacity in these feedyards ranged from 3,000 to 12,000 head; approximately 40,000 head collectively in pens of 50 to 300 head. Pens were open-dirt lots, maintained by scraping, typically once per month. The feedlots involved in this study fed primarily dry-rolled corn, high-moisture corn, wet corn gluten feed, wet distillers grains, alfalfa hay, corn silage, and other byproducts. Cattle pens were selected from the 5 commercial feedyards at the time of routine re-processing. Pens were bypassed, or pens with fewer cattle were chosen for sampling, during weeks when more pens were available than could be managed by the culturing capacity of the laboratories. Sampled pens ranged from 36 to 231 (median 107) cattle. At sampling, cattle had been in the feedyards 19 to 108 (median 51) days and the mean body weight per pen ranged from 764 to 1175 lbs (median 930 lbs).

Microbiology

Culture methods were specific to the type of sample but included selective enrichment and immunomagnetic separation. Isolates were confirmed by standard methods including PCR. Methods for recovery of *E. coli O157:H7* from feces were modifications of those recently reported (Laegreid et al., 1999. Epidemiol Infect. pp291-298).

Statistical methods

The dependent variable was the pen-prevalence of *E. coli* O157:H7 defined as the percentage of cattle within a pen from which the organism was isolated from feces. The correlation between the magnitude of pen-prevalence of *E. coli*

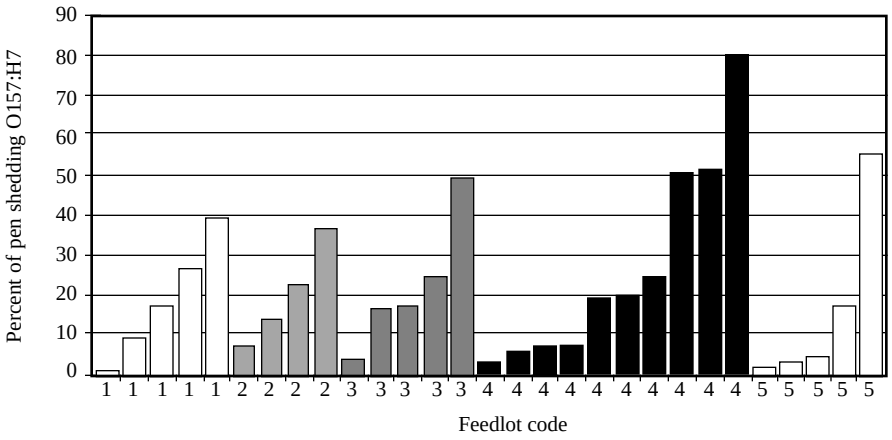

Figure 1. Percentage of cattle shedding detectable *Escherichia coli* O157:H7 in each of 29 pens of feedlot cattle in five Midwestern feedyards. Prevalence levels of fecal-shedding for individual pens are represented by bars arranged in order of increasing prevalence by feedyards of origin.

Table 1. Continuous or ordinal variables describing 29 feedlot pens from 5 Midwestern US feedyards and the correlation of the variable to the percentage of cattle within pens found shedding *Escherichia coli* O157:H7 in the feces.

Variable	Range of values (Median)	Spearman's rank correlation coefficient	P-value
Pen size	336-231 (107)	r = 0.08	0.67
Days in the feedyard	19-108 (51)	r = -0.21	0.28
Average body weight	764-1175 (930)	r = 0.00	1.00
Temperature of water in tank	53.7-67.5 (61.1)	r = -0.17	0.37
pH of water in tank	6.2-8.2 (7.2)	r = -0.10	0.62
Cleanliness of water in tank	1-5 (3)	r = -0.02	0.93
pH of feed in bunk	4.2-7.3 (4.8)	r = -0.11	0.55

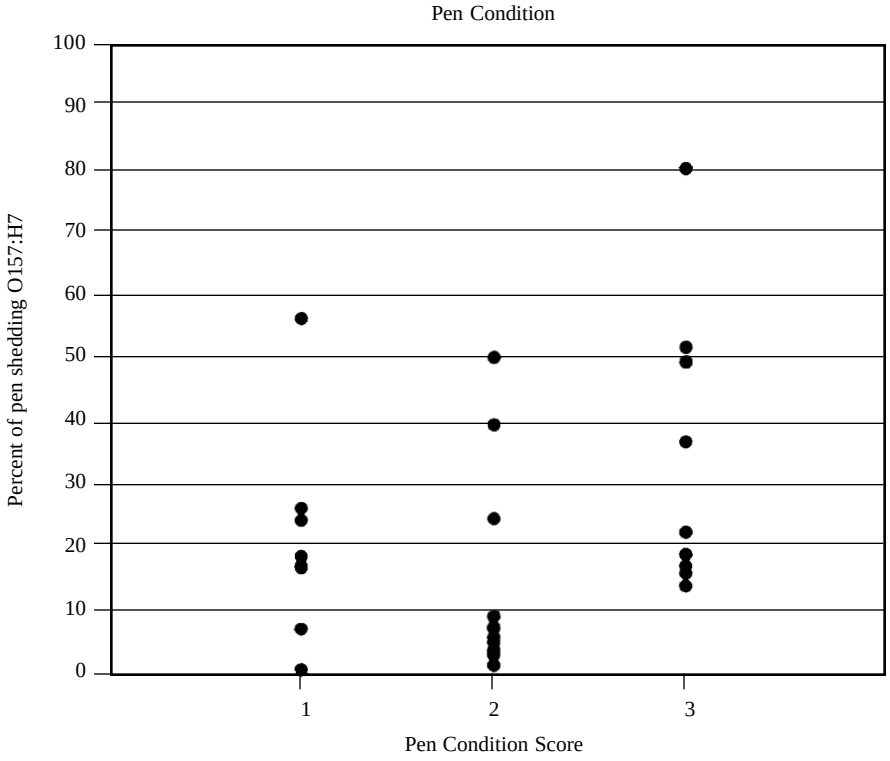

Figure 2. Percentage of cattle shedding detectable *Escherichia coli* O157:H7 in pens subjectively classified by pen environment as: 1-dry and dusty, 2-normal condition, 3-wet and muddy. Compared to pens with normal environmental conditions, pens classified as wet and muddy had significantly greater pen prevalence of *E. coli* O157:H7.

O157:H7 (rank order of pen-prevalence) and variables representing pen characteristics which were at least ordinal was tested using Spearman's rank correlation. Association of the magnitude of pen-prevalence with categorical variables was tested using non-parametric methods.

Results

E. coli O157:H7 was isolated from the feces of 714 of 3162 cattle tested (23%), including at least one animal from each of the 29 pens. The pen prevalence of cattle shedding detectable levels of the organism ranged from 0.7% to 79.8% (median 17.1%). Feedyards did not differ by pen prevalence (Kruskal-Wallis P=0.81); however, within each feedyard the pen prevalence differed widely (chi square P<0.001; Figure 1).

E. coli O157:H7 was recovered from the water tanks of seven pens and the feed from the bunk of one pen. Pen prevalence was not associated with recovery of the agent from feed (Wilcoxon rank sums P=0.31), or water (Wilcoxon rank sums P=0.15). Pen prevalence was not correlated with the temperature, pH, or cleanliness of water from the water tanks, or pH of the feed, number of cattle, mean body weight or number of days in the feedyard (Table 1).

The condition of the pen surface, subjectively evaluated as dry, normal, or wet, was associated with the level of pen prevalence (Kruskal-Wallis P<0.05; Figure 2). Specifically, wet pen conditions were associated with higher pen prevalence than pens in normal condition (Wilcoxon rank sums, P=0.01).

The prevalence of fecal shedding within feedlot cattle herds and pens has been reported to be low. However, the reliability of *E. coli* O157:H7 prevalence estimates in cattle may vary by the diagnostic method employed, the number of cattle sampled and the type of samples collected. The overall 23 percent of fecal shedding observed in this study is consistent with other reports suggesting that at times the organism may be widespread in beef cattle populations. For example, in a recent Canadian study, the organism was recovered from 19.7 percent of fecal samples collected at slaughter from yearling cattle and cull cows during the summer months (Van Donkersgoed et al. 1999 Canadian Vet J. pp 332-338).

The pen prevalence of fecal shedding did not differ between the five feedyards. This finding suggests that *E. coli* O157:H7 may be ubiquitous to feedlot cattle populations. In a multistate cross-sectional study, researchers cultured the feces of 120 cattle each (4 pens x 30 fecal pats) in 100 feedyards (Hancock et al. 1997 J Food Prot. pp 462-465). This sampling strategy may prevent detection of low prevalence pens. Despite a low overall prevalence of shedding (1.6%), *E. coli* O157:H7 was found in 61% of the feedyards surveyed. Other surveys, using serology (Laegreid et al. 1998 Conf Res Workers Anim Dis P26) and bacterial culture of feces (Sargeant et al. 1998 Conf Res Workers Anim Dis Abstract 41), suggest that exposure to *E. coli* O157:H7 is widespread and most beef cattle have been exposed to the organism before weaning. Because of commingling, widespread exposure of cattle to *E. coli* O157:H7 after arrival in large cattle feedlots is plausible, at least during certain seasons. Cattle recently arriving in the feedyard have been demonstrated to be at greater risk for shedding *E. coli* O157 than cattle on feed longer (Dargatz et al. 1997 J Food Prot pp 466-470).

All pens we observed had some cattle shedding the organism in the feces. In spite of the apparent ubiquity of the organism, the pen-prevalence of cattle shedding *E. coli* O157:H7 varied greatly within each feedyard. Pens with high and low prevalence of fecal shedding were observed in each feedyard. Factors that explain the variability in pen-prevalence of *E. coli* O157:H7 fecal shedding may be risk factors that could be managed as control points in a HACCP-based feedlot production food safety program.

The environmental condition of the pen was the only pen characteristic that was associated with pen prevalence.

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Pens with the greatest percentage of cattle shedding *E. coli* O157:H7 were more likely to be wet and muddy at the time of sample collection. Pens with dusty conditions were intermediate in the percentage of cattle shedding the organism. The association between the environmental condition of a pen and the percentage of cattle shedding *E. coli* O157:H7 seems plausible. Compared to the normal pen conditions, muddy or dusty conditions would be expected to facilitate fecal-oral transmission of enteric agents because of greater opportunity for the agent to move with water or dust particles.

It is unlikely that selection bias was introduced by voluntary recruitment of the feedyards or selection of cattle pens by convenience. There was no prior knowledge of the *E. coli* O157:H7 status of any of the feedyards. Pens were selected for inclusion in the study with consideration for the feedyards' re-implanting schedule and the workload of the laboratories. When there was an option, pens with fewer cattle were preferentially chosen for study to minimize costs. Pens were selected without knowledge of the results from previous pens in the feedyards.

The results of this study suggest that *E. coli* O157:H7 should be considered an ubiquitous organism in pens of feedlot cattle and that factors in the pen environment may help to explain the prevalence of cattle shedding the organism. The limited time-period of the study (summer months) and the cross-sectional nature of the study did not permit observing the effect of time dependent variables on the outcome of pen prevalence. It would be interesting to observe changes in pen prevalence over time as pen conditions change.

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