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Biosecurity and biocontainment in alpaca operations☆

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Abstract

Biosecurity on South American camelid operations involves both external and internal measures to prevent the introduction and spread of disease. External biosecurity involves practices and techniques directed at the prevention of entry of new diseases into a group of animals. Internal biosecurity or biocontainment, involves practices and techniques that are directed at the prevention or spread of disease within an existing group of animals. External biosecurity is particularly important in North America camelid operations due to the extensive movement of animals for breeding or show purposes. Internal biosecurity typically involves this the prevention and treatment of failure of passive transfer, maintenance of proper nutrition and housing, and the implementation of an appropriate vaccination program for endemic or relevant diseases. Attention to appropriate cleaning and disinfection procedures related to housing, feeding, and treatment equipment is important for the maintenance of both internal and external biosecurity practices. This paper discusses various risk factors associated with the control of infectious disease in the context of external and internal biosecurity measures in camelids operations.

Keywords: Biosecurity; Biocontainment; Alpaca

1. Introduction

Over the last decade, the concept of 'biosecurity' has been the subject of many scientific papers and lay-press articles devoted to various animal production systems. The concept of biosecurity is not new, however it is likely that renewed awareness has been accelerated by several factors. Recent international events such as the outbreak of foot and mouth Disease (FMD) in the United Kingdom and Bovine Spongiform Encephalopathy (BSE, mad cow disease) in Europe and US has demonstrated vulnerability of national animal resources. The potential risk of agri-terrorism has also helped spur global interest in biosecurity. Notwithstanding these events, biosecurity in the alpaca industry is, and will be, primarily driven by breeders and veterinarians in order to optimize the care and production of alpacas.

Biosecurity can be defined as those efforts designed to prevent the introduction and spread of disease in a

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population, herd, or group of animals (Thomson, 1999). These efforts can be further categorized into external measures (external biosecurity), those directed at prevention of entry of new diseases into a group; internal measures (internal biosecurity, biocontainment), those directed at prevention of spread of disease within a group (Dargatz et al., 2002). Therefore, biosecurity can be implemented at various levels, from those involving specific farms to governmental regulationzs involving importation of animals. To be valid, the minimum biosecurity plan should address: (1) the means of isolating new animals introduced into an existing herd or group of animals, (2) the regulation of animal, worker and equipment trafficking (movement), and (3) the design and implementation of cleaning and disinfection procedures directed at the reduction of pathogen load within a herd or group of animals.

The goal of this paper is to review the tenets of biosecurity as it pertains to the alpaca industry. Though comprehensive coverage will neither be claimed nor attempted, it is hoped that it will serve as source for continued discussion and review.

2. General principals

Recent technologic advances in vaccinology, therapeutic agents, and diagnostic testing have greatly improved our ability to control disease. Yet, overdependence on these technologies may have inadvertently fostered a level of indifference to more traditional management components involved in disease control, namely biosecurity (Anderson, 1998). Many examples exist whereby in the face of an outbreak, both producers and veterinarians rapidly seek the development of a new vaccine rather than address basic principals of internal and external biosecurity. Ideally, management should strive to incorporate and coordinate a spectrum of available tools, from the execution of optimal husbandry practices to the implementation of modern technologies.

Biosecurity efforts should be prioritized to address factors which pose the greatest risk of disease introduction. Regardless of the species of animal, the most common means by which contagious diseases are introduced to a herd involves the introduction of new animals. Clearly, introduction of new animals displaying any clinical signs of disease should be avoided. Moreover, producers must realize that the mere exclusion of clinically affected animals is insufficient for preventing disease introduction. Animals that appear to be clinically normal can be either incubating disease or be subclinically affected. In fact, it is well documented that within most populations of animals, only a fraction of animals typically exhibit clinical disease, whereas a larger proportion are subclinically affected. Consequently, appropriate and effective efforts in biosecurity must focus on the entire population of animals, rather than prioritize only those clinically affected.

3. External biosecurity

Several animal industries have developed and adopted comprehensive biosecurity programs (poultry, swine, dairy, etc.). While not all of the characteristics of these existing programs may be relevant for alpaca herds, some may be very worthwhile considering.

Fundamental issues concerning external biosecurity include the isolation of new animals, quarantine procedures, disease testing, preventative measures, and hygiene. As previously mentioned, the most prevalent means of introducing disease into a group of animals is via the addition of new animals to the herd. It is important to realize the breadth of the concept of this "new animal" (or animals). Acquisition of an animal which has never resided on a farm is inherently seen as new. However, the concept of a new animal should also include the reintroduction of those which have been temporarily residing at other facilities. When animals are commingled at breeding farms or shows, there is an increased risk of disease transmission. Importantly, transfer of certain agents does not necessarily require direct contact between animals. Some pathogens are efficiently transmitted in the air or water, some can survive in soil or organic debris for extended periods (weeks to months), and some are efficiently transmitted via fomites (equipment, tack, etc.), pests (flies, rodents, etc.), or personnel (Barrington et al., 2002).

To lessen the risk of disease introduction by new animals, it is important that buyers are knowledgeable concerning the health status of the new animal's herd of origin (or the herd where animals are temporarily housed). This is most efficiently accomplished when open communication and trust exists between the buying and selling parties. Buyers should not only be knowledgeable about the current health status of the herd of origin, but also seek historical information concerning past diseases or conditions within the herd. Specific conditions to inquire about might include respiratory diseases, gastro-intestinal conditions (diarrhea, etc.), ill thrift, failure of passive transfer, abortion, and other herd-based disease. In addition to seeking historical information concerning disease occurrence, buyers should also be knowledgeable concerning fundamental biosecurity practices of the herd of origin. Questions regarding animal movement, quarantine practices, disease testing, vaccination practices, de-worming schedules, and other herd health practices should be asked. Finally, it is rational to suggest that prospective buyers minimize the number of source-herds from which newly acquired animals are purchased.

Acquisition of alpacas during public sales, show, or auctions deserves a special comment. Typically such events include the commingling of numerous animals from different sources. Many animals have traveled long distances and have been housed for varying periods of time. Upon arrival, changes in environment can serve as a source of stress for animals. Some changes might include new footing/bedding, different temperatures/humidity/ventilation, variation in lighting, different water or feed source, and different personnel. Thus, it is reasonable to assume that significant risk of disease exists in these settings, despite the fact that animals attending such events typically have been examined and deemed to be healthy on health certificates. The stresses of travel, commingling, and environmental changes may exacerbate latent disease conditions resulting in the onset of clinical disease, or at least the shedding of organisms that went unnoticed during the time of veterinary inspection.

Newly purchased animals or animals returning from events where commingling has occurred (breeding farms, shows, etc.) should be placed in quarantine for a minimum of 30 days. To be effective, quarantine facilities must be physically separate from the main herd, its handling facilities and housing. Though a defined distance of separation is difficult to define, it is rational to state that the farther the separation of the quarantine facility, the better. Ideally, the quarantined animals should be housed several hundred yards away and positioned such that prevailing winds or surface drainage do not carry aerosols or contamination toward the main herd. Lastly, it is prudent to locate isolation facilities such that access is difficult or impractical by personnel attending the main herd or unauthorized personnel.

Animals in quarantine should be monitored on a daily basis. Basic parameters should include attitude, activity, appetite, water consumption, urination, and defecation. Furthermore, owners should be instructed regarding potential signs of disease such as nasal or ocular discharge, coughing, changes in stool, decreased activity, etc. Periodic recording of body temperature can be recommended, however the temperatures should be obtained during the same time of day. If any animal shows signs of disease, it should be further separated from other quarantined animals and examined by a veterinarian. If multiple animals are placed in an isolation facility concurrently, it is important that all animals leaving the facility do so at the same time (all in, all out). The animal last placed in quarantine will dictate the time whereby all other animals are allowed to leave.

Personnel attending quarantined animals should always don protective clothing (coveralls, etc.) and boots or shoe covers that are devoted solely to the quarantine facility. Clothing and boots should be washable and boots or shoe covers should be made of rubber or other impervious materials. All other equipment and supplies used in a quarantine facility (halters, ropes, blankets, feeders, buckets, etc.) must be solely devoted to the facility. Ideally, personnel working with quarantined animals should have minimal or no contact with the main herd. If separate personnel are not available, quarantined animals should be worked with only after animals in the main herd have been attended to.

Disease testing (serology, fecal culture, fecal egg quantification, etc.) can be accomplished during the period of isolation. A quarantine period of at least 15 days should allow adequate time for the return and evaluation of test data. Preventative measures (de-worming, vaccination) can also be accomplished during the quarantine period.

The potential for disease transmission by visitors and personnel should not be underestimated. Owners should be educated regarding this risk and advised in order to minimize exposure. Ideally, visitor contact with herd animals should be discouraged if not prohibited. However, if visitor contact is allowed, herd managers/owners should obtain the recent background of visitors, especially with regards to contact with alpacas or other domestic livestock. Visitors should arrive in clean clothing and be provided with clean coveralls and boots if the visit requires interaction in close proximity to animals. Protective clothing items can be recovered or disposed of at the conclusion of the visit and the visitors should have access to an area to wash hands. Access to a herd by the general public should be disallowed.

The practice of exporting alpacas to breeding farms warrants further mention since this practice is common within the industry. Without doubt, all of the comments mentioned above should be adhered to since animals returning from these farms are essentially equivalent to a newly imported animal. Furthermore, an argument for more stringent devotion to the guidelines is rational since breeding farms typically mimic a sale-type situation. Without a doubt, commingling of numerous animals from varying backgrounds, including mature females and their nursing crias, carries an extremely high risk for exposing these animals to infectious diseases. Younger animals are typically more immunologically naïve than mature animals, thus more susceptible to infection and disease. Diseased animals often shed substantial numbers of pathogens, often placing even immunologically competent animals at risk.

Other animal species may function as mechanical or biologic vectors of infectious agents. Domestic pets, and vermin (insects, rodents, birds) can be of particular importance, especially if present in high numbers.

An often overlooked vector which presents a significant disease transmission risk is the common house fly, *Musca domestica* (Graczyk et al., 2001). These insects have physical characteristics (mouth parts, hairs, sticky foot pads) and activities (defecation, vomiting) which greatly enhance their ability to transmit large numbers of pathogens. Under the right conditions, flies can harbor certain pathogens (e.g. *Cryptosporidium parvum*) for up to 3 weeks (Graczyk et al., 2000). Numerous methods have been described for controlling flies during different points in their life cycle, including the use of various chemical agents. In addition to chemical means, control must also include the removal of feces and wet organic debris, since fly larvae require the appropriate substrates and levels of humidity (>90%).

Rodents are often overlooked as sources of disease transmission. In dairy, beef, and poultry operations, mice have been implicated in the transmission of salmonellosis (Davies and Wray, 1995; Henzler and Opitz, 1992; Hunter et al., 1976; Tablante and Lane, 1989). Mice are also significant reservoirs of *Cryptosporidium*. Importantly, significant numbers of rodents can be present long before their signs (feces) become noticeable.

4. Internal biosecurity

Many risk factors are potentially associated with both the occurrence and propagation of disease within a herd. These factors can be categorized into those that are related to either the host animal(s), the environment, or the infectious agent. Recognition of the presence of specific risk factors on a farm, followed by correct interpretation of the relative significance of each factor, is necessary for the implementation and coordination of specific biosecurity practices to mitigate potential problems of disease.

4.1. Risk factors associated with the host animal

The occurrence of developmental, congenital, or heritable abnormalities in a cria can act as a risk factor for disease depending on the location and degree of the defect. Any abnormality that prevents a cria from behaving normally (nursing, ambulating, etc.) will likely increase the risk of disease.

Failure of passive transfer (FPT) of maternal immunity is a major risk factor for the development of neonatal disease, principally neonatal diarrhea (Barrington et al., 1999). To obtain adequate passive transfer of immunity, crias must consume and absorb an adequate mass of colostral immunoglobulin in a timely manner. In general, alpaca colostrum contains a relatively high concentration of immunoglobulin, therefore FPT rarely occurs as a result of poor colostrum quality. Instead, FPT in crias generally results from a failure to nurse appropriately within the first hours of life. Factors associated with a cria that is unable to nurse include neonatal maladjustment (hypoxia at parturition), cleft palate, choanal atresia, fractures or other causes that limit mobility or nursing. Hypothermia or mis-adventure could result if a cria is born unsupervised or at pasture. Maternal factors associated FPT in crias include mis-mothering, teat or udder abnormalities, agalactia, or conditions causing recumbency of the dam. While the degree of intervention deemed necessary during and after parturition is debatable, at the least owners should be instructed to visually monitor the birthing process and initial nursing activity.

In both neonates and mature animals, the general nutritional status within a herd can influence the occurrence of disease. Under-conditioned or mal-nourished animals are more prone to infectious diseases since metabolic demands required for appropriate immunity may be compromised. The thick fiber coat of alpacas can easily mask a loss of condition. Owners should be instructed to routinely weigh their animals, or alternatively be instructed in methods of palpation to determine body condition scores. Once animals are determined to be thin or loosing body condition, owners should be assisted in determining the cause of the weight loss. In contrast to the problem of underfeeding or thin body-conditioned animals, overfeeding of alpacas is typically a more frequent occurrence. Obese animals are more likely to be infertile and develop hyperthermia. Over-conditioning of animals may also exacerbate primary diseases, both non-infectious and infectious. For example, over conditioned animal run the risk of developing hepatic lipidosis as a complication to many systemic primary diseases.

Dietary deficiencies or excesses can include factors other than protein or energy. Inappropriate levels of macronutrients (calcium, phosphorous), trace minerals (cobalt, copper, selenium, zinc, iodine, iron) or vitamins (B complex, A, D, E, K) can result in either primary disease or exacerbation of secondary disease states (Pugh et al., 1999). Finally, alpacas should always be provided access to unlimited consumption of clean water. This is especially important in areas with high ambient temperatures combined with high relative humidity.

4.2. Risk factors associated with the infectious agent

The primary risk factors associated with infectious agents include specific virulence factors, the size of the inoculum or pathogen load, and whether single or multiple infections exist (Barrington et al., 2002).

Virulence factors typically include mechanisms that enhance pathogen survival, attachment or invasion, or drug resistance. In general, the effect of such virulence mechanisms as they relate to alpacas is similar to those of other domestic livestock. For example, exposure of crias to entero-invasive strains of *E. coli* is more likely to result in bacteremia or sepsis. Exposure to multiple-drug resistant strains of *Salmonella* spp. may result in a herd outbreak of disease. Table 1 lists disease agents which have been identified in alpacas.

Table 1
Disease agents of alpacas

Bacteria
Streptococcus zooepidemicus
Mycobacterium avium subsp. *Paratuberculosis*
Hemoplasmas (hemotropic mycoplasmas)
Salmonella spp.
Leptospirosis spp.
Mycobacterium tuberculosis
Brucella abortus
Viruses
Contagious echthyma (Orf)
Equine herpes virus 1
Bovine viral diarrhea virus
Rotavirus
Coronavirus
Bluetongue virus
Foot and mouth disease virus
Parainfluenza virus-3
Respiratory syncitial virus
Vesicular stomatitis virus
West Nile virus
Rabies
Protozoa
Coccidia
Giardia
Cryptosporidium
Parasites
HOT complex
Trichuris
Liver flukes
Mites
Lice
Paralaphostrongylus tenuis

While alpacas are known to suffer diseases similar to other domestic livestock, the matter of vaccinating alpacas for these diseases can generate much debate. Despite the fact that no vaccines have been approved for use in camelids in the United States, it is obvious that many are used in an extra-label fashion. Importantly, extra-label use carries no assurance of efficacy or safety. Therefore, the basic foundation for immunizing alpacas is rather limited and includes immunization with *C. perfringens* type C and D toxoid, and *C. tetani* toxoid. A killed rabies vaccine and a leptospirosis bacterin can be used if either disease is endemic. While several other vaccines have been administered to alpacas, it is advisable that any modified-live virus vaccine or live bacterin be used with extreme caution in an extra label manner. Finally, no legitimate scientific information exists concerning the timing of vaccinating alpacas. In general, similar schedules to other domestic livestock are used with alpacas.

A unique risk factor for disease in alpacas appears to be exposure to *Streptococcus equi*. subsp. *zooepidemicus.* The organism was first associated with a condition known as "alpaca fever" in Peru and has since been implicated as an important primary pathogen in North America (Cebra, 1999; Fowler, 1998). Alpaca fever may occur in either acute, subacute, or chronic forms with high fever and anorexia usually present in the acute and subacute manifestations. Systemic infection, usually involving the lungs or serosal surfaces of the thoracic or abdominal cavities, can follow ingestion of the organism and death may occur within 4–8 days of the onset of clinical signs. While the origin of the organism is often not determined, it is possible that exposure of alpacas to carrier-horses or other species may be an important risk factor.

4.3. Risk factors associated with the environment

Prior to domestication, alpacas and other New World Camelids evolved on low population density, wide-open grazing areas in the Andean Mountains. In this setting, the risk of pathogen introduction or propagation was low, direct contact between animals was minimized and exposure of pathogens to unfavorable environmental conditions was maximized.

Today, it is now common for alpacas to reside in environments that vary from lower-population density pasture settings, to high-population density dry-lots with enclosures, barns, etc. Fortunately, risk factors associated with the environment are often most amenable to the implementation of specific biosecurity measures. Specific risk factors include atmospheric conditions (temperature, humidity, ventilation, etc.); housing (barns, pastures, etc.); physical environment (bedding, animal exposure, cleaning and dis-infection, etc.); general hygiene and hygiene related to feeding practices; miscellaneous stresses such as transportation, handling, etc.

While it is obviously not possible to alter general atmospheric conditions, management changes can be implemented which improve animal comfort. In cold climates or seasons, animals should be provided adequate bedding and shelter from excessive moisture and wind. Ad libitum access to a diet with adequate energy density and protein content should be provided. To maintain appropriate hydration, animals should be allowed free access to water sources that do not freeze. In hot and/or humid climates such as the South-East and Western United States, heat stress is widely recognized. Prevention of heat stress should center on management changes that facilitates cooling (Middleton and Parish, 1999). Shearing practices should be adjusted to coincide with seasons of high environmental temperature. Alpacas should always have access to sufficient shade, and ideally be housed with damp, sandy soils which facilitate thermoregulation when animals lie in ventral recumbency. Sprinklers that spray on the animal's ventrum, or wading ponds can be used. Provision of adequate clean, fresh drinking water is essential. In severe conditions, air-conditioned stalls may be necessary. Importantly, any time animals are housed in confined areas (either during hot or cold weather), attention must be paid to provide adequate ventilation. As a general rule of thumb, if the individual inspecting a facility is not reasonably comfortable because of excessive moisture, odors, wind chill, etc., it should be concluded that the animals will not be comfortable.

Alpacas are generally clean and fastidious animals. Frequent manure removal and provision of well drained soils or bedding material will aide in minimizing pathogen build up. Feeding practices, centered on preventing contamination with fecal material, should include the use of hay bunks or raised mangers. Water systems should also be designed to prevent fecal contamination. Lastly, contamination of feeds or water by rodents or other animals (cats, dogs, etc.) should be considered.

Other miscellaneous activities or stresses may be considered to be an element of the environmental risk factors. Handling, holding, and transportation facilities should be designed and managed to alleviate undue tension or distress. Appropriate ventilation, temperature and footing should be considered. When appropriate, animals should have access to fresh water and feed.

5. General cleaning and disinfection

Appropriate cleaning and disinfection is critical to breaking transmission cycles of disease agents that contaminate housing, feeding, and treatment equipment, or other vectors or fomites. Personal hygiene of animal handlers is also crucial to stopping the transmission of pathogens from animal to animal, or even from animal to humans. Personal hygiene should include frequent hand washing with hot water and soap, cleaning and disinfection of boots, and thorough washing of clothing with the use of bleach.

The most important first step to cleaning involves the thorough removal of all organic debris (feces, urine, milk, sputum, etc.), be it from a workers' hands and clothes, feeding equipment, or a physical area (pen or stall). Vigorous cleaning must precede the application of disinfectants in order for these substances to attain maximum effect.

Numerous products are available for disinfection of equipment or premises. In addition to their chemical characteristics, other variables will determine the effectiveness of each product. These include the product concentration, contact time, temperature, pH, water content, water hardness, and the amount of organic debris present. Sodium hypochlorite (bleach, NaOCl) is readily available as a 5.25% solution (household bleach) and is both cost effective and environmentally safe. At sufficient concentrations, contact time, and temperature it is effective against most bacterial and viral pathogens, though not all (e.g. *Cryptosporidium* oocysts). Recommended concentrations of sodium hypochlorite for use in human environments range from 500 ppm (1:100 dilution) and 10 min contact time at room temperature to 5000 ppm (1:10 dilution) and 1 min contact time at room temperature, the higher concentrations being used in more critical areas (Barrington et al., 2002). For viruses in veterinary hospitals, a 0.175% solution (1:32 dilution) and a 10-min contact time at room temperature, has been recommended (Scott, 1980).

The characteristics of environmental surfaces in farm equipment will influence the success or failure of a cleaning and disinfection protocol (Morgan-Jones, 1981). For example, unfinished plywood retains approximately 15-fold more microorganisms than painted or varnished plywood. Yet, varnished plywood retains approximately 115-fold more microorganisms than plastic surfaces. On smooth impervious surfaces such as metal or plastic, washing with soap and water to remove visible contamination results in the elimination of approximately 99% of the microbial load. Similar washing of typical household surfaces removes approximately 90% of the microbial load and it is reasonable to presume that washing of rough lumber will remove even less organisms. Application of this knowledge can be used to recommend cleaning and disinfection protocols, as well as construction plans of facilities or acquisition of equipment. Finally, knowledge of pathogen survival on various substrates may be useful in the investigation and management of disease outbreaks.

6. Biosecurity and reproductive biotechnologies

Although still not accepted by breed registries in North America and some European countries, biotechnologies such as in vitro embryo production, embryo transfer and artificial insemination with preserved semen are used in some countries. The potential for transmission of pathogens by semen (Guerin and Pozzi, 2005; Wentink et al., 2000) and embryos produced in vivo (Stringfellow and Givens, 2000) or in vitro (Bielanski, 1997) is well established in other agricultural animals. There are no studies on the potential of common disease causing microorganisms to be transmitted by semen. In other species, the International Animal Health Code of the Office of International des Epizooties (OIE) provides detailed recommendations for the collection, handling and processing of embryos destined for international exchanges, in order to minimize risk of disease transmission (Stringfellow and Givens, 2000).

Embryos enter the uterus in the hatched blastocyst stage which may represent a danger of disease transmission. The lack of a zona pellucida facilitates contamination and make adhesion of the microorganisms to the trophoblastic cells relatively easy. In addition, the washing or trypsin treatment recommended by the International Embryo Transfer Society (IETS) for ruminant embryos may not be adequate for camelid embryos.

The risk of transmission of viruses (foot and mouth disease, vesicular stomatitis, bluetongue) and bacteria (*Brucella abortus*, *Mycobacterium tuberculosis*) by the camelid embryo has been assessed by computer simulation (Sutmoller, 1999). The risk of transmission seems to be low, however more in vivo data is needed.

7. Conclusion

Biosecurity is a concept that encompasses a large number of activities and events which strive to minimize the introduction and spread of disease within a population of animals. The basic principals include a thorough knowledge of the health status of any incoming or returning animals, the application of appropriate quarantine procedures and animal trafficking, employment of proper hygiene, diagnostic procedures, and preventative medical practices.

In general, the alpaca industry is amenable to incorporation of many of the biosecurity practices currently in place in other animal industries. Furthermore, the high value of the animals in combination with the progressive, well-informed nature of most owners suggests that the industry could excel in areas of biosecurity. The sharing of health information between buyers and sellers could prevent the spread of contagious diseases. Acceptance and employment of proper hygiene and cleaning techniques would aid in blocking the transmission of diseases within a herd. One potentially underutilized practice appears to be that of quarantining newly purchased animals, or animals returning from breeding farms or shows. Quarantine facilities and all supplies and equipment should be physically separate from the main farm. Animals must be monitored, however, personnel should be kept separated and cross tracking of equipment, supplies or human contact should be minimized.

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