Enterococcus durans infection and diarrhea in Thoroughbred foals

Natasha J. Williams 1 | Nathan M. Slovis 1 | Nimet S. Browne 1 | Mats H. T. Troedsson 2 | Steeve Giguère 3,4† | Jorge A. Hernandez 3

1Hagyard Equine Medical Institute, Lexington, Kentucky, USA
2Gluck Equine Research Center, Lexington, Kentucky, USA
3Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, Florida, USA
4Department of Large Animal Medicine, College of Veterinary Medicine, University of Georgia, Athens, Georgia, USA

Correspondence
Jorge A. Hernandez, Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, FL, USA.
Email: hernandezja@ufl.edu

Abstract

Background: Diarrhea remains an important cause of morbidity and mortality in neonatal foals, and correct identification of etiologic agents is essential for effective disease management.

Objective: To examine the association between diarrhea and detection of Enterococcus durans or other enteropathogens in neonatal foals on 1 breeding farm in Kentucky, USA.

Animals: Fifty-nine Thoroughbred foals and their broodmares.

Methods: Prospective observational study. Study foals and broodmares were sampled and tested for E. durans and other enteropathogens during the first 10 days after foaling. The frequency of foals in which E. durans or other enteropathogens was compared between foals with or without diarrhea.

Results: Seven of 59 foals developed diarrhea. The frequency of foals with E. durans infection was higher in foals with diarrhea 5/7 (71%), compared to foals without diarrhea 0/51 (0%; P < .01). Detection of E. durans in foals was associated with detection of E. durans in broodmares; in 2/7 (29%) foals with diarrhea, the 2 broodmares tested positive for E. durans, and, in 51/51 (100%) foals without diarrhea, all broodmares tested negative for E. durans (P = .01). Based on the spatial and temporal distribution of foals with diarrhea, 5 of 6 additional cases of diarrhea were attributed to lateral transmission of E. durans infection.

Conclusions and Clinical Importance: Detection of E. durans was associated with diarrhea in foals. Implementation of enhanced biosecurity measures might mitigate disease transmission associated with E. durans infection in foals.

KEYWORDS
biosecurity, diarrhea, Enterococcus durans, foals

Abbreviations: EDTA, ethylenediamine tetraacetic acid; IgG, immunoglobulin G.

† Deceased.
1 | INTRODUCTION

Diarrhea remains an important cause of morbidity and mortality in neonatal foals. Identification of pathogens that can cause diarrhea in foals is an important element for disease risk management at both animal and farm levels. *Clostridium perfringens*, *Clostridioides* (*Clostridium*) *difficile*, *Salmonella*, and rotavirus are frequently detected in hospitalized foals with diarrhea. In a study conducted on 6 horse farms, the frequency of foals less than 3 days of age with *C. perfringens* was high in foals both with diarrhea (5/6 or 83%) or without diarrhea (102/113 or 90%); an indication that *C. perfringens* might be part of the normal microflora in neonatal foals. In a study conducted on 32 Thoroughbred breeding farms, the frequency of foals with rotavirus was higher in foals with diarrhea (18/51 or 35%), compared to foals without diarrhea (1/37 or 3%). In all 3 studies, foals with or without diarrhea were not tested for *Enterococcus* (*Streptococcus*) *durans*.

An outbreak of diarrhea occurred in foals at 1 Thoroughbred breeding farm in Kentucky, USA in spring 2009. The main pathogens identified in foals with diarrhea were *C. difficile* toxin A, *C. difficile* toxin B, or *C. perfringens*. The next year, an epidemiologic investigation targeted foals with or without diarrhea on the same farm, and *Enterococcus durans* was included as a potential hazard in foals with diarrhea. *Enterococcus durans* is a naturally occurring inhabitant of the gastrointestinal tract in domestic animals, in addition to being found in water, soil, sewage, and vegetation. Experimental infection with *E. durans* causes profuse watery diarrhea in foals within 24 hours of inoculation. *Enterococcus durans* infection is associated with cases or outbreaks of diarrhea in rats, calves, piglets, or dogs. The objective of the study reported here was to examine the association between diarrhea and a positive diagnosis of *E. durans* or other enteropathogens in neonatal foals on 1 breeding farm in Kentucky, USA.

2 | MATERIALS AND METHODS

2.1 | Study site

The study was conducted on a Thoroughbred breeding farm in central Kentucky, USA from January to May of 2010. The farm was selected because of an outbreak of diarrhea in foals in spring 2009, when 21 of 59 (36%) foals were diagnosed with and treated for diarrhea by a single attending veterinarian. In that year, the main pathogen(s) identified in foals with diarrhea were *C. difficile* toxin A, *C. difficile* toxin B, or *C. perfringens*.

2.2 | Study farm

The study farm had a total of 72 Thoroughbred mares housed in individual stalls within 8 barns at their broodmare division. It is a breeding farm where mares and foals are stabled separately from the weanlings, yearlings, race horses, and breeding stallions. The farm has 1 foaling barn with 22 stalls, where most mares deliver their foal in a designated stall. The mare and foal stay in the foaling barn for 3 to 5 days before being moved into another barn. The farm has a 16-stall hospital barn, where foals that develop diarrhea are placed in isolation.

2.3 | Biosecurity procedures

The farm undertook yearly biosecurity assessments by 1 of the authors (Nathan M. Slovis). Biosecurity assessments included a walkthrough of the foaling facility, discussing hand hygiene practices, barn and equipment cleaning/disinfecting protocols, foaling protocols and response triggers for isolation which would include fevers >102.5 °F or passage of loose manure. During biosecurity assessments new staff were educated on the importance of biosecurity and the use of personal protective equipment (PPE) during foaling and when handling young foals.

In spring 2009, foals with diarrhea but alert and without fever remained in the foaling barn for ease of treatment. If foals had profuse watery diarrhea for >24 hours, they were moved to the hospital barn. In foals with diarrhea, feces were collected (fecal sample or rectal swab) for examination for *C. difficile* toxin A, *C. difficile* toxin B, *C. perfringens*, and *Salmonella*. Foals without further signs of diarrhea were moved out of the hospital barn after 72 hours. Foals remained in the hospital barn for 2 weeks if *C. difficile* toxin A, *C. difficile* toxin B, or *C. perfringens* was detected. Foals detected with *Salmonella* remained in the hospital barn until they tested negative to that pathogen 3 consecutive times. During isolation, PPE consisting of single-use disposable protective gowns, plastic foot protection (booties) and gloves were required when handling any foal. Gloves and gowns used on each foal were discarded after each use, and booties were changed every 24 hours or earlier if either excessively soiled or if any visible holes were noted. Stalls were power washed to remove any organic debris from the stall walls/floors before disinfecting with a phenol disinfectant (1 : 128 dilution; Tek-Trol ABC Compounding Company, Inc, Atlanta, Georgia).

In spring 2010, enhanced biosecurity measures were implemented on the study farm. Disinfecting ethyl alcohol handwipes were placed on each stall for easy hand hygiene for 3 days once a foal was born. Mare’s udders were cleaned with 2% chlorhexidine-soaked cotton before the foal nursing. Latex gloves were worn when handling any foal until they were 3 days of age. If a foal was diagnosed with diarrhea, the foal was immediately moved to the hospital barn, where treatment was performed by separate farm personnel assigned only to that facility. During isolation, PPE consisting of single-use disposable protective gowns, plastic foot protection (booties) and gloves were required when handling any foal. Gloves and gowns used on each foal were discarded after use. Plastic foot protection was changed every 24 hours or earlier if either excessively soiled or if any visible holes were noted. A foal with diarrhea remained in the hospital barn for 2 weeks if *C. difficile* toxin A, *C. difficile* toxin B, or *C. perfringens* was detected. Foals detected...
with *Salmonella* remained in the hospital barn until they tested negative to that pathogen 3 consecutive times. Foals were moved out of the hospital barn after 72 hours if no further signs of diarrhea were observed.

### 2.4 Study design

The investigation was designed as an observational longitudinal study. Foals were observed for early detection of diarrhea during the first 30 days after foaling. A fecal sample (teaspoon, about 5 g) or 6 rectal swabs (BBL CultureSwab Collection and Transport System, Becton Dickinson and Company, Sparks, Maryland), if fecal sample was no available, were collected from each foal (*n* = 59) and broodmare (*n* = 59) on the study farm by trained personnel from January 25 through May 10. In both foals and their broodmares, fecal samples were collected on day 3 and day 10 after foaling (sample No. 1 and No. 2, respectively) for diagnosis of selected pathogens that can cause diarrhea. If foals developed diarrhea before day 3, fecal samples were collected from these foals and mares at the onset of clinical signs and again at 10 days after foaling. In addition, blood samples were collected from all foals at 12-24 hours after foaling to measure IgG levels. Fecal samples and blood samples were shipped to designated laboratories the same day; or were kept refrigerated at 4 °C until shipped (within 24 hours) for further processing and laboratory analyses at the designated laboratories.

### 2.5 Diagnosis of diarrhea

In this study, foals diagnosed with diarrhea had an increase in water content of feces and increased frequency of defecation (3 consecutive watery bowel movements over a 24-hour period). Cases of diarrhea were initially detected by farm personnel and later confirmed and treated by the attending veterinarian.

### 2.6 Laboratory procedures

Fecal samples were processed and cultured for *Salmonella*, *Escherichia coli*, *C. perfringens*, *A. hydrophila*, and *E. durans*. Cultures for fecal aerobic and anaerobic pathogens were performed according to protocols developed by Hagyard Diagnostic Medical Laboratory. For *Salmonella*, specimens were inoculated to Hektoen Enteric (HE) agar and selenite F broth and then incubated at 35 °C for 12 to 18 hours. After incubation, the HE agar was examined for the presence of blue-green to blue colonies with or without black centers, and the Reveal test for *Salmonella* (Neogen, Lansing, Michigan) was performed on any suspicious colonies. For animals that were Reveal negative but there was a clinical suspicion of salmonella, suspect colonies were isolated and a BD BBL Cystal identification system (BD Diagnostics, Sparks, Maryland) was used to confirm. Following incubation, selenite F broth was subcultured to HE, streaked for isolation, incubated at 35 °C for a further 12 to 18 hours, and the plates were examined for blue-green to blue colonies and further isolation procedures were performed as described previously.

Anaerobic cultures were performed by inoculating fecal specimens to a blood agar plate (BAP) and anaerobic BAP. The anaerobic BAP was then placed in a BD GasPak EZ Pouch System (BD Diagnostics, Sparks, Maryland), and both plates were incubated at 37 °C overnight. The anaerobic BAP was examined at 24 and 48 hours for double zone beta hemolysis, and colonies were compared to the aerobic BAP colonies. Any double zone beta hemolysis colonies were isolated and again plated to BAP and anaerobic BAP. Double zone beta hemolytic colonies growing only on the anaerobic and not regular BAP were Gram stained to confirm as *C. perfringens*. Isolated colonies that had double-zone beta-hemolysis, only grew anaerobically, and Gram stained as Gram positive rods with blunt ends were reported as *C. perfringens*.

For aerobic culture, fecal specimens were inoculated to BAP, MacConkey (MAC) agar and Columbia Naladixic Acid (CNA) agar, isolation streaks were performed, and the plates were incubated at 37 °C overnight. Plates were examined at 24 and 48 hours for any predominant pathogenic organism, which if recognized were quantitated and identified.

Fecal flotation using sodium nitrate was performed for detection of *Strongyloides westeri* (Ovatector, BGS Medical Products, Inc).

Fecal samples were submitted to IDEXX for molecular detection (real-time PCR) of pathogens/toxins: *Cryptosporidium*, *C. perfringens* enterotoxin, *Clostridioides* (*Clostridium*) difficile toxin A, *C. difficile* toxin B, *Rhodococcus equi*, * Lawsonia intracellularis*, *Neorickettsia risticii*, rotavirus, and coronavirus. In addition, blood samples were processed for detection of IgG concentrations using an immunoturbidimetric assay on either lithium heparinized- or EDTA-blood.

### 2.7 Data collection

For each foal, data were collected: foal and broodmare identification number, foaling date, barn identification and stall number, sampling date, sample number, IgG levels, diarrhea (yes, no), date of diarrhea onset, and diagnosis of investigated pathogens/toxins (positive, negative).

### 2.8 Data analysis

A weekly frequency of newborn foals and those affected with diarrhea was presented by constructing a clustered column chart. The null hypothesis that diarrhea in foals was not associated with detection of *E. durans* or other investigated pathogens was tested by using the Fisher’s exact test. In addition, the null hypothesis that diarrhea in study foals was not associated with detection of *E. durans* or other investigated pathogens in study mares was tested by using the Fisher’s exact test. Values of *P* < .05 were considered significant.
Diarrhea
Weekly frequency of newborn foals from January 25 to May 10 (n = 59). Seven of 59 foals were diagnosed with diarrhea within 1-2 days of foaling the weeks of March 8 (n = 1), March 15 (n = 3), March 22 (n = 2), or April 12 (n = 1).

3 | RESULTS

Fifty-nine Thoroughbred foals and their broodmares were included in the study. All foals were ≤10 days old. Thirty-two of 59 foals were male and 27 were female.

All foals with diarrhea were classified as receiving adequate transfer of passive immunity (minimum = 994 mg/dL of IgG, maximum >1200 mg/dL).

The first 35 newborn foals did not develop diarrhea during the follow-up period. The first case of diarrhea (foal No. 36) was diagnosed during the week of March 8, 2 days after foaling. The foal tested positive to C. perfringens (culture), C. difficile toxin A and toxin B in sample No. 1 (at onset of diarrhea), as well as Cryptosporidium, C. difficile toxin A and toxin B in sample No. 2 (10 days after foaling). The foal tested negative to E. durans, but the broodmare tested positive to E. durans.

Five additional cases of diarrhea (foals No. 37, 38, 39, 40, and 42) were diagnosed in the same barn as the first case, 3 to 12 days after the first case (Figure 1). Foals No. 37, 38, 39, and 42 were 2 days old, and foal No. 40 was 1 day old. The first 2 additional cases (foals No. 37 and 38) occurred 3 days after the first case. The third, fourth, and fifth additional case occurred 5, 10, and 12 days after the first case, respectively.

Foals No. 37 to 40 tested positive to E. durans in sample No. 1, and foal No. 42 tested positive in sample No. 2. The broodmare of foal No. 39 tested positive to E. durans, and the remaining 4 mares tested negative.

The last case of diarrhea (foal No. 55) was diagnosed in a different barn than the previous cases during the week of April 12, 2 days after foaling. The foal tested positive to E. coli, C. perfringens enterotoxin, and coronavirus. The foal and broodmare tested negative to E. durans.

Table 1 shows the frequency of foals with or without diarrhea and diagnosis of investigated pathogens. The frequency of foals with a positive diagnosis of E. durans was higher in foals with diarrhea 5/7 (71%), compared to foals without diarrhea 0/51 (0%; P < .01). In our study, the frequency of C. perfringens (culture), C. perfringens (enterotoxin), or C. difficile (toxin A) was not different (P > .6) in foals with diarrhea (86%, 57%, 71%, respectively) or foals without diarrhea (85%, 44%, 81%, respectively). In addition, the frequency of C. difficile (toxin B) was lower in foals with diarrhea (17%), compared to foals without diarrhea (83%; P < .01). The number of samples that were submitted as fecal sample or rectal swab was not recorded.

All foals tested negative to Salmonella, Aeromonas hydrophila, L. intracellularis, N. risticii, R. equi, rotavirus, S. westeri, and C. perfringens β2.

A positive diagnosis of E. durans in foals was associated with a positive diagnosis of E. durans in broodmares (P = .01; Table 2).

All mares tested negative to A. hydrophila, L. intracellularis, C. difficile toxin B, C. perfringens enterotoxin, N. risticii, R. equi, Salmonella, coronavirus, and rotavirus.

4 | DISCUSSION

This study provides new epidemiologic evidence that detection of E. durans is associated with diarrhea in foals. A strength of this investigation is that both foals with and without diarrhea were targeted for detection of enteropathogens within 10 days of birth. In foals with diarrhea, fecal samples were collected and tested at the onset of clinical signs, as well as from their respective broodmares. The inclusion of foals without diarrhea as a comparison group offers epidemiologic evidence that E. durans was associated with diarrhea in study foals.

The first case of diarrhea in foals tested negative to E. durans, but its broodmare tested positive to E. durans. It is possible that this case had a false negative culture result of E. durans. It is also possible the source of infection was its broodmare, which tested positive to E. durans, or environmental contamination with that pathogen.

Five additional cases of diarrhea were detected in foals 3 to 12 days after the first case. The 5 additional cases tested positive to E. durans. All 6 cases of diarrhea were housed in the same foaling barn. It is possible the 5 additional cases of diarrhea on the same barn over a 2-week period were the result of lateral transmission; but the evidence is inconclusive because the 6 E. durans isolates were not further examined using genetic diagnostic tools. On the study farm, foals diagnosed with diarrhea were managed using isolation procedures (eg, use of gloves, plastic boots, gowns, and footbaths) by personnel attending the sick foals. It is possible the implementation of enhanced biosecurity measures mitigated further disease transmission associated with E. durans infection in foals. In the subsequent 7 weeks (after the first 6 cases of diarrhea were diagnosed), 1 of 16 newborn foals was diagnosed with diarrhea; but both the foal and broodmare tested negative to E. durans.

In this study, the frequency of C. perfringens and C. difficile (toxin A) was high, but similar in foals with or without diarrhea. These 2 pathogens were implicated as causes of diarrhea in hospitalized foals in 3 previous studies3,11,12; however, the evidence is inconclusive because foals without diarrhea were not sampled and tested for diagnosis of enteropathogens, including C. perfringens and C. difficile. For example, in our study, the frequency of C. perfringens (culture), C. perfringens (enterotoxin), or C. difficile (toxin A) was not different (P ≥ .6) in foals with diarrhea (86%, 57%, 71%, respectively) or foals
without diarrhea (85%, 44%, 81%, respectively). In addition, the observed frequency of *C. difficile* (toxin B) was lower in foals with diarrhea (17%), compared to foals without diarrhea (83%). Furthermore, in a previous study on 6 equine premises, the observed frequency of *C. perfringens* was lower in foals with diarrhea (5/6 or 83%), compared to foals without diarrhea (102/113 or 90%). In that study, *C. perfringens* was postulated to be a normal part of the microflora of neonatal foals. To our knowledge, no other studies have examined the relationship between a positive diagnosis of *C. perfringens* or *C. difficile* and diarrhea, in foals with or without diarrhea.

This study had several limitations. The study was conducted on 1 Thoroughbred breeding farm in Kentucky. Thus, study results cannot be extrapolated to other farms in different geographic regions or with different risk management standard operating procedures designed to mitigate risk of diarrhea outbreaks in foals. The diagnostic sensitivity and detection rate of selected laboratory procedures (eg.

| Pathogen/toxin                      | Foals with diarrhea | Foals without diarrhea | P     |
|-------------------------------------|---------------------|------------------------|-------|
|                                     | n = 7 (%)           | n = 52 (%)             |       |
| Coronavirus                         |                     |                        | .11   |
| Positive                            | 1 (14)              | 0                      |       |
| Negative                            | 6 (86)              | 52 (100)               |       |
| *Escherichia coli* (culture)        |                     |                        | 1     |
| Positive                            | 7 (100)             | 50 (96)*               |       |
| Negative                            | 0 (0)               | 2 (4)                  |       |
| *Clostridium perfringens* (culture) |                     |                        | .71   |
| Positive                            | 6 (86)              | 44 (85)*               |       |
| Negative                            | 1 (14)              | 8 (15)                 |       |
| *Clostridium perfringens* (PCR) Enterotoxin |             |                        | .6    |
| Positive                            | 4 (57)              | 23 (44)                |       |
| Negative                            | 3 (29)              | 29 (56)                |       |
| *Clostridium difficile* (PCR) Toxin A |                     |                        | .62   |
| Positive                            | 5 (71)              | 42 (81)                |       |
| Negative                            | 2 (29)              | 10 (9)                 |       |
| *C. difficile* (PCR) Toxin B        |                     |                        | <.01  |
| Positive                            | 1 (17)              | 43 (83)                |       |
| Negative                            | 5 (83)              | 9 (17)                 |       |
| *Enterococcus durans* (culture)     |                     |                        | <.01  |
| Positive                            | 5 (71)              | 0 (0)*                 |       |
| Negative                            | 2 (29)              | 51 (100)               |       |

*Fifty-one of 52 foals without diarrhea were tested for diagnosis of *E. coli*, *C. perfringens*, and *E. durans.*

**Table 1** Association between diarrhea and detection of investigated pathogens in study foals

| Pathogen/toxin                      | Status of mare | Foals with diarrhea | Foals without diarrhea | P     |
|-------------------------------------|----------------|---------------------|------------------------|-------|
|                                     | n = 7 (%)      | n = 52 (%)          |                        |       |
| *Escherichia coli* (culture)        | Positive       | 6 (86)              | 42 (81)*               | 1     |
|                                     | Negative       | 1 (14)              | 9 (19)                 |       |
| *Clostridium perfringens* (culture) | Positive       | 0 (0)               | 5 (10)*                | 1     |
|                                     | Negative       | 7 (100)             | 46 (90)                |       |
| *Clostridium difficile* (PCR) Toxin A | Positive     | 0 (0)               | 1 (2)                  | 1     |
|                                     | Negative       | 7 (100)             | 51 (98)                |       |
| *Cryptosporidium*                   | Positive       | 0 (0)               | 2 (4)                  | 1     |
|                                     | Negative       | 7 (100)             | 50 (96)                |       |
| *Enterococcus durans* (culture)     | Positive       | 2 (29)              | 0 (0)*                 | .01   |
|                                     | Negative       | 5 (71)              | 51 (100)               |       |

*Fifty-one of 52 foals without diarrhea were tested for diagnosis of *E. coli*, *C. perfringens*, and *E. durans.*

**Table 2** Association between diarrhea in study foals and detection of investigated pathogens in study mares
E. durans culture) when using fecal samples or rectal swabs are not known. The sensitivity can be less than 100% and lead to false negative results. In addition, it is not known if the culture detection rate of E. durans is the same, lower, or higher, when using rectal swabs, compared to fecal samples. In this study, testing both foals and broodmares mitigated the risk of misclassification bias, specifically false negative results. Furthermore, sampling of foals and their broodmares was limited to a single sample on day ≤3 and day 10 after foaling for diagnosis of selected pathogens that can cause diarrhea. By increasing the number of sampling periods, we could have enhanced our ability to detect additional cases (and shedding patterns) of E. durans in foals and their broodmares. Finally, although the small number of foals in which E. durans was detected was sufficient to declare the observed association with diarrhea as statistically significant, the small sample size affected our ability to assess potential confounding or interaction effects of other factors associated with diarrhea (eg, mono- or co-infections with other enteropathogens).

ACKNOWLEDGMENT
No funding was received for this study.

CONFLICT OF INTEREST DECLARATION
Authors declare no conflict of interest.

OFF-LABEL ANTIMICROBIAL DECLARATION
Authors declare no off-label use of antimicrobials.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION
Authors declare no IACUC or other approval was needed.

HUMAN ETHICS APPROVAL DECLARATION
Authors declare human ethics approval was not needed for this study.

ORCID
Jorge A. Hernandez https://orcid.org/0000-0002-3096-4762

REFERENCES
1. Cohen ND. Causes of and farm management factors associated with disease and death in foals. J Am Vet Med Assoc. 1994;204:1644-1651.
2. Slovis N, Elam J, Estrada M, et al. Infectious agents associated with diarrhea in neonatal foals in central Kentucky: a comprehensive molecular study. Equine Vet J. 2014;46:311-316.
3. Frederick J, Giguere S, Sanchez L. Infectious agents detected in the feces of diarrheic foals: a retrospective study of 233 cases (2003-2008). J Vet Intern Med. 2009;23:1254-1260.
4. Tillotson K, Traub-Dargatz JL, Dickinson CE, et al. Population-based study of fecal shedding of Clostridium perfringens in broodmares and foals. J Am Vet Med Assoc. 2002;220:342-348.
5. Tzipori S, Hayes J, Sims L, Withers M. Streptococcus durans: an unexpected enteropathogen of foals. J Infect Dis. 1984;150:589-593.
6. Rogers DG, Zeman DH, Erickson ED. Diarrhea associated with Enterococcus durans in calves. J Vet Diag Invest. 1992;4:471-472.
7. Cheon D-S, Chae C. Outbreak of diarrhea associated with Enterococcus durans in piglets. J Vet Diag Invest. 1996;8:123-124.
8. Collins J, Bergeland M, Lindeman C, et al. Enterococcus (Streptococcus) durans adherence in the small intestine of a diarrheic pup. Vet Pathol. 1988;25:396-398.
9. Yaeger M, Funk N, Hoffman L. A survey of agents associated with neonatal diarrhea in Iowa swine including Clostridium difficile and porcine reproductive and respiratory syndrome virus. J Vet Diag Invest. 2002;14:281-287.
10. Hoover D, Bendele S, Wightman S, et al. Streptococcal enteropathy in infant rats. Lab Anim Sci. 1985;35:635-641.
11. Hollis A, Wilkins P, Palmer J, et al. Bacteremia in equine neonatal diarrhea: a retrospective study (1990-2007). J Vet Intern Med. 2008;22:1203-1209.
12. Weese JS, Slovis N, Rousseau J. Clostridoides (Clostridium) difficile in neonatal foals and mares at a referral hospital. J Vet Intern Med. 2021;35:1140-1146.

How to cite this article: Williams NJ, Slovis NM, Browne NS, Troedsson MHT, Giguère S, Hernandez JA. Enterococcus durans infection and diarrhea in Thoroughbred foals. J Vet Intern Med. 2022;36(6):2224-2229. doi:10.1111/jvim.16568