New Era of Parasite Control-BMPs for Beef Cattle

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Abstract
Control of gastrointestinal nematodes (GIN) may have economic and health impacts in beef cattle operations. In the past several decades, GIN control has relied almost exclusively on the use of anthelmintics. With the increase in anthelmintic resistance (AR) new strategies must be developed. Knowledge of GIN biology and epidemiology in the region based on climate and weather; and specific information from the ranch, such as quantitative fecal egg counts (FEC), estimates of AR through fecal egg count reduction tests (FECRT), ages of the cattle and pasture management are necessary to develop GIN control programs. Control programs should integrate grazing management, management of the immune system so cattle can resist infection, and anthelmintic use.

Key Words: Beef cattle, gastrointestinal, parasites, nematodes, anthelmintic resistance

Introduction
Control of GIN may have positive economic and health impacts in beef cattle operations in the United States (U.S.). In the past several decades, GIN control has been based almost exclusively on the use of anthelmintics. The increase in AR dictates that new strategies be developed. This paper will focus on the information needed to develop control strategies and give some basic recommendations that can be tailored to individual cow-calf and stocker operations.
**Major GIN of Concern**

The GIN of cattle that have significant prevalence and veterinary importance in the U.S. are *Cooperia* spp. (*oncophora, punctate* and *pectinata*), *Haemonchus placei* and *contortus*, and *Ostertagia ostertagi*.\(^1,2\) National Animal Health Monitoring System (NAHMS) data from 2007-2008 showed that over 80% of operations submitting fecal samples were positive for GIN\(^3\).

*Ostertagia ostertagi* is most the most important GIN of cattle because of its high pathogenicity and its impact on a wider age range of cattle.\(^4\) *Haemonchus placei* and *contortus* are also very pathogenic but usually only impact weanlings and yearlings. *Cooperia* spp. are less pathogenic than either *Haemonchus* or *Ostertagia*, but in warm wet conditions may be present in very large numbers and become economically and clinically significant.

Anthelmintic resistance (AR) is covered in more depth in the previous paper but warrants mention here. Level of AR is highly variable depending on location but there is no question that AR is reported across the U.S. for all of the major GIN. Of particular concern is the emergence of AR to *Ostertagia*.\(^5,6\) Deaths due to *Ostertagia* in adult cattle have been reported in Louisiana (C. Navarre, personal communication).

**Goals of Control Programs**

There are two goals in controlling GIN: control economic losses; and control clinical disease. The level of infection determines both health and economic impacts of GIN. At low levels, there may be no economic impact and development of immunity can be protective to health. At moderate levels, production losses occur without evident clinical disease. The most studied impact from GIN is on weight gains in young growing animals but impacts on
reproductive efficiency and milk production in adult cows is also reported.1,4,7 A study from 2013 looking at efficacy and production benefits following use of extended-release injectable eprinomectin showed significant differences in weight gain of 30.4 kg, 19.1 kg and 8.6 kg in calves from Louisiana, Arkansas and Missouri, respectively.8 In this study efficacy was high with fecal egg count reductions > 95% at all sites and these gains might not be obtained in the face of lower efficacy from AR. Clinical disease from high GIN burdens can occur, even in adults, especially when other stressors occur, particularly nutritional stress.

There is no question that there are economic and sometimes health benefits from controlling GIN in cattle. But predicting the outcomes of deworming on an individual ranch is difficult. Extrapolating research findings to individual farms and expecting similar gains in growing cattle is risky. Levels of AR as well as management factors (weather, nutrition, other diseases, etc.) all impact growth in young cattle. Deworming benefits in older cattle are even less predictable. It’s important to remember that AR is not static and that extrapolating gains from studies from even a few years ago can be misleading. On ranch monitoring and trials are the best way to adapt recommendations to individual ranches.

**Background Information Needed to Develop Control Programs**

Control programs should integrate grazing management, management of the immune system so cattle can resist infection, and anthelmintic use. The first step is to understand what is happening on an individual ranch. This takes knowledge of GIN biology and epidemiology in the region based on climate and weather, and specific information from the individual ranch, such as quantitative fecal egg counts, estimates of AR through FECRT, ages of the cattle and pasture management. The reader is encouraged to go to other sources to get more in depth
Knowledge in these areas. This paper will focus on how to put this information into practice to develop integrated GIN control programs.

**Climate and Weather**

A basic understanding of how climate and weather impact GIN biology is advantageous when developing pasture management plans. In the norther U.S. shorter grazing seasons and extended freezing temperatures keep GIN at levels lower than the southern U.S. The gulf coast states region typically has higher rainfall than the south central region. The generally low stocking density and low rainfall in the southwestern United States greatly lessen GIN transmission compared to the gulf coast states. In the southern U.S. the climate is too hot most of the summer for the free living stages of GIN to survive, although there are exceptions. The greatest infection risk for *Ostertagia* is from fall through spring. *Ostertagia* does not survive at any time in southern most parts of Florida and Texas although this may be changing (Tom Craig, personal communication). *Cooperia* and *Haemonchus* are more heat tolerant than *Ostertagia* and can be problematic in wet summers. Areas with higher rainfall tend towards higher GIN problems. It should be noted that rainfall may be increasing across the U.S. above what is typical which may change GIN epidemiology from what has been seen in the past.

Climate also impacts seasonal arrestment of development of GIN, the most important of which is the late spring and early summer arrestment of *Ostertagia* in the south and winter arrestment in the north. Resumed development in the fall or spring, respectively, can lead to Type II ostertagiosis, which is not common, but is severe when it occurs. It most commonly occurs in older steers, replacement heifers and bulls.
On a given ranch weather plays an important role in GIN transmission by speeding up or slowing down the free living portion of life cycle. The ranges vary somewhat depending on the species, but under conditions of moderate temperatures (7-25°C) and moisture (at least 1 inch of precipitation per month), the period from egg hatching to the infective larval stage is 7-14 days.\textsuperscript{10–12} Colder weather can lengthen this period as well as decrease the percent hatch of eggs.\textsuperscript{4} Larva must have moisture to migrate from the fecal pat, so drought can delay pasture contamination.\textsuperscript{13} If cattle shedding eggs remain on pastures, there can be a buildup of eggs that hatch in a short period of time once rains resume. This can lead to an overwhelming infection, precipitating more severe economic losses and even clinical disease.

Weather also impacts the longevity of the infective stages of larva, which can range from days to several months.\textsuperscript{10,11} Infective larva have limited energy stores. In hot weather, their metabolism is faster and these energy stores are used up quickly. The opposite is true in cooler weather. Leaving pastures unoccupied for a few months in the summer (as long as there is rain to make any eggs already there hatch) can greatly reduce the GIN burden.

**Pasture and Grazing Management**

Pasture management is an important component of GIN control as well as delaying and/or reversing AR. While pasture type, quality, topography and drainage can all influence prevalence of GIN on pasture, these are usually factors that are difficult to change. Grazing management offers the most practical solution.

Pastures with reduced GIN contamination (“safe” or “clean” pastures”) can be especially helpful in controlling GIN in stocker cattle (Thomas A. Yazwinski and Tucker 2006). There are several ways of making clean pastures:
• Pasture rest in summer
  o Must have rain at the beginning of the rest period
• Alternating land use as pasture and crop/hay production
• Annual or biannual pasture renovation
• Co-grazing with alternate, less suitable hosts
  o Alternate calves with adult dry cows
  o Horses (sheep and goats not as suitable as they share GIN species with cattle)

Avoidance of over-stocking is a common recommendation to avoid buildup of GIN on pasture but “over stocking” should be defined. It usually refers to too many animals grazing continuously on limited land. Some high intensity “mob” grazing systems have very high stocking rates but for very short periods of time with long periods of rest. This type of grazing could be detrimental in the short term if pastures are contaminated since cattle will graze close to the ground. But it may have benefits in the long term by decreasing GIN levels from long rest periods. More research is needed to elucidate benefits and risks.

The combination of safe pastures and suppressive anthelmintic use can hasten the development of AR. Treating an entire group of cattle and turning onto safe pasture will lead to a high population of AR GIN. If that land is not permanent pasture but made safe again following a period of grazing (one season), then the impact on AR is minimal. If however that pasture is used continuously, AR will increase.

Pasture rotation at a set length of time is frequently cited as a way to control GIN. This may be true if the life cycle was not so unpredictable based on weather. Estimates of vertical migration of infective larva is also often used to try to prevent transmission via controlling grazing height. Many factors determine vertical migration (forage type, GIN species,
temperature and moisture)\textsuperscript{10,14} so predicting where the GIN will lie in wait to try to thwart them with grazing management is difficult and impractical. Grazing management should be based on best management practices for the particular forage being grazed in a particular locale which maximizes forage sustainability and nutritional benefits to the cattle.

**Management that Impacts the Immune System**

Understanding how GIN burdens impact the immune system of cattle is beyond the scope of this paper but readers are encouraged to consider the impact of GIN on vaccine response and disease resistance when developing comprehensive herd health plans. Conversely, understanding how the immune system of cattle impacts GIN burdens is also an important component of developing GIN control programs.

Age, sex, breed, genetics and overall health all influence susceptibility to GIN. Young cattle, especially stocker calves and replacement heifers, are most susceptible.\textsuperscript{7} But older cattle can have severe parasitic disease including mortality when GIN burdens are combined with other stressors or are not allowed to develop immunity. This is most evident in brood cows in winter that are either nursing a calf or heavy pregnant depending on the calving season. A combination of high GIN contamination of pastures and poor nutrition, severe weather and/or other GIN (liver flukes in particular) can lead to serious disease. Males are more susceptible to GIN than females and bulls should not be overlooked when designing GIN control programs.\textsuperscript{15} Cattle don’t have as drastic a periparturient drop in GIN resistance as is seen in small ruminants.

There is some evidence that *Bos indicus* breeds of cattle may be more susceptible to *Ostertagia* (Thomas Craig, personal communication). The theory is that these breeds were developed in parts of the world that were too hot for *Ostertagia* to survive, so there was no
evolutionary pressure to develop an immune response to *Ostertagia*. Research is needed to clarify this potential species difference in susceptibility.

Some cattle are genetically more susceptible to GIN than others. It’s estimated that 20% of cattle harbor 80% of the GIN in a herd. With a moderate heritability index of 0.3, genetic selection for GIN resistance is possible over time.\textsuperscript{16–18} FECs could theoretically be used as one selection tool in cattle but only in young animals and only with *Cooperia* and *Haemonchus*, not *Ostertagia*. Unfortunately, putting this into practice is more complicated as several other factors may influence FECs. Time of year impacts the FECs and the heritability index and therefore impacts the power of genetic selection based on FECs.\textsuperscript{17} Also, the milking ability of the dam is inversely correlated with GIN burdens in nursing calves\textsuperscript{19} and may influence FECs and selection. Selecting for GIN resistance may have positive or negative impacts on other production traits and much more research is needed to reveal candidate genes that may infer GIN resistance and how these selection tools correlate with other traits of importance.

**Diagnostics**

Given all of the variables discussed so far, it’s easy to see why collecting data on individual ranches is a must. Diagnostic methods are covered in the previous paper. Regardless of the specific techniques chosen and the shortcomings of FECs and FECRT data, this information is still critical to developing control programs on individual ranches. FECs are primarily considered useful for monitoring patterns for grazing management rather than assessing infection levels (ie. treatment threshold).\textsuperscript{20} Magnitude of change in weight gains between treated and untreated calves are generally correlated with FECs. In the study by Kunckle cited previously, the greatest change in gains was in LA where egg counts were higher
(140-271 FECS) than in Arkansas and Missouri (60-68 and 51-77 FECS, respectively). But a true universal FEC treatment threshold recommendation is illusive and is best determined with on-ranch trials. In herds where management and nutrition are optimal and FECs remain low, deworming may not be necessary and these herds have the opportunity to put resources elsewhere.

Periodic surveillance of FECs in different groups of cattle at different times of year and under different management schemes and stressors give insight into the magnitude and timing of GIN burdens. When FEC data over years is combined with production, weather, and grazing data, more targeted treatment decisions can be made. Surveillance of young cattle, particularly at the later part of the nursing period, and 6-8 weeks after turnout of stocker cattle are top priority. Monitoring adult cattle under nutritional stress may also be helpful. Changes in management or weather, particularly rainfall, should be taken into consideration when comparing FECs from year to year. FECRT data is a must for guiding refugia-based treatment and management recommendations.

**Principles of Control**

Refugia-based GIN control strategies offer the best balance of short-term economic benefits of deworming and long-term sustainability of anthelmintic efficacy. “Refugia” are those parasites not exposed to an anthelmintic at the time of treatment and represent a reservoir of genes which impart anthelmintic susceptibility. Refugia provides a source of susceptible worms to mate with resistant worms. When refugia is increased, the rate of resistance development will be reduced. GIN in refugia can be on pasture or in animals and we need to preserve one or the other or both populations. Deworming all animals at once and moving them shortly to a “clean” pasture should be avoided. Also avoid deworming all cattle at the same time where the climate
and/or weather is not conducive to survival of larva in the environment. For example, “strategic” deworming of cattle in the south—all animals in the early summer—was a common recommendation and is no longer appropriate. Warmer and wetter environments may be more conducive to GIN propagation, but it’s harder to eliminate refugia in these areas except under suppressive deworming regimes. This can be an advantage in refugia based programs.

Two main refugia-based strategies exist: targeted treatment (TT) and targeted selective treatment (TST). TT is treatment of the whole herd at the most appropriate times bearing in mind the need to maintain refugia. Treating a herd for *Ostertagia* in the winter or spring in the southern U.S and avoiding treatment in the summer when there is no refugia on pasture is one example. TT can be further enhanced by TST which is selective treatment of only those animals that will most benefit from treatment, leaving the rest of the herd untreated. FAMACHA in sheep and goats is a great example of TST. Unfortunately, there is no chute-side test in cattle like the FAMACHA score in small ruminants to help decide who to treat. TST strategies in cattle that are being researched are based on FECs, weight or weight gain, milk production, age or a combination of these. More research is needed to elucidate which strategies are best in different situations but refugia based principles can be incorporated in recommendations now.

The following recommendations are meant to be a starting place for developing control programs. These recommendations are made somewhat in a “vacuum” and must be integrated with other herd health and production management decisions.

When it is deemed appropriate to use anthelmintics, they should be used properly. To minimize AR, whenever deworming is necessary, products from two or three classes of anthelmintic should be used concurrently. Following label directions for storage of products is critical. Don’t store products at the processing area unless it is climate controlled.
There are other non-anthelmintic alternatives (fungi, dung beetles, copper, etc.) that may offer control options in the future. These have been studied more extensively in small ruminants and more research is needed in cattle.

**Cow Calf Operations**

Increasing overall herd immunity through nutrition, vaccinations, biosecurity and avoiding stress (weaning, handling, heat, etc.) will allow animals to minimize the impacts and increase immunity to GIN. It is the opinion of the author that lack of proper winter nutrition is the biggest risk to adult cows and in turn calves to develop serious parasitic losses and disease.

GIN control recommendations cannot be made without understanding grazing management on the farm. It’s commonly recommended that heifers be managed separately from the older cows for a variety of reasons. Using the same pastures year after year for the heifers should be avoided. Either rotate dry cows through these pastures or have enough pens to be able to rotate and rest pastures. Bulls are the next most susceptible group and the same recommendations hold for bulls.

Anthelmintic resistance develops on farm but it can also be brought in with herd additions. Buying from ranches with active refugia based control programs would be ideal but difficult to find at this time. If the status of AR is unknown then recommendations are to deworm on arrival with at least two classes of dewormer, drylot for 48 hours, then put onto pastures with some refugia. Buying heifers that have been in multiple source stocker operations is a risk for bringing in AR. Bringing naïve cattle to the southern U.S. from northern states or very southern parts of Texas and Florida that may have very little exposure and therefore immunity to GIN is also a risk.
FECs are higher in calves, but because of the higher volume of feces put out by cows, total output can be greater in cows. Therefore, cows serve as a good source of refugia. A general recommendation for maintaining refugia in cow calf operations is leave adult females four years of age and older untreated. First calf heifers are still growing, lactating and trying to reproduce, so don’t need the added stress of GIN, especially Ostertagia. There are exceptions so this is just a starting place. To make this recommendation work, cattle must be healthy and have appropriate nutrition. In fall calving herds the greatest lactation demands coincide with high risk of Ostertagia exposure. Management of purebred Brahman cattle may include second calf heifers into the group that gets dewormed since they are later maturing animals and may be more susceptible to Ostertagia.

One exception to the above recommendation of not treating older females is when there is a need to treat for liver flukes. Areas with severe liver fluke problems may need to treat all adult cattle. The current products available in the U.S. to treat liver flukes also impact GIN. Careful consideration should be given of the impact of liver fluke treatment on GIN refugia. To minimize the impact on GIN AR, two classes of dewormer should be used. Only one of these products needs to be effective against flukes. Having pastures with refugia to graze following treatment of all adult brood cows simultaneously would then be appropriate.

Selection of cattle that do well in a particular environment, including level of GIN pressure, can improve herd productivity and lessen use of dewormers and hence AR. One of the advantages of not deworming adult cows is that selection for productive cows is done under the GIN pressure on that ranch. Selecting productive cows does not equate to selecting GIN resistant cows as many factors influence production. But selecting cows under heavy deworming
may lead to selecting cows that are not GIN resistant. As AR becomes more widespread, this could become a future problem.

Replacement heifers are especially susceptible to *Ostertagia* and usually benefit from deworming. If the entire group is to be dewormed, then maintenance of pasture refugia is important. If that is not possible, consider deworming 90% of the heifers, leaving the heaviest 10% untreated. This ratio of treated vs. untreated may need to be shifted based on results of FECRT.

Bull should generally be managed like replacement heifers. Fencing requirements for bulls makes it more difficult to rotate them to different pastures. But because bulls are more susceptible to GIN, every effort should be made to manage pastures for refugia.

Management of GIN in nursing calves depends on level of exposure. Deworming nursing calves prior to weaning can impact weaning weights and also improve weaning vaccination response. Calving season influences level of exposure. Fall born calves will be grazing when GIN burdens are potentially high in the winter and spring and may benefit from deworming prior to weaning. Spring born calves in general will be exposed at an older age and waiting to deworm at weaning may be appropriate. Calves from spring calving herds in high rainfall areas may have high exposure earlier like fall calving herds.

Control principles are summarized below:

- Increase overall herd immunity
  - Proper nutrition
  - Decrease stressors
  - Decrease other disease pressures
- Graze cows after calves
- Maintain biosecurity practices to prevent introduction of resistant GIN with herd additions
- Incorporate resistance to GIN in genetic selection programs
- Keep refugia
  - Avoid deworming all animals before turnout onto clean pastures
- Especially critical with macrocyclic lactones and other long-acting products
  - In cow/calf operations consider only deworming cattle < 5 years old and allow older cows to serve as refugia
  - Be aware of special circumstances that may alter this recommendation such as nutritional stress, treatment for liver flukes
- Use and store products properly
  - Always use at least two classes of dewormer at the same time
  - Dose based on actual weights if possible
  - Don’t store products at the processing area unless it is climate controlled
  - Follow label directions for storage

**Stocker Operations**

There are basically two different scenarios to consider when developing GIN control programs for stocker cattle: calves from single source where AR levels are known; and calves from multiple sources where the AR levels are not known. Stocker calves with some history are much easier to manage as their AR and treatment history can be combined with knowledge of the pastures they are grazing to better control GIN and further development of AR.

Stocker calves from multiple sources will likely come in parasitized and stressed. Deworming these calves with an effective dewormer may increase weight gains and may or may not have an impact on morbidity and mortality\(^{28,29}\). Grazing on non-permanent pastures (ie. wheat crop) is ideal as the pasture rest and crop preparation steps help to decrease pasture contamination from year to year and buildup of AR. Even if the entire group of calves is treated, AR risk from year to year is minimal. In contrast, grazing permanent pastures combined with frequent use of dewormers has a high risk for development of AR. This is especially true of the macrocyclic lactones which have a residual effect for weeks to months. Deworming entire groups of calves and using the same pastures continually with no rest is no longer sustainable with the current levels of AR that calves have on arrival (Ray Kaplan, personal communication). The two practical options are to leave at least 10% of the calves untreated, or to have enough
pasture to allow for rest. Only grazing stockers in the fall-spring allows pastures to rest in the summer, which is the best time to decrease contamination in the south. Resting pastures in the winter may not impact contamination very much. More research is needed on high intensity (“mob”) grazing techniques as this might offer some solutions.

Sample Control Programs for Cow Calf Herds

The following are templates for developing GIN control programs based on calving season. As discussed above, results of FECs and FECRT monitoring as well as knowledge of grazing and other management factors should be used to fine tune these recommendations for individual ranches. These recommendations assume use of multiple classes of deworms and refugia based grazing management as discussed above and are not meant as stand-alone recommendations.

Spring Calving Herds

- Summer
  - Monitor FECs in calves mid-summer, especially in warm, wet weather
  - Preweaning
    - Deworm calves at least one month before weaning
    - Earlier if heavy burdens
- Fall
  - Monitor FECs in cows, including flukes if necessary
  - Deworm young cows and replacement heifers
  - Deworm adult cows if deemed necessary for liver fluke control
  - Deworm calves depending if and when calves were dewormed preweaning
- Winter
  - Monitor FECs in adult cows and replacement heifers, especially if under nutritional and weather stress
  - Monitor FECs in bulls and consider deworming at time of breeding soundness exams
- Spring
  - Monitor FECs in cows as an indicator of potential pasture contamination for calves
**Fall Calving Herds**

- **Winter**
  - Monitor FECs in calves mid-winter
  - Preweaning
    - Deworm calves at least one month before weaning
  - Earlier if heavy burdens
  - Monitor FECs in adult cows, replacement heifers and bulls, especially if under nutritional and weather stress
    - Fall calving cows have the additional stress of lactation during this time

- **Spring**
  - Deworm calves depending if and when calves were dewormed preweaning

- **Fall**
  - Monitor FECs in cows, including flukes if necessary
  - Deworm young cows and replacement heifers
  - Deworm adult cows if deemed necessary for liver fluke control
  - Monitor FECs in bulls and consider deworming at time of breeding soundness exams

**Economics**

The variability of GIN load and level of resistance on individual operations makes determining the return on investment (ROI) from GIN control very difficult. Key performance indicators (KPIs) of successful GIN control that can be easily measured are weight gain, feed conversion and milk production. Other beneficial impacts of GIN control are harder to measure, such as the impact on reproduction, carcass quality and the immune system. On farm trials may be the best way to evaluate the ROI. Diagnostic tools (ex. pepsinogen, serum antibodies) that correlate better than FEC with level of infection and KPIs. Economic models are beginning to surface that when combined with accurate diagnostics may improve decision making. 30–32

**Summary**

There is a large body of knowledge about GIN and their control in cattle but there are still many gaps in that knowledge. Much of the recent research has focused on the economic benefits
(mostly weight gain) of anthelmintics while epidemiological data is decades old. More recent epidemiological data as well as documentation of the effectiveness of refugia based control programs and non-anthelmintic alternatives is needed.

Waiting for all of these knowledge gaps to be filled is not an option. GIN control in cattle can no longer be just about which product to use and when to use them. Changing practices from simple to complex is not easy but is necessary if we are to sustain some anthelmintics for future use. Control programs need to take into account what we do know about GIN epidemiology and combine that knowledge with specific information from diagnostic testing and ranch management. Gathering FEC and FECRT data is necessary and costly in the short term, but in the long term can better equip ranches to make sound management and cattle selection decisions that result in more productive and sustainable ranches.

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