BIOEXCLUSION PLANS – THEORETICAL AND PRACTICAL ASPECTS FOR VETERINARY PRACTITIONERS.

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RESUMO

Bioexclusion relates to preventive measures designed to avoid the introduction of pathogenic infections into herds. The introduction of infectious agents into dairy and beef farms may be either through direct (purchased cattle, reintroduced resident cattle and contact with contiguous cattle) or indirect (fomites, visitors, other species, and biological materials) transmission routes. In this paper, the evidence supporting these transmission routes for the introduction of infectious diseases is presented. In addition newly developed practical guidelines which may be used by veterinary practitioners to draw up farm-specific Bioexclusion Plans are detailed.

INTRODUCAO

BIOSECURITY has been defined as a strategy of management practices to prevent the introduction of disease and pathogens to an operation and to control spread within the operation. Biosecurity is comprised of two components, bioexclusion and biocontainment. BIOEXCLUSION relates to preventive measures (risk reduction strategies) designed to avoid the introduction of pathogenic infections (hazards), whereas BIOCONTAINMENT relates to measures to limit within-farm transmission of infectious hazards and onward spread to other farms.

Currently there is a lack of consensus internationally in the published literature regarding bioexclusion protocols, their efficacy and their cost-effectiveness. These barriers may explain the slow adoption of such practices by many farmers (Sayers et al., 2012). This gap was recently identified by Animal Health Ireland (AHI) as a key task which needed addressing prior to the development of farmer guidelines on biosecurity. AHI is a not-for-profit, partnership-based organisation providing national leadership and coordination of non-regulatory animal health issues in Ireland (More et al., 2011).

Hence, the objective of this paper is to examine the existing scientific literature on bioexclusion in dairy and beef cattle enterprises; this formed the basis of a recently published review (Mee et al., 2012). In addition current best practice is summarised based on that review; this has been developed into a series of information leaflets providing practical guidelines suitable for veterinary practitioners to develop Bioexclusion Plans (Mee, 2013).

Bioexclusion risks and best practice responses

The introduction of infectious agents into farms may be either through direct (purchased cattle, reintroduced resident cattle and contact with contiguous cattle) or indirect (fomites, visitors, other species, and biological materials) transmission routes (see AHI leaflet: **Understanding Infectious Diseases**; www.animalhealthireland.ie). Each of these is detailed hereunder.

Purchased (and hired) cattle

Purchase of cattle, where incoming stock remains in direct contact with the recipient herd for an extended period of time, presents the highest risk for introducing infectious hazards. Farming practices such as hiring a bull and returning it after the breeding season significantly increase the risk of entry of venereally-transmitted infections such as BVD, IBR and leptospirosis. The asymmetry of

information between vendor and purchaser about vendor herd health status may result in cattle for sale, particularly in markets, having a higher prevalence of disease than in the general cattle population.

Bluetongue virus

Purchase of pregnant heifers from bluetongue restriction zones resulted in the introduction of virus (BTV-8) during the midge-free season through transplacental and contact transmission into an expanding naïve dairy herd in Northern Ireland, a BTV-8-free region (Menzies et al., 2008). Subsequent Dutch work confirmed a role for vertical transmission in the epidemiology of BTV-8 in cattle (Santman-Berends et al., 2010).

Bovine herpes virus-1 (BHV-1)

While cattle purchase is an important risk factor for the introduction of BHV-1 (van Schaik et al., 2002), interactions with herd size (purchase risk only detected for small herds and herd type (strong association for dairy herds and a weak association for mixed herds, Van Wuijckhuise et al., 1998) have been shown.

Bovine respiratory syncytial virus

Seroconversion and severe outbreaks of respiratory disease in isolated dairy herds caused by bovine respiratory syncytial virus have been associated with the purchase of new animals (Elvander, 1996). Imported cattle were linked to the introduction and consequent outbreaks of BRSV in multiple Norwegian cattle herds in 1995 (Uttenthal er at., 1996).

Bovine viral diarrhoea virus (BVDv)

A well documented way of introducing bovine viral diarrhoea virus into a herd is purchase of transiently or persistently infected cattle (Valle et al., 1999), or of a dam ('Trojan cow') carrying a persistently infected (PI) foetus (Lindberg and Houe, 2005). Larger herds are at particular risk of BVDv introduction as they are more likely to be open (Bishop et al., 2010).

Digital dermatitis

Digital dermatitis increases markedly in incidence in expanding dairy herds (Faust et al., 2001), especially after restocking (Holliman 2003). Rodriguez-Lainz et al. (1999) showed that farms which purchased heifers had a significantly higher prevalence of digital dermatitis than farms which did not and that there was a positive association between the risk of digital dermatitis and the number of heifers purchased.

Mycobacterium avium subspecies *paratuberculosis*

Purchase of bulls or purchase of a large numbers of breeding females (Wells, 2000), has been strongly associated with higher seroprevalence (van Winden et al., 2005) and clinical incidence (Norton et al., 2009) of Johne's disease in dairy herds**.** Restocking after herd depopulation and importation of animals have also been associated with Johne's disease (Richardson et al., 2009; Barrett et al., 2011).

Mycobacterium bovis

Herd breakdowns due to bovine tuberculosis (bTB) have been found to be strongly associated with cattle movements (Gilbert et al., 2005). Purchase of stock, in particular from markets, has also been significantly associated with the risk of bTB breakdown on farm, even in areas endemic with bTB (Ramírez-Villaescusa et al., 2010).

Leptospira spp.

Animal purchase has been identified as a significant risk factor for herd seropositivity to *Leptospira interrogans* serovar *hardjo,* specifically, (van Schaik et al., 2002) and for any *Leptospira* serovar (Oliveira et al., 2010). The appearance of leptospirosis as a clinical problem has recently been attributed to importation of cattle from high seroprevalence countries (Jones, 2011).

Mastitis

New herd infections caused by transmission of contagious mastitis pathogens between herds, both nationally and internationally has been associated with recent purchase of heifers or cows, for example, following restocking after a disease outbreak (Olde Riekerink et al., 2010). In addition, high numbers of cattle introductions have been associated with a higher incidence of subclinical mastitis and higher bulk milk somatic cell count (Brouwer et al., 2010).

Mycoplasma bovis

The risk of *Mycoplasma bovis* culture-positive bulk milk (Passchyn et al., 2012) and seropositivity in adults (Burnens et al., 1999), as well as clinical disease (both lameness and respiratory disease) in weanlings (Byrne et al., 2001) and in adults, have each clearly been shown to be associated with purchase of cattle.

Mycotic dermatitis

Ringworm (mycotic dermatitis) has been reported as a particular problem in imported naïve heifers contracting infection following purchase (Holliman, 2003). Papini et al. (2009) reported that

prevalence rates of *Trichophyton verrucosum* were also higher when the cattle present in the farm were of mixed origin, rather than when the whole stock was purchased or was born in the farm.

Neospora caninum

Between-herd movement of *Neospora caninum*-infected cattle significantly enhances the spread of *N. caninum*, particularly into low seroprevalence herds after restocking following a disease outbreak (Woodbine, et al., 2008). Furthermore, Holliman (2003) described several *N. caninum* abortion outbreaks which followed the purchase of pregnant cattle.

Salmonella spp.

Farmers who purchase cattle (asymptomatic latent carriers or persistent excretor calves or adults) are significantly more likely to introduce *Salmonella* spp. into their dairy herds (van Winden et al., 2005; Bergevoet et al., 2009), particularly where the purchase is recent and from dealers (Evans, 1996).

Risk reduction strategies

Maintaining a closed herd is the most important biosecurity measure as it eliminates infection risk from purchased cattle. However, even specific pathogen-free and closed herds experience disease breakdowns (van Schaik et al., 2002), reflecting the important role of other transmission routes. Furthermore, self-containment is not always practical where herds are expanding as currently prior to the abolition of the EU milk quota regime in 2015. Hence alternative risk reduction strategies (pre-movement, movement and post-movement) have been proposed (see AHI leaflet: **Purchasing Stock: Reducing Infectious Disease Risks When Buying in Stock**; www.animalhealthireland.ie).

Pre-movement risk reduction strategies

a. Minimise the number of cattle purchased and the number of source herds

Reducing the number of animals purchased will reduce the risk of introduction of infectious agents. Reducing the number of herds from which these animals are purchased will reduce the risk of selecting an animal from a high disease prevalence herd. Purchases from markets or dealers present a very high biosecurity risk.

b. Purchase cattle which have not previously bred

Purchasing non-pregnant animals reduces the risk of transmission of infection from an infected foetus, such as can occur with BVDv. Venereal diseases are more likely to be spread by animals which have been bred; Sanderson et al., (2000) reported that using non-virgin bulls were associated with an increased risk of both trichomoniasis and campylobacteriosis.

c. Purchase from herds with likely low disease prevalence

Herds which are likely to have lower likely disease prevalence include:

- Certified disease-free herds. The risk of introducing specific diseases can be greatly reduced by purchasing stock from certified disease-free source herds or high health status markets.
- Closed herds. As discussed above one key factor associated with increased disease prevalence is having an open rather than a closed herd.
- Smaller herds. For many diseases seroprevalence in cattle has been found to be proportionate to the size of the source population (Ortiz-Pelaez and Pfeiffer, 2008).

d. Obtain cattle disease history

Such information may include a vendor or veterinary declaration of clinical disease incidence, medication and vaccine usage and previous laboratory results from the source herd. Bergevoet et al. (2009) concluded that dairy herds could economically prevent the introduction of *Salmonella* spp. by excluding animals based on bulk milk antibody results. For diseases with long incubation periods (e.g. Johne's disease), pro-active assurances of freedom from clinical disease for three years or more is recommended (Pritchard, 1996).

e. Clinically examine the cattle for sale

While a clinical examination by the purchaser or their veterinary practitioner will not detect asymptomatic carrier animals, and the sensitivity of such examinations is variable, it is recommended for detection of the clinically obvious infectious disease. The examination may include cow-side examinations such as rectal temperature, body condition score, CMT test, and udder, gait and reproductive examinations. However, such examinations applied singly have low sensitivity (Barkema et al., 2009), though for some diseases, e.g. digital dermatitis, clinical examination is the only available diagnostic modality.

f. Quarantine cattle before movement

Quarantine has been defined as the isolation of cattle in an area that prevents direct contact with other livestock or the possibility of cross-contamination of animal waste. Commonly 4 weeks is advised to cover the period of greatest risk of clinical disease after purchase, e.g. salmonellosis. Quarantine prior to sampling will improve the value of pre-purchase test results by allowing detectable seroconversion to an exposure that occurred immediately prior to quarantine. In addition, quarantine reduces the risk of post sampling infection on the farm of the vendor, and facilitates multiple observations and examinations.

g. Test cattle before movement

Laboratory testing prior to animal introduction is commonly recommended for many infectious diseases and can greatly enhance the sensitivity of detecting an infectious animal and therefore reduce risk. In general, the consequences of a false negative far outweigh those of a false positive; sensitivity should be favoured over specificity for pre-introduction tests. Test insensitivity, especially in young animals, is a problem with Johne's disease detection but also in non-clinical adults where the probability of non-detection increases with the number of cattle purchased and greater prevalence. Pre-movement testing is not equally successful for all diseases, being proportionally less successful in BVD, IBR, Johne's disease and salmonellosis, in descending order (van Winden et al., 2005).

h. Medicate cattle before movement

In some cases, targeted medication can eliminate carrier status or reduce the probability of a carrier becoming infective. Treatment with parenteral antibiotic, anthelmintic and flukicide, antibiotic foot-bathing and vaccination has been recommended (Bazeley, 2009), but may have a minimal effect depending on the disease (van Winden et al., 2005). Vaccination courses should be completed at least 2 weeks before release from quarantine. Vaccination of resident cattle at the same time is also important as this can significantly reduce the risk of disease transmission.

The strategies discussed above are discussed in the order which they are applied. However, if we were to rank the strategies in order of their likely impact our order would be: information on the disease and biosecurity status of the source herd; the number and history of the individuals purchased; pre-introduction testing; quarantine and medication.

Movement risk reduction strategies

The movement process itself may be targeted to reduce the risk of infection transmission by (1) loading and unloading animals at the perimeter of the farms, (2) not mixing animals from different sources in the transport vehicle, (3) transporting purchased cattle in the purchaser's vehicle and (4) minimising transport distances and other stressors such as overcrowding**.**

Post-movement risk reduction strategies

Quarantine, testing and medication have been discussed above as pre-movement strategies, but all may also be applied at the recipient farm (post movement). This may reduce infection spread from stressed, clinically affected animals breaking down within weeks of movement. It is particularly important to prevent contact with breeding animals, e.g. BVDv. Pregnant cattle should be group-segregated and isolated until calved (O'Farrell et al., 2001). Testing of the progeny of females purchased while pregnant can detect infectious agents transmitted transplacentally, e,g, BVDv and *Neospora*.

Reintroduced resident cattle

Reintroduction of cattle returning from out-farms, common pastures, common accommodation, contract rearer accommodation, agricultural shows and marts or sales presents a risk of introducing infection. As they are not new additions to the herd, they are often not viewed as a threat to the resident herd disease status.

Co-grazing cattle with cattle from other herds is a significant risk factor for introduction of BHV-1, BVDv, *Leptospira hardjo* and *Salmonella spp.* to the resident herd. Co-grazing with sheep and

goats constitutes a risk for BVD, Johne's disease and leptospirosis (Caldow, 2004). Sharing of cattle housing where cattle from different herds co-mingle is a significant risk factor for BVD (Valle et al., 1999). Return of cattle following unsuccessful sale has been reported as a significant risk factor for introduction of BHV-1, BVDv, *E coli* 0157, *Leptospira hardjo* and *Salmonella* Dublin to the resident herd (Cernicchiaro et al., 2009; van Schaik et al., 2002). Participation in agricultural shows is a significant risk factor for introduction of BHV-I (van Schaik, 2001), *Salmonella* spp. (Davison et al., 2003) and malignant catarrhal fever (MCF), (Moore et al., 2010).

Risk reduction strategies

Key practices include not using common pastures or shared cattle housing, not directly returning unsold cattle, selling at high health status physical sales, maintaining cattle-proof boundaries on out-farms and not participating in agricultural shows. Testing cattle prior to admittance to shows lowers, rather than eliminates, the risk of BHV-1 transmission (Breidenbach et al., 2005).

Contiguous contacts

Cattle are social animals with individuals and groups interacting whenever possible. Most farm boundaries have evolved to demarcate ownership of property and not for biosecurity purposes.

Risk reduction strategies

To reduce the risks the following strategies have been recommended (see AHI leaflet: **Bioexclusion: Keeping Infectious Diseases Out of Your Herd**; www.animalhealthireland.ie):

- Double spaced boundary fencing with a gap of at least 5m has been proposed to significantly reduce the risk of spread of disease such as BVD or IBR.
- Electric scare wires on each side of the boundary fence or a strip of uninterrupted hedge or trees also ameliorate the risk of transmission of infection (Caldow, 2004).
- Vaccination against specific pathogens, e.g. BVDv.

In a study of contact between cattle farms in the UK, Brennan et al. (2008) found that over half of boundary fences perceived to prevent contact, nose-to-nose contact was in fact possible with animals on adjacent farms.

Fomites

Fomites have been implicated in the transmission of various cattle pathogens such as BVDv, Foot-and-mouth disease virus, cryptosporidium and ovine herpesvirus. Contaminated farm machinery, visitor vehicles and veterinary equipment, (e.g. needles and syringes, nose tongs, halters, obstetrical equipment, dosing equipment, dehorning equipment, hoof paring equipment) can all act as mechanical vectors for introduction of infectious agents into herds.

Risk reduction strategies

In order to reduce the risks posed by such fomites, farmers should use their own cattle equipment rather than use veterinarians' equipment and thoroughly clean, disinfect and rinse equipment before and after use (see AHI leaflet: **Bioexclusion: Keeping Infectious Diseases Out of Your Herd**; www.animalhealthireland.ie).

Visitors

Visitors to farms are potential infection vectors particularly via their hands but also their clothing, boots, equipment and vehicles. Visitors can be categorised as low or high risk. High-risk visitors include collectors of dead stock, other farmers, veterinary practitioners, AI technicians, lay scanners and lay foot trimmers.

However, although visitors are known to be potential disease vectors, there is only limited published evidence which quantifies the risk of disease introduction from farm visitors. In a study where professional visitors did not always use protective clothing there was an increased risk of introducing BoHV-1 (van Schaik 2001). Not providing boots for visitors has been shown to be a significant risk factor for seropositivity to bovine coronavirus and BRSV (Ohlson et al., 2010).

Risk reduction strategies

The key procedures to reduce the risks posed by high risk visitors are: (1) providing personal protective equipment, e.g. gloves, footwear and overalls; restricting visitor contact only to the necessary stock; installing a vehicle bath with appropriate disinfectant at the single farm entrance; providing hand-washing and boot-washing facilities (disinfectant footmats have been shown to significantly reduce bacterial contamination of footware; and moving fallen stock to an area separated from livestock and farm activities and restricting collection service staff access only to this area. See AHI leaflet: **Bioexclusion: Keeping Infectious Diseases Out of Your Herd**; www.animalhealthireland.ie for further details.

Other Species

Resident cattle may have indirect contact with other non-bovine domestic animals, feral animals, wildlife, vermin and humans (walkers, passing motorists, hunters, etc). For example, wild

ruminants (deer and mouflon) act as reservoirs and may be involved in the dissemination and persistence of bluetongue virus (Garcia-Bocanegra et al., 2011). *Neospora caninum* is a coccidian parasite of domestic dogs (and other canids) (King et al., 2011). Wild deer are a potential source of infection for livestock of a broad range of bacteria, viruses and parasites (Böhm et al., 2007). *Clostridium botulinum* intoxication of cattle has been associated with poultry litter contamination of pasture (McLaughlin et al., 1998).

Risk reduction strategies

Several broad principles are relevant when seeking to reduce risk associated with other species (see AHI leaflet: **Bioexclusion: Keeping Infectious Diseases Out of Your Herd**; www.animalhealthireland.ie), including: providing and maintaining boundaries between known areas of significant wildlife populations and the other areas of the farm and securely storing animal foodstuffs and animal wastes to remove potential attractants to wildlife (including birds). The measures necessary will vary depending on the geographic area and the wildlife species involved.

Biological Material

Introduction of biological material (colostrum, colostrum replacers, whole milk, semen, embryos, vaccines, slurry) into a farm is a potential biosecurity risk. For example, MAP can be transmitted in colostrum or whole milk, as can EBL virus. Semen and embryos can transmit various infectious agents including BVDv and BHV-1, and cases of vaccine contamination with BVDv have been reported (Lindberg and Alenius, 1999). Slurry and dirty water can be a biohazard with *E. coli* O157, *Salmonella* and *Campylobacter* surviving for up to three months in them (Nicholson *et al.,* 2005).

Risk reduction strategies

Avoiding introduction of biologicals of uncertain health status is the best method of avoiding risk. Purchase of semen from artificial insemination centres approved for intercommunity trade and of embryos processed by internationally approved sanitary protocols will reduce disease introduction risks (EFSA, 2006). Pasteurisation of colostrum can reduce the load of infectious agents (Godden et al., 2006). See AHI leaflet: **Bioexclusion: Keeping Infectious Diseases Out of Your Herd**; www.animalhealthireland.ie for further details.

Conclusions

This paper has highlighted the relative importance of direct transmission of infectious agents via purchased cattle as the primary biosecurity risk and detailed the key protocols which can reduce this risk. Such protocols need to be developed into farm-specific Bioexclusion Plans by veterinary practitioners.

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