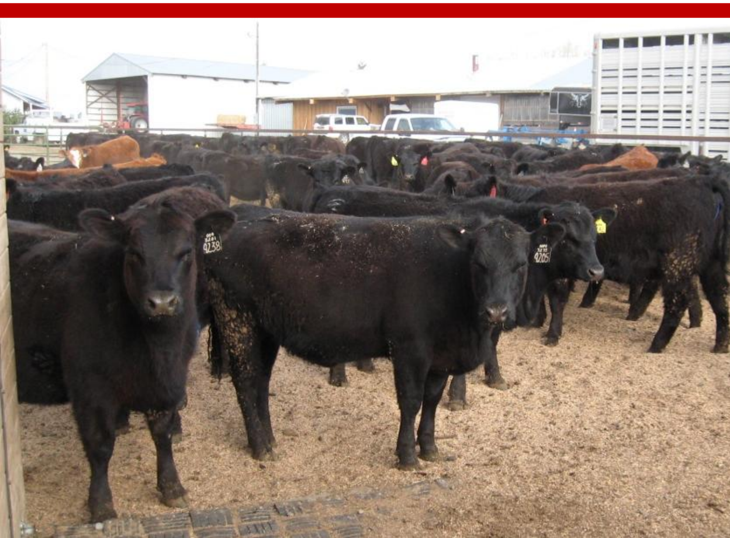
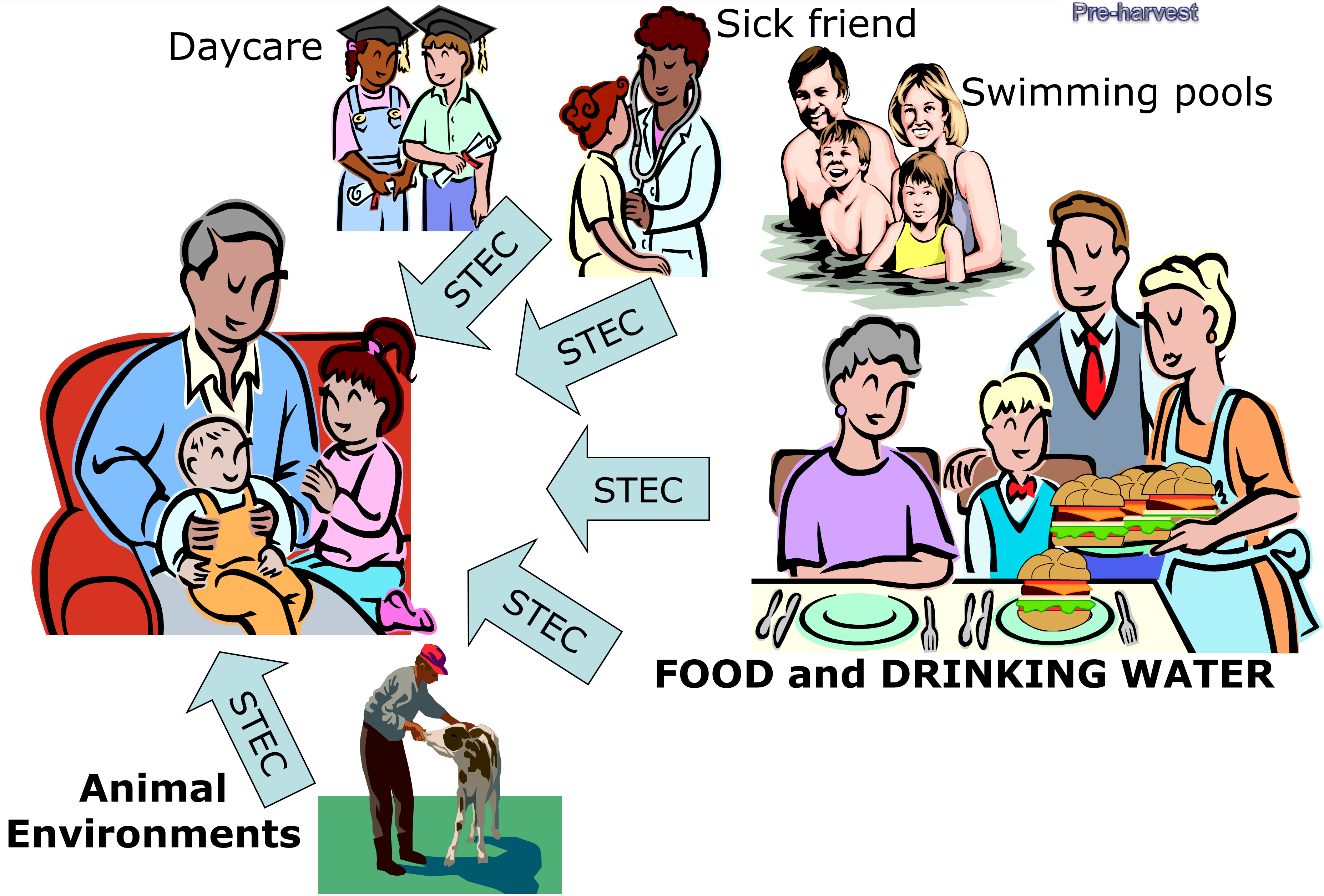
DOES WHAT WE FEED CATTLE HAVE AN EFFECT ON O157 SHEDDING?

DAVID R. SMITH, DVM, PHD

E. coli Webinar

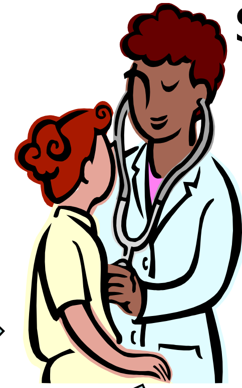
Washington State University
University of Nebraska-Lincoln



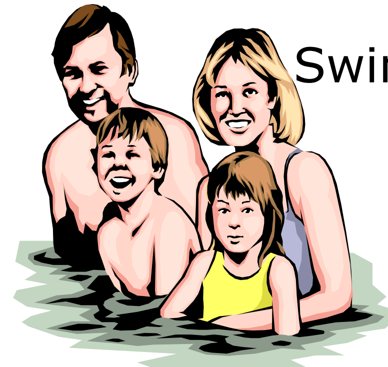

Daycare
Sick friend
Swimming pools
STEC
STEC
STEC
STEC
STEC
FOOD and DRINKING WATER
Animal Environments

Daycare

Sick friend



Swimming pools



STEC

STEC

STEC

STEC

STEC

Direct and indirect exposure to <u>human or animal feces</u>

FOOD and DRINKING WATER

Animal Environments

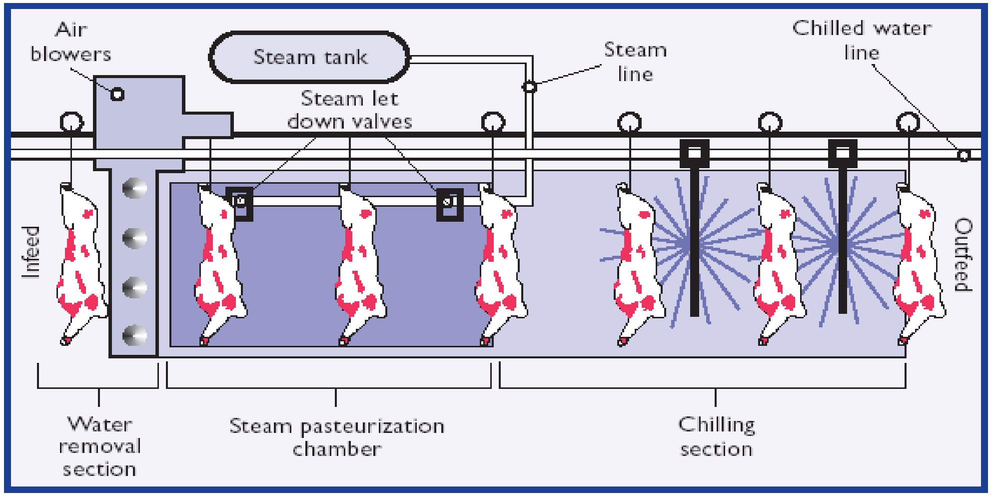
FoodNet: *E. coli* O157 incidence in 2010 was 0.9 infections /100,000 persons (3.3 / 10^5 for children <5 yrs of age)

FoodNet, MMWR 2011 60(22) 749-755

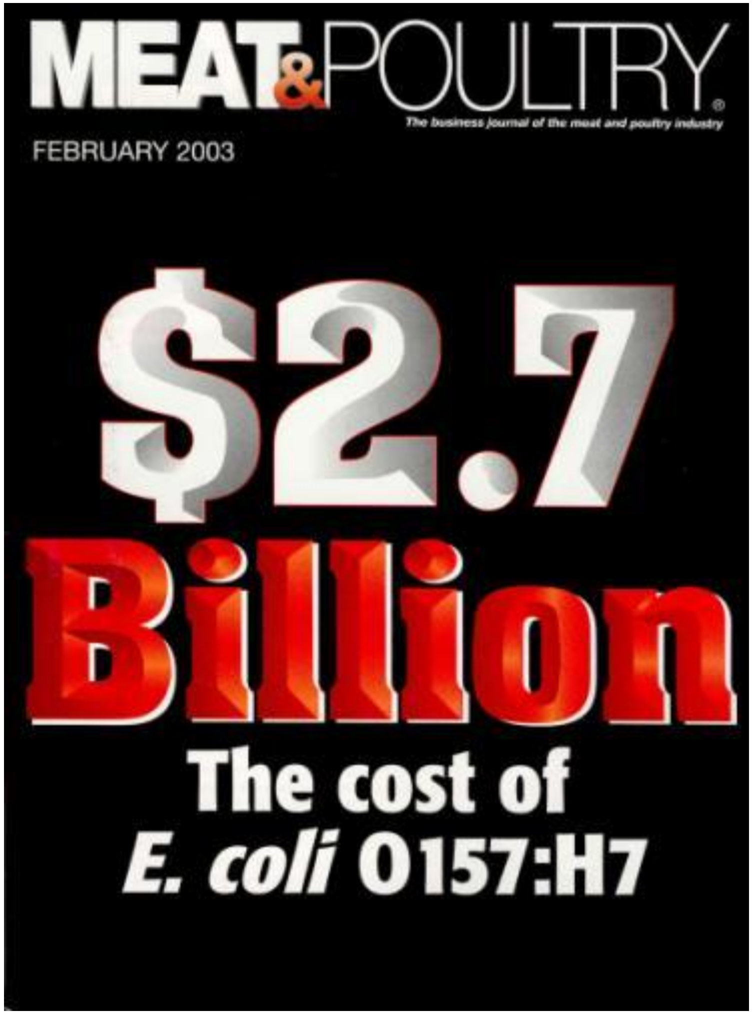
Beef industry post-harvest interventions

- Hide treatments
- Careful evisceration
- Carcass washes
- Steam pasteurization
- Test and hold

Figure C-3
Beef Steam Pasteurization System — Static Chamber Unit

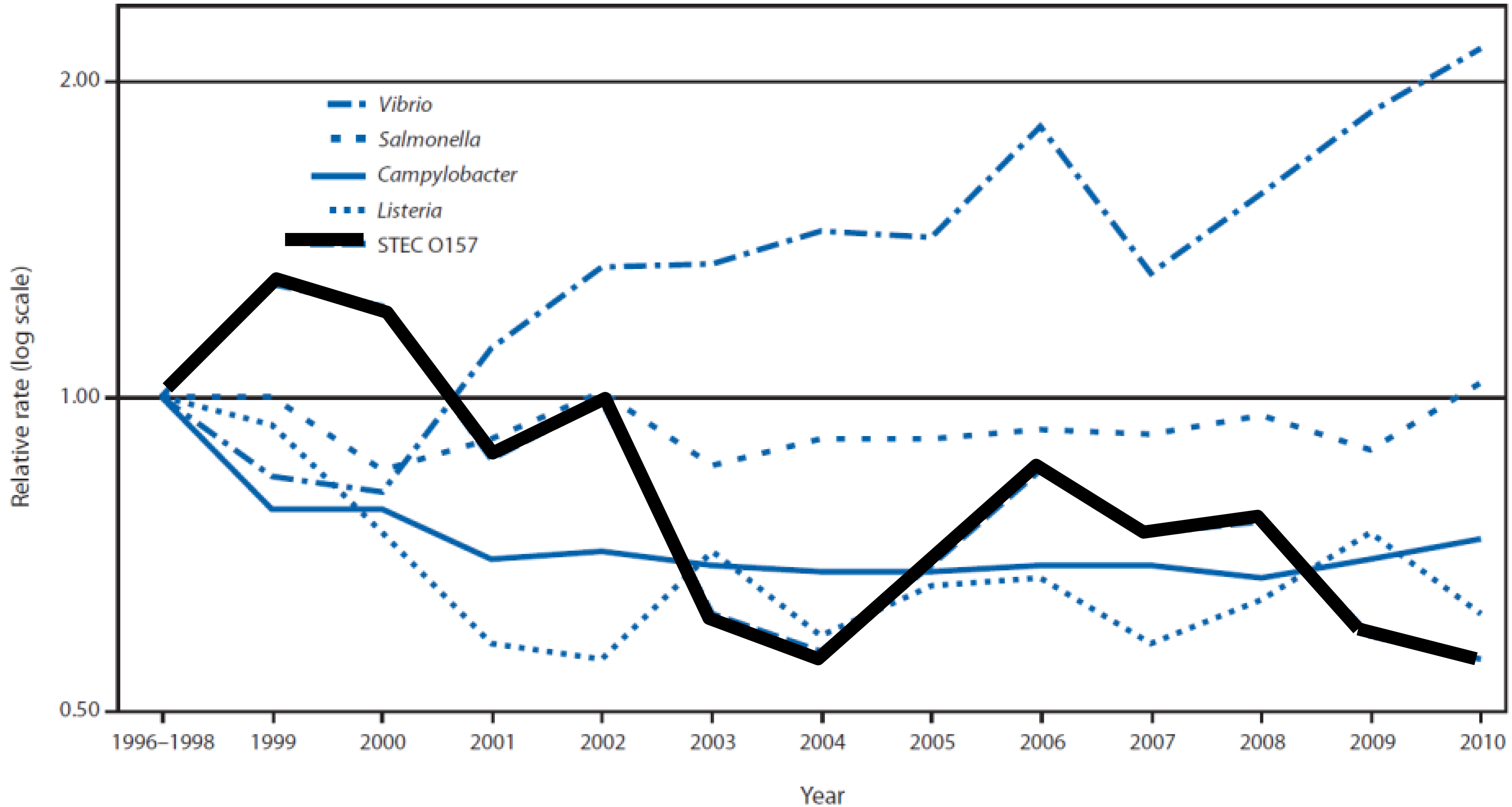


Source: Frigoscandia Equipment



MMWR 2011 60(22) 749-755

FIGURE 1. Relative rates of laboratory-confirmed infections with *Campylobacter*, STEC O157, *Listeria*, *Salmonella*, and *Vibrio*, compared with 1996–1998 rates, by year — Foodborne Diseases Active Surveillance Network, United States, 1996–2010*



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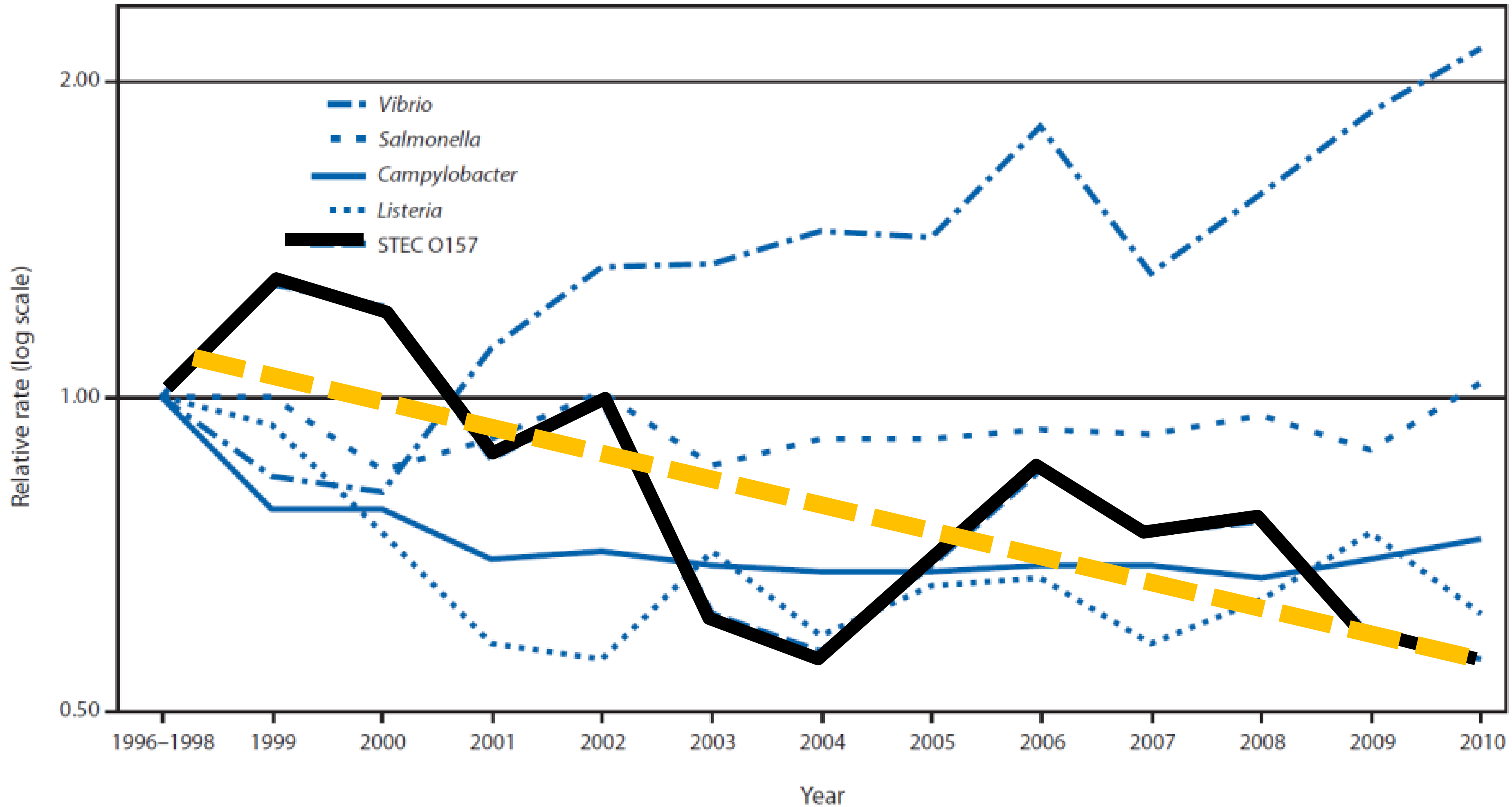

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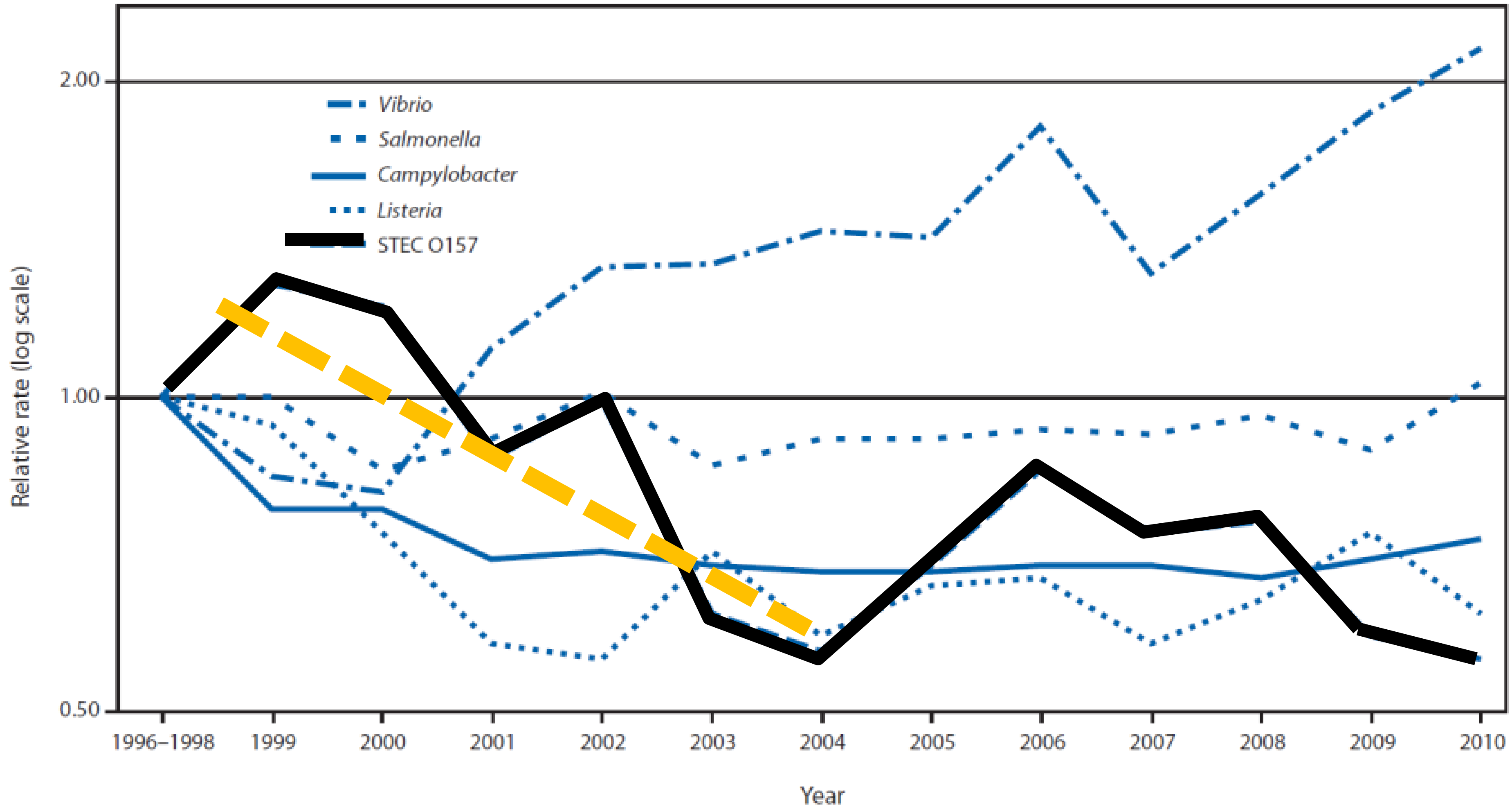

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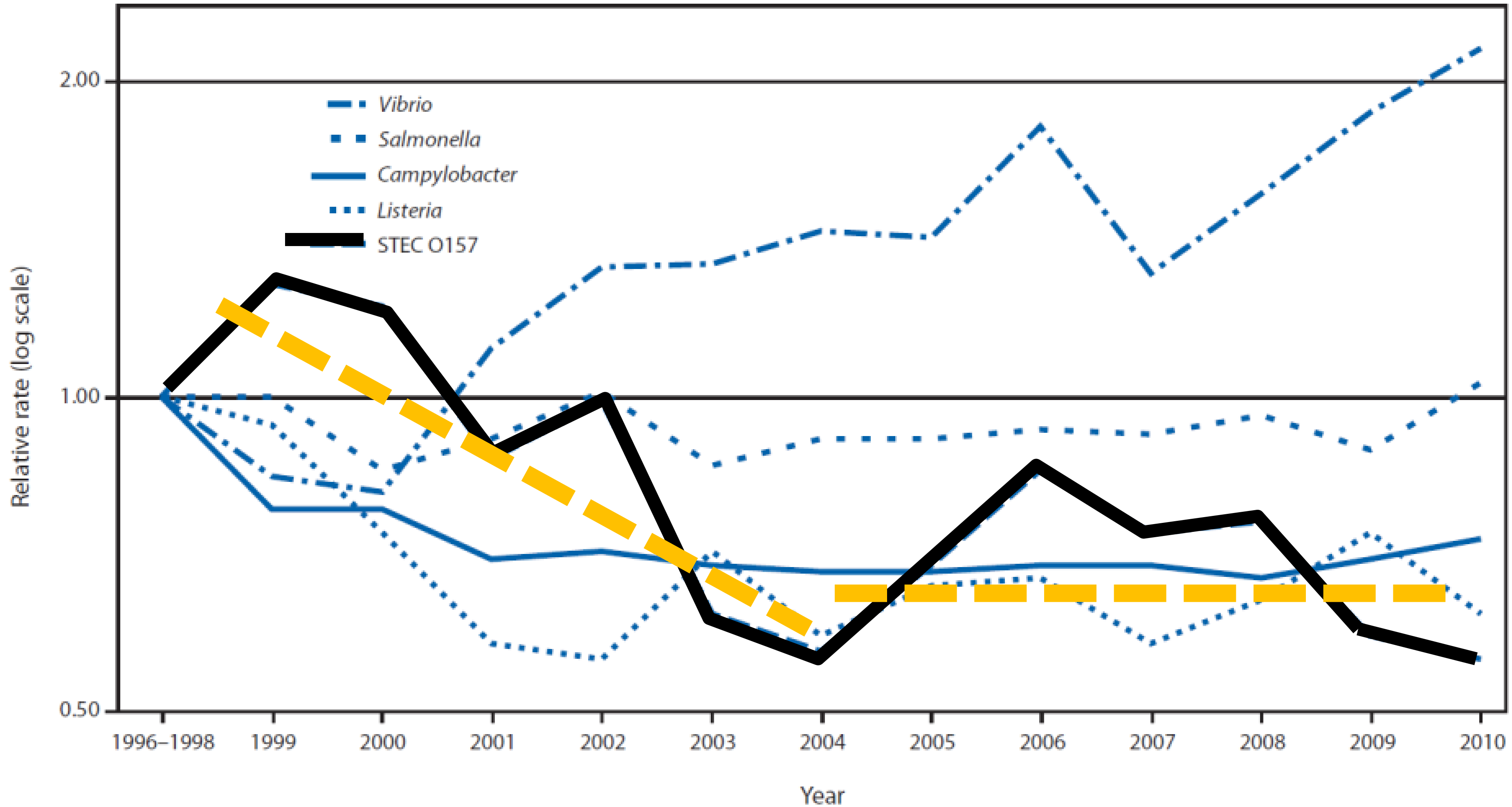


There is a positive correlation between carcass contamination and pre-harvest carriage of O157:H7 by cattle

"The association between fecal prevalence and carcass contamination indicates a **<u>role for control of EHEC O157 in cattle on the farm</u>** toward reducing the risk of human infection from ingestion of undercooked beef or cross-contamination of other foods. **Obviously, such a control program would also reduce the risk of environmental contamination, another potential source of human infection**." Elder et al. 2000. Proc Nat Acad Sci

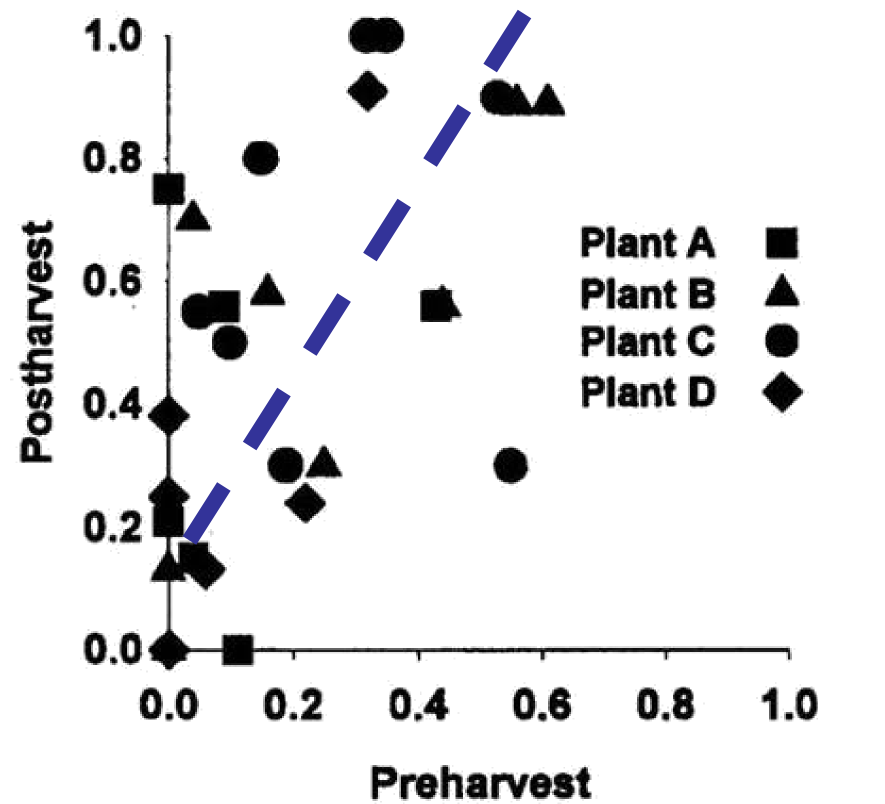


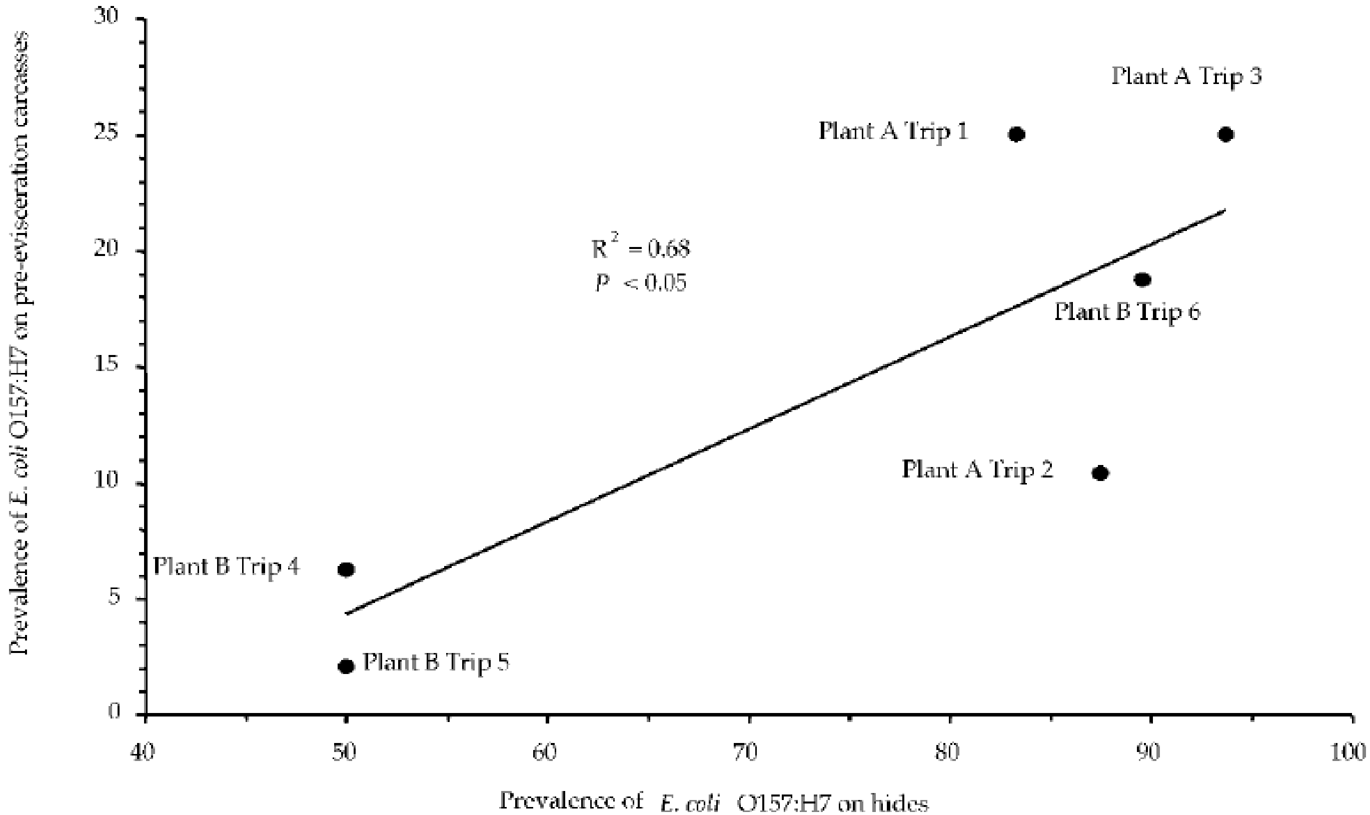
Fig. 1. Spearman rank correlation of EHEC O157 prevalence in all fecal and hide samples (preharvest) versus prevalence of carcasses positive on any sample (postharvest), by lot. Spearman rank correlation coefficient (r_s) = 0.58 (95% confidence interval 0.27–0.78), P = 0.001, n = 29.

See also: Arthur et al. 2004. J Food Prot,67(4) 658–665

There is a positive correlation between carcass contamination and pre-harvest carriage of O157:H7 by cattle

Correlations between hide and pre-evisceration bacterial levels.

E. coli O157 prevalence for the pre-evisceration and hide samples is plotted for each sampling trip (n = *48 per trip).*



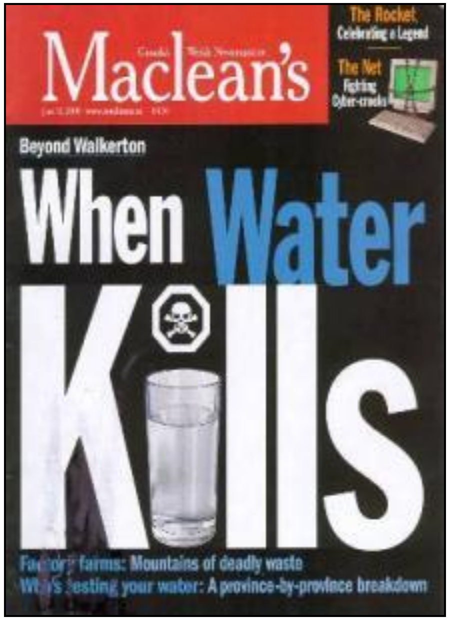
Arthur et al. 2004. J Food Prot,67(4) 658–665

Live cattle serve as an important reservoir for human *E. coli* O157:H7 exposure

Live cattle populations are an important reservoir of *E. coli* O157:H7

The cattle industry lacks on-farm interventions!

Research focus:
What affects the probability for cattle to shed the organism?



What can we do about it?

Bacterial ecology: what affects the probability for cattle to shed *E. coli* O157:H7?

1) a **pen environment** when it favors bacterial survival and fecal-oral transmission, and/or

2) a **gut environment** when it favors its colonization and replication

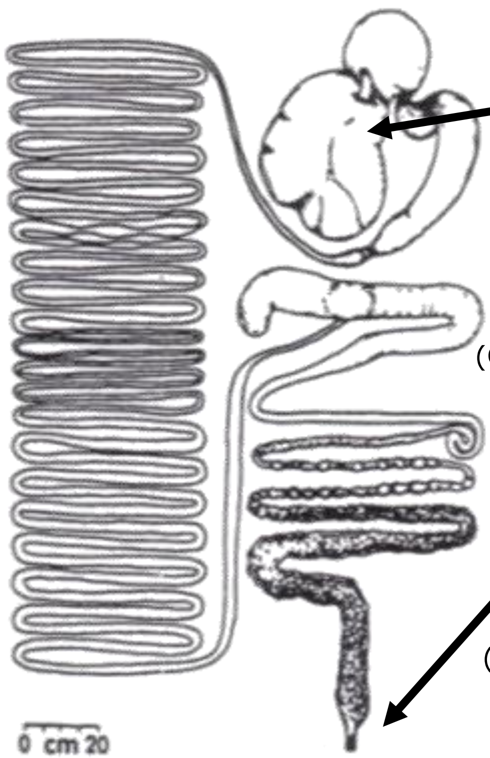
•Smith et al. J Food Prot. 2001, 64 (12) 1899-1903.

•Khaitsa et al. J Food Prot 2003, 66 (11) 1972-1977.

•Smith et al. Foodborne Pathogens and Disease. 2005, 2(1):50-60

Making the gut unfavorable to STEC infection

Primary Sites of *E. coli* O157:H7 colonization:



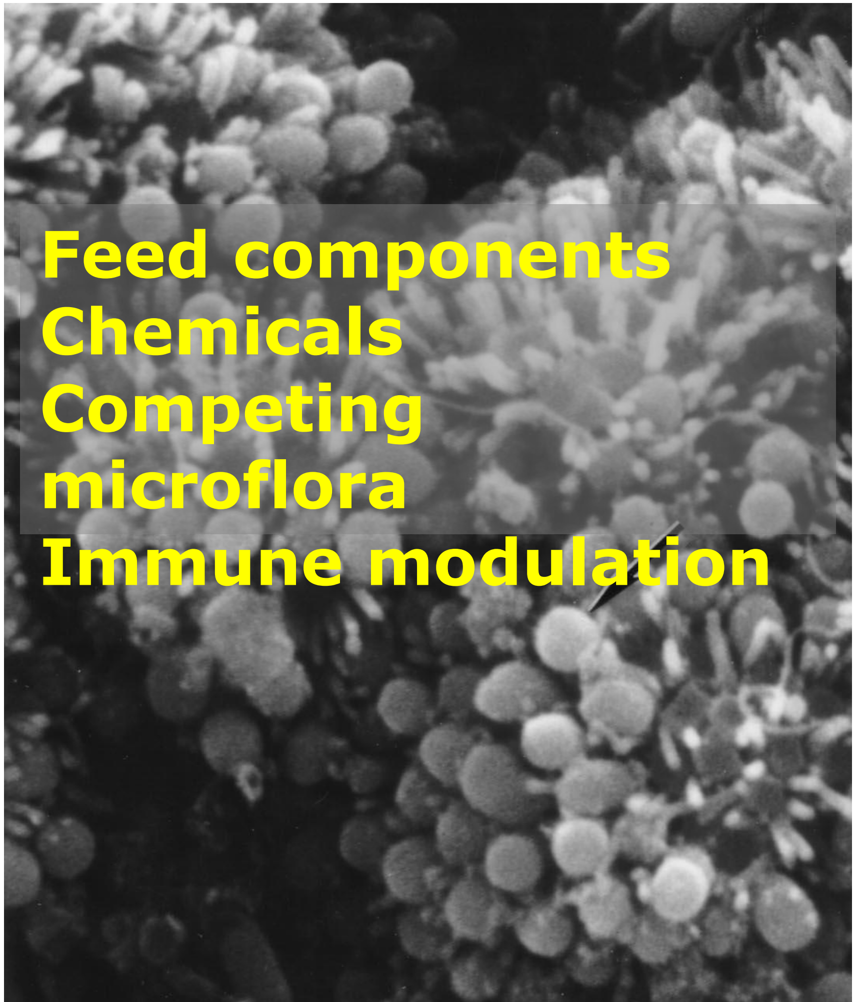
rumen
(Brown et al. 1997)

colon*
(Cray & Moon, 1995)
(Grauke et al. 2002)

terminal rectum*
(Naylor et al. 2003)

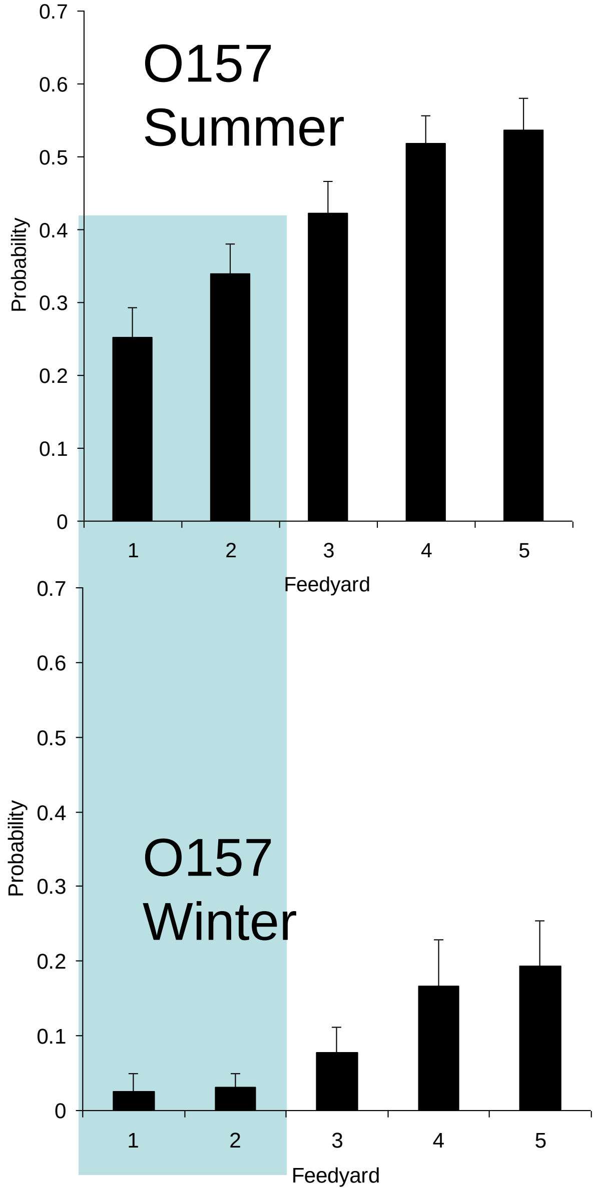
(Argenzio, 1993)

Enterohemorrhagic *E. coli* colonization and infection of calf rectum



Moxley & Francis. 1986. Infect. Immun. 53:339-346.

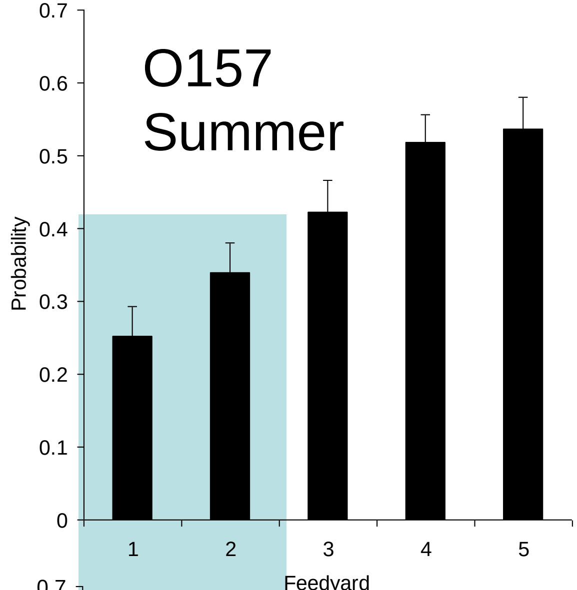
Smith et al. Foodborne Pathogens and Disease. 2005, 2(1):50-60

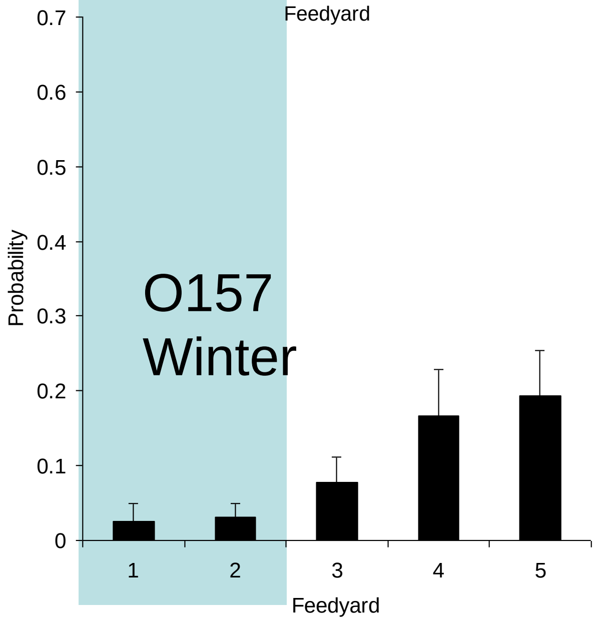


Feedlots differ in *E. coli* O157 carriage - suggesting that the cattle production system influences food safety outcomes

Everyone should be like those guys!

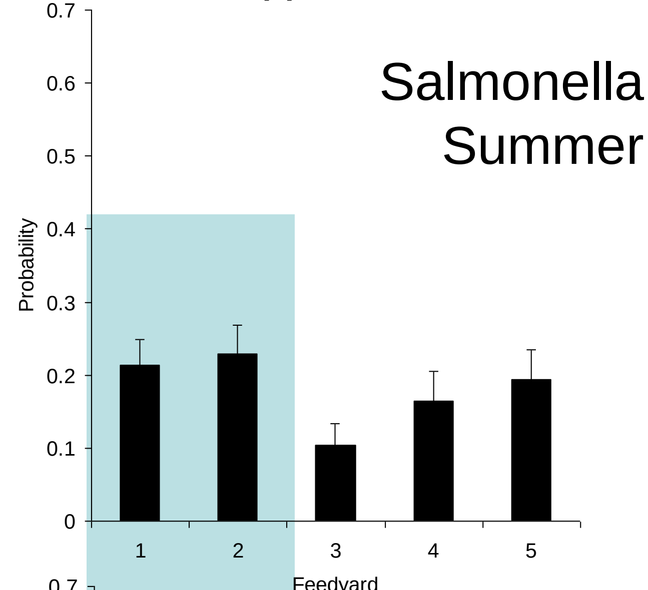
Smith et al. Foodborne Pathogens and Disease. 2005, 2(1):50-60

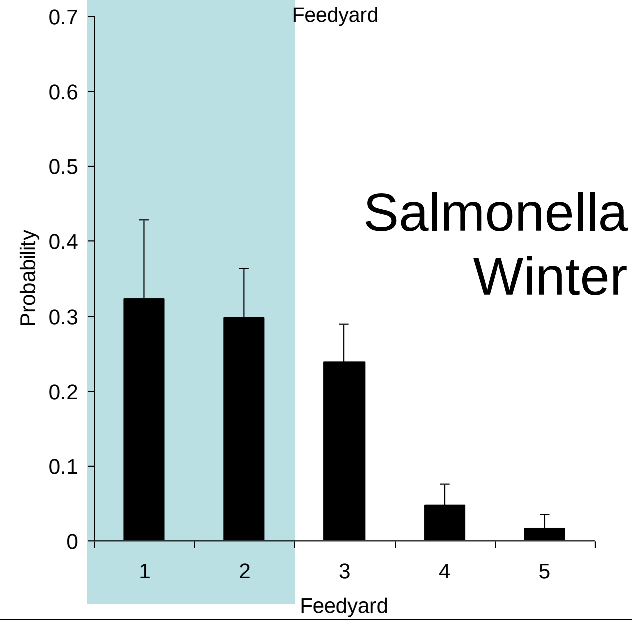




cattle systems may favor different agents

Smith et al. Foodborne Pathogens and Disease. 2005, 2(1):61-69





The effects of diet and production system on STEC O157



- Forage vs. grain feeding
- Production system
- Abrupt dietary change
- Fasting
- Grain type
- Grain processing
- Byproduct feeds
- Direct-fed microbial products

http://extension.wsu.edu/vetextension/ec/Documents/LiteratureReviewTable_ExtensionPub-edited.pdf

University of Nebraska Lincoln

Washington State University Veterinary Medicine Extension

Published Literature on Dietary Components that Affect the Carriage of Shiga-Toxin Producing *Escherichia coli* O157 (STEC O157) in Cattle

Forage vs. Grain Feeding

Author	*E. coli*[a] Population	Study Design	Sample Type	Comparisons	Results
Diez-Gonzalez et al., 1998	Generic *E. coli*	Observed generic *E. coli* population	Fecal samples	No grain vs. 60% rolled corn vs. 80% rolled corn	Higher concentration in grain diet
Gilbert et al., 2005	Generic *E. coli*	Observed generic *E. coli* population	Fecal samples	Roughage vs. roughage + molasses vs. grain diet	Higher concentration in grain diet
Grauke et al., 2003	Generic coliforms	Observed generic coliforms	Rumen, duodenum, and fecal samples	90% Grain +10% triticale silage vs. 50% alfalfa + 50% timothy hay	Higher concentration in grain diet (rumen and fecal samples). No difference in concentration (duodenum samples).
Krause et al., 2003	Generic *E. coli*	Observed generic *E. coli* population	Rumen, jejunum, ileum, caecum, and fecal samples	100% Rhodes grass vs. 70% rolled sorghum + 30% rhodes grass	Higher concentration in grain diet
Stanton and Schutz, 2000	Generic *E. coli*	Observed generic *E. coli* population	Fecal samples	85% Whole corn vs. 30% millet hay + 62% whole corn	Higher concentration in grain diet
Grauke et al., 2003	STEC O157	Experimental Challenge Study	Fecal samples	90% Grain +10% triticale silage vs. 50% alfalfa + 50% timothy hay	No difference in concentration or duration of shedding
Hovde et al., 1999	STEC O157	Experimental Challenge Study	Fecal samples	62% Barley + 19% corn vs. 90% corn vs. 100% alfalfa hay vs. 100% timothy hay	No difference in concentration. Increased duration of shedding in hay diet
Kudva et al., 1997	STEC O157	Experimental Challenge Study in Sheep	Fecal samples	100% Grass vs. 50% corn + 50% alfalfa	Higher concentration and increased duration of shedding in forage diet
Tkalcic et al., 2000	STEC O157	Experimental Challenge Study	Fecal and rumen fluid samples	1.9 kg Bermuda grass + 3.8 kg concentrate mix vs. 3.8 kg bermuda grass +1.9 kg concentrate mix	No difference in concentration (fecal and rumen samples)
Van Baale et al., 2004	STEC O157	Experimental Challenge Study	Fecal samples	85% Forage + 15% grain vs. 15% forage + 85% grain	Higher concentration and increased duration of shedding in forage diet
Diez-Gonzalez et al., 1998	Generic acid resistant *E. coli*	Observed generic *E. coli* population	Fecal samples	100% Timothy hay vs. 45% rolled corn vs. 90% rolled corn	Higher concentration in grain diets
Grauke et al., 2003	Generic acid resistant coliforms	Observed generic coliforms	Rumen, duodenum, and fecal samples	90% Grain +10% triticale silage vs. 50% alfalfa + 50% timothy hay	Greater probability to detect in grain diet (rumen and fecal samples). No difference in probability to detect (duodenum samples)

Can what we feed cattle affect the safety of beef?

The New York Times
nytimes.com

September 11, 1998

Shift in Cow Feed May Make Beef Safer

By JANE E. BRODY

Microbiologists at Cornell University have found a way to virtually rid cattle of harmful strains of E. coli bacteria, including the bacteria that have caused scores of deaths and sickened thousands of consumers of undercooked hamburgers.

Their studies, described in today's issue of the journal Science, demonstrated that the grain-based feedlot diet usually fed to cattle before slaughter fosters growth of E. coli bacteria, some of which can cause disease. Among the dangerous strains that can survive when cattle are fed grain is E. coli O157:H7, the most deadly E. coli known.

The findings were met with enthusiasm by both the cattle industry and food safety experts.

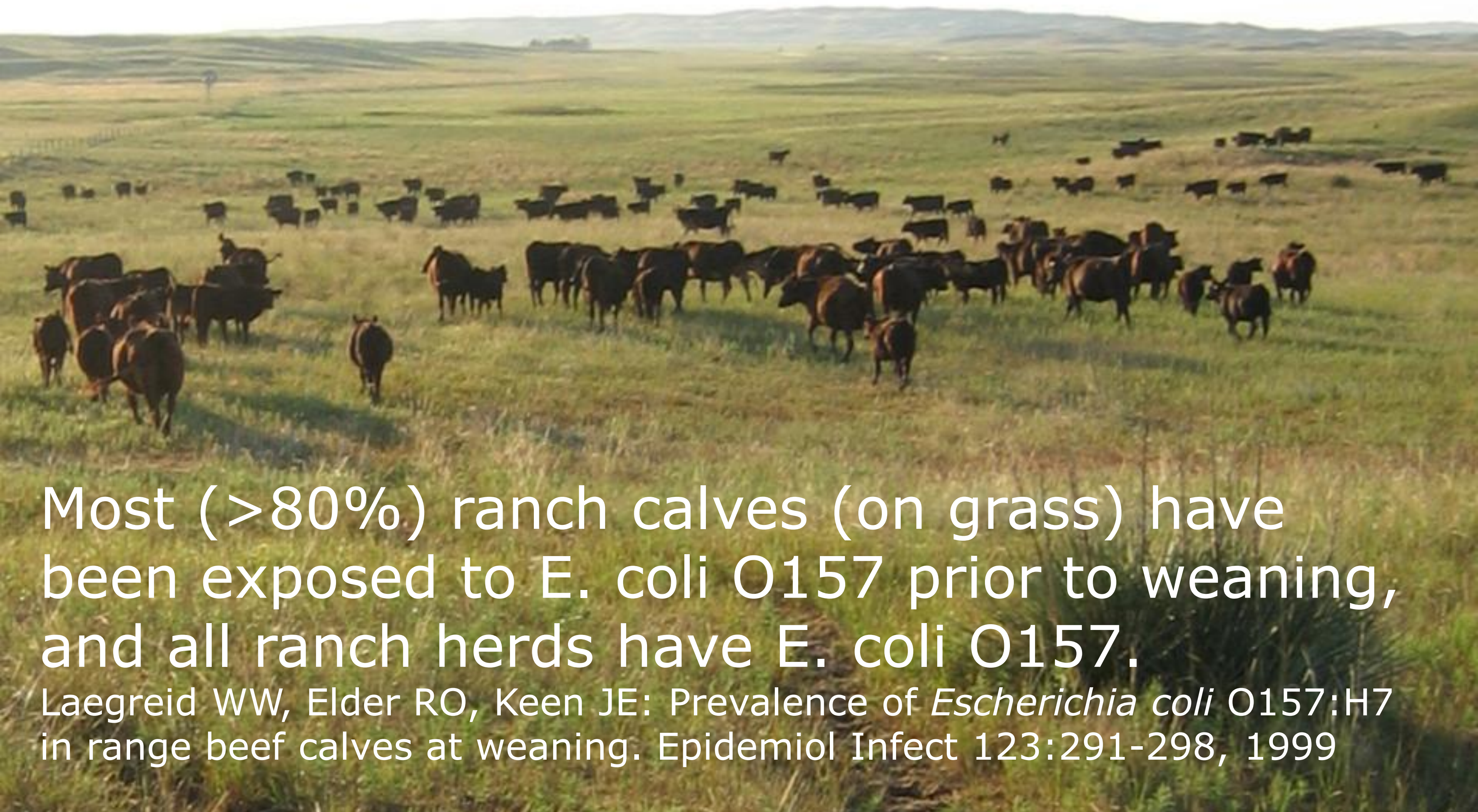
Can what we feed cattle affect the safety of beef?

grass-fed vs.
grain-fed beef

Grass vs. Grain

- Evaluate the original literature –many Internet summaries confuse generic *E. coli* with STEC O157
- Numerous studies associate grain feeding with increased fecal concentration of generic and acid-resistant E. coli
- In contrast, forage-based diets have been most commonly associated with <u>increased</u> shedding levels or increased duration of shedding of STEC O157

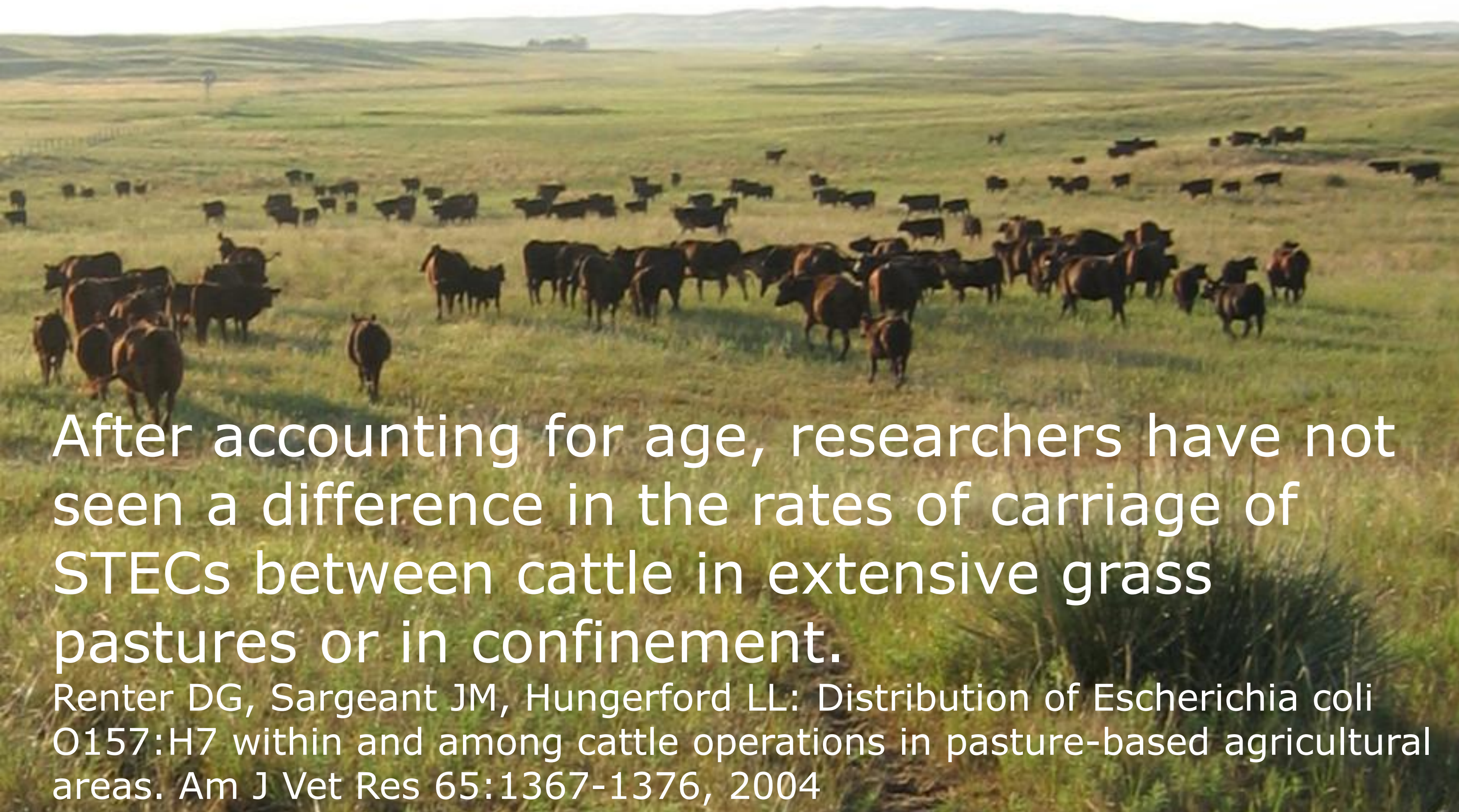
Confinement vs. Pasture



Most (>80%) ranch calves (on grass) have been exposed to E. coli O157 prior to weaning, and all ranch herds have E. coli O157.

Laegreid WW, Elder RO, Keen JE: Prevalence of *Escherichia coli* O157:H7 in range beef calves at weaning. Epidemiol Infect 123:291-298, 1999

Confinement vs. Pasture

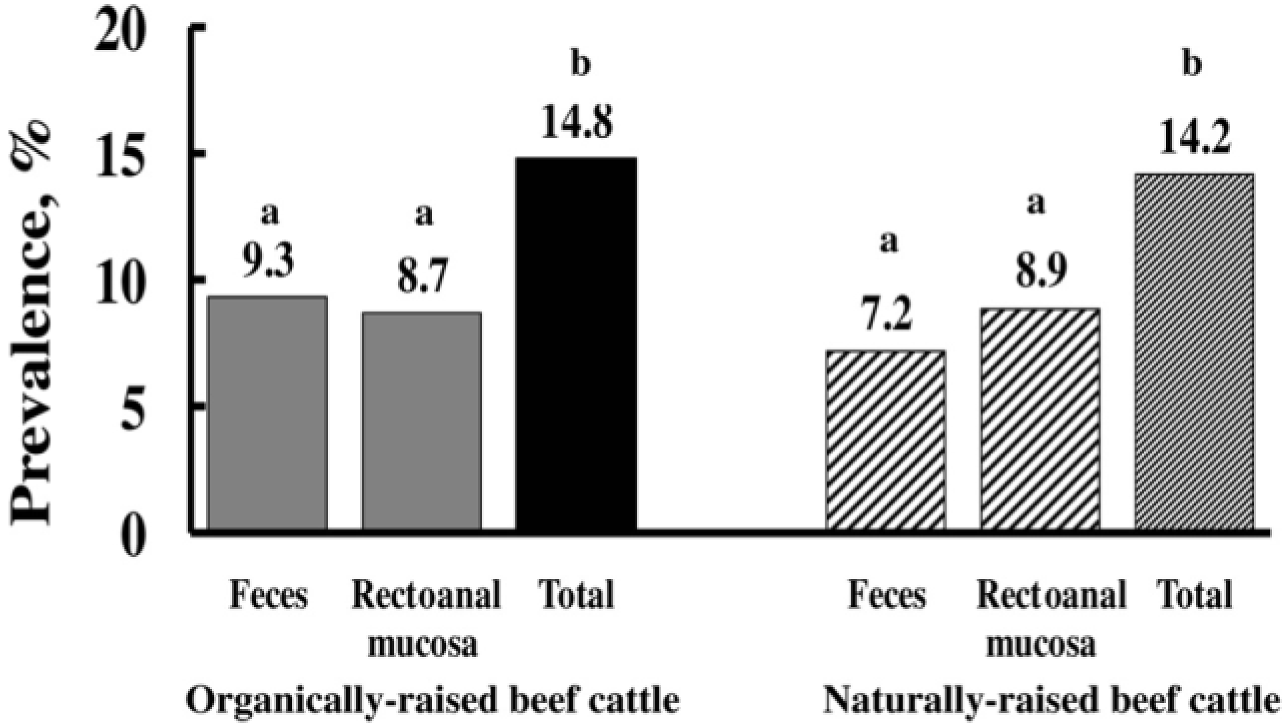


After accounting for age, researchers have not seen a difference in the rates of carriage of STECs between cattle in extensive grass pastures or in confinement.

Renter DG, Sargeant JM, Hungerford LL: Distribution of Escherichia coli O157:H7 within and among cattle operations in pasture-based agricultural areas. Am J Vet Res 65:1367-1376, 2004

Organic vs. Natural -Beef

Reinstein et al. Prevalence of *Escherichia coli* O157:H7 in Organically and Naturally Raised Beef Cattle. APP ENVIR MICROB. 2009, 75(16) 5421–5423



"Our study found similar prevalences of *E. coli* O157:H7 in the feces of organically and naturally raised beef cattle, and our prevalence estimates for cattle in these types of production systems are similar to those reported previously for conventionally raised feedlot cattle."

Organic vs. Conventional -Dairy

P. Kuhnert et al. / Veterinary Microbiology 109 (2005) 37–45

"We could not find significant differences in the prevalence of STEC and O157:H7 or the risk to carry such organisms in the cattle population as a whole nor on the farm level between organic and conventional farming."

Risk-factors for the presence of STEC

Variable	OR	*p*-Value	LCL	UCL
Age at last lactation	0.68	0.028	0.49	0.96
Lactose in milk (%)	1.60	0.039	1.02	2.50
Urea in milk (mg/dl)	1.02	0.033	1.00	1.04
Lactation number	1.42	0.047	1.00	2.02
Unifeed trailor	4.84	0.000	2.94	7.94
Paddock available	1.65	0.019	1.09	2.51
Pasture 3–5 h vs. no pasture	2.16	0.004	1.28	3.65
Pastures >5 h vs. no pasture	2.17	0.001	1.38	3.42
Organic vs. conventional farming	1.05	0.774	0.74	1.51

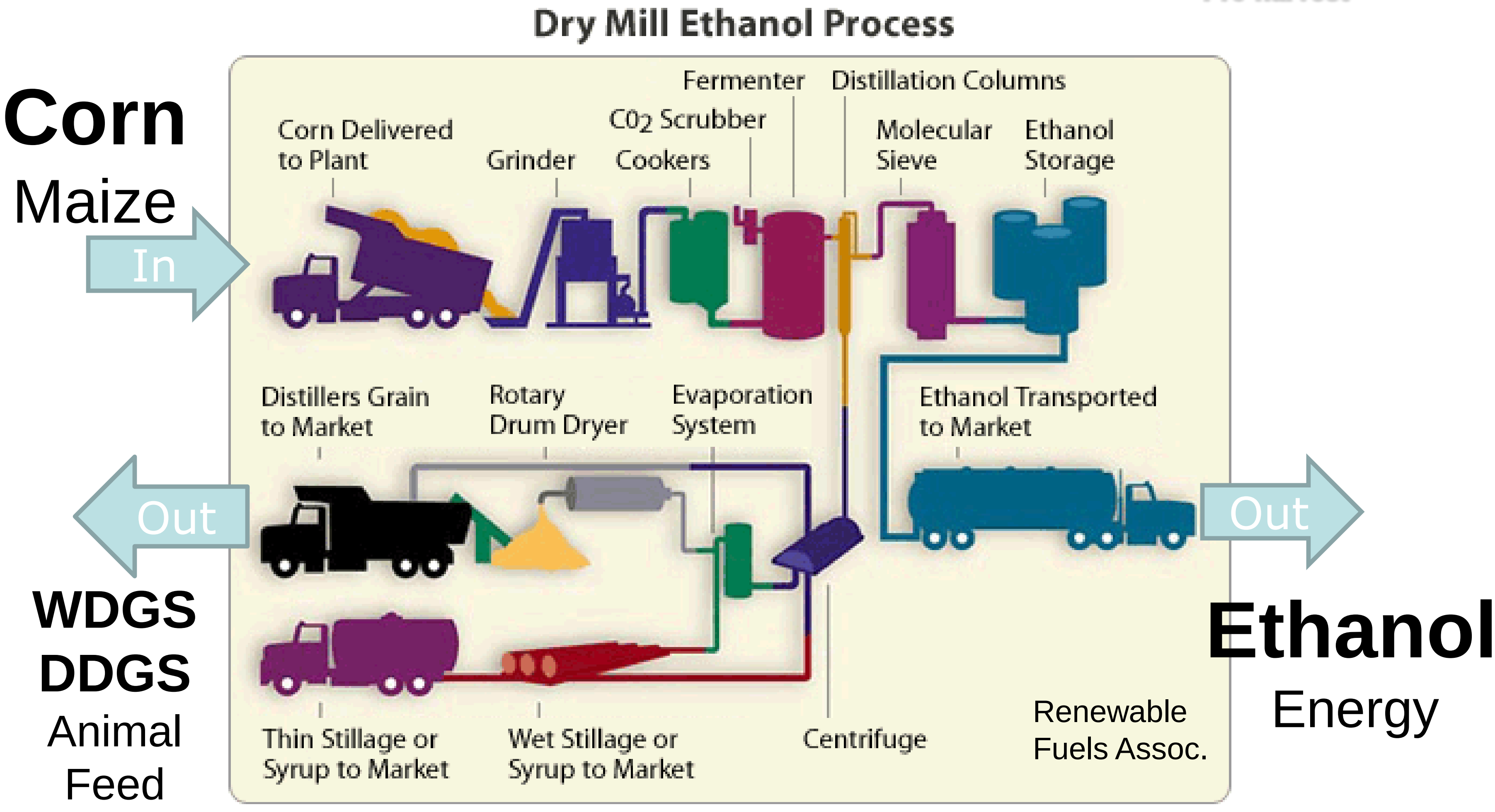
OR, odds ratio; LCL, lower confidence interval; UCL, upper confidence interval.

Abrupt feed changes and fasting

- Most diet-change studies have evaluated its effect on generic E. coli.
  - Generally change to roughage lowers concentration of generic E. coli
- No evidence that fasting affects STEC O157 shedding

Grain type and processing

- Greater risk for STEC O157 shedding with barley-based concentrate feeds
- Greater risk for STEC O157 shedding with steam-flaked processed corn
- Also, conflicting results…

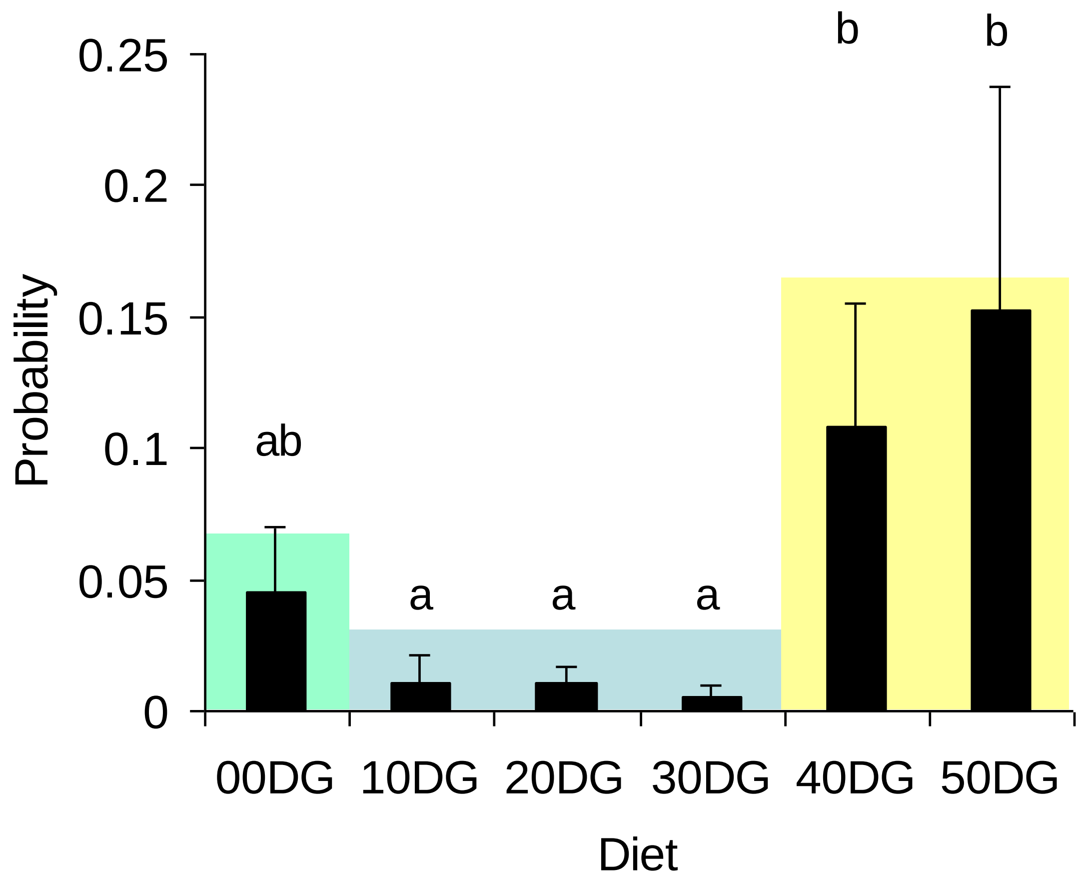


The feeding value of WDGS in cattle finishing diets is consistently higher than corn. Studies suggest a 31 to 43% improvement in feed efficiency when WDGS replaces intermediate levels of DRC (15 to 40% of diet DM)

Effect of level of distiller's grains on *E. coli* O157:H7 colonization by cattle

"The probability to detect *E. coli* O157:H7 in TRM from cattle was different for cattle fed different levels of [WDGS]."

"However, the mechanisms by which diet or diet components might affect *E. coli* O157:H7 fecal shedding patterns are unclear."



Wet distiller's grains plus solubles replaced corn in each treatment diet

Peterson et al. 2007. J Food Prot. 70(11)2568-2577

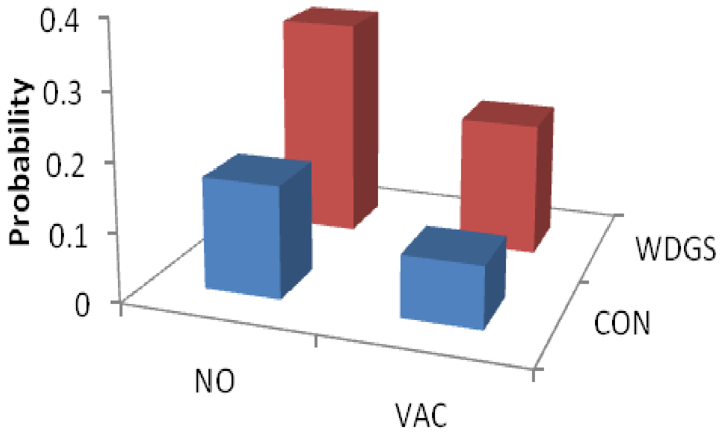
The effect of feeding distiller's grains and vaccination on *E. coli* O157:H7 fecal shedding by feedlot cattle

- **2x2 factorial design**
  - **Vaccination**
    - 3-dose regimen compared to non-vaccinated cattle
    - d 1, 26, 53/54
  - **Diet**
    - WDGS 40% of dry-matter compared to control diet
    - Dietary treatments consisted of a 3:2 ratio of high moisture (HMC) to dry rolled corn (DRC) or 40% WDGS replacing the 3:2 HMC:DRC (DM basis)

	Vaccine	No-vaccine
WDGS	**15 pens**	**15 pens**
Control	**15 pens**	**15 pens**

STEC O157

Pre-harvest



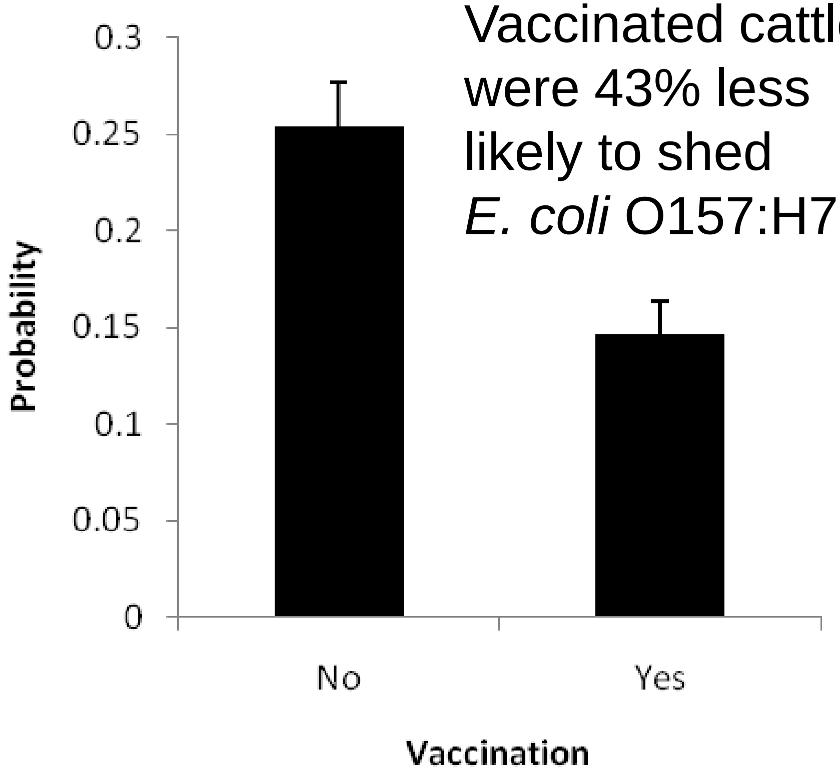
	Odds ratio	95% Confidence Interval		p-value
Vaccination vs not	0.50	0.36	0.70	<0.0001
Feeding WDGS vs control	2.50	1.81	3.45	<0.0001
Sampling Block 1 vs 2	0.48	0.30	0.77	0.0013
South Feedyard vs North	0.55	0.32	0.95	0.0318

Interaction between primary treatments was not significant (p=0.97)

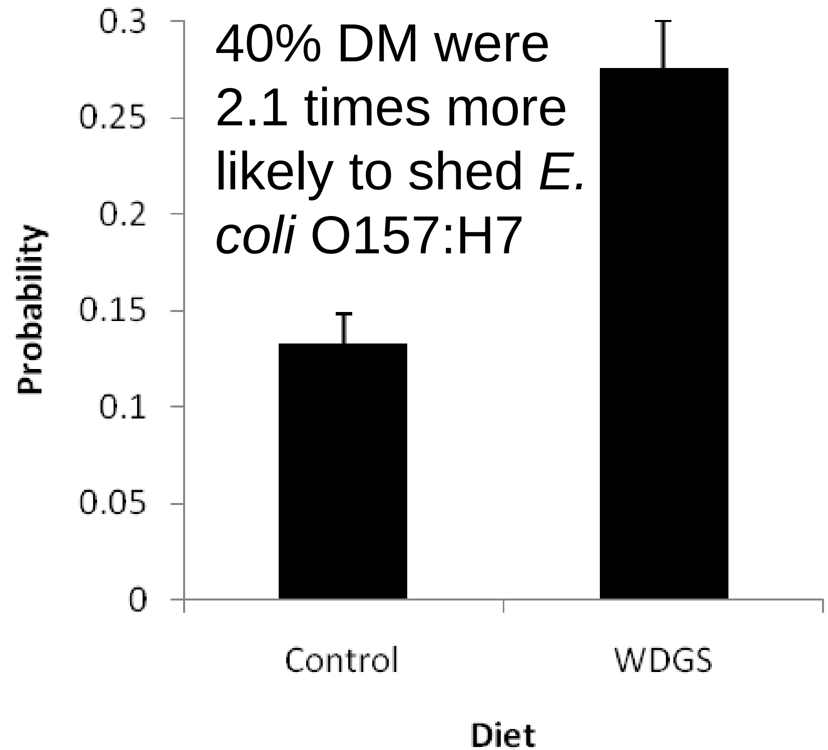
Test period was not significant (p=0.17)

Interaction of primary treatments and test period were not significant (p>0.40)

Vaccinated cattle were 43% less likely to shed *E. coli* O157:H7



Cattle fed WDGS 40% DM were 2.1 times more likely to shed *E. coli* O157:H7



More Questions…

Are there nutrient components that might explain a WDGS effect?

Protein
Fat
Fiber
Moisture
Sulfur

Environmental fate?

Can we feed cattle for food and environmental safety?

Probiotics / Direct-Fed Microbials

Lactobacillus acidophilus NP51
10^9 CFU/head/day

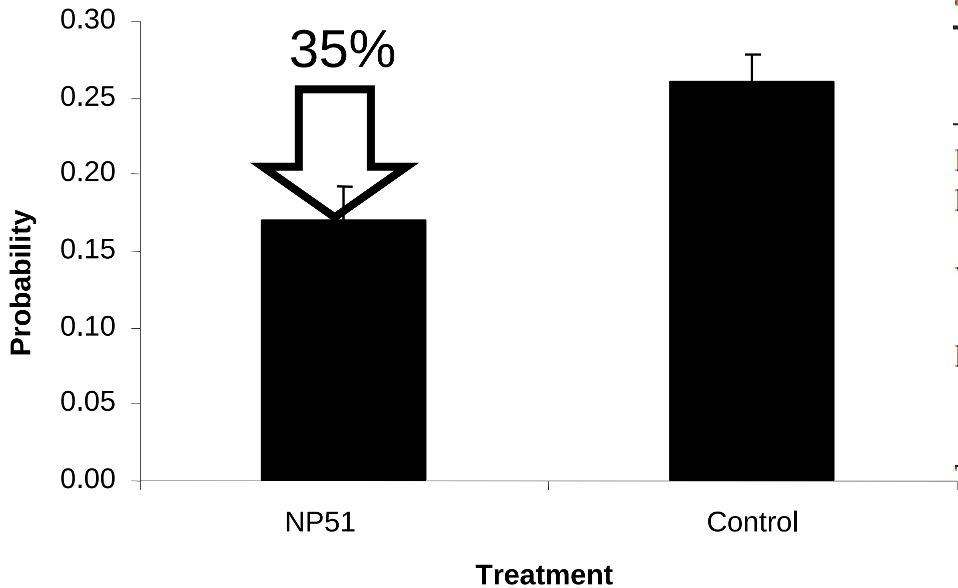
STEC O157

Pre-harvest

Journal of Food Protection, Vol. 70, No. 2, 2007, Pages 287–291

Effect of *Lactobacillus acidophilus* Strain NP51 on *Escherichia coli* O157:H7 Fecal Shedding and Finishing Performance in Beef Feedlot Cattle†

R. E. PETERSON,[2] T. J. KLOPFENSTEIN,[2] G. E. ERICKSON,[2]* J. FOLMER,[2] S. HINKLEY,[1] R. A. MOXLEY,[1] AND D. R. SMITH[1]



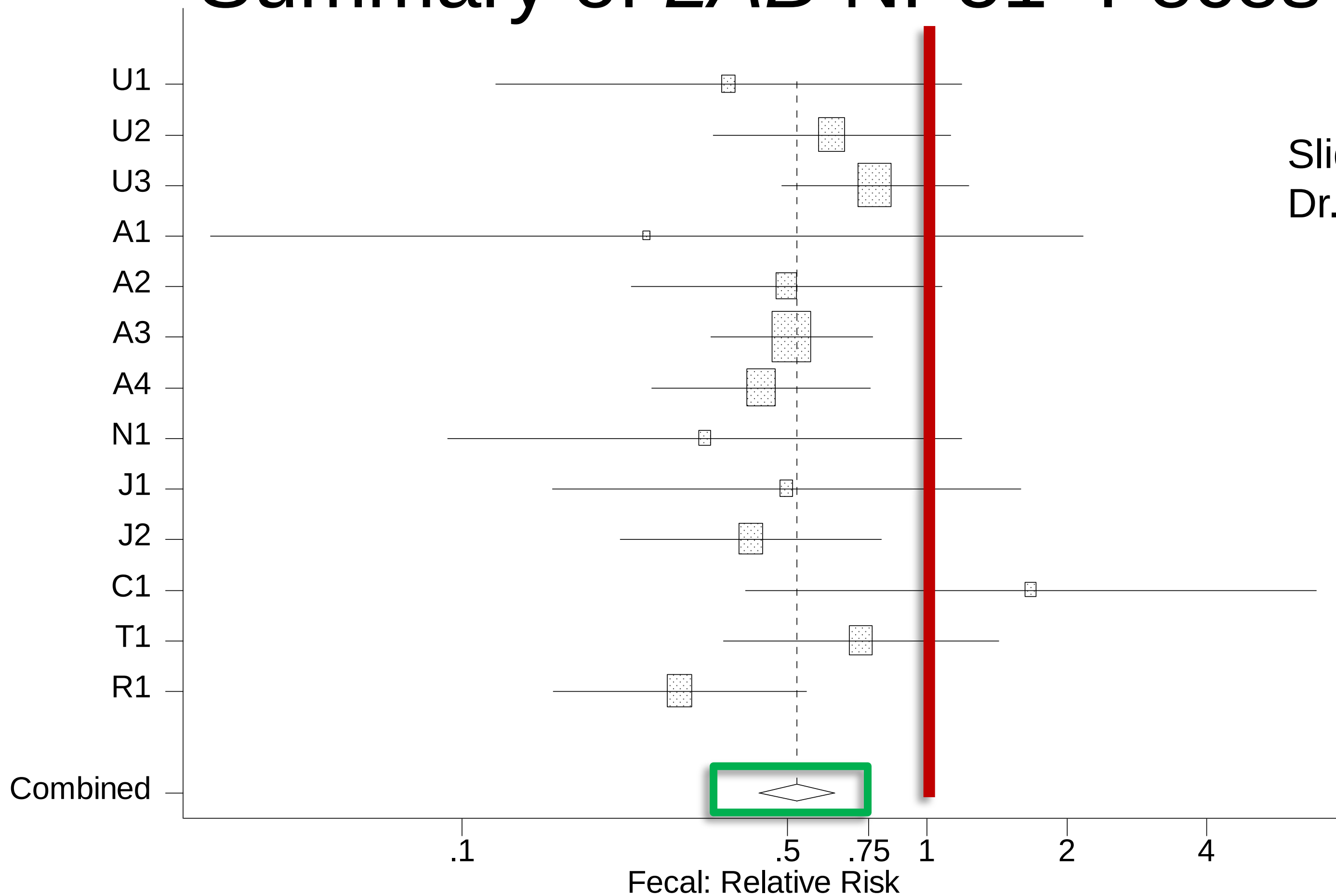
NP51-treated steers were 35% less likely to shed *E. coli* O157:H7 than were steers in untreated pens (odds ratio = 0.58, p=0.008).

TABLE 1. *Multivariable logistic regression model of the probability to detect* E. coli *O157:H7 from feces*

Variable	Unit	Parameter	Odds ratio	95% confidence interval		*P* value
Intercept		−2.829				
NP51	Yes	−0.545	0.58	0.41	0.82	0.008
	No	Ref.[a]	1.00	Ref.		
Year	2002	−0.537	0.58	0.44	0.78	0.004
	2003	Ref.	1.00	Ref.		
Block	1	−0.509	0.60	0.37	0.99	0.02
	2	−0.818	0.44	0.27	0.71	
	3	Ref.	1.00	Ref.		
Test period	1	−0.207	0.81	0.48	1.38	0.01
	2	−1.256	0.28	0.16	0.52	
	3	−0.635	0.53	0.33	0.84	
	4	−1.309	0.27	0.16	0.45	
	5	−0.157	0.85	0.52	1.39	
	6	Ref.	1.00	Ref.		

[a] Ref., reference group.

Summary of *LAB* NP51 -Feces



Slide courtesy of
Dr. Guy Loneragan

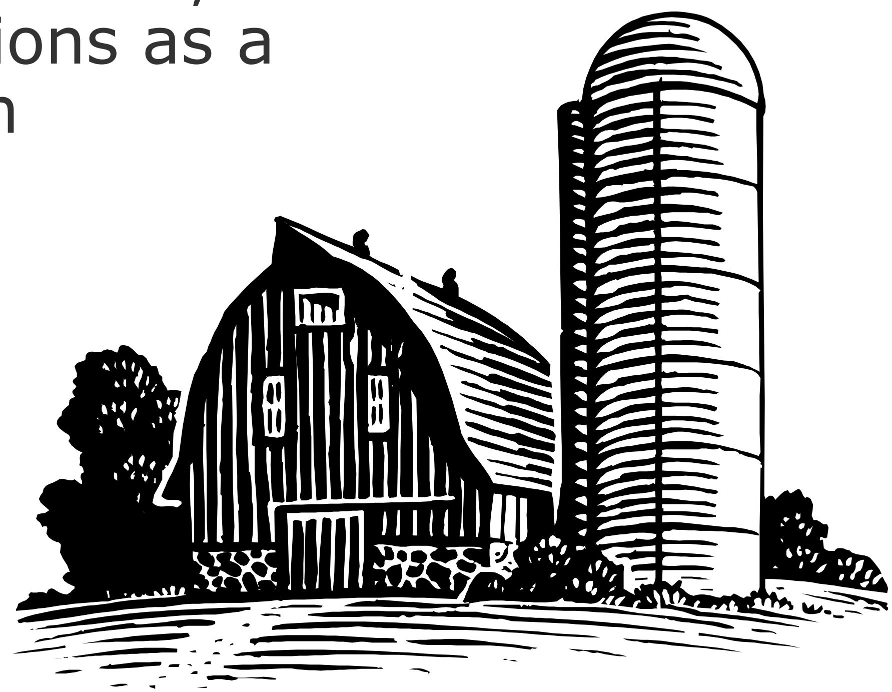
RR Feces	Product Efficacy	Lower 95% CL	Upper 95% CL	*P* value
0.60	40%	0.49	0.75	<0.01
P value assoc. with Q stat = 0.46; Between study variance = 0.00				

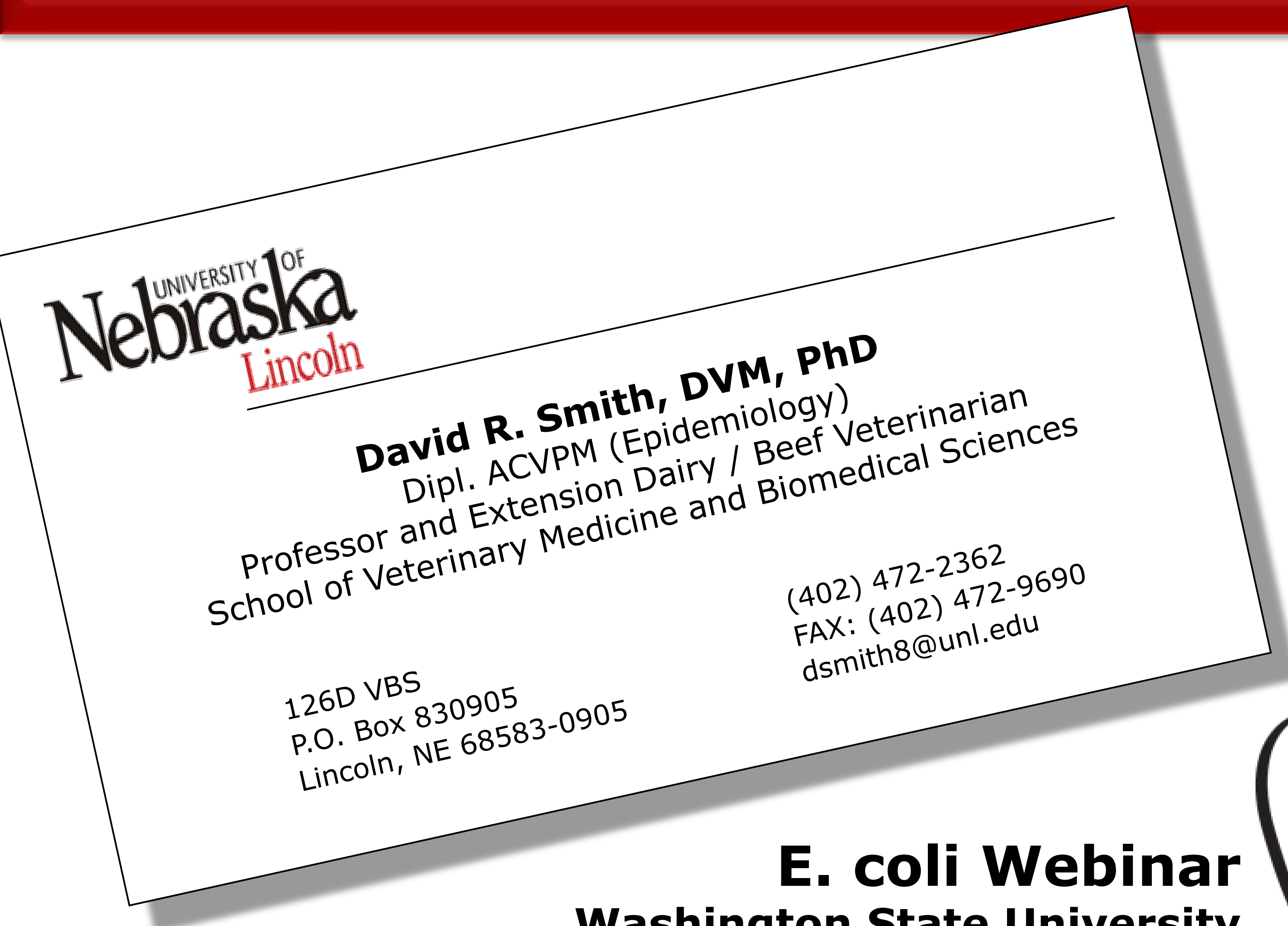
Discussion

It seems reasonable that what we feed cattle might affect the bacterial population of the gut

It is not yet clear how cattle rations affect *E. coli* O157:H7, or how to use to cattle rations as a pre-harvest intervention

Other pre-harvest interventions can mitigate the risk of *E. coli* O157:H7 under feedlot conditions of natural exposure

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