

Available Sheep Anthelmintics (Dewormers)

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Key words: worms, treatment, medication, internal parasites, sheep, cost, economics, formulations, doses

The following text is designed to provide Midwestern sheep producers with a detailed review and a “working knowledge” of deworming medications (anthelmintics) commonly employed in flock internal parasite treatment and prevention programs. Some of the medications are no longer available, but will be considered for historical understanding of product evolution and use. Furthermore, several products discussed in the text are not approved for use in sheep in this country. However, lack of available products often necessitates application.

Anthelmintic medications commonly used in the sheep industry fall into two basic classes: 1) FDA approved anthelmintics for sheep, and 2) FDA non-approved anthelmintics for sheep. Whether or

not an anthelmintic is approved by the FDA often becomes a "sticky" issue for both the producer and veterinarian. Anthelmintics approved for use in cattle may not be approved for use in sheep. Even various administration forms (drench vs injectable) of the same anthelmintic may have different approval labeling. While extra-label (non-FDA approved) use of medications in food-producing animals is not encouraged, it does occur, especially if FDA-approved medications are not available for treatment of a particular parasite. Any extra-label use of medications must be accompanied by a strict veterinarian - client - patient relationship (VCPR) and requires additional labeling by the veterinarian involved.

Thiabendazole (no longer available - presented for historical perspective)

General: Thiabendazole had been available for many years as an FDA approved product. However, due to resistance problems that developed over the past several decades, regular thiabendazole use in the sheep industry decreased in popularity. In fact, until recently, thiabendazole products were still available as over-the-counter anthelmintics marketed at feed mills and farm supply stores. Beginning producers often chose readily available thiabendazole products as their initial deworming medication. Due to continued, long term use and inadequate dose rates, internal parasites gradually developed product resistance. While currently not marketed as an anthelmintic, some producers may still have access to various product formulations. For this reason, we will discuss various thiabendazole preparations. However, thiabendazole is not recommended for use as an anthelmintic medication for sheep.



Parasites and predators are two of the biggest “headaches” for pastured ewes and lambs.

Thiabendazole dose rates are often listed according to the level of parasite infection (e.g., severe, moderate, light), therefore, dosing levels can be confusing. The product is safe and tends to be more effective at the doses listed for severe infections. In the past, veterinarians administered thiabendazole at 10 times the label dose to kill immature forms (migrating larva) of intestinal parasites. While high doses of thiabendazole can be larvacidal, the cost of administration of large doses of thiabendazole and the advent of more modern anthelmintics that are larvacidal at normal doses makes this practice somewhat outdated. Thiabendazole is also safe for pregnant ewes. Personal opinion would be to avoid use of this product, especially if you have continually dewormed your flock with thiabendazole and may have thiabendazole resistant parasites on your farm.

Thiabendazole sheep boluses contain 2 grams of thiabendazole per bolus and are labeled to be dosed at 1 bolus per 100 lbs. of body weight. At the label dose, a typical 150-lb. sheep would receive 1.5 boluses. Producers choosing to use thiabendazole preparations should consider dosing the product at 4 grams of thiabendazole (2 boluses) per 100 lbs. of body weight—this is roughly 2 times the label recommendation. At this extra-label dose of 4 grams of thiabendazole per 100 lbs. of body weight, a 150-lb. sheep would receive 3 boluses. Cost would be approximately \$0.60 for the label dose and \$1.20 for dosing at double the label recommendation.

Thiabendazole drench products were available as a 1-gallon pre-mixed suspension containing 4 grams of thiabendazole per fluid ounce. Product label recommendations of 3/4 ounce of product for a 100 to 150 lb. sheep should probably be increased to the 1.5 ounce level (also an extra-label dose). The product is marketed for horses, but in the past was also labeled for use in sheep and goats. The thick consistency and large volume dosage makes use of this product rather difficult in newer, low-volume drench guns. According to technical representatives from the company, the old TBZ powdered sheep drench concentrate is no longer available. The cost of a 1.5-ounce dose of the thiabendazole suspension is about \$0.50 per 150 lbs.

Thiabendazole cattle dewormer paste products are supplied in a caulking gun-like preparation that utilizes disposable tubes of a 43% thiabendazole paste. The tubes only work in a special dosing gun supplied by the manufacturer. The medication dosing gun costs about \$12 to \$15. Use of the dosing gun is limited to this 43% paste product. The product is only labeled for use in cattle—sheep applications are considered extra-label use. The medication gun is designed to deliver 7.5 grams of thiabendazole for each complete compression of the trigger. Each complete trigger compression is divided into 3 "clicks" administering 2.5 grams of thiabendazole per "click." At the higher extra-label thiabendazole dose of 4 grams/100 lbs., this would amount to 2½ "clicks" per 150-lb. sheep. Because half "clicks" are difficult to obtain, a complete trigger compression dose (3 "clicks," the entire 7.5 grams) per 150 lbs. is suggested. Trying to dose moving sheep while listening for the subtle one, two, or three "click" sound is often difficult. Dosing at 7.5 grams of thiabendazole per 150 lbs. costs about \$0.65.

Thiabendazole feed medications were also available for use in sheep. CAUTION: *There were a variety of products available with varying concentrations of thiabendazole. Products included pellets, premixes, and salt formulations. Some products were approved for sheep and some were not.*

Generally speaking, feed applications of most anthelmintics are usually not as effective as dosing individuals (fenbendazole, the main exception, will be discussed later in the series). Individual intake will vary with palatability of the product, available bunk space, and behavioral and social patterns of the flock. By necessity, feed-type anthelmintics need to have a wide margin of safety to cushion variabilities in intake. Anthelmintic-medicated salts do have merit when used in a controlled grazing program or for special parasite management problems, such as meningeal worms carried by the white-tailed deer. Special salt applications will be discussed under the fenbendazole section.

Pelleted thiabendazole products designed for top-dress administration to sheep usually contained 15 grams of thiabendazole per pound of product. Label recommendations for these 15-gram products suggest dosing at the rate of 0.13 lbs. of medicated pellets per 100 lbs. of body weight. At this dose rate sheep are only receiving 2 g of thiabendazole per 100 lbs. of body weight ($0.13 \text{ lbs.} \times 15 \text{ g/lb.} = 2\text{g}$). As suggested earlier, this dose should be increased to 0.25 or 0.3 lbs. per 100 lbs. of body weight ($0.3 \text{ lbs.} \times 15 \text{ g/lb.} = 4.5 \text{ grams}$). This 0.25 or 0.3 lb. per 100 lbs. of body weight dose roughly equates to 0.4 lbs. of product for each 150 lbs. (6 g of thiabendazole per sheep). Remember, increasing the dose is an extra-label application of the product.

Cattle products containing 6.6% thiabendazole concentrations ($0.066 \times 454 \text{ g/lb.} = 30 \text{ grams}$ of thiabendazole per pound of pellet) were also available. This 30-gram level is twice the level of the previously mentioned sheep product. Dosing this cattle product at the rate of 0.13 lbs. of the 6.6% thiabendazole pellet for each 100 lbs. of body weight provides roughly a 4-gram dose of thiabendazole. Thus, 0.2 lbs. of the 6.6% thiabendazole product would be used to treat a 150-lb. sheep ($0.2 \text{ lbs.} \times 30 \text{ g of thiabendazole/lb.} = 6 \text{ grams of thiabendazole}$). The cost for this 6-gram dose of thiabendazole would be about \$0.53 per 150-lb. sheep. Remember, this is an extra-label application. CAUTION: *Other highly concentrated thiabendazole medicated premixes were also available. Check the label! Also check to see that other problem items are not included in the product, especially copper.*

A thiabendazole salt block for cattle was also available. The protein-based block contains calcium, phosphorus, trace minerals (including copper), vitamin A, and 3.3% thiabendazole. This 3.3% level of thiabendazole is equivalent to 15 grams of thiabendazole per pound of block. Concerns with this product would include inadequate block consumption by sheep and the potential for copper toxicity to occur (sheep being more sensitive to copper than cattle). Use of this product would be considered extra-label.

Thiabendazole's range of activity includes most of the common stomach and intestinal worms affecting sheep, but does not include tapeworms, lungworms, or liver flukes. The cost of deworming a 150-lb. sheep with a thiabendazole product was dose- and product-dependent and ranged from about \$0.50 to \$1.20 per sheep.

Sheep slaughter withdrawal times for labeled doses of thiabendazole are product dependent, but customarily involve a 30-day period following administration. Milk discard times for cattle, sheep, and goats are listed as 96 hours (8 milkings) after administration. It is interesting that the milk discard time for cattle is 96 hours (4 days), while the slaughter withdrawal time for cattle is listed at only 3 days after treatment!

Levamisole

Several forms of levamisole are currently utilized by the sheep industry. Levamisole products are reasonably priced and are effective on most of the major stomach and intestinal worms that affect sheep. Additionally, levamisole products are also effective against lungworms of the Dictyocaulus species, but have no activity on liver flukes or tapeworms. Levamisole products are usually marketed under the trade names of Tramisol or Levasole, with formulations that include drenches, injectables, boluses, gels (recently discontinued), feed pellets, water medication for pigs, and a pour-on. Only levamisole bolus and drench products are approved for use in sheep. Levamisole is considered safe for pregnant ewes and has a slaughter withdrawal time of only 72 hours for sheep (48 hours for cattle). Because levamisole products are not approved for use in lactating animals, no official milk withdrawal exists. While levamisole products are safe, they do not have nearly the margin of safety of the benzimidazole (thiabendazole, fenbendazole, oxfendazole, etc.) anthelmintics and thus should not be double or triple dosed. As a temporary side effect, muzzle foam may be noticed for several hours after administration of any levamisole product.

Common Sheep Anthelmintics

Anthelmintic	Trade Name	Formulation	FDA Status
ALBENDAZOLE	Valbazen	Drench	Approved
	Valbazen	Paste	Approved
FENBENDAZOLE	Panacur 10%	Drench	Non-Approved
	Panacur 22%	Granules	Non-Approved
	Panacur 10%	Paste	Non-Approved
	Safe-Guard	Pellets	Non-Approved
	Safe-Guard	Block	Non-Approved
	Safe-Guard	Mineral Supp.	Non-Approved
IVERMECTIN	Ivomec	Drench	Approved
	Ivomec 0.27%	Injectable	Non-Approved
	Ivomec 1%	Injectable	Non-Approved
	Eqvalen	Paste	Non-Approved
	Zimectrin	Paste	Non-Approved
	Ivomec	Pour-on (does not work on sheep)	Non-Approved
LEVAMISOLE	Levasole	Drench, Bolus	Approved
	Tramisol	Drench, Bolus	Approved
	Levasole	Injectable	Non-Approved
	Tramisol	Injectable	Non-Approved
	Levasole	Water Med.	Non-Approved
	Tramisol	Water Med.	Non-Approved
	Tramisol	Feed	Non-Approved
	Totalon	Pour-On (does not work on sheep)	Non-Approved
OXFENDAZOLE	Synanthic	Drench	Non-Approved
	Synanthic	Paste	Non-Approved
	Synanthic	Injectable (injected into rumen)	Non-Approved
THIABENDAZOLE	TBZ Boluses	Bolus	Approved
	TBZ 43%	Paste	Non-Approved
	E-Z-EX	Block	Non-Approved
	Equizole	Drench	Approved
	TBZ Pellets	Top-Dress	Approved

Levamisole drench products are sold as packets of levamisole powder that are designed to be added to water. Drench formulations of levamisole are approved for use in sheep. *CAUTION:* There are several different concentrations of levamisole soluble powder products. The sheep drench product is a 13-gram packet containing 11.7 grams of levamisole. It is designed to be added to 1 quart of water and is dosed at the rate of 1 ounce of drench for each 100 lbs. of body weight. Therefore, each 13-gram packet (containing 11.7 grams of levamisole) will dose twenty-one 150-lb. sheep at a cost of about \$0.45 per animal. The cattle drench product (also labeled for sheep) contains 46.8 grams of product. The cattle drench product has 4 times more levamisole than does the sheep product. The cattle product is labeled for sheep but is designed to be mixed with 1 gallon of water. *Be careful not to confuse the two concentrations!* Slaughter withdrawal time for either drench product is 72 hours.

Levamisole sheep boluses are approved for use in sheep. Sheep-sized boluses are marketed as a 0.184 gram bolus of levamisole designed to be dosed at one bolus per each 50 lbs. of body weight (3 boluses to a 150-lb. sheep). A larger-sized bolus is also marketed for cattle, so use caution when ordering. Sheep bolus products are available in bottles containing 100 boluses per bottle. Cost is about \$0.30 per bolus, leading to a total cost of about \$0.90 to deworm a 150-lb. sheep. While the bolus preparations cost about 2 times more than levamisole drench, they are very convenient for use in small flocks that do not have a drench gun. Administering multiple boluses to sheep, however, is not extremely labor or cost efficient if you need more than your fingers and toes to count your flock! Drench medications or injectable products are more efficient and cost effective. Slaughter withdrawal time for the sheep bolus preparation is 72 hours.

Levamisole injectable products, although commonly used in sheep (*extra-label use*), are not approved for use in this species. Injectable levamisole is marketed only for use in non-lactating cattle and is sold as a 13.65% sterile solution of levamisole. The injectable levamisole products come in a 500-ml and 100-ml size with the 500-ml product usually being the better buy. In cattle, the product is designed for subcutaneous injection (under the skin) using a dose of 2 mls/100 lbs. of body weight. A similar dose of 2 mls of the 13.65% levamisole solution per 100 lbs. of body weight is commonly used in sheep. A 3-cc dose of injectable levamisole administered subcutaneously to a 150-lb. sheep would cost about \$0.35 per animal. Injectable levamisole is an extremely economical, easily administered, safe, and effective anthelmintic for sheep. Side effects include transient muzzle foam and a transient stinging sensation at the point of injection. Because injectable levamisole is not approved for use in sheep, there is no official slaughter withdrawal time. However, the withdrawal time for cattle is 7 days.

A *pelleted top-dress formulation* of levamisole for cattle and a drinking water medication for pigs are also available. The *levamisole gel* product is no longer available. The pelleted formulation (*not approved for sheep*) is fed to cattle at the rate of 1 lb. of pellets for each 1000 lbs. of body weight. Thus, a very small amount of pellets would be fed to a 150-lb. sheep. Individual sheep consumption variations could affect both safety and efficacy of this pelleted formulation; therefore, this product probably should not be used for sheep.

Pig dewormer drinking water formulations of levamisole contain the same form of levamisole found in the sheep drench, but the concentration is different. Pig drinking water medication is commonly marketed in a plastic bottle containing 18.15 grams of levamisole or in smaller packets of powder. The 18.15 gram bottle of levamisole powder is roughly 1.5 times the amount of levamisole found in the approved sheep drench packets. The price of the pig wormer is usually very similar to the sheep drench packets so there may be an economic advantage to using the pig product **if** the pig product is diluted properly. Sheep producers, however, should attempt to use labeled products when these products (such as the levamisole sheep drench) are commercially available.

A pour-on cattle deworming product marketed as Totalon is also available. The pour-on product is a special preparation of levamisole and butyl dioxitol that is absorbed through the skin of cattle. While very convenient for use in cattle, because sheep skin structure is different from cattle, *Totalon is not absorbed and therefore is not effective when*

used in sheep.

Albendazole

Albendazole is a broad-spectrum deworming agent marketed under the trade name of Valbazen. Commercial preparations include an oral drench and an oral paste. **Albendazole has received FDA approval for use in sheep (dose rate of 3.4 mg/lb with a 7 day meat withdrawal and warning not to use during the first 30 days of pregnancy).** However, FDA approval has not been listed on the label. Albendazole is an effective, economical, easily administered, and broad-spectrum anthelmintic that treats all of the major intestinal parasites that typically infect Midwestern sheep. It is effective against the common adult and larval forms of stomach, intestinal, and lung worms of sheep. It is also effective against tapeworm segments and heads, and the upper Midwest's unique liver fluke (*F. magna*).

Current slaughter withdrawal time is 7 days for sheep and 27 days for cattle. Sheep producers wishing to administer albendazole dewormer to sheep should also be aware of certain problems that may be associated with the use of this medication. Albendazole (Valbazen) has been associated with fetal deformities in both newborn calves and lambs. Pregnant cows and ewes dewormed with albendazole during early pregnancy may give birth to deformed offspring. Thus the medication is labeled as being "teratogenic," causing or contributing to birth deformities in the fetus.

While the exact teratogenic mechanisms of albendazole are not known, it is recognized that: 1) large doses (3–4 times a normal label dose) along with 2) administration during very early pregnancy (first several days following conception) can contribute to birth deformities. This does not appear to be the case when albendazole is administered after the very early stages of pregnancy. Thus, albendazole (Valbazen) should not be administered during the first 30 days of pregnancy or for 30 days following the removal of the ram. This is similar to the current label recommendations for cattle which are increased to the first 45 days of pregnancy.

Albendazole drench is marketed for cattle as an 11.36% suspension of albendazole. Commercial preparations include 500-ml, 1-liter and 5-liter containers. The recommended cattle dosage of 4 ml of the 11.36% albendazole suspension per 100 lbs. of body weight (10 mg/kg) is commonly used on sheep; however, this dose can be reduced to 3 ml/100 lbs. of body weight. Sheep-producing countries that have used albendazole for years generally dose albendazole at 3 ml/100 lbs. of body weight (7.5 mg/kg). Cost is about \$0.10/ml or about \$0.50 to deworm an average-sized sheep. (FDA approved dose for sheep is 3.4 mg/lb - not listed as approved on the label - 7 day slaughter withdrawal)

Albendazole paste is also marketed under the trade name of Valbazen paste. The 30% albendazole paste comes in a caulking gun cartridge application labeled for use in cattle. The dosing gun can be set for various cattle doses with the lowest available dose rate designed for a 65–200 lb. animal. Cost of the paste application is about \$0.80 per sheep, in addition to the initial purchase of the administration gun.

Fenbendazole

Fenbendazole is another broad-spectrum anthelmintic usually marketed under the trade name Panacur or Safe-Guard. Fenbendazole anthelmintic preparations are designed as drenches, pastes, pellets, granules, and salt mixes carrying oral administration approval for cattle, horses, or hogs. It is *not approved for use in sheep* but is safe, and is commonly used for sheep in other countries. Fenbendazole also has a wide margin of safety, is safe for pregnant ewes, and treats all of the major intestinal parasites that typically infect Midwestern sheep. It is effective against the common adult and larval forms of stomach, intestinal and lung worms of sheep. It is also effective against tapeworm segments and heads but has no effect

on external parasites or nasal bots. Fenbendazole has minimal effects on liver flukes. Since fenbendazole preparations are not approved for use in sheep or for use in lactating cattle, no official milk withdrawal time is listed. Slaughter withdrawal time for cattle, however, is 8 days following administration of the drug.

Fenbendazole drench is marketed as a 10% suspension (100 mg/ml) of fenbendazole. The drench is labeled for use in horses or cattle. Some common trade names include 10% Panacur Suspension (Horse), 10% Panacur Suspension (Cattle) or Safe-Guard 10% Cattle Dewormer. While labeled dosing directions for horses and cattle may be different, the product concentration (100 mg/ml) is the same.

Because fenbendazole dosing is dependent upon the parasites that are targeted, the cattle and horse products list two different doses. Approved cattle and horse doses are labeled at either 5 mg or 10 mg of fenbendazole/kg of body weight. These doses represent either 2.5 ml of the 10% solution per 100 lbs. of body weight (the 5-mg/kg dose) or the higher dose of 5 ml of the 10% solution per 100 lbs. of body weight (the 10-mg/kg dose). Sheep producers commonly use the 2.5 ml of 10% fenbendazole solution/100 lbs. of body weight dose for treating most common parasites found in sheep and increase the dose to 5 ml/100 lbs. to increase the effectiveness on tapeworms, lungworms, and larval stages of various parasites. Cost for treating a 150-lb. sheep would be roughly \$0.45 to \$0.90 per animal (dose dependent).

Fenbendazole paste is marketed as a 10% fenbendazole paste (each gram of paste contains 100 mg of fenbendazole) approved for use in horses or non-lactating cattle. The 10% fenbendazole paste comes in a 92-gram syringe for cattle, a 290-gram caulking gun cartridge for cattle, and a 25-gram paste syringe for horses. The 92-gram and 25-gram paste products are marketed in a dial-a-dose syringe with multiple 250-lb. dose increments (at the lower 5 mg of fenbendazole/kg dose). Therefore, a 250-lb. dose of fenbendazole paste would deworm a 250-lb. sheep at the 5-mg/kg dose or a 125-lb. sheep at the higher 10-mg/kg dose. With either paste syringe product it is difficult to administer less than a 250-lb. marked dose. Therefore, a 150-lb. sheep would most likely receive a 250-lb. dose of the paste. Cost for this would be roughly \$1.25 per dose for the horse product and \$0.65 per dose for the cattle paste. While the 25-gram horse paste product may be convenient for a small hobby farm, it only deworms 4 average-sized sheep and is rather expensive. The 92 gram cattle paste product could deworm about 16 average-sized sheep at a per dose cost of roughly half the cost of the horse product.

Ten percent fenbendazole paste is also marketed in a cattle caulking gun application containing 290 grams of paste. Each depression of the trigger is designed to dispense a 220-lb. dose of product (at the lower 5 mg of fenbendazole/kg dose). Each tube contains 58 of the 220-lb. doses. Realistically, a typical 150-lb. sheep would receive a 220- or 440-lb. dose of paste. One 220-lb. dose of paste from the caulking gun application would cost roughly \$0.62 per dose.

Fenbendazole also is marketed in a granular form. Currently a 22.2% fenbendazole granule is marketed for horses or dogs. Each gram of this 22.2% fenbendazole granule contains 222 mg of fenbendazole. The dog and horse products are marketed in 1-lb. jars of granules that are very similar in cost. While the dose of fenbendazole in horses and sheep is similar (5-10 mg/kg), dogs require a higher dose (50 mg/kg) of fenbendazole. Fenbendazole granules are designed to be added to the feed of dogs or horses. Each level teaspoon of the 22.2% fenbendazole granules contains about 570 mg of fenbendazole at a cost of roughly \$0.61 per teaspoon. Thus a level teaspoon dose of the granules would deworm a 230-lb. sheep (at the 5 mg of fenbendazole/kg dose) or a 120-lb. sheep at the higher fenbendazole dose (10 mg/kg). A typical 150-lb. sheep could be dewormed with 2/3 of a level teaspoon of granules (a dose of 5 mg/kg) at a cost of \$0.42 or 1 and 1/3 of a level teaspoon of granules (the 10 mg/kg dose) at a cost of about \$0.83. The cost is quite reasonable and the major advantage of the granules would be feed applications to sheep that were not easily handled.

Fenbendazole is also formulated in a cattle top-dress pellet containing a concentration of 0.5% fenbendazole. Each pound of top-dress pellet contains 2.27 grams of fenbendazole. The top-dress pellet is supplied in 10- or 20-lb. containers and approved for use only in non-lactating cattle. Slaughter withdrawal is labeled at 13 days after treatment.

Top-dress pellets are typically dosed for cattle at the rate of 1 lb. of the 0.5% fenbendazole pellet for each 1000 pounds of body weight (the 5-mg/kg dose). Pellets can either be mixed in the feed or top-dressed at the time of feeding. Therefore, one pound of the top-dress pellets would deworm six 150-lb. sheep (at the 5-mg/kg dose) or three 150-lb. sheep at the higher dose rate. Per animal cost would be roughly \$0.42 for the 5-mg/kg dose and \$0.84 for the higher dose rate.

Fenbendazole medicated salt/mineral blocks are also marketed for use in non-lactating cattle. These products, like the top-dress formulations, require a 13-day slaughter withdrawal in cattle. They are not approved for use in sheep. Fenbendazole has a wide margin of safety and is a good anthelmintic when ingested at low levels over a 3-day period of time. Medicated salt/mineral blocks incorporate fenbendazole, salt, and minerals into a free-choice preparation that utilizes salt levels to regulate consumption. Free-choice consumption is designed to allow daily ingestion of 1.67 mg of fenbendazole/kg of body weight over a 3-day period. This daily 1.67 mg/kg dose provides a combined 3-day total dose of 5 mg of fenbendazole/kg of body weight. The product is designed to be a convenient form of parasite control when cattle are on pasture.

Fenbendazole salt block preparations are marketed as a molasses-flavored salt/mineral block containing 750 mg of fenbendazole per pound of block. Non-medicated blocks of a similar formulation are also marketed to help adapt animals to block location and encourage adequate block intake. These adjustment blocks should be fed prior to placement of the medicated blocks. The medicated blocks are fed for 3 consecutive days. At the end of 3 days a total 5-mg/kg fenbendazole dose would require a 150-lb. sheep to eat 0.46 lbs. of the medicated block. This would amount to a consumption level of 0.15 lbs. of block daily (about 2.5 ounces per day). Cost for a typical commercial sheep would be about \$0.54 for the 3-day treatment.

Adult sheep will typically average 0.5 ounce of salt consumption per day in a free-choice system. The 2.5-ounce daily level of block consumption needed to supply an adequate fenbendazole dose actually contains about 0.5 ounce of salt. Therefore, while the molasses flavoring encourages adequate block intake, the salt level contained in the block discourages over consumption. Producers using the fenbendazole block system are encouraged to monitor consumption of the adjustment blocks to make sure that intake is adequate at the time the medicated blocks are introduced. Limited experience with block versions of fenbendazole suggests that adequate sheep intake is possible.

CAUTION: *Fenbendazole block preparations can contain copper. Copper levels in the Hoechst-Roussel Safe-Guard/En-Pro-Al block product are 67 ppm (compared to the typical 330 ppm of copper in most granular trace-mineral salt marketed for cattle). However, daily copper intake levels with the block should be very similar to copper intake if a typical cattle trace mineral salt were fed free-choice (because block intake amounts are roughly 5 times that of straight cattle trace-mineral salt). While copper levels could potentially be a problem for some copper-sensitive flocks, occasional 3-day use of the product should be safe for most farms.*

Fenbendazole free-choice granular mineral formulations are marketed in 10- and 20-lb. bags containing 1.9 grams of fenbendazole per pound of product. The product contains salt, minerals and fenbendazole and is only approved for use in non-lactating cattle. According to the company, the Hoechst-Roussel Safe-Guard Free-Choice Mineral fenbendazole product has no added copper. Producers concerned about copper levels in their flock might wish to consider this product instead of the block.

Like the fenbendazole block, the granular salt/mineral fenbendazole formulation is designed for free-choice feeding to cattle. It is only approved for use in non-lactating cattle and carries a 13-day slaughter withdrawal time. Sheep exposed to the

granular product should eat a daily quantity of the mixture limited by a daily intake of about 0.5 ounce of salt. Since the mixture is roughly 1/3 salt, sheep intake should average between 1.0–1.5 ounces of product per day. At this level of intake a 150-lb. sheep should receive adequate 3-day levels of fenbendazole. If a 150-lb. sheep consumed one ounce of product daily (0.8 mg of fenbendazole/lb. of body wt/day) this would amount to a total 3-day dose of 2.4 mg of fenbendazole per pound of body weight (5.3 mg/kg). At the higher 1.5-ounce consumption rate (1.18 mg of fenbendazole/lb. of body wt/day) the animal would receive a 3-day total dose of fenbendazole approaching 3.56 mg of fenbendazole per pound of body weight (7.8 mg/kg). Either dose should be adequate for sheep. Cost for a 3-day treatment with granular varieties of fenbendazole should amount to about \$0.68 to \$0.90 per animal.

Free-choice granular or block preparations medicated with fenbendazole can be especially useful in intensive grazing systems where handling individual animals is not always an option. With either of these products, it is important that the medicated product is the only source of salt available during treatment and that animals are adequately adjusted to salt before the medicated product is made available. Producers should also avoid **total** reliance of their anthelmintic control program on free-choice applications.

The free-choice fenbendazole system can also be useful in preventing a specific problem parasite such as the meningeal worm (brain worm). Meningeal worm treatment must be targeted to the time interval before the parasite enters the nervous system. Producer compliance is difficult to attain when sheep must be individually dosed at repeated 10-day intervals.

Oxfendazole

Oxfendazole, much like fenbendazole and albendazole, is one of the newer-generation benzimidazole dewormers. It is marketed by Syntex and sold under the trade name of Synanthic. Oxfendazole is in common use for sheep in many of the major sheep-producing countries in the world.

Oxfendazole anthelmintic preparations for cattle are designed for oral administration as drenches or are directly injected into the rumen via a special rumen injector apparatus (don't use this device in sheep). A new paste version designed to fit into a typical automatic syringe has also just been released. **Oxfendazole is not approved** for use in sheep but is considered safe, has a wide margin of safety, is safe for pregnant ewes, and treats all of the major intestinal parasites that typically infect Midwestern sheep. It is effective against the common adult and larval forms of stomach, intestinal, and lung worms of sheep. It is also effective against tapeworms but has no effect on external parasites or nasal bots. Oxfendazole's effectiveness on liver flukes is questionable. It is only approved for use in non-lactating cattle and has no approval for use in sheep. Cattle slaughter withdrawal time for oxfendazole is labeled as 7 days following administration of the product.

Oxfendazole drench is marketed in 1-liter bottles as either a 9.06% suspension of oxfendazole (containing 90.6 mg oxfendazole/ml) or a 22.5% suspension of oxfendazole (containing 225 mg oxfendazole/ml). In cattle, both suspensions are dosed at the rate of 4.5 mg of oxfendazole/kg of body weight (this is 2.05 mg/lb).

The 9.06% suspension of oxfendazole is designed for deworming lighter weight cattle and is dosed at 2.5 ml/110 lbs. of body weight. A similar dose is used in sheep. A 150-lb. sheep would be dosed at 3.5 mls of the 9.06% oxfendazole suspension at a cost of about \$0.42 per dose. Realistically, however, most producers would administer 4 mls of the suspension because most drench guns would be difficult to accurately adjust to ½-ml increments, thus a cost of \$0.48 per dose is more realistic.

The 22.5% oxfendazole suspension is designed for deworming heavier cattle. It requires much less volume of medication to treat the same amount of body weight than does the 9.06% suspension. The 22.5% oxfendazole product is labeled to

be dosed to cattle at the rate of 1 ml per 110 lbs. of body weight. While the 22.5% suspension could be used on sheep, the logistics of small volume dosing would be difficult.

An 18.5% oxfendazole paste has just recently been released to the market. The product is designed to administer 10 adult cow doses of oxfendazole per tube of paste. This product may prove useful if the dose can be accurately delivered to 100–200-lb. animals and if the cost is competitive with the 9.06% drench product. This paste product is designed to adapt to a typical automatic syringe, allowing accurate low-volume dosing.

CAUTION: Sheep producers, by necessity, are notorious for trying new things. Use of the rumen injector gun is not recommended for administration of oxfendazole to sheep. The gun is designed for injection of oxfendazole suspension directly through the flank and into the rumen. It is cattle sized, cattle designed, and inappropriate for use in sheep.

Be Careful With Low-Volume Dosing

A constant theme throughout this articles has been the problem of accurately dosing the newer low-volume anthelmintic drenches using standard drenching outfits. New drench attachments designed to slip on to a standard Roux 50-ml automatic syringe should help solve this problem. These adapters can be ordered from Pipestone Veterinary Supply for about \$8.00 each. They should help to more accurately deliver 1–5 ml doses of anthelmintic.

Ivermectin

Several forms of ivermectin are currently utilized by the sheep industry, but *only the drench is approved for use in sheep*. Ivermectin food animal products are marketed under the trade name Ivomec, with horse formulations sold as Eqvalen or Zimectrin. Formulations include drenches, injectables, pastes, and pour-ons.

Ivermectin products are usually more expensive than many of the other anthelmintics but are extremely effective on the common stomach, intestinal, and lung worms that affect sheep. Ivermectin has no effect on liver flukes or tapeworms but is effective on nasal bots and has excellent larvacidal activity. Ivermectin is most effective against sucking louse varieties; however, if newly hatched lice are to be affected (breaking the life cycle of the louse), a second treatment needs to be administered 10–14 days after the first. Ivermectin has limited effects on the biting louse. Ivermectin is safe for use in pregnant ewes and has a wide margin of dosing safety. The dose of ivermectin generally recognized for sheep is 200 mcg/kg of body weight.

Ivermectin sheep drench is marketed as a 0.08% solution of ivermectin. The sheep drench comes in both a 960-ml and 4800-ml size container. Dosing is listed as 3 ml of solution per 26 lbs. of body weight. Therefore, 18 mls of the 0.08% ivermectin solution would be administered orally to a 150-lb. sheep. Costs per animal would vary between \$0.80 to \$1.10 per dose, depending on the size purchased. Usually, the larger the container the cheaper the cost per dose. Ivermectin sheep drench is roughly 2 times more expensive than the levamisole drench product mentioned earlier.

Ivermectin drench has a wide margin of safety, is safe for pregnant ewes, and has a slaughter withdrawal time of 11 days for sheep. Ivermectin products are not approved for use in lactating animals; therefore, no official milk withdrawal exists.

Ivermectin injectable products are available for both cattle and hogs, but are *not approved for use in sheep*. However, use of the injectable ivermectin products in the sheep industry is common. Injectable forms of ivermectin are

marketed as a 1% sterile solution labeled for cattle and either a 1% or a 0.27% sterile solution labeled for hogs. Most sheep producers use the cattle product. Except for the dosage (1 ml/110 lbs. in cattle, 1 ml/75 lbs. in hogs), the 1% sterile solution for cattle or hogs is identical. Costs of each product are also very similar. Producers should be aware that the 0.27% solution exists and avoid confusion during ordering. The less concentrated 0.27% sterile solution is designed for use in lighter- weight feeder pigs.

Use of the injectable product is considered an "extra-label" application and thus has no official meat withdrawal time. Most producers use the 1% cattle product as a subcutaneous injection administered at the rate of 1 ml of the 1% sterile ivermectin solution/110 lbs. of body weight (same dose as cattle). This similar dose in cattle has a 49-day withdrawal time for slaughter. Cost would be roughly \$0.75 to \$1.10 for a 150-lb. sheep, depending on purchase volumes. Realistically, most injectable products are administered to the flock via an automatic syringe. Dose rates in most automatic syringes can only be adjusted in 1 ml increments. For this reason, the 1.4 ml dose for the 150-lb. sheep actually becomes 2 mls, thus increasing the cost considerably. The 1% injectable ivermectin product is marketed in 50-ml, 200-ml and 500-ml vials. Price drops significantly with the purchase of larger containers.

Paste formulations of ivermectin are approved only for use in horses. Ivermectin paste is sold under the trade name of Eqvalen (the veterinary label) or Zimecterin (the over-the-counter version of the same product). Both equine products contain a 1.87% ivermectin paste loaded in a syringe designed to deliver a 200 mcg/kg oral dose of ivermectin. This 200 mcg/kg oral horse dose of ivermectin is identical to the ivermectin drench dose used in the sheep product. Each tube contains enough paste to deworm a 1250-lb. horse. The syringes are further graduated to deliver 250-lb. dose increments of ivermectin paste. Therefore, the paste syringes could be used for sheep using the same weight/dose gradations marked on the tube. Use of the equine paste product might be reasonable for small hobby flocks of 6 or 8 sheep but this paste formulation is generally too expensive for commercial operations. Equine paste formulations of ivermectin cost about \$10.00 per tube and doses for less than a 250-lb. animal are difficult to deliver. Thus a 150-lb. sheep would, most likely, receive a 250-lb. dose of paste. This equates to a cost of about \$2.00 to deworm a 150-lb. sheep with the horse product.

Horse drench formulations of ivermectin are also marketed under the trade name of Eqvalen Liquid. This product is designed to be administered to horses via oral drenching or through a stomach tube. The product has the identical concentration of ivermectin as the 1% ivermectin injectable cattle product and is dosed orally at the similar rate of 1 ml/110 lbs. of body weight. The cost of deworming a 150-lb. sheep with 1.4 mls of this product is similar to injectable ivermectin. Again, we also have the problem of giving a small dose through a drench gun. Any wastage or spillage from the sheep could affect efficacy.

*** *An ivermectin pour-on for cattle is available and approved only for use in non-lactating cattle. This product, like the levamisole pour-on, does not work in sheep.****

Ivermectin is also marketed in combination with clorsulon under the trade name of Ivomec-F. This subcutaneous injectable product is designed and approved only for use in non-lactating cattle. The product includes clorsulon for the treatment of the fluke species *Fasciola hepatica*, which is not common in the Midwest sheep population. *Fascioloides magna*, the liver fluke carried by the white-tailed deer, is commonly found in the upper Midwest region in swamp-lands that have dense populations of white-tailed deer. While clorsulon does have some therapeutic effect on the *F. magna* fluke, the cost of the combination product, limited efficacy, and dose variations between sheep and cattle may make albendazole (Valbazen) a better choice for treatment of *Fascioloides magna* (the deer fluke).

Doramectin (Dectomax)

Doramectin is a member of the avermectin family of anthelmintics. It is very similar to the ivermectin beef cattle injectable product in both spectrum of activity, formulation and dose. Doramectin is manufactured by Pfizer and sold under the trade name of *Dectomax*. It is marketed as a 1% injectable solution approved only for use in non lactating cattle. Primary use is in the beef industry. In beef cattle, the injectable (SQ or IM) dosage rate is 200 $\mu\text{g}/\text{kg}$ of body weight which is 1cc of the 1% Dectomax product per 110 lbs of body weight. The meat withdrawal time for cattle is 35 days post injection. While this product is not approved for use in sheep it has been used SQ by some producers in a very similar manner to the ivermectin injectable product. In sheep, a similar SQ 1cc/110 lb dose is usually employed. Cost is usually very similar to Ivomec injectable. This is not an approved product for sheep, therefore, there is no approved slaughter withdrawal time. Like Ivomec, this product is not effective against liver flukes or tapeworms.

Other Cattle Pour-on Products

Recently two cattle pour-on type avermectin dewormers have entered the market. They include **Eprinex** (*eprinomectin*) by Merck and **Cydectin** (*moxidectin*) by Ft Dodge. Neither are likely to be effective approved for use in sheep.

Medication Summary

In summary, remember that there are many other anthelmintics that could accommodate extra-label use in sheep. Many of these medications, such as mebendazole and pyrantel, are commonly used sheep anthelmintics in other countries. While they are marketed in this country for use on other species, they are not as readily available and they are not usually labeled for use in other ruminant species such as cattle. I have tried to concentrate on anthelmintics that do have approval and slaughter withdrawal times for cattle. This way there are at least some food-animal type data to back up use decisions and dosing rates. The medications, doses, costs, and preparations listed in this article are not meant to endorse or slight any product. Costs will also vary significantly and product formulations are always changing.

Sheep, as a minor species, are not likely to receive FDA approval for use of many new medications. Sheep approval is costly, time consuming, and a financially unsound decision for most pharmaceutical companies. The U.S. sheep market is just too small (and the bureaucracy too big) to warrant the expenses of approval. U.S. sheep producers and their veterinarians will, by necessity, need to occasionally utilize anthelmintics that are not approved for use in sheep. Like the ostrich, we can bury our heads in the sand or throw up our hands and say we have no approved medications to treat the problem, or we can use common sense and knowledge to encourage flock health and economic survival of the producer.