

Epidemiology and disease control in everyday beef practice

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Abstract

It is important for food animal veterinarians to understand the interaction among animals, pathogens, and the environment, in order to implement herd-specific biosecurity plans. Animal factors such as the number of immunologically protected individuals influence the number of individuals that a potential pathogen is able to infect, as well as the speed of spread through a population. Pathogens differ in their virulence and contagiousness. In addition, pathogens have various methods of transmission that impact how they interact with a host population. A cattle population's environment includes its housing type, animal density, air quality, and exposure to mud or dust and other health antagonists such as parasites and stress; these environmental factors influence the innate immunity of a herd by their impact on immunosuppression. In addition, a herd's environment also dictates the "animal flow" or contact and mixing patterns of potentially infectious and susceptible animals. Biosecurity is the attempt to keep infectious agents away from a herd, state, or country, and to control the spread of infectious agents within a herd. Infectious agents (bacteria, viruses, or parasites) alone are seldom able to cause disease in cattle without contributing factors from other infectious agents and/or the cattle's environment. Therefore to develop biosecurity plans for infectious disease in cattle, veterinarians must consider the pathogen, as well as environmental and animal factors.

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1. Introduction

One component of epidemiology is understanding the interaction among animals, potential pathogens, and the environment, in order to implement a herd-specific biosecurity plan [1,2]. Biosecurity is the attempt to keep infectious agents away from a herd, a state, or a country and to control the spread of infectious agents within a herd. Infectious agents (bacteria, viruses, or parasites) alone are seldom able to cause disease in cattle without contributing factors from other infectious agents and/or the cattle's environment. Therefore to develop biosecurity plans for infectious disease in cattle, veterinarians

must consider pathogen, environmental, and animal factors.

2. Disease triad: pathogen–animal–environment

2.1. Pathogen factors

Pathogens differ in virulence, contagiousness, and modes of transmission (Table 1). These differences exist not only among pathogens, but for virulence and contagiousness, can also differ among strains of the same species of pathogen. A more virulent pathogen causes more severe clinical signs of disease, with a greater likelihood of death. A pathogen with greater contagiousness will infect more animals in a shorter interval when introduced into a population. These factors are not related; therefore, highly virulent

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Table 1
Examples of pathogen factors affecting diseases of cattle

Pathogen factors	Examples
Virulence	Infection with some strains of BVD or IBR (and other agents) causes much more severe disease and higher mortality percentages than infection with other strains
Contagiousness	IBR and PI3 will infect more animals in a shorter interval than will BVD following introduction of the virus into a herd
Method of transmission	
Inhalation	IBR and BVD
Ingestion—any age	BVD, <i>Salmonella</i> sp., <i>Leptospirosis</i>
Ingestion—age specific	<i>E. coli</i> K-99 – only for a few hours following birth
Sexual contact	Johne's – most infectious early in life
Intermediate host	Vibrio, Trichomoniasis
Fomite	Liver flukes (snail), <i>Neospora caninum</i> (canine)
	BLV, Anaplasmosis—ticks, horse flies, surgical instruments

pathogen may not be very contagious, and a very contagious agent may not be highly virulent. In addition, different pathogens have various methods of transmission that impact how they interact with a host population. Some pathogens are spread via inhalation or ingestion. Infectious agents spread in these ways are further differentiated by the length of time the agent can survive outside the host in the environment, by the distance they can travel and remain infectious, and by the age of host that is susceptible to infection or disease. Other pathogens are spread only through sexual contact and are not contagious outside the act of mating. And still other pathogens require an intermediate host or transmitting fomite such as an insect, snail, or mammal.

2.2. Animal factors

The two primary animal factors that affect protection of cattle herds from disease are specific and innate immunity. Specific immunity relates to an immune response directed at a specific infectious agent that the animal has been exposed to in the past, either via natural infection or vaccination, for which “memory” remains. Innate immunity is strongly influenced by the overall health of the animal. Nutritional status such as adequate energy, protein, vitamins, and minerals impacts an animal's overall health and immune status. Stress due to crowding, inclement weather, unsanitary housing, or concurrent disease can cause varying degrees of immune suppression.

In populations of animals, not only do pathogen factors such as virulence, and the length of the latent and infectious periods influence the number of animals infected, animal factors, such as the number of immunologically protected individuals (either due to specific or innate immunity) also determine the number of individuals the pathogen is able to infect and the speed of spread through a population [2].

2.3. Interactions between animal and pathogen populations

Whenever a veterinarian is looking at a beef herd, they are observing not only a population of animals, but also an unseen population of present or potential pathogens. Both populations have their own life cycle, immunology, and adaptations. When we investigate a disease, we almost always consider the animal side of the infectious disease interaction, because the incubation period (interval from infection to onset of clinical signs), the symptomatic period (interval from onset to end of clinical signs), and non-diseased state (interval after the end of clinical signs) are relatively visible and measurable. Concurrently, the pathogen population and its dynamics are often given little attention. For the pathogen population, its interests are described by the latent period (interval from infection of one host to the time its offspring can infect a new host), the infectious period (duration that the pathogen's offspring can infect other hosts), and the noninfectious period (interval when the pathogen population of one host can no longer infect other hosts). The infectious period can end when the immune system clears the organism from the host's body, the infectious host animal is removed from the susceptible population (isolation), the animal is sent to slaughter, or the host animal dies. The relationship between the time line of infectiousness (pathogen's perspective) and the time line of disease (animal's perspective) differs between pathogens/diseases and is influenced by the virulence of the pathogen and the host's response to it.

Understanding the relationship between these two time lines for a particular disease is important when developing a biosecurity plan to deal with that disease. The biosecurity tools available are (Table 2): (1) test and cull; (2) test and isolate; (3) test and treat; (4) prophylactically treat all; (5) vaccinate; (6) management.

Table 2

Biosecurity strategies (available to veterinarians) and their requirements or characteristics

Biosecurity strategy	Requirements or characteristics	Example diseases
Test and cull	Accurate test Carrier animals are only or primary source of infectious agent Complete strategy that combines testing with movement restriction prior to testing	Bovine Viral Diarrhea (BVD) Bovine Leukosis virus (BLV) Brucellosis <i>Mycobacterium paratuberculosis</i> (Johne's) and <i>Neospora caninum</i> —not ideal examples because tests are not accurate
Test and isolate	Accurate test If using clinical signs as test, infectious period must not begin before clinical signs If using diagnostic laboratory test, the carrier state must be short-lived and self-limiting or isolation must be life-long	Calf scours (coronavirus, rotavirus) BLV, Anaplasmosis (life-long isolation)
Test and treat	Accurate test Treatment must effectively clear carrier	Anaplasmosis Leptospirosis?
Prophylactically treat all	High prevalence or high cost disease Prophylactic treatment must effectively clear carrier state or prevent transmission	Anaplasmosis Bovine Respiratory Disease
Vaccinate	If combined with testing strategy, must not interfere with test accuracy Must either prevent infection or decrease transmission	Infectious Bovine Rhinotracheitis (IBR)
Management		
Limit population size	Even with same animal density, will decrease number of contacts	IBR?
Decrease transmission	Decrease animal density, isolate susceptible age animals from potential carriers Sanitation to decrease environmental transfer	Calf scours, Johne's, Trichomoniasis
Decrease immunosuppression	Decrease social stressors: commingling, aggressive handling Decrease environmental stressors: mud, heat, cold, dust Adequate nutrition	Calf scours, Johne's, leptospirosis Almost all diseases

If an animal with a particular infectious disease becomes infectious at approximately the same time as clinical symptoms appear, diagnosis and isolation or culling will help, and may completely stop the spread of the disease (e.g., rotavirus and coronavirus scours in calves). In contrast, if a particular pathogen infects a host before the animal shows symptoms, diagnosis and isolation will not greatly affect the spread of the disease (e.g., IBR- and BVD-induced respiratory disease). If a disease has a long-term carrier state that accounts for all or most of the source of the infectious agent (anaplasmosis, BLV, BVD, Johne's, *Vibrio*, *Lepto*, etc.) and a testing system has both high sensitivity and specificity, a test and cull strategy may be appropriate (anaplasmosis, BLV, BVD, and *Vibrio*), whereas a test and isolate strategy could be considered for a disease with a short-term carrier state or a minimally pathogenic disease with a long-term carrier state (BLV, anaplasmosis) [2–4]. A test and treat strategy

may be appropriate if the carrier state can be cleared with treatment (anaplasmosis, leptospirosis). If an effective treatment exists to clear a carrier state, but testing or diagnosis lacks sensitivity or exceeds the cost of testing, prophylactic treatment of an entire population may be an appropriate biosecurity strategy (anaplasmosis, BRD). For disease with no easily defined carrier state or for which accurate tests are not available, vaccination should be considered as a primary biosecurity tool if vaccination will result in an increased percentage of animal resistant to infection or a decreased likelihood of transmission of the agent (IBR). Vaccination can be an adjunct biosecurity measure for diseases that have an accurate test used for test and cull as long as vaccination does not interfere with interpretation of the test. For some diseases that lack either a defined carrier or an accurate diagnostic testing strategy, management intervention to decrease the probability of effective contact is the primary

biosecurity intervention strategy (Johne's). Biosecurity for almost all diseases are enhanced by management strategies to reduce the likelihood of transmission and to decrease events that lead to immunosuppression.

2.4. Environmental factors

A cattle population's environment includes its housing type, animal density, air quality, weather effects, mud, dust, footing, and health antagonists such as internal parasite burden, external parasite burden, and social stress. These environmental factors influence the innate immunity of a herd by their impact on immunosuppression.

In addition to effects on immunosuppression, a herd's environment also dictates the "animal flow" or contact and mixing patterns of potentially infectious and susceptible animals. Some infectious agents preferentially infect only certain ages of cattle. *Mycobacterium avium* subspecies *paratuberculosis* (Johne's) is primarily infectious to young animals, whereas *Trichomonas fetus* (Trichomoniasis) is primarily infectious to older bulls. Some infectious agents will infect all ages of cattle, but are only likely to cause disease in certain ages. Rotavirus and coronavirus infections are likely to cause clinical disease (calf scours) in young calves, but not in adults. In contrast, initial infection with the parasite

Anaplasma marginale (anaplasmosis) is not likely to cause clinical disease in young animals, but will cause disease in adult animals.

3. Conclusion

The future of food animal veterinary medicine will involve a greater emphasis on biosecurity to implement and monitor systems to prevent the introduction and spread of common livestock diseases. Cattle farms will increase the use of testing and isolation systems, as well other biosecurity strategies to minimize the costs of disease to production. With an increased level of sophistication and knowledge necessary to implement these systems, veterinary involvement in food production will continue to increase.

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