Grass, Goats, and... Uninvited Guests!

Small Ruminant (Goat and Sheep) Parasitology and Diagnostics

Facilitator's Guide

Publication 4H-876

Purpose Statement: The purpose of this activity is to increase understanding of the importance of small ruminants (sheep and goats) to agriculture, increase content knowledge of parasites affecting small ruminants as well as diagnostic methods to identify issues, discuss the importance of sustainable use of medications, develop STEM understanding/skills, and to encourage positive youth development through intentional cultivation of life skills.

Contents

Authored by Dr. Chantel Wilson, Assistant Professor and 4-H STEAM Extension Specialist, Virginia State University

Reviewed by Dr. Dahlia O'Brien, Professor and Small Ruminant Extension Specialist, Virginia State University; Susan Schoenian, Sheep and Goat Specialist, University of Maryland; Bethany Eigel, Unit Coordinator and Extension Agent, 4-H Youth Development, Virginia Cooperative Extension; and Lenah Nguyen, Extension Agent, 4-H Youth Development, Virginia Cooperative Extension

Subjects: Animal Science/Veterinary, Biology/Ecology, Agriculture, Mathematics

Time for Activities: Up to 2 hours (Parts 1-8), Additional Time for Part 9 (at least 3 hours recommended)

Ages: Suitable (with modification) for all ages. Recommended for ages 9-14.

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Background

Goats and sheep belong to a group of animals called small **ruminants**. These mammals have a stomach with four compartments and the ability to digest tough plant material using **fermentation**. Following grazing of food materials such as grass, food will travel through the four parts of the stomach including the **rumen**, **reticulum**, **omasum**, and the **abomasum** (figure 1). The abomasum is similar to a human's single-compartment stomach. Ruminants typically regurgitate partially digested food as **cud** and will chew the material to help with the fermentation and digestion process.

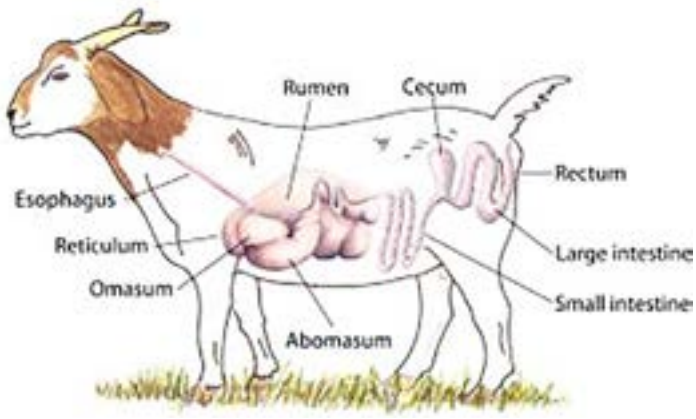

Figure 1. Goat digestive system. Image from eXtension.org Hart 2008.

Goats and sheep are important sources of agricultural products including milk, meat, and fiber. Some people also choose to keep goats as pets or even to control plant growth on their properties. To prevent serious illness and losses in terms of agricultural product value, goats and sheep must receive prompt care if they show signs of infection with **parasites**. For example, the parasitic barber pole worm *(Haemonchus contortus)* feeds on blood, and severe infections can cause a goat to lose a significant amount of blood in a single day. The average blood loss per worm per day is approximately 0.5 milliliters (Clark, Kiesel, and Goby 1962). Parasitic infections cause **anemia**, weight loss, weakness, jaw **edema** (bottle jaw), diarrhea, and death.

Many agricultural producers and keepers will allow their goats and sheep to graze grass and other vegetation in pastures. Animals that browse – that is, those that eat leaves of trees, shrubs, and vines that have woody stems rather than grasses – typically do not get worm infections. Pasture-grazed animals are vulnerable to barber pole worm infections, especially if grasses are short and are growing in warm, moist soil conditions. Goats and sheep may swallow worm **larvae** present in the grass as they are grazing. The larvae will develop into adults and attach to the abomasum of the goat or sheep to feed on blood. Eggs are released by female worms into the abomasum and intestines after mating, which are then excreted in the goat or sheep's **feces** to return to the pasture. The life cycle of the worm starts again when the eggs in the pasture hatch and larvae are released into the grass (figure 2).

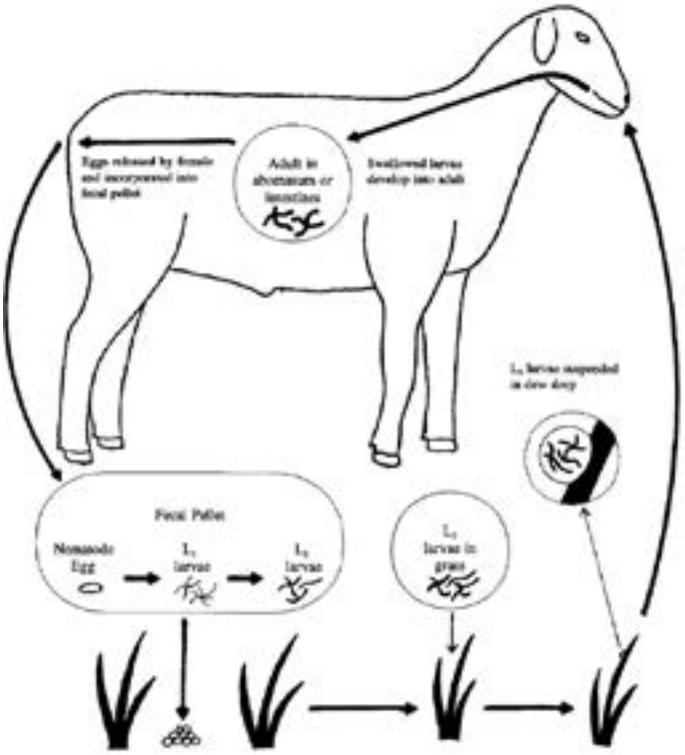

Figure 2. Life cycle of *Haemonchus contortus.* Image from Machen et al. 2017.

The purpose of this activity is to familiarize participants with the barber pole worm life cycle, the signs and symptoms of parasite infection in goats or sheep, the use of tools to diagnose parasitic infections, and the appropriate time to use an **anthelmintic**/dewormer product as a treatment to deworm animals.

Participants will also have the opportunity to research parasites and diseases in their favorite animal, create a model, and take the lead in teaching others about their model as a project.

This activity incorporates important life skills from the Targeting Life Skills Model by Iowa State University Extension such as Critical Thinking, Decision Making, Learning to Learn, Goal Setting, Planning/Organizing, Wise Use of Resources, Keeping Records, Communication, and Social Skills (Hendricks 1996).

In the real world, goat and sheep health is assessed using the Five Point Check which includes FAMACHA, dag scoring, body condition scoring, presence of bottle jaw, and coat/nose condition. In this activity, participants will use the **FAMACHA** system, animal body condition scoring, the **Dag** Score scale, fecal egg counting, and determination of packed cell volume (blood **hematocrit**) using plush goat or sheep models and centrifuge tubes. Each goat/sheep has been named Nacho, Ginger, or Peanut and they each represent a different condition: Nacho is relatively healthy; Ginger is borderline; and Peanut is a severely parasitized animal. The individual components or structure of the activity can be adjusted according to available resources or content to suit a particular age group of children and can also be used for adult training.

The website for the American Consortium for Small Ruminant Parasite Control (ACSRPC; http://www.wormx.info/) has several resources, including videos for additional background information.

It may be beneficial to contact a small ruminant specialist, Extension agent, research scientist, or livestock veterinarian to assist with understanding the background material or to deliver the content. This would give participants the chance to meet real individuals employed in STEAM (science, technology, engineering, agriculture, and math) fields and give them a chance to talk about career options.

The FAMACHA System

The FAMACHA system was developed by Dr. Faffa Malan (FAffa MAlan CHArt) in South Africa as an indirect method to assess the level of anemia in small ruminants. Anemia is a common symptom of parasitic infections resulting in blood loss. Anemia occurs when there are not enough red blood cells in the body and the ability of the blood to carry oxygen to tissues is reduced. The FAMACHA system uses a chart (figure 3) with five colors that corresponds to an animal's bottom eyelid and ranks the severity of anemia from 1 (red: optimal/no anemia) to 5 (white: severe/fatal). Animals with a score of 1 or 2 are not usually recommended for parasite treatment. Animals with a score of 3 are borderline, and may or may not be recommended for treatment, depending on other factors. Animals with a score of 4 or 5 are recommended to receive parasite treatment as soon as possible.

Research has shown that the FAMACHA system correlates well to packed cell volume and fecal egg counts to determine parasite load status in small ruminants (Kaplan et al. 2004). See the "FAMACHA in a Nutshell" video at (https://www.wormx.info/videos-from-attra) for further explanation and to see how the system is used with a real animal.

The goat/sheep models in this activity have eyelids that can be pulled down to reveal a colored area corresponding to the FAMACHA chart. The healthiest goat/sheep, Nacho, has a red eyelid color indicating the highest number of red blood cells and good health. Ginger has a pink eyelid color indicating borderline anemia. Peanut has a whitish eyelid color indicating severe anemia, the lowest amount of red blood cells, and poor health. "Blood" samples provided in the next part of the exercise correspond to the anemia levels in each of the animals. Subjectivity due to variances in colors/scores can be controlled by allowing a choice of just three scores for the activity (1, 3, or 5) instead of 1 through 5.

Figure 3. FAMACHA card

Packed Cell Volume/Hematocrit

Determination of packed cell volume/hematocrit is a more direct method to assess the level of anemia in small ruminants. An anemic animal will have a lower percentage of red blood cells (lower packed cell volume/hematocrit) as compared with a healthy animal. The ratio of the volume of red blood cells to the total volume of blood is typically determined by centrifugation, in which a whole blood sample from an animal is spun in a centrifuge tube. The red blood cells separate to the bottom of the tube (red), followed by a thin layer of white blood cells and platelets, with the plasma rising to the top of the tube (yellow) (figure 4). To determine the packed cell volume, the length of the red blood cell column is divided by the total length of the blood column and multiplied by 100. For example, if

a 50 milliliter blood sample is spun in a centrifuge tube, the total blood volume is 50 milliliters (this will also include the top of the yellow plasma layer in the tube). If the red blood cell layer reaches the 15 milliliter mark in the tube, then the packed cell volume/hematocrit is 15/50, or 0.3. To determine the percent, multiply by 100; in this case, 30%. In goats, a packed cell volume of 19%-38% is considered to be in the normal range (Jain 1986). In this activity, participants will be given tubes representing a 50 milliliter blood sample that has been spun in a centrifuge. Red gelatin will represent red blood cells and yellow gelatin will represent plasma for the determination of packed cell volume. Centrifuge tubes should be labeled with the goat/sheep's name. Participants with the animals named Nacho (the healthiest animal) should be given a tube with a 30% packed cell volume. Those with Ginger should be given a tube with 20% packed cell volume, and those with Peanut should be given a tube with 10% packed cell volume.

For more information on hematocrit determination, see the "Haematocrit or PCV Determination" video from the Labs for Life project, online at https://www.youtube.com/watch?v=RoS3w_Sng_Q. Another video, "Obtaining a Blood Sample From Your Small Ruminant" from Purdue Extension, is also useful for showing how to get a blood sample from a sheep or goat: https://www.youtube.com/watch?v=47tlmqXX3eE.

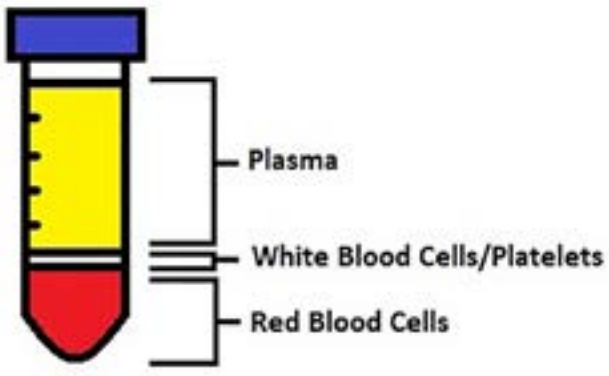

Figure 4. Whole blood sample following centrifugation.

Dag Scoring

Dag scoring refers to the degree of fecal soiling and/or diarrhea present on the rear end of a goat or sheep (figure 5). Diarrhea is not a symptom of barber pole worm infection; however, mixed infections with other parasites can result in diarrhea. Checking dag scores is useful for determining the need to deworm due to infection from these other parasites, especially in animals with FAMACHA scores of 3. A dag score of 0 corresponds to no fecal soiling, whereas a score of 5 indicates very severe watery diarrhea. For small ruminants infected with worms, treatment is usually not recommended for dag scores of 2 or below. Deworming treatment should be considered for a 3 score. Deworming treatment is recommended for animals with a 4 or 5 dag score.

In this activity, the backsides of the goat or sheep models are colored with washable brown marker to create dags/diarrhea staining. Nacho does not have any fecal soiling (clean) and has a dag score of 0. Ginger has a moderate level of fecal staining corresponding to a dag score of 3. Peanut has a very severe level of fecal staining corresponding to a dag score of 5. If there is concern with the subjective nature of assigning scores, leaders may want to instruct participants to choose from dag scores of 1, 3, and 5 only instead of 0 through 5.

Figure 5. Dag score scale. Image courtesy of Sheep Improvement Limited 2017.

Body Condition Scoring

A body condition score helps gauge nutrition and health by assessing the amount of muscle and fat an animal has. A body condition score of 1 indicates a very thin animal, whereas a body condition score of 5 indicates an obese animal (figure 6). Goats and sheep should have a body condition score between 2 and 4 with 3 being ideal. See the "Body Condition Scores in Goats" video at https://www.wormx.info/external-videos for more explanation and to see how body condition is determined in a real animal.

In the goat and sheep models used in this exercise, wooden dowels are inserted to represent the backbone. Stuffing is removed from the backbone area to create "thinner" animals. The length of the dowel to represent the transverse process (side projections of the backbone) close to the hip area is exaggerated in the thin animals, and has been reduced in the healthier animals. The dowel rods can be felt most easily in Peanut and with difficulty in Nacho. The body condition scores for Ginger and Nacho may be more subjective, depending on the participant. For this reason, leaders might want to instruct participants to pick between a body condition score of 1 (Peanut), 2.5 (Ginger) or 3.5 (Nacho) instead of 1 through 5.

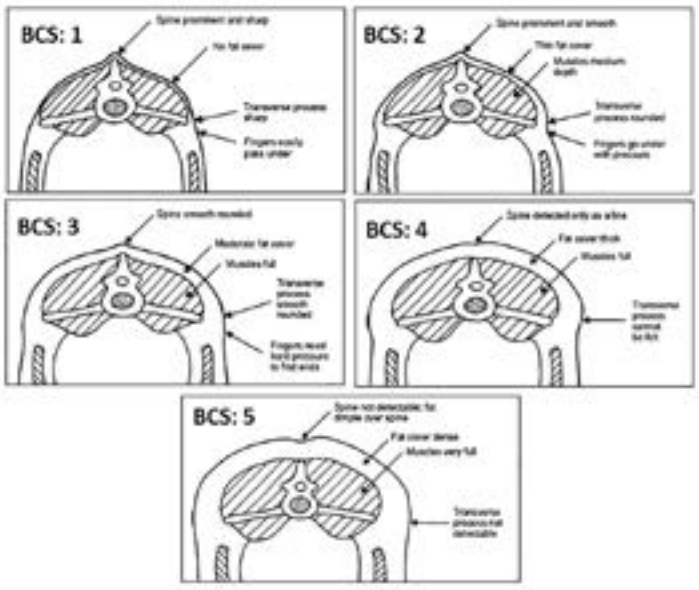

Figure 6. Body Condition Scores. (Images from Thompson and Meyer 2018.)

Fecal Egg Counts

Fecal egg counting is a method used to estimate the number of parasites (load) in an animal. Fecal samples are manually removed from a sheep or goat and then the McMaster Test is used to determine the number of worm eggs excreted per gram of feces. This test involves "floating" the worm eggs in a saturated salt or sugar solution to separate the eggs from the feces, and then using a specialized microscope slide with a counting grid to count the number of eggs. Higher egg counts suggest a heavier parasite load than a sample with fewer eggs. Fecal egg counts are generally not used in isolation to determine if a goat or sheep needs to be treated for worms. For more information, see the "How to Conduct a Fecal Egg Count in Sheep and Goats" video from Purdue Extension at https://www.youtube.com/watch?v=5vELgijcad4. For additional information, see the "How and Why to Do Sheep and Goat Fecal Egg Counting" video at https://www.wormx.info/videos-nesmrum. The laboratory procedure starts at 29:46 of the video (McMaster Test).

In this activity, fecal samples are represented by a piece of chocolate candy and the worm eggs are represented by nonpareils (candies/sprinkles used as a dessert topping). The "eggs" are gently rolled/pressed into the surface of the chocolate, placed in a small bag (labeled as "fecal sample"), and are placed in the abdominal cavity of the goat/sheep model. Peanut has the highest number of eggs in the fecal sample to correspond to a higher number of worms present and the most severe symptoms. Ginger has an intermediate number of eggs in the fecal sample. Nacho has the fewest number of eggs in the fecal sample to correspond to the lowest number of worms present and a lack of obvious symptoms of infection. If comparing the fecal egg count data from each of the participant groups, the number of eggs should be fairly consistent for each animal of the same name (Peanuts, Gingers, and Nachos).

Worms and Treatment

When treating for parasitic worms in real life, it is not recommended to treat entire flocks of animals. It can be expensive and increases resistance to anthelmintic medications, rendering the medications ineffective. Deworming medications are not effective against all parasites, and the diagnosis should first be confirmed. Veterinarians can help to differentiate between worm infections and other types of infections. Veterinarians must be consulted to use a medication in a manner for which it was not intended (extra-label) to comply with the law. Participants will decide if they should treat their animals based on the information they collected from the other parts of this activity. In a practical setting, the FAMACHA score and/or the packed cell volume can be used to estimate anemia and determine when treatment is needed (see table 1 O'Brien 2018 and Schoenian 2019). Anemia is most commonly caused by worms, but it may be caused by other diseases or parasites so diagnoses should be confirmed by a veterinarian. Peanut is the only goat/sheep in this activity that is definitely recommended for treatment. Ginger may or may not be treated. Nacho does not need treatment.

FAMACHA Score	Eyelid Color	Packed Cell Volume %	Red Blood Cell Level	Treatment Recommended?
1	Red	≥ 28	Optimal	No
2	Red-Pink	23-27	Acceptable	No
3	Pink	18-22	Borderline	Possibly
4	Pink-White	13-17	Dangerous	Yes
5	White	≤ 12	Fatal	Yes

Table 1. Parasite treatment recommendations taking into account FAMACHA score, packed cell volume, eyelid color, and anemia level (red blood cell level). Adapted from http://www.sheep101.info/201/parasite.html (Schoenian 2019)

In this activity, parasitic worms are represented by gummy worms. Peanut has the highest number of gummy worms, followed by Ginger, and Nacho has the fewest number of worms. The gummy worms are placed in a small bag labeled as the abomasum and placed in the abdominal cavity of the goat/sheep model (should be behind the fecal sample, closer to the head than the rear of the stuffed animal). When participants perform the deworming treatment on the goats or sheep, they may eat the gummy worms.

In real life, chemical anthelmintic medications or other treatments (for example, copper oxide wire particle [COWP] bolus/pill) may be used to control barber pole worms. See the "How to Administer COWP Boluses" video at https://www.wormx.info/videos-from-attra to show how an animal is given the COWP bolus. Caretakers typically mark treated animals with a bright crayon following deworming treatment. In this activity, participants may use an ear tag or washable marker to mark stuffed animals that have been treated. Participants may also treat the dags by using a moist washcloth to remove the washable marker from the rear end of the animal.

References

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Definitions

Abomasum: the fourth part of a ruminant's stomach, similar to a human's single-compartment stomach

Anemia: a condition that develops as the result of a deficiency of red blood cells

Anthelmintic: a medicine used to treat parasitic worms

Cud: partially digested food material regurgitated by ruminants for further chewing to aid in digestion

Dag: dried excrement (poop) and matted wool on the rear end of a ruminant

Edema: swelling caused by a buildup of fluids in the body

FAMACHA: method by which small ruminants are assessed for anemia using a chart as compared to eyelid color

Feces: excrement (poop)

Fermentation: a process of chemical breakdown (digestion) of food material by bacteria

Hematocrit: the ratio of the volume of red blood cells to the total volume of blood

Larvae: immature stage of a worm or insect's life cycle

Omasum: the third part of a ruminant's stomach; receives material from the reticulum

Parasite: an organism that derives benefits and nutrients at a host's expense, often causing disease

Reticulum: the second part of a ruminant's stomach, which has a structure resembling a honeycomb

Ruminants: mammals with a unique four-part stomach, includes animals such as sheep, goats, and cows

Rumen: the first part of a ruminant's stomach that partially digests food with the aid of bacteria (site of fermentation)

Activity Model Construction

Any mention of product trade names is for clarification purposes only and does not represent an endorsement for that particular product. Products listed in parentheses were used by faculty during the development of this activity. ***Other items may be used.***

Goat/Sheep Models with Fecal Samples and Worms

The goat/sheep models should be constructed in sets of three to demonstrate a severely ill (Peanut), mildly ill (Ginger), and relatively healthy (Nacho) animal. Ideally, all participants should have their own model and should work in groups of three with one of each of the animals. Before the activity begins, check if any of the participants have food allergies and check ingredient labels. Clay/fun dough fecal samples or plastic fishing worms may be substituted if alternate food products are not available. Models may be made with removable eyelids/washable dags if participants will be taking their model home. Otherwise, permanent markers can be used to apply dags, and the eyelids may be sewn or glued on for permanent teaching models. Costs decrease when items are bought in bulk- consider purchasing materials with other groups/Extension Units when possible.

Materials for a Set of Three Goats or Sheep and Fecal Egg Counting

3 FAMACHA cards, dag score cards, and body condition score cards (see appendix for printable cards, contact an Extension agent or small ruminant specialist, or complete training in person or online at https://web.uri.edu/sheepngoat/famacha/ to purchase real cards).

3 plush goats or sheep (such as the 8-inch Rocky Mountain Goat or Black Face Sheep by Aurora World Inc.).

1 sheet white (or gray for sheep) craft felt (such as Go Create white craft felt, 9 inch by 12 inch). Will have extra.

1 sheet red craft felt (such as Go Create red craft felt, 9 inch by 12 inch). Will have extra.

1 sheet pink craft felt (such as Go Create baby pink craft felt, 9 inch by 12 inch). Will have extra.

1 sheet cream craft felt (such as Go Create cream craft felt, 9 inch by 12 inch). Will have extra.

White fabric (such as an old long-sleeve T-shirt sleeve) for abdominal pouch (2"x4" squares, 3 each)

Sewing needle

White sewing thread

Seam ripper

Scissors

Needle nose pliers

Adhesive OR sew-on hook and loop fabric fasteners (such as adhesive Velcro)

Washable brown marker (such as Crayola Ultra-Clean Washable Markers), OR brown permanent marker

2 sets of bamboo chopsticks or thin wooden dowel rods

6 safety pins

3 sheets construction paper, multiple colors (yellow, blue, green, orange) for ear tags

Duct tape

1 bag gummy worms (such as Black Forest Organic Gummy Worms, 9 oz. bag, approximately 24 gummies)

1 bag chocolate candies (such as Twix Minis, 9.7 oz. bag, approximately 28 per bag). Will have extra.

1 container nonpareils dessert topping (such as Kroger Nonpareils Dessert Topping, 3.75 oz.)

3 petri dishes with counting grids, OR plain petri dishes with counting grids drawn on paper

3 popsicle sticks

6 small resealable plastic bags, approximately 2 inches by 3 inches

Black permanent marker

3 disposable pipettes (optional — may need to trim end if narrow)

3 magnifiers (optional)

3 small cups (such as plastic condiment cups, optional)

Water or vegetable oil

Ear Tags

Create nametags for each of the goats or sheep using small strips of construction paper. One nametag should say "Nacho" (yellow), one should say "Ginger" (blue), and the last should say "Peanut" (green). These nametags should be attached to each of the goat's or sheep's ears using safety pins. Using small pieces of orange construction paper, create three tags with "treated" on the label. The "treated" tags should be attached to the goat or sheep's ears following deworming treatment near the end of the activity.

Eyelids

Place the sheet of white (or gray for sheep) felt on top of the red felt to make eyelids for Nacho. Cut out two small squares relative to the eye size of the stuffed animal. Initially, the red felt squares should be the same size as the white felt squares. Keeping the white felt on top of the red felt, trim the squares into a "D" shape. Then, trim the red felt so that it is slightly smaller than the white felt. Use a sewing needle and thread to stitch together the white felt and the red felt at the rounded side of the D (figure 7). If necessary, use scissors to trim the hair underneath the eye of the stuffed goat/sheep, and then place a small piece of the fuzzy end of the adhesive hook and loop closure underneath the eye. Place the adhesive hook end of the closure on the back of the red part of the eyelid, and then press to attach the eyelid to the stuffed animal. The white felt should obscure the red, and participants should be able to pull down the white part to reveal the red part of the eyelid. Repeat this process, replacing the red felt with pink felt for Ginger, and using the cream-colored felt for Peanut.

Abdominal Cavity and Backbone

Use a seam ripper to open up the rear end of the animals along the seams underneath the tail, or cut to make a new opening. This should represent access to the rectum/abdominal area. For the body condition scoring part of the exercise, use a bamboo chopstick to represent the backbone (figure 8). First, hold the chopstick next to the animal to get a proper measurement. Make sure one end of the chopstick is in the head area. Using the needle nose pliers, cut the chopstick off at the rear end of the animal. Do this for each of the animal models. For the transverse process of the spine, cut three small pieces of a chopstick: 1.25 inches for Nacho; 2.25 inches for Ginger; and 2.75 inches for Peanut. Using two small pieces of duct tape, attach the transverse process pieces to the backbone pieces, making an inverted cross. Remove stuffing to make Peanut appear thinner, and add stuffing to make Nacho appear heavier (Ginger should be in between the other two). The idea is for the ill animals to appear thinner and have a transverse process that is easier to detect by sight and/or touch. Insert the chopsticks so that the longest piece enters the head, and the cross part representing the transverse process is close to the hip area. You may need to hold the "backbone" in place by adding a couple stitches, sewing the chopstick to the fabric on the animal's back, near the area with the transverse process.

Figure 7. Goat/sheep eyelid assembly and use.

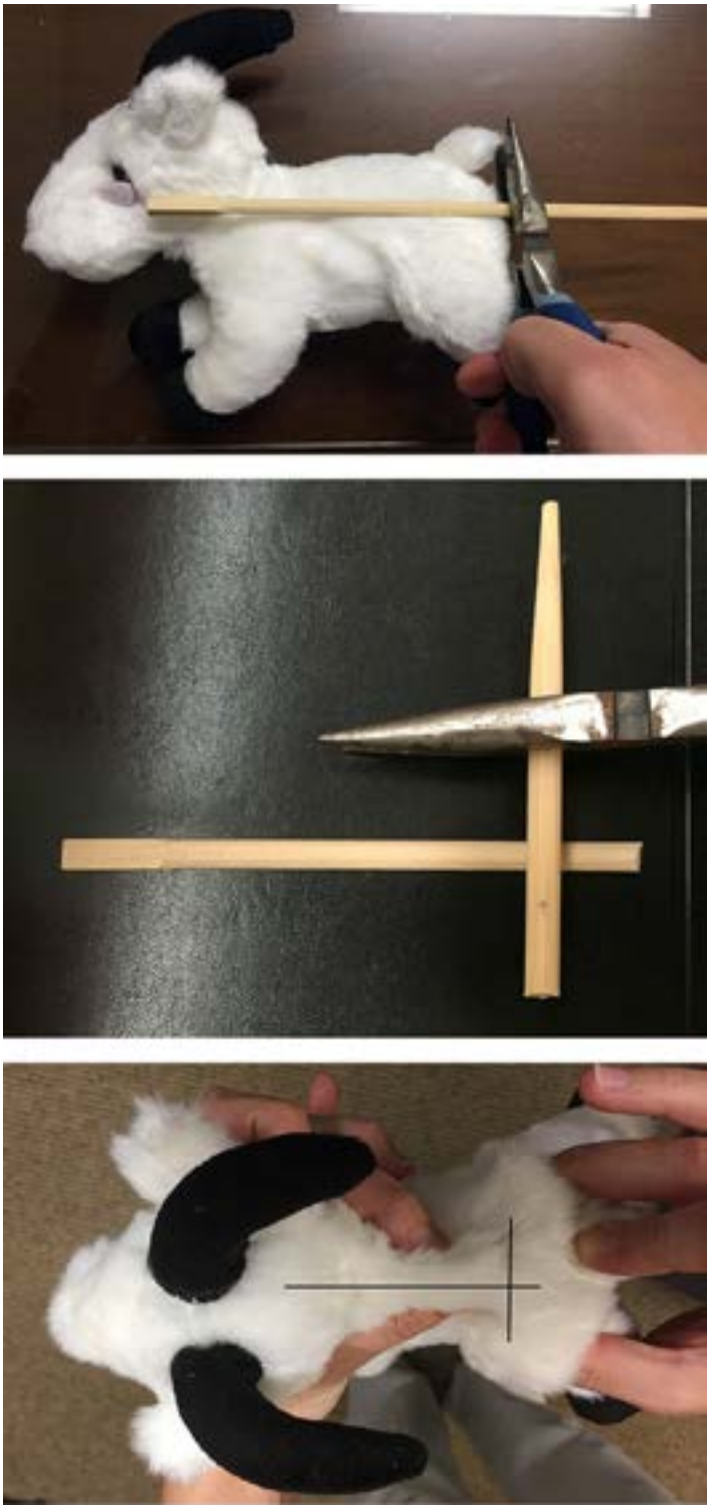

Figure 8. Goat/sheep "backbone" assembly for body condition scoring. Bottom photo courtesy of Tammy McCausland.

Once the "backbone" is in place, you will need to make a fabric pouch to hold the abomasum and the fecal sample for each of the animals. Either use two pieces of 2.5" x 4" fabric, or you can trim a sleeve about that size from an old long-sleeve t-shirt for each pouch. Sew the pieces together to form a pouch, with the opening on one of the short sides. Sew the pouch into animal by stitching the open-end edges of the pouch to the edges of the hole you made in the rear end of the animal. Add a strip of adhesive hook and loop closure to the top and the bottom of the outer rim of the opening, so the pouch can be opened and closed.

Figure 9. Goat/sheep abdominal pouch assembly.

Worms

For each goat or sheep, use the permanent marker to label one small plastic bag as the "abomasum" to hold the gummy worms. Using clean hands (or gloves), add gummy worms to each of the plastic bags. Nacho should have the fewest worms (or none), Ginger should have a few worms, and Peanut should have the most worms. It may be easiest to use one worm for Nacho, two for Ginger, and three for Peanut, depending on the size of the stuffed animal used. Seal the bags, and then push each bag into the back of the pouch for each animal.

Fecal Sample with Worm Eggs

For each goat or sheep, use the permanent marker to label one small plastic bag as the "fecal sample." Using clean or gloved hands, unwrap the chocolate. Place some of the nonpareil candies (representing worm eggs) on a hard surface or a small dish to roll/press the chocolate gently into the nonpareils until they stick to the surface of the chocolate (figure 10). If the chocolate is hard, it may need to be held in your hand for a few seconds to warm it up. Place the fecal sample with eggs in the plastic bag. Alternatively, the chocolate and nonpareils can be placed in the bag separately, especially for younger children who might have difficulty scraping the eggs off the chocolate. Nacho should have only a few nonpareils (or none, if no worms were used in the step above). Ginger should have an intermediate amount, perhaps 1/16th of a teaspoon, and Peanut should have the most, about 1/8th of a teaspoon. Seal the bags, and then push each bag into the pouch for each animal. Close the pouch using the Velcro closure. It is recommended this activity be held indoors or in cooler weather to avoid melted chocolate.

Figure 10. Fecal sample/worm egg assembly and finished products (note differences in eyelid colors, worm numbers, and number of eggs in fecal samples).

Dags/Fecal Soiling

Ginger and Peanut should have dags/fecal soiling as a symptom of worm infections. For comparative purposes, Nacho should not have any staining since the infection is either absent or not severe. Refer to the SIL Dag Score Scale chart in the background material (figure 5). Ginger should have a dag score of approximately 3 and Peanut should have a dag score of approximately 5. Using the brown marker, color the rear end of the area of the stuffed animal (and down the legs as necessary) to match the fecal soiling patterns (figure 11). Use a washable

Figure 11. Goat/sheep dag creation

marker if participants will be removing the staining after treatment, or if participants will be taking the stuffed animals home after the activity.

Materials for Blood Tubes (Packed Cell Volume/Hematocrit)

PREPARE IN ADVANCE (day before activity)

3 50 mL conical centrifuge tubes (polypropylene/food-safe and sterile)

1 package yellow gelatin dessert (will have extra; 2 cups gelatin = ~473mL)

1 package red gelatin dessert (will have extra; 2 cups gelatin = ~473mL)

Water (amount according to gelatin dessert instructions)

Measuring cup

Bowl

Saucepan/kettle

Spoon/whisk

Refrigerator

Coffee cup

Paper towels/scrap paper

Permanent marker

3 popsicle sticks/narrow spoons (optional — for eating)

Label the centrifuge tubes as "blood samples" and include the name of each goat or sheep (Nacho, Ginger, or Peanut) on the tube using the permanent marker. Prepare the red gelatin according to the package directions. While the water is boiling, arrange the centrifuge tubes in a coffee cup to make sure they remain upright, and use paper towels or scrap paper as necessary to hold them in place (figure 12). Pour the red gelatin into each of the tubes, taking the tubes out of the cup one at a time to measure, if necessary. Fill one tube to 15 milliliters (for Nacho), one to 10 milliliters (for Ginger), and another to 5 milliliters (for Peanut). Place the tubes in the refrigerator uncapped until the red gelatin is completely set. After the red gelatin is set, prepare the yellow gelatin according to the package directions. If the liquid yellow gelatin is still very hot, allow the liquid to cool slightly before adding to the centrifuge tubes. Yellow gelatin should be added to each of the tubes until it reaches the 50 mL mark (figure 13). Place the tubes back in the refrigerator until the yellow gelatin is set. Cap the tubes when the gelatin is set.

NOTE: If a permanent classroom set of blood tubes is desired, or if the facilitator does not want the tubes to be edible, red and yellow kinetic sand or something similar can be used to fill the tubes in the same manner.

Figure 12. Centrifuge tube positioning

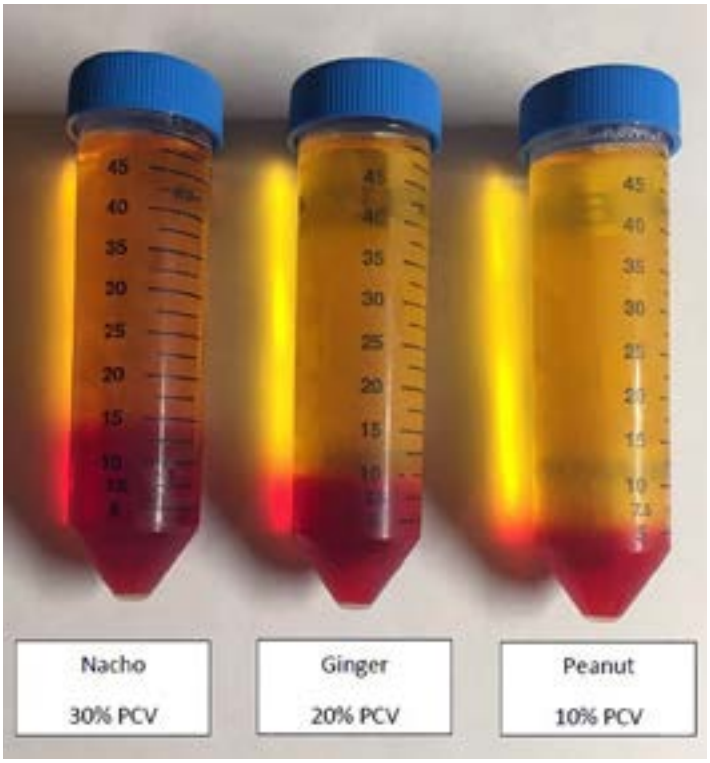

Figure 13. Completed PCV/Hematocrit tubes

Figure 14. Printable (see Appendix A) FAMACHA Cards (print in color) **DO NOT USE ON REAL/LIVE ANIMALS.** The colors on the copy you print may not be accurate.

Figure 15: Printable (see Appendix B) SIL Dag Score Charts.

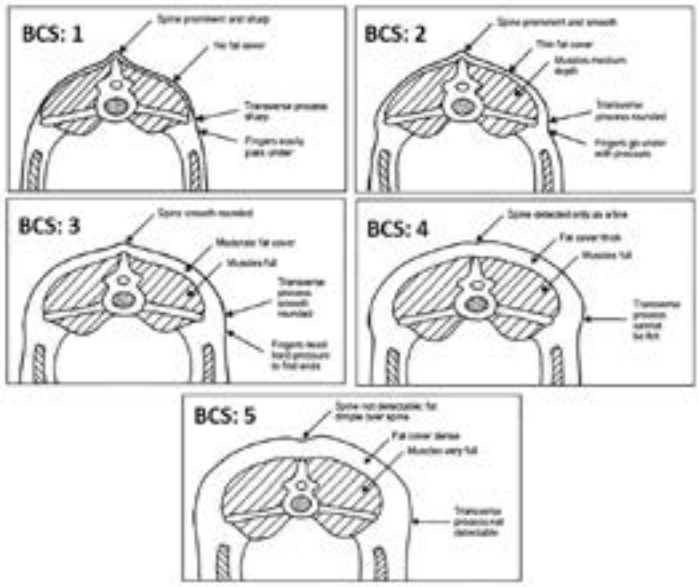

Figure 16. Printable (see Appendix C) Body Condition Scores (Participants can color these.)

Content Delivery

This activity has nine parts. Parts 1-8 can be completed in approximately two hours (or less, if some parts are omitted). The time needed for Part 9 is variable, although at least three hours is recommended to allow participants enough time to research and create their models. A Participant Activity Sheet is included to guide the activities and serve as a written worksheet for participants if needed. The Participant Activity Sheet was designed for Intermediate/Senior 4-H members. Facilitators can choose to omit or alter some material based on the grade or maturity level of participants. However, it is best to bring all of the concepts together for the most complete understanding of parasitism in small ruminants and extension of the information through a project (see the Relevant Virginia Standards of Learning section for more information). Suggestions have been added where appropriate for added fun or learning experiences if resources are available.

Be sure to read the entire guide and participant activity sheet to understand the background material and activities as a whole before omitting or modifying the parts. It is also a good idea to limit any "lecture" type of background material to 15 minutes at a time to hold the participants' attention.

Participants should be given the opportunity to discuss their individual results with others and explain their reasoning if they do not agree. This presents an opportunity for participants to engage in the real scientific process of "peer review" and allows for practice of respectful discussions when there is disagreement with possibly subjective data. The level of subjectivity also may be controlled by limiting the number of scores to be assigned for FAMACHA scoring, dag scoring, and body condition scoring to three choices (instead of five).

Pre-Activity

Divide participants into groups of three. If possible, make sure that each participant has their own goat or sheep and that there is one Nacho, Ginger, and Peanut distributed to each group. Blood sample tubes should be distributed to each participant based on which animal they have. If resources are limited, several participants may be assigned to one stuffed animal/blood tube model. Make sure there are plenty of extra gummy worms, chocolate "fecal samples," and/or gelatin for each participant to sample following the activity, especially when several participants are assigned to one model. Distribute FAMACHA cards, dag score scale cards, body condition cards, and fecal egg count materials to each participant as well.

Part One: Inquiry

The purpose of the "inquiry" section is to give participants a chance to make observations without having any background material. This can be either a written or a verbal activity. Without touching the goat/sheep models, ask the participants what they see. They could describe the color, shape, or appearance of the model. Encourage participants to compare differences between their animal and the other group members' animals. Then, ask them to make observations by feeling the models externally (gently press down or squeeze the back and hip areas). Do they notice any differences among the three models?

Lastly, ask the participants if they think the goats or sheep in their group are healthy or sick. Ask them to explain why, based on what they saw or what they felt.

Part Two: Guided Inquiry

In this part of the exercise, provide the participants with general background material. This should include basic information about the digestive system of goats and sheep, the barber pole worm and its life cycle, signs and symptoms of barber pole worm infection in goats/sheep, and definitions of relevant terms. Avoid giving the background material for the diagnostic activities and treatment at this point — instead, provide background material for each respective diagnostic section before beginning each. Ask the participants if they think their animal and the other animals in their group are infected with parasites. Ask how they would find out if their goat/sheep is infected.

Suggestion: *This is a good time to use a slide show to show pictures or use a chalk/whiteboard to do illustrations.*

Part Three: FAMACHA

In this part of the exercise, provide each participant with a FAMACHA card (figure 14, printable version in appendix) and the background information for its use. Depending on your printer's settings, the colors may or may not be a perfect match to an official card. For this reason, only official FAMACHA cards (not ones printed for exercises like this one) should be used on a real animal.

Participants should gently pull down on the white "eyelid" for their goat/sheep to reveal the colored area, and use the FAMACHA card to assign a score of 1 to 5 (or 1, 3, or 5 to decrease subjectivity). Explain that this is an INDIRECT measurement of anemia. Ask if their animal appears to lack anemia, if it is borderline anemic, or if it is severely anemic. Participants should also discuss their results with group members. If they do not agree with another participant's observations, they should have the opportunity to respectfully discuss with the other participant and explain their reasoning.

Suggestion: *Show the "FAMACHA in a Nutshell" video (available at* https://www.wormx.info/videos-from-attra*) to demonstrate how the method is used with a real animal. An even better way to engage the participants is to have a trained individual (Extension agent/specialist, farmer, veterinarian, etc.) demonstrate the use of FAMACHA on a live animal in-person. The eyelids on the models are removable if participants wish to keep their stuffed animal.*

Part Four: Packed Cell Volume

In this part of the exercise, participants observe the blood tubes and calculate packed cell volume. Provide background information regarding anemia and packed cell volume/hematocrit determination. See the background information for instructions to calculate packed cell volume from the 50 milliliter blood sample (assumed to be pre-spun in a centrifuge). Explain to participants that this method is a DIRECT measure of anemia. Ask participants how their packed cell volume results compare to their FAMACHA results for anemia determination. Participants may eat the "blood sample" following completion of the activity (if tubes are too narrow, it is possible to use the popsicle/craft sticks to remove the gelatin).

Suggestion: *Show Purdue Extension's "Obtaining a Blood Sample from Your Small Ruminant" video (*https://www.youtube.com/watch?v=47tlmqXX3eE*) and the "Haematocrit or PCV Determination" video from the Labs for Life (*https://www.youtube.com/watch?v=RoS3w_Sng_Q*). Use the gelatin tubes either indoors or during cooler weather to avoid melting.*

Part Five: Dag Scoring

In this part of the exercise, participants assess the severity of dags. Use the background information on dag scoring at the beginning of this guide. Show participants the SIL Dag Score Scale chart or distribute a copy of the chart to

each participant (figure 15, printable versions in appendix B). Explain that the severity of illness/diarrhea can be assessed using the score chart, and that more severely ill animals will have a higher score. Participants should check the rear end of their goat or sheep for dags and then assign a score of 0 through 5 (or 1, 3, or 5 to reduce subjectivity). Ask how their dag score results relate to the severity of anemia in their animal. They should also discuss their results with group members. If they do not agree with another participant's observations, give them the opportunity to respectfully discuss with the other participant and explain their reasoning.

Suggestion: *If participants are permitted to keep their goat/sheep models and a washable marker was used to indicate the fecal soiling, tell them that the coloring can be removed with a damp washcloth.*

Part Six: Body Condition Scoring

In this part of the exercise, participants assess the health of their goats/sheep by assigning a body condition score. Show participants the body condition score images from the background information section or distribute a copy of the chart to each participant (figure 16, printable version in appendix C). Explain that parasitic infections, anemia, and diarrhea can cause weight loss and weakness in animals, resulting in a lower body condition score. Participants should be asked to feel the backbone area of the animal as well as the transverse process (represented in the area near the hips) to help assign a body condition score of 1 through 5 (or to choose among scores of 1, 2.5, and 3.5 to reduce subjectivity). The backbone and transverse process will be more prominent and easier to feel in animals with a lower body condition score (animals that are more ill). They should also discuss their results with group members. If they do not agree with another participant's observations, give them the opportunity to respectfully discuss with the other participant and explain their reasoning.

Suggestion: *Show the video "Body Condition Scores in Goats," https://www.wormx.info/external-videos. An even better way to engage the participants is to have a trained individual (Extension agent/specialist, farmer, veterinarian, etc.) demonstrate body condition scoring on a live animal in-person. Younger students may choose to color the provided BCS charts if you need a "break" activity.*

Part Seven: Fecal Egg Counts

Choose an option for content delivery: the "wet" method or the "dry" method. In both methods, Participants will assess the parasite load of their goats/sheep by counting worm eggs in a fecal sample.

Wet Method: The "wet" method is a little more representative of actual fecal egg counting since it uses a liquid component and pipetting, but it is not critical to demonstrate the concept. Distribute pipettes and small cups to each participant with a small amount of water or vegetable oil in the cup (enough to cover the eggs and allow for pipetting). Instruct the participants to remove the fecal sample from their animals by opening the pouch at the rear of the animal. They should use the popsicle/craft stick to scrape (or dump out) all of the eggs from the fecal sample/bag into the cup of water/vegetable oil. Then, the pipette should be used to transfer all of the eggs/solution into the petri plate with a counting grid. The purpose of the grid is to assist with counting. Participants can be given optional magnifiers to assist with counting the eggs. They should count all eggs within the grid (add the number of eggs in A1, A2, A3, etc.). Participants may eat the chocolate after completing the activity.

NOTE: Some brands of nonpareils will melt too quickly in water. Test how quickly your brand melts in water before the activity; if the candies melt, use vegetable oil instead of water, or use the dry method.

Dry Method: Instruct the participants to remove the fecal sample from their animals by opening the pouch at the rear of the animal. They should use the popsicle stick to scrape all of the eggs from the fecal sample/bag (or dump the eggs out of the bag) into the petri plate with a counting grid. The purpose of the grid is to assist with counting. Participants can be given optional magnifiers to assist with counting the eggs. They should count all eggs within the grid (add the number of eggs in A1, A2, A3, etc.). Participants may choose to eat the chocolate after completing the activity.

Suggestion: *Show participants the "How to Conduct a Fecal Egg Count in Sheep and Goats" video from Purdue Extension (https://www.youtube.com/watch?v=5vELgijcad4). If available, show participants prepared microscope slides of real barber pole worm eggs. For an additional challenge, participants could construct graphs comparing class data for each of the goats/sheep (and relate the data to worm count or packed cell volume). If teaching quantitative analysis/graphing is desired, make sure to control the number of eggs provided in each fecal sample (approximately similar amounts for each of the Nacho animals, Ginger animals, and Peanut animals; Nacho should always have the least number of eggs, Ginger should have an intermediate number, and Peanut should have the most worm eggs). If comparing to the number of worms in each individual, make sure to control the number of worms in each animal the same way.*

NOTE: Complete this activity indoors or during cooler weather to avoid melted chocolate.

Part Eight: Worms and Treatment

In this section of the activity, participants will extract the "abomasum" from the stuffed animal and assess the parasite load directly (the number of worms present in the abomasum/true stomach). Participants should count the number of worms and assess whether their goats or sheep should be treated based on all of the information gathered up to this point. Present background material, including the chart for recommendation of treatment (see table 1 in the background material). After the participants have assessed the need for treatment, allow them to perform deworming treatment on their goats/sheep (whether it is needed or not) by eating the gummy worms. Be sure to have extra gummy worms to distribute to those who have fewer candies than the other participants. Once the deworming is complete, participants should mark the animals with a "treated" ear tag or washable marker. If a washable marker was used for the dags and fecal soiling, participants may also use a moist washcloth to provide treatment by removing the staining.

Suggestion: *Show the "How to Administer COWP Boluses" video (https://www.wormx.info/videos-from-attra) to the participants to demonstrate how a real animal receives deworming treatment. If available, show participants prepared specimens of barber pole worms. For an additional challenge, participants can construct graphs comparing class data for each of the goats/sheep (and relate the data to fecal egg count or packed cell volume as described above).*

Part Nine: Be the Expert! Project

The final part of this activity brings together all of the material learned to allow participants to creatively construct a model of their own, apply general concepts learned, and to teach another person. Participants should be encouraged to pick their favorite animal and research some diseases or parasites affecting that animal. They should keep a "lab notebook" and write down the sources of their information as a real scientist would to cite literature and reflect on the work of others. Stress the importance of reputable sources of information, keeping good notes, and creating repeatable results and instructions.

Participants should also be instructed to create a "proposal" for their work to formulate and organize their objectives and plan to create their models. The club leader or facilitator should review the proposals and provide comments before participants begin to construct a model. Then, participants should each create a model and write detailed instructions for another person to be able to construct their model (just as a real scientist does so another person can replicate their experiments). This is a great opportunity for a take-home project for teens or clubs with independent project work.

Suggestion: *For an added challenge, provide a variety of materials or methods for participants to construct their model, but assign a dollar value to each of the components. Participants could be given a set budget to create their model, and must choose between materials to stay within budget but also create an effective model. Scientists typically have to manage a budget from grants and set funding may limit their experimentation. Sometimes, they have to get creative to find solutions.*

Note: Younger participants may need help with research and developing a "proposal." Consider pairing older participants with younger participants or assigning teen volunteers to help younger participants.

After participants have constructed their models, they should be given an opportunity to teach another club member, parent, friend, or other person about their animal and disease/parasite. They should also share the instructions they used to make the model. Participants should ask their "students" about the most interesting thing they learned, and if they think they could build the model based on the instructions provided (constructive feedback). Then, the participants should evaluate their own experience creating the model, the

research, and their teaching (see the activity sheet for possible questions — these should include areas for the participants to reflect on both their strengths and weaknesses).

Extra Fun! Word Find (page 21)

This is an optional word find activity to relate relevant terms/definitions.

Using Experiential Learning and Inquiry

This curriculum uses a blend of experiential learning and different types of inquiry. 4-H learning is built on the "Do, Reflect, and Apply" cycle of learning. Following each activity, highlight the relevant life skills (pg. 24) and ask youth to reflect on how the activity helped to build these skills. In Part 1-8, youth will "Do". Facilitators are encouraged to ask relevant questions, including those found in the worksheet on pg. 16 (the worksheet may be used for older youth, or related questions can simply be asked verbally for younger youth). Part 1 uses pure, inquiry in which youth should have as little guidance as possible to explore the models and begin to conduct observations. In Part 2, the facilitator should take more of an active role and guide the inquiry, providing some background to help youth begin to understand some background material content as they explore the models in a hands-on manner. In Part 3-8, youth practice skills and explore relevant content. In Part 8, youth should be directed to reflect on each diagnostic criteria and apply the knowledge they have learned to make final treatment recommendations for each of the animals. The Be The Expert! Project is a great way to take "Do, Reflect, Apply" a step further. In this part of the activity, youth will have the chance to "Do" by researching diseases/parasites affecting their favorite animals and creating models of each. Reflection questions are presented as part of the activity to help youth understand if their teaching model was effective in helping someone else to learn about diseases/parasites. Soliciting feedback from the learner is critical in helping youth to develop life skills such as the ability to communicate and teach others. To close the cycle of experiential learning for application, allowing the youth to modify their models or repeat their teaching experience with modification will allow them to learn from shortcomings and improve their skills. Be sure to use the questions included in the participant worksheet (pg. 20).

Your Name: _____ Goat/Sheep Name: _____

Grass, Goats, and...Uninvited Guests!

Participant Activity Sheet

Part One (Inquiry)

1. Visually observe your animal and its blood samples, as well as the other animals and blood samples belonging to your group members. Are there any differences you can see between Nacho, Ginger, and Peanut?

2. Feel your goat or sheep by gently pressing down on or gently squeezing the back and hip areas. Do the same thing for the other animals belonging to your group members. Are there any differences you can feel between Nacho, Ginger, and Peanut?

3. Based on what you have seen and what you have felt, make a hypothesis: Is your animal healthy or sick? Why do you think so? List your predictions/reasons for your group members' goats/sheep as well.

   Nacho:

   Ginger:

   Peanut:

Part Two (Guided Inquiry)

1. Now that you have learned about parasites, do you think that Nacho, Ginger, and Peanut are infected with parasites? What do you think is the best way to find out?

   Nacho:

   Ginger:

   Peanut:

   How to find out:

Part Three (FAMACHA)

1. Describe the FAMACHA system. What is it used for? How do you use it?

2. Use the FAMACHA card with your goat/sheep. What is your animal's score? Is your goat/sheep optimal, borderline anemic, or severely anemic?

3. What FAMACHA scores did your group members assign to their goats/sheep? (List the goat/sheep name.) Did they answer optimal, borderline anemic, or severely anemic? Do you agree with their conclusion? If not, describe why and respectfully tell your group member(s) why.

Goat/Sheep Name:	Their Score:	Their Answer (Anemia)?	Do you Agree?

Part Four (Packed Cell Volume)

1. What is packed cell volume and what is it used for?

2. How is packed cell volume calculated?

3. How many milliliters of blood are in your goat/sheep's sample tube (hematocrit and plasma)?

4. How many milliliters of red blood cells are in your goat/sheep's sample tube?

5. What is the packed cell volume (hematocrit) percentage from your goat/sheep's sample tube?

6. Based on the packed cell volume, is your goat/sheep optimal, borderline anemic, or severely anemic? How does the packed cell volume anemia results compare with your FAMACHA results?

7. Fill in the chart below based on each of the packed cell volumes (PCV) listed. What FAMACHA score would you expect a goat/sheep to have for each PCV? What color would you expect their eyelid to be (white, pink, or red) with each PCV?

Packed Cell Volume %	FAMACHA© Score	Eyelid Color
30%		
10%		
18%		
20%		

Part Five (Dag Scoring)

1. Describe dag scoring. What is it used for? How do you use it?

2. Use the dag score chart with your goat/sheep. What is your animal's score? Does it have no fecal soiling, moderate fecal soiling/dag, or severe fecal soiling/dag?

3. What dag scores did your group members assign to their animals? (List the goat/sheep name.) Did they answer no fecal soiling, moderate fecal soiling/dag, or severe fecal soiling/dag? Do you agree with their conclusion? If not, describe why and respectfully discuss with your group.

Goat/Sheep Name:	Their Score:	Their Answer (Dag)?	Do you Agree?

4. How does your dag score results compare to the anemia level in your animal? How do your group members' scores compare with the anemia levels?

Part Six (Body Condition Scoring)

1. Describe body condition scoring. What is it used for? How do you use it?

2. Use the body condition score chart with your animal, and assign a score of 1, 2.5 or 3.5 (only one of the goats/sheep in your group has each score — you may need to compare with your group members). What is your animal's score? Why did you assign this score?

3. What body condition scores did your group members assign to their animals? (List the goat/sheep name.) Do you agree with their conclusion? If not, describe why and respectfully discuss with your group.

Goat/Sheep Name:	Their Score:	Do you Agree?

Part Seven (Fecal Egg Counts)

1. Extract the "fecal sample" from your goat/sheep. Scrape the "worm eggs" into the counting grid dish using a popsicle stick. You may eat the "fecal sample" after extracting all of the eggs (Disclaimer: please do not eat real goat/sheep poop!). How many eggs did you find in your fecal sample? How many eggs did your group members find in their samples?

Goat/Sheep Name:	Egg Count:

2. Do you think the number of worm eggs in the feces, the FAMACHA score, and the packed cell volume are related? If so, describe why and hypothesize how many worms you think your animal is infected with (none, low number of worms, moderate number of worms, or high number of worms).

3. Using the data from your class, use a computer to construct graphs. Find a correlation (R^2) value for an added challenge:

   a. Packed Cell Volume and FAMACHA score

   b. FAMACHA score and Fecal Egg Count

   c. Fecal Egg Count and Packed Cell Volume

Part Eight (Worms and Treatment)

1. Based on your FAMACHA score, packed cell volume, and fecal egg counts, would you recommend deworming treatment for your goat/sheep, and why? What about your group members' goats/sheep?

Goat/Sheep Name:	Treatment Recommendation:

2. Extract the abomasum from your goat/sheep. How many worms, if any, are present? How many worms did the other animals in your group have? Is this what you expected? If so, describe why.

Goat/Sheep Name:	Number of Worms:

3. Describe how goats/sheep are treated for worms in real life below. Feel free to perform deworming treatment on your goat by eating the worms! (Disclaimer: Please do not eat real goat/sheep worms!)

4. Why is it a bad idea to use deworming medicines too frequently or on animals that don't need it?

Part Nine (Be the Expert! Project)

Now that you have learned about parasites and diseases in goats and sheep using a stuffed animal model, it is your turn to become an expert and create a model of your own. This is your chance to be creative and use ANY kind of model you like! You could build animals from materials in your recycle bin, use a computer animation program, create a video, create a webpage, write/illustrate a pop-up storybook, use construction paper, or anything else you can think of.

1. Choose your favorite animal or one that you would like to work with for this project:

2. Create a lab notebook to take notes throughout the process. Use the internet, videos, books, or people as resources find out about diseases or parasites that affect your animal. What are some of these diseases or parasites?

3. Choose a disease or parasite that you thought was the most interesting. Try to find out as much as you can about the disease or parasite. Become the disease or parasite expert! Be sure to write down where you found the information. List the disease or parasite below, as much information as you can find, and the source:

4. Write a rough draft "proposal" for your project. This should include your animal, the disease/parasite you want to focus on, and the objectives for creating your model. Your club leader/facilitator will review your proposal and provide comments.

5. Create a model to teach others about the parasite or disease. Include your animal, how the animal becomes infected, symptoms, models of the parasitic organism, treatment or any other information you like. Write down the steps you took and materials you used to build your model so that others can replicate your work, just as real scientists do!

6. Choose a family member, friend, club leader, or community member. Use your model to teach them about your animal and the disease/parasite you chose. Show them the steps you used to build the model. Ask the participant:

   a. What is the most interesting thing you learned from my model or my teaching?

   b. Do you think you could build my model based on the instructions I provided?

7. Reflect on your experience creating the model, the research you did, and your teaching:

   a. Do you think that your model was a good representation of the animal and the disease you chose? Why or why not?

   b. What part of this project do you think you were the most successful at accomplishing (researching, building the model, teaching, etc.)?

   c. How do you think you could improve your project (research, building the model, teaching, etc.)?

   d. What did you enjoy the most when completing this project?

8. Give it another try! Make improvements to your model or try a different type based on the feedback you received. Try to teach the same personb. Did things go better this time?

Extra Fun! (Word Find)

C D E F M E N P X Q E I L M C
N P A R A S I T E S H A A U U
B V K U S T N A N I M U R L D
A M A N E M I A M Y E U W U N
F H R Y O Y E B N U M W L C S
F E C L R I F O D E M O H I H
N V O A W S T M N E V J E T Y
C H D V M Z X A O C F P M E P
N A S R X A B S T E E O A R L
M U S A M O F U X N C K T O O
U J Q L H E E M I D E V O T M
A O O R B D P W H A S M C R I
L R A P V E N E E B T G R Y D
C I T N I M L E H T N A I E R
J O I S O A A K Q A Y D T I F

1. A condition that develops as the result of a deficiency (too few) of red blood cells, causing pale eyelids in goats/sheep:
2. Swelling caused by a buildup of fluids in the body:
3. This is the fourth part of a goat/sheep's stomach. This is where barber pole worms attach and feed on blood:
4. Partially digested, regurgitated food returned to a goat/sheep's mouth for chewing:
5. Dried excrement (poop) and matted wool on the rear end of a goat/sheep, usually indicates diarrhea:
6. Waste matter discharged from the rectum following digestion of food. Worm eggs can be found in this material:
7. The ratio of the volume of red blood cells to the total volume of blood (also known as packed cell volume):
8. Method by which goats/sheep are assessed for anemia using a chart as compared to eyelid color:
9. The third part of a goat/sheep's stomach (third to receive food material):
10. Organisms that live in or on another organism, and are detrimental to the host species:
11. The second part of a goat/sheep's stomach, which has a structure resembling a honeycomb:
12. The immature stage of a worm's life cycle:
13. Mammals with a unique four-part stomach. Sheep, goats, and cows belong to this group:
14. The first part of a goat/sheep's stomach that partially digests food with the aid of bacteria:
15. Goats/sheep can digest tough plant material due to this bacterial process in the gut:
16. A medicine used to treat parasitic worms:

Word Bank:

Abomasum	Dag	Fermentation	Parasites
Anemia	Edema	Hematocrit	Reticulum
Anthelmintic	FAMACHA	Larval	Ruminants
Cud	Feces	Omasum	Rumen

Relevant Virginia Science Standards of Learning*

From: Commonwealth of Virginia Board of Education. 2010. Science Standards of Learning for Virginia Public Schools. Accessed October 2018. http://www.doe.virginia.gov/testing/sol/standards_docs/science/2010/complete/stds_all_science.pdf

*Next Generation Science Standards Referenced in parentheses ()

Grade 6 (LS1, LS2, LS3, LS4, ETS1)

Scientific Investigation, Reasoning, and Logic

Grade Six: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

____ observations are made involving fine discrimination between similar objects and organisms

____ hypotheses are stated in ways that identify the independent and dependent variables

____ a method is devised to test the validity of predictions and inferences

____ data are collected, recorded, analyzed, and reported using metric measurements and tools

____ data are analyzed and communicated through graphical representation

____ models and simulations are designed and used to illustrate and explain phenomena and systems

____ current applications are used to reinforce science concepts

Grades 7-12(MS-LS1, MS-LS2, MS-LS4, MS-ETS1, HS-LS4, HS-ETS1)

Life Science

The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

____ data are organized into tables showing repeated trials and means

____ a classification system is developed based on multiple attributes

____ models and simulations are constructed and used to illustrate and explain phenomena

____ dependent variables, independent variables, and constants are identified

____ data are organized, communicated through graphical representation, interpreted, and used to make predictions

____ patterns are identified in data and are interpreted and evaluated

____ current applications are used to reinforce life science concepts. The student will investigate and understand interactions among populations in a biological community. Key concepts include

____ symbiotic relationships

The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long-term changes in their environment. Key concepts include:

___ dormancy

___ factors that increase or decrease population size

___ climate changes, and catastrophic disturbances

The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

___ hypotheses are formulated based on direct observations and information from scientific literature

___ graphing and arithmetic calculations are used as tools in data analysis

___ conclusions are formed based on recorded quantitative and qualitative data

___ appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions

___ research utilizes scientific literature

___ current applications of biological concepts are used

Relevant Careers to Discuss:

Research and Academia	Epidemiologist	Agribusiness
Ecologist	Extension Agent or Specialist	K-12 Agriculture Educator
Agricultural Producer	Environmental Scientist	Phlebotomist
Veterinarian/Technician	Food Scientist	Laboratory Scientist/Technician
Biologist	Pathologist	Statistician
Parasitologist	Animal Pharmaceuticals/Chemical Engineering	Biotechnologist

STEAM and 4-H Connections:

S: Animal Science, Biology, Veterinary

T: Technology to create models, research, video instruction

E: Engineer animal & disease models

A: Issue affecting agricultural production

M: Mathematics to calculate PCV, correlation

Targeted Life Skills

HEAD:

Decision Making: Emphasize the need to make wise decisions regarding the treatment of animals using available information.

Critical Thinking: Not everything is as it seems! Encourage youth to dive deeper and explore reasons for observations. Learning to Learn: The project component is used to encourage youth to develop the skills needed to explore their interests. Use available resources to ask questions and do your own research.

Goal Setting: Encourage youth to set goals, particularly with the project component. Many will want to exercise their creativity, but remind them how to manage their time and effectively meet their goal of teaching another person about a disease/parasite occurring in their favorite animal.

Planning/Organizing: Encourage youth to plan out their project ahead of time and complete the project component in smaller steps. Small, planned goals will be more manageable for youth.

Wise Use of Resources: Explain that antibiotics are a resource to treat illness in animals and people, but they must be used wisely. Otherwise, misuse can lead to treatment-resistant pathogens, environmental damage, and wasted money by agricultural producers. Misuse of antibiotics can also cause further illness in animals.

Keeping Records: Emphasize the need to keep observational records of the health of animals in a flock. This will help to a producer/caretaker to identify health problems in their animals, and to track if symptoms/signs of disease worsen.

HEART:

Concern for Others: Animals can feel pain and experience illness much like people do. Point out that animals need medical care for issues such as parasitic worms, and as a caretaker, we have a responsibility to make sure that animals are treated humanely.

Cooperation: Group work in these lessons are used to encourage cooperation between other students to identify signs and symptoms of disease in their animal models.

HANDS:

Marketable Skills, Teamwork, Self-Motivation

HEALTH:

Disease Prevention, Healthy Choices, Self-Responsibility

MODIFICATIONS FOR DIFFERENT AGE GROUPS

Depending on the target age of youth involved, a good first step is to identify relevant Standards of Learning. These can be national standards such as the Next Generation Science Standards or educational standards set by your state. For younger audiences: written worksheets are not ideal. Some younger children may have trouble with fine motor skills and may need assistance from an older adult when pipetting. Encourage youth to use visual representations of what they learn, and use pictures/templates for them to record their observations (for example, a grid can be used for youth to record the number of eggs they see in each box for the Fecal Egg Counting portion of the activity). If completing the project portion of the curriculum, younger individuals may need assistance doing research and will benefit from the help of an adult or older youth in a mixed group setting. For older audiences: encourage the use of computers and libraries to do research on their own for the project component. The activity can be modified to encourage the creation of graphs and use statistics to find correlations. Many older youth also want to see the correlation of this activity to the "real world", especially with respect to career interests. It is highly recommended to follow these experiences with a field trip to a farm or a laboratory so they can have a chance to witness and/or practice the concepts. Allowing the chance to engage with agricultural producers or scientists can help to spark interest in agriculture/STEM careers.

Appendix A: Printable FAMACHA Cards (print in color) DO NOT USE ON REAL/LIVE ANIMALS. The colors on the copy you print may not be accurate.

Appendix B: Printable SIL Dag Score Scale (Participants can color these.)

Appendix C: Printable Body Condition Scores (Participants can color these.)