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Preweaned heifer management on US dairy operations: Part IV. Factors associated with the presence of *Escherichia coli* O157 in preweaned dairy heifers

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ABSTRACT

Dairy calves shed pathogenic *Escherichia coli* O157 (O157) in feces and are a potential route of exposure for human infections. As part of the National Animal Health Monitoring System's (NAHMS) Dairy 2014 study, we evaluated farm, animal, and environmental factors associated with O157 presence in dairy heifer calves. For this O157 study, calves were enrolled from 100 dairy operations in 13 states. Each operation collected data from calves from birth to weaning over an 18-mo period. A single fecal sample was collected from 487 calves in western states and from 871 calves in eastern states (n = 1,358 total), and O157 was detected in 2.5% (n = 34) of fecal samples. Descriptive statistics and univariable screening were used to determine which farm practices, environmental factors, and calf health measures were associated with O157 detection. Multilevel logistic models, controlling for dairy operation, were created using backward elimination of screened variables. The final O157 main effects model included variables for source of colostrum, temperature-humidity index (THI), and serum IgG concentration. Higher serum IgG was associated with lower odds of O157 shedding, whereas calves fed colostrum from their own dam had higher odds of O157 shedding than calves fed colostrum from pooled sources. Interaction models showed that THI level modified the effect of colostrum source on O157 shedding; calves with a THI indicative of heat stress had a significantly increased presence of O157 when fed colostrum from a first-lactation dam. The THI level also modified the effects of serum IgG. Calves with thermoneutral or heat stress THI values had increased presence of O157 with poor (<10 g/L) or adequate (10–15 g/L) serum IgG levels compared with those having excellent (≥15 g/L) serum IgG levels. These results highlight factors that influence the presence of O157 in preweaned dairy heifer calves and may be used to guide practices that mitigate shedding through improved animal husbandry.
Key words: dairy calf, *Escherichia coli* O157, risk factor, serum IgG, colostrum

INTRODUCTION

Escherichia coli O157:H7 (**O157**) is a gram-negative, pathogenic bacterium capable of causing bloody diarrhea, abdominal cramps, and hemolytic uremic syndrome in humans (Karmali et al., 2010; Nguyen and Sperandio, 2012; Croxen et al., 2013). The most recent data available estimate that up to 149,000 domestically acquired human O157 infections occur annually in the United States and are associated with ingestion of contaminated bovine products and other food sources (Scallan et al., 2011). Cattle play a central role in contamination of the food chain, as they can shed O157 in their feces. Once shed from bovine reservoirs, the O157 bacterium can survive under a multitude of conditions and travel far from sites of deposition by meteorological factors and processes such as irrigation and manure fertilization (Avery et al., 2008; Chauret, 2011; van Elsas et al., 2011). Attempts to control O157 after it is disseminated in feces (Food Safety and Inspection Service standard operating procedures for slaughter, USDA codes for food preparation, Pasteurized Milk Ordinance; https://www.fda.gov/downloads/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Milk/UCM612027.pdf) have had limited success, which is

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evidenced by persistent human outbreaks (Chekabab et al., 2013; Majowicz et al., 2014). To reduce the future burden of human disease, understanding the dynamics of cattle carriage with O157 and developing strategies that reduce shedding at the animal level are necessary.

After infection via the fecal-oral route, dairy cows that shed O157 have the ability to directly contaminate diverse food products, including milk, meat, and manure-fertilized crops (Meyer-Broseta et al., 2001). This is particularly important, because national studies have indicated that O157 is frequently present within the environment of US dairy herds (Wells et al., 1998; USDA, 2003). Previous studies have revealed that dairy cow shedding patterns are intermittent and complex, but can be influenced by environmental, farm management, host health, and lactation factors (Shere et al., 1998; Menrath et al., 2010; Williams et al., 2015; Venegas-Vargas et al., 2016; Stenkamp-Strahm et al., 2017a). Although risk factors in lactating cows have been measured, less is known about O157 shedding in preweaned calves. Calves may play a pivotal role in both maintaining O157 within the farm environment and directly spreading the pathogen to humans. Calves may shed greater numbers of O157 for prolonged periods (Dean-Nystrom et al., 1997b; Cobbold and Desmarchelier, 2000), and both on- and off-farm human contact tend to be greater with calves than with adult cows (Crump et al., 2002; Smith et al., 2004). Shedding of O157 in calves cannot be directly compared with shedding in adult cows because preweaned calves are monogastrics, and their diet, housing, and overall management on a dairy operation are different from that of cows. Further, O157 may cause diarrhea in calves, whereas adult animals do not experience clinical signs of disease during carriage (Cray and Moon, 1995; Quinn et al., 2015).

Previous studies have shown a low prevalence of shedding in calves (Garber et al., 1995; Rugbjerg et al., 2003; Stenkamp-Strahm et al., 2017b), but this finding is not consistent across the literature (Mechie et al., 1997; Cobbold and Desmarchelier, 2000; Irshad et al., 2012; Jaros et al., 2016). When attempting to define factors that influence carriage of O157 by calves, studies have indicated that dietary shifts, the presence of multiple gastrointestinal (**GI**) pathogens, and administration of anticoccidial agents may play a role (Cray et al., 1998; Smith et al., 2004; Cho et al., 2013). Operation-level factors, including calving strategy, colostrum administration, housing, and amount of contact between adult cows and calves, may also affect preweaning O157 prevalence (USDA, 1996; Rugbjerg et al., 2003; Cernicchiaro et al., 2012). In the United States, dairy operations are located across the country and are diverse in their calf-rearing approaches and overall methods of farm management (USDA, 2016). Although some factors for calf shedding have been elucidated, results from studies to date have lacked generalizability. This is due to an absence of comprehensive managerial and calf health data and characterization of samples from geographically discrete areas at few seasonal time points. To develop strategies that reduce the prevalence of O157 on-farm, the dynamics of shedding in calves should be analyzed on a national scale that incorporates information for geography, management, and animal health. The objective of the current study was to examine managerial, environmental, and animal health parameters for associations with the presence of O157 in preweaned heifer calves, using USDA's National Animal Health Monitoring System (**NAHMS**) Dairy 2014 Calf Component study data. Understanding these parameters may then be used to guide the development of management strategies that reduce O157 shedding in calves.

MATERIALS AND METHODS

Study Design

National surveys of US livestock and poultry industries are conducted annually by NAHMS. In 2014, NAHMS researchers collected information on the health, management, and productivity of the US dairy industry (USDA, 2013). This study also included a longitudinal study that collected data regarding dairy heifer calf health (NAHMS Dairy 2014 Calf Component).

The NAHMS Dairy 2014 Calf Component study was conducted over 18 mo from March 2014 to September 2015. A convenience sample of 104 dairy operations was enrolled from 13 states in 2 regions: California, Colorado, and Washington (western region) and Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Vermont, Virginia, and Wisconsin (eastern region). Enrolled operations were categorized based on the number of mature cows: small (30–99 cows), medium (100–499 cows), and large ($\geq$500 cows).

At the study outset, each operation was instructed to enroll 24 heifer calves (roughly 2/mo) for a 1-yr period. Due to lower than anticipated participation and a lag in calf enrollment, the target number for participating operations was increased to 48 calves, over an 18-mo period.

Calf Health Card and Sampling of Biologics

Before enrollment, calves were tested for bovine viral diarrhea virus (BVDV) and excluded if positive. For on-farm testing, the Idexx SNAP BVDV Antigen