Coccidiosis 1

Coccidiosis control to maximise feed utilisation

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Broiler growth and feed consumption are not linear. Based on a Ross 308 as-hatched broiler, the final two weeks of feed consumption before slaughter at 28 days accounts for 50% of the growing time, but 75% of the feed that the broiler will consume. The final two weeks of a 35-day broiler represent 40% of the growing time, but 64% of the feed consumption. For a 42 day broiler, the final two weeks represent only 33% of the growing time, but 55% of the feed consumption. At 49 days, the same two weeks represent only 29% of the growing time, but 47% of the feed consumption. In other words, the last two weeks in the field are critical to the overall feed utilisation as the broiler will consume at least half of the total feed during this period of time. This means that any disease or management insult during the final two weeks before slaughter can have a disproportionate adverse effect on feed utilisation and performance.

Poultry producers are aware of obvious clinical disease problems, but subclinical disease can be silently stealing performance by causing malabsorption or diverting energy to immune response instead of growth. Subclinical coccidiosis during the final two weeks before slaughter is one of the most common and significant causes of performance loss in broilers. Anticoccidial programs using ionophores or a chemical-ionophore shuttle often result in subclinical coccidiosis lesions at some point from 24-49 days of age, depending upon anticoccidial efficacy, bird density and environmental conditions.

Dr Robert Teeter (Prof. Emeritus, Oklahoma State University) converted the broiler performance loss due to subclinical coccidiosis into caloric equivalents (Arkansas Nutrition Conference, 2010). He estimates that +2 subclinical coccidiosis during the final week before slaughter can make a 2.4kg broiler fed a 3250kcal diet perform as though it had been fed a 2700kcal diet. Even +1 subclinical coccidiosis can cause performance loss equivalent to feeding a 2975kcal diet (Table 1). All of the effort and expense that is put into developing the ideal feed for maximum productivity can be lost due to very low levels of subclinical coccidiosis during the final week. It is critical for all poultry producers to monitor the coccidiosis status of flocks throughout their growth cycle, but especially during the final two weeks before slaughter. Producers can use post-mortem sessions to look for lesions of subclinical coccidiosis.

It is important to determine the species and severity of the infection, as well as the exact timing and frequency of affected flocks. When post-mortem is not possible, oocyst counts per gram of faeces can be made based upon sequential faecal samples collected at the farm. Oocyst counts cannot always predict the performance impact, but they can serve as a map to determine when subclinical coccidiosis is appearing during the growth of the flock. Samples should be collected twice per week to capture the rapid rise and fall of peak oocyst shedding to know when the challenge occurs. Successful feeding programs to maximise productivity must include a coccidiosis control strategy that avoids subclinical coccidiosis during the final 1-2 weeks in the field.

Table 1. Performance expected at different dietary caloric density (Teeter, 2007).

	Caloric density Kcal MEn			
	2700	2883	3066	3250
Body weight (g)	1972[d]	2122[c]	2285[b]	2361[a]
FCR	2.10[a]	1.85[b]	1.67[c]	1.64[d]
Carcase protein (g)	236.6[c]	254.7[b]	272.4[a]	276.8a
Carcase fat (g)	192.2[c]	211.1[bc]	219.9[b]	244.2[a]

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Coccidiosis 2

Coccidiosis vaccination: sustainable control of broiler coccidiosis

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For decades, coccidiosis control was accomplished through the use of effective in-feed anticoccidial drugs. But no single anticoccidial is sustainable when used without rotation. Used over decades, rotation/shuttle programs have begun to lose their efficacy, especially in smaller broilers with higher stocking density and more flock cycles per year in a single facility. Reduced efficacy has forced producers to rotate more frequently, and many producers have seen an increase in subclinical coccidiosis lesions between 24 and 42 days of age.

Vaccination with live coccidiosis vaccine that contains sporulated oocysts from each of the important Eimeria species provides an alternative to traditional anticoccidials. Vaccines are highly antigenic, but full development of immunity still requires each bird in the flock to be subjected to 3 to 4 life cycles of the parasite. The birds will shed oocysts from hatchery vaccination beginning at 4 to 6 days of age into the poultry house. If the environment is conducive to Eimeria sporulation, the oocysts become infective and complete the remaining life cycles in the house, providing a field boost, free-of-charge and without administration labour. The time from vaccination until complete immunity is 21 to 28 days, depending upon the vaccine and house conditions.

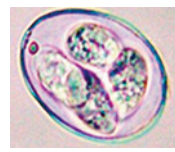
Uniform administration is critical because birds that are missed by the hatchery vaccination will enter the poultry house in a naïve condition. They are subject to wild Eimeria oocysts that remain in all poultry houses despite thorough cleaning and disinfection. They are also subject to the oocysts shed by their properly vaccinated hatch-mates.

Uniformity of oocyst recycling in the poultry house is also critical for the next 3 to 4 weeks. The young broilers must have access to sporulated oocysts to complete each successive life cycle. 'Sporulation' is a process that must happen to make the oocysts infective. Heat, moisture (25% litter moisture or 60% RH) and oxygen are needed for the sporulation process to occur. Field recycling may be disrupted by dry litter conditions and low flock density.

Reduced sensitivity of poultry Eimeria to anticoccidials, results in the appearance of subclinical lesions between 24 and 42 days of age, together with shedding of wild-type oocysts into the litter immediately before slaughter. The late build-up of oocysts in the litter can cause carry-over of oocysts to the next flock, despite cleanout and disinfection. Initial vaccinated flocks must contend with early exposure to the wild strain, before complete immunity is developed. But these flocks will not, themselves, have a late build-up of oocysts. Thus, the carryover challenge becomes less and less through sequential flocks.

Vaccine is not subject to resistance. Proper vaccination is a sustainable program that avoids late subclinical coccidiosis and provides protection flock after flock. Therefore, it is important to monitor house conditions to ensure proper sporulation and recycling is continuing to occur. This is particularly true for antibiotic-free flocks that are placed with lower stocking density and lower litter moisture.

Monitor flocks using sequential faecal oocyst counts or lesion scoring sessions to ensure the self-boosting program continues as seasons and house conditions change. Coccidiosis vaccination is an effective and sustainable coccidiosis control method that can result in performance that exceeds an anticoccidial program.



(Dr Steve Fitz-Coy)

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Coccidiosis 3

Coccidiosis control strategies utilising vaccination

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Coccidiosis vaccination has become a significant control strategy for broiler integrators, reaching 25% of all broilers placed in the US (2015), according to estimates by MSD Animal Health. How is it being used? There are three major strategies: vaccine as a sustainable year-round program, vaccine in rotation with anticoccidials, and a vaccine-anticoccidial hybrid shuttle program.

An important concept to understand when exploring these programs is 'carryover' – the carryover of coccidial oocysts from one broiler flock to the next, with or without clean-out and disinfection. It is caused when broiler flocks are slaughtered during active subclinical coccidiosis. Since active subclinical infections occur with a peak between 24 and 42 days of age, small bird integrations that slaughter between 30 and 36 days are most affected.

Strategy 1 – Sustainable year-round vaccination program

Until now, this program has been employed largely by organic producers, but integrators producing conventionally raised birds have committed multiple complexes to this practice during the past year as the interest in antibiotic free production has increased in the US. The vaccine is used in flock after flock with continued success. Producers have used the program continuously for 6+ years, and continue to perform at industry parity. Without the late oocyst shedding typical of anticoccidial programs, the overall cocci challenge on the farm declines with time.

Strategy 2 – Vaccine in rotation with anticoccidials

Rotation is the most common use of vaccine. Vaccine is used for at least three sequential flock cycles during a production year, followed by rotation to an anticoccidial program for two to three cycles, then returning again to vaccine. Anticoccidial rotation is predominantly used during winter or wet months. This strategy maintains sensitivity of the farm Eimeria population to the anticoccidials, helping those anticoccidials to work at their best during the peak coccidiosis challenge season. In this program, coccidiosis challenge tends to build up through the successive anticoccidial flocks, with significant subclinical coccidiosis and oocyst shedding in the 24-42 day period at the end of winter or rainy season. This high carryover oocyst burden puts pressure on the first vaccination cycle each year.

Strategy 3 – Hybrid vaccine-anticoccidial shuttle

This is a sustainable program that can be used year-round or in rotation. Vaccine is administered at the hatchery and the starter feed is unmedicated to enable the vaccine to recycle and to begin to develop immunity. A 'leaky' anticoccidial – either low-dose ionophore or zoalene – is added to the grower or finisher feed. Ideally, the anticoccidial medication is not added to the diet until the process of building immunity is complete (about 21-25 days of age). Thus, a sensitive vaccine is always introduced at the beginning of a flock, enabling the shuttle anticoccidial to be effective. The building of immunity and shedding of oocysts is usually a bell-shaped curve. The anticoccidial cuts the back half of the bell-curve off, enabling birds to recover faster and, according to users, perform better.

All three strategies for the use of coccidiosis vaccine require an understanding of how the Eimeria population dynamics of one flock will affect the subsequent flocks. Management adjustments to encourage consistent vaccination response make sustainable coccidiosis control achievable.

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Coccidiosis 4

Management of coccidiosis vaccination First critical weeks

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Coccidiosis immunity is developed through multiple exposures to the Eimeria parasite antigens. Unlike viral vaccines, coccidiosis vaccines are 'self-boosting': they recycle under the correct field conditions. It is critical that coccidiosis-vaccinated birds continue to have access to their faeces containing shed oocysts until immunity is complete. When chicks ingest a coccidiosis vaccine, the sporulated oocysts break open and the parasites will infect the intestinal cells, completing multiple stages of the Eimeria life cycle. After this initial life cycle, new oocysts are shed into the litter. To achieve immunity, the oocysts must become infective by sporulating in the litter, and the birds must ingest them to initiate the next life cycle. A third and sometimes a fourth or fifth life cycle must be completed to induce fully protective immunity against all Eimeria species. Several factors interact under field conditions to speed or slow the onset of immunity.

1. Sporulation

The newly shed oocysts must sporulate to become infective. This process requires oxygen, warmth and humidity. Usually, there is sufficient oxygen and warmth in a poultry house, but humidity can become a problem where the environmental relative humidity is very low or where the bird density is low, resulting in less faecal moisture in the litter. Relative humidity of about 70% is recommended.

2. Oocyst output

Technically, we might be able to achieve immunity by gavaging (direct oesophageal application) only 10 sporulated oocysts twice per week for 2-3 weeks. But under field conditions, 25,000 birds in a broiler house must be able to consume enough fully sporulated oocysts to initiate a secondary infection, and they must do it at approximately the same time. This requires access to many oocysts. If we introduce too few oocysts with the initial vaccination, the oocyst output will be low. In this case, it could take days for each bird in the house to find an infectious dose from the litter. If the litter is dry, and sporulation rate is low, it can take even longer. If it takes too long, some naïve birds remain in the house when others have already begun to shed oocysts from the second life cycle. Then the naïve birds may become exposed to an extra high dose of vaccine oocysts or they may become exposed to wild strains, resulting in clinical coccidiosis.

3. Bird density

High bird density means that many oocysts will be shed into a given area, and more faecal moisture results in higher sporulation rates. High bird density promotes rapid exposure of the entire flock to coccidial oocysts. Very high density may also mean a very heavy exposure to oocysts, potentially resulting in intestinal pathology and negative performance consequences. Conversely, very low density means that it will be difficult for every bird to develop uniform exposure and immunity. Replacement pullets are often placed at lower density. This can sometimes result in slower and less uniform onset of immunity. In general, non-attenuated vaccines require 0.5ft^2 per bird or 21 birds/m^2 for the first seven days to initiate the second life cycle after hatchery vaccination. After that, spreading the birds out to at least 0.65ft^2 per bird or 16.5 birds/m^2 is recommended to avoid excessive moisture and excessive oocyst exposure.

It is important for all components of recycling to be balanced: environmental conditions for sporulation, oocyst output and bird stocking density. This ensures rapid and uniform development of immunity with coccidiosis vaccine.

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Coccidiosis 5

Antibiotic Free Production and Coccidiosis Control

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A series of press releases by prominent US restaurant chains and wholesalers demanding poultry raised 'without antibiotics that are important to humans' (number one restaurant chain, McDonald's) or 'no antibiotics ever' (number three chain, Subway) has caused a rapid paradigm shift in US broiler production toward the reduction or elimination of antibiotic use. Poultry labelled raised without antibiotics that are important to humans (RWA) allows the use of ionophores to control coccidiosis. Ionophores, such as monensin, narasin and lasalocid, are defined as antibiotics by the USDA, while chemical anticoccidials, such as nicarbazin, robenidine, clopidol and diclazuril are not antibiotics and may be used in no antibiotics ever (NAE) labelled poultry. Coccidiosis vaccines may be used to control coccidiosis for either label.

Coccidiosis vaccination with Fortegra® (Coccivac®B-52) can be used every year in rotation with the chemical anticoccidials to seed farms with sensitive vaccine-origin coccidiosis strains. The effect of renewing sensitivity will be temporary, so producers must rotate to vaccination for 3-4 flock cycles out of every year. Coccidiosis vaccination can also be used exclusively on a year-round basis as the fundamental coccidiosis control program. Some integrators are also experimenting with hybrid shuttle programs that use coccidiosis vaccination to start every flock, followed by a shuttle to an in-feed anticoccidial (either ionophore or chemical) after partial or full immunity has developed.

Necrotic enteritis and dysbacteriosis are caused by imbalance of the intestinal microflora, and usually controlled by antibiotics. Without antibiotics, extra care must be taken to avoid conditions that could stimulate an imbalance of microflora. A simple concept to understand is that microflora imbalance is caused by too many nutrients (particularly protein) reaching the lower intestine during the first three weeks of life. Highly digestible feed ingredients should be used during the starter phase to avoid undigested nutrients reaching the caeca. Spending the money for a highly digestible starter feed may provide a strong return on investment in an antibiotic-free production environment. Steady-state eating is important to maintain because excessive consumption speeds feed through the intestinal tract, leaving too many nutrients to reach the lower gut. Management conditions that cause over-eating in response to a feed outage, a temperature change, a lighting change or a feed form or formulation change can initiate enteritis. Enzymes and feed additives that enhance feed digestibility are helpful.

Where available, a complete healthy microflora culture (such as Aviguard®) is an ideal probiotic to seed the intestine with a complete, balanced microflora. Probiotics with selected, defined beneficial microflora may be helpful. Acidification of water and encapsulated acids in the feed will provide the appropriate environmental conditions within the gut to maintain a healthy microflora. Fibre to encourage the production of butyric acid or encapsulated butyric acid itself as well as mannanoligosaccharide (MOS) products will assist in repair and reduce dehydration of intestinal villi damaged by coccidia or enteritis. Management of coccidiosis vaccination to achieve consistent timing and magnitude of vaccine cycling and management of chemical anticoccidial programs to avoid escapes or leakage at the end of the starter feed period are critical in antibiotic free production systems. Avoid multiple insults that fall within the critical window for enteritis (14-22 days of age), such as feed changes or movement from partial to full house. When these occur simultaneously with coccidiosis activity in the intestine, either from vaccination or from loss of anticoccidial sensitivity, the conditions are right for development of enteritis.

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Coccidiosis 6

Coccidial vaccination and feed strategy

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Feeding strategy should be considered when vaccinating with a live coccidial vaccine, especially under antibiotic free conditions. The immune response to live coccidial vaccine requires exposure to multiple life cycles of each of the Eimeria species in the vaccine.

The peak of Eimeria reproduction in the digestive tract is generally at 14-21 days of age, depending upon environmental conditions. Most vaccinated flocks do not need special feeding considerations. However, when using grains other than corn, or when growing antibiotic-free broilers, the feeding strategy should prepare flocks to withstand the response to vaccination, and then should help the birds maximise their performance for greatest economic advantage.

Pre-starter/starter phase:

Ideally, the early feeds should be divided into a pre-starter for about 7-8 days of age, followed by a starter feed. Avoid feed changes during the critical peak of Eimeria oocyst output, as changes to the feed form or formulation can disrupt intestinal microflora, resulting in dysbacteriosis or enteritis. The formulation of the pre-starter is most critical for companies raising birds without antibiotics, but the ideal strategy is the same for all vaccinated flocks.

The focus for early feeds is on digestibility. The pre-starter should consider the use of synthetic amino acids to avoid undigested protein in the hind gut. Corn-soy rations may have 88% lysine digestibility in chicks over 10 days old, but the digestibility can be as low as 78% in baby chicks (Batal, 2002). Low digestibility means that the extra 22% of lysine goes to the lower intestine and caeca, where it can feed the growth of unfriendly microflora, such as Clostridium perfringens. Pre-starter cereals should be pre-cooked and extruded; proteins should be animal-based or synthetic amino acids. Fats should come from high quality vegetable sources only. Diets based upon wheat must use a high-quality enzyme package to improve digestibility.

The starter phase may benefit from coarse particle size to encourage the production of butyrate and to develop a more diverse microflora population. Encapsulated butyrate can also be added to the ration to maximise villus development and repair, in the presence of the mild coccidial challenge produced by vaccination. The addition of betaine during this phase helps to regulate the movement of water across the intestinal cell membranes, preventing coccidiosis-induced dehydration of the villi. To reduce inflammation and enhance cellular immunity to coccidiosis, the mannan-oligosaccharide (MOS) products as well as vitamin E and selenium have important roles. Growth during this period is not emphasised; protection of intestinal villi and maintenance of intestinal microflora balance are more critical.

Grower/finisher phase:

Once immunity has developed, the flock will grow quickly to meet or exceed its genetically programmed weight. Protein and energy to support the desired feed efficiency or breast yield are critical during this phase. When energy cost is high, coccidial vaccinated birds have a more efficient utilisation of low energy finisher feed (Newman & Teeter, 2012), while still achieving the final target weight. In-feed anticoccidial flocks often experience a mild coccidiosis challenge at the later stages of growth and may not tolerate low energy or cheaper ingredients. Coccidial vaccinated flocks are tolerant during this period of growth, so costs of the later feeds can be reduced to compensate for some of the higher-cost ingredients used in the pre-starter or starter phases.

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Coccidiosis 7

Vaccination to control coccidiosis in cage and floor-reared layer pullets

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Coccidiosis vaccination for layer pullets has become more common, whether the birds are raised in cages, aviary systems or on the floor. Vaccination has been a successful method of coccidiosis control in broiler breeder replacements for decades, but layer pullets present different challenges. Application, management of environmental humidity and access to faeces to ensure recycling of Eimeria oocysts are important areas of focus.

Application

Hatchery spray, feed spray, 'wet feed' (diluted vaccine mixed with feed and immediately fed to birds) and drinking water application have all been successfully used, depending upon local management conditions. A water circulation system must be in place to vaccinate pullets via drinking water to ensure that the heavy oocysts stay suspended. The vaccine is a low dose of oocysts, designed to initiate a life cycle in the birds with minimal intestinal damage. Birds that are missed in the initial application will be subject to wild strain infection or to ingestion of a higher dose of oocysts shed by their hatch-mates when the first vaccinal life cycle has completed and the next generation of oocysts are shed into the environment. Therefore, uniformity of the initial application is crucial.

Immunity development

Development of immunity requires the flock to ingest the oocysts that are shed following the initial vaccination life cycle, and again following subsequent life cycles until four or five life cycles have been completed in the flock. *Eimeria necatrix* and *Eimeria brunetti* are deadly species that require significantly longer exposure to ensure complete immunity. Recycling of oocysts requires re-ingestion of oocysts from the faecal material. Flocks in cages present a unique challenge, and some coccidiosis vaccines specifically state on the label that they should only be used in floor-reared birds. Successful vaccination in cages requires using some kind of durable paper on the cage floor for at least 16 days, and preferably for 21-28 days. Feed is spread on the papers for the first 7-10 days to encourage picking up both feed and Eimeria oocysts. When pullets are started in central tiers and then moved to upper and lower tiers as they grow, the papers are split into two in each cage. As pullets are moved up or down, half of the paper is moved to the new cages to maintain access to oocysts. In aviary systems, as pullets move to the floor, the papers can be moved to the floor with them. Floor-reared pullets may start in a more confined floor area to ensure sufficient bird density to have uniform exposure to shedding oocysts. Due to variability of management and local environmental conditions, each system should be evaluated as an individual case, with critical attention to detail in the program design.

Humidity

Eimeria oocysts require heat and humidity to 'sporulate' and become infective. Without humidity, the Eimeria life cycle stops or stutters, resulting in uneven coverage and uneven development of immunity. Environmental relative humidity of 60% is strongly recommended. When faeces, litter or papers are very dry at five weeks of age, it is an indicator that the flock could have problems later on when they are moved to the layer site and they become exposed to flies and faeces. Work with a knowledgeable technician to develop farm-specific strategies to enhance oocyst exposure and critical humidity levels. Pullet vaccination can be monitored by faecal oocyst counts at three-day intervals beginning at day 14. The counts provide a map of vaccine recycling and they can be used to measure the effects of environmental modification. Partial dosing of vaccine or use of anticoccidial medication in the feed or water post-vaccination can hurt immunity development.

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Coccidiosis 8

Choosing the right coccidiosis vaccine for layer and breeder chickens

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Layer and breeder birds have a long life that is under constant threat of coccidiosis, which can cause mortality, hurt pullet uniformity or reduce egg production. The only effective coccidiosis control method is to develop immunity, either through step-down anticoccidial programs that allow natural exposure to the Eimeria parasites or by vaccination with a complete breeder or layer coccidiosis vaccine.

Immunity development by natural exposure leaves complete protection to chance. Parasitologists recognise seven to nine species of Eimeria found in chickens, and they do not cross-protect against each other. Natural exposure assumes that the flock will become exposed to all of the key species within the first six weeks of life. Insufficient natural exposure to one or more species can result in naïve flocks that will suffer outbreaks later in life.

Vaccination is the best way to ensure that birds have protection against the most critical pathogenic Eimeria species: Eimeria acervulina, E. maxima, E. tenella, E. necatrix and E. brunetti. Vaccines that include even more species help to ensure more complete protection against poor individual growth rate that could hurt flock uniformity and production.

One critical feature of a coccidiosis vaccine is the number of sporulated oocysts in the product. Scientists have proven that a low-level or 'trickle' infection is more effective at stimulating immunity than a massive exposure to Eimeria oocysts.

The vaccine must contain enough viable oocysts to start an infection process that will result in oocysts shedding into the litter. Once in the litter, the shed oocysts must be of a sufficient number that every single bird in the flock can find and consume enough sporulated oocysts to initiate a second life cycle and then a third and fourth until immunity is complete.

Low dose vaccines may not have enough output to initiate a uniform secondary life cycle under field conditions. Uneven recycling of a vaccine can result in individual birds remaining naïve, only to later consume a large dose of oocysts shed by their vaccinated hatchmates, resulting in clinical coccidiosis.

All vaccines are susceptible to conditions that are not conducive to vaccine reproduction such as low bird density and dry conditions, but low-dose vaccine may be more vulnerable to these problems.

Uniformity of application is essential to avoid missed, naïve birds that could consume too many vaccine oocysts or remain naïve to infection later on. Management of environmental conditions to match the type of vaccine selected (higher output non-attenuated vaccine or lower output precocious vaccine) is essential for development of effective immunity without adverse effects.

And finally, choose a vaccine that contains all of the critical pathogenic species as well as problematic lesser species to maximise the breadth of protection.

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