Back to the basics – let's talk vaccines

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Abstract

Vaccination is an important management tool utilized in all food animal production models. Multiple vaccines exist for beef and dairy cattle that cover a myriad of diseases from respiratory viruses and bacteria to venereal infections. The core vaccinations recognized both in beef and dairy cattle include vaccinations for respiratory disease, leptospirosis, and clostridial disease. Vaccination schedules vary depending on the operation. This proceeding will discuss some of the diseases of beef and dairy cattle that are protected against by vaccinations and common vaccination schedules.

Key words: beef cattle, dairy cattle, vaccinations

Introduction to vaccines

There are several different types of vaccinations available depending on the pathogen that is to be protected against. Bacterial vaccinations are generally considered killed, meaning there is no live component of the bacteria in the vaccination. These killed vaccines can be either bacterins that target the actual bacteria itself that causes disease or toxoids that target the toxins produced by overgrowth of infectious bacteria. Viral vaccinations can also be killed or can be modified-live. Modified-live vaccinations have a live component of the pathogen that has been modified to avoid causing clinical disease but to stimulate a strong immunological response. Finally, autogenous vaccinations are killed vaccinations made from a specific strain of the pathogen that is affecting a specific animal or herd. These vaccinations are made to protect a herd from a specific bacterial pathogen that is causing clinical disease within that herd.

Clinically, there is a difference between modified-live and killed vaccinations. Modified-live vaccinations will generally stimulate a stronger immune response due to the ability of the pathogen to replicate within the body, requiring only one dose of vaccination. Killed vaccinations will not stimulate a strong enough immune response with one dose for the body to create effective antibodies because the pathogen will not replicate within the body. Therefore, a follow-up dose, or booster, is required for full immunity. Modified-live vaccinations are marketed as a dry cake containing the pathogen that must be reconstituted with a specific volume of sterile water. This product has a long shelf life when not reconstituted but once reconstituted it is recommended to use the entire vaccination within hours or days. Killed vaccinations have a longer shelf-life and do not need to be reconstituted.

Pathogens protected by vaccinations in cattle

Respiratory viruses

The bovine respiratory disease complex, also known as "shipping fever", is one of the costliest diseases that affects beef cattle. The cost of treatment, loss of condition and productivity for individual animals, and mortality associated with respiratory disease can be devastating to a beef producer. The bovine respiratory disease complex includes both respiratory viruses and bacteria. The four main viral diseases of concern are bovine respiratory syncytial virus (BRSV), infectious bovine rhinotracheitis (IBR), bovine viral diarrhea virus (BVDV), and parainfluenza-2 (PI-3).

BRSV is a paramyxovirus that affects the lower respiratory tract. Respiratory epithelial cells become multi-nucleated giant cells (known syncytial cells) that compromise lung function. BRSV can be asymptomatic but will clinically cause an interstitial pneumonia that can result in death. Clinical signs include fever, dyspnea, open-mouth breathing, bullae formation in the caudal lung fields that may rupture and lead to atelectasis, and subcutaneous emphysema over the thorax (often following atelectasis). On necropsy, affected animals will have inflated lungs that do not collapse when the chest cavity is open. PI3 is also a paramyxovirus but will not cause severe clinical disease as a sole infectious agent. Instead, this virus will exacerbate other viral and bacterial infections. Clinical signs may include cough, fever, and malaise/lethargy.

IBR is caused by bovine herpesvirus-1 which causes an upper respiratory infection. Clinical signs include fever, cough, nasal discharge, hyperemia of the nares, and diphtheritic membranes on the nasal mucosa that appear as white plaques. No lower respiratory involvement is noted with this infection. Bovine herpesvirus-1 may also lead to late gestation abortion and abortion storms. Like with herpesviruses of other species, the animal will not fully clear the infection and instead will go through periods of remission. Recrudescence of the virus occurs during times of stress.

BVDV has two phenotypic types – type I and type II. BVDV does not classically cause primary respiratory disease. Instead, it is an extremely immunosuppressive virus. Transient infection is possible in young and adult animals where animals will remain viremic for two weeks and may show little to clinical signs (although immunosuppression is evident). Infection in pregnant animals will, however, lead to more obvious clinical presentation. Cattle affected within the first 45 days of gestation will experience early embryonic loss. Cattle affected between day 45 and 125 (30-150) will give birth to a persistently infected calf. This calf can be born appearing healthy or be weak and unthrifty. The calf will shed the virus in all bodily fluids including mucus, blood, tears, urine and feces and help to spread the disease among the herd. Only about 25% of persistently infected calves will live to adulthood and produce offspring, which will be persistently infected. The other 75% either succumb to other disease (the virus is still severely immunosuppressive in persistently infected calves) or develop the fatal mucosal disease which involves either mutation from the non-cytopathic form of BVDV that classically creates persistently infected animals to the cytopathic form or superinfection with the cytopathic form. This is often a rare presentation. Cattle affected between day 75-150 may have calves that develop birth defects including the most common, cerebellar hypoplasia. Cattle affected after 180 days gestation will either have late-term abortion, a stillborn calf, or a calf that is born without the virus (the calf was

immunocompetent enough to avoid becoming persistently infected). BVDV type II is known to also cause thrombocytopenia along with immunosuppression.

Many companies market vaccinations for respiratory viruses. Both killed and modified-live options exist. Respiratory virus vaccinations are considered a core vaccination for cattle and are utilized in both beef and dairy production models. See below for a vaccination schedule example.

Respiratory bacteria

The respiratory bacteria that affect cattle include *Mannheimia hemolytica*, *Pasteurella multocida*, *Histophilus somni* and *Mycoplasma bovis*. These bacteria are secondary invaders often following viral respiratory infection. *Mannheimia hemolytica* and *Pasteurella multocida* are normal inhabitants of the nasal passage and will invade the lower respiratory tract to establish disease when the mucociliary apparatus is not functioning well and the respiratory immune functions are overwhelmed. *M. hemolytica* will cause fibrinous bronchopneumonia with extensive damage to the lung cranioventrally. An exotoxin, specifically a leukotoxin, leads to *M. hemolytica* being one of the most destructive pathogens. On necropsy, extensive fibrin covers the lungs and affected lung tissue is plum to gray, heavy, and sinks in formalin. *Pastuerella multocida* can cause a similar clinical picture with less destruction and bronchopneumonia is characterized as purulent.

Histophilus somni causes a generalized vasculitis that can lead to several clinical diseases. Pneumonia from this pathogen is characterized as purulent bronchopneumonia, but this vasculitis is also known for leading to thromboembolic meningoencephalitis. This causes neurologic signs in cattle where they develop a fever, become depressed then recumbent. As the disease progresses, they may become more neurologic with opisthotonos and seizures and will ultimately die. *H. somni* may also cause arthritis and otitis interna/media. *Mycoplasma bovis* causes a caseonecrotic bronchopneumonia with micro abscess formation in the lungs. Other infections caused by *M. bovis* include mastitis, arthritis, otitis interna/media and keratoconjunctivitis.

Commercial vaccinations are available for *M. hemolytica, P. multocida*, and *H. somni*. *M. hemolytica* is a killed toxoid, *H. somni* is a killed bacterin, and *P. multocida*is a killed bacterial extract. These pathogens are often given in combination with respiratory viral vaccination although a stand-alone product with a *M. hemolytica* and *P. multocida* combination does exist. These vaccinations may be useful prior to shipment of animals. Respiratory viral pathogen combination products contain modified-live versions of the respiratory viruses and therefore boosters are not needed with these products. The *M. hemolytica* and *P. multocida* product recommends a single 2-milliliter dose intramuscularly followed by a booster only if stressful scenarios are expected. These vaccinations are not considered core vaccinations across the cattle industry.

Clostridial pathogens

There are many clostridial pathogens that can affect cattle. There are vaccinations that typically protect against 7 or 8 different clostridial pathogens labeled for use in cattle. These vaccinations are killed vaccines that are given as a 5-milliiter dose under the skin. These vaccinations may cause reaction site lesions at the injection location.

The 8-way clostridial vaccination protects against *Clostridium chauvoei*, *C. novyi*, *C. sordelli*, *C. septicum*, *C. haemolyticum*, *C. perfringens* type C and D and *C. tetani* (7-way clostridial vaccinations do not have a *C. tetani* component). "Blackleg" caused by *C. chauvoei* is considered a major concern in cattle and is often the most common clostridial disease recognized by cattle producers. It is important to remember that almost all clostridial pathogens (except for *C. perfringens*) are found in the soil. These pathogens are opportunistic and cause disease in two ways – either the bacteria invade the body through external wounds or through micro-abrasions in the mouth and travel via the bloodstream to a target organ or the bacteria will cause infection after soil or fecal material contaminate a wound. Clostridial pathogens are also anaerobic and do require an anaerobic environment to be created to multiply. Finally, it is important to remember that clostridial pathogens cause disease by producing toxins that affect the body. The following table may be helpful to organize the clostridial pathogens:

Table 1: Clostridial pathogen organization tool.

Bacteria	Pathogenesis	Target organ	Clinical disease
Clostridium chauvoei	Dormant spores activated by tissue damage and/or contaminated wounds	Muscle	**Blackleg**- subcutaneous emphysema and necrotizing myositis
Clostridium novyi type B	Dormant spores activated by tissue damage	Liver	**Black Disease**- necrotic hepatitis
Clostridium haemolyticum	Dormant spores activated by tissue damage	Liver	**Bacillary Hemoglobinuria (Red Water)**- hemolytic anemia, hemoglobinuria
Clostridium septicum	Dormant spores activated by tissue damage and/or contaminated wounds	Muscle	**Malignant Edema**- local/ regional pain, swelling, signs of shock
Clostridium sordelli	Contaminated wounds	Subcutaneous tissue	**Big Head**- swelling, edema, necrosis of tissue

Geographically, herds may consider use of the 8-way clostridial vaccination in the Pacific Northwest, Southeast and the Great Lakes regions of the country to protect from more than just the classic "Blackleg". This is due to the presence of liver flukes. Liver flukes will migrate through the liver, causing damage to the liver tissue and allowing for dormant spores of *C. novyi* type B and *C. haemolyticum* to activate. Both conditions are fatal, making prevention paramount.

Reproductive pathogens

Leptospirosis is an important pathogen of cattle that can lead to liver and kidney damage as well as abortion. A commercially available vaccination is labeled for cattle. This vaccination is a 5-way leptospirosis vaccination that includes the serovars Pomona, Hardjo-Bovis, Grippotyphosa, Icterohemorrhagiae and Canicola. Hardjo-Bovis is considered host-adapted to cattle. Abortion can be caused by many of the serovars listed above. Leptospirosis is transmitted via urine from affected animals, and vaccination may be most appropriate for animals that live in areas with standing water (ponds, areas of poor drainage). Unfortunately, the vaccination for leptospirosis (a killed bacterin with a 2-milliliter dose) has a short duration of immunity often only lasting several months. Leptospirosis is considered a core vaccination in most dairy production models and is given at multiple points in the cow's production life due to this short duration of immunity.

The venereal diseases of cattle, found mostly in beef cattle, are caused by *Campylobacter fetus* subspecies *fetus, Campylobacter fetus* subspecies v*enerealis*, and *Tritrichomonas foetis*. These pathogens are spread during coitus. Bulls are asymptomatic and will infect cows leading to early pregnancy loss, infertility, prolonged calving season, and pyometra (especially with *T. foetis*). The newest vaccination available for cows claims to reduce the spread of *T. foetis* and protect against *C. fetus*. This vaccination is a killed bacterin and comes as a combination product with both venereal pathogens or as a singular *T. foetis* vaccination. It is recommended to give 2-milliliters of the single pathogen product or 5-milliliters of the combination product under the skin then booster 2-4 weeks later. The final booster should be done at least four weeks prior to the breeding season. In the past, many vaccinations for venereal diseases were not considered very reliable, but this new product shows promise. This is not a core vaccination across the cattle industry but is most useful in cow-calf operations utilizing natural cover.

Brucella abortus is the final reproductive vaccination that may be recommended for cattle. *Brucella abortus* is a reportable disease that can lead to abortion in cattle. This vaccination is a modified-live vaccine that can only be administered by licensed and class II accredited veterinarians. It is a zoonotic pathogen, and disease transmission can occur via the vaccination. This vaccination is only approved for use in heifers between the age of 4 and 12 months of age. No booster is required.

Pinkeye

Infectious bovine keratoconjunctivitis, also known as "pinkeye" is caused by multiple bacteria including *Moraxella bovis, Moraxella bovoculi, Mycoplasma bovis* and *Mycoplasma bovoculi*. These bacteria will lead to epiphora, blepharospasm, central corneal ulceration, corneal edema and neovascularization of the cornea. A commercial vaccination is available for *Moraxella bovis* which is a killed bacterin. The efficacy is questionable especially with the variety of pathogens that can cause clinical infectious bovine keratoconjunctivitis. Autogenous vaccination may be more effective at preventing pinkeye in herds that routinely deal with this problem.

Foot Rot

Foot rot is caused by *Fusobacterium necrophorum*. This condition is caused by an environmental pathogen that is ubiquitous in the soil and will cause interdigital dermatitis that does not extend beyond the interdigital space. Both beef and dairy cattle can be affected by this disease. Extensive environmental and animal management is necessary to control infection and reduce clinical cases including the use of foot baths and flushing to avoid standing manure in barns, management tasks that are easier to accomplish in the dairy industry.

A commercial vaccination does exist for *F. necrophorum,* but the efficacy of this product is questionable. Other management practices such as removal of animals from wet, muddy or manure-heavy pastures and the implementation of foot baths may be better alternatives to vaccination.

Rabies

Rabies is a fatal neurologic infection caused by lyssaviruses of the family Rhabdoviridae. Rabies is zoonotic and fatal to humans. The rabies vaccination is a killed vaccine. The rabies vaccine for large animals is only labeled for sheep, cattle and horses. Rabies vaccination should be done after calves are over three months of age and should be boostered annually. The most common large-animal-specific rabies vaccination requires a 2-milliliter dose administered under the skin. It is highly recommended that any bovid with regular human contact (pet, petting zoo, educational animal) should be vaccinated for rabies in endemic areas.

Mastitis

There are several commercial products available for vaccination against coliform mastitis. The main pathogen included in this vaccination is *E. coli*. Dairy farms may utilize this vaccination in their vaccine protocol, especially if coliform mastitis is a common occurrence on the farm. Other management techniques such as clean and dry calving pens, proper flushing of free-stall alleys, and adequate bedding turn-over in freestalls can aid in prevention of coliform mastitis.

Scours

Vaccination against common pathogens that lead to calf scours are commercially available. It is recommended that these vaccinations be administered to the dam prior to parturition, limiting the shedding of pathogens from the dam and into the environment while adding antibodies to the colostrum for the newborn calf. Healthy pregnant cows and heifers can be administered 2-milliliters of killed vaccination intramuscularly followed by a booster three weeks later. Ideally this vaccination will be boostered 3-6 weeks before calving. This killed vaccine for the dam contains *E. coli*, rotavirus, coronavirus, and *Clostridium perfringens* type C.

A modified-live viral vaccination is also available for calves. This vaccination contains coronavirus and rotavirus and is administered as a 3-milliliter dose orally to newborn calves. Dams can also be vaccinated with this product and will receive two 3-milliliter doses three weeks apart. Ideally, the second booster dose should be given 30 days prior to parturition to allow for proper antibody deposition into the colostrum.

Scour vaccinations may be helpful on dairy and beef operations, but cleanliness and proper management of newborns can be just as helpful. For bottle raised calves, making sure that all equipment is properly cleaned and sterilized after use is essential. Removing fecal material from the calf's environment will also decrease exposure to pathogens classically found in the manure.

Vaccination schedule

The following vaccination schedules are suggestions. Different operations may elect to provide vaccinations at different times during the life of the animal or elect to add other "core" vaccinations depending on diseases found within that herd. The recommended core vaccinations for cattle in almost all management systems are respiratory virus vaccination, leptospirosis vaccination and clostridial vaccination.

Dairy cattle

This protocol is primarily for heifers and cows due to the short tenure of bulls on most dairy farms. At birth it is recommended to give a modified-live intranasal respiratory virus vaccination to all calves, although bull calves may not be vaccinated due to their short tenure on the farm. This vaccination contains BRSV, PI3 and IBR. Injectable products are not recommended until the animal is at least six weeks of age at which time injectable respiratory viruses/leptospirosis vaccinations (either killed or modified-live)and clostridial vaccination (killed) are recommended. At 9-10 weeks of age any killed respiratory virus/leptospirosis vaccination should be boostered and the clostridial vaccination will require a booster.

Depending on the farm, producers may elect to administer the first injectable vaccinations at 4-6 months of age. Often called "calfhood" vaccines, this set of vaccination includes the respiratory virus/leptospirosis vaccination and the clostridial vaccination but also the *Brucella abortus* vaccination. Appropriate boosters for killed vaccinations would follow 3-4 weeks later but *B. abortus* does not require a booster. Pre-breeding vaccinations will be administered at 10 months of age or three weeks prior to breeding and include boosters to the respiratory viruses/leptospirosis vaccine and clostridial vaccine. Finally, at pregnancy diagnosis it is recommended to booster the leptospirosis vaccination.

Dry off for dairy cattle is an important time to provide protection from pathogens that may lead to complications in the future. For far-off cows (cows in the first 30 days of dry off), leptospirosis vaccination and vaccination for coliform mastitis (if the producer is interested in this) are recommended. Thirty days later, when cows are considered in the close-up dry off stage, leptospirosis vaccination, clostridial vaccination, and (if elected) vaccination for coliform mastitis pathogens and vaccination against agents that cause scours in calves are recommended. In the 3-4-week post-partum period, it is recommended that cows receive the respiratory virus and leptospirosis vaccinations, clostridial vaccination, and the final coliform mastitis pathogen vaccination. Pre-breeding vaccinations will then start the cycle over again for multiparous females.

Beef cattle

Although dairy cattle vaccination protocols may vary greatly from farm to farm, there is more consistently than in the beef production model. Vaccination in the beef cattle industry depends on how often cattle are handled. Ideally, calves will be given an initial dose of respiratory virus/leptospirosis and clostridial vaccinations two-three months prior to weaning and a booster one month later. This would allow immunity to be established prior to weaning the calf, an extremely stressful time in the calf's life. However, many beef producers may elect to wean and vaccinate calves at the same time which is often counter-productive. The stress from weaning will interfere with immunity development stimulated from the vaccination.

For cows being bred with live cover, pre-breeding vaccination for *Campylobacter* spp. And *Tritrichomonas foetis* is recommended. Pre-breeding vaccination, like dairy cattle, involving respiratory virus/leptospirosis vaccination and clostridial vaccination may also be recommended. Pre-calving vaccination with respiratory virus/leptospirosis and clostridial vaccination as well as scour pathogens vaccination is recommended with the booster being given three to four weeks before calving. Depending on where producers are geographically, it is more challenging to plan a structured beef cattle vaccination program. For example, in the southeastern United States it is very common for bulls to be with cows year-round. This means there is no structured calving season and it is challenging (if not impossible) to have a structured vaccination program. Many cow-calf producers will provide a once-a-year booster vaccination for respiratory virus/leptospirosis and clostridial disease to cows while vaccinating calves close to weaning or at weaning.

Conclusion

There is a myriad of vaccinations available for beef and dairy cattle, and vaccination strategies may differ within each industry. It is important that the veterinarian recognize what vaccinations should be considered core vaccines (respiratory virus, leptospirosis and clostridium) and what vaccinations can be added on a herd-by-herd basis. Veterinarians benefit producers by working with them to establish vaccination protocols that best fit their operations and by making producers aware of the disease threats that vaccinations can protect against.

