The epidemiology of Rhodococcus equi foal pneumonia is changing and remains ill-defined. Few foal-specific or farm-specific factors have been correlated with occurrence of this disease. The density of mares and foals and the airborne concentration of virulent isolates of R. equi are associated with the disease, but a causal relationship has not been established for either factor. Author’s address: Equine Infectious Disease Laboratory, Department of Large Animal Clinical Sciences, College of Veterinary Medicine and Biomedical Sciences, Texas A&M University, College Station, Texas 77843-4475; e-mail: ncohen@cvm.tamu.edu. © 2010 AAEP.

1. Introduction
Epidemiology is a scientific discipline concerned with quantifying the distribution of disease and determinants of disease and health in populations. Accurately quantifying the distribution of Rhodococcus equi foal pneumonia (REFP) is challenging because of the absence of comprehensive listings of farms from which complete or random samplings can be selected and because the incidence of disease seems to vary among farms in a non-random manner. Some breeding farms never experience the disease and some are affected sporadically, whereas other farms experience cases of R. equi foal pneumonia on a recurrent basis.1 Perhaps the biggest challenge to quantifying the burden of disease is the transformation of case definition that has resulted from increased efforts to screen foals to detect pathological changes attributed to R. equi before the onset of clinical signs. Cumulative incidences at breeding farms based on clinical signs of disease tend to be around 10%, but cumulative incidences greater than 20% are not unusual.2–5 When ultrasonographic screening is used to identify foals with subclinical or preclinical pulmonary consolidation, cumulative incidences attributed to R. equi are considerably higher, reaching 50% of foals in a season at some farms.6 Reported case fatality rates derived from studies of multiple farms have generally ranged from 10% to 30%, but higher rates have been observed.2,4 Case fatality rates are expected to be considerably lower when screening tests are used to detect pre- or subclinical disease, such as ultrasonographic findings of pulmonary consolidation in the absence of clinical signs of disease. Indeed, the objective of screening for early disease is to reduce morbidity and mortality attributable to this insidiously developing disease.

Questions of critical importance regarding the epidemiology of REFP are: (1) why are some foals affected, whereas others in the same environment remain unaffected, and (2) why does the disease occur regularly at some farms but not at others? Answering these questions requires studies designed where the units of analysis are individual foals (foal-level studies) and individual farms (farm-
level studies), respectively. Evidence from foal-
level and farm-level studies will be reviewed.

2. Foal-Level Studies

Evidence indicates that exposure of mares and foals to \textit{R. equi} is widespread in their environment: seroprevalence is high,\textsuperscript{7–9} and numerous reports describe that the organism can be isolated from feces, soil, air, and feed at horse breeding farms in many countries.\textsuperscript{5,10–18} Given this widespread distribution, it is likely that all foals are exposed to virulent \textit{R. equi}, yet only some foals develop clinical signs of disease. Conceivably, a greater exposure (i.e., higher inoculum size or more persistent contact) might cause some individual foals to develop disease. Greater concentration of virulent \textit{R. equi} in the feces of dams did not seem to explain the risk of \textit{R. equi} pneumonia for their individual foals.\textsuperscript{10} Nevertheless, the finding that all mares at a breeding farm were shedding virulent \textit{R. equi} in their feces indicates that mares are a source of virulent \textit{R. equi} for the environment of foals. Whether the airborne concentration of \textit{R. equi} in stalls during the peripartum period determines risk of disease for individual foals remains to be determined.

If greater exposure to individuals does not explain the disease, it is possible that some foals are particularly susceptible to disease caused by \textit{R. equi} infection. To the author’s knowledge, only one study has specifically attempted to address signalment, history, and management factors of individual foals for their association with \textit{R. equi} pneumonia.\textsuperscript{19} That study identified significant differences in disease incidence between farms and between years, but no other foal-level factors were significantly associated with the disease.

Anecdotally, some mares are described as being more likely to have affected foals. These anecdotes suggest the possibility of genetic contributions to susceptibility to \textit{R. equi} pneumonia. Polymorphisms in microsatellite regions of foal DNA and the interleukin 7 receptor-encoding solute carrier 11A1 (formerly \textit{NRAMP1}) as well as transferrin genes have been associated with susceptibility to \textit{R. equi} pneumonia.\textsuperscript{20–23} However, the associations have not been compellingly strong, and the phenotypic outcome for some of these studies was infection rather than disease. Nevertheless, genetic factors likely influence host susceptibility; these mechanisms are likely to be complex and polygenic in nature and modulated by environmental factors, such as the farm density of mares and foals. New genome- and transcriptome-wide tools may prove valuable in determining which genes differ in sequence or expression between susceptible and resistant foals.

Considerable experimental data, and some observational data from foals with and without \textit{R. equi} foal pneumonia, indicate that innate and adaptive host-immune responses play a critical role in the pathogenesis of \textit{R. equi} pneumonia. The concentrations of neutrophils (innate immune cells) and the ratio of CD4+:CD8+ T lymphocytes (adaptive immune cells) were significantly lower at 2 wk of age among foals that subsequently developed \textit{R. equi} pneumonia than among age-matched controls from the same environment that failed to develop the disease.\textsuperscript{24} At the time of clinical signs of disease, however, absolute concentrations or ratios of CD4+ and CD8+ T lymphocytes do not seem to differ between foals with \textit{R. equi} and age-matched controls.\textsuperscript{24,25}

In sum, limited data are available regarding foal-level risk factors for \textit{R. equi} pneumonia. Those studies conducted to date have been both valuable and valid but have not yielded compelling data regarding any particular causal factor(s).

3. Farm-Level Studies

Farm-level studies indicate that the size (total acreage or total number of horses) and density of mares and foals per acre seem to be positively correlated with incidence of \textit{R. equi} pneumonia.\textsuperscript{2,4,5} To date, geochemical parameters evaluated in soil of horse breeding farms have not been associated with the occurrence of \textit{R. equi} pneumonia.\textsuperscript{26} A number of recent studies have documented that the presence or concentration of \textit{R. equi} in soil fails to explain the incidence of \textit{R. equi} at breeding farms.\textsuperscript{5,11,13} At breeding farms in Kentucky, the proportion of virulent isolates of \textit{R. equi} in soil was increased later in the breeding/foaling season.\textsuperscript{3} Airborne concentrations of \textit{R. equi} were correlated with disease incidence at Thoroughbred breeding farms in Australia.\textsuperscript{11} Factors that were associated with increased air concentration of \textit{R. equi} at these Australian farms included site (holding pens/lanes relative to paddocks), warmer ambient temperature, less soil moisture, reduced grass height, and later date during the breeding/foaling season.\textsuperscript{11} One needs to be careful to distinguish between statistically significant associations and causal associations in environmental/ecological studies of \textit{R. equi}, because establishing the temporality of cause preceding effect is generally difficult.

Studies of management practices associated with the occurrence of \textit{R. equi} pneumonia remain scant.\textsuperscript{2–4} Some evidence exists that foaling in pasture may reduce the risk of \textit{R. equi} pneumonia.\textsuperscript{4,27} The disease seems to occur more commonly at well-managed farms that use practices generally deemed to be desirable for preventing infectious diseases of foals.\textsuperscript{2–4} This association is not likely causal but does indicate that practices effective for preventing other infectious diseases of neonates are of limited benefit against \textit{R. equi}. It does not seem that the incidence of disease at farms is explained by farm-specific strains of \textit{R. equi}.

4. Conclusions

Relatively few studies have been conducted regarding foal- or farm-level risk factors for \textit{R. equi} pneumonia. Much work remains to be done to identify key foal- and farm-level risk factors for \textit{R. equi}.


