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Biphasic appearance of corticated and decorticated ascarid egg shedding in untreated horse foals

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ABSTRACT

Parascaris spp. infects foals worldwide and may cause airway inflammation in addition to small intestinal impaction and rupture. It is observed that acquired immunity eliminates ascarid burdens beginning at about 6 months of age, and current evidence suggests that a single parasite generation propagates in each foal crop. The purpose of this study was to monitor natural parasitic infections in untreated mixed breed horse foals over the course of 0–300 days of age. Fecal samples were collected monthly from all foals born in 2014 ($n = 13$), beginning July 2014 through February 2015. Fecal egg counts (FECs) were performed in triplicates using the Mini-FLOTAC method. The foals were necropsied between 154 and 298 days of age and all intestinal ascarid were collected and identified to stage. Ascarid FECs exhibited a biphasic distribution with an initial peak at 91–120 days of age and, after a steady decline, a second, smaller peak at 241–300 days of age. Numbers of corticated and decorticated ascarid eggs were compared, with decorticated FECs remaining consistently low with a slight increase directly after the first corticated FEC peak. Overall, 4.36% of the total ascarid eggs counted were decorticated. Ascarid FECs showed a sharp peak in September, declined, and then steadily increased beginning in December and continuing through February. Upon necropsy, moderate to high number of ascarid specimens were recovered from foals between 8 and 10 months of age, coinciding with the second peak for the FECs. Eleven of the 13 foals harbored immature ascarid stages indicating a recent reinfection. However, these data demonstrates that apparently a second, smaller wave of infection is present in 8–10 month old foals. It may be of value to monitor egg counts in this age group to make sure that all parasite categories are well controlled.

1. Introduction

Two ascarid species are known to infect foals, *Parascaris equorum* and *Parascaris univalens*, with *P. univalens* being the predominant species according to a recent study (Nielsen et al., 2014). Foals with ascarid infections display a variety of clinical signs. These may include a coarse hair coat, coughing, and nasal discharge (Clayton, 1980). Weight loss and lethargy are common symptoms as well (Clayton and Duncan, 1978; Clayton, 1980). In addition to these external symptoms, the migratory pattern of *Parascaris* spp. may result in the damage of internal organs. Migration can lead to inflammation and leave fibrous scars, as well as pulmonary damage (Clayton, 1980).

The largest concern with ascarid infection is small intestinal impaction and rupture. Foals are at the highest risk of impaction after receiving anthelmintic treatment (Southwood et al., 1996), but the condition may occur spontaneously. As the dead or paralyzed worms move down the small intestine by peristalsis, an obstruction may occur within 24 h of treatment (Cribb et al., 2006). Surgery can be performed to relieve small intestinal obstructions, but these procedures typically do not have a good prognosis. A total of 52 cases were examined between three studies in which severe cases were admitted to the hospital and a portion underwent surgery for intestinal impaction (Southwood et al., 1996; Cribb et al., 2006; Tatz et al., 2012). The long-term survival rate of these foals ranged from 8 to 60% with the highest rate reported in a recent Israeli study (Tatz et al., 2012). Post-operative complications are common and foals often suffer from adhesions, focal necrotizing enteritis, and possible rupture of the small intestine (Southwood et al., 1996). For these reasons, it is critical that the horse owner and veterinarian remain well aware of ascarid infec-

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tions in foals prior to anthelmintic treatment. The prepatent period for ascarids is about 10–12 weeks. Therefore it has been recommended that foals be given an ascaridicide beginning at about 6–8 weeks of age before these parasites mature. This should result in a reduced bulk of worms and thus less risk of the small intestinal impaction (Drudge and Lyons,1983).

Anthelmintic resistance in *Parascaris* spp. is becoming an increasingly pressing issue. It was first noticed when macrocyclic lactone treatment failed to decrease ascarid egg counts in the Netherlands and Canada (Boersema et al., 2002; Hearn and Peregrine, 2003), and macrocyclic lactone resistance has now been reported worldwide (Reinemeyer, 2009; Peregrine et al., 2014). The pyrimidine and benzimidazole drug classes remain more effective. Only two studies found evidence of resistance to pyrantel pamoate (Craig et al., 2007; Lyons et al., 2008), whereas resistance has not yet been reported to benzimidazole drugs (Peregrine et al., 2014). Nonetheless, the increasing levels of anthelmintic resistance in equine ascarid parasites poses a risk for accumulating worm burdens and subsequently increased risks of clinical disease.

For the reasons given above it is recommended to monitor foals for the presence of ascarids by performing fecal egg counts (Nielsen et al., 2013). Equine ascarid eggs characteristically carry a dark outer proteinaceous capsule, although a small proportion can appear decorticated without this capsule (Fig. 1). To our knowledge, egg shedding dynamics of decorticated ascarid eggs have not been studied in horses.

It is uncommon to diagnose horses with ascarid infection beyond two years of age. This is due to acquired immunity to the parasite (Reinemeyer, 2009), and the available evidence suggests that a single ascarid generation propagates in each foal crop before the parasites are expelled and strongyles begin to dominate the parasite community. In a study monitoring ascarid infections in both naturally reared foals and foals previously kept parasite free, it was observed that most of the larvae in the older foals died or had been destroyed in the liver and lungs, unlike the younger foals, where a higher number of larvae completed the migration. This led to the conclusion that immunity to the parasite is age-dependent and primarily directed towards the migrating larvae (Clayton et al., 1979).

The aim of this study was to monitor ascarid burdens in untreated foals during their first 300 days of life, through examination of fecal egg counts as well as intestinal ascarid worm burdens. A secondary aim was to investigate the occurrence of decorticated ascarid eggs across age in these foals.

2. Materials and methods

2.1. Horses

For this study, thirteen mixed breed horse foals born in 2014 were used. All of the foals were born into the University of Kentucky's parasitology herd, which has not received any anthelmintic treatment since 1979 (Lyons et al., 1990). Therefore, each foal in the study harbored natural parasitic infections. All foals were kept on the same pasture throughout this study. The study protocol was reviewed and approved by the University of Kentucky animal care and use committee (IACUC), under protocol number 2012-1046.

2.2. Fecal egg count

Fecal samples were collected from the foals monthly. Fecal egg counts (FECs) were performed using the Mini-FLOTAC method (Cringoli et al., 2013; Barda et al., 2014) with a saturated glucose-salt solution (specific gravity of 1.26) and a detection limit of 5 eggs per gram (EPG). Numbers of strongyle, and both corticated and decorticated ascarid eggs were recorded throughout the study. Egg counts were conducted in triplicate in order to account for variability in a sample.

2.3. Necropsy

Beginning at 154 days of age, foals were euthanized and underwent necropsy. Here, the small intestine was removed and all ascarids present were collected, counted, and identified to gender and stage.

2.4. Statistical analyses

All analyses were carried out using SAS software (version 9.3, SAS Institute, Cary, NC, USA). Mixed linear models were constructed for analyzing the relationship between ascarid egg counts and gender, foal birth month, sample month, and foal age. The 'mixed' procedure was used with repeated measures and foal ID and egg count replicate as random effects. Gender, age, birth month, and sample month were kept as class variables, while all other variables were considered continuous. Egg count data were log-transformed to achieve normal distribution. The influence of all covariates was evaluated using traditional forward and backward elimination of covariates. All covariates with p-values of 0.20 or below were kept in the model. Whenever the variables gender, age, or sample month

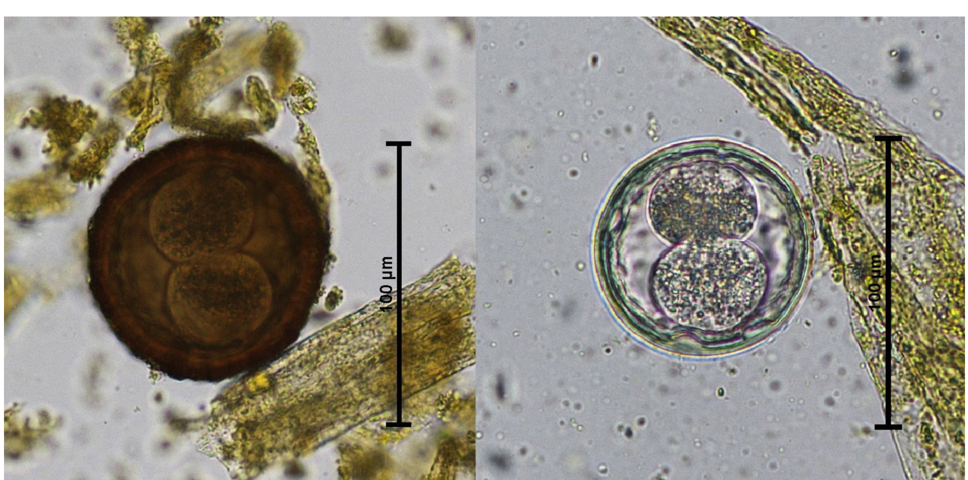

Fig. 1. A corticated (left) and a decorticated (right) *Parascaris* spp. egg.