Bovine respiratory disease: Commercial vaccines currently available in Canada

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Abstract — Bovine respiratory disease (BRD) remains a significant cost to both the beef and dairy industries. In the United States, an estimated 640 million dollars is lost annually due to BRD. Losses are largely a result of pneumonic pasteurellosis ("shipping fever"), enzootic pneumonia of calves, and atypical interstitial pneumonia. In Canada, over 80% of the biologics licensed for use in cattle are against agents associated with BRD. The objectives of this paper were (a) to summarize information available concerning commercial vaccines currently used in Canada for protection against BRD, and (b) to provide an easily accessible resource for veterinary practitioners and researchers. Information from the most recent Compendium of Veterinary Products has been tabulated for each vaccine by trade name, according to vaccine type, and the pathogens against which they are designed to protect. Additional information from published articles (peer-reviewed and other) has been provided and referenced.

Résumé — Maladie respiratoire bovine : vaccins présentement disponibles dans le commerce au Canada. La maladie respiratoire bovine (MRB) représente toujours des frais importants pour l'industrie de la viande bovine et pour l'industrie laitière. Aux États-Unis la MRB coûte au bas mot de 640 millions de dollars par année. Les pertes sont dues en grande partie au pneumonies à pasteurella («fièvre des transports»), aux pneumonies enzootiques des veaux et aux pneumonies interstitielles atypiques. Au Canada, plus de 80 % des produits biologiques homologués pour utilisation chez les bovins sont destinés à être utilisé contre les agents associés à la MRB. Les objectifs de cet article étaient (a) de récapituler l'information disponible ur les vaccins commerciaux présentement utilisés au Canada pour protéger contre la MRB et (b) de fournir des renseignements vétérinaires facilement accessible pour les praticiens et les chercheurs. Les données du plus récent «Compendium of Veterinary Products» ont été présenté sous forme de tableaux ou chaque vaccin est identifié par sa marque de commerce, selon le type de vaccin et avec la liste de pathogènes contre lequel il est réputé efficace. Des informations supplémentaires provenant d'articles publiés (révisés par les pairs et les autres) ont été fourni avec les références.

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The etiology of BRD is multifactorial. Despite many years of research, understanding of exactly how and why it occurs is incomplete. Discussion of mechanisms of pathogenesis and debate surrounding the proposed contribution of individual infectious agents are beyond the scope of this paper, but excellent reviews are available (1–13). Bovine respiratory disease appears to be precipitated by an imbalance in the triad of interaction among one or more infectious agents, host defenses, and environmental stressors. Viruses isolated from cattle with BRD include infectious bovine rhinotracheitis virus [(IBRV), bovine herpesvirus-1 (BHV-1)], bovine viral diarrhea virus (BVDV), bovine respiratory syncytial virus (BRSV), parainfluenza-3 virus (PI-3V), BHV-4, malignant catarrhal fever virus, bovine adenovirus, bovine rhinovirus, bovine reovirus, bovine calicivirus, bovine coronavirus, bovine parvovirus, and bovine enterovirus (14–16). Bacterial pathogens associated with BRD include *Pasteurella haemolytica* A1 (now *Mannheimia haemolytica*), *Pasteurella multocida* A:3, *Haemophilus somnus, Actinomyces pyogenes, Mycoplasma bovis, Mycoplasma dispar, Mycoplasma hyorhinis, Ureaplasma diversum, Chlamydia* spp., *Mycobacterium bovis, Streptococcus pneumoniae,* and *Stapylococcus aureus* (12,17). Host factors that can contribute to BRD include inadequate colostral transfer

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Table 1. Commercial vaccines currently available in Canada against agents associated with bovine respiratory disease

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
VIRAL AGENTS		• The advantages of MLV over killed virus (KV) vaccines are thought to be induction of strong antibody responses in fewer doses, longer duration of humoral immunity, less reliance on adjuvants, and antigen processing is apparently more similar to natural infection (43). • Disadvantages include concerns regarding safety and storage requirements (15). • MLV vaccines are generally less expensive per dose than their killed counterparts (44).								
MODIFIED-LIVE VIRUS (MLV) VACCINES										
1-way MLV vaccines										
BoviShield™BRSV	Pfizer Animal Health	BRSV	10 D 50 D	2 mL	IM	2 doses (3–4 wk apart)	1 dose annually*	not stated	NO	• If calves vaccinated at < 6 mo of age, revaccinate at 6 mo*
BRSV Vac®	Bayer	BRSV	10 D 50 D	2 mL	IM	2 doses (3 wk apart)	NO	not stated	NO	• If calves vaccinated at < 6 mo of age, revaccinate at 6 mo*
• BRSV infections are seasonal, with peak occurrence in the fall and winter. Outbreaks are rare in spring and summer months, precipitated by stress such as movement, crowding, and temperature fluctuations (11). • The presence of maternal antibodies did not prevent disease in calves challenged with BRSV at 3 d of age, but incidence and severity of disease were inversely related to the amount of maternal antibodies calves had obtained (47). • In contrast to other agents associated with BRD in MLV vaccines, 2 doses of BRSV MLV vaccine are required for protection. • Modified live BRSV does not appear to be abortigenic when administered to pregnant cows; however in the past, contamination of BRSV MLV vaccines with BVD virus has occurred (11). • Serum antibody that develops in response to BRSV infection/vaccination with MLV may not be protective. Rather, it is often the coincident induction of unmeasured cell-mediated immune response that has been suggested to be protective (11).										
2-way MLV vaccines										
BoviShield™ IBR-PI3	Pfizer Animal Health	IBRV PI-3V	10 D 25 D 50 D	2 mL	IM SC	1 dose	1 dose annually*	NO, incl. calves nursing pregnant cows	NO	• In a challenge study, BoviShield™ IBR-PI3 appeared to interfere with protection against *P. haemolytica,* when administered concurrently with Pneumo-Star™, to calves at feedlot arrival (46). However, in a similar field study, this product did not appear to interfere with protection afforded by Somnu-Star™, but there were no animals that did not receive IBR-PI3 MLV to for comparison (34).†
Herd-Vac™-2	Pharmacia & Upjohn	IBRV PI-3V	50 D	2 mL	IM SC	1 dose	1 dose annually*	NO, incl. calves nursing pregnant cows	NO	• If calves vaccinated < 6 mo, revaccinate at 6 mo*
IBR-PI3 48™	Boehringer Ingelheim	IBRV PI-3V	10 D 50 D	2 mL	IM	1 dose	NO	NO, incl. calves nursing pregnant cows	NO	• If calves vaccinated < 6 mo, revaccinate at 6 mo*
• Infectious bovine rhinotracheitis virus (IBRV, "red nose") is bovine herpesvirus type 1 (BHV-1) (47). • IBRV can predispose cattle to severe fibrinous bronchopneumonia caused by *P. haemolytica* A1 (4). • Most respiratory infections occur when an infected animal is introduced to a herd or when cattle are confined (2). • IM administration of IBRV MLV can prevent conception if administered at breeding time (43), and cause abortion when administered to pregnant cattle past the 5th month of gestation (15). • IBRV-induced abortions have been reported when non-immune dams that suckled beef calves were vaccinated with IBRV MLV, and shedding of vaccine virus can apparently occur in severely stressed or immunosuppressed animals (15). • Passive immunity to IBRV is thought to be protective (15). • It has been shown that calves do not respond serologically to IM vaccination with IBRV MLV until maternal antibody is gone; however, priming for subsequent MLV IBR vaccination appears to occur in the presence of maternal antibody (46,48,49). • Administration of IBRV MLV vaccines can exacerbate infectious bovine keratoconjunctivitis (IBK; pink eye) and should not be used in a herd in which IBK is occurring (15). • PI-3V infection is usually subclinical, but can be exacerbated by adverse environmental conditions (2). • Infection with PI-3V is rarely fatal, but can cause morbidity in intensively housed calves and predispose feedlot cattle to severe bacterial pneumonia and subsequent morbidity and/or mortality (2,4). • The major threat of PI-3V infection is predisposition of cattle to severe fibrinous bronchopneumonia caused by *P. haemolytica* A1 (3). • PI-3V infection is common in calves 2–8 mo old; maternal immunity wanes at approximately 2 mo (2), and is thought to be partially protective (15). • PI-3V can be abortigenic, but it is not thought to be a major cause of abortion in cattle (15).										

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
2-way MLV vaccines (intranasal)										
TSV-2®	Pfizer Animal Health	IBRV PI-3V	10 D 50 D	2 mL (1 mL each nostril)	IN	1 dose	1 dose annually*	YES	NO	• Immunity in 7–14 d; if calves vaccinated < 6 mo, revaccinate at 6 mo* • Calves from vaccinated dams were protected from aerosol challenge with IBRV and PI-3V (49).† • Calves IN administered IBR-PI3 MLV vaccine were protected from challenge with IBRV by 72 h post-vaccination (50).† • It has been suggested that calves housed in dairy facilities be vaccinated at 1 to 4 wk of age, followed by IM administration of a MLV vaccine at 3 mo and 6 mo (15).† • Circulating lymphocyte blastogenesis and serum antibody responses to PI-3V did not significantly differ between pre-and 3–4 wk post-vaccination blood samples obtained from 18 dairy heifers IN administered TSV-2® at 3–6 mo old (51).†
• IN administration is thought to be more effective in induction of an immune response on the mucosal surface of the upper respiratory tract, the presumed site of initial exposure to these viruses (32). • Although IN administration of vaccine is more difficult and time consuming, it is 1 of 2 alternatives (the other being the chemically attenuated IBRV and PI-3V in the Cattlemaster™ products) for safe administration of IBR MLV to pregnant cattle and calves suckling pregnant cows (15). • IN administration of IBR-PI3 MLV is recommended for use in stressed cattle and in bulls whose semen will be frozen for use in artificial insemination programs (43).										
3-way MLV vaccines										
BoviShield™ IBR-PI3-BRSV	Pfizer Animal Health	BRSV IBRV PI-3V	10 D 25 D	2 mL	IM	1 dose (followed by 1 dose of BRSV MLV 2–4 wk later)	NO	NO, incl. calves nursing pregnant cows	NO	
BRSV Vac®3	Bayer	BRSV IBRV PI-3V	10 D 50 D	2 mL	IM	1 dose (followed by 1 dose of BRSV MLV 2–4 wk later)	1 dose annually	NO, incl. calves nursing pregnant cows	NO	
Bar Vac™3	Boehringer Ingelheim	BVDV IBRV PI-3V	10 D 50 D	2 mL	IM	1 dose	NO	NO, incl. calves nursing pregnant cows	NO	• Recommended for use in animals > 4 mo old* • If calves vaccinated between 4–6 mo, revaccinate at 6 mo*
BoviShield™3	Pfizer Animal Health	BVDV IBRV PI-3V	10 D 50 D	2 mL	IM	1 dose	1 dose annually	NO, incl. calves nursing pregnant cows	NO	
Herd-Vac™3	Pharmacia & Upjohn	BVDV IBRV PI-3V	50 D	2 mL	IM SC	1 dose	NO	NO, incl. calves nursing pregnant cows	NO	

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
Pyramid™MLV 3	Ayerst	BVDV IBRV PI-3V	10 D 50 D	2 mL	IM SC	1 dose	1 dose annually	NO, incl. calves nursing pregnant cows	NO	• Protect animals from exposure for 14 d post-vaccination*
• BVDV is an extremely important pathogen of North American cattle. There are 2 biotypes of BVDV: cytopathic and non-cytopathic (far more common) based on viral behavior in cell culture (9). There are 2 known genotypes of BVDV, apparently unrelated to biotype (13). • Clinical disease may be in the form of postnatal bovine viral diarrhea, fetal disease, or mucosal disease. Animals with subclinical or persistent BVDV infection appear to be more susceptible to severe *P. haemolytica* pneumonia (13). • Concerns regarding BVDV MLV vaccines include immunosuppression following administration, postvaccinal mucosal disease, and fetal loss (15). • Severe outbreaks of BVD can occur in intensively housed dairy calves (15). • BVDV can cross the bovine placenta. Infection during the first 6 mo of pregnancy can result in fetal loss or "immune tolerance" which facilitates persistent seronegative infection (43). • Postvaccinal mucosal disease becomes apparent 14–21 d following vaccination (15). • Recommendations for beef breeding herds include vaccination with a BVDV MLV vaccine prior to breeding. Replacement heifers should be vaccinated 2 or more times between weaning and breeding, followed by a final vaccination at least 1 mo prior to breeding (43). • It is thought that most calves born to dams immune to BVDV will not serologically respond to vaccination for 6–8 mo (15). However, in a repeat vaccination study, calves serologically responded to BVDV with titers of maternal antibody between 1:96 and 1:20 (52). Similarly, calves vaccinated at 84 d old were able to serologically respond to BVDV MLV in the presence of 1:32 maternal antibody (53). • A single dose of BVDV MLV vaccine at 14 mo may be adequate for life-long immunity. However, concerns of waning herd immunity and subsequent exposure to heterologous strains of BVDV result in recommendations for annual or alternate-year boosters (15).										
4-way MLV vaccines										
BoviShield™4	Pfizer Animal Health	BRSV BVDV IBRV PI-3V	10 D 50 D	2 mL	IM	1 dose (followed by 1 dose of BRSV MLV 2–4 wk later)	1 dose annually*	NO, incl. calves nursing pregnant cows	NO	• Calves vaccinated with BoviShield™4 were shown not to shed virus when stressed (54).†
BRSV Vac®4	Bayer	BRSV BVDV IBRV PI-3V	5 D 10 D 50 D	2 mL	IM	1 dose (followed by 1 dose of BRSV MLV 2–4 wk later)	NO	NO, incl. calves nursing pregnant cows	NO	• Recommended for use in calves > 6 mo* • Contains the Baker strain of IBRV (BHV-1) and the Oregon C24V strain of BVDV (55).† • Calves, treated with dexamethasone (to activate and recrudesce latent virus), and tested for antibodies recognizing IBRV, were determined not to be infected. Animals were then vaccinated with BRSV Vac® according to manufacturers' instructions and were comingled with non-vaccinated animals. None of the control animals developed antibody or lymphocyte blastogenesis responses to virus, demonstrating that vaccinal IBRV was not shed (54).† • A field trial demonstrated that 1 dose of Horizon®4 administered 3 wk prior to weaning effectively primed calves for an immunizing dose of BRSV Vac®4 (MLV) at weaning, as measured by production of virus neutralizing antibody recognizing IBRV and BVDV (55).†
Pyramid™MLV 4	Ayerst	BRSV BVDV IBRV PI-3V	10 D 50 D	2 mL	IM SC	1 dose	1 dose annually*	NO, incl. calves nursing pregnant cows	NO	• Protect animals from exposure for 14 d post-vaccination* • Transient, mild injection site swelling may be observed*
• One dose of a 4-way MLV vaccine at weaning has been suggested as part of a beef calf management program (39).										

Table 1. *(Continued)*

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
KILLED VIRUS (KV)										
1-way KV vaccines										
		• In general, killed or inactivated vaccines do not replicate within the host and are, therefore, thought to be safer than vaccines containing MLV. They usually contain adjuvants, can be used in pregnant animals and calves suckling pregnant cows, and require 2 doses for primary vaccination and annual boosters to maintain immunity. They are more expensive, but when administered according to manufacturers' instructions, are apparently as efficacious as MLV vaccines. • The lag period between priming and immunizing doses make killed vaccines unsuitable for vaccination programs in which vaccines are administered to naive animals upon arrival at the feedlot (15). • A major cause of failure of vaccination programs to adequately protect can arise from failure to follow up the initial (priming) dose of KV vaccine with the 2nd (immunizing) dose (15).								
Tandem™SV	Merial Canada	BRSV	50 D	2 mL	IM SC	2 doses (3–4 wk apart)	1 dose annually/ prior to stress or exposure*	not stated	not stated	• Calves vaccinated < 3 mo, revaccinate at 4–6 mo or at weaning*
Cattlemaster™BVD-K	Pfizer Animal Health	BVDV	10 D 50 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	YES	YES aluminum hydroxide	• Occasional hypersensitivity, observed up to 6 h post-vaccination, appears to affect 227–409 kg dairy heifers more frequently* • Contains both cytopathic and noncytopathic BVD* • Calves vaccinated < 6 mo, revaccinate at 6 mo*
Triangle™1	Ayerst	BVDV	50 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	YES	YES Enhance™ dual adjuvant system	• Protect cattle from exposure for 14 d after last dose* • Calves vaccinated < 6 mo, revaccinate at 6 mo or at weaning*
• It has been suggested that some methods of inactivation of BRSV used for production of commercial vaccines may alter viral epitopes that elicit virus neutralizing antibodies (56). • Some inactivated BVDV vaccines do not appear to protect against infections with heterologous strains of BVDV (15). • Inactivated BVDV vaccines are not recommended for use in a BVD outbreak, cattle entering the feedlot, or other cases where exposure to BVDV is likely to occur before 2nd dose can be administered (15).										
3-way KV vaccines										
Tandem™3K	Merial Canada	BVDV IBRV PI-3V	50 D	3 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	not stated	not stated	• Calves vaccinated < 6 mo, revaccinate at 6 mo*
Triangle™3	Ayerst	BVDV IBRV PI-3V	10 D 50 D	5 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually*	YES	YES Enhance™ dual adjuvant system	• Protect cattle from exposure for 14 d after last dose* • Viruses inactivated using ImmuneGuard™ process* • Calves vaccinated < 6 mo, revaccinate at 6 mo or at weaning*
Virabos™-3	Vetrepharm	BVDV IBRV PI-3V	5 × 5 D 20 D 50 D	5 mL	IM	2 doses (4–5 wk apart) feeder calves: before shipping	1 dose annually*	YES	YES Immunostim® (mycobacterial cell wall components)	• Do not vaccinate 60 d before slaughter* • Lactating dairy cows may show a decrease in milk production & transient depression 4–5 d following vaccination* • Vaccinate during dry-off period* • Contains both cytopathic and noncytopathic BVDV*
• Inactivated IBRV vaccines can be used safely during IBK (pink eye) outbreaks (18).										
4-way KV vaccines										
Dairymune™4	Vetrepharm	BRSV BVDV IBRV PI-3V	5 × 5 D 20 D 50 D	5 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	YES	YES aluminum hydroxide and Immunostim® (mycobacterial cell wall components)	• May be temporary swelling at injection site* • Contains both cytopathic and noncytopathic BVDV* • If calves vaccinated before weaning, revaccinate after weaning*

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
Sentry™4	Boehringer Ingelheim	BRSV BVDV IBRV PI-3V	10 D 50 D	5 mL	IM	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	YES, including lactating cows	not stated	• If vaccinated 2–4 wk before weaning, revaccinate at weaning*
Tandem™4K	Merial Canada	BRSV BVDV IBRV PI-3V	10 D 50 D	5 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually	not stated	not stated	• If vaccinated < 6 mo, revaccinate at 6 mo or weaning* • Contains BRSV isolate 375 (56).† • The antibody response to BRSV was assessed in 5–6-month-old calves that received 2 doses (14 d apart) of Triangle™4, Tandem™4, or Cattlemaster™4. Total anti-BRSV antibody and virus neutralizing antibody were assayed on Day 0 and Day 24 of the trial. Although vaccinated calves were comingled with non-vaccinated calves, animals were not shipped or challenged. Calves vaccinated with Cattlemaster™4, containing MLV BRSV had significantly greater virus neutralizing antibody titers than non-neutralizing antibody titers, whereas, Triangle™4 and Tandem™4, which contain inactivated BRSV, induced significantly greater non-neutralizing than neutralizing antibody titers (56).†
Triangle™4	Ayerst	BRSV BVDV IBRV PI-3V	10 D 50 D	5 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	YES	YES Enhance™ dual adjuvant system	• Protect cattle from exposure for 14 d after last dose* • Viruses inactivated using Immune Guard™process* • If vaccinated < 6 mo, revaccinate at 6 mo or at weaning* • Contains a field isolate of BRSV obtained in 1986 (56).† • See reference (56) cited for Tandem™4K above.†
Virabos™-4	Vetrepharm	BRSV BVDV IBRV PI-3V	5 × 5 D 20 D 50 D	5 mL	IM	2 doses (4–5 wk apart) feeder calves: before shipping	1 dose annually	YES	YES Immunostim® (mycobacterial cell wall components)	• Do not vaccinate 60 d before slaughter* • Lactating dairy cows may show a decrease in milk production & transient depression 4–5 d following vaccination* • Vaccinate during dry-off period* • Contains both cytopathic and noncytopathic BVDV*
Killed/Modified Live Combinations (K/MLV)		• See sections describing MLV and KV vaccines above.								
3-way K/MLV vaccines		• See sections describing 3-way MLV and KV vaccines above.								
Cattlemaster™3	Pfizer Animal Health	BVDV IBRV PI-3V	10 D 25 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	YES	YES aluminum hydroxide	• Occasional hypersensitivity, observed up to 6 h post-vaccination, appears to affect 227–409 kg dairy heifers more frequently* • Contains both cytopathic and noncytopathic BVDV* • Calves vaccinated < 6 mo, require booster at 6 mo*
Tandem™3KL	Merial Canada	BVDV IBRV PI-3V	10 D 50 D	2 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	NO, incl. calves nursing pregnant cows	not stated	• If calves vaccinated < 3 mo, require booster at 4–6 mo or at weaning*
4-way K/MLV vaccines		• See sections describing 4-way MLV and KV vaccines above.								
BarVac™3-BRSV	Boehringer Ingelheim	BRSV BVDV IBRV PI-3V	10 D 50 D	2 mL	IM	2 doses (3 wk apart)	1 dose annually/ prior to stress or exposure*	NO, incl. calves nursing pregnant cows	not stated	• If vaccinated < 6 mo, revaccinate at 6 mo*

Table 1. *(Continued)*

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
Tandem™SV + 3	Merial Canada	BRSV BVDV IBRV PI-3V	10 D 50 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	NO, incl. calves nursing pregnant cows	not stated	• If vaccinated < 3 mo, revaccinate at 4–6 mo or at weaning*
Cattlemaster™4	Pfizer Animal Health	BVDV BRSV IBRV PI-3V	5 D 10 D 25 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	YES	YES aluminum hydroxide	• Contains chemically altered IBRV and PI-3V MLV* • Occasional hypersensitivity, observed up to 6 h post-vaccination, appears to affect 227–409 kg dairy heifers more frequently* • Contains both cytopathic and non-cytopathic biotypes of BVDV* • Calves vaccinated < 6 mo, revaccinate at 6 mo* • Contains BRSV isolate 375, attenuated by repeated passage in culture (56).† • This product has been suggested as an optional part of a beef calf management program: 1 dose at branding (2–4 mo), followed by 1 dose at preweaning processing (4–6 mo) (39).† • The antibody response to BRSV was assessed after 5–6-month-old calves were administered 2 doses (14 d apart) of Triangle™4, Tandem™4, or Cattlemaster™4. Total anti-BRSV antibody and virus neutralizing antibody were assayed on Day 0 and Day 24 of the trial. Although vaccinated calves were comingled with non-vaccinated calves, animals were not shipped or challenged. Calves vaccinated with Cattlemaster™4, containing MLV BRSV, had significantly greater virus neutralizing antibody titers than non-neutralizing antibody titers, whereas, Triangle™4 and Tandem™4, which contain inactivated BRSV, had significantly greater non-neutralizing than neutralizing antibody titers (56).†
Horizon®1 + Vac®3	Bayer	BVDV BRSV IBRV PI-3V	10 D 50 D	2 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually*	NO, incl. calves nursing pregnant cows	YES Prolong®	• Viruses killed using Sofkil™ inactivation process*
Horizon®4	Bayer	BVDV IBRV BRSV PI-3V	10 D 50 D	2 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually*	not stated	not stated	• Preconditioning/preweaning: vaccinate 2–4 wk prior to weaning and at weaning* • Calves vaccinated prior to weaning, revaccinate at weaning* • Contains the Baker strain of IBRV and the Oregon C24V strain of BVDV (56).† • A field trial demonstrated that 1 dose of Horizon®4 administered 3 wk prior to weaning effectively primed calves for an immunizing dose of BRSV Vac®4 (MLV) at weaning, for production of virus neutralizing antibody recognizing IBRV and BVDV (56).†
Tandem™4KL	Merial Canada	BRSV BVDV IBRV PI-3V	10 D 50 D	2 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	NO, incl. calves nursing pregnant cows	not stated	• If calves vaccinated < 3 mo, revaccinate at 4–6 mo or weaning*

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
Tandem™3KL IBR Plus	Merial Canada	BVDV IBRV BRSV PI-3V	10 D 50 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	NO, incl. calves nursing pregnant cows	not stated	• If calves vaccinated < 3 mo, revaccinate at 4–6 mo or weaning*
Tandem™SV IBR Plus	Merial Canada	BRSV IBRV BVDV IBRV PI-3V	10 D 50 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	NO, incl. calves nursing pregnant cows	not stated	• If calves vaccinated < 3 mo, revaccinate at 4–6 mo or at weaning*
Tandem™4KL IBR Plus	Merial Canada	BRSV BVDV IBRV PI-3V	10 D 50 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually/ prior to stress or exposure*	NO, incl. calves nursing pregnant cows	not stated	• If calves vaccinated < 3 mo, revaccinate at 4–6 mo or at weaning*
BACTERIAL CULTURE SUPERNATANTS & SURFACE EXTRACT VACCINES		• These vaccines are listed as "Bacterin-Toxoids" for regulatory reasons. This is a misnomer. Bacterins are vaccines containing killed whole bacteria. Toxoids are vaccines containing inactivated toxin. • These vaccines contain leukotoxin and/or recombinant leukotoxin, serotype-specific cell surface antigens, and/or extracted cell surface proteins from *P. haemolytica* A1, and/or extracted outer membrane proteins (OMPs) of *H. somnus*.								
One Shot™	Pfizer Animal Health	*P. haemolytica*	10 D 50 D	2 mL	IM SC	1 dose minimum 10 d prior to weaning, shipping, or exposure to stressful or infectious conditions	1 dose whenever subsequent stress or exposure is likely*	not stated	YES	• Safe for use in cattle of all ages* • Transient swelling at IM injection site in some dairy calves* • Moderate swelling at SC injection site, resolution within 2–4 wk* • Contains some killed bacteria* • The concentration of leukotoxin has been reported to be 353 U/mg (57).† • May be used as part of preweaning program: 1 dose at 4–6 mo (39).† • Four-month-old calves were NOT significantly protected against transthoracic challenge with virulent *P. haemolytica* A1 83 d or 97 d (typical time of shipment) later (58).†
Pneumo-Star™	Biowest	*P. haemolytica*	10 D 50 D 100 D	2 mL	IM	2 doses (2–6 wk apart) feedlot cattle: 1st dose 2–6 wk prior to entry, 2nd dose on arrival	1 dose annually*	not stated	YES	• Contains recombinant leukotoxin* • Stimulates toxin neutralizing antibodies* • Calves vaccinated < 6 mo, revaccinate > 6 mo* • May be used as part of preweaning program: 1 dose at 4–6 mo age (39).†
Presponse®	Ayerst	*P. haemolytica*	10 D 50 D	2 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	not stated	YES, double adjuvant system	• Suggested injection site in neck area anterior to shoulder* • Safe for use in cattle of all ages* • Stimulates toxin neutralizing antibodies* • Presponse® was the first of the new generation of *P. haemolytica* vaccines† • The concentration of leukotoxin has been reported to be 110 U/mg (57).† • May be used as part of preweaning program: 1 dose at 4–6 mo (39).† • Vaccine efficacy of 60–70% was demonstrated in a controlled, experimental challenge with virulent *P. haemolytica* A1 (60).† • In a challenge study, 1 dose of Presponse® (25.78% pneumonic tissue, PT; 13% mortality, M) was as efficient as 2 doses (25.18% PT, 12% M) at eliciting a protective immune response, compared to unvaccinated controls (45.30%PT, 33% M) (61).

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
Somnu-Star Ph™	Biowest	*P. haemolytica*, *H. somnus*	10 D 50 D 100 D	2 mL	IM	2 doses (2–6 wk apart) feedlot cattle: 1st dose 2–6 wk prior to entry, 2nd dose on arrival	1 dose annually*	not stated	YES	• Calves vaccinated < 6 mo, revaccinate > 6 mo* • Contains recombinant leukotoxin of *P. haemolytica* A1 and extracted OMPs of *H. somnus** • Stimulates leukotoxin neutralizing antibodies* • May NOT protect against *H. somnus* if administered only on arrival at feedlot* • In a field study, a single SC dose administered concurrently with BoviShield™ IBR-PI3 upon arrival at the feedlot was protective (34).†
Somnu-Star™	Biowest	*H. somnus*	10 D 50 D 100 D	2 mL	IM	2 doses (2–6 wk apart) feedlot cattle: 1st dose 2–6 wk prior to entry, 2nd dose on arrival	1 dose annually*	not stated	YES	• Contains extracted OMPs of *H. somnus** • Administration with a MLV vaccine containing IBR & PI3 may reduce the immune response to OMPs of *H. somnus**

- Culture supernatant/bacterial extract *P. haemolytica* vaccines should not be confused with older *P. haemolytica* and *P. multocida* bacterins which were ineffective at the very least, and actually exacerbated disease in some cases (15). Commercial *P. haemolytica* or *P. multocida* bacterins are no longer available in Canada.
- *P. haemolytica* A1 plays a central role in pathogenesis of "shipping fever" and is a major pathogen of feedlot cattle (8).
- The greatest respiratory morbidity in the feedlot usually occurs within 2–4 wk of arrival (22).
- Because primary IBR, PI3, BVD, and BRS virus infections are thought to predispose stressed cattle to pneumonic pasteurellosis, many vaccine strategies over the last few years have focused solely on prophylaxis of primary viral infections (62). This has been largely ineffective at reducing morbidity and mortality associated with shipping fever (15).

BACTERINS		• Bacterins contain killed or inactivated whole bacteria.								
Somnugen™	Boehringer Ingelheim	*H. somnus*	10 D 50 D	2 mL	IM	2 doses administered to calves > 3 mo (3 wk apart)	1 dose annually	not stated	YES (aluminum hydroxide)	• Revaccinate at 6 mo* • Bacteria chemically inactivated using Thimerosal* • Feedlot cattle should be vaccinated 28 d before arrival, otherwise vaccinate upon arrival* • Protection from systemic and respiratory *H. somnus* infections*
Somubac™	Pfizer Animal Health	*H. somnus*	10 D 50 D	2 mL	IM SC	2 doses administered to calves > 3 mo (2–4 wk apart)	1 dose annually	not stated	YES	• Contains 3 chemically inactivated strains of *H. somnus**

- *H. somnus* causes thromboembolic meningoencephalitis (TEME), septicemia, fibrinous pneumonia, vulvovaginitis, and abortion in cattle (63).
- Recently, the number of observations of acute respiratory disease associated with *H. somnus* appears to be increasing (35).
- It has been reported that *H. somnus* is isolated almost as often as *P. haemolytica* or *P. multocida* from pneumonic lungs of cattle (5).
- The reported incidence of *H. somnus* and *Mycoplasma* spp. might be much lower than the actual incidence because of difficulty culturing these organisms (12).
- *H. somnus* may be a very important pathogen in Canadian feedlots. Vaccination apparently reduced mortality in steers by 17%, but didn't affect the mortality of heifers (64).
- Reproductive disease caused by *H. somnus* is the main concern for cow-calf operations. Lack of definitive efficacy studies and unclear understanding of the epidemiology of reproductive disease make it a questionable part of the vaccination program for a cow-calf operation (43).
- There are very few field trials reporting *H. somnus* bacterin efficacy. This is not necessarily reflective of ineffective vaccines, but more likely the sporadic nature of clinical syndromes caused by the organism (15).
- Nonetheless, *H. somnus* bacterins were ranked 9th out of 22 (in order of utility) of commercial bacterial/rickettsial/protozoal vaccines (15).
- Vaccine-induced immunity against *H. somnus* has apparently been most successful against natural and experimental TEME. Commercial bacterins have produced variable effects against pneumonia (63).
- One dose of *H. somnus* bacterin administered at arrival on the feedlot was apparently as effective as 2 at reducing mortality; however, comments regarding morbidity were lacking (64).
- On the other hand, vaccination against *H. somnus* is not recommended for feedlot cattle because infection is apparently more effectively treated with antimicrobials rather than vaccination (12,15).

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
COMBINATION VACCINES		• See sections above describing 2-way MLV vaccines and bacterins.								
2-way MLV + *H. somnus* vaccines										
IBR-PI3/Somnugen™	Boehringer Ingelheim	IBRV PI-3V *H. somnus*	10 D 50 D	2 mL	IM	2 doses administered to calves > 4 mo (3 wk apart)	1 dose annually	NO, incl. calves nursing pregnant cows	YES (aluminum hydroxide)	• Vaccines containing IBR MLV in clear vials are inactivated within 2 min when exposed to sunlight* • See Somnugen™*
Resvac®3/Somubac™	Pfizer Animal Health	IBRV PI-3V *H. somnus*	10 D 50 D	2 mL	IM	2 doses administered to calves > 3 mo (2–4 wk apart)	1 dose annually	NO, incl. calves nursing pregnant cows	YES (aluminum hydroxide)	• Viral strains produced under frozen Stable Cell Bank™ system* • See Somubac™*
3-way MLV + *H. somnus* vaccines										
BarVac™3/ Somnugen™	Boehringer Ingelheim	BVDV IBRV PI-3V *H. somnus*	10 D 50 D	2 mL	IM	1 dose (boost with Somnugen™ 3 wk later)	1 dose Somnugen™ annually*	NO, incl. calves nursing pregnant cows	YES (aluminum hydroxide)	• See BarVac™3 and Somnugen™
Resvac®3/Somubac™	Pfizer Animal Health	BVDV IBRV PI-3V *H. somnus*	10 D 50 D	2 mL	IM	2 doses administered to calves >3 mo (2–4 wk apart)	1 dose annually*	NO, incl. calves nursing pregnant cows	YES (aluminum hydroxide)	• Viral strains produced under frozen Stable Cell Bank™ system* • See Somubac™*
4-way MLV + *H. somnus* vaccines		• Vaccination against IBRV, BRSV, BVDV, PI-3V, *H. somnus*, and *P. haemolytica* have been suggested for preweaning and preconditioning programs (15).								
Resvac®4/Somubac™	Pfizer Animal Health	BRSV BVDV IBRV PI-3V *H. somnus*	10 D 50 D	2 mL	IM	1 dose administered to calves > 3 mo, followed by 1 dose BRSV and *H. somnus* vaccines 2–4 wk later	1 dose annually*	NO, incl. calves nursing pregnant cows	YES (aluminum hydroxide)	
4-way KV + *H. somnus* vaccines		• See sections describing 4-way KV and bacterins above.								
Sentry™4/Somnugen™	Boehringer Ingelheim	BRSV BVDV IBRV PI-3V *H. somnus*	10 D 50 D	5 mL	IM	2 doses (2–4 wk apart) calves: 1st dose 2–4 wk before weaning, 2nd dose at weaning	1 dose annually*; prior to stress or exposure*	YES	YES (aluminum hydroxide)	• Recommended for use in cattle of all ages, including veal calves*
Triangle*4 + HS	Ayerst	BRSV BVDV IBRV PI-3V *H. somnus*	10 D 50 D	5 mL	IM	2 doses (2–4 wk apart)	1 dose annually*; prior to stress or exposure*	YES	YES (Enhance™ dual adjuvant system)	• *H. somnus* fraction consists of extracted OMPs* • Protect animals from exposure for 14 d after last dose* • Immune Guard™ inactivant & process to kill viruses* • Calves vaccinated < 6 mo, revaccinate at 6 mo or weaning*

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
Virabos™-4 + *H. somnus*	Vetrepharm	BRSV BVDV IBRV PI-3V *H. somnus*	5 × 5 D 20 D 50 D	5 mL	IM	2 doses; calves: vaccinate at 3 mo, 2–4 wk apart; adults: 2–4 wk apart	1 dose annually*; booster at weaning* (those calves vaccinated before weaning)	YES	YES (Immunostim® (mycobacterial cell wall component)	• Contains both cytopathic & non cytopathic BVDV* • Temporary, localized swelling may occur at injection site* • Vaccinate during drying off period* • Decrease in milk production may be observed in dairy cows 2–4 d following vaccination* • Decrease in food consumption may be observed up to 24 h post-vaccination* • Do not vaccinate 60 d before slaughter*
4-way K/MLV + *H. somnus* vaccines		• See sections describing 4-way MLV and KV vaccines and bacterins above.								
BarVac™3/Somnugen™/ BRSV	Boehringer Ingelheim	BRSV BVDV IBRV PI-3V *H. somnus*	10 D 50 D	2 mL	IM	2 doses (3 wk apart)	1 dose annually* or prior to stress or exposure*	NO, incl. calves nursing pregnant cows	not stated	• See Somnugen™* • Calves vaccinated < 6 mo, revaccinate at 6 mo*
Resvac®3 BRSV/ Somubac™	Pfizer Animal Health	BRSV BVDV IBRV PI-3V *H. somnus*	10 D 50 D	2 mL	IM	2 doses administered to calves > 3 mo (2–4 wk apart)	1 dose annually*	NO, incl. calves nursing pregnant cows	YES (aluminum hydroxide)	• Viral strains produced under frozen Stable Cell Bank™ system* • See Somubac™*
3-way KV + 5-way Lepto vaccines		• See sections describing 3-way KV vaccines and bacterins above.								
Tandem™8K	Merial Canada	BVDV IBRV PI-3V *Leptospira* serovars	50 D	5 mL	IM	2 doses (3–4 wk apart)	1 dose annually*, prior to breeding	not stated	not stated	
Triangle*8	Ayerst	BVDV IBRV PI-3V *Leptospira* serovars	10 D 50 D	5 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually*	YES	YES (Enhance™ dual adjuvant system)	• Immune Guard™ inactivant & process to kill viruses • Calves vaccinated < 6 mo, revaccinate at 6 mo or at weaning

- Although *Leptospira* spp. are associated with reproductive disease, *pomona* and *hardjo* serovars being the most frequent cause of abortion in US cattle (15,45), the use of vaccines containing the 4 primary viral agents associated with BRD and 5 serovars of *Leptospira* spp. are commonly used, and are, therefore, included here.
- Commercial vaccines currently available contain *Leptospira* serovars *canicola, grippotyphosa, hardjo, icterohaemorrhagea,* and *pomona.*
- Serovars *canicola, grippotyphosa,* and *icterohaemorrhagea* are not associated with leptospirosis in North America and their inclusion in current vaccines has been described as gratuitous (15).
- Vaccination every 12 mo (closed herd) or every 6 mo (endemic areas) with 5-way Lepto has been suggested (43).
- Problems with abortions from *Leptospira* serovar *pomona* are commonly encountered in dairy herds vaccinated with inactivated multiple-antigen vaccines containing IBRV, BVDV, PI-3V and 1 or more *Leptospira* serovars administered annually. It is suggested that semiannual vaccination with these vaccines replace annual vaccination to prevent leptospirosis (15).
- Administration has been suggested as part of feedlot arrival processing (65).

4-way MLV + 5-way Lepto vaccines		• See sections describing 4-way MLV vaccines and 3-way KV + 5-way Lepto vaccines above.								
BoviShield™4 + L5	Pfizer Animal Health	BRSV BVDV IBRV PI-3V *Leptospira* serovars	5 D	2 mL	IM	1 dose (followed by BoviShield™ BRSV 2–4 wk later)	1 dose annually*	NO, incl. calves nursing pregnant cows	not stated	

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
BRSV Vac®9	Bayer	BRSV BVDV IBRV PI-3V *Leptospira* serovars	5 D 50 D	2 mL	IM	1 dose (followed by BRSV vaccine 2–4 wk later)		NO, incl. calves nursing pregnant cows	not stated	• Calves vaccinated prior to weaning, revaccinate at weaning*
4-way KV + 5-way Lepto vaccines		• See sections describing 4-way KV vaccines and 3-way KV + 5-way Lepto vaccines above. • These vaccines are currently the largest sellers in Canada.								
Dairymune™9	Vetrepharm	BRSV BVDV IBRV PI-3V *Leptospira* serovars	5 × 5 D 20 D 50 D	5 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	YES	YES (aluminum hydroxide and Immunostim® (mycobacterial cell wall component))	• Contains both cytopathic and non cytopathic BVDV* • Calves vaccinated prior to weaning, revaccinate at 6 mo or weaning*
Sentry™9	Boehringer Ingelheim	BRSV BVDV IBRV PI-3V *Leptospira* serovars	10 D 50 D	5 mL	IM	2 doses (2–4 wk apart)	1 dose annually*; prior to stress or exposure*	YES, including lactating dairy cattle	not stated	• Recommended for calves of all ages, including veal calves • No post-vaccinal milk discard required • Calves vaccinated < 6 mo, revaccinate at 6 mo or weaning
Tandem™9K	Merial Canada	BRSV BVDV IBRV PI-3V *Leptospira* serovars	10 D 50 D	5 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually*	not stated	not stated	• Calves vaccinated < 3 mo, revaccinate at 6 mo or weaning
Triangle™9	Ayerst	BRSV BVDV IBRV PI-3V *Leptospira* serovars	10 D 50 D	5 mL	IM SC	2 doses (2–4 wk apart)	1 dose annually*; prior to stress or exposure*	YES	YES Enhance™ dual adjuvant system	• Immune Guard™ inactivant & process to kill viruses* • Protect animals from exposure for 14 d after last dose* • Calves vaccinated < 6 mo, revaccinate at 6 mo or weaning* • Calves were vaccinated 18 d prior to weaning according to label instructions with Cattlemaster™4 + L5, Triangle™9, or not vaccinated prior to challenge with IBR and BVD viruses. The challenge was meant to mimic the fall "run." Morbidity (M) and mortality (m) were compared. Calves vaccinated with Cattlemaster™4 + L5 (M = 0%, m = 8%) experienced significantly less mortality and morbidity than calves vaccinated with Triangle™9 (M = 13%, m = 33%) or not vaccinated (M = 58%, m = 100%). Although protection afforded by Cattlemaster™4 + L5 was found to be superior, those vaccinated with Triangle™9 also experienced significantly less mortality and morbidity than non vaccinates (66).
4-way K/MLV + 5-way Lepto vaccines		• See sections describing 4-way K/MLV vaccines and 3-way KV + 5-way Lepto vaccines above.								
Cattlemaster™4 + L5	Pfizer Animal Health	BVDV BRSV IBRV PI-3V *Leptospira* serovars	5 D 10 D 25 D	5 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	YES	YES	• Calves vaccinated < 6 mo, revaccinate at 6 mo* • Contains chemically altered IBR and PI3 MLV* • Contains both cytopathic and non cytopathic BVDV* • Occasional hypersensitivity observed up to 6 h post-vaccination, appears to be more frequent in 227–409 kg dairy heifers* • See comment for Triangle™9.

Table 1. ***(Continued)***

Product	Company	Agents	Presentation	Dose	Route	Primary vaccination	Recommended boosters	Use in pregnant cows	Adjuvant	Comments
Horizon®9	Bayer	BVDV IBRV BRSV PI-3V *Leptospira* serovars	10 D 25 D	3 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	not stated	YES Prolong®	• Preconditioning/preweaning: vaccinate 2–4 wk prior to weaning and at weaning • Sofkil™ inactivation of IBRV and BVDV • Calves vaccinated prior to weaning, revaccinate at weaning
MISCELLANEOUS RESPIRATORY/ REPRODUCTIVE COMBINATION VACCINES										
Cattlemaster™4 + L5	Pfizer Animal Health	BVDV BRSV IBRV PI-3V *Leptospira* serovars *C. fetus*	5 D 10 D 25 D	5 mL	IM	2 doses (2–4 wk apart)	1 dose annually*	YES	YES (aluminum hydroxide)	• Calves vaccinated < 6 mo, revaccinate at 6 mo* • Contains chemically altered IBRVand PI-3V MLV* • Contains both cytopathic and non cytopathic BVDV* • Occasional hypersensitivity observed up to 6 h post-vaccination, appears to be more frequent in 227–409 kg dairy heifers*
Preg-Guard9®	Pfizer Animal Health	BVDV IBRV PI-3V *Leptospira* serovars *C. fetus*	10 D 25 D	2 mL	IM	1 dose 60 d prior to breeding cow or heifers or being added to the herd	1 dose annually*	NO, incl. calves nursing pregnant cows	not stated	• In non-infected herds in endemic areas, 2nd dose may be administered 2 wk following first*
Sentry™9/Somugen™	Boehringer Ingelheim	BRSV BVDV IBRV PI-3V *Leptospira* serovars *H. somnus*	10 D 50 D	5 mL	IM	2 doses (2–4 wk apart)	1 dose annually*; prior to stress or exposure*	YES, including lactating dairy cattle	not stated	• Recommended for calves of all ages, including veal calves* • No post-vaccinal milk discard required* • Calves vaccinated < 6 mo, revaccinate at 6 mo or weaning* • See Somnugen™*
Breed Back9/Somugen™	Boehringer Ingelheim	BVDV IBRV PI-3V *Leptospira* serovars *C. fetus* *H. somnus*	5 D 20 D	5 mL	IM	2 doses (2–3 wk apart)	1 dose annually*	NO	YES	• Recommended for cattle > 4 mo • Calves vaccinated 4–6 mo should be revaccinated at weaning • See Somnugen™

- *Campylobacter fetus* causes vibriosis, a venereal disease of beef cattle characterized by temporary infertility and, occasionally, abortion (42).
- Active immunization is apparently sufficient to ensure reproduction, but not to prevent infection of the vaginal mucosa of the dam. It has been suggested that the carrier state may be eliminated in bulls by administration of 2.5 times the recommended dose twice the first year, followed by annual boosters 1 mo prior to breeding (42).

IM — intramuscular; IN — intranasal; SC — subcutaneous
*Comments from manufacturer
†References from publications

(18,19), impaired mucociliary clearance from the lung (20), impaired innate and immune defenses (21), and malnutrition, or dehydration (22). Environmental stressors that can predispose to disease include transportation, temperature extremes, processing, crowding, poor ventilation, and movement through marketing channels (12, 22).

Commercial vaccines currently available in Canada offer protection against only IBRV, BVDV, BRSV, PI-3V, *P. haemolytica,* and *H. somnus* (23). Various combination vaccines containing modified live virus (MLV), killed virus (KV), bacterins, and/or bacterial culture supernatants/surface extracts are available.

Depending on the type of cattle operation, various infectious agents are of greater concern than others. For example, BRD pathogens of economic concern in feedlots include *P. haemolytica* A1, *H. somnus, P. multocida* A:3, and *A. pyogenes* (12). Primary viral infection with IBRV, PI-3V, BVDV, and/or BRSV is thought to predispose animals to more severe secondary bacterial infections. A common approach to BRD control in the feedlot over recent years has been to vaccinate against viral agents alone (15,24–26). This approach has been largely ineffective (15,27,28).

There are few controlled challenge studies demonstrating commercial vaccine efficacy presented in refereed journals. However prior to licensure, manufacturers are required to demonstrate vaccine efficacy in the target species by using an appropriately controlled challenge with "virulent" organisms according to Title 9 of the American Code of Federal Regulations (9CFR) (29–31). The degree of virulence of organisms used in licensure studies may vary by company and product. This may affect reported efficacy, resulting in differences in performance among apparently similar products. The Canadian government uses definitions and requirements for efficacy, safety, purity, and potency, similar to those in 9CFR (personal communication, P. Agarawal, Veterinary Biologics and Biotechnology Section, Animal Health and Production Division, Canadian Food Inspection Agency, Government of Canada).

The use of vaccines is not free of risk (32). Appropriate choice of vaccine and timing of vaccination, in addition to storage and administration of biologics according to manufacturer's instructions, will help to ensure a successful vaccination program. It has been argued that marketing and management practices discourage producers from following label recommendations, particularly in cow-calf operations and feedlots (33–35).

Considerable debate exists in the scientific and practice-oriented literature with regard to the most cost effective and efficacious approach to BRD prevention (22,24–26,33–39). In the 1970s and 1980s, much excitement surrounded the implementation of preconditioning programs. Preconditioning included immunization, surgical procedures, and parasite control. Calves were weaned approximately 45 d prior to shipment, and were trained to eat milled feed and drink from an automatic water dispenser (39). Preconditioned calves were to be sold as "premium" animals. Less morbidity and mortality, it was hypothesized, led to reduced loss, healthier animals, improved average daily gain (ADG), and, therefore, improved return for both the cow-calf and feedlot producers. Controversy over effectiveness, in addition to highly variable returns for the cow-calf operator, has rendered such preconditioning programs all but abandoned (39–41). Preweaning programs, on the other hand, appear to have gained interest from both cow-calf and feedlot producers. Preweaning implies that the calf has had some combination of surgical procedures, parasite control, and immunization while still nursing (39). Acclimation to feed and water prior to shipment are not included in preweaning programs; therefore, costs to the cow-calf operator are reduced. Currently, identification and provision of documentation for animals in preweaning programs remain inconsistent.

Recent evidence suggests that methods of treatment for BRD, in addition to the means of identification of calves requiring treatment at the feedlot, may be inadequate to prevent significant production losses associated with BRD (28,42). Certainly, the design and implementation of a herd vaccination program is, in itself, multifactorial. It depends upon the experience and knowledge of the practitioner, participation and cooperation of the producer, consideration of geographic location, individual products, and particular animals. Therefore, no absolute conclusions or recommendations regarding the best strategy for vaccination have been made in this summary. Hjerpe (15) recommends that the veterinarian aim to ascertain as much information as possible about the history, current status, and future use of the animals to be vaccinated. In addition, he suggests that knowledge of (a) the management scheme for the particular operation, (b) the rate of occurrence of infectious diseases in the geographic area, and (c) the biologics commercially available will make easier the decisions regarding rational herd vaccination programs to protect cattle from BRD. Provided here is a compilation of information about those products currently available to practitioners in Canada (Table 1).

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COMING EVENTS

ÉVÉNEMENTS À VENIR

CVMA Conventions/ Congrès de l'ACMV

2000
Saint John, New Brunswick
July/juillet 5–8

2001
Vancouver, British Columbia
August/août 4–11

FEBRUARY/FÉVRIER 2000

Ottawa Academy of Veterinary Medicine — Radiology and Ultrasound. February 3, 2000 at the Embassy West Hotel in Ottawa, Ontario. Contact: Dr. Susan Kilborn, Ottawa Academy of Veterinary Medicine, 125 Owl Drive, Ottawa, Ontario K1V 9J5; tel.: (613) 736-7673; fax: (613) 736-9502.

Lifelearn Inc. Residential Courses — Module 1: Upper and Lower GI Endoscopy. February 4–5, 2000 at the Lifetime Learning Centre, Ontario Veterinary College in Guelph, Ontario. Contact: Anne Behnan, Lifelearn Inc., tel.: (800) 375-7994; fax: (519) 767-1101; e-mail: abehnan@lifelearn.com.

Office International des Épizooties — International Conference on Risk Analysis in Aquatic Animal Health. February 8–10, 2000 in Paris, France. Contact: Dr. K. Sugiura, Office International des Épizooties, 12 rue de Prony, 75017, Paris, France; tel: 33 (0) 1 44 15 18 88; fax: 33 (0) 1 42 67 09 87; e-mail: k.sugiura@oie.int; Web site: http://www.oie.int.

2000 Elk Conference for Veterinarians. February 9–10, 2000 at the University of Minnesota, St. Paul Campus, in St. Paul, Minnesota, USA. Contact: Veterinary Outreach Programs, College of Veterinary Medicine, University of Minnesota, 440 Vet. Teaching Hospitals, 1365 Gortner Avenue, St. Paul, Minnesota, USA; tel.: (612) 624-3434; fax: (612) 625-5755; Web site: www.cvm.umn.edu/outreach.

American Animal Hospital Association — Veterinary Management Development School — Level I. February 9–12, 2000 in Denver, Colorado, USA. Contact: AAHA Member Service Center, tel.: (800) 883-6301 or (303) 986-2800.

Ontario Veterinary Medical Association — Annual Conference. February 17–19, 2000 at the Ottawa Congress Centre/Westin Hotel in Ottawa, Ontario. Bovine, equine, small animals and public health sessions. Special registration fees for out-of-province delegates. Contact: Ineke Vanden Beukel, Delegate Coordinator, Ontario Veterinary Medical Association, 245 Commercial Street, Milton, Ontario L9T 2J3; tel.: (905) 875-0756; fax: (905) 875-0958; e-mail: info@ovma.org.

American Animal Hospital Association — Veterinary Management Institute — Financial Management Module. February 25–27, 2000 at Purdue University in West Lafayette, Indiana, USA. Contact: AAHA Member Service Center, tel.: (800) 883-6301 or (303) 986-2800.

MARCH/MARS 2000

American Animal Hospital Association — Veterinary Management Institute, Series IX (Strategic Thinking Module). March 3–5, 2000. Contact: AAHA, Member Service Centre; tel: (800) 883-6301 or (303) 968-2800.

Lifelearn Inc. Residential Courses — Module 2: Biopsy Retrieval and Upper Respiratory Endoscopy. March 4–5, 2000 at the Lifetime Learning Centre, Ontario Veterinary College in Guelph, Ontario. Contact: Anne Behnan, Lifelearn Inc., tel.: (800) 375-7994; fax: (519) 767-1101; e-mail: abehnan@lifelearn.com.

Veterinary Orthopedic Society — 27th Annual Conference. March 3–11, 2000 in Val d'Isere, France. Contact: Daman-Nelson Travel, 2 Harrison Street, San Francisco, California 94105 USA; tel.: (800) 782-4554 or (415) 247-5500; fax: (415) 247-5510.

Veterinary Homeopathy Course. March 22–25, 2000 at the College Inn in Guelph, Ontario. Case-taking, repertory and materia medica, remedy selection, evaluating responses, managing acute and chronic cases, practical use of homeopathy in a clinical setting. Contact: Dr. David Evans, Natural Care Clinic for Pets, RR#3 Chester Basin, Nova Scotia B0J 1K0, tel.: (902) 275-3553, fax: (902) 275-2435.

Ottawa Academy of Veterinary Medicine — Reconstructive Surgery Seminars. March 29, 2000 at the Embassy West Hotel in Ottawa, Ontario. Contact: Dr. Susan Kilborn, Ottawa Academy of Veterinary Medicine, 125 Owl Drive, Ottawa, Ontario K1V 9J5; tel.: (613) 736-7673; fax: (613) 736-9502.

APRIL/AVRIL 2000

American Animal Hospital Association — Veterinary Management Development School — Level I. April 1–4, 2000 in Toronto, Ontario. Contact: AAHA Member Service Center, tel.: (800) 883-6301 or (303) 986-2800.

American Animal Hospital Association — 67th Annual Meeting. April 1–5, 2000 in Toronto, Ontario. Contact: AAHA Member Service Center, tel.: (800) 883-6301 or (303) 986-2800.

American Institute of Ultrasound in Medicine — 44th Annual Convention. April 2–5, 2000 at the Moscone Center in San Francisco, California, USA. Contact: AIUM Professional Development Department, 14750 Sweitzer Lane, Suite 100, Laurel, Maryland 20707-5906 USA; tel.: (301) 498-4100 or 1 (800) 638-5353; fax: (301) 498-4450; e-mail: conv_edu@aium.org, Web site: www.aium.org.

Lifelearn Inc. Residential Courses — Module 3: Rigid and Avian/Exotic Endoscopy. April 7–8, 2000 at the Lifetime Learning Centre, Ontario Veterinary College in Guelph, Ontario. Contact: Anne Behnan, Lifelearn Inc., tel.: (800) 375-7994; fax: (519) 767-1101; e-mail: abehnan@lifelearn.com.

Science on Safari — Wildlife Immobilization Course. April 15–22, 2000 in Kruger National Park, South Africa. Contact: Science on Safari, Box 681, White River, South Africa; tel.: +27 13 751 2446; fax: +27 13 751 750013; e-mail: onsafari@global.co.za.

Ottawa Academy of Veterinary Medicine — Endocrinology. April 27, 2000 at the Embassy West Hotel in Ottawa, Ontario. Contact: Dr. Susan Kilborn, Ottawa Academy of Veterinary Medicine, 125 Owl Drive, Ottawa, Ontario K1V 9J5; tel.: (613) 736-7673; fax: (613) 736-9502.