WELCOME

We deeply appreciate your attendance at this 22nd Annual Goat Field Day of the E (Kika) de la Garza American Institute for Goat Research of Langston University. The Field Day is one of the most important things we do each year. The primary purpose of the Field Day is for education and extension in areas of greatest interest to clientele of the Institute. Thus, please share your thoughts with us on today's activities and suggestions for the Field Day next year. In addition to extension and education, the Field Day provides an excellent opportunity for the staff of the Institute to meet other people that work with goats. Such interaction helps make our program the most appropriate it can be for the people it serves. The proceedings of the Field Day is a very useful tool for the Institute beyond impact realized from the program today. First, there are reports on Field Day presentations. After this information, there are highlights of research, extension, and international activities of the Institute in the past year. This section is an aid to assess our recent progress, display current activities, and contemplate future directions to be followed. We hope you will take time later to look through this information. This year's general theme "Herd Health - Old, New, and Emerging Issues." I have looked over the articles on these topics in the proceedings, as well as the others, and it looks like we will all learn a great deal of useful new information today. And remember, we attendees also can learn a lot from each other, so let's all make a point of visiting whenever possible. Here is the exciting program planned for today that has developed from your input.

The morning program consists of:

- **Biosecurity and Prevention** — *Dr. Bruce Olcott*
- **Goat Diseases** — *Dr. Lionel Dawson*

The afternoon workshops are:

- **More on Prevention** — *Dr. Bruce Olcott*
- **More on Diseases** — *Dr. Lionel Dawson*
- **Cheesemaking Overview** — *Dr. Steve Zeng*
- **Basic Goat Husbandry** — *Mr. Jerry Hayes*
- **Managing External Pests** — *Dr. Justin Talley*
- **Nutrition for Health and Production** — *Dr. Steve Hart*
- **Tanning Goat Hides** — *Dr. Roger Merkel*
- **Internal Parasite Control** — *Dr. Dave Sparks*
- **DHI Training** — *Ms. Eva Vasquez*
- **Goat Cooking** — *Mr. Willy Young*
- **Body Condition Scoring as a Management Tool** — *Dr. Maristela Rovai*
- **Benefits of Government Programs** — *Mr. Dwight Guy*
- **Fitting and Showing for Youth and Adults** — *Ms. Kay Garrett*
- **Fun Tenth for Youth** — *Ms. Sheila Stevenson*

Please let us know your wishes for the 2008 field day, and we will do our best to again provide a quality program with requested and timely topics. On behalf of the staff of E (Kika) de la Garza American Institute for Goat Research, we thank you for your continuing interest and support.

Tilahun Sahlu

Director, E (Kika) de la Garza American Institute for Goat Research

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Biosecurity for Meat Goat Producers

Dr. Bruce Olcott

Louisiana State University

Introduction

The term "biosecurity" is one that seems to have become very popular lately. It is frequently used in the media and usually is associated with terrorists or national security or maybe something that a huge commercial livestock corporation would use. However, for anyone involved in livestock enterprises, agriculture in general or just trying to stay healthy, biosecurity is a simple and important tool. Biosecurity programs are any program that attempts to prevent the introduction of disease causing agents into an enterprise. Once a disease is present on farm, then we turn to biocontainment programs to control the spread of disease within the herd.

Here is an example of a biosecurity program in action. One of the most common ways for humans to get infected with the common cold is for a person with a cold to sneeze into their hand and then touch a fomite (let's say a telephone) with that hand. Subsequently, another person handles the telephone and then rubs their eyes with their now contaminated finger. What just happened was the transfer of the virus that causes colds from the respiratory tract of the first person to the mucus membranes of the second person. How could we have prevented the second person from getting a cold? If the sick person had stayed home with his cold (biocontainment) none of this would have happened. If he had used a disposable tissue (sanitation) it wouldn't have happened. If he had washed his hands (disinfection) after sneezing it wouldn't have happened. If you had washed your hands after handling the phone it wouldn't have happened. These are all pretty much common sense and we will apply these same principles to your goat operation to minimize the impact of communicable disease.

Many producers have the mistaken impression that their herd doesn't need a biosecurity program. Let's look at an example where a total lack of biosecurity could wreak havoc on a herd. This is a small group of registered Boer goats. The owners sell goats all over the United States and Canada. One of their neighbors makes them a "real deal" on a goat because it isn't doing so well. It is obvious that the goat has footrot; it also has a draining abscess under its ear. Not so obvious is the fact that it has multiple drug resistant Haemonchus in its abomasum and is infected with a bacteria called Chlamydia which causes abortions. In a short space of time all of these disease agents have been spread to the new farm. Now we have foot rot which is a pain in the rear end. Anthelmintics are no longer effective. Goats that have been sold are being sent back because they have abscesses popping up and our pregnant does are aborting. Wow, our goat farm just got real complicated and now no one wants to buy our goats. We are spending all of our time treating sick goats, production is down, and the best buck has an abscess. What a mess and a very simple biosecurity program would have prevented all of this from happening.

How do we prevent the entry of an animal that may be carrying a disease into your herd? The simple answer is to never allow any animals into your herd, instead, buy only semen and embryos. While you are at it, put up an 8 foot high security fence around your farm. Never allow animals back on the farm once they leave. Don't allow any visitors on site and after you have gone to town change clothes and shower prior to re-entering your farm. I think that all of us would agree that sounds pretty extreme but realize that on large biosecure farms that is exactly how things are set up. For those farms the risk of introducing a disease into a 10,000 head confinement swine farm makes those extremes worth their while. For your farm you need to

consider the risk of disease entry into your farm and the costs and benefits of keeping disease out of your farm.

The Cost of Disease

Costs of disease are usually thought of in terms of animals that die. However, those are usually only a small portion of the true cost of disease. Animals that become temporarily disabled from disease have to be treated which means veterinary fees, medications, feed, housing and labor. During their disease they will not gain weight or they will not reproduce which means lost productivity. The good news is that at some point they will recover and go back to work. The bad news is that these animals never really catch up with their contemporaries and will be poor producers forever. They won't weigh as much at slaughter, their carcass won't grade as well, there will be more condemnations and carcass trim and of course you will need to hold the animal until all drug residues are gone. Animals that are permanently disabled from disease require the same costs in veterinary fees, medication, housing and labor to treat but, unfortunately, these animals will never return to production and will either die or be euthanized. In this case we end up with a dead animal on which we spent a lot of time and money prior to its death. The time and resources spent with sick animals could be used more productively taking care of healthy animals.

In addition to production costs, there are also costs associated with loss of markets. If you are selling fat goat kids to a local slaughter house and one of them has a big CL abscess then you have probably lost that market. If you are selling breeding animals locally to farmers and word gets out that after buying one of your does several farms experienced abortion storms then you have probably lost that market. If you are selling nationally or internationally and one of your does tests positive for any of the federally or internationally regulated diseases (e.g., Brucella, Tuberculosis) you have just been removed from that market.

There are some intangibles associated with the presence of disease in a herd. These are loss of reputation and loss of pride in your operation. It just isn't as much fun to raise goats when there is always one limping, or dead or when people just think that your goats aren't good enough.

Obviously, the cost of disease is high but many of these costs are "hidden costs." Costs associated with prevention programs are usually very obvious costs. Prevention programs always entail increased labor, increased capital outlays for biosecure facilities, increased expenses for disinfectants and disposables. Somehow it is always easier to spend money to treat sick animals then it is to spend money to prevent them from being exposed to disease. The question then becomes not whether you need a biosecurity program but how much of a program are you willing to afford?

At this point you need to sit down and make a list of the diseases that you know you have in your herd already and then write a list of diseases that you don't want in your herd. (Table 1 is a list of common critical diseases of goats.) Then picture your farm as it is now and picture your farm with those new diseases in it. What is the value to you of keeping those diseases out? Now picture your farm and list all of the ways those diseases could enter your farm. How biosecure are you? Is it time to step up to the next level? If it is, then you need to focus on a biosecurity program that is cost effective for your farm.

Disease Transmission

How do diseases enter a herd? There are two broad ways that disease agents can be transmitted, either Horizontally or Vertically. Vertical transmission means the spread of disease from mother to kid shortly before, during, or shortly after birth (the perinatal period). It can occur via chromosomes, across the placenta or through colostrum. An important example for goat producers would be CAE which is spread via colostrum from mother to kid immediately after birth.

Table 1: Critical Contagious Diseases of Goats

Contagious Infectious Diseases	
Caprine arthritis encephalitis (CAE)	
Transmission:	Mostly vertical via colostrum.
Prevent Entry:	Serotest all new purchases.
Control:	Isolate seropositive does and raise offspring on pasteurized milk.
Goal:	Eradication.
Caseous lymphadenitis	
Transmission:	Horizontal: direct contact or fomites.
Prevent Entry:	Examination of all new purchases for presence of abscesses. Serotest all new entries.
Control:	Cull affected animals or quarantine.
Goal:	Eradication.
Foot rot	
Transmission:	Horizontal: fomites.
Prevent Entry:	Examine and treat feet of all new entries.
Control:	Trim feet, foot bathe in 10% $ZnSO_4$ and treat with parenteral antibacterials.
Goal:	Eradication.
Johne's disease	
Transmission:	Horizontal: ingestion of feces, Vertical: ingestion of milk.
Prevent Entry:	Serological testing and fecal cultures of all new entries.
Control:	Serotest and cull all seropositive animals. Eliminate fecal oral transmission.
Goal:	Eradication.
Contagious ecthyma, soremouth, orf	
Transmission:	Horizontal: direct contact or fomites.
Prevent Entry:	Examine and quarantine all new entries.
Control:	Vaccinate.
Goal:	Prevention of clinical signs.
Pinkeye	
Transmission:	Horizontal: vector is the face fly.
Prevent Entry:	Quarantine and examine the eyes and conjunctiva of all new entries.
Control:	Parenteral antibacterials.
Goal:	Prevent clinical signs.
Chlamydial abortions	
Transmission:	Horizontal: contact with aborted material. Vertical – transplacental to fetus.
Prevent Entry:	Prevent entry of carrier animals during critical times (pregnancy).
Control:	Tetracyclines can be used to clear the carrier state and to halt abortion epizootics. A vaccine is available to confer longer term resistance.
Goal:	Prevention of abortion.
Q fever	
Transmission:	Horizontal: ingestion and respiration.
Prevent Entry:	Prevent entry of carrier animals at any time. Serotest all new additions.
Control:	Tetracycline is effective but a better control program would be test and slaughter.
Goal:	Eradication.

Parasitic Diseases	
Multiple Drug Resistant Haemonchus contortus	
Transmission:	Horizontal: fecal oral.
Prevent Entry:	Quarantine and deworm all new entries with several unrelated anthelminthics. Release from quarantine only with a negative fecal egg count.
Control:	Minimize the number of dewormings per year. Rotate drugs on an annual basis. Perform egg count reduction assays at every deworming.
Goal:	Minimize drug resistance, production loss and death loss.
Lice and Mange	
Transmission:	Horizontal: direct contact, fomites.
Prevent Entry:	Examine all incoming goats for the presence of ectoparasites or any skin condition. Treat all incoming animals with a systemic acaricide labeled for lice and mange.
Control:	Treat all animals in the herd with an effective acaricide.
Goal:	Eradication.

Federally Regulated Diseases	
Brucellosis	
Transmission:	Horizontal: ingestion of aborted material. Vertical – transplacental to fetus.
Prevent Entry:	Serotest all individuals prior to entry in the herd.
Control:	Test the entire herd and remove all positive animals.
Goal:	Eradication.
Tuberculosis	
Transmission:	Horizontal: direct.
Prevent entry:	Intra-dermal test all new entries into the herd.
Control:	Test the entire herd and remove all true positives.
Goal:	Eradication.
Scrapie	
Transmission:	Vertical: doe to kid.
Prevent entry:	Only buy goats from herds that are enrolled in the scrapie program eradication program and are certified scrapie free.
Control:	Remove any clinically affected goat and their offspring from the herd.
Goal:	Eradication.

Other Diseases	
Contagious Mastitis	
Transmission:	Horizontal: fomites.
Prevent Entry:	CMT and milk culture on all entering lactating does. Dry doe treat all entering dry does.
Control:	1. Milk only clean and dry teats. 2. Use properly functioning machines. 3. Post-milking dip all teats in an effective disinfectant. 4. Dry doe treat all teats of all does at dry off. 5. Treat all new infections quickly with effective antibiotics and cull chronic cases.
Goal:	Minimize the number of new infections.

Horizontal transmission means the spread of disease between animals. Horizontal is more important than vertical transmission in most cases and is all that can occur in the absence of reproduction. For instance, in a pen of wethers there would be no possibility of vertical transmission.

Horizontal transmission is divided into Direct and Indirect transmission. Direct transmission between animals requires contact. This can be fence-line contact, introduction of an animal into the herd or an animal that went to a show and came back home. Animal movement is by far the most important method of bringing a disease from one herd to another. This is especially true of homologous animals (animals of the same species) but can occur with heterologous animals (animals of different species). In other words, on the goat farm the most dangerous animal to bring into your herd is another goat. However, bringing in a cow can also expose your goats to very serious diseases as well.

Indirect transmission is either by fomites or by vectors. These are a little more complicated to control than direct transmission. Fomites are inanimate objects that carry disease. This would include the soles of your shoes when you walk through manure going from one pen of animals to another. Vectors of disease are animate objects that carry disease. This can include domestic animals, wild animals or insects. Vectors can be either mechanical or biological. Mechanical vectors just carry a disease agent whereas biological vectors play a role in the life cycle of the disease agent. Examples would be a cat carrying salmonella bacteria on its feet from one feed trough to another and a cat whose feces have Toxoplama oocysts spreading disease by defecating in feed bins.

1. Horizontal.
    A. Direct.
        i. Direct contact.
        ii. Direct projection (droplets).
    B. Indirect.
        i. Fomites.
        ii. Vectors.
            a. Biological.
            b. Mechanical.
        iii. Airborne.
            a. Dust.
            b. Droplet nuclei.
2. Vertical.
    A. Transovarial.
    B. In-utero.
    C. Colostral.

Bringing new animals into the herd

Let's look at how these principles apply directly to your farm. The most common source of new infections is by bringing a new animal into the herd. It is necessary to bring new genetics into breeding herds on a regular basis. The safest way is to bring in only frozen semen or embryos. However, even these can serve as a source of disease. Once you have decided on an animal whose genetics are necessary for your herd what do you do next?

Step 1: Find out the disease history of the herd of origin, the results of previous testing in the herd and the status of the herd with any certification program. Disease histories can be obtained from the owner of the herd and through the farm's veterinarian. Have your veterinarian call their veterinarian. The questions you want to ask are:

1. What diseases do you test for?
2. What diseases do you have?
3. What diseases do you not have?

If the herd is certified free of Brucellosis, Tuberculosis and Scrapie then those are 3 diseases you won't have to worry about. If the herd doesn't test for any diseases then they don't know what diseases they have. If they have tested all goats for CAE and all were negative then they probably don't have CAE. If they haven't tested any for CAE then their status is unknown. All diseases are not created equal and some are much more important than others. The important thing here is to know what diseases they don't have.

Step 2: Determine the pre-purchase disease status of the individual animal(s) that you are purchasing. You and your veterinarian would want to see all records on this animal that would show what immunizations it has had, which diseases it has been tested for and what problems it has been treated for. Next you are going to want to request a panel of tests to determine the disease status of the individual animal. The diseases you test for are diseases that there is some chance the goat may have. For instance, in the U.S. it would be foolish to require a goat to be tested for Foot and Mouth Disease. However, it would be reasonable to want it tested for things like Johne's disease. Some testing can be done only by examination. For instance to determine if a goat was free of lice or foot rot someone has to look at it. Ideally this would be the veterinarian for your herd who does the examination. If it is not practical for your veterinarian to do the examination then the veterinarian who works for the source herd would be a suitable alternative. Veterinarians are legally and ethically bound to provide honest and accurate assessments of health status.

Step 3: Assuming the goat is negative historically and on the current tests then we will bring it to our herd but keep it in quarantine. How long in quarantine? Well the answer is longer is better than shorter. Ideal duration is probably 60 days and the shortest interval you would use would be 30 days. What is a quarantine facility? A quarantine facility is an animal holding facility that is physically completely separated from the rest of your herd. That means no fence line contact, no aerosol contact, no manure runoff contact and no potential for spread by fomites or vectors. Ideally, it is far enough away that you need to drive there. A manageable protocol on a large farm is to have an employee that only takes care of quarantine. On small farms make sure that the quarantine barn is visited at the end of the day. Change boots and clothing before entering quarantine facilities and don't go back to the main herd after you have been in the quarantine unit. Feed, feed buckets, bedding and manure cannot be exposed to the nucleus herd. The most important issue here is transferring disease back to the nucleus herd but neither do we want the quarantined animals to be infected by the nucleus herd.

Step 4: At the midpoint of the quarantine period (30 days) a careful physical examination should be performed on the animal to make sure that it is free of physically obvious disease. At the same time consider retesting the animal for whatever critical diseases you are trying to exclude from your herd. There exists a distinct possibility that the purchased animal will test positive to a disease which it was negative for at time of purchase. The following situations could cause this scenario:

1. The animal was incubating the disease at the time of purchase.
2. The initial test was a false negative.
3. The stress of movement caused a latent infection to reactivate.
4. The animal was exposed to the disease in transit or after reaching your farm.
5. Some form of dishonesty or "laboratory error" has occurred.

Step 5: At this time it may be beneficial to administer an appropriate antibacterial to the animal either by injection or in the feed to attempt to eliminate agents of disease which may exist in a sub-clinical fashion. For a goat this would most commonly be a tetracycline. (Note: some veterinarians and producers are opposed to

the use of prophylactic antibacterials (metaphylaxis). If you use antibacterials make sure it is used according to the label and that the withdrawal times are followed.)

It will also be necessary to make the goat as parasite free as possible. Ideally, this is done by checking a fecal sample for parasites and then deworming successively until the goat is parasite free. If fecal exams can't be done, then dosing with three unrelated drugs will go a long way towards removing parasites from the incoming goat. For example, dose with Ivomec, Albendazole and Levamisole simultaneously. At this time you would vaccinate the incoming animal for any know endemic diseases of your herd. So if you had Chlamydia in your herd you would want all new entries to be fully immune to Chlamydia prior to entry into the herd.

Step 6: The incoming animal should be acclimatized to your herd. This includes environment, feed, water and diseases. If you are buying a goat from Canada and bringing it to a hot humid place like Louisiana you will need to slowly acclimatize the goat to the environment. This will allow the animal's innate resistance to be minimally stressed and will help the goat in preventing disease. The same holds true for feed and water. Sudden changes in food and water are viewed with suspicion with goats which means they may eat or drink less than they should. Hungry goats can overeat on a new ration and cause gastro-intestinal upset which may set the stage for infectious diseases. For some diseases we don't have vaccines. The incoming animals should be acclimatized to diseases existing in your herd by contact between it and members of the herd.

Step 7: At the end of the quarantine period it would be wise to allow exposure of the new animal to a small sentinel group of animals. Sentinel animals are animals from your herd that act like a "canary in a coal mine." If they don't get sick after mixing then it is safe to assume that the rest of your herd will be safe. If they do get sick then they can be kept in quarantine until cured or removed from the herd. At any rate, at least your whole herd didn't come down with the disease and you have proven to yourself that the incoming animal is not a carrier of disease.

Other sources of direct contact

In addition to bringing a new animal into the herd, direct animal contact can occur by fence line contact, show or sale contacts, or your goat may share a trailer ride with some other goats. All of these allow direct contact and exposure. That would mean that the exposed goat would need to go through a quarantine period again to be safe. If there is an adjoining neighbor with goats then there will be fence-line contact. The solution to this is to double fence the perimeter. The space between the two fences is used as a corridor. When greeting new arrivals goats snort and blow nasal secretions. These droplets will travel up to 3 feet so make sure that animals are separated by at least twice that far (6 feet).

Livestock shows

Shows provide a real challenge to biosecurity programs. The ideal solution is to never bring home an animal from a show. For terminal meat class shows that is the obvious solution, for breeding class shows it is not a practical solution. Shows create an environment where animals of different species, breeds, age, sex, geographical locations, management systems and disease status come together for a brief period of time and intermingle. The animals are stressed from travel, noise, and unfamiliar settings. Stress can lead to increases in pathogen shedding and to increases in susceptibility to disease. A show is like elementary kids going back to school in the fall. There is always an outbreak of respiratory disease, diarrhea or the flu.

Before the show

Make sure that the exhibition center provides adequate housing, that pens are cleaned and disinfected and that ventilation is adequate. Make sure that all animals entering the show will be examined by the show veterinarian and that all state and local animal health laws will be enforced. Work with your veterinarian to establish a herd health program for your show goats and for the goats staying home that will be exposed

to the show goat on its return. Do not mask signs of illness in your goat. If it is sick then stay home. Make sure that you have a Scrapie Tag for your goat (wethers excluded) and that you have any required health tests performed and that you have a current Certificate of Veterinary Inspection. Minimize stress on your goat by providing it with a pen that is as close to those in the exhibition facility as is possible and use the same bedding, feed and water source as you will have at the show. Keep fans on the goat at home, the white noise they produce will be the same as you will recreate at the show. Transport your goat in your own trailer. Avoid traveling in a commercial trailer or commingling with other livestock.

At the show

Keep your goats comfortable. Use adequate bedding and fans to provide white noise and ventilation. Use the same water, feed and hay that the goat was fed at home. Avoid sharing grooming equipment, feed buckets, manure shovels, etc. If you loan out equipment disinfect it before using it on your goats. Discourage visitors from touching or feeding goats by putting signs up. Practice good personal hygiene yourself (wash your hands before handling your goat or your goats food). Try to get a corner pen so that animal traffic and contact is minimal.

After the fair

Disinfect all equipment that went to the fair. Don't forget your trailer. Place the goat into your quarantine system and watch carefully for signs of clinical disease. Pamper your goat. Its more exhausted and stressed than you are.

Diseases from other species

In addition to other goats you need to prevent access of other animals to your goats. In general the more closely related the animal is to a goat the more dangerous it is in terms of disease transmission. Sheep and goats share the same parasites. Cattle and goats share a number of diseases. Unrelated animals are not necessarily safe. For instance Toxoplasmosis is a disease that causes abortions in goats. It is transmitted by the domestic cat which is a biological vector for the agent. Cats get infected by eating mice, the parasite completes its lifecycle in the cat and only in the cat and then the cat defecates in a feed bin and goats get fed grain which is contaminated with cat feces. Cats can also serve as mechanical vectors. It is amazing how much manure and disease agents can attach itself to the foot of a cat and it is amazing how they can travel from pen to pen and trough to trough.

Now you might say "wait a minute, my cats control rodents on my farm and rodents transmit disease." It is true that mice and rats can spread some important diseases like Leptospirosis which is spread in the urine of rodents. Cats are generally inefficient at rodent control and if you are relying on cats only then you will have a rodent problem. Rodents can be controlled by cats in addition to traps and baits but there are obvious dangers to the cats with this system. For the most part Toxoplasmosis is spread only by young cats (kittens). As the cat matures it becomes resistant to infection. Kittens can be avoided by spaying and neutering cats and maintaining a population of only adult cats.

Diseases introduced by fomites

The major categories of fomites that may expose your goats to new diseases would be: People, Trucks, Trailers, Feed and Water. People include friends, neighbors, buyers, veterinarians, employees and delivery personnel. Recognize that some of these are more dangerous to your goats than others. A friend from the city who has no livestock is a minimal threat. A veterinarian that has just come from treating a sick goat and is wearing the same boots and coveralls may be a serious threat.

Facilities with extremely high biosecurity standards discourage casual visitors from entering the livestock holding areas. When visitors do come they would require them to disrobe, shower and dress them in protective clothing and boots from the unit. Is all that necessary for you on your farm? Probably not, but again,

think of the principles involved and implement it to the extent that is practical for your operation. It is best to keep people (especially other livestock producers) from getting in the casual habit of walking through your facility. People who go out to see the animals should have a real reason and the reason "just because they are cute" is certainly a valid reason; but those people must realize that a sick animal isn't cute. If at all possible set up your pens so that goats can be observed from outside the pen or by putting all of your sale goats into a separate pen and not moving them back to the nucleus herd.

For people the most dangerous fomite is usually their shoes. People who have on boots that cannot be sanitized and that have been around livestock during the last week are a threat. For those people keep some disposable plastic boot covers handy or keep some spare boots around. For people with boots that can be sanitized a boot scraper, boot wash and sanitizing dip is a practical way to minimize the contamination they may carry. For visitors who will be handling animals on the farm hand washing and protective clothing is appropriate. Have a sink and soap handy for before and after visits. Hand washing after visits is especially important for children and people with compromised immune systems. Remember that goats can carry zoonotic diseases (diseases which are passed from animals to humans). The resulting diseases can sometimes cause serious human health issues. Protective clothing can be in the form of coveralls, apron, jacket, etc. Just make sure it is something that will cover the outer clothing of your visitor. At first your visitors will think that you are crazy when you ask them to follow these procedures. In the long run what you will find is that people who want to buy animals from you will appreciate the obvious efforts you make to keep them healthy and disease free.

Trucks and trailers

Trucks and trailers that are used for hauling livestock accumulate manure and other body fluids. If these vehicles are not washed and sanitized between loads they can serve as a very efficient fomite. If you are buying or selling an animal that will be transported by truck or trailer, inquire about the provisions the driver makes to insure the sanitation of his vehicles. Also ask about the presence of other livestock passengers on the trip. If your goats get on a trailer with goats from 10 other farms they will share the pathogens from all 10 farms. If you are trying to sell high health status goats you have a problem and need to find a new transporter.

When a vehicle comes to pick up your animals have it park outside the livestock area and bring the animals to the vehicle. This avoids the possibility of feces falling from the trailer into your biosecure area and it also prevents the possibility of an animal escaping from the vehicle and contaminating a large area. If you have a loading area on your farm place it at the quarantine area or the pen from where you sell goats. Similar arrangements should be made for feed trucks and other farm service vehicles. If they don't have to enter your biosecure areas have them off load outside into your vehicle and transport the material to where it needs to go.

Feed

Feed can be a source of infectious material being imported onto your farm. Bovine Spongiform Encephalopathy (BSE) was transmitted all over the world by putting rendered ruminants into feed for ruminants. It is now illegal in the U.S. and the rest of the world to use rendered ruminants in ruminant feed. More common than mad cow disease, feed can serve as a source of Salmonella infections. The feed can get contaminated at the mill, at the store, or on your farm by feces from birds, snakes or rats. This results in feeding grain mixed with Salmonella to your livestock. The solution is to buy feed from reputable suppliers and try to minimize storage times. On farm, keep the feed in rodent proof containers and avoid having spilled grain on the premises as it serves to draw birds and rodents.

Water

In most cases, municipal water is a very safe source of drinking water for livestock. However, there have been instances where even municipal water was a vehicle of disease. Well water can be a source of contamination from runoff and may serve as a source of disease. Probably of more concern is surface water in ditches and ponds. Water that flows onto the property from other livestock enterprises should always be fenced off.

Diseases introduced by vectors

Vectors are animals or insects that spread disease. They can be either biological vectors and be a required part of the life cycle of the agent or they can just carry disease agents inside or outside their bodies. Many viral diseases are insect vectored. This would include diseases such as Bluetongue and West Nile Virus. The insect is necessary in both of these cases and the time the virus spends in the host is what makes it infectious. In the case of West Nile Virus, a mosquito would feed on an infected bird and then a week later feed on your goat giving it the disease. In this case, control would be difficult because the infected bird may have flown from hundreds of miles away. Obviously, it would take a very stringent biosecurity program to prevent the entrance of mosquitoes into the biosecure area. One solution would be to use mosquito repellant and immunize the goat against the disease.

Biocontainment

We have protected the nucleus herd from outside threats, now it is time to worry about controlling diseases which already exist in our herd. The first goal is one of biocontainment. That means we want to limit the disease to a certain population of animals in the herd or to a certain geographic location in the herd and not allow it to spread from there. Let's say we have a goat that develops a caseous lymphadenitis abscess. This is caused by a highly contagious bacterium which can live in the environment for about 6 months. The first goal would be to isolate the goat in a pen away from the rest of the herd. That way if the abscess ruptures prior to being treated it will not contaminate other goats in the herd or the environment.

The second goal might be to get a non-infected kid off of this doe. We know that kids may be infected by ingesting colostrum and that the longer the kid stays with its mother the more likely it is to become infected. Our plan here might be to have a "clean herd" and a "dirty herd." The infected doe is the dirty herd and since the rest of the herd is uninfected; they are the clean herd. If the newborn kid can be removed from its mother without becoming infected then it can join the clean herd. The best plan is to remove the kid at birth. Raise it on a bottle and place it with the clean herd. To increase the possibility that the kid was not infected we could do a blood test on it when it gets to be 6 months of age.

Visitors moving through an animal enterprise can serve to spread disease from one area to another. When visitors enter the unit they should visit only the areas they need to see and they do it in order of the livestock disease susceptibility. This means that they would visit the neonatal unit first, the breeding unit next, then gestating animals, then weanlings or replacement doelings and, lastly, any animal that is sick and needs attention. The concept here is that baby goats are very easily infected with disease agents and that as they age they become more and more disease resistant. The cycle begins again when the doe becomes pregnant and has a fetus inside her which is again very susceptible to disease. Visitors would never go in reverse order or go back to a unit after they had visited the next unit. These same rules apply to employees on the farm.

Feeding systems

Feed and feed buckets can serve as fomites within the different units of the farm. If you have two houses of kids you are bucket feeding and you exchange buckets between the houses then you are getting cross contamination with pathogens between the two houses. The same would hold true for feed and feed buckets.

One of the common mistakes people make is using equipment to move manure and also to move feed. For instance a front end loader on a tractor is used to scrape manure out of the lot and is then used to haul bails of hay to the goats in the pasture. The hay has become contaminated with feces and could serve to spread parasites or diseases like Johne's disease. On a smaller scale this feces to hay contamination can be done by cleaning fecal pellets out of a trough with the same scoop that you use to get feed.

Goats are very adept at climbing into troughs and defecating. This serves as a source of infectious material for other goats. This can be avoided by making feed troughs and hay racks goat proof. Goats love to get on top of round bales and while they are on top they defecate and urinate. This serves as a mechanism of disease transfer but also results in the goats refusing to eat the soiled hay. Round bales need to be placed in round bale feeders that allow goats to eat the hay but not get up on top of it. This will prevent fecal to oral disease transmission and also minimize the amount of hay wasted. Alternatively, hay can be fed in limited quantities to limit the amount of waste.

Milk feeding systems

In general meat goat kids receive milk only from their dams. There is possibility of disease transmission but it is fairly minimal. Under some circumstances kids are fed or supplemented with milk from other does and sometimes with milk from does from other farms. Non-pasteurized milk can contain a variety of pathogens including those that cause mastitis (e.g., Staph and Strep), diarrhea (e.g., E. coli, Salmonella), respiratory disease (e.g., Pasturella and Mycoplasma), abscesses (Corynebacterium pseudotuberculosis) and a variety of systemic diseases (e.g., Listeriosis, CAE, and Brucellosis). The odds of one doe having disease may be low but if you pool milk from 100 goats then you are increasing the odds of exposing the kid to disease risk. Disease transmission by non-pasteurized milk is a huge problem for dairy goat operations. Pasteurizing milk or feeding a milk replacer eliminates this possibility of disease transmission.

Watering systems

Water in waterers can become a source of community infection. If every goat in the herd drinks out of the trough and one of them has sores on its mouth caused by Contagious Ecthyma then the virus deposited in the waterer may well infect a substantial number of goats. This problem can be minimized by keeping troughs filled with fresh water at all times and by chlorinating water. City water is chlorinated out of the tap. Well water can be chlorinated by adding chlorine to it. The rule of thumb here is that if you should not expect goats to drink water that you would not drink.

Manure programs

The invention most responsible for the longevity of humans is not the miracles of modern medicine but the invention of the flush toilet. Animals that are exposed to feces and forced to eat them have more disease problems than those that are not forced to eat feces. Why would a goat eat feces? If you watch goats eat you will learn that they are very picky eaters and that they especially avoid eating close to fecal pellets. They don't even like to eat grass that is close to fecal pellets on the pasture. However, if they get really hungry they will overcome this natural instinct to avoid feces.

Goats that are forced to lie in feces will be forced to eat feces. The doe that lies in feces gets them on her teats. Her kid nurses her and ingests feces along with its milk. The doe later grooms herself and ingests feces from her hair coat. How do you avoid the problem? Goats hate to lie in feces or on wet ground. Given a choice they like to lay up high and dry. Slatted bedding frames can be built that will allow goats to be off the ground and in a dry environment. Any feces they pass go through the slats to the area under the goats. Wooden pallets function in the same way.

Periodically, the feces need to be removed. They will be composted by putting the feces in a pile. The temperatures in the pile will help kill many of the pathogens normally found in feces. It also improves the

quality of the fertilizer you are producing. Make sure the manure pile is contained and that there is no run off of liquid from areas of manure concentration to pastures where goats are grazing. In particular, make sure there is no runoff from the feces of adult animals to pastures that house immature animals.

Feces should be applied to crop land, not to pastures. Fertilization of pastures with raw goat manure will result in disease transmission to grazing animals. The most important disease transmitted by feces is intestinal parasites. Fertilization of a hay field with goat manure and the subsequent cutting of a hay crop will not result in animals eating disease producing agents.

All–in–all–out

Another important concept of biocontainment is that of "all–in–all–out". This means that we bring a set of animals into a facility, raise them to a specified production level, remove all animals at the same time, then clean and disinfect the facility prior to introducing the next group. This concept was invented by the poultry industry and has improved their health standards dramatically.

Let's apply this to a simple example goat farm. We buy 100 goats and put them on a 10-acre pasture. Over a period of months the goats contaminate the pasture with parasite eggs which hatch into larvae. We recognize the parasite problem and remove all but ten goats from the pasture. These ten goats will continue to maintain levels of parasite contamination on the field. Months later we put 100 goats back on the pasture. They will quickly become parasite infected just like our original group. If we had removed all goats from the pasture and let the pasture sit or used it for a hay field, the pasture would have been parasite-free for our next group. This same principal can be applied to kidding barns and weanling pens. When a group of animals is ready, move all animals out. Most parasites and pathogens can't live for very long without their hosts. Continuous occupation results in continuous maintenance of pathogens. This cycle can be broken by removing the host and sanitizing the facility.

Immunization of the Nucleus Herd

Health in goats is a balance between the resistance of the animal to disease and the dose of disease to which the animal is challenged. Sanitation is the tool that is used to reduce the disease challenge to animals. Disease resistance is composed of environmental factors and immunologic factors. Goats that are well fed and housed will be more resistant to disease than goats that are poorly nourished and poorly housed. Goats that are immunized against a specific disease by vaccination will be more resistant to it than goats that have no immunity. Dollars spent on a healthy environment always return more money than dollars spent on immunization.

An animal that is immunized against a disease is resistant to that specific disease. Immunization can be done with the injection of commercially available vaccines (e.g., tetanus toxoid) or by the administration of immunoglobulins (e.g., colostrum or tetanus antitoxin) or by natural exposure to the disease producing agent (coccidia or toxoplasmosis). All of these result in an animal that is partially or completely immune to the disease. Vaccination means to administer a modified live or killed microbiological agent with the goal of preventing an infectious disease. Vaccination is sometimes incorrectly used as in "I vaccinated my goat with Bo-Se to prevent it from getting white muscle disease."

Immunization programs take some of the risks out of raising livestock. Vaccinating goat kids against tetanus will save the life of a kid that otherwise would have died. Fortunately, tetanus is not a contagious disease which means that tetanus doesn't spread from one goat to another. So the vaccine will only save the goat that received a vaccination. Rabies is an infectious and contagious disease. When a kid is vaccinated against rabies he is not only protected from the disease but other goats are protected from getting rabies from the vaccinated goat. In the case of tetanus, it is important that all animals be immunized against tetanus.

In the second case it would probably be adequate if the dog was immunized against rabies and none of the goats were immunized.

If immunization is going to be relied on to protect our goats from disease, then it is important that immunization occur prior to the challenge of disease. If does get infected with Chlamydia and abort only when they are pregnant, then the doe needs to be immunized prior to breeding. See the Preventive Health section for details on immunization programs. Sit down with your veterinarian to make an immunization plan specific to your farm and your management.

Disease Surveillance

Disease surveillance can be a very useful tool in disease control programs. Disease surveillance lets you know how your disease control program is working at various points in time. There are two general methods to survey the level of disease in a herd. One of them is by examining animals and the other is by examining data from animals. If the level of clinical parasitism in a herd of goats is a concern then do a FAMACHA test on the goats. The FAMACHA is described in the parasite control section but in brief you look at the conjunctiva (inner lid) of the goat's eye and if it is bright red it gets a score of 1 and if it is white it gets a score of 5. Goats with scores of 3, 4, and 5 are anemic as a result of clinical parasitism. If your goats score 1 or 2 your parasite control program is working very well.

Alternatively, fecal samples and blood samples could be collected and a laboratory could determine the Packed Cell Volumes (PCV) and the Fecal Egg Counts (FEC). If PCV's are all over 30% and FEC are less than 100 EPG then the parasite control program is working very well. Some diseases may present few external signs. Johne's disease is a chronic mycobacterial enteritis that causes malabsorption and maldigestion in ruminants. It takes years to develop. Instead of waiting for disease signs, it would be appropriate to test by serology or by fecal bacterial culture. It is important to understand that when you see clinical disease in one goat of a herd you are usually just looking at the "tip of the iceberg." With most diseases, such as Johne's disease for example, 10-20 subclinical cases can be found for every one clinical case seen.

Necropsy

A very useful surveillance tool is to have necropsies performed on dead and moribund animals. Whenever there is an unexpected death in the herd it would be appropriate to have your veterinarian perform a necropsy. In addition to finding the cause of immediate death, necropsies also allow your veterinarian to examine all tissues for evidence of disease. Necropsies will be most informative if the animal has just died or is moribund and can be euthanized.

Euthanasia

Occasions arise when a goat has become seriously injured or permanently debilitated and the humane procedure is to alleviate the animal's suffering by euthanasia. This is a controversial subject and is one which commonly evokes outrage from animal rights groups. Putting an animal to sleep can be a traumatic experience for the owner as well as for the animal. The American Veterinary Medical Association (AVMA) recommends the following techniques as being humane methods of euthanizing goats:

1. Intravenous drug overdose with barbiturates.
2. General anesthesia followed by injection of potassium chloride.
3. Penetrating captive bolt.
4. The following methods are "conditionally acceptable" for euthanizing goats:
5. Sedation followed by intravenous Chloral hydrate.
6. Gunshot.
7. Electrocution.

Lethal overdosing with barbiturates or other anesthetic agents is as humane a method as can be performed. Done correctly the animal becomes unconscious and then its heart and lungs stop all activity. Appropriate drugs given intravenously are required and generally this will require a veterinarian. Drugs used to euthanize animals remain in the carcass and will be fatal if ingested by scavengers (birds of prey, coyotes, etc.). It is critical that these carcasses be disposed of in such a way that the carcass does not end up in the food chain.

Captive bolt guns have the advantage over firearms that there is no projectile which can damage people or other objects. Used correctly, the application of a captive bolt to the head of the animal renders it instantly senseless. However, although the animal is brain dead and no longer has sensation it still will thrash around for varying periods of time. Sedation prior to captive bolt or gunshot will alleviate this problem.

Electrocution across the brain will render an animal temporarily unconscious. Death occurs when the electricity is strong enough to stop the animal's heart or when other methods are used to insure that the animal doesn't awaken. Sedation prior to electrocution is recommended.

Methods of euthanasia which are listed as inhumane include:

1. Drowning.
2. Air embolism.
3. Blows to the head.
4. Stunning.
5. Cyanide.
6. Exsanguination.
7. Injected household solvents.
8. Hypothermia.

Disposing of Mortality

Disposing of a dead animal has become a larger problem since the advent of BSE. Rendered ruminant products are no longer allowed to be fed back to ruminants in the form of meat and bone meal. Rendering goats is not technically illegal but many rendering facilities now have strict policies that they will not render sheep or goats due to concerns about scrapie.

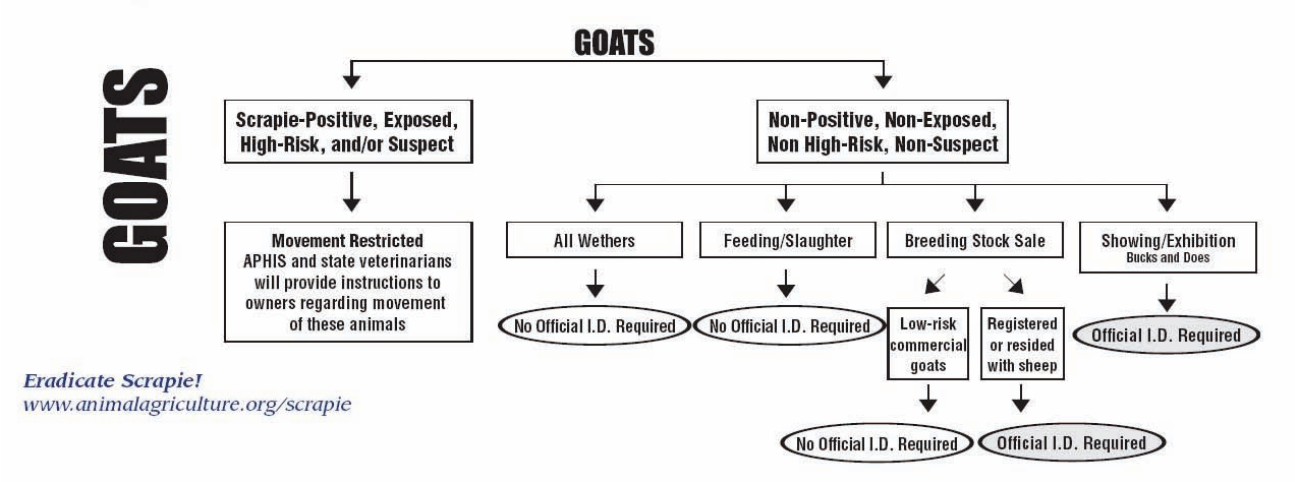
This leaves the following methods of carcass disposal:

1. Incineration.
2. Burial.
3. Compost.

Incineration is the most expensive of the three. It has the advantage of speed; however, the smell of burning animals is guaranteed to cause complaints in most areas. Prior to burning carcasses in the open or in an incinerator check with your local government for ordinances that may ban or regulate the activity.

Burial is inexpensive but may cause problems with runoff, contamination of water tables and odors. Predators are drawn to burial sites and may disinter the remains. In general you want to bury the carcass at least three feet deep and make sure you are at least 5 feet above the water table. Check with your local government for ordinances that may ban or regulate the activity.

Composting is an inexpensive, environmentally friendly method of carcass disposal. However, it requires a fairly extensive knowledge of the technique to work successfully. It has the same problems as burying in that runoff, contamination of ground water, and odors may all be problems.



Identify Your Animals

To evaluate individual animals you will need individual identification of animals. Each animal will need a tag, tattoo, neck chain, ear notches or electronic chip so that you or anyone else can identify it. Due to the nature of goats it is wise to use at least 2 forms of identification in case one is lost. Currently, if you show goats or have purebred/registered goats that you sell or you have sheep mixed with your goats then they are required to have a scrapie tag.

National Scrapie Eradication Program

Scrapie is a very rare disease in goats, however, it is commonly reported in sheep in the U.S. Because of these factors goats are part of the National Scrapie Eradication Program (NSEP). The good news is that because of the low level of disease in goats the regulatory requirements are less than those for sheep. You will need to determine what requirements you must fulfill with your goats.

There is an excellent web site (http://www.animalagriculture.org/scrapie/Scrapie.htm) that details all the information you will need to meet the NSEP requirements.

The first step is to determine if you need to identify your goats. In general this will only be necessary if you are showing sexually intact does and bucks (wethers are exempt), or plan to sell breeding stock that are registered goats or have goats that have been raised in contact with sheep. See the accompanying chart.

The second step is to obtain a premise/flock number. Eventually, this will be the same as your National Animal Identification System Number. Call 866-USDA-TAG to obtain your premise/flock number.

The third step is to determine which approved ID system will work best for you. In general, you can use tags supplied by the program or official custom made tags or if you have registered goats with tattoos or chips you can probably use them with some modifications. Check with your state and federal veterinarians to make sure you are in compliance.

The fourth step is to set up a record system that lists each goat. You will be required to retain ID records for 5 years. The records don't need to be detailed but they do need to include births, deaths, and movements of animals.

The fifth step is to make sure that every animal that leaves your farm and requires a tag has one in their ear.

The sixth step is to remember that all breeding animals and sexually intact goats moving across state lines must have a Certificate of Veterinary Inspection (CVI) which was issued in the last 30 days. In addition to

verifying scrapie identification requirements have been met, the goats may also have to be tested for diseases such as Tuberculosis and Brucellosis. Results can take up to a week to obtain so make sure you plan ahead. Individual states can have requirements that are more stringent than the federal requirements listed above. When you contact your veterinarian to obtain a CVI make sure you tell him/her where the animals will be traveling, their age, sex, registry status, and purpose of movement. Your veterinarian will contact the state veterinary office of your destination and determine what tests and requirements must be fulfilled.

National Animal Identification System

In the near future you will be required to have your farm and animals enrolled in the National Animal Identification System (NAIS). Recent cases of BSE in cattle have made it critically obvious that the U.S. needs a uniform system of animal identification that will allow regulatory agencies to track the movements of animals quickly and efficiently. The NAIS is being put into place to accomplish those goals. Under this system every facility that handles animals (farms, ranches, livestock shows, livestock sales, veterinary offices, etc.) will have a unique 7 character premises identification number. These numbers began to be issued in 2005.

Once the premise identification is in place, 15 character Animal Identification Numbers (AIN) and 13 character group/lot numbers will be distributed. Animals that are normally moved and marketed as a group (poultry, feeder pigs, etc.) will have a group number. All other animals will have an individual AIN. The program will determine suitable ID systems, such as tags or implants, for each animal species. The program will eliminate redundancy in identification numbers so that an animal's AIN number will be the same as its registry number or the same as its scrapie number, etc. It is the stated goal of this program that in the event of disease exposure all exposed animals will be tracked within 48 hours.

Naturally, certain individuals are nervous about the program and see it as an invasion of their privacy. The USDA has guaranteed that the only information the system will track is the location of the animal and any movements that occur during its life.

Setting up a Biosecurity Program: Risk Analysis

Evaluate risks

What are the risks to your herd at various levels of disease? How many goats are you willing or can you afford to lose to disease? If all of your does aborted one year would you be able to stay in business? If you had foot rot in the herd would the extra labor and expense be worth the savings of not having had a biosecurity program? What are your marketing risks? If you had CL in your goats would your clients refuse to buy slaughter goats from you? If you had Johne's disease would you still be able to sell breeding stock to other producers?

The process of evaluating your farm to determine levels of risk and practical methods of limiting or eliminating risk is called risk analysis. Risk analysis involves you and your veterinarian evaluating your facilities, your disease status, your animals, and your management. When the analysis is over you should have a prioritized list of any significant risks to your animal's health and a plan to minimize or eliminate them.

Evaluate your facilities

Map your farm and see where you are. Do you have fence-line contact with other livestock? Do you have drainage problems that will contaminate fields with manure runoff? Do you have an area where you can quarantine incoming animals? Do you have adequate facilities that you can separate healthy animals from sick animals?

Evaluate your disease status

What diseases do you have in the herd at this time?

Is it worth eradicating those diseases you already have?

Evaluate your animals

Are your animals genetically superior animals that would be hard to replace or would you be better off depopulating and repopulating now?

Evaluate management

Is management motivated enough to develop a plan and stick to it?

Is management capable of following through on a plan or will there not be enough time or expertise available?

Set goals

Set health goals for your existing animals. For example "all of my goats will be negative for CL." Be very specific with goals and make no exceptions to these rules. Not even for your favorite pet goat. Set health goals for incoming animals. For example "All incoming goats will have to test negative for CL."

Prepare a written protocol

Do this with your veterinarian. Consider your goals, animals, facilities, current disease status and management and make up a plan that fits your operation. The plan needs to cover biocontainment of existing diseases, disease surveillance, entry of new animals, quarantine procedures and visitors. Put the protocol in writing. Post it in appropriate places and stick with it.

Communicate

Communicate with employees, neighbors, customers and delivery personnel. Let them know what is being done and what will be required of them to do. Post signs that clearly delineate biosecure areas from non-secure areas.

Implement the plan

Put it in play. See if it is workable. At least once per year sit down and re-evaluate. Is everything working as envisioned?

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Meat Goat Herd Health Procedures and Prevention

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Introduction

The goal of a herd health program is to improve the goat herd's productivity through general husbandry, nutrition, parasite control, vaccination, and environmental management. An understanding of various management practices and common diseases on the farm is necessary to accomplish this goal. An effective herd health program is an essential part of a successful goat management program. Good feeding and breeding will not result in maximum production if goats are not kept in good health. Conversely, good nutrition and herd management will greatly reduce the complexity and cost of the herd health program.

Herd health programs are always described in very general terms and then modified to fit individual herds. The exact makeup of any program depends on the herd size, purpose of having the herd, and the production goals of the owner. For the most part, goats are managed as small groups of five to a hundred animals per herd. There are relatively very few large commercial goat herds with numbers above 500 head in the United States. Large herds may have problems associated with high density of animals and continuous turn over. Small herds tend to have higher nonproductive/productive ratios than do larger herds. This is because small herd owners often keep animals that would normally be culled in large commercial herds. Often, the net result is the maintenance of animals with chronic illnesses that may serve as reservoirs of disease.

Since each herd is different, each owner should work with his/her veterinarian to create an individual herd health plan. Keep good records for each animal regarding medications, vaccinations, dewormers, diseases, breeding, culling etc., and use this information to plan your herd health program. Preventive medicine is usually less expensive than treating the disease as the highest economic returns are realized when disease problems are at a minimum. Many diseases have similar symptoms and a producer should work with a veterinarian familiar with common goat diseases. A veterinarian familiar with goats has the training and experience needed to provide diagnosis and recommend animal health products used in goats to treat these conditions.

General Herd Health Considerations

An obvious key to a successful meat goat operation is having a healthy, productive herd. Herd health can be affected by a number of factors including genetics, environment, nutrition, and management, among others. The purchase of healthy animals and the provision of a healthy environment with proper nutrition, sanitation, biosecurity measures, and preventative health care are necessary in establishing and maintaining a healthy herd. However, goats can be affected by a variety of diseases and no matter how diligently one follows a strict herd health regime, from time to time animals will become ill.

The onus of detecting sick animals or animals undergoing nutritional or other stress falls on the owner or caretaker and can only be accomplished by daily observation. The producer should observe unrestrained animals in order to learn how his animals look and behave in a normal manner. This includes general appearance and movement, normal behavior patterns, fecal consistency, eating behavior, teeth, body parts,

etc. Any deviation from a goat's "normal" appearance and behavior should be cause for concern and further investigation. When an animal does become ill, it is important to identify that particular animal with the aim of trying to determine what course of action should be taken.

When illness does occur consider that it may be a herd health problem rather than an individual animal problem. This is because goats tend to stay close to one another which can promote the spread of any infectious condition. The following steps can assist you in dealing with a potential disease outbreak.

- Isolate any affected animals.
- Determine if the condition is a single occurrence or the start of a bigger problem.
- Check all animals carefully to identify sick ones.
- Contact your veterinarian to limit loss. It is important to have a prior relationship with a veterinarian. If a veterinarian understands your operation he/she can be of help in preventing health problems as well as treating diseases.

If death occurs, submit the goat to your local veterinarian for a post-mortem exam or take appropriate tissues from the animal for diagnosis at a state or other laboratory facility. A post-mortem exam may be more useful in determining the cause of a disease than examining live animals. The results of such an exam may yield an accurate disease diagnosis and allow for proper treatment to begin immediately. It is important to keep the body of a dead animal cool with ice or refrigeration until the examination can be performed. Freezing the carcass will make microscopic evaluation impossible.

Begin with Healthy Animals

To minimize the incidence of disease, it is important that only healthy animals are introduced into the herd. This begins at the time of purchase. Producers should buy only from reputable sources to minimize the chance of buying diseased animals. If animals are purchased at an auction, one can usually expect problems. New purchases should be quarantined for at least 30 days. This allows any diseases that are lingering to express themselves; provides time for new animals to adapt before being exposed to new herd mates; and gives time for the owner to deworm, administer vaccinations, etc., according to his/her established herd health protocol. Depending on the type of operation, testing for any of several disease entities may be advisable. A producer's quarantine protocol along with other procedures to minimize the risk of introducing diseases into the herd should be listed in the farm's biosecurity plan. See the "Biosecurity for Meat Goat Producers" section for more information on potential threats and recommended biosecurity plan components.

If animals are moved across state lines, a certificate of veterinary inspection (health paper) is required. This is a common procedure and should not be difficult to obtain. State requirements vary. To view your state's requirements log on to http://www.aphis.usda.gov/vs/sregs. Be sure to allow plenty of time to obtain the certificate as some states may require testing that may take several days.

Basic Herd Health Equipment and Supplies

It is best to plan ahead and prepare a basic herd health kit before the need to use it arises. Many of the items included will be used in the preventative care conducted as a part of a comprehensive herd health program and, thus, should already be on the farm. The following list is by no means exhaustive and should be used as a guide for a beginning health kit. As you consult with your veterinarian on a herd health program and annual herd health calendar, the items needed to maintain herd health will become apparent.

Basic herd health supplies

General Health Kit

- Thermometer.
- Record book.

- Alcohol.
- Balling gun and(or) capsule forceps for oral dosing of bolus medication.
- Dewormers (anthelmintics).
- Antibacterials/antibiotics (penicillin and tetracycline are most commonly used).
- Biologicals (Tetanus antitoxin, Tetanus toxoid, C. perfringens toxoid, C. perfringens antitoxin.
- Deworming or drench gun.
- Injectables (vitamin A, D, & E, vitamin B complex, BoSe, etc.).
- Syringes and needles of various sizes and gauges.
- Sharp's container for used needles such as an old soda bottle.
- Ear tagger and tags.
- Wound dressing.

Kidding Kit

- Iodine (7% tincture) for dipping navels after they are trimmed. Empty film canisters (2/3 full) are handy to prevent spilling or contaminating the main bottle. Spray bottles and teat dip containers can also be used.
- Betadine Scrub® (Povidone iodine) or Nolvasan Scrub® (Chlorhexidine). Disinfectant soap used to disinfect skin or vulva of goat and hands of people. Squeeze bottles are handy for dispensing.
- Nolvasan® solution. Use diluted to disinfect scissors and other equipment.
- Betadine Solution®. Use diluted to disinfect skin, wounds and tissue.
- Obstetrical sleeves and sterile lubricant.
- Paper towels for washing off doe, and for hands.
- Exam gloves.
- Newspapers for insulation and sanitation.
- Cloth towels to clean off newborn kids.
- Clean bottle (20 oz. soda bottle) and nipple to feed colostrum.
- Red rubber feeding tube (12 to 14 French) or similar flexible plastic tube, with 60 ml catheter tip syringe or funnel to feed colostrum to weak kids.
- Heat lamps, heating pad, or other means to warm chilled kids.
- Body socks or warming box for chilled or weak kids. Frozen colostrum or source of synthetic colostrum.
- Quality milk replacer.

Common Herd Health Procedures

In the normal course of herd health management it will be necessary to perform different herd health procedures. Some of these procedures are performed to collect information on an animal's condition that can be relayed to a veterinarian. Others are needed in the course of disease prevention or treatment. A producer should only attempt those procedures in which they feel comfortable and sufficiently proficient so that no harm can come to the animal. If there is any doubt, consult a veterinarian. The most common procedures done by producers are listed below with a brief explanation of correct methods.

Taking temperature – rectally

The first procedure usually performed on an animal suspected to be ill is to take its temperature. In goats, this is performed rectally. Either a digital or mercury thermometer can be used. Plastic digital thermometers do not break and may be considered as safer to use than a mercury thermometer. A small amount of lubricant may be put on the thermometer and it should be inserted with a twisting motion. A normal goat's temperature should be 103 - 104ºF (39 - 40ºC).

Determining body temperature.

Proper procedure for determining heart rate.

Determining rumen movement.

Checking mucous membranes.

Pulse or heart rate

There are several places on the goat where the pulse or heartbeat can be felt and measured. Heartbeat can be felt by placing one's fingertips between the ribs behind the elbow. Pulse can be measured using the femoral artery on the inside of the rear leg roughly ⅓ of the way down. Pulse may also be detected by placing the index and middle fingers on the artery located below and slightly inside of the jaw roughly two-thirds to the rear of the muzzle. A normal range is 70 to 90 beats per minute.

Respiration

Respiration is detected by watching movement of the flank or chest. A normal range is 12 to 20 per minute.

Rumen movements

Adequate rumen function is essential for a goat's health. One sign of adequate function is regular ruminal movement. This can be detected by placing the hand on the left flank of the animal. If the rumen feels soft and water-filled this should be noted and reported to your veterinarian. Rumen contractions should be easily felt and should occur 1-2 times per minute.

Checking mucous membranes

Paleness of the mucous membranes in the mouth (gums), vagina and prepuce can be an indicator that the animal is in hypovolemic shock, meaning that there is a decrease in the blood volume circulating in the animal. The color of the conjunctiva around the eyes can be an indicator of anemia that could be caused by a heavy internal parasite burden. Roll down the lower eyelid to look at the color. A pale, whitish color indicates anemia. This color can be scored using the FAMACHA system which is described in the section on Parasites of Goats. Remember that irritation of any type causes membranes to turn red. This means that an anemic goat with pinkeye may still have red membranes.

Drenching and dosing

Drenching or dosing an animal entails the oral administration of a liquid. The obvious goal of this procedure is to ensure that the animal swallows the full amount given. Grasp the animal under the jaw to raise its head. Raising the head of the animal will assist in ensuring the liquid is swallowed. A finger or thumb

Drenching.

Proper tubing technique.

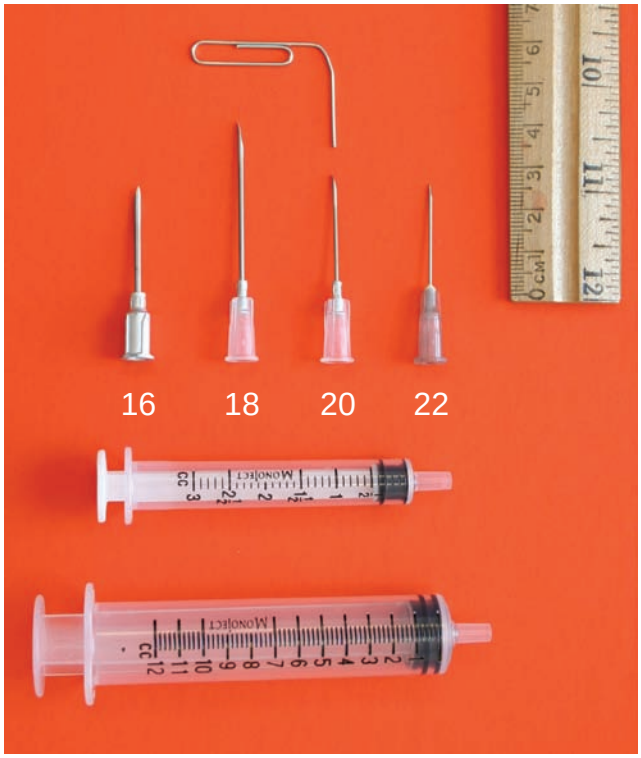
can be put into the mouth where there are no teeth (goats lack canine teeth as do all ruminants) to assist in opening the mouth for the drenching equipment. Generally a bottle with a tube over the end or a drenching gun is used. Liquids should be given slowly to allow time for the animal to swallow. Dewormers must be given using appropriate drenching equipment ensuring that they are given over the back of the tongue and swallowed.

Tubing an animal

In some cases it may be necessary to pass a tube down the mouth directly into the stomach in order to administer a large volume of a liquid. This could also be used to feed a young animal incapable of nursing or to either sample rumen contents or insert rumen contents into an animal having severe digestive problems. The size of the tube passed should be appropriate for the animal's size. Generally, a ½ to ¾ inch (1 to 2 cm) diameter tube should be used for adult goats. A short metal or PVC pipe (speculum) larger in diameter than the tube to be inserted is placed in the mouth to prevent the goat from biting or chewing the plastic tube. Some people prefer to use a "Harp" speculum instead. The hard-sided tube or speculum is inserted into the mouth of the goat and holds their mouth open while you pass the tube. The plastic tube is then passed down the throat and into the stomach. Administer liquids slowly. Have a veterinarian or person trained in this technique instruct you before attempting it the first time.

The procedure for tubing a neonatal kid is similar to that for adult animals with a few distinctions. For kids, one does not need to use a PVC tube or speculum. The size tube used is smaller for baby goats (12 to 14 French or roughly ¼ inch inner diameter). The tube should be flexible without any hard edges to harm the kid's mouth or throat. Hold the kid's mouth open and pass the tube gently over the hump or base of the tongue at the back of the mouth and into the stomach.

There are some precautions to take in tubing an animal to ensure that liquids are not inadvertently administered into the lung. The first precaution is to always hold the goat's head in its normal flexed position. If you extend the head and throat, your tube has a straight shot down the trachea. When doing this, preferably have the goat standing. As the tube is inserted, watch and feel the throat area. The tube needs to enter the esophagus and not the trachea or windpipe. The esophagus is a smooth, flexible tube leading to the stomach and one can feel or see the stomach tube sliding downwards. The trachea is a rigid tube and the stomach tube can neither be seen nor felt from outside the animal. When the tube is in the esophagus, feel the bottom of the neck. You should feel "two tubes." One will be the trachea and the other will be the rigid tube inside the esophagus.



Hypodermic needles and syringes.

Another check can be done while midway down the trachea/esophagus is to suck on the end of the tube. If you are in the esophagus, it will collapse on the tube and you will create a vacuum. Alternatively, blow in the tube and you will see a bolus of air go down the esophagus. If using a stethoscope applied to the goat's rumen on the left side of the body, you will hear air bubbling. Sucking on the tube while it is in the rigid walled trachea will not create a vacuum. One can also check for the smell of rumen fluid to ensure correct

Recommended needle sizes and lengths used in goats			
Age	Gauge	Needle length	
		Intramuscular injection	Subcutaneous injection
< 4 weeks old	20	½ inch	½ inch
4 to 16 weeks	20	⅝ to ¾ inch	½ inch
4 to 6 months	20	1 inch	½ inch
> 6 months	18 to 20	1 inch	½ inch

placement. To ensure proper depth of penetration, place the tube along the outside of the animal stretching from the mouth to the last rib, a point that would be inside the stomach, and put a mark on the tube. Use this as a guide when inserting the tube. Never rely on the goat coughing as a guide to proper tube placement. It is not a reliable test.

Bolus administration - "Balling"

A "balling gun" is used to administration tablets or boluses to an animal. A balling gun has a holder for the tablet in the end and a plunger to expel the tablet into the throat. Large boluses should be lubricated with vegetable or mineral oil for easier swallowing. Pass the balling gun over the hump of the tongue and press the plunger while holding and tilting the goat's head upwards. Ensure the tablet is swallowed by holding the mouth shut. Stroking the throat can also elicit a swallowing reflex.

Be very gentle in placing the balling gun into the mouth and expelling the pill. The tissues of the throat are very delicate and pills and guns have sharp edges. This can result in serious damage to your goat or minimally a goat with a very sore throat that will not eat. Newer model balling guns have soft plastic heads that reduce the potential for injury.

Paste administration

Dewormers, rumen pastes, and the like may come in a tube and are given through the use of an instrument resembling a caulking gun. Hold the animal as described for "balling," insert the end of the tube into the mouth and squeeze the handle the correct number of "clicks" to deliver an appropriate dose. Again, holding the goat's mouth shut will assist in swallowing.

Giving injections

Administering drugs via injection is a common herd health procedure routinely practiced by almost all producers. Following proper guidelines for each type of injection and using proper equipment will ensure that injections are done correctly and inflict minimum stress on an animal. Proper sanitation will ensure that you don't inject bacteria into your goat and cause an infection. Dirty needles and syringes should never be used. Using needles and syringes on multiple animals can transmit disease. After making six to ten injections with a needle it will be dull and should be changed and disposed of properly.

Needle selection

Proper injection technique includes selection of an appropriate size syringe and needle. Syringes should have volume markers that would ensure administration of the correct amount of drug. Needle gauge should be considered as it relates to injection type and thickness or viscosity of drug. In general, 18 to 20 gauge needles (as gauge number increases, needle diameter decreases) are sufficient.

Proper injection sites

Live animals are considered unprocessed food, especially if those goats are intended for slaughter and later used in the food chain. Injection site lesions should be a major product quality concern for goat producers raising goats for meat. Injection-site defects are lesions or scars found in cuts of meat that result from tissue irritation caused by the administration of intramuscular or sometimes subcutaneous injections. In addition to the scarred tissue, tenderness of the meat is also significantly reduced in the affected area surrounding the site. Proper injection sites are described for each type of injection described.

Common injection methods

The three most common injection methods are subcutaneous (SQ, under the skin), intramuscular (IM, in the muscle), and intravenous (IV, into a blood vessel, usually the jugular vein). Subcutaneous injections are the easiest to give and intravenous the most difficult. Whenever a drug or vaccine lists SQ as an option for injection use the SQ route. Only experienced personnel should attempt to give an intravenous injection and professional assistance should be used in most instances. Intravenous injections provide the fastest absorption of a drug by the animal while subcutaneous the slowest.

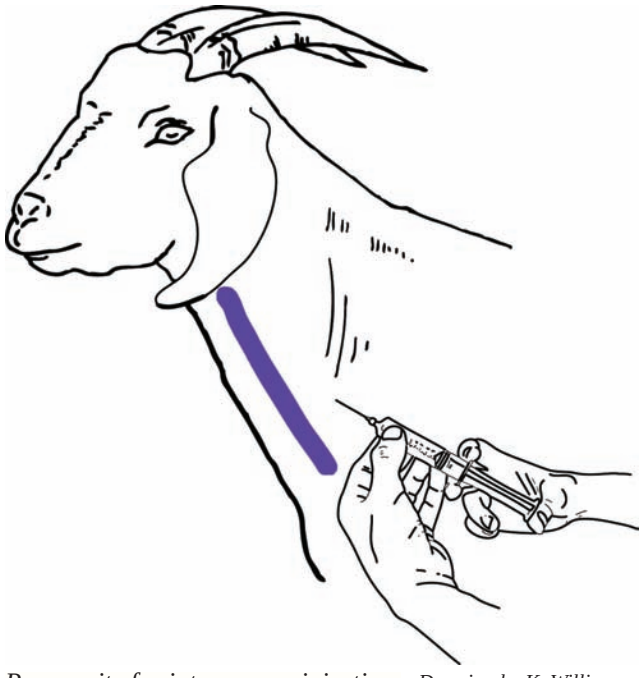
Subcutaneous injections

To inject subcutaneously, pull up a pinch of skin making a tent. Insert the needle into the tent taking care not to pierce through the other side. Depress the plunger slowly. Injecting with the needle pointing towards the ground will lessen the likelihood of the material leaking out of the hole left by the needle. Massage the injected area. If administering large amounts of a drug, over 3 milliliters (ml or cc), it is best to divide the dose among two or more sites not giving more than 2 or 3 cc per site. The preferred site for SQ injections is the skin just behind the elbow, although they can also be given in the triangular area in front of the shoulders between the top and bottom of the shoulder blade and corner of the jaw. Vaccines often cause swellings or "knots" and a knot behind the elbow indicates an injection site whereas a knot in the neck in front of the shoulder could possibly be confused with a caseous lymphadenitis abscess.

Intramuscular

An intramuscular injection calls for the needle to be inserted into a muscle. Intramuscular injections are commonly given in the triangular area of the neck, in front of the shoulder. Do not give intramuscular injections in the loin or hind leg of goats that are used for meat purposes to prevent injection site blemishes from occurring that lowers the value of the meat. Volume given in the muscle should not be more than 3 ml per site.

After inserting the needle, pull back on the plunger slightly to make sure a blood vessel has not been penetrated. Administer the drug slowly. If a blood vessel has been pierced, the needle can be withdrawn slightly, repositioned, and checked again. Never give an injection near the spine to prevent accidentally causing nerve damage.

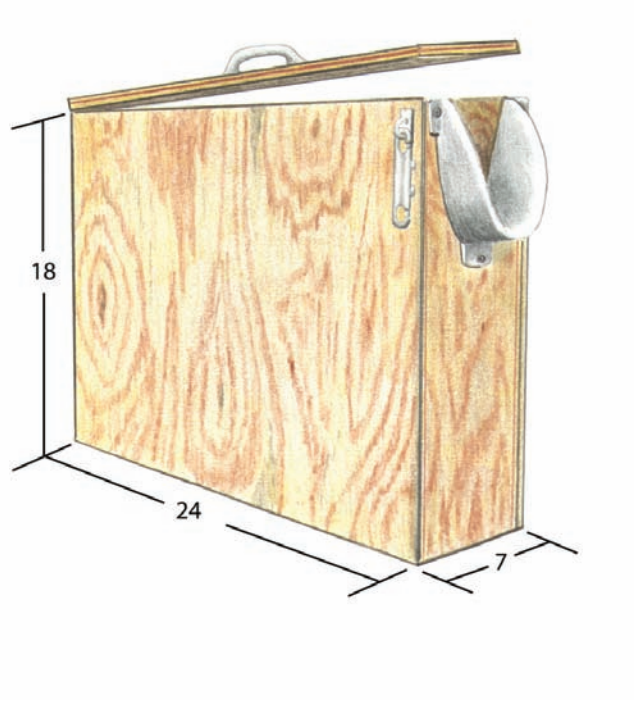


Proper site for intravenous injection. *Drawing by K. Williams.*

Intravenous

An intravenous injection requires skill to locate a vein, usually the jugular vein in the neck, insert the

needle, and ensure that the needle remains in the vessel while the drug is given. Prior to attempting this, it is best to receive training from a veterinarian. Animals may react quickly to drugs given in this fashion due to rapid absorption. Very few drugs need to be given intravenously; however, blood samples often need to be collected and the technique is the same. The easiest approach is to have someone straddle the goat to hold it securely. The holder will elevate the goat's head up and to the side. If you have clippers, clip all of the hair off the bottom third of the neck. Feel for the trachea on the neck and move towards the top of the neck. The area between the trachea and the muscles of the neck is the "jugular groove" and is where the jugular vein lies. Put pressure at the bottom of the groove and you will see the groove swell from your finger up to the jaw of the goat. The vein is now filled with blood. Using an 18 to 20 gauge needle, direct it at an angle of 45 degrees then stab through the skin. Pull back on your syringe and see if there is blood present. If not, adjust the depth (deeper or more shallow) or move up or down the side of the groove until blood is obtained.



Disbudding box (Dimensions in inches).
Drawing by K. Williams.

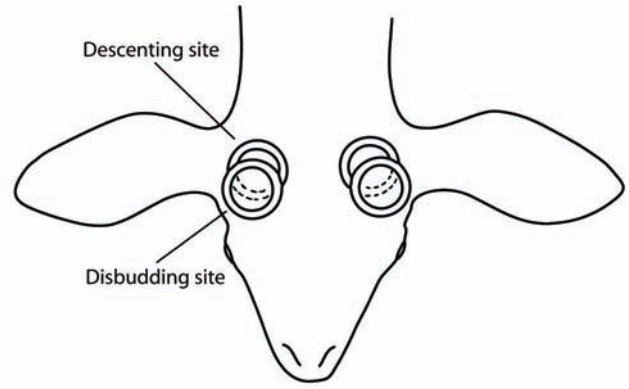
When you are injecting drugs IV, it is important to ensure that all of the drug enters the vein. Give the drug slowly. The jugular vein will take the administered drug straight to the heart and at high concentrations many drugs can cause problems with the heart. IV drugs given around the vein instead of in the vein can cause an irritation or inflammation of the vein.

Minor Surgical Procedures

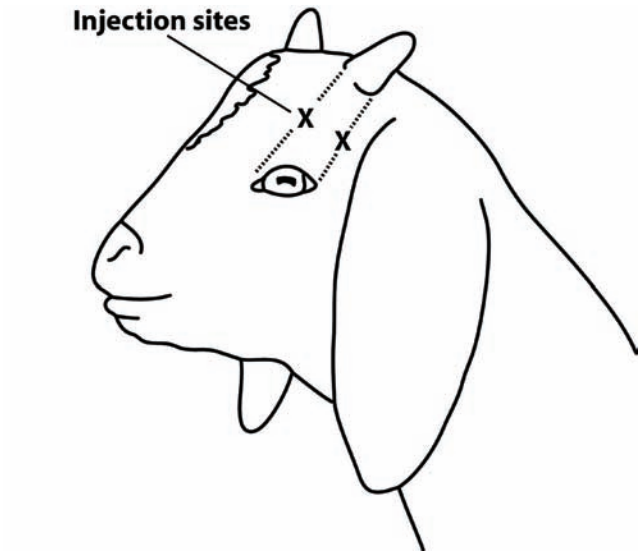
Castration

Males not wanted as replacement bucks should be castrated. Castration can be done by various mean as early as between 2 to 4 weeks of age. There are several methods of castration and the method selected will depend upon the age of the animal. The most common methods are elastrator band, Burdizzo® or other clamp, or surgical methods. General sanitation and vaccination precautions should be followed. Additional information on castration procedures can be found in the Meat Goat Management section.

Some producers may delay castration until bucks are 2 to 3 months of age. This may lessen the incidence of urinary calculi or bladder stones (see the Goat Diseases section) in animals on a high grain or concentrate diet. Also, remember that intact bucks have high levels of testosterone which acts as a growth promotant and stimulates the production of lean muscle mass. Many goat meat consumers that eat young goats do not care if the meat comes from intact or castrated males. There are some ethnic markets that actually prefer meat from mature bucks. Know the market in your area.



Proper placement of disbudding iron.
Drawing by K. Williams.



Injection sites for anesthetics for disbudding.
Drawing by K. Williams.

The point being that if it is not necessary to castrate goats for marketing purposes, then don't. However for breeding purposes realize that some bucks are fertile and ready to breed by 3 months of age and unwanted males should be castrated or separated from fertile females. In most climates photoperiod effects keep this from being a practical problem until kids are 9 to 12 months of age. In general, castration at an early age is the normal practice to reduce shock to the animal. Older animals should receive some type of anesthesia prior to castration and a veterinarian consulted.

Dehorning

Most meat goat producers will elect not to dehorn their goats. If the decision is made to raise goats without horns then kids should be disbudded in the first two weeks of life. Buck kid horns grow faster than doe horns. Some large single buck kids should be disbudded within the first week after birth. Disbudding a buck kid is the true test of proficiency of the person doing the dehorning and many fail, judging by the number of scurs seen on adult bucks. If you try to disbud a buck kid whose horn base is wider than a regular disbudding iron, you will get regrowth of the horn in a crown outside the burned area. If you try to disbud a small kid with a wide calf dehorner, you may get regrowth of the horn from the center of the ring. If one person is doing the job, a disbudding box offers the best and safest restraining device. Approximate dimensions are given the accompanying illustration.

The use of a local anesthetic is commonly advocated; however, the actual technique is not easy and the baby goat will scream while being held in preparation for a ring block or a cornual nerve block. One week old kids are small animals and cannot be given large doses of lidocaine or toxicity will result. A one week old kid should get no more then 1 cc total of lidocaine. One technique used is to dilute the lidocaine with distilled water allowing a larger volume to be injected into the locations shown below. Have a veterinarian administer the anesthetic or train you in the procedure.

Veterinarians typically use systemic anesthetics to anesthetize the goat for dehorning. The commonly used drugs are xylazine (Rompun) and ketamine (Vetalar). These can only be administered by a veterinarian.

The disbudding equipment most commonly used is an electric-heated metal rod with a hollowed-out end. Newer cordless, butane gas powered dehorners are available. Some disbudding irons have problems in maintaining a constant temperature, and it is extremely important to match temperature and time. Underburning of the horn bud will result in scurs while over-burning will lead to brain damage or death. The horn buds can generally be felt in young kids to ensure proper location to burn. After the disbudding iron is hot, apply it firmly over the horn area and rock it around slowly for 3.5 to 4 seconds. Remove the iron and repeat if necessary and do the other side. Evaluate the success of the procedure by its appearance. The goal is to have the area look like "chrome tanned leather." Black color represents burned hair and is indicative of inadequate burning. Clipping the site prior to burning will eliminate the problem of burned hair. Scent glands are located near the base of the horn and descenting could be done at the same time if desired. Inject the kids with 150 IU tetanus antitoxin. Although the risk of tetanus after disbudding is not great, it is a good practice to administer tetanus antitoxin.

An alternate disbudding method is the use of a caustic paste. The hair around the horn bud should be clipped and the paste applied. A ring of petroleum jelly around the horn bud may help prevent the paste from burning other skin tissue. Caustic paste sounds more benign than burning horn tissue; however, the paste has a bad habit of causing chemical burns on other parts of the goat or on his/her pen mates. To use caustic paste, make sure the kid is kept by itself so that it doesn't rub the chemical on the udder of its mother or the faces of its friends (not practical with most meat goat kids) and that it is kept out of the rain so that rain water doesn't wash the chemical into the goat's eyes.

Lancing abscesses

Goats get a variety of swellings or "knots" at various locations on their bodies. Some of these are cysts (fluid filled structures) and some of these are abscesses (puss filled structures). There is a disease of goats called caseous lymphadenitis (CL) that causes abscesses in the lymph nodes of goats. See the section on Meat Goat Herd Health - Common Diseases for more details.

One way of speeding the healing of an abscessed goat and of containing all of the infectious material from the abscesses is to lance it. This is usually a very simple and safe procedure. The first thing to do is be patient. Wait until the abscess comes to a "head." This is when the abscess is attached to the skin and the hair has begun to come off at the top of the abscess. The center of the abscess will soften. At this point, there are no vital blood vessels or other structures between the puss in the abscess and the outside of the goat.

Since pus is infectious to other animals and humans, wear gloves when performing this procedure. Remove any remaining hair from the region. Scrub the area with disinfectant soap (Betadine Scrub®) and restrain the goat. If this is done correctly it is not a painful procedure for the goat. Take a pinch of skin in the center of the abscess with your gloved hand or a surgical tool (such as a towel clamp) and stab a scalpel or sharp, sterilized knife blade deeply into the abscess and cut out a circle of skin. Just slashing the abscess may allow the cut to seal over before the abscess has healed from the inside out. There will be some white, or greenish white, odorless puss come out of hole created in the abscess. Catch it in a disposable bag and dispose of it where other goats can't get into it. Caseous lymphadenitis is a contagious disease. It is also a zoonotic disease, meaning it can be transmitted to humans, so wear gloves and sanitize your hands and equipment used after this procedure.

After lancing the abscess flush the area with diluted Betadine Solution® (10:1, 10 parts water to 1 part solution) to flush out any residual puss or bacteria. Make sure you keep the goat away from other goats until the lesion has completely healed.

Normal Range for Goat Physiological Parameters

Temperature, rectal	103–104° F (39–40° C)
Heart rate	70–90 beats per minute
Respiration	12–20 per minute
Rumen movements	1–2 per minute
Puberty	4–10 months
Estrous cycle	21 days
Estrus (standing heat)	12–48 hours
Gestation	150 days

Extra-Label Drug Use

There are few drugs for use in goats that have Food and Drug Administration (FDA) approval. Administering any drug not specifically labeled for use in goats or any product, either prescription or over the counter, that is not used as directed on the label is considered "Extra-label" or "off-label" drug use. Only veterinarians

may prescribe or use products “off-label” or “Extra-label” provided they have a valid veterinarian - client - patient relationship (VCPR) with the producer.

The issue of “extra label” use also applies to feed medications not approved for use in goats. While extra-label use of medications in or on animal feed is prohibited, in 2001 the FDA provided guidance on extra-label use of medicated feeds in minor species such as goats. In brief, extra-label use of medicated feed in minor species is limited to treatment of animals whose health is suffering or is threatened or whose death may result from failure to treat. If medicated feed is to be used in a food producing minor species, the product used must be approved for use in a food producing major species. The FDA discourages use of medicated feed in an extra-label manner for improving rates of weight gain, feed efficiency, or other production purposes.

Most goat producers are unaware that they do NOT have “extra-label” drug use privileges. Only veterinarians who have established a VCPR with a particular client may prescribe or use drugs in an extra-label manner on that client’s animals if the animal health is threatened and suffering or death may result from failure to treat. To establish a VCPR, the veterinarian should have visited the farm, and have a thorough knowledge of the management of these animals, or has recently seen the animal to be treated. Once a VCPR has been established, the veterinarian may use drugs in an extra-label manner provided that the client has agreed to follow his or her recommendations.

Three conditions of extra-label drug use:

1. The veterinarian has examined the animal(s) in question recently and has made a diagnosis and a determination that products with proper labeling will not work in this instance.
2. The client has been instructed by the veterinarian in the proper use and administration of the product, a withdrawal period has been determined, and the client is willing to follow the instructions given by the veterinarian.
3. The veterinarian is available to respond to any adverse reaction or follow up examination and treatment that may occur to the animal due to the administration of the drug or failure of the drug to work.

FDA criteria for Using Pharmaceuticals Extra-Label

The FDA has also established five criteria that must be met before any drug may be used in a food-producing animal in a manner different from that product’s label.

1. The veterinarian must first examine the animal and assumes responsibility for making clinical decisions regarding the health and treatment of the animal within the guidelines of a VCPR. Often a goat owner will not have the animal examined by a veterinarian, but will telephone a veterinarian, who may never have visited the farm, with a list of symptoms and ask for a recommended treatment. This does not qualify as VCPR!
2. The second criterion requires that the veterinarian determine there is no marketed drug specifically labeled to treat the diagnosed condition, or that the recommended dosage on the label for that product is clinically ineffective. Since there are few drugs labeled for use in goats, it is not difficult to determine whether or not there is a legally licensed product available.
3. The third criterion requires that the individual animals to be treated are clearly identified, and that accurate records be maintained regarding the treatment of those specific individuals. If there is no permanent identification such as an ear tag, notch, or tattoo, the owner must make some effort to identify the treated animals with a visible temporary mark by using temporary tags or paint. If possible, these animals should be isolated. Records on animals and treatment must be kept for future reference to avoid any drug residues in the meat or milk.
4. The fourth criterion requires that a significantly extended time period be assigned for drug withdrawal prior to marketing meat or milk from treated animals. The owner must keep accurate records of

the treatment, namely the person treating this animal, date, route of administration, product used and a proper withdrawal period. Proper withdrawal period can be obtained from your veterinarian. Veterinarians can access drug information at the Food Animal Residue Avoidance Databank, http://www.farad/org.

5. Many goat owners casually treat their animals and do not keep proper records of animals treated, drugs used, or proper withdrawal period for that product. If no information is available to establish a withdrawal time, then the treated animal or animal products such as milk and meat are permanently barred from the human food chain. This is to prevent illegal drug residues in products for human consumption. Although there are no drug residue test kits marketed specifically for goat meat, owners should be aware that drug residue testing is conducted on milk and meat produced for human consumption.
6. The last criterion details the information that must be listed on the drug dispensed for extra-label use. The label should include the name and address of the veterinarian, the established name of the drug(s), and the specific directions for use including: dosage, routes of administration, frequency of treatment, duration of therapy, cautionary statements, and the withdrawal time for any food that might be derived from the treated animal.

Ten Drug Use Tips

The following drug use tips can help ensure the proper administration of drugs and adherence to proper withdrawal times. All producers should restrict access to drugs to prevent indiscriminate or improper use. Remember that animal health products can be human health hazards.

1. Read the label carefully – labeling directions change frequently.
2. Use drugs only in animal species listed on the label or follow the "extra label" directions of a veterinarian.
3. Use the proper dose for the size of animal to be treated – overdosing can cause illegal residues.
4. Calculate pre-slaughter drug withdrawal times accurately – determine pre-slaughter withdrawal and milk discard times from the latest drug administration.
5. Use the correct route of administration – giving drugs incorrectly can lead to drug ineffectiveness, adverse reactions, illegal residues, and possible animal deaths.
6. Do not "double dose" – use of the same drug in the feed and by injection can cause illegal residues.
7. Select needle size and injection sites carefully, if injections are necessary – misuse can lead to tissue damage, reduced effectiveness, and/or illegal residues.
8. Allow proper withdrawal times for feed containing drugs – during the withdrawal time ensure that storage bins and feed are completely free of medicated feed and feed only drug-free feed or illegal residues may result.
9. Keep accurate records of drugs used and animals dosed – poor records can be costly if drug residue violations occur.
10. Seek the advice of your veterinarian – your records will allow him/her to provide safer and more effective treatment and save you money by preventing illegal residues.

For a complete explanation of all the precautions you need to take in using any particular drug or feed medication, first consult the drug label or feed tag. If you have any questions about the proper use of any drugs, see your veterinarian.

Medications Commonly Used in Goats and Approximate Withdrawal Times

Dr. Seyedmehdi Mobini, Georgia Small Ruminant Research & Extension Center, Fort Valley State University, Fort Valley, GA

The drugs listed in this table are commonly used in goats. There are only a few drugs approved by the FDA to be used in goats. ***Use of drugs listed as "extra-label" is legal only if prescribed by your veterinarian in the context of a valid client-patient relationship.*** The withdrawal times for various drugs were compiled from different sources. The listed dosages and withdrawal times, as well as drug status and legality of use, is subject to change. Your veterinarian will prescribe the latest, most up-to-date drugs, dosages, and provide the correct withdrawal period. ***Consult your veterinarian before beginning any treatment!***

I. Antibiotics:	**Brand Name**	**Approval**	**Dosage**	**Route**	**Frequency**	**Withdrawal Time**	
						Meat	Milk
Ceftiofur	Naxcel®	APPROVED	0.5-1 mg/lb	IM	Once a day	0 days	0 days
Neomycin	Biosol® and other products	APPROVED	5 mg/lb	PO	Twice a day	3 days	NA
Amoxicillin	Amoxi-inject®	extra-label	5 mg/lb	SQ	Once a day	26 days	120 hours
Ampicillin	Polyflex®	extra-label	5 mg/lb	SQ	Once a day	10 days	72 hours
Benzathine Pen G	Pen BP-48®	extra-label	20,000 IU/lb	SQ	Every 48 hours	30 days	NA
Erythromycin	Erythro-200®	extra-label	1 mg/lb	SQ	Once a day	5 days	96 hours
Florfenicol	Nuflor®	extra-label	9 mg/lb	IM	Every 48 hours	28 days	120 hours
Oxytetracycline	LA-200®	extra-label	9 mg/lb	SQ	Every 48 hours	29 days	144 hours
Procaine Pen. G	Crysticillin®	extra-label	10,000-20,000 IU/lb	SQ	Once a day	16-21 days	120 hours
Sulfadimethoxine	Albon®	extra-label	25 mg/lb Day 1, 12.5 mg/lb Days 2 - 5	PO	Once a day	12 days	5 days
		EXTRA-LABEL USE IS PROHIBITED IN LACTATING DAIRY COWS. DO NOT USE IN LACTATING DAIRY DOES.					
Tylosin	Tylan®-200	extra-label	10 mg/lb	IM	Once a day	30 days	96 hours
Chloramphenicol	Chloramphenicol	EXTRA-LABEL USE IS PROHIBITED					
Enrofloxacin	Baytril® 100	EXTRA-LABEL USE IS PROHIBITED					
Furacin, nitrofurantoin	Furox®	EXTRA-LABEL USE IS PROHIBITED					
Gentamicin	Gentocin®	DO NOT USE					
Tilmicosin	Micotil®	DO NOT USE – TOXIC TO GOATS					

II. Anti-inflammatory Drugs:	Brand Name	Approval	Dosage	Route	Frequency	Withdrawal Time	
						Meat	Milk
Aspirin	Aspirin	extra-label	100 mg/kg	PO	Once a day	1 day	24 hours
Flunixin meglumine	Banamine®	extra-label	1.1-2.2mg/kg	IV or IM	Once a day	10 days	72 hours
Phenylbutazone	Bute	extra-label	10-20 mg/kg	PO	Once a day	60 days	DNU
		DO NOT USE IN LACTATING ANIMALS					
Dipyrone	Dipyrone	EXTRA-LABEL USE IS PROHIBITED					

III. Prevention of Coccidiosis:	Brand Name	Approval	Dosage	Withdrawal Time	
				Meat	Milk
Decoquinate	Deccox®	APPROVED	13-91 gm/ton of feed	0 days	24 hours suggested minimum, DNU
Monensin	Rumensin®	APPROVED	15-20 gms/ton of feed	0 days	96 hours suggested minimum, DNU
Amprolium	Corid®	extra-label	25-50 mg/kg BW in feed or water	2 days	48 hours
Lasalocid	Bovatec®	extra-label	20-30 gms/ton of feed	0 days	24 hours

IV. Anthelmintics:	Brand Name	Approval	Dosage	Route	Withdrawal Time	
					Meat	Milk
1. Avermectins:						
Doramectin	Dectomax®	extra-label	0.3 mg/kg	SQ	56 days	40 days
Eprinomectin	Eprinex®	extra-label	0.5 mg/kg	PO	NA	NA
Ivermectin	Ivomec® Drench	extra-label	0.3 mg/kg	PO	14 days	9 days
Ivermectin	Ivomec® 1%	extra-label	0.3 mg/kg	SQ	56 days	50 days
Moxidectin	Quest®, Cydectin®	extra-label	0.5 mg/kg	PO	23 days	56 days
	Cydectin® drench	extra-label	0.3 mg/kg	PO	14 days	NA
	Cydectin® Injectable	extra-label	0.2 mg/kg	SQ	30 days	DNU

2. Benzimidazoles:						
Albendazole	Valbazen®	extra-label	10 mg/kg	PO	7 days	120 hours
Fenbendazole	Panacur®/ Safeguard®	APPROVED at 5 mg/ Kg, extra-label as recommended	10 mg/kg	PO	14 days	120 hours
Oxfendazole	Synanthic®	extra-label	10 mg/kg	PO	14 days	120 hours
3. Cholinergic Agonists:						
Morantel Tartrate	Rumatel®	APPROVED	10 mg/kg	PO	30 days	0 days
Levamisole	Levasole®	extra-label	8 mg/kg	PO	10 days	4 days

V. Anesthetics and Tranquilizers	**Brand Name**	**Approval**	**Dosage**	**Route**	**Withdrawal Time**	
					Meat	Milk
Ketamine	Ketaset®	extra-label	5-10 mg/kg	IV or IM	3 days	48 hours
Lidocaine	Lidocaine	extra-label	Variable for local anesthesia use, 1% in goats			
Thiamylal Na	Biotal	extra-label	10-20 mg/kg	IV	1 day	24 hours
Xylazine	Rompun®	extra-label	0.05-0.1 mg/kg	IV or IM	5 days	72 hours
Yohimbine	Yobin	extra-label	0.25 mg/kg	IV	7 days	72 hours

VI. Hormones:	**Brand Name**	**Approval**	**Dosage**	**Route**	**Withdrawal Time**	
					Meat	Milk
Cloprostenol	Estrumate®	extra-label	125 microgram	IM	0 days	0 days
Dexamethasone	Azium®	extra-label	20-25 mg	IM	14 days	4 days
Dinoprost	Lutalyse®	extra-label	5-10 mg	IM	1 day	24 hours
Oxytocin	Oxytocin	extra-label	10-20 IU	IM	0 days	0 days

VII. Electrolytes	**Brand Name**	**Approval**	**Dosage**	**Route**	**Withdrawal Time**	
					Meat	Milk
Calcium	Calcium borogluconate	extra-label	60 to 100 ml of 20 to 25% Solution	IV	0 days	0 days
Calcium	Calcuim gluconate	extra-label	50 to 100 ml 10 to 23% calcium ion solution	IV	0 days	0 days

NOTE: In the table above PO = oral administration; SQ = subcutaneous injection; IM = intramuscular injection; IV = intravenous injection.

DNU = insufficient data available to make WDI estimation, this drug is not approved for lactating goats.

Medications Commonly Used in Goats and Approximate Withdrawal Times

The following tables list medications commonly used in goats with their dosages and estimated withdrawal times (WDT). These tables are adapted with permission from the author Dr. Seyedmehdi Mobini of Fort Valley State University, Fort Valley, GA, from a paper that appeared in the proceedings of the Georgia Veterinary Medical Association Food Animal Conference in 2003. These recommendations were formulated by Dr. Mobini through a review of the literature in the United States and foreign countries, recommendations of the Food Animal Residue Avoidance Databank (FARAD), and personal experience. For many of the drugs mentioned, FARAD has calculated a Withdrawal Interval (WDI) to distinguish from the regulatory and approved WDT. The WDI is based on foreign drug approvals or extrapolations based on available tissue residue and/or related pharmacokinetic data on these drugs. In some cases, there is insufficient or no pharmacokinetic data from which FARAD can derive a WDI for goats. In those instances, FARAD has relied on sheep or cattle data and then added a scientifically-based time period to extend beyond the approved WDT to ensure safety as well as compliance with the Animal Medicinal Drug Use and Clarification Act of 1994 (AMDUCA).

Finally, the reader should be aware that there are several drugs which may be approved for specific species at a specific dose and route of administration, but are PROHIBITED FROM EXTRA-LABEL USE in any major or minor food animal species. These include Fluoroquinolones/Enrofloxacin (Baytril) and Phenylbutazone (Dairy). Other drugs are PROHIBITED FOR USE UNDER ANY CONDITION IN ANY ANIMAL THAT WILL BE USED FOR HUMAN FOOD. These drugs are: Dipyrone, Clenbuterol, Nitrofurazones, Nitrofurans (Furacin), Nitroimidazole (Metronidazole, Dimetridazole, Ipronidazole), Diethylstilbesterol, Glycopeptides (Vancomycin) and Chloramphenicol.

Herd Health at Different Production Stages

Goats have different health needs according to their stage of production. Providing for these health needs will increase your chances of having a healthy, productive herd.

Pre-breeding

Breeding does

Thirty to sixty days before the breeding season does should be examined for their udder and teat conformation, dentition (teeth), musculo-skeletal problems, and feet and body condition. Culling decisions should be made. Some common conditions seen in does include lameness, chronic mastitis, bad teats, and poor body condition due to a chronic disease, parasitism, old age, or other cause. Doelings should be at least 65 to 70% of their mature weight before their first breeding.

Prebreeding vaccination for *Chlamydia* should always be given. *Leptospirosis* and *Campylobacter* are less common causes of reproductive failure and abortion and vaccinations may be done, if the disease is present. Monitor fecal egg counts and deworm if needed. Does can be supplemented (flushed) with grain 2 to 4 weeks before breeding this will improve their fecundity (number of kids born per doe). Abrupt fence line exposure to bucks in the late transition period in the fall when does can begin to come into heat can help bring about cycling.

Breeding bucks

Bucks are too often neglected and omitted from herd health management practices. Some of the common conditions seen in bucks are urinary calculi (stones), lameness, urine scalding around the prepuce, and front leg injury due to a dominant buck in the pen. In the case of urinary scald, wash the affected area. Application of petroleum jelly can help protect the affected areas. Maintain a 2:1 ratio of dietary calcium to phosphorous

and provide a high level of salt (up to 4%) and 1 to 2% ammonium chloride in the diet to prevent urinary calculi. Bucks should be vaccinated at the same time as the does and for the same diseases. Body condition and breeding soundness should be evaluated at least 4 weeks before the breeding season and adjustments made to prevent bucks from becoming overly thin or obese. As breeding season approaches, extremely aggressive and dominant bucks may need to be penned separated to prevent injury. Monitor fecal egg counts in bucks or FAMACHA score and deworm as needed.

Breeding Season

Watch does and bucks carefully during the breeding season. This is a particularly strenuous time for bucks. Lame or sick bucks will not be able to breed adequate numbers of does. Fertility is drastically decreased by hot weather. Do everything you can to cool the buck off. This may include shade and fans during the day in very hot climates.

Gestation

Pre-parturition

A kid health and management program should actually begin prior to parturition with attention to the nutritional needs of the gestating doe in late lactation and during the dry period. An adequate diet for dry does is essential to produce healthy kids. Pregnant does should be fed to have a good body condition (score of 3.0 to 3.5 just prior to kidding). Does should be scored in early pregnancy and again six weeks prior to kidding. Remember that most fetal growth occurs in the last one-third of gestation and feed quantity and quality may need to be increased during this time. Clean, cool water and free choice trace-mineralized salt should be available.

Booster vaccinations for Clostridium perfringens C and D and tetanus toxoid should be given not less than 3 weeks prior to kidding. Vitamin E/selenium injections may be given during the dry period to prevent white muscle disease in kids, especially in areas where soils are selenium deficient and supplementation is inadequate. However, a nutrition program designed to provide adequate dietary selenium is preferable to providing injections. Provide other vaccinations or boosters for diseases causing abortion. Monitor fecal egg counts or FAMACHA score and deworm as needed.

Parturition (kidding)

While most meat goat does kid on pasture, there may be times when animals are brought indoors for kidding. The doe should kid in a clean environment; either a well-drained clean pasture or a stall bedded with straw or other absorbent material. The kid prior to birth has been existing in a germ-free environment and parturition represents exposure to common disease organisms to which the mature animal has developed resistance. The kidding stall or pasture should be located near a well-traveled area so that the doe can be frequently observed for kidding difficulties. Few adult does require assistance at the time of kidding though

Normal presentation.

Leg-back presentation.

Head-back presentation.

Drawings by K. Williams.

problems are always a possibility. First-freshening does should be closely watched, especially if bred to bucks known to sire large kids.

Signs of impending kidding include udder engorgement, swelling of the vulva, restlessness, and mucous discharge. The ligaments in the pelvic area will relax and the udder secretion's will change from clear honey-like to thick white milk (colostrum). The doe may also lose appetite. There are three stages of parturition. Stage 1 consists of uterine contraction and cervical dilation. This stage may last from three to six hours or more. The water bag ruptures at the end of this stage. Abdominal contractions will occur in Stage 2 and the fetus should be born within one hour. If the doe is having to provide undue straining or birth is delayed then examination and assistance may be needed; particularly if the doe is straining hard for 15 minutes or more. A veterinarian may need to be called. Stage 3 consists of expulsion of the placenta and usually occurs within a few hours after the last fetus is born.

Problems in parturition

Most does will kid with little to no assistance required; however, problems can occur. Many of these problems revolve around either incorrect presentation of the fetus or a kid that is to large for the mother's pelvis. In a normal birth presentation the forefeet will enter the birth canal first, the hooves will be pointed downwards, and the head will be between the legs. Another presentation that is sometimes seen that usually causes little problem is when the rear legs enter the birth canal first. In this case, the kid's hooves will be pointed upwards. Abnormal presentations include the rump first (breech) or any of the legs or the head bent backwards. In these cases, assistance is required.

When assisting birth, it is important to clean the area around the vulva with disinfectant soap and warm water and to have clean hands. Wear gloves. There are certain diseases that can be transmitted to humans during this time period. Pregnant women should not assist with the kidding process. Lubricate the hand prior to entering the vagina. Feel and identify the parts of the kid. Try to ensure that all body parts felt belong to the same kid and not to two separate bodies. If you feel only one leg or no legs at all, reach further and try to determine the exact position of the fetus. Arrange the legs and/or head gently in a proper position for birth. The fetus may have to be pushed forward towards the doe's head until a leg can be grasped and repositioned. Once the limbs are in a proper position, the kid should be gently pulled out and downwards using only your hands. Clear the mouth and nasal passages of the kid with straw or a towel and ensure it is breathing. Rubbing the body with a piece of cloth can sometimes stimulate breathing. Never pull on any presentation other than a normal presentation of two front legs and a head or a presentation of two hind legs and a tail. Pulling on any other arrangement of limbs and body parts will only make the problem worse.

If the anticipated kidding problems appear severe, call for a veterinarian immediately.

Kid management at birth

At birth two management practices are critical to the future health and survival of the newborn kid. The navel cord should be dipped in a solution of tincture of iodine (7% iodine solution) to prevent entry of disease-causing organisms through the navel cord and directly into the body of the kid. Make sure the entire cord is immersed in the iodine solution. If necessary, a long navel cord can be cut to 3 or 4 inches in length. Dipping the cord in iodine not only prevents entry of organisms but promotes rapid drying and the eventual breaking away of the cord from the navel.

Another critical practice is the feeding of colostrum as soon after birth as possible. The colostrum, or first milk, contains antibodies, which the doe does not pass to the fetal kid in the womb. Consumption of colostrum must occur as early as possible, ideally within 2-4 hours of birth. At 24 hours after birth there is a rapid reduction in the permeability of the intestinal wall to colostral antibodies. If a newborn kid does not or cannot nurse, the colostrum should be bottle-fed or the kid should be tube fed to insure adequate

consumption. Excess colostrum can be frozen for use in orphan or bonus kids. Recent research indicates that disease organisms, especially caprine arthritis encephalitis (CAE), may pass from doe to kid through milk and transmission might be avoided through the use of extra colostrum frozen from does tested and shown to be CAE-free or by feeding pasteurized colostrum. CAE is not considered to be a problem on most meat goat farms.

Kids should receive colostrum equal to 10% of their body weight during the first 24 hours of life. For example a six pound kid (96 ounces) should receive 10 ounces (roughly 300 ml) of colostrum within 24 hours of birth. This should be divided into at least 3 feedings. If fresh or frozen goat colostrum is not available, a commercial goat, sheep or cow colostrum replacement could be used. Fresh cow colostrum may also be used if necessary.

Under certain conditions newborn kids may benefit from injections of vitamins A and D approximately four days after birth. An iron dextran injection can be given but care is needed as iron is potentially toxic. A vitamin E/selenium injection may be beneficial in areas of selenium-deficient soils. These injections should be planned with your veterinarian as part of your herd health calendar. In general injection of vitamins and minerals is not necessary. If supplementation is necessary it is done more safely by dietary supplements. Realize that the fat soluble vitamins and minerals are toxic if given in excess.

Kids should be checked carefully at birth for any physical deformities or abnormalities. Pneumonia is a major killer of young kids. A clean, dry, draft-free environment is an excellent preventative measure.

Artificial raising of kids

Milk is the principal component of the diet of the pre-weaning kid. Most meat goat kids will nurse their dam until weaning. However, for orphaned kids or for kids of does that have lactation problems it may be necessary to use a milk replacer. Goat milk replacers are commercially available. If necessary, a lamb milk replacer may be used as a substitute for goat milk. Typical lamb milk replacers contain 22 to 24 % protein and 28 to 30% fat (on a dry matter basis). If no other milk replacer is available whole cows milk or calf milk replacers can be used. Maintaining milk replacer quality after mixing is particularly important when kids are fed ad libitum (all they can consume).

Milk can be fed by using bottles, pails, or self-feeder units. The method chosen will depend upon such factors as the size of the herd and available labor, as well as personnel preference. With any system, the health of the kid, sanitation, and available labor are the major factors to consider.

Under natural suckling, kids consume small amounts of milk at very frequent intervals. Ideally, artificial rearing should mimic natural suckling but the constraint of available labor precludes frequent feeding. Nevertheless, kids should be fed 4 to 5 times daily for the first and second week and 2 to 3 times daily thereafter. Bottle feeding is more labor intensive but kids receive more individual attention and are easier to handle post-weaning than kids that are allowed to suckle does. Pail or pan feeding may reduce labor somewhat but bodyweight loss and need for extra “training sessions” at the beginning must be expected.

Feeding schedule and amount for bottle fed kids.

Age	Amount of Fluid/Feeding	Feeding Schedule
1 to 3 days	4 ounces	5 times a day
3 days to 2 weeks	8 to 12 ounces	4 times a day
2 weeks to 3 months	16 ounces	3 times a day
3 months to 4 months	16 ounces	2 times a day

For larger herds, self-feeder units such as a "lamb bar" may successfully reduce labor. The key to use of the system is the maintenance of a low temperature of the milk (40°F) that will limit intake by the kid at any one time. Small, frequent feedings increase digestibility and decrease digestive disturbances. Rapid consumption of large quantities of milk may lead to fatal bloat due to entry of milk into the reticulo-rumen. Rapid passage of milk through the abomasum and small intestines can result in diarrhea or nutritional scours.

The biggest problem with kids bottle fed lamb milk replacer occurs with the feeding schedule. Frequently kids become "pets" and there is a tendency to feed them as much milk as they will consume each feeding. Unfortunately, this may result in bloat and sudden death due to enterotoxemia or diarrhea. A restricted feeding schedule and amount is necessary.

Dam raised kids

Most meat goat kids will be raised with their dams on pasture. While this removes the need for feeding milk replacer, these kids should not be forgotten in terms of nutritional and health needs. Producers must remember that since these kids are raised in the same environment as their dams, they are also exposed to the same health, disease, management, and grazing conditions. If internal parasites are a problem in the dams, expect the same in the kids and take management steps to reduce exposure to internal parasites through pasture rotation or other means. Crowding should be avoided and, if housed at any time, clean bedding and adequate ventilation are a must. Kids are naturally curious and will begin nibbling on items in their surroundings early in life. If there are toxic substances or plants, plastic, or other harmful materials lying about chances are some kids will eat them. If pasture is of very poor quality, kids beginning to nibble on grass or hay will not receive much nutritional benefit. This can slow down early growth.

Early access to a creep feed or creep pasture containing lush, nutritious forage will benefit kids becoming accustomed to solid feed, the development of their gastrointestinal tract, and in their early growth. Entry into the area containing creep feed or pasture should be restricted to kids by fencing or gates that prevent the entry of adult animals.

Weaning

In raising goat kids, increases in size and weight are not the only measure of success. A well-formed skeleton and proper development of internal organs are often neglected when the emphasis is on rapid gains. Dry feed consumption is important in developing body capacity. By increasing body capacity, feed intake and digestion increase.

In bottle fed kids over two weeks of age, limiting daily milk consumption to about 48 ounces will encourage daily consumption of dry feed. No later than three to four weeks of age a goat/lamb creep feed, other suitable creep feed, or even a calf starter should be offered. As the hay and grain consumption increases, gradually reduce the milk being fed. When the kid is eating ¼ pound of grain per day plus some hay and is drinking water from a bucket, it is time for weaning. Research has shown that at two months of age a weaned kid has a reticulo-ruminal capacity 5 times as large as suckling kids of the same age.

Kids on pasture should be consuming forages such as pasture grass or hay by two weeks of age and grain within four. Careful attention needs be given to formulation of a concentrate supplement for the pre-weaning kid. Palatability is of primary concern. Molasses at the rate of 10% of the total dry matter, corn (preferably chopped or rolled) and whole or rolled oats make up the energy "core" of a good pre-weaning diet. Balance the crude protein needs by adding cottonseed or soybean meal or another high protein source. Though few studies with kids have been done, crude protein contents of the pre-weaning ration should be within the range of 14-18%. Ground alfalfa may be added at 5% or less to provide additional stimulation for reticulo-ruminal development.

Several factors need to be considered when making the decision as to weaning. The most important consideration is whether or not the average daily consumption of concentrate and forage is adequate for growth and development to continue in the absence of milk. Fixed weaning ages are less desirable than weight goals such as 2.0 to 2.5 times birth weight.

Vaccination Schedule for Meat Goats

Other disease preventive measures

Dam – 1 month prior to kidding

Period	Time to Vaccinate	Disease	Booster
Kids	4 and 8 weeks of age.	C. perfringens C&D*. C. tetanus – toxoid.	Prebreeding.
	Between 8 and 12 weeks of age (single vaccination).	Contagious ecythma.	If a problem in herd.
	8 and 12 weeks of age.	Caseous lymphadenitis.	If a problem in herd.
	16 weeks of age.	Rabies.	Given if there is a rabies concern. Yearly booster.
Prebreeding			
Doelings and bucklings	60 and 30 days prior to breeding.	Chlamydia. Campylobacter. Leptospirosis.	If a problem in herd.
Does and bucks	30 days prior to breeding.	Chlamydia. Campylobacter. Leptospirosis. C. perfringens C&D*. C. tetanus - toxoid.	If a problem in herd.
Gestation			
Does	30 days prior to kidding.	C. perfringens C&D*. C. tetanus - toxoid.	

****-8-way clostridials like Covexin 8 could be used instead of C. perfringens C, D &T.***

- CDT vaccine to help increase antibodies against enterotoxemia and tetanus in the colostrum. In areas deficient in Se and where supplementation is inadequate, BoSe® to raise selenium levels and prevent white muscle disease in kids and retained afterbirth in dam. Providing a proper mineral nutrition program to ensure adequate consumption of all minerals is preferable. Get local veterinary advice on selenium injections as the need and dosage level depend upon how much selenium is in the soil in the region, as well as on the dietary supplementation.

Herd Health Calendar

A custom designed calendar is an excellent way to ensure the health of the herd is maintained. A calendar can be designed based upon your specific herd's production cycle. Consult with a veterinarian on the timing and need for vaccinations and other management procedures related to the health and well-being of your herd.

Planning Calendar for Meat Goat Herd Health

Stage	Suggested Health Practices	Additional Practices
Pre-breeding (30-60 days)	*Bucks* • Be aware of heat stress. • Breeding Soundness Evaluation done. • Vaccinate for Clostridium perfringens type C&D, plus Tetanus Toxoid. • Vaccinate for Chlamydia, Campylobacter and Leptospirosis, if necessary. • Trim feet. • Body Condition Score and adjust management accordingly. • Deworm based upon fecal egg counts or FAMACHA score. *Does* • Vaccinate for Chlamydia, Campylobacter, and Leptospira if necessary. • Vaccinate for Clostridium perfringens type C&D, plus Tetanus Toxoid. • Trim feet. • Body Condition Score and adjust management accordingly. • Deworm based upon fecal egg count or FAMACHA score at least two weeks before breeding. • Final cull of does based on production records, udders, feet, and type.	• Vitamin E and selenium given to does 30-45 days before breeding in selenium-deficient areas. • See Vaccination Schedule for Meat Goats • Put bucks next to doe pens. The "buck effect" will bring transitional does into heat.

Breeding	*Bucks* • Provide additional feed. • Be aware of heat stress, provide shade. *Does* • Observe for heat or use marking harness on bucks • If desired, check for pregnancy at 45-60 days with ultrasound.	• Make sure cats are not defecating in feed to prevent Toxoplasmosis. • Perform fecal egg count or check FAMACHA score and deworm if necessary. • Treat for flukes if a problem in the herd.
Pre-kidding (15-30 days)	*Does* • Booster Clostridium perfringens type C&D, plus Tetanus Toxoid. • Deworm based upon fecal egg counts or FAMACHA score. • Body Condition Score, adjust management accordingly • Watch for pregnancy toxemia.	• Perform fecal egg count or check FAMACHA score and deworm if necessary. • Begin to collect supplies for kidding.
Kidding	*Does* • Observe 3-5 times per day. • Assist if needed. *Kids* • Clip, dip, and strip: • Clip navel cord to 2-4”, • Dip navel in 7% iodine, • Strip small amount of milk to make sure teat ends are open.	

Nursing/Lactation	*Does* • Feed extra feed to does with multiple kids. *Kids* • Observe daily for signs of diarrhea or respiratory disease. • Vaccinate – Clostridium perfringens type C&D and Tetanus, revaccinate at four weeks after first injection. • Castrate males before three months of age. • Start creep feeding by two weeks of age.	• See Vaccination Schedule for Meat Goats
Weaning	• Weaning at three to five months or when marketed as young kids. • Check for internal parasites and deworm if needed.	• May want to use coccidiostat in creep feed and post-weaning feed.
Post-weaning/Drying	• About every four weeks, check for internal parasites and deworm as needed. • Reduce feed to does just before weaning. • May want to reduce water availability for a day or two after weaning.	

Goat Guideline for Anthelmintic Dosages (internal parasite dewormers) July 2006

Important --- Please read notes on the following page before using this chart

		Oral dosing. Note: 1 ml = 1 cc						Subcutaneous injection
		Valbazen Albendazole[1]	SafeGuard Fenbendazole[2]	Ivomec Ivermectin[3]	Levasole Levamisole[4]	Cydectin Pour-on Moxidectin[5]	Cydectin Drench Moxidectin[6]	Cydectin *Injectable* Moxidectin[7]
Animal Weight		20 mg/kg	10 mg/kg	0.4 mg/kg	12 mg/kg	0.5 mg/kg	0.3 mg/kg	0.2 mg/kg
lbs	kg	2 ml/ 25 lb	1.1 ml/ 25 lb	6 ml/ 25 lb	3 ml/ 25 lb	1.1 ml/25 lb	3.4 ml/25 lb	1 ml/ 110 lb
20	9.1	1.6	0.9	4.8	2.4	0.9	2.7	0.2
25	11.4	2.0	1.1	6.0	3.0	1.1	3.4	0.2
30	13.6	2.4	1.4	7.2	3.6	1.4	4.1	0.3
35	15.9	2.8	1.6	8.4	4.2	1.6	4.8	0.3
40	18.2	3.2	1.8	9.6	4.8	1.8	5.4	0.4
45	20.5	3.6	2.1	10.8	5.4	2.1	6.1	0.4
50	22.7	4.0	2.3	12.0	6.0	2.3	6.8	0.5
55	25.0	4.4	2.5	13.2	6.6	2.5	7.5	0.5
60	27.3	4.8	2.7	14.4	7.2	2.7	8.2	0.5
65	29.5	5.2	3.0	15.6	7.8	3.0	8.8	0.6
70	31.8	5.6	3.2	16.8	8.4	3.2	9.5	0.6
75	34.1	6.0	3.4	18.0	9.0	3.4	10.2	0.7
80	36.4	6.4	3.6	19.2	9.6	3.6	10.9	0.7
85	38.6	6.8	3.9	20.4	10.2	3.9	11.6	0.8
90	40.9	7.2	4.1	21.6	10.8	4.1	12.2	0.8
95	43.2	7.6	4.3	22.8	11.4	4.3	12.9	0.9
100	45.5	8.0	4.6	24.0	12.0	4.6	13.6	0.9
105	47.7	8.4	4.8	25.2	12.6	4.8	14.3	1.0
110	50.0	8.8	5.0	26.4	13.2	5.0	15.0	1.0
115	52.3	9.2	5.2	27.6	13.8	5.2	15.6	1.0
120	54.5	9.6	5.5	28.8	14.4	5.5	16.3	1.1
125	56.8	10.0	5.7	30.0	15.0	5.7	17.0	1.1
130	59.1	10.4	5.9	31.2	15.6	5.9	17.7	1.2
140	63.6	11.2	6.4	33.6	16.8	6.4	19.0	1.3
150	68.2	12.0	6.8	36.0	18.0	6.8	20.4	1.4

Footnotes:

1. **Valbazen** Suspension (11.36 % or 113.6 mg/ml): ***Do NOT use in pregnant does in the first trimester of pregnancy.*** Meat withdrawal time is 9 days and 7 days for milk (FARAD).
2. **Safe-Guard/ Panacur** Suspension (10% or 100 mg/ml): Approved in goats at 5 mg/kg with meat withdrawal time of 6 days and no withdrawal period for milk. Although the label dose in goats is 5 mg/kg, it is generally recognized that 10 mg/kg dosage is required for good efficacy. At 10 mg/kg dosage, meat withdrawal is 16 days and 4 days for milk (FARAD).
3. **Ivomec Sheep Drench** (0.08% or 0.8 mg/ml): Protect from light. Coughing may occur during and following drenching. Meat withdrawal time is 14 days (FARAD).
4. **Levasole Soluble Drench Powder (Sheep)**: Oral solution ONLY. To prepare use 1 packet (13 gm/11.7 gm active ingredient) dissolved in 262 ml [8.9 oz.] water (44.7 mg/ml) {or 52 gram packet dissolved in 1048 ml water [35.4 oz.].} NOTE: This is different dilution from the label directions for administration. Meat withdrawal time is 4 days (FARAD).
5. **Cydectin Pour-on for cattle** (0.5% or 5 mg/ml): Meat withdrawal time is 23 days. ***Not for use in lactating dairy goats.***
6. **Cydectin Drench for sheep** (.1% or 1 mg/ml): Meat withdrawal time is 14 days. ***Not for use in lactating dairy goats.***
7. **Cydectin Injectable for cattle** (1% or 10 mg/ml): GIVE SQ. Meat withdrawal time is 30 days. ***Not for use in lactating dairy goats.***

NOTE for Guideline for Anthelmintic Dosages in Goats

The attached chart was developed by Ray M. Kaplan, D.V.M., Ph.D. (University of Georgia) and modified by Patty Scharko D.V.M., M.P.H. (University of Kentucky) and Lionel Dawson D.V.M., M.S. (Oklahoma State University). It is provided as a possible guideline for anthelmintic (deworming) dosages for goats. Producers should consult their veterinarian for advice on their specific management situation for determining dosages for their herd. ***With the exception of fenbendazole administered at the 5 mg/kg dose, these drugs are not approved by the Food and Drug Administration (FDA) for use in goats, and when used in goats are considered extra-label use (fenbendazole at the recommended dose rate of 10 mg/kg is considered extra-label usage). The FDA regards extra-label use of drugs as an exclusive privilege of the veterinary profession and is only permitted when a bona fide veterinarian-client-patient relationship exists and an appropriate medical diagnosis has been made. The chart is intended to serve as guideline for improving accuracy when dosing goats with an anthelmintic, but these drugs should be used in goats only when appropriate veterinary advice has been received.***

Drug resistance in parasites of goats is extremely common. The effectiveness of an anthelmintic should always be tested before being used by performing a FECRT (Fecal Egg Count Reduction test) or larval development (DrenchRite) assay if available.

*** The current recommendation is to use the Cydectin cattle **injectable** formulation and **NOT** the **pour-on** formulation (orally) or the sheep oral drench. When administered by subcutaneous injection, moxidectin provides improved drug levels as compared to oral administration.*

The proper citation for this article is:

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Meat Goat Herd Health
Common Diseases

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Introduction

While goats are normally very healthy animals, they can succumb to disease just like other domestic livestock species. Diseases can be very serious and result in lost productivity, reduced reproduction, or even death. Some diseases are contagious and can spread quickly throughout a herd. Other diseases have the potential to be zoonotic, meaning they can be passed to humans. It is essential for goat producers to have basic knowledge of the diseases most likely to affect their animals. This knowledge should include how a disease is transmitted, its signs and symptoms, how it can be treated and, most importantly, how it can be prevented and controlled. While basic knowledge of diseases will assist a producer, a veterinarian is the correct person to provide proper diagnosis and to prescribe appropriate drugs and treatment regimes.

Reproductive Disease: Infectious Abortions

General

Of all the disease problems which can affect a herd of goats, those causing abortion and reproductive failure are always the most costly. Estimates for expected pregnancy wastage in goats are in the range of 5 to 8% per year and in abortion epidemics could reach greater than 80%. Abortions can be due to many factors including malnutrition, temperature, genetics, hormones, stress, and trauma. However, abortions due to diseases that may spread throughout the herd have the potential to be the most devastating.

When faced with an animal which aborts, it is imperative that appropriate procedures are followed if a diagnosis is to be made. Record the animal number, date, and any other important information about the abortion. Four samples (clearly labeled with animal number and date) always suggested to be taken include:

1. Fetus – fresh, chilled if delivery to a diagnostic lab is within 2 days, otherwise freeze.
2. Placenta - as above.
3. Blood collected at the time of abortion - if possible, allow blood to clot and collect the serum (pale yellow fluid that rises above the clot) and freeze.
4. Blood collected 2 to 4 weeks after the abortion – as above.
5. It is important to remember that many of the diseases causing abortion in goats are zoonotic diseases and can be transmitted to humans. Gloves should always be worn when collecting samples from the abortion and hands should be cleaned carefully after handling potentially infectious material. Pregnant women should not assist with kidding.

In general, it is safest to assume that all abortions are caused by contagious organisms. Always isolate the doe and dispose of all aborted material (fetus, placenta, and fluids) by burning or burying. Contact a veterinarian to determine a course of action and potential treatment programs.

Chlamydiosis

Chlamydia is a common cause of infectious abortion in goats. In chronically infected herds almost 50% of abortions are the result of infection with these bacteria (*Chlamydia psittaci*). The birth of weak kids may also be associated with Chlamydia. Chlamydia can cause conjunctivitis (pink eye), and polyarthritis (arthri-

tis in multiple joints), though the exact strains of the Chlamydia bacteria causing these diseases differ from those causing abortion. Goats become infected orally from bacteria shed in the feces and uterine discharges of infected goats.

Signs and symptoms

A history of late term abortions, stillbirths, and birth of weak kids is always suggestive of Chlamydiosis. The aborted fetus may be fresh or decomposed in appearance. The time from infection to abortion may vary. Female kids infected with the organism at birth may abort in their first pregnancy. Does exposed to the bacteria in the first half of gestation may abort in the last trimester of that pregnancy. Does exposed in the last half of gestation usually abort in the subsequent pregnancy. Once abortion has occurred, does appear to have immunity as affected animals seldom abort more than once due to Chlamydiosis.

Treatment, prevention, and control

Remove aborting does from the herd for at least 3 weeks. Placentas and fetuses should be removed and burned or buried. To minimize exposure, ensure that all feed and water sources are protected from fecal contamination. Treating all does in an abortion outbreak with tetracycline may reduce additional abortions. Consult your veterinarian for drugs, dosage, and withdrawal information. There is a vaccine approved for sheep available as a single antigen or in combination with Campylobacter. Consult your veterinarian for potential use in goats.

Toxoplasmosis

Toxoplasma gondii is a protozoan parasite that can infect goats and is second in importance only to Chlamydia as a major cause of infectious abortion. Cats are the primary host for toxoplasmosis, becoming infected by eating infected rats and mice. The parasite matures in the intestine of the cat and infective eggs or oocytes are passed in the feces which can infect goats and other animals if consumed. Other than cat feces, the only source of infection for does is by consuming the infected placenta or birth fluids from aborting does. Younger cats are more of a threat to spread the disease than older cats. Cats develop immunity as they mature and persons who want cats should use neutered adult males as they are less likely to be a source of infection.

Toxoplasma can be transmitted to humans via drinking milk from infected does and from handling aborted material. Pregnant women should not assist with kidding or handle aborted material.

Signs and symptoms

Does infected early in pregnancy may reabsorb the fetus or abort a mummified fetus. Infections later in gestation can result in abortion and stillbirth. Diagnosis is usually made based on the appearance of the placenta. White to yellow focal “rice grain” lesions are typically found on the cotyledons. Another common finding is brain abnormalities in stillborn or weak kids.

Treatment, prevention, and control

Remove does which abort from the herd for a minimum of 4 weeks. Bury or burn all aborted material. During gestation, all cats should be kept away from pregnant does. Remove all feed which may have been contaminated with cat feces and prevent cats from defecating in feeders, on hay bales, etc. There are no vaccines available in the U.S. for toxoplasmosis. Feeding monensin throughout pregnancy has been shown to have some protective effect (Rumensin 60 made by Elanco fed at 20 grams monensin per ton of feed).

Properly cook all goat meat and pasteurize all goat milk to be consumed, particularly that fed to infants. Pregnant women should be careful when handling goats. Wear protective gloves when handling fetus and placenta.

Q-fever

Q-fever is a bacterial infection (*Coxiella burnetti*) that causes fetal resorption, stillbirths, and late term abortions often with retained placentas. It is transmitted through the air and inhaled or is consumed via infected abortion material, urine, or grazing contaminated pastures. Tick bites may also be a source of transmission. Q-fever's primary significance is its zoonotic potential.

Signs and symptoms

Q-fever infects cattle, goats, sheep, and wildlife. Most infected goats will be carriers of the disease without showing any signs. Carrier animals will shed the disease in milk and at parturition. Signs include stillbirths and late term abortion. Some aborted goats will have a retained placenta.

Treatment, prevention, and control

Tetracycline is the drug of choice and may be used under veterinary supervision. The aborted placenta, fetus, and birth fluids should be buried or burned. Colostrum and milk also have high levels of organisms. There is currently no effective vaccine available. The organism is resistant to drying which means it aerosolizes and can be inhaled. This is a zoonotic disease meaning it can be contracted by humans so a mask should be worn when scraping manure or sweeping the area. Pasteurize all milk before drinking.

Brucellosis

Brucellosis is a bacterial disease of mammals that can affect goats causing abortions in does and inflammation of the testicles in bucks. While brucellosis in goats is usually caused by *Brucella melitensis*, they can also become infected with *Brucella abortus* which is the brucella of cattle. *Brucella melitensis* is not found in the United States at present; however, it is present in Mexico. *Brucella abortus* is rare in the United States. If brucella enters a herd there is usually an abortion "storm." Brucellosis is an important zoonotic disease and is called "Malta fever" in humans. It is characterized by recurrent flu-like symptoms and high fever.

Signs and symptoms

Abortion in late pregnancy, stillbirths, and birth of weak, infected kids are all possible signs. Does may show fever, lameness, and sometimes nervous system signs.

Treatment, prevention, and control

There is no effective treatment and infected animals should be slaughtered. Burn or bury all aborted materials. Consult your veterinarian if brucellosis is suspected. Any brucellosis cases must be reported to state veterinarians. Additions to the herd can be tested for presence of the disease organism. This disease is spread to humans by direct contact or by drinking unpasteurized milk or consuming products made from infected milk. Wear protective clothing when assisting with birthing problems or abortions. Do not drink or use raw milk.

Other abortion-causing diseases

Campylobacter (vibriosis) and Leptospirosis are two other diseases that can cause late-term abortions; however, these diseases are rarely seen in goats. Campylobacter is spread orally via feces and the aborted fetus and placenta of infected animals. A common sign is a bloody, pus-like vaginal discharge before or after abortion. Leptospira is usually transmitted by the urine of infected animals that can be goats but more commonly are rodents. Ensure that feed and water sources are not contaminated with feces or urine. Control rodents and other animals that may be vectors for these diseases. Listeriosis, caused by *Listeria monocytogenes* can cause mid- to late-term abortions. It can also cause "Circling Disease" and is discussed later in this chapter. For these abortion diseases, consult a veterinarian for treatment regimes and possible vaccination protocols if deemed necessary.

Musculo-Skeletal Diseases

Caprine arthritis encephalitis (CAE)

Caprine arthritis encephalitis (CAE), caused by a retrovirus, can affect all breeds of goats but is most common in the dairy goat industry. Up to 80% of all dairy goat herds tested have infected animals compared with only up to 10% of meat goat herds. The CAE virus is transmitted from an infected adult goat to kids through consumption of colostrum and milk. There is also evidence to suggest that CAE can be transmitted directly from goat to goat possibly through saliva, nasal secretions, urine, feces, venereal transmission from infected bucks, and mechanical transmission (needles, tattooing equipment, etc.). While generally not a deadly disease, CAE can result in lost production, particularly in older goats. CAE is not an important disease in most meat goat herds at the present time.

Signs and symptoms

There are four forms of the disease, a CNS or "central nervous system" form that affects kids, an arthritic form that affects adults, a pneumonia form, and a mastitic form. The arthritic form in older goats is most commonly seen.

In the CNS form, young kids (2 to 4 months of age) develop a weakness in the rear legs, stumble, and finally cannot rise. The unused leg muscles lose strength and terminally affected kids are unable to sit up and can only lie on their sides. Throughout the course of the disease, kids remain bright and alert and will continue eating and drinking with assistance.

In the arthritic form, goats will have one or more swollen joints. The knee joints are most frequently affected followed by the hocks and stifles. Lameness results and goats may eventually walk on their knees. Affected goats gradually lose weight and condition, have poor hair coats, swollen knees, and have signs of joint pain particularly during cold weather.

The pneumonia form is usually seen during advanced pregnancy when the animal is stressed. The mastitic form occurs in adult does and is also known as "hard bag." At the time of parturition the udder is swollen, firm, and hard but contains very little milk.

Treatment, prevention, and control

There is no treatment. Infected animals can be assisted by good nutrition, nursing care, and pain relief with anti-inflammatory drugs.

Prevention and control consist of purchasing CAE-free animals, culling infected animals, raising CAE-free kids, and preventing potential goat-to-goat transmission. Blood tests can detect CAE and animals can be tested prior to purchase. Periodic blood testing is required to monitor herd CAE status as animals will seroconvert (meaning they will blood test positive for the disease) at different times. An animal may test negative and three months later test positive. Once an animal tests positive, it will not revert to negative status. Repeated annual or biannual testing and strict culling is necessary to keep a herd CAE-free.

To raise CAE-free kids, remove them from affected dams at birth and feed pasteurized colostrum and milk, feed bovine colostrum and milk, or feed artificial products. Colostrum can be heat treated by raising the temperature to 133°F [56°C] for 60 minutes or 165°F [74°C] for 15 seconds. Milk is pasteurized by treating at 145°F [63°C] for 30 minutes or 165°F [74°C] for 15 seconds. The temperature is critical for colostrum because a higher temperature will denature colostral proteins that provide disease immunity and a lower temperature will not kill the virus. Pasteurization can be accomplished using a water bath heated by an electric frying pan or by equipment purchased for the task. It is probably not safe to feed unpasteurized milk from test negative does.

Finally, because there is evidence that any body fluid from an infected goat is a possible source of the disease, separation of infected and uninfected animals is important. Disinfect anything that could transmit body fluids (milk, saliva, feces, blood, or nasal discharges) between goats. This includes milking machines, tattoo needles, etc.

Contagious footrot

Footrot in goats is caused by infection with two bacteria, *Dichelobacter nodosus* (from the feet of infected animals) and *Fusobacterium necrophorum* (commonly found in the environment). Footrot can occur throughout the U.S. but is particularly prevalent in the southern states. The source of *D. nodosus* is the hooves of chronically infected carriers that occur in approximately 10% of affected small ruminants. Because of *D. nososus*' short life span outside the hoof (usually less than four days), pastures or paths left alone by sheep and goats can be considered to be noninfectious after two weeks in wet/warm environments and after one week in a dry environment.

Outbreaks of footrot occur only when pastures are continually wet and mean daily temperatures are above 50°F [10°C]. Wet conditions soften tissues surrounding the hoof and can lead to infection or dermatitis making the skin more permeable to infectious bacteria. In an outbreak, 70 to 90% of all animals in the herd will be affected. About 10% of the animals will remain infected for life and 20% will remain uninfected. Those animals infected early in the course of the outbreak tend to stay infected for long periods of time; those infected late in the outbreak typically recover spontaneously in a short period. Resistance can be enhanced by selective breeding for footrot resistance, vaccination, maintaining feet in a dry condition, routine foot trimming, and administering zinc to animals deficient in that element.

Signs and symptoms

Both a mild (benign) and a severe (virulent) form of footrot may occur. In the mild form, often called foot scald, skin between the hooves will be inflamed, swollen, and damaged. There may be some secretions and the skin may have a "cooked meat" appearance. Lameness is mild and the problem responds readily to treatment and usually disappears spontaneously when the feet are exposed to dry conditions. Usually only a few animals are affected.

Severe, or virulent, footrot is caused by strains of the bacteria which rapidly digest the keratinized tissues found in the hoof wall. Initially, the foot is red, swollen, and moist and the goat experiences moderate lameness. As the infection progresses, the layers of the hoof separate and exude a dark, foul-smelling pus. Walking on the affected foot causes movement of the separated hoof layers resulting in severe pain. The animal will limp or walk on its knees. An affected animal may have a fever and will lose productivity.

Treatment, prevention, and control

Treatment, prevention, and control generally consist of combinations of antibiotic use, foot baths, foot trimming, and possibly vaccination. The use of injectable antibiotics is highly effective and penicillin, erythromycin, florphenicol, or oxytetracyline can be given under the advice of your veterinarian. Treated goats should be kept in a dry environment for at least 24 hours following treatment. In dry environments, topical treatment of antibiotics (5% tincture of tetracycline) or antiseptics (10% zinc sulfate, 10% copper sulfate solution) is adequate for benign footrot where small flocks of animals are involved or when routine foot trimming is being done. These can be applied with a brush or spray. Some commercial products for good hoof health are also available. Ensure good, prolonged contact with infected tissues.

Foot baths

Large goat herds are treated more practically with foot baths. In an outbreak, goats should be treated weekly for four weeks. Separate infected from noninfected animals, treat, and then place on separate pastures. Preventive use of foot baths during the transmission season is recommended for herds with endemic foot-

rot. Troughs must be deep enough to allow complete coverage of the foot and can be made from concrete, fiberglass, or plastic-lined wood. Foam rubber or wool can be placed in the solution to prevent splashing of caustic substances. Goats are adept at walking on small ledges so sides should be smooth. As goats can jump long distances, foot baths should be at least 8 to 10 feet long (~ 3 meters). Provisions should be made for drainage and proper solution disposal so as to prevent environmental contamination.

Copper sulfate (5%) and zinc sulfate (10%) are commonly used foot bath chemicals. Zinc sulfate is generally preferred as it does not stain hair and has less toxicity concerns than copper sulfate. Zinc sulfate is also not decomposed by organic matter to the extent seen with copper sulfate meaning that the solution need not be changed as frequently. Both chemicals are slow to penetrate the hoof and soaking periods of an hour or longer are necessary. Using a detergent, such as dishwashing detergent, in the solution may help penetration. Dry foot baths (85% limestone, 15% zinc sulfate) can also be beneficial.

Foot trimming

Routine foot trimming is crucial in the prevention and treatment of footrot. Overgrown hooves provide an anaerobic environment for *D. nodosus* to grow and stress the foot increasing the chance of damaging skin and allowing entry of bacteria. In treatment, it is crucial to pare the feet adequately to expose infected areas when topical disinfectants are used. Do not trim so severely as to cause bleeding. Blood stop powder can help stop bleeding.

Eradication

Eradicating footrot can be difficult, particularly in wet, moist environments. A typical program includes:

- Trim and examine the feet of all animals. Clean and disinfect hoof shears between animals by using alcohol, dilute iodine, or chlorhexidine.
- Separate infected from noninfected animals.
- Run both groups through a foot bath, standing in the solution for a minimum of 30 minutes, then place on clean pastures.
- Repeat treatment weekly for two to four weeks.
- Cull those animals that do not respond to treatment.
- Consult your veterinarian on a potential vaccination regime.
- Select breeding animals that are less affected.

Once the program has been completed, monitor the herd on a monthly basis and remove relapsing animals. New additions to the herd should be checked for lesions and treated appropriately. Animals returning from shows should be foot bathed prior to re-entry into the herd.

A multivalent vaccine for footrot (Footvax) is available and can decrease the duration, severity, and incidence of footrot. However, its effectiveness is highly variable and repeated injections may be needed to maintain resistance.

Nutritional muscular dystrophy, white muscle disease

White muscle disease is caused by a deficiency of the mineral selenium and(or) vitamin E. Kids from does consuming a selenium-deficient diet are most affected. Selenium deficiency can occur when animals graze or are fed feedstuffs grown in low selenium-containing soils. White muscle disease affects both heart and skeletal muscle, usually in young, fast-growing animals under 6 months of age. Both selenium and vitamin E protect cell membranes from oxidation and to a certain degree act together and substitute for one another. A deficiency of one or both will overwhelm the abilities of the remaining compound(s) to protect body cells.

Signs and symptoms

Animals with the heart muscle affected will show signs of weakness, respiratory distress, rapid heart beat, and sudden death, particularly after exercise. Animals with the skeletal form will be stiff, stand with difficulty, and reluctant to move. Muscles, particularly in the hind legs, will be hard and painful. Upon necropsy (autopsy), the heart and skeletal muscles may have white streaks.

Treatment, prevention, and control

Treatment consists of injections of a product containing selenium and vitamin E such as Bo-Se. This can be repeated 24 hours later.

White muscle disease can be prevented by providing supplemental selenium and vitamin E, particularly if soils in your area are deficient. Supplements can be fed as additions to the regular diet or in a mineral mixture. Dietary concentrations of Se should be no more than 0.1 to 0.3 parts per million (ppm). Follow recommended guidelines on selenium feeding.

For additional protection, or in animals with an unknown history, Bo-Se may be injected subcutaneously shortly prior to kidding at 2.5 cc/100 lbs live weight.

Skin Diseases

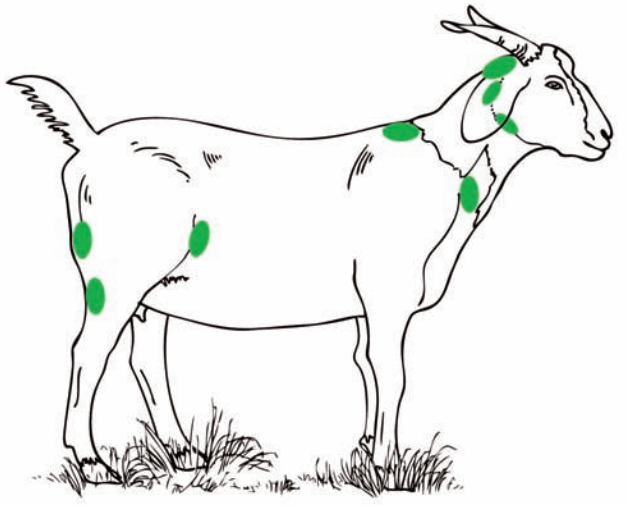
Caseous lymphadenitis, pseudotuberculosis, abscesses

Caseous lymphadenitis (CL) is an extremely common disease of goats that is usually ranked as the most important disease goat owners have in their herds. CL is characterized by one or more abscesses involving lymph nodes, typically associated with nodes in the head and neck. Occasionally, the organism will involve internal lymph nodes and result in a wasting syndrome. CL is transmitted orally and through direct contact with skin. Some goats within a herd appear to be very resistant to CL while others are very susceptible. The causative agent, *Corynebacterium pseudotuberculosis*, can live for long periods of time in soil and, thus, is extremely difficult to eradicate. Once a goat is infected, it remains infected for life.

Signs and symptoms

The most commonly seen sign is an enlargement of one or more of the lymph nodes. The enlarged lymph nodes are very thick-walled and filled with thick, greenish pus.

Treatment, prevention, and control



Location of lymph glands.
Drawing by K. Williams.

Antibiotic use is not successful in the treatment of this disease. Affected animals should be isolated and abscesses opened and drained away from the herd and grazing areas. All pus and discharge should be caught and burned or buried. This disease can affect humans so gloves should be worn. For proper procedure, see the lancing abscesses section of the Meat Goat Herd Health Procedures and Prevention chapter. The affected goat should be isolated from the herd until the opened abscess is completely healed over. Goats with multiple abscesses should be culled.

The best prevention is to maintain a closed herd or to carefully screen new additions to the herd by performing a blood test and by examining for the presence of abscesses or scars from old abscesses.

All affected animals should be isolated from the herd or culled. Once this disease has entered a farm, it is difficult to eradicate. There is a vaccine available for sheep which will decrease the incidence and severity of the disease. It is a killed vaccine which requires 2 doses initially and an annual booster. The vaccine has no efficacy in animals which are already infected. Custom vaccines can be made from the organism found in your herd.


Kid with orf.

Contagious ecthyma, sore mouth, orf

Sore mouth is a highly contagious disease of goats most prevalent in young kids within a few weeks of birth or weaning. It is caused by a poxvirus. Some strains of the orf virus cause more severe and extensive symptoms than others. People can get this disease so gloves should be worn when treating animals or giving vaccines.

Signs and symptoms

The virus causes sores to develop, usually around the mouth, that can spread throughout the lips and occasionally to the inside of the mouth. Lesions may also develop on the teats, vulva, face, and legs of affected goats. Lip lesions are extremely painful and inhibit the willingness of the kid to nurse or eat while does with teat sores may be unwilling to let kids suckle. This combination means that without special attention affected kids will succumb to simple starvation. Infection is spread by direct and indirect contact from infected animals or by scabs or saliva from infected animals. Immunity following disease is for less than 1 year. However, subsequent outbreaks are usually less severe.

Treatment, prevention, and control

Treatment is to reduce pain of affected animals and prevent spread of the virus. Lesions are carefully cleaned and coated with antibiotic ointment. It is crucial to make sure that affected kids continue to eat and that affected does don't develop mastitis. The virus has the ability to live in scabs that fall from an animal for at least a year thereby being a source of later infections. Producers with infected herds may wish to vaccinate annually against the disease. The vaccines are modified live viruses which are inoculated topically on scarified skin (like the old smallpox vaccine in the U.S.).

Dermatophilosus, streptothricosis, rain scald

Dermatophilosus is a common contagious skin condition caused by the bacterium *Dermatophilus congolensis.* It is usually seen in moist, humid, wet conditions. The organism enters the body through skin abrasions and injury and can penetrate moist skin after prolonged contact. The ears, nose, face, and tail may be affected beginning with a low-grade, scaly, skin infection that spreads along the back and flanks. In mild cases, goats are not too itchy but in severe cases may scratch constantly. The bacteria can survive in soil or dust on an animal's skin during dry weather and are transmitted by direct contact, infected equipment, flies, etc. Chronic ear infestation of some animals may also spread the disease. This disease is zoonotic so care should be taken when handling affected animals.

Signs and symptoms

Dermatophilosus starts with scabs forming around the ears, face, nose, lower legs, or tail. These will later form crusty, scaly lesions that can spread over the back and flanks of the animal. The affected areas are also

susceptible to secondary bacterial infection. Lesions around the mouth may be confused with contagious ecthyma (orf). Infection of the feet with formation of large crusts is called strawberry footrot.

Treatment, prevention, and control

Antibiotics such as Procaine penicillin G (20,000 to 70,000 units/kg body weight for 4 to 7 days) or oxytetracycine (LA 200 at 9 mg/50 kg or 4 to 5 cc/100 lbs) can be injected. Topical treatment options include zinc sulfate 0.2 to 0.5%, 0.2% copper sulfate, or 1% potassium aluminum sulfate. Prevent by providing shelter from rain for animals on pasture and ensuring good nutrition and control of external parasites.

Ringworm

Ringworm is caused by one of several fungi. The infection is commonly seen on the face, ears, and neck. Goats commonly acquire it by direct contact with infected animals or from the environment such as by rubbing on wooden posts or mangers contaminated with fungal spores. Young animals and animals living in dark, damp environments or having nutritional or other debilitating diseases are most at risk. Ringworm is a zoonotic disease so care should be taken when handling affected animals.

Signs and symptoms

Goats will be itchy and have typical circular patches of hair loss on the face, ears, or neck.

Treatment, prevention, and control

Treatment can limit spread in the herd and can reduce environmental contamination. Topical compounds such as 2% iodine, 3% captan, 2% chlorohexidine, and 2% lime sulfur are effective. Prevention practices include disinfecting equipment used on goats.

Caprine Respiratory Disease

Respiratory diseases can affect goats of all ages. Causes of respiratory disease include various viral or bacterial infections, irritants to the nasal passages, injury to the throat or trachea, and some flies and parasites. In kids, respiratory diseases are usually from infectious agents. Post-weaning, a variety of risk factors for the development of respiratory disease occur. These include:

- Changes in nutrition,
- Transportation,
- Commingling of animals of different groups,
- Loss of maternal antibodies,
- Exposure to new pathogens,
- Adverse housing conditions, and
- Crowding.

Dusty conditions and exposure to moldy/dusty hay or gaseous irritants (such as ammonia in a poorly ventilated barn) can lead to widespread nasal and tracheal irritation. When inspecting housing facilities for irritants, make sure the inspection is done at the level of a goat's nose, i.e., low to the ground. Respiratory problems due to trachea injury can arise from improper use of balling and drenching guns.

There are two generalized areas of concern for respiratory diseases, lower tract diseases and upper tract diseases. Lower tract diseases usually result from a disease-causing agent. Upper tract diseases are normally associated with inhaling foreign bodies or irritants, or injury to the trachea although viral and bacterial diseases can occur.

Lower Respiratory Tract Diseases

Blood-borne infections

Most respiratory disease problems of baby kids are due to septicemia or blood-borne infections. While these diseases involve all systems of the kid, respiratory symptoms often predominate. Commonly, these infections are due to inadequate colostrum consumption and housing in an environment with heavy bacterial loads. Some organisms responsible for these infections include *E. coli*, *Mannheimia haemolytica, Pasturella multicoda, Mycoplasma,* and *Streptococci.*

Signs and symptoms

These diseases generally occur where wet, unsanitary, and crowded conditions exist. The onset is sudden with kids becoming weak and depressed, refusing to eat, running a fever, and breathing rapidly. Sometimes, sudden death is the only sign. Large numbers of triplet or quadruplet litters may increase incidence.

Treatment, prevention, and control

Kids exhibiting these signs are in a medical emergency. Treat using antibiotics having a gram negative/gram positive spectrum to counteract a wide variety of organisms. A veterinarian may prescribe ceftiofur (Naxcel), florfenicol (Nuflor), or oxytetracycline. Anti-inflammatory drugs will help alleviate signs and symptoms. Provide fluids and ensure the kid is eating.

Proper management of dams and kids can prevent occurrence. Late gestation dams should be in good body condition (3 – 3.5). Maternity pens and kidding pens should be clean and adequately ventilated. Ensure navels are dipped in iodine at birth and that kids consume adequate colostrum.

Enzootic pneumonia

Enzootic pneumonia (EP) is the end stage of infections by a variety of primary agents (mycoplasma, chlamydia, adenovirus, syncytial virus, IBR, PI-3, Caprine herpes virus) or by the various stresses experienced in intensive weanling management, most notably coccidiosis. This pneumonia is usually a herd problem in goats raised in confinement or under intensive management. Predisposing conditions include crowding, inadequate ventilation, and high humidity.

Signs and symptoms

Animals will have a moist, soft cough, increased respiratory rate, nasal discharge, watery eyes, and decreased gains. When listening to the lungs, crackling and wheezing is heard.

Treatment, prevention, and control

Many of the pathogens associated with caprine pneumonias are not susceptible to certain drugs. Products that may be effective include tetracyclines, tylosin, Lincocin, Nuflor, and Spectagard given under the supervision of a veterinarian. Reduce stress and overcrowding, maintain adequate ventilation and sanitation to reduce incidence.

Pasteurella

Pneumonic pasteurellosis (pasteurella) is a killer pneumonia in all livestock species affected. Pasturella pneumonia is caused by either *Mannheimia hemolytica* that causes sudden death or *Pasturella multicoda* that causes respiratory signs with pneumonia. *M. hemolytica* is blood-borne and outbreaks usually occur in feedlot conditions where animals are stressed, transported, and commingled. Usually several animals will be involved. They will be noticeably sick and off by themselves. Commonly, nutritional management, ventilation, and parasite control are less than ideal.

Signs and symptoms

Typically, the first animal is found dead followed by signs of pneumonia noticed in herdmates. Affected animals will be off feed, have a moist cough, and appear depressed. The lungs will typically make a wheezing or crackling sound. *P. multicoda* is capable of entering the blood stream and causing arthritis and mastitis (Blue bag mastitis).

Treatment, prevention, and control

Antibiotics such as Naxcel, Nuflor, and others can be used in treatment. There are no pasteurella vaccines made just for goats. While there are a variety of bovine pasteurella vaccines available, their effectiveness in goats has not been conclusively proven.

Mycoplasma pneumonia

The Mycoplasma species are commonly involved in pneumonias of goats, although usually more of a problem for dairy goat than meat goat producers. In general, they cause a "cuffing" pneumonia with bronchitis that is commonly seen as a form of enzootic pneumonia. Pleuropneumonia is a specific disease caused by *Mycoplasma mycoides* and is a significant cause of sickness and death in does and kids. In kids, the organism is transmitted orally through contaminated milk or colostrum. Outbreaks often occur when animals are stressed, such as in overcrowded conditions and up to 80 to 90% of affected kids die or are euthanized as a result of permanent joint damage. The mycoplasma organisms are commonly isolated from the ear canal of goats. It is postulated that ear mites (*Psoroptes cuniculi*) may be involved in transmission.

Signs and symptoms

The disease is highly contagious and usually involves multiple animals in the herd. Signs include fever, cough, respiratory distress, joint damage and lameness, nervous system disorders, and/or mastitis. Young animals are usually involved with outbreaks of the pneumonic or polyarthritic forms. Three clinical syndromes seen in goats include:

1. Peracute illness characterized by high fever and death within 12 to 24 hours.
2. Central nervous system syndrome with neurologic signs and death within 24 to 72 hours.
3. Acute to subacute syndrome with high fever, multiple joint arthritis, mastitis, and pneumonia.

Treatment, prevention, and control

Antibiotics must have a mycoplasma spectrum of activity. Penicillin, amoxicillin, and cephalosporin may not be effective. Products such as tylosin, tetracycline, erythromycin, and Nuflor may be effective. Consult your veterinarian. Treatment can assist in relieving symptoms of the disease but affected animals may shed the organism for life. Some animals may appear to respond to treatment but will relapse and be chronically poor performing.

The organism is spread by direct contact, through the air, milk, and ear mites. Control is by the following program.

1. Separate groups by age (adults and weanlings).
2. Maintain all–in–all–out flow of animals or quarantine all new arrivals.
3. Pasteurize milk prior to feeding.
4. Control earmites with Ivermectin.
5. Optimal sanitation and air quality for housed animals.

Verminous pneumonias

Verminous pneumonia is a common infection of small ruminants on pasture caused by certain types of lungworms (e.g., *Dictyocaulus filarial*, *Muellerius capillaries*, and *Protostrongylus rufescens*). Young grazing animals (weaners) are most commonly affected. These parasites prefer low lying, moist pastures. Some of

the parasites, *Muellerius* and *Protostrongylus*, for example, require snails or slugs as intermediate hosts in their life cycle. Heavy pasture contamination with these parasites can occur from high stocking densities.

Signs and symptoms

Signs usually consist of a persistent, chronic coughing in a herd or flock. Animals will have increased respiration rate and lose weight. The most severely affected animals will be young animals on their first full season of grazing.

Treatment, prevention, and control

It is unclear how effective treatment is for this condition. Anthelmintics will stop parasite egg production but may not effectively remove the parasite. Prevention strategies include avoiding low, wet pastures, particularly during the early morning hours or at night. Clean up piles of wet, rotting vegetation where snails may live. Avoid mixing different age groups of animals or having young animals graze on pastures contaminated by adults. Frequent deworming with certain anthelmintics can also help control the parasite. However, this is not recommended as frequent, herd-wide use of anthelmintics will increase the rate of drug resistance by other internal parasites such as *Haemonchus contortus* (barberpole worm).

Upper Respiratory Tract Diseases

Irritants, trachea injury

Constant or long-term inhalation of irritants, such as dust or ammonia, and trachea damage through incorrect use of balling or drenching guns can cause respiratory problems.

Signs and symptoms

The predominant sign is coughing and sneezing. Animals may have nasal discharge. With simple inflammation of the respiratory passages due to inhaling dust or other irritants, animals appear healthy other than the annoying cough and sneeze. In the case of pharynx injury, the animal may be in severe respiratory distress and may make a snoring sound when exhaling. Other signs would include foul odor to the breath, off feed, cough, and nasal discharge.

Treatment, prevention, and control

Remove all sources of respiratory irritants from the environment. Dispose of moldy hay, shake dusty hay away from animals, or wet the hay. Environmental dust can be eliminated by wetting the area. Clean bedding to remove urine and feces. Ensure good ventilation and maintain as clean an environment as is possible. Follow proper procedure when using balling and drenching guns. For more information on using these instruments, refer to the Meat Goat Herd Health – Procedures and Prevention section.

Nasal bots

Nasal bots (*Oestrus ovis*) are uncommon in the deep southern portion of the United States but are common elsewhere. Sheep are the primary host; however, goats are readily infected. The gadfly deposits eggs on the nostril of sheep and goats. The larvae migrate to the frontal sinuses and are expelled by sneezing. Human cases have been reported.

Signs and symptoms

The main symptom is violent sneezing in the late summer. Affected animals have a copious nasal discharge that may be tinged with blood. Some animals may make a snoring sound due to nasal obstruction. During larval deposition, animals are very agitated and run in circles, and flock under trees or buildings. Animals may also not exhibit breeding behaviors, hence, the name *Oestrus ovis.*

Treatment, prevention, and control

Ivermectin will kill the larvae at any stage. Other treatments include Ruelene sprayed in each nostril in the fall or winter.

Neurologic Diseases

Tetanus

Tetanus is an important and highly fatal disease of goats. It occurs commonly in all ages of unexposed and unvaccinated farm animals with the horse most susceptible and the cow the least. The causative agent, *Clostridium tetani*, is found in soil and feces (particularly of horses) and is capable of surviving in soil for prolonged periods of time. *C. tetani* usually enters a body through deep puncture wounds and, following an incubation period, produces a neurotoxin that travels to the central nervous system. Some management practices that may increase the chance for tetanus infection include castration, ear tagging, dehorning, vaccinating, and banding. Elastrator bands are particularly dangerous in predisposing animals to tetanus.

Signs and symptoms

Following an incubation period of 1 to 3 weeks (up to several months) the following signs develop:

- Muscular stiffness/tremor.
- Jaw clenching, lockjaw.
- Unsteady gait due to stiffness of the limbs.
- Stiff tail.
- Bloat/constipation/retention of urine.
- Difficulty in eating.
- Anxious expression of the face.
- "Sawhorse" stance.
- Lying down with convulsions.
- Death in 3-10 days by asphyxiation (unable to breath).

Treatment, prevention, and control

Wounds should be cleaned and open to the air to keep them aerobic (exposed to oxygen). Any dead tissue should be removed and the wound flushed with hydrogen peroxide. Give penicillin and tetanus antitoxin injections (15,000 IU twice daily, preferably in the vein, for 2 days for an adult goat). Convulsions and seizures can be controlled by sedatives given under the supervision of a veterinarian. Tetanus antitoxin is used for treatment, before surgical procedures, or after any wound. Tetanus toxoid is used for vaccinations.

Prevention consists of good hygiene and vaccination. Pens and barns should be clean. Routine vaccination with tetanus toxoid must be incorporated into the herd health program (see the Vaccination Schedule for Meat Goats in the section on Meat Goat Herd Health – Procedures and Prevention) and should include:

- Does - third trimester of pregnancy to increase tetanus antibodies in colostrum.
- Kids - 4 and 8 weeks of age.
- All animals - annual booster.

Polioencephalomalacia, PEM, cerebrocortical necrosis

Polioencephalomalacia (PEM) is a common nervous disorder of small ruminants caused by inadequate thiamine (vitamin B1) in the animal. Thiamine is a necessary component of several enzymes involved in carbohydrate metabolism. Normally, the bacteria in the rumen produce enough thiamine for an animal's needs. However, under certain conditions thiamine production may decrease and(or) available thiamine may be destroyed leading to a deficiency and the appearance of PEM signs. While outbreaks can be seen following any major dietary change, animals at the highest risk for PEM are young goats, usually 2 months to 3

years of age, who have just begun consuming high concentrate rations or grazing lush pasture. Up to 25% of groups of feeder goats may be involved.

There is little evidence to show any one factor as being "the cause" of PEM and probably a variety of factors are involved including:

1. Inadequate thiamine in the diet.
2. Inadequate microbial synthesis of thiamine in the rumen.
3. Presence of thiaminase (compounds that breakdown thiamine) activity in forages such as moldy hay.
4. Presence of thiaminase producing bacteria in the rumen (*Bacillus* sp. and *Clostridium sporogenes*).
5. Ingestion of pyrimidine containing structural analogs of thiamine (amprolium) that compete with thiamine in metabolic systems.
6. Increased tissue demand for thiamine in the brains of young animals on high carbohydrate rations.
7. High levels of sulfates in the diet.
8. Deworming with levamisole may predispose animals to PEM.

Signs and symptoms

Signs include stargazing, sudden loss of appetite, depression, decreased rumen motility, head pressing, aimless wandering, blindness, grinding of teeth, muscle tremors, and excitability. Typically, there is no fever and pulse and respiration are normal.

Treatment, prevention, and control

Thiamine HCl (10 – 20 mg/kg body weight [BW] intramuscular injection) is given every three hours for a total of five doses. Early cases respond within 6 to 8 hours with complete recovery in 24 hours. Absence of response in 6 to 8 hours may suggest the need for emergency slaughter. Animals not recovered by 72 hours will never fully recover but with good nursing care may make satisfactory pet animals. During an outbreak all animals should be considered at risk and treated appropriately.

Avoid sudden dietary changes. Thiamine may be added to feed at a minimum rate of 3 mg/kg of feed. During an outbreak all susceptible goats should receive a dose of thiamine 10 mg/kg BW.

Floppy kid syndrome

Floppy kid syndrome often refers to any kid that is normal at birth but then develops a sudden onset of muscular weakness early in life, generally from 3 to 10 days of age. This syndrome is increasingly seen in normal, healthy Boer goat kids that suddenly develop the disease and do not recover. The cause is unknown. While several kids may be affected simultaneously, it is not known if an infectious agent is responsible.

Signs and symptoms

Affected kids are normal at birth and develop a sudden onset of profound muscular weakness and muscle incoordination at 3 to 10 days of age. Some kids are described as "looking drunk." Cases seem to occur most commonly late in kidding seasons. Affected kids are depressed and cannot use their tongues to suckle but can swallow. The kids have acidosis and an abnormal acid base balance. They do not suffer diarrhea, respiratory disease, or show other signs.

Treatment, prevention, and control

Early detection and correction of the electrolyte imbalance as well as good supportive care are critical. Less severe cases are most commonly treated by owners with oral bicarbonate or Pepto-Bismol at the onset of signs. Two teaspoons of baking soda and a half a teaspoon of common salt in 1 liter (1 quart) of water can be mixed and 2 to 3 ounces given orally 2 to 3 times a day. Kids may need to be fed milk by stomach tube.

Listeriosis, circling disease

Listeriosis is caused by the bacteria *Listeria monocytogenes* that can affect all mammals including humans. In goats it is called "Circling Disease" because affected animals commonly walk compulsively in a circle. It can also cause mid- to late-term abortions. The bacteria are found in the environment, especially in rotting vegetation such as poorly prepared silage. Infection is usually caused by ingesting the organism through environmental or fecal contamination of feedstuffs. There is the possibility of venereal transmission. The disease is mostly seen during cool weather. It is also a disease of refrigerated foods causing serious disease and abortions in humans.

Signs and symptoms

Early signs are depression, decreased appetite, decreased milk production, and fever. There are two clinical forms seen:

1. *Encephalitic form (in the brain)*: In this form, the bacteria enter through breaks in oral mucosa and migrate to the brain. Signs include incoordination, circling in the same direction, seizures, hind limb paralysis, facial nerve disorders (facial paralysis, ear droop, excessive salivation, slack jaw, impaired swallowing), keratitis (cornea inflammation), and a very high mortality rate.
2. *Septicemic form (blood-borne)*: The bacteria enter through the intestines. The signs are diarrhea, abortion, and death.

Treatment, prevention, and control

Successful treatment requires detection early in the course of the disease. Large doses of antibiotics such as penicillin and tetracycline are generally given. The goat should be given fluids, electrolytes, and appropriate nursing care.

Does that abort should be isolated and all aborted materials burned or buried. Kids should only be fed pasteurized colostrum or milk. Suspect recently introduced animals. Stop feeding poor quality silage and clean floors and pens. No vaccine is currently available.

This disease is zoonotic so take appropriate precautions. Human infection could result from consumption of unpasteurized milk and milk products and from handling the placenta, fetuses, or even newborn kids of infected animals. Precautions include using gloves when handling aborted material and only consuming milk products from pasteurized milk

Scrapie

Scrapie is a progressive, degenerative, fatal disease of the central nervous system that affects sheep and, rarely, goats. The route of transmission appears to be both horizontal (from goat to goat) and vertical (from doe to kid in the uterus). The incubation period for the disease is very long and the disease is usually not seen before two years of age. Scrapie is a reportable disease, meaning that authorities must be notified when affected animals are discovered. Scrapie is a member of the family of transmissible spongiform encephalopathies of which Bovine Spongiform Encephalopathy (BSE), commonly called Mad Cow Disease, is the most well-known. The zoonotic potential (transmission to humans) is unknown.

Signs and symptoms

Initial signs of scrapie are non-specific and include behavior changes, excitability, lethargy, and weight loss. As the disease progresses the behavioral changes become more pronounced. Tremors of the head, neck, or whole body, high-stepping with the front legs, excessive salivation, apparent blindness, and other changes will occur. Death will follow.

Treatment, prevention, and control

There is no treatment. If scrapie is suspected, contact a veterinarian immediately. There is a National Scrapie Eradication Program for goat producers. More information can be found in the chapter on Biosecurity.

Urinary Tract Disease

Obstructive urolithiasis, urinary calculi, stones

Obstructive urolithiasis, urinary calculi, or stones is a disease where crystals are formed in the bladder, usually the result of deviation from the desired dietary ratio of calcium (Ca) to phosphorus (P) of two to two and one-half parts Ca per part P (2:1 to 2.5:1). The crystals can lodge in the urethra of male goats preventing them from urinating. Female goats are largely unaffected and the disease is most commonly seen in male goats consuming large amounts of concentrates, such as pet goats. It is virtually non-existent in animals that receive little to no grain with the exception of animals grazing western pastures with high silica content.

Types of urinary calculi

Stones regularly associated with calculi formation in goats include silicate, calcium (calcium carbonate, calcium oxalate), and phosphate (magnesium ammonium phosphate called struvite). While calculi can form in any geographical region, silicate stones are generally limited to goats grazing forages grown on western pastures that have excess soil silica content.

Calcium carbonate stones result from feeding rations very high in calcium, typically high legume diets (clovers and alfalfa) such as seen in the major alfalfa producing areas of the U.S. Legumes contain 1 to 2% calcium and have very high ratios of calcium to phosphorus (Ca:P of 6:1 to 10:1). Calcium oxalate stones form as a result of diets high in calcium and in oxalates. Certain plants are oxalate accumulators (rape/kale family, rhubarb, sugar beet tops, pigweed).

Phosphate or struvite stones occur when feeding rations having a disproportionate ratio of Ca to P (< 2:1) or high levels of magnesium and phosphorous. In general, grasses are low in magnesium, Ca, and P but are balanced in terms of Ca:P ratios (1.5:1 to 2:1). Thus, grazing goats rarely experience urinary stone problems. Rather, affected goats typically are fed high levels of grain and/or pelleted feeds. Grains are high in P and low in Ca and have Ca:P ratios of 1:4 to 1:6.

Most P in grains is bound in phytates and cannot be absorbed by non-ruminants (horses, pigs, etc.). In ruminant animals, bacteria in the rumen produce enzymes (phytase) that break down phytates freeing the P for absorption. This is the reason why dietary P requirements for ruminants are lower than those for monogastric animals and why diets for monogastric animals generally have high P concentrations. Thus, feeding swine or horse rations to ruminants is a bad idea from the standpoint of Ca and P because of the high amount of P in the feed. Every feedstore has an "All Stock Pellet" which they claim can be fed to any animal. These mixes are not appropriate for prolonged feeding to male goats.

Contributing factors

There are several factors that can contribute or predispose an animal to suffering from urinary calculi. These include early castration, the pH of the urine, and inadequate salt intake. Early castration of ruminants results in decreased diameter of the urethra, the passageway for urine, increasing the chance of blockage. If castrated male goats will be kept into adulthood, castration should be delayed until puberty (3 to 4 months of age).

The normal alkalinity found in ruminant urine favors the formation of urinary stones. Reducing the pH to acidify the urine reduces the likelihood of crystal formation. To acidify urine, goats receiving high grain or concentrate diets can be fed ammonium chloride up to 2% of the total ration (200 to 300 mg/kg diet/day) or ammonium sulfate at 0.6 to 0.7% of the ration. Ammonium chloride is unpalatable and higher levels will

reduce intake. Alternately, feed ¼ lb/head/day of Bio-Chlor, a highly palatable protein supplement with high levels of chlorine and sulfate that is used in the dairy cow industry. Urine should be acidic within one week.

Ensure that animals have access to salt and fresh, clean water. The chlorine in salt helps prevent crystal formation. Salt also acts to increase water consumption and subsequent urination that keeps the bladder flushed. Goats are finicky drinkers and will not drink dirty, tepid, algae-infested water, etc. Hard water can be a source of calcium and magnesium. Keep fresh, clean, chlorinated water available at all times.

Signs and symptoms

The main sign is a male goat persistently straining to urinate but passing little to no urine. Urine may be blood-tinged. Drops of urine and blood or urine crystals may be seen on the hair of the sheath. Affected animals will be restless, switch their tails, and kick at their bellies. As the blockage progresses, some goats will vocalize in pain. The bladder will be enlarged with possible swelling around the sheath. Some goats will eventually pass the stone but are likely to have continual problems.

Severe blockage can lead to the rupture of the urethra or bladder. Initially, this will alleviate the discomfort felt by the animal. However, due to urine inside the body, the animal will quickly go off feed, become weak, depressed, and eventually die.

Treatment, prevention, and control

There are varying levels of treatment that can be attempted. Acidifying the urine, increasing salt content of the diet, and Vitamin C may help dissolve the calculi. If the calculi or stones are lodged in the urethral process (the whip-like structure at the end of the penis), the process can be removed. Gritty, sandy material present in the urethral process can sometimes be successfully milked out without removing the process itself.

If the stones are lodged in the urethra, tranquilizers may help relax the muscles of the urethra and facilitate natural expulsion of the stone by the pressure of attempted urination. A catheter could be passed into the urethra to permit infusion of sterile saline in an attempt to enlarge the urethra and dislodge the offending stone. For severe cases in valuable animals, surgical methods may need to be used. For some animals, salvage slaughter may be chosen but must be done prior to bladder rupture.

Dietary management is the key to controlling and preventing urinary stones. Maintain a Ca:P ratio of 2:1 to 2.5:1 in the diet. Do not feed excess grain supplement to goats. If a high grain diet is fed, include products such as ammonium chloride, ammonium sulfate, or Bio-Chlor to acidify urine and(or) increase the salt content. Ensure an adequate supply of clean, fresh water. Delay castration until puberty if planning on keeping the animal as an adult or do not keep early castrated males older than one year. Provide a free-choice loose mineral mix with 2:1 Ca:P ratio.

Diseases of the Gastrointestinal System

Diarrhea, scours (neonatal diarrhea complex)

Diarrhea or scours is the most common cause of disease and death in kids 1 to 30 days of age. Diarrhea is usually associated with intensive rearing of goats under conditions of overcrowding and poor sanitation. Extreme weather conditions during the kidding season can predispose young kids to diarrhea. While diarrhea can affect meat goats, it is more common in dairy kids that are weaned early, group penned, crowded, and housed in a damp, dirty environment. Diarrhea causes a loss of body water and electrolytes and can result in death if not treated quickly.

Major causes of diarrhea are bacterial (*E. coli, Clostridium perfringens* type C, *Campylobacter jejuni*, Salmonella); parasitic (coccidia, cyrptosporidia, giardia, strongyloides); viral (coronavirus, rotavirus); and noninfectious (milk replacer, antibiotics). While the cause is often assumed to be a specific bacteria (*E.*

coli), surveys of diarrhea in young kids have consistently failed to identify specific causes in the majority of cases.

Cryptosporidia seems to be the most common cause of diarrhea in kids less than a month old. Cryptosporidiosis can occur alone or in conjunction with other pathogenic bacteria, viruses, and protozoa. Cryptosporidia is difficult to treat because there are no drugs available to control it. Infection is usually from consuming fecal matter from infected animals, even from a different livestock species. A fuller discussion of Cryptosporidiosis is in the section on Internal and External Parasites later in this chapter.

Older kids (>1 month) are prone to diarrhea caused by coccidia and other internal parasites (Giaridia). Nutritional causes of diarrhea in young kids are often associated with husbandry and feeding practices, mainly seen in dairy kids due to overfeeding, milk replacers, etc. Under most circumstances, outbreaks of diarrhea are probably not caused by any one factor but by a combination of factors, hence, the name "Neonatal Diarrhea Complex."

Signs and symptoms

Affected kids develop a loose stool. The consistency can vary from pasty to watery. Kids quickly become dehydrated from loss of body fluid and electrolytes and become progressively weaker. Terminally, kids are severely dehydrated, lie on their side, have cool extremities, and are unwilling to drink.

Treatment, prevention, and control

With increasing fluid loss, the kid goes into progressive shock, cannot maintain body temperature, and dies. Causes of death in uncomplicated cases of neonatal scours are dehydration, electrolyte losses, and hypothermia. Treatment consists of supplying the kid with fluids to restore normal fluid and electrolyte levels. Commercially available electrolyte and alkalinizing products are available. Initially, milk can be removed from the diet and electrolytes given. Milk is then gradually reintroduced to the kid in small feedings alternated with electrolytes. Electrolyte solutions should continue to be used until the stool returns to a near normal consistency. Injectable antibiotics such as Naxcel or Exenel can be given to prevent the infection from becoming blood-borne. Oral antibiotics are commonly used to treat diarrhea and scours but their efficacy is not well proven. Be aware that feeding electrolytes alone for more than 2 days will result in a significant caloric deficit. It is critical that the goat be kept warm.

The keys to preventing scours are to reduce exposure of kids to pathogens causing the disease and to increase resistance of kids to the disease-causing agents. To reduce exposure to pathogens, ensure that kidding takes place on fresh pasture and a clean, dry area. Assist with kidding if necessary and ensure that all navels are dipped in iodine. Monitor nursing behavior and force feed colostrum if no nursing is seen within 6 hours of birth. Avoid congregating kids to prevent overcrowding conditions. Use separate kidding and nursery areas. Resistance can be strengthened by optimum pre-kidding maternal nutrition and following a prescribed vaccination schedule. This will strengthen antibody production in the dam and improve resistance gained by the kid through colostrum. If deemed necessary, oral *E. coli*, corona and rota virus vaccines can be given to newborn kids before they nurse the doe.

Enterotoxemia, overeating disease

Overeating disease is an important and highly fatal disease that mostly affects young kids. It is not caused by overeating but by the toxin produced by the bacteria *Clostridium perfringens* Type C or Type D. *C. perfringens* is found widely in the environment and in the intestinal tract in normal quantities. Under certain conditions, the organisms proliferate in the intestine and produce toxin in lethal quantities. This most commonly occurs when goats have a sudden exposure to grain or large increases in the quantity of milk consumed. At these times, the passage rate for food through the intestinal tract is slowed, providing ideal conditions for *C. perfringens* to grow.

Signs and symptoms

A typical history is of a young, vigorous kid found dead. The affected kid has a consistent history of nursing a heavy milking doe or being on full feed. Animals have actually been observed to drop to the ground, convulse, and be dead within a matter of minutes.

Adults appear to be more resistant to the disease as a result of continuous exposure; however, the resistance can be overwhelmed. A typical history for an older animal dying from overeating disease is that the animal was sick and off feed from some other disease (e.g., parasitism). As the animal recovers it quickly increases feed intake resulting in a mild grain overload. This allows the proliferation of *C. perfringens* and ultimately the death of the goat.

Treatment, prevention and control

There is usually no opportunity to treat animals with enterotoxemia. Specific antitoxin (CD&T) is available for treatment and should be given according to label directions. Affected animals should be treated with high levels of penicillin (6 cc/100 lbs) and fluids.

All goat herds need to have a regular vaccination program for overeating disease. This includes annual vaccination of does roughly 30 days prior to expected parturition to protect the newborn for the first 1 to 2 months of life. Kids are given a series of two vaccinations at 4 and 8 weeks of age. A booster dose is given at the time of weaning or when going on full feed. See the Meat Goat Vaccination Schedule in the Meat Goat Herd Health - Procedures and Prevention chapter.

Milk fever, parturient paresis, hypocalcemia

Milk fever is a disease more commonly associated with dairy goats. It is not a fever but is due to inadequate amounts of calcium available in the blood stream for use in milk production during early lactation. This usually occurs in does with high milk production and ones fed high levels of calcium in late pregnancy. In milk fever, the doe cannot mobilize calcium from her bones as quickly as it is needed for milk production necessitating the use of blood calcium. When blood calcium levels drop too low, milk fever occurs. High levels of dietary calcium fed in late pregnancy prevent the doe's metabolic system from becoming accustomed to mobilizing bone calcium. Does having triplets or quadruplets may be more prone to milk fever

Signs and symptoms

Milk fever usually occurs close to kidding, up to about 3 weeks after birth, but can occur before kidding. Animals will show a wobbly gait, foot dragging, and muscle incoordination. Some animals will be unable to stand and, if prior to kidding, be too weak to deliver.

Treatment, prevention, and control

Treatment consists of intravenous calcium therapy with 50 to 100 cc of 25% calcium borogluconate. Some veterinarians prefer to give an additional 50 to 100 cc subcutaneously after the intravenous treatment. Oral calcium preparations are used in mild cases. Prevent milk fever by feeding a low calcium diet the last month of gestation. This prepares the doe's metabolic system to mobilize calcium from her skeleton.

Paratuberculosis, Johne's disease

Paratuberculosis or Johne's disease is a chronic wasting and diarrhea disease of ruminants caused by the bacteria *Mycobacterium avium* subspecies *paratuberculosis* (*M. johnei*). The organism is capable of living on infected premises for up to a year and the same bacterial strain can infect any ruminant. This means that goats sharing pastures with infected cattle are susceptible.

The primary mode of transmission is via the fecal oral route with kids most susceptible to infection. In general, it is safe to assume that if the doe is infected her kids will also be infected. Infected animals shed

the bacteria for months or years prior to developing clinical signs. This results in heavy contamination of pastures before it is known that the disease is present.

Signs and symptoms

Signs rarely occur prior to 1 year of age with peak incidence of disease at 2 to 3 years of age. Goats will show weight loss, loss of appetite, depression, and general wasting. Watery diarrhea is seen in cattle but is a rare finding in goats. As the disease progresses, anemia and bottle jaw (swelling of tissues under the jaw) may develop. Affected goats also seem to become more susceptible to internal parasites such as the barberpole worm (*Haemonchus contortus*).

Johne's disease is suspected whenever a goat is losing weight for unknown reasons. The diagnosis may be confirmed by biopsy, necropsy, bacterial culture, or one of several serologic (blood) tests.

Treatment, prevention, and control

There are no treatments available for Johne's disease. Prevent by not allowing infected ruminants (cattle, goats, sheep, etc.) on your premises. Purchase animals from farms with no history of Johne's Disease and blood test all incoming ruminants. Remove any that test positive. There is a vaccine licensed for use in the prevention of paratuberculosis. It is apparently effective but produces large swellings at the injection site that last for years. Vaccination will also cause hypersensitivity to the tuberculosis test. In order to use the vaccine you must to obtain permission from your State Veterinarian.

Eradication of Johne's disease is difficult. Identification of animals in your herd is problematic in that blood tests will give both false positives and false negatives. Fecal culture or DNA probe testing will not give false positives; however, these tests may miss up to 50% of infected animals. Multiple tests or several different tests are required. A second problem is the contamination of pastures and housing. These should be free from diseased animals for at least 12 months before housing disease-free goats. Ensure that kids are not exposed to the feces of infected adults by housing them separately and have fecal-free feed troughs, boots, and clothes at all times.

Pregnancy toxemia, ketosis

Ketosis, pregnancy disease, pregnancy toxemia, or twinning disease usually occurs during the last few weeks of gestation and is caused by the competition for glucose between the doe and her rapidly growing fetus(es). It is more commonly seen in does carrying more than two kids or overly fat does, although very thin animals can be affected. Because the uterus, fetuses, placenta, and other pregnancy tissues take up an increasing amount of abdominal space there is less and less room for feed consumption. If a doe is overly fat, she also has less room to hold feed. Thus, feed intake decreases and the doe is forced to break down fat stores for energy. Ketones are a chemical by-product of fat breakdown. While the body can use small amounts of ketones, excessive amounts cause the appearance of ketosis.

Signs and symptoms

Does with pregnancy toxemia are depressed, weak, and have poor muscle coordination. They may also star gaze and grind their teeth. Animal may have a strong smell of ketones (sweetish smell) on their breath.

Treatment, prevention, and control

Treatment consists of 2 to 3 ounces of propylene glycol twice a day. If the does are too weak to stand, treatment may not be successful in getting them up until they deliver their kids. Induce parturition around 145 days in gestation to have live viable kids. Have a veterinarian perform a Caesarian section if they are close to term to try and save the doe and kids.

Prevent by not letting does get overly fat early in gestation. Feed good quality grains or grain by-products and good quality hay. If a particular doe is very large or has a history of having more than two kids, increase her energy intake.

Acidosis, carbohydrate engorgement, grain overload

Goats frequently fall victim to the disorder called grain overload that leads to acidosis. This is a condition which affects all ruminants and results from the over consumption of highly fermentable carbohydrates such as cereal grains and many pelleted diets. The bacteria in the rumen are responsible for digestion of the majority of what a goat eats. Under normal conditions of a steady diet these bacteria become very specialized at their task. If the diet is changed very quickly, rapid, dramatic, and often fatal changes occur within the rumen. As the excessive carbohydrates are metabolized, they are broken into small particles which draw water into the rumen resulting in dehydration. As they are fermented, the rumen pH decreases from a normal of 6.0 to 7.0 to very low (acid) levels (pH of 3.5 to 4.5). This acid solution kills many of the ruminal bacteria and damages the wall of the rumen itself.

These rapid dietary changes occur from improper feeding often as a result of two facts of goat husbandry. The first is that some goat owners extrapolate principles of human nutrition to their goats. While knowing that humans do not suffer from eating too much corn, flour, and the like, they do not realize that this can be fatal to goats. The second reason is the inquisitive nature of goats and their skill at getting into places where they should not be. This allows them to gain access to grain stores and consume them free-choice.

Signs and symptoms

Affected goats become dehydrated, their rumens become distended with fluid, and in the later stages of disease they develop diarrhea. The ruminal inflammation due to the acidic conditions is painful and goats act uncomfortable, grind their teeth, and may vocalize. Generally, signs develop 6 to 12 hours after the overconsumption of carbohydrates.

Death can result from the dehydration, acidosis, and electrolyte disturbances associated with the disease. Alternatively, during the course of the grain overload, a large amount of undigested food travels to the intestinal tract. This provides an ideal environment for *Clostridium perfringens* to proliferate and produce deadly toxins causing overeating disease (enterotoxemia). As a sequel to acidosis, the rumen can be damaged severely enough that bacteria gain access to the liver and cause liver abscesses. This will cause ill thrift and chronic weight loss in affected goats.

Treatment, prevention, and control

In mild cases, goats should be given hay and not fed any grain or concentrate. The grain or concentrate feedstuffs can then be reintroduced into the diet gradually. Alkalinizing agents such as oral antacids (10 to 20 grams or 0.7 ounces magnesium oxide, 50 grams or 1.75 ounces magnesium hydroxide, or 20 grams or 0.7 ounces sodium bicarbonate) can be given or a solution of 2 to 4 teaspoons of baking soda in a quart of water can be used. However, if too much feed is in the rumen these will act only temporarily.

In severe cases, goats should be given intravenous fluids containing 5% sodium bicarbonate. Large amounts of oral fluids should be avoided because they will not be absorbed and may actually increase rumen distension and discomfort. A stomach tube can be passed into the rumen and the contents washed with water and the fluid removed. Alkalinizing agents can be used as in mild cases. In very severe cases, surgery must be done to remove the consumed feed. Thiamine (500 mg IM, three times daily) has been shown to be helpful in recovery. Anti-inflammatory drugs can be given to make the goat more comfortable.

Normal rumen bacteria flora can be reestablished by transferring some rumen contents from a healthy goat, or cow, into the rumen of the sick goat. This may be done by tubing the animals though it would be wise

to consult a veterinarian. Various probiotics (e.g., Biosol) or live culture yoghurt will have some beneficial effect. The diet for the recovering goat should be forages only for at least 3 weeks.

Prevention is by gradual adaptation of the rumen to changes in diet. This process should take a period of 3 weeks of gradually increasing grain intake. At high levels of grain intake (feedlot or dairy goats), feed frequent small meals rather than fewer larger ones. Maintain a rigid feeding time to avoid simple rumen upset. All stored grains must be kept in well secured goat proof buildings.

Bloat, ruminal tympany

Bloat is the accumulation of free gas or froth in the rumen due to the inability of goats to rid themselves of gas produced by ruminal microorganisms during the breakdown of feedstuffs. This condition is always an emergency.

There are two causes of bloat but both have the same symptoms and effects. Frothy bloat can be caused by feeding on rapidly growing legumes and small grain pastures (wheat, barley, oats, rye). This occurs most often when goats are suddenly changed to grazing these types of pastures with no adaptation period. Frothy bloat can also occur when animals consume too much finely ground grain. Free gas bloat is caused by consumption of a diet that causes excessive gas production, such as a high grain diet, or blockage of the esophagus due to choking, a foreign object, swollen lymph nodes, nerve damage, etc.

Two types of trocar and cannula for treating severe bloat.

Signs and symptoms

The gas trapped in the rumen causes the left side of the animal, where the rumen is just under the skin, to swell. The goat will experience pain, discomfort, and have difficulty breathing. If left untreated, the internal pressure will make it increasingly difficult to breath and the animal will die from a lack of oxygen.

Treatment, prevention, and control

Treatment consists of relieving the pressure caused by the gas. For mild cases, a stomach tube can be used to free the trapped gas. If this is not effective, remove the tube and look for the presence of froth at the end. Frothy bloat can be treated by orally giving through the stomach tube:

1. Poloxalene (Therabloat), 30 ml or 1 ounce,
2. Diocytyl sodium sulfosuccinate (DSS), 30 ml or 1 ounce,
3. Detergent, such as liquid hand soap or dishwashing soap, 10 ml in 1 to 2 ounces of water, or
4. Mineral or vegetable oil, 3 to 4 ounces or 1 to 1½ cups.

Severe bloat should be treated using a trocar and cannula or very large gauge needle to pierce the left side of the animal releasing the gas. This should only be done in extreme emergencies as animals treated in this way may later encounter problems due to infection that can lead to death. If performed, antibiotics should be administered.

Prevent bloat by avoiding sudden dietary changes. If animals will graze lush pastures, feed hay or forage prior to grazing to prevent goats from gorging themselves. In cases where frothy bloat may be a problem, poloxalene can be provided in a mineral supplement. Ionophores such as monensin, lasalocid, or decoqui-

nate can be fed. Free gas bloat can be prevented by slow adaptation to high grain diets allowing ruminal microbes to adapt.

Internal and External Parasitic Diseases

Coccidiosis

Coccidiosis is a diarrhea disease caused by any one of a number of protozoan parasites of the *Eimeria* species. Coccidiosis is likely the most common cause of diarrhea in young kids but can affect older animals. Stress, weather changes, weaning, diet changes, and kidding can all bring about the onset of this disease. Young kids 1 to 4 months of age appear most susceptible.

The coccidia causing diarrhea in goats are host specific meaning that they rarely infect other animal species. Thus, coccidia that affect goats will not infect sheep and vice versa. Transmission is oral. The coccidia shed eggs or oocysts in the feces that must sporulate outside of the animal to become infective. Sporulation occurs under moderate temperatures and moist conditions. The oocysts can survive a wide range of temperatures and live for years in the environment. The life cycle for coccidia under ideal conditions is two to three weeks.

Constant exposure to low levels of coccidia can confer some level of immunity to the animal. However, consumption of large numbers of coccida at one time can overwhelm the immune system. Further, each individual species of *Eimeria* is independent of the others and there is no cross-immunity. An animal with immunity to one type of *Eimeria* can still develop coccidia from exposure to a different species.

Signs and symptoms

Coccidia enter the body and destroy cells lining the intestinal tract causing that animal to develop watery diarrhea, usually without blood. Other signs include straining to defecate, decreased appetite, dehydration, weight loss, and anemia. Some animals may suffer rectal prolapse. In acute cases, kids can die in 1 to 2 days and losses can be severe. Older animals may have diarrhea for up to 2 weeks before recovering. Some animals suffer chronic infection having intermittent diarrhea and poor growth. Coccidia can be seen when performing a fecal egg count but presence of coccidia does not mean the disease is occurring.

Treatment, prevention, and control

Treatment includes giving fluids and coccidiostats. Coccidiostats have little effect upon the existing infection but can reduce the spread of the disease. In addition to preventing coccidiosis, coccidiostats also confer the advantages of increased feed efficiency and enhanced growth. However, continuous feeding of coccidiostats increases the risk for drug resistance to develop. Coccidiostats are normally fed during periods of extreme stress and wet conditions. If feeding coccidiostats for prolonged periods, fecal exams should be done to evaluate the drug's efficacy.

Coccidiostats approved for use in the U.S. include decoquinate (Deccox, 0.5 mg/kg body weight or 13 – 91 grams/ton feed) and monensin (Rumensin, 10 – 30 grams/ton feed). Amprolium (Corid, 50 mg/kg body weight per day) is not approved for use in goats and can only be used in the context of a valid veterinarian-client-patient relationship. Amprolium should only be fed for periods of 3 to 4 weeks. Prolonged feeding can predispose kids to polioencephalomalacia (PEM). Lasalocid (20 – 20 grams/ton feed) is approved for sheep but not goats. Be aware that both lasalocid and monensin are toxic to horses.

Prevention is accomplished by improved sanitation, not overcrowding animals, minimizing stress, and a good nutrition program.

Cryptosporidiosis

Cryptosporidiosis is a protozoan-caused diarrhea disease in kids. Occurrence is more common in kids raised in a barn or in confinement than kids raised on pasture. The infective agent is *Cryptosporidium parvum*. Unlike coccidia that need to sporulate outside the animal to become infective, cryptosproridium sporulate inside the animal. This means that the protozoa can be self-sustaining in the animal resulting in severe disease. This also means that the feces of infected animals contain sporulated eggs that can directly infect other goats thereby quickly spreading the disease. Further, the disease is zoonotic and people can become infected from handling feces.

Signs and symptoms

Affected kids are usually less than two weeks of age. Diarrhea is bright yellow and watery and can last from 2 to 14 days. Kids are dehydrated, have decreased intake, poor growth, and depression. The diarrhea ranges from self-limiting to very severe and fatal. Recovered animals frequently suffer relapses.

Treatment, prevention, and control

Kids should be isolated, provided fluids, and kept warm. Any pens holding diseased animals should be cleaned. The organism survives in the environment and is resistant to many disinfectants; however, a 5 to 10% ammonia solution is effective. Proper sanitation and reduced fecal contamination of feed and water are preventive measures. Decoquinate (Deccox) at 2.5 mg/kg orally may be useful in prevention.

Stomach and intestinal worms

There are a number of stomach and intestinal worms that can affect goats. The most common and devastating in terms of death, lost productivity, and cost is the barberpole worm (*Haemonchus contortus*). A complete discussion of this and other internal parasites as well as chemical and other control methods can be found in the section on Internal & External Parasites. Anthelmintic drugs and dosages and procedure to perform a fecal egg count can be found in the Meat Goat Herd Health – Procedures and Prevention section.

Mange

Mange is caused by mites feeding on the skin of affected animals. Three types of mange that affect goats in the U.S. are psoroptic, demodectic, and chorioptic. Psoroptic mange (ear mange) is caused by the mite *Psoroptes cuniculi* and usually infests the ears but can spread to the head, neck, and body. Demodectic mange is caused by *Demodex caprae* that infests skin glands and hair follicles of the limbs, face, and back. Chorioptic mange is caused by the mite *Chorioptes caprae* and usually affects the scrotum, lower limbs, and abdomen. Transmission is usually from animal to animal though these mites can live in the environment for limited periods of time, up to 3 months for *C. caprae*, for example. Some goats may be unaffected carriers of the mites. Saliva from mite bites causes intense inflammatory reactions in the skin resulting in skin lesions and hair loss.

Signs and symptoms

In demodectic and chorioptic mange, goats will develop blisters or scabs on areas affected by the particular mange mite. Hair loss is common and the skin on the back, sides, and limbs of the animal may become crusty in appearance. Goats will scratch removing scabs and leaving a wound that is susceptible to secondary bacterial infection. In psoroptic mange, animals will shake and scratch their head, sometimes using their hind foot. Hair loss around the ears is common. Mange occurrence is most severe in fall and winter. In all cases, animal productivity will decline.

Treatment, prevention, and control

Isolate affected animals. Topical treatments include dips or thorough sprays (coumaphos 0.3%, lime sulfur 2%, and phosmet 0.15 to 0.2%) that should be done at weekly intervals. Commercial products are available

that contain these ingredients. Ivomec or Cydectin injections (0.2 mg/kg body weight) can be done at weekly intervals. For psoroptic mange, any products approved for sheep will work with goats. Another alternative is to use a louse or ear mite external medication, such as used with dogs. Lactating dairy goats should be treated only with lime-sulfur solution. If necessary, the animals can be treated using sprays or dips containing organophosphates (diazinon, metrifonate, propetamphos) or pyrethroids (deltamethrin, flumethrin) as permitted.

Lice

Lice infestation is most common in winter months when animals are closely quartered due to outside temperature and the feeding practices used. Both biting lice (*Bovicola caprae, B. limbatus* and *B. crassipes*) and sucking lice (*Linognathus stenopsis* and *L. africanus*) affect goats. *L. africanus* is probably the most important sucking louse for goats, attacking anywhere on the body. Lice suck blood and can cause severe anemia. They are spread by direct contact or by contact with contaminated areas of the environment.

Signs and symptoms

Goats will be itchy, have patches of bare skin from hair loss, lose weight, and suffer from anemia in severe cases. Lice can be seen crawling on the skin of the animal.

Treatment, prevention, and control

Treating the environment surrounding the goats to try and rid the area of lice is difficult. Treatment of affected animals includes using dips, sprays, or dusts. Commonly used products are coumaphos (0.125% spray or 0.5% dust), malathion (0.5% spray or 4% dust), and permethrin sprays or pour-on products. Ivomec or Cydectin injections (0.2 mg/kg body weight) can be used against sucking lice. They have limited effectiveness against biting lice. Treat animals at 2 week intervals for at least 2 treatments to ensure that lice emerging from eggs are killed.

Diseases of the Eye

Pinkeye, infectious keratoconjunctivitis

The term pinkeye is often used to refer to any condition resulting in watery, red, or cloudy eyes in goats. There are many causes of eye irritation including air-borne irritants and foreign bodies such as dust or small hay particles; trauma to the eye such as scratching from hay, straw, or wire; or from an infectious agent. Common infectious agents causing pinkeye include mycoplasma, chlamydia, and listeria. Certain viruses and parasites can also cause this condition. In most cases, an infectious agent is responsible and even in cases of irritation or trauma treatment to prevent secondary infection by bacteria is commonly done.

Signs and symptoms

Signs of goats suffering from pinkeye include watery eyes, redness of the eye, swelling of the eyelids, sensitivity to light, and a cloudy cornea. The onset of this disease is quick and it can spread through animal to animal contact.

Treatment, prevention, and control

Isolate affected animals to prevent disease spread. Treatment includes the use of an antibiotic eye ointment, long acting tetracycline, or tylosin injections. If it is not treated early, permanent eye damage or blindness can result. Inspect all new arrivals before mixing with new herdmates.

Toxicosis

There are numerous toxicities that can be caused by consumption of certain plants. Goats are generally not as susceptible to plant toxicities as other livestock because of their grazing habit. Goats are browsers and normally consume a wide variety of forage species daily thereby avoiding overconsumption of any one plant.

For a plant to be poisonous it must be consumed in sufficient quantities to cause illness in a natural grazing setting. In goats this may happen when forage is limited, such as during drought, and goats are forced to overconsume plant species not normally eaten. Some ornamental plant species can also cause toxicity.

Plant toxicities can cause a variety of signs and symptoms from mild irritation to central nervous system disorders to abortion and death. Most do not respond well to treatment and prevention is best. Activated charcoal given to adsorb toxins is recommended for many toxicities. Others can be treated by chemicals that usually only a veterinarian would carry. Most plant toxicities can be avoided by supplying hay or grain during drought, not overstocking pastures, and preventing access to ornamental plants and clippings. Examples of plant species causing various toxicities are listed.

Azalae, rhododendron, laurel poisoning

Azaleas, rhododendrons, and laurels are members of the *Ericaceae* family. These plants contain a toxin which causes anorexia, salivation, vomiting, abdominal pain, weakness, staggering, and death. Death usually occurs after several days of illness. Affected goats typically vocalize and vomit. Relatively small doses of these plant species are effective in causing clinical signs. For a mature goat, a cupful of leaves would be toxic. Goats that have consumed and recovered from eating these plants may repeatedly ingest them in large and often fatal quantities. Treatment is non-specific in nature. Mineral oil and activated charcoal may be given orally to adsorb residual unabsorbed toxin. Fluids and relief of pain are given as needed.

Fescue toxicity

Fescue toxicosis is caused by consumption of tall fescue infected with the endophyte *Acremonium coenophialum*. Affected animals show poor growth. In cooler months, the mycotoxin can cause gangrene or death of extremities like the tail and feet. Goats appear to be less sensitive to fescue toxicity than cattle. Do not feed tall fescue to pregnant animals. If feeding to other classes of animals, dilute with other forage.

Hydrocyanic acid poisoning

This condition is most commonly associated with Sudan grass, Johnson grass, sorghums, and white clover. Under conditions of drought or frost the plants release cyanide. Cool growing conditions and use of nitrate fertilizers are also implicated. Animal symptoms include muscle tremors, labored breathing, and sudden death, often within minutes of consuming a fatal dose. The blood of affected animals is bright red as the cyanide prevents hemoglobin from releasing oxygen. Prevent by limiting access to pastures in the conditions listed above. Plants can be most toxic during early regrowth. Sorghum at least 2 feet tall is generally safe. Some plants found on range or pasture such as choke cherry and oleander can also cause this problem. Contact a veterinarian for treatment.

Nitrate poisoning

Nitrates are essential for plant growth and normal concentrations are not high enough to cause problems. However, the increased use of nitrogenous fertilizers has raised the potential for nitrate poisoning to occur from not only nitrates in plants, but through contamination of water supplies. Nitrate poisoning is usually associated with sorghums and Sudan grass but can also occur when grazing sugar beet tops, kale, Italian ryegrass, white clover, and oats. Drought, recent fertilization, and retarded plant growth can cause nitrates to accumulate in plants. Highest nitrate concentrations are found in stems and leaves in the cool, early morning. The nitrate does not allow the blood to exchange oxygen. Signs include weakness, tremors, increased heart rate, collapse, and sudden death. Contact a veterinarian for treatment.

Selenium toxicity

Certain plants can accumulate high levels of selenium. If an animal consumes a large amount of these plants, acute poisoning can occur with damage to the liver, kidney, and lungs. Animals become weak, have

difficulty breathing, experience bloating, and can die from respiratory failure. Some plants that accumulate selenium include broomweed, desert aster, princess plume, and saltbush.

Photosensitization

Photosensitization is a condition where photodynamic chemicals accumulate under the skin and react to sunlight on unpigmented areas of the skin. Capillaries in the skin are damaged resulting in skin death and sloughing. Liver damage can also occur in some instances. Skin around ears, eyes, and muzzle is usually affected and becomes red, swollen, and irritated. Secondary infections can occur. Remove the plant causing the photosensitization and protect the animal from the sunlight. Prevent or treat secondary infections. Some plants known to cause photosensitization include St. John's wort, buckwheat, wild carrot, Lantana, ragwort, rape, and kale.

Abortions and fetal defects

Some plants contain toxic substances called teratogens that can cross placental membranes and cause fetal deformities, fetal resorption, abortion, or stillbirth. Teratogens may cause different defects depending upon the stage of gestation and amount consumed. The first trimester of pregnancy is when the fetus is most susceptible. Usually, restricting pregnant animals from pastures containing these plants during the first third of gestation is sufficient; however, plants such as milk vetch and locoweed should be avoided throughout pregnancy. Other plants known to have these reproductive effects include broomweed, lupine, tobacco, desert tobacco, and *Veratrum californicum* called false hellebore, skunk cabbage, or corn lily.

Liver damage

The liver can be vulnerable to toxicosis due to its role in detoxifying substances in the body. Some plants consumed in excess can cause liver damage. Signs are usually non-specific and overlap with signs of other toxicities and include vomiting, diarrhea, and going off feed among others. Some plants that can cause liver damage include cocklebur, crotalaria, Lantana, sneezeweed, bitterweed, rubberweed, St. John's wort, blue-green algae, horsebrush, oak, rhubarb, castor bean, and mistletoe.

Kidney damage

Kidneys can be damaged due to plant toxicosis with renal failure resulting in extreme cases. Signs are non-specific and include depression, off feed, going down, and death. Plant species implicated include lambs-quarter, pokeweed, Russian thistle, pigweed, rhubarb, oak, and Ponderosa pine.

Central nervous system effects

There are many plant toxicities that have central nervous system signs. These signs differ for different plant species but include one or more of the following: paralysis, muscle convulsions, tremors, incoordination, vomiting, depression, weakness, coma, and death. Plants causing these symptoms include locoweed, larkspur, Indian hemp, milkweed, lupines, Jimson weed, water hemlock, poison hemlock, nightshade, false hellebore, death camus, sneezeweed, greasewood, horsebrush, rubberweed, rhodendron, mountain laurel, azaleas, castor bean, and horse chestnut. Treat animals that have consumed these plants with one pound activated charcoal to adsorb the toxin.

Aflatoxins

Aflatoxins are produced by a number of fungi that contaminate grains and soybeans. Affected animals will go off feed, may experience bleeding, tremors, weakness, and death. Abortions and liver damage can also occur. Drought or excessively warm and moist conditions are factors in occurrence. Identify toxins in feed and feed toxin-free diets.

Genetic Conditions

Intersex condition, pseudohermaphrodite

The intersex condition is the most important genetic anomaly of goats. This condition is particularly prevalent among polled goats and results in offspring which are female in appearance but develop portions of the male reproductive tract including testicles. The kids have decidedly male behavioral characteristics beginning at the time of puberty. The actual mechanism of the development of intersex is unknown. During fetal development, the intersex kid is exposed to high levels of endogenously produced testosterone. This results in a masculinizing effect on the kid's genotypic female reproductive tract. This condition has been reported to be as high as 22% of all offspring in certain lines of goats.

Signs and symptoms

Kids should be carefully examined for abnormalities in external sex organs. Testicles in intersex kids are often confused with the developing mammary gland. The depth of the vagina can be checked for normality. Usually, by the time of puberty behavioral attributes clearly suggest that the goat is an intersex. Additional tests would include measurement of serum testosterone levels and chromosomal typing.

Treatment, prevention, and control

There is no treatment. The existence of the intersex trait is the primary reason why goat breeders select against the polled trait. The polled trait is dominant to horns meaning that horned goats may be homozygous for the horned trait and almost always free of the intersex trait.

Zoonotic Diseases

Transmission and susceptibility

Contact among humans results in the transmission of infectious agents. If you have a cold and don't take precautions you may give your cold to others. For some diseases, contact between humans and animals can result in the transmission of infectious agents. Diseases that can sicken both humans and animals are called zoonotic diseases. This is a two-way street in that some human diseases can infect goats while some goat diseases can infect humans.

Zoonotic diseases can be transmitted from animals to humans via feces, urine, saliva, blood, milk, meat, fetuses, and uterine discharges. Infection can occur by breathing in aerosolized pathogens, ingesting them, or by direct contact with skin or mucous membranes. Touching animals and then eating before washing your hands puts you at risk of eating fecal material. Similarly, if you rub your eyes while working with your animals, bacteria may pass from your fingers to the membranes surrounding your eye.

Exposure to animal pathogens is a common occurrence for persons raising livestock. In almost all cases, our body's immune system protects us from the pathogens we encounter. However, the very young and the very old are persons at higher risk of possible infection with a zoonotic disease. Young children are highly susceptible to disease. The *E. coli* 0157:H7 found in animal manure commonly produces a fatal disease in young children but rarely is a serious disease in adults. Elderly people need to be conscious of zoonotic diseases because immune systems lose some ability to ward off disease as a person ages. Pregnant women need to be very careful around diseased animals as some diseases can affect the human fetus. In addition to age and pregnancy status, other factors or conditions such as a compromised immune system may affect an individual's ability to fight off disease. For example, Cryptosporidia that only causes diarrhea in normal people can be fatal to persons suffering from HIV.

Prevention

Practice a little common sense and follow some simple rules when working with animals. Wash your hands after being with animals and particularly prior to eating or putting anything into your mouth. Wear gloves when you are handling potentially infected material including diarrhea kids, aborted fetuses, etc. A "mudroom" where your work clothes and boots stay and never enter the house where a toddler may be crawling will help prevent the entry of pathogens into your home. If possible, install a washer and dryer in the mudroom room so that your farm clothes never come in contact with household clothes.

Cuts and lacerations offer an immediate opening for bacteria to enter your body. Cover all cuts with a waterproof bandage and wear latex gloves if the cut is on your hand. Keep very young children out of livestock units. When they are old enough to enter, make sure they understand the concepts of sanitation. Help young children who handle animals to wash their hands or use disinfectant wipes. Explain and follow these procedures with visitors to your farm.

If you work with animals and become ill seek medical help. Inform your physician that you work with animals. Physicians often have very little knowledge of zoonotic diseases and you may need to help them figure out what you have.

Conclusion

The aforementioned diseases are by no means an exhaustive list of all the ailments that can afflict goats. A good relationship with a qualified veterinarian is essential in maintaining the health of a goat herd and in devising a comprehensive herd health strategy. Producers should always call a veterinarian when a disease outbreak is suspected.

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Some important zoonotic diseases of goats.

Anthrax	
What is it?	Bacterial disease found in the soil in certain areas and in dead carcasses.
How do you get it?	Ingestion, inhalation, or skin contact.
What does it cause?	Gastrointestinal form, respiratory form, and skin form.
How do you prevent it?	Avoid contact with infected/contaminated animals, hides, and soil.
How do you treat it?	See a physician. Antibiotic treatment.
Brucellosis	
What is it?	Bacterial disease spread by cows, horses, and goats.
How do you get it?	Direct contact or ingestion. Often via handling an aborted fetus or placenta, via urine or vaccine injection.
What does it cause?	Abortion, inflammation of the testicles, undulant fever, headaches, weight loss.
How do you prevent it?	Vaccinate all cattle if needed. Test all new entries. Wear protective clothing when dealing with dystocias and aborted animals. Take special care with vaccine.
Campylobacteriosis	
What is it?	Bacteria causing diarrhea, fever, and abortion in livestock.
How do you get it?	Fecal to oral transmission.
What does it cause?	Diarrhea with fever and vomiting. Mucus and blood in stool.
How do you prevent it?	Avoid getting feces from livestock in your mouth. Wash hands after handling livestock or raw meat.
How do you treat it?	Fluids, antibiotics.
Caseous lymphadenitis	
What is it?	Bacterial disease causing abscesses of lymph nodes especially in sheep and goats.
How do you get it?	Contact with pus from abscesses.
What does it cause?	Abscesses of lymph nodes both external and internal.
How do you prevent it?	Remove infected animals from the herd. Use gloves to handle pus and contaminated surfaces.
How do you treat it?	Antibiotics. This can be very difficult to cure.
Chlamydia trachomatis	
What is it?	Rickettsia causing abortions, conjunctivitis, polyarthritis, and pneumonia in sheep and goats.
How do you get it?	Oral transmission.
What does it cause?	Miscarriage, respiratory disease.
How do you prevent it?	Don't handle aborted fetus, placenta, or doe.
How do you treat it?	Antibiotics.
Cryptosporidiosis	
What is it?	Protozoa similar to coccidia that can infect almost any animal.
How do you get it?	Ingestion of feces.
What does it cause?	Diarrhea.
How do you prevent it?	Hand washing. Sanitation.
How do you treat it?	Self-limiting in normal people, fatal in immune suppressed individuals.
Giardiasis	
What is it?	Flagellated protozoa that can infect almost any animal.
How do you get it?	Ingestion of feces.
What does it cause?	Diarrhea.
How do you prevent it?	Hand washing. Sanitation.
How do you treat it?	Metronidazole.

Leptospirosis	
What is it?	Bacteria which can infect the kidneys of goats.
How do you get it?	Ingestion, through mucous membranes, and cuts in skin.
What does it cause?	Renal (kidney) disease, hepatic (liver) disease.
How do you prevent it?	Avoid aborted fetuses and urine of animals.
How do you treat it?	Antibiotics.
Orf	
What is it?	Parapox virus causing skin lesions in sheep and goats.
How do you get it?	Direct or indirect contact.
What does it cause?	Skin lesions.
How do you prevent it?	Do not handle goats with lesions on their lips or elsewhere without protective gloves.
How do you treat it?	No treatment. Self-curing in one month.
Q fever	
What is it?	Bacteria *Coxiella burnetti*.
How do you get it?	Inhaling aerosolized organisms.
What does it cause?	Abortions in goats and humans, liver disease. Can be fatal.
How do you prevent it?	Test your goats. Don't handle aborted fetus or placenta.
How do you treat it?	Antibiotics.
Rabies	
What is it?	Viral disease of all mammals.
How do you get it?	Direct contact with an infected animal.
What does it cause?	Neurologic disease with paralysis.
How do you prevent it?	Avoid handling animals with suspicious behavior.
How do you treat it?	Anti-serum and hospitalization. Usually fatal.
Salmonellosis	
What is it?	Bacteria which can infect all animals. Generally causing diarrhea.
How do you get it?	Oral ingestion of feces.
What does it cause?	Severe, often bloody diarrhea.
How do you prevent it?	Protective clothing when handling goats with diarrhea.
How do you treat it?	Antibiotics.
Tuberculosis	
What is it?	Bacterial disease.
How do you get it?	Ingestion and inhalation.
What does it cause?	Various symptoms including pneumonia, weight loss, weakness, fever, chest pain.
How do you prevent it?	Avoid contact and close proximity to infected/contaminated animals. Do not drink un-pasteurized milk.
How do you treat it?	See a physician.
Yersinia enterocolitica	
What is it?	Bacteria which can cause diarrhea in goats and other animals.
How do you get it?	Oral ingestion of feces.
What does it cause?	Severe diarrhea.
How do you prevent it?	Hand washing. Sanitation.
How do you treat it?	Antibiotics.

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External Parasites of Goats

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Introduction

Arthropod pests limit production in the goat industry in many ways. External parasites feed on body tissue such as blood, skin, and hair. The wounds and skin irritation produced by these parasites result in discomfort and irritation to the animal. Parasites can transmit diseases from sick to healthy animals. They can reduce weight gains and milk production. In general, infested livestock cannot be efficiently managed to realize optimum production levels.

Lice

Lice (*Phthiraptera*) are wingless, flattened, permanent ectoparasites of birds and mammals. Over 3000 species have been described, mainly parasites of birds. Lice infest a wide range of domestic livestock, including pigs, cattle, goats and sheep and cause a chronic dermatitis (pediculosis), characterized by constant irritation, itching, rubbing and biting of the hair or fleece. Lice are divided into two main groups: the Anoplura (sucking lice) and Mallophaga (chewing or biting lice). Goat lice are host specific and only attack goats and their close relatives such as sheep.

Louse-infested animals may be recognized by their dull, matted coat or excessive scratching and grooming behavior. Biting lice have chewing mouthparts and feed on particles of hair, scab and skin exudations. Sucking lice pierce the host's skin and draw blood. The irritation from louse-feeding causes animals to rub and scratch, causing raw areas on the skin or loss of hair. Weight loss may occur as a result of nervousness and improper nutrition. Milk production is reduced about 25 percent. Also, the host is often listless and in severe cases the loss of blood to sucking lice can lead to anemia.

Lice are generally transmitted from one animal to another by contact. Transmission from herd to herd is usually accomplished by transportation of infested animals, although some lice may move from place to place by clinging to flies. Lice are most often introduced to herds by bringing in infested animals.

Lice of goats can be controlled by both production practices and chemical intervention. Providing a high-energy diet can be an effective louse control strategy. If possible, it is important to keep animals in uncrowded conditions and to spot-treat or quarantine any infested individuals until they have been successfully deloused. Most louse populations on animals vary seasonally, depending on the condition of the host. Louse populations on livestock are typically greater during in the winter months and reach peak activity in late winter and early spring. Animals under stress will usually support larger louse populations than normally found. Insecticides are usually best applied in late fall. Control of louse infestations is needed whenever an animal scratches and rubs to excess. Louse control is difficult with just a single insecticide application since they will not kill the louse eggs. A second application is needed 2 weeks after the initial one to allow the eggs to hatch.

There are 3 principle species of biting lice and 3 principle species of sucking lice that can attack goats.

Biting Lice

The goat biting louse (*Bovicola caprae*), Angora goat biting louse (*B. crassipes*), and *B. limbata* are the three main species that can be found on goats.

All three species live on the skin surface and feed on hair, skin, and debris. Eggs hatch in 9-12 days and on average the entire life cycle is completed in 1 month. The biting lice of goats are distributed world-wide with winter-time populations being the most severe. Optimal control can be achieved with a residual insecticide spray with re-treatment in 2 weeks after the initial treatment.

Sucking Lice

Three species of blood-sucking lice are found on goats; the goat sucking louse (*Linognathus stenopsis*), African goat louse (*L. africanus*), and sheep foot louse (*L. pedalis*).

The goat sucking louse can be dispersed over the entire body of goats and the African goat louse is usually dispersed around the head, body, and neck regions. Both the goat sucking louse and the African goat louse are bluish-gray in appearance. The sheep foot louse is an occasional pest of goats and can be found on the feet or legs of the animal. These blood-feeding lice species cause the most severe damage. Excessive feeding causes scabby, bleeding areas that may lead to bacterial infection. Mohair on Angora goats may be damaged to the extent of reduction in value of 10-25 percent. Control can be obtained utilizing the same methods described for biting lice.

Nose Bot Fly

The nose bot fly exhibits a unique quality by depositing live larvae (maggots), not eggs as in the case of other fly species, in the nostrils of goats. Infested animals exhibit symptoms such as discharge from nostrils, extensive shaking of the head, loss of appetite and grating of teeth. Another sign of a nose bot infestation is the presence of blood flecks in the nasal discharge. The behavior of goats in the presence of adult bot flies is very excitatory and usually animals will rush or snort with their noses in dust.

Larvae migrate to the head sinuses and, after development, migrate back down the nasal passages, dropping to the ground where they complete development to the adult form. Migration of the bot larvae to and from the head sinuses causes nasal membranes to become irritated and secondary infections can occur at the irritation sites.

At this time there is only one registered product available for the treatment of nose bots in goats. Ivomec® (ivermectin) is registered as a 0.08 percent AI oral drench, administered at a rate of 3.0 ml / 26 lb body weight. The pre-harvest interval is 11 days. Nose bots are usually a winter-time problem so treatment should be administered after the first hard frost, which kills the adult bot flies and assures no reinfestations.

Keds

Keds more often called sheep ticks are actually a wingless fly. They spend their entire life cycle on sheep or goats, transferring between animals by contact. Sheep keds, Melophagus ovinus, are primarily a pest of sheep, but occasionally are found on goats. The adults are grayish-brown, six-legged, and 1/4 inch long with a broad, leathery, somewhat flattened, unsegmented, saclike abdomen covered with short spiny hairs. Sheep keds can live up to 6 months, during which time the female produces around 10-15 young at the rate of one every 8 days. Reproduction is continuous, though slow during the winter, producing several generations a year.

Unlike most insects, the female sheep ked gives birth to living maggots, which are nourished within her body until they are fully grown. The maggots are 1/4 inch long, whitish, oval, and without legs. The skin turns brown within a few hours after birth and forms a hard puparium (case) around the larva. These cases are often called eggs, nits, or keds. Adult keds emerge from the pupal cases in 2 to 5 weeks, depending on temperature. They crawl over the skin and feed by inserting their sharp mouthparts into capillaries and sucking blood, much like a mosquito. This results in considerable irritation, which causes the animal to rub, bite,

and scratch. Another effect observed from animals infested with keds is the condition known as "cockle." Hide buyers downgrade skins with "cockle" because it weakens the hide and discolors them.

Keds usually do not cause great damage if the animal is fed on a highly nutritious diet, but sheep or goats grazed throughout the year on pasture or range may acquire heavy burdens of keds during winter months and early spring. In addition, keds in large numbers can cause anemia, which can weaken the animal and make it more susceptible to other diseases.

Sprays, dips, and power or hand-dusting with insecticides are all effective methods for controlling sheep ked.

Mites

Goats can be infested by several species of mites but the species that are more commonly found on goats are: goat follicle mite (*Demodex caprae*), scabies mite (*Sarcoptes scabiei*), psoroptic ear mite (Psoroptes cuniculi), and chorioptic scab mite (*Chorioptes bovis*).

The goat follicle mite causes dermal papules and nodules and this resulting condition is known as demodectic mange in goats. These papules or nodules are the result of hair follicles or gland ducts becoming obstructed and producing these swellings, trapping the mites within these lesions. These continue to enlarge as the mites multiply, sometimes reaching several thousand mites per lesion. Cases of demodectic mange occur most commonly in young animals, pregnant does, and dairy goats. Papules usually appear on the face, neck, axillary region, or udder and these papules can enlarge to 4 cm in diameter as more mites multiply. Nodules can rupture and exudes the mites resulting in transmission of the mite to other animals. Transmission of the goat follicle mite to newborn goats typically occurs within the first day following birth. Other possible means of transfer are licking and close contact during mingling or mating. Certain breeds of goats (e.g., Saanen) tend to be much more sensitive to demodectic mange than others.

Scabies mite burrow into the skin of their hosts causing varying degrees of dermatitis a condition known as sarcoptic mange. Although cases of sarcoptic mange in goats often resolve themselves without developing severe signs, heavily infested goats may exhibit crusty lesions and extensive hair loss around the muzzle, eyes, and ears; lesions on the inner thighs extending to the hocks, brisket, underside, and axillary region; dermal thickening and wrinkling on the scrotum and ears; and dry, scaly skin on all parts of the body, especially in areas of hair loss.

The psoroptic ear mite or ear mange mite causes lesion on or in the ear of the host animal. These lesions cause crust formation, foul odor discharges in the external ear canal, and behavioral responses such as scratching the ears, head shaking, loss of equilibrium, and spasmodic contractions of neck muscles. Psoroptic ear mite lives its entire life under the margins of scabs formed at infested sites. There the eggs are deposited and hatch in 4 days. The complete life cycle takes about 3 weeks. All stages of this nonburrowing mite pierce the outer skin layer. Transmission of this mite occurs between animals by direct contact. Prevalence rates as high as 90% have been reported in dairy goats, including both kids and adults, in the United States. Goats usually less than 1 year old generally exhibit higher infestation rates than do older animals. Signs of the psoroptic ear mite in kids are often observed as early as 3 weeks after birth, reflecting transfer of mites from mother to young. By 6 weeks of age most kids in infested goat herds are likely to harbor these mites. Chronic infestations have lead to anemia and weight loss in goats.

Chorioptic scab mite causes chorioptic mange in domectic animals especially in cattle, sheep, goats, and horses. This mite occurs primarily on the legs and feet of its hosts, where all of the developmental stages are likely to be found. Eggs are deposited singly at the rate of one egg per day and are attached with a sticky substance to the host skin. Adult females usually live for 2 weeks or more, producing about 14-20 eggs during this time. The eggs are often clustered as multiple females lay their eggs in common sites. The eggs hatch

in 4 days. The immature stages last anywhere from 11 to 14 days and the entire life cycle is completed in 3 weeks. Infestations of chorioptic scab mite tend to be higher in goats than in sheep, with up to 80-90% of goats in individual herds being parasitized. The mites occur most commonly on the forefeet of goats, where the largest numbers of mites and lesions are usually associated with the accessory claws. However, they also can occur higher on the foot. Lesions are generally mild and seldom draw attention.

Treatment and control of mites should focus on all animals in a herd to achieve control. Delayed egg hatch requires retreatment at 10-12 days. To reduce the risk of introducing mites into herds, isolation of new animals should be practiced with at least a week to observe the animal for signs of mange.

Fleas

Adult fleas are small (1-8 mm), wingless insects that are narrow and are compressed on the sides with spines (combs) directed backwards. Most species move about a great deal and remain on the host only part of the time to obtain a blood meal. The legs are well developed and are utilized to jump great distances (7 - 8 in.).

The flea goes through a complete life cycle with 4 stages: egg, larva, pupa, and adult. Under ideal conditions, a generation can be completed in as little as 2 weeks. Mating takes place on the host and eggs are laid on the host. Eggs then drop off the host to the ground or bedding material and hatch in 2 days but can delay hatching up to several weeks. Development of the larval and pupal stages occurs in the host's bedding material. The larva are very small worm-like, legless insects with chewing mouthparts. In several weeks they go through 3 larva stages, feeding on organic material. The pupal stage lasts approximately one week and then the newly emerged adult flea is ready to feed on blood within 24 hrs.

There two species that commonly infest goats: cat flea (*Ctenocephalides felis*) and sticktight flea (*Echidnophaga gallinacea*). Female cat fleas can lay up to 25 eggs per day for a month, contributing to very high densities of fleas in a relatively short time. Cases of severe anemia associated with high numbers of cat flea bites have been reported in domestic animals. The sticktight flea attaches firmly to its host usually around the face and ears. This species remains attached to its host for as long as 2 to 3 weeks. Large populations of this flea may cause ulcers on the head and ears. Both of these flea species can easily spread to other animals so special considerations of monitoring herd dogs should be implemented if fleas become a problem in a goat herd.

Summary of Currently Available Insecticides Registered for Goats

Permethrin:

- Artoban 11% EC Insecticide
- Catron IV
- GardStar 40% EC

Zeta-pymethrin:

- Python Dust

Ivermectin:

- Ivomec 0.08% Oral Drench

The use of trade names in this publication is solely for the purpose of providing specific information. OSU or Langston University does not guarantee or warranty the products named, and references to them in this publication does not signify our approval to the exclusion of other products of suitable composition. All chemical should be used in accordance with directions on the manufacture's label. Use pesticides safely. Read and follow directions on the manufacture's label.

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Meat Goat Nutrition

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Introduction

Proper nutrition is essential for the health and productivity of all animals and is the basis of successful production systems. A well planned and executed preventive health program cannot overcome problems that are created by poor nutrition. Nor can advanced reproductive technologies overcome nutritional limitations of reproduction. Therefore, nutrition of the goat is of paramount importance for successful goat production. Nutrition is the science of providing nutrients to animals in adequate amounts and in forms that the animals will consume. For sustainable and profitable production, these nutrients must also be provided in a cost-effective manner.

The ruminant stomach

Goats are ruminants, animals with a four-compartment stomach, as are cattle, sheep, and deer. The compartments are the reticulum, rumen, omasum, and abomasum (true stomach). Monogastric or simple-stomached animals such as humans, dogs, and cats consume food that undergoes acidic breakdown in the stomach and enzymatic digestion in the small intestine where most nutrients are absorbed. In ruminants, feed first undergoes microbial digestion in the reticulum and rumen (together often called the reticulo-rumen) prior to acidic digestion in the abomasum and enzymatic digestion and nutrient absorption in the small intestine. It is the microbial digestion in the reticulo-rumen that allows ruminants to consume and utilize grass, hay, leaves, browse, etc.

The reticulum and rumen form a large fermentation vat that contains microorganisms, mainly bacteria, that breakdown and digest feedstuffs, including the fibrous component of grass, forbs, and browse that cannot be digested by monogastric animals. Some of the breakdown products produced through digestion of feed by bacteria are absorbed by the animal through the rumen wall and can supply a large part of the energy needs. The rest of the byproducts of digestion, undigested feed, and ruminal microorganisms flow out of the reticulo-rumen into the omasum where large feed particles are trapped for further digestion and water is reabsorbed. Material then flows into the abomasum where acidic digestion takes place and then to the small intestine for further enzymatic digestion and nutrient absorption.

The rumen provides several advantages to the goat in addition to digestion of dietary fiber. The bacteria in the rumen are capable of synthesizing all B vitamins needed. Bacteria can also synthesize protein from nitrogen recycled in the body, which may be advantageous on low protein diets. For proper ruminal function, goats require a certain level of fiber (measured as crude fiber, acid detergent fiber, or neutral detergent fiber) in the diet. Goats have bacteria in the rumen that can detoxify antinutritional factors, such as tannins. This enables goats to better utilize feedstuffs containing high tannin levels such as those found in browse. There are very few situations in which a goat will not consume adequate fiber, but one is when a very high grain diet is being fed. Inadequate fiber consumption can then lead to several disease conditions. The most important disease condition is acidosis or an extremely low pH in the rumen, causing decreased feed consumption.

When ruminants are born, the first three compartments of the stomach are underdeveloped and the stomach functions similar to that of a monogastric animal. This enables absorption of antibodies in colostrum and efficient utilization of nutrients in milk. As the young ruminant consumes solid feed, especially high in

fiber, and the microbial population is established, the rumen is stimulated to develop. The rumen must have an acceptable degree of development for successful weaning.

The greatest asset of goats is the ability and tendency to utilize woody plants and weeds, not typically consumed by other species of animals (e.g., cattle and sheep), converting them into a saleable product. Therefore, these plant species can be inexpensive sources of nutrients and make for a very profitable goat enterprise. Goats typically consume a number of different plant species in any one day and can utilize some poisonous plants because they do not consume enough to be toxic. Similarly, goats are believed to have a relatively high ability to detoxify absorbed anti-nutritional factors. Goats are more resistant to bloating than other ruminants, and after a brief adaptation may graze alfalfa without bloating.

Nutrients

Nutrients are defined as substances that aid in the support of life. The six classes of nutrients include protein, carbohydrate, fat, vitamins, minerals, and water. Nutrients are often classified as organic (carbon-containing) or inorganic (minerals).

Energy is not considered a nutrient, but can be derived from the breakdown of several nutrients including fat, protein, and both simple and complex carbohydrates. Energy is required to propel the biochemical processes that are necessary to sustain life. A deficiency of energy will cause weight loss, low productivity, and ultimate death of an animal. An oversupply of energy will usually result in excessive fatness, which is also unhealthy. A simple unit of measurement of energy is pounds of total digestible nutrients (TDN). A lb of TDN, equivalent to a pound of digested carbohydrate, equals 2,000 Kilocalories (or Calories as used in human nutrition) of digestible energy. There are a number of other measures of energy used, but they are less easily understood.

Water

Water is an essential nutrient for all animals and is sometimes overlooked. While goats require less water than cattle, they do need water and require additional supplies when lactating or coping with hot weather. A 110 lb goat will require 1 to 3 gallons of water per day depending upon diet, intake, and weather, toward the lower range in winter and toward the upper range in the hottest days of summer. A lactating goat will require an additional 1 quart of water for every 1 pint of milk produced. If a goat is producing 5 pints of milk at peak lactation while raising twins, 2.5 gallons of water are required each day. If goats are eating green material, a substantial part of their water requirement can be met by water contained in the plant material. However, if dry feed such as hay is consumed, water must be supplied to meet the requirement.

Water should be kept clean to encourage intake. This usually involves regular cleaning of the waterer. It is important that the area around the waterer not be muddy, as this is a good environment to spread foot rot and internal parasites. Placing some rock or gravel around the waterer can help keep feet dry and reduce disease problems. Water cleanliness is especially important for bucks on high grain diets. Their water needs to be shaded in summer and warm in the winter to encourage intake and reduce the risk of urinary calculi.

Carbohydrates

Carbohydrates usually provide the majority of energy to goats. Carbohydrates can be classified as simple, such as sugars (easily identified by their sweet taste; maybe 1, 2, or 3 sugar molecules linked together), or complex, such as starch (found in grains) or cellulose (i.e., fiber). Grass, forb, and browse plant species generally contain high levels of cellulose, which must be digested by rumen bacteria to provide energy.

Cellulose is often referred to as fiber, although the term fiber also pertains to other substances such as hemicellulose and lignin. Fiber in young plants may be highly digestible and provide a high level of energy, but fiber in older, mature plants is often poorly digested and may only provide half the energy of other

carbohydrates. Fiber in the diet may be characterized chemically in several ways, such as crude fiber (CF), acid detergent fiber (ADF), and neutral detergent fiber (NDF). These abbreviations are used in hay analysis and may appear on feed tags. In general, the lower the fiber level, the higher the level of digestible energy. However, a certain minimum fiber level is required for healthy rumen function.

Goats do not adapt as easily to high concentrate diets as cattle and sheep and are more likely to get acidosis, founder, urinary calculi, and enterotoxemia. To avoid these problems, very gradually increase the concentrate level in the diet when placing goats on high concentrate diets and maintain a minimum of 12% crude fiber in the diet or about half of the diet as grass, browse, or hay. Goats are typically not feed efficient, except for some rapidly growing Boer goats, and may require 7 lbs or more of feed per pound of gain. Also, one must be very alert for health problems with goats on high grain diets.

Fats

Fats, also called lipids, are very high in energy, providing more than twice the energy of carbohydrate on a weight basis. The fat content of ruminant diets is generally low, as plants have a low fat content. Plant waxes are fats that goats consume as they graze and browse, but they are not digested. Fat may be added to diets to increase the energy content. However, high levels of added fat depress fiber digestion unless treated to be inactive in the rumen. These fat sources are termed "bypass" and may be used in dairy goat diets but are generally not used in meat goat diets.

Protein

Protein is composed of building blocks called amino acids that the body uses to produce all of the different proteins required for growth, production, and maintenance. Protein is required in the diet for accumulation of new body mass (growth) and for replacing protein lost by normal wear and tear.

Ruminant animals are usually fed supplemental protein to make up for dietary shortfalls. In the rumen, bacteria degrade much of the consumed protein and use the amino acids to form bacterial protein. Bacteria can also form protein from nonprotein sources such as urea and, if provided with sufficient energy, can form significant quantities of protein. To prevent breakdown and digestion by ruminal bacteria, some protein sources are protected from degradation by coating or other means. Some natural proteins are also resistant to ruminal degradation by bacteria. These types of proteins are referred to as "bypass protein" as they bypass digestion in the rumen. Other common terms for bypass protein are "ruminal escape" and "rumen undegraded." Bypass protein sources are very important in dairy cow nutrition, but have lesser significance in most meat goat production systems.

Urea is the main nonprotein nitrogen source fed to ruminants. However, goats are not fed urea as frequently as cattle. This may be because goats are more subject to urea toxicity than cattle. Goats appear more efficient than other species at recycling nitrogen in the body to the rumen where it can be used to form microbial protein, given that sufficient energy is available. This recycling of urea to the rumen helps to reduce the amount of protein required in the diet. When animals are consuming a low quality forage, a grain supplement may also improve protein status by providing additional energy for protein synthesis by ruminal microbes.

Vitamins

Vitamins function as critical chemicals in the body's metabolic machinery and function as co-factors in many metabolic processes. A deficiency of a vitamin will slow or block the metabolic process in which that vitamin is involved, resulting in deficiency symptoms. Vitamins are divided into those that are fat soluble (i.e., A, D, E, and K) and those that are water soluble (i.e., B vitamins and C).

The bacteria in the rumen of the goat can synthesize adequate amounts of the water soluble vitamins. Thiamine, or vitamin B1, may become deficient under some conditions (e.g., feeding a high concentrate diet, especially those with high sulfur which may come from a high level of molasses) and cause the disease

polioencephalomalacia. Another situation that could lead to thiamine deficiency is improper feeding of the coccidiostat Corid®. The coccidiostat ties up thiamine, making the coccidia unable to reproduce. Feeding Corid® longer or at higher levels than recommended could lead to polioencephalomalacia. Polioencephalomalacia is a nervous disorder where the animal becomes blind, depressed, presses with his head, and the pupil slit in the eyes becomes up and down rather than the normal side to side profile. Treatment requires immediate injection of large quantities of thiamine.

Fat soluble vitamins must be supplied to the goat because the body cannot directly make them. The recommended levels of vitamins in formulated feed is 5,000 IU (international units, a measure of the potency of vitamins) of vitamin A per lb, 2,000 IU/lb of vitamin D, and 20 IU/lb of Vitamin E. The liver can store significant amounts of the fat soluble vitamins.

Vitamin A can be synthesized from carotene, the pigment that gives grass and hay their green color. As long as sufficient green feed is consumed, vitamin A intake will be adequate. Vitamin A is necessary for normal epithelium (skin) development and vision. A deficiency of vitamin A causes many symptoms, including tearing of the eyes, diarrhea, susceptibility to respiratory infection, and reproduction problems. Vitamin A is often supplied to animals not consuming green forage such as in winter months. Many mineral and vitamin supplements contain vitamin A.

Vitamin D is called the sunshine vitamin because animals can synthesize the vitamin with the help of the sun. Ultraviolet light in sunshine converts pre-vitamin D found in the skin to a pro-vitamin D form that is used by the animals. Usually, even limited sunlight exposure is adequate to provide a day's supply of vitamin D. Sun-cured hay contains Vitamin D. Vitamin D is necessary for calcium absorption and metabolism by the body. A deficiency of vitamin D, called rickets, results in lameness, weak bones, and bowed and crooked legs. The liver is the main Vitamin D storage site in the body. Vitamin D is normally present in mineral supplements and often added to complete feeds.

Vitamin E functions as an antioxidant in conjunction with the mineral selenium. The requirements for one can be partially met by the other. Thus, vitamin E is very important in areas with marginal or deficient levels of selenium. A common vitamin E deficiency disease, particularly in newborn or young animals, is white muscle disease, where white spots are seen in the heart and skeletal muscle due to oxidation damage. A marginal deficiency of vitamin E can depress the immune system and cause reproductive failure. Green grass and green sun-cured hay have high levels of vitamin E. Most mineral supplements and complete feeds contain vitamin E, especially in areas that are deficient in selenium. Vitamin E is expensive and minimal supplemental levels are used in contrast to vitamins A and D that are less expensive and often included at generous levels.

Vitamin K is technically required by animals and functions in the clotting of blood. Vitamin K is produced by bacteria in the digestive tract and absorbed. Generally, goats do not need to be supplemented with vitamin K.

Minerals

The inorganic nutrients are called minerals. Minerals are further subdivided into macrominerals, those required at 0.1% or more in the diet (macro means large), and microminerals, those required at the part per million (ppm) level (micro means small). A ppm is the weight of a paperclip in a thousand pounds of feed. A hundred ppm is equal to 1.6 ounces in a thousand pounds of feed. Macrominerals include calcium, phosphorus, sodium, potassium, chloride, sulfur, and magnesium. Microminerals include iron, copper, cobalt, manganese, zinc, iodine, selenium, molybdenum, and others. Minerals function in many ways in the body. Some such as calcium and phosphorus are major structural components of bones and teeth, as well as having other functions. Other minerals facilitate nerve functioning or fulfill a role as electrolytes. The mineral requirements

for goats are not as well known as they are for other livestock species and have often been extrapolated from sheep or cattle requirements due to a lack of studies in goats. As such, mineral recommendations for goats often have a wide range because of lack of accurate goat-specific information.

Macrominerals

The macrominerals are listed below, followed by the abbreviation, normal dietary range, function, deficiency symptoms, and major dietary sources.

Calcium (Ca) 0.3 - 0.8%

The major biological function of calcium is for bones. Bones contain 99% of the calcium in body. Calcium is also necessary for muscle contraction, nerve conduction, and blood clotting. The main deficiency symptoms are seen in the skeletal system. Bones can become soft and weak and may be deformed resulting in lameness. This condition is called rickets or osteomalacia. Vitamin D deficiency causes similar symptoms due to the role of vitamin D in the absorption and metabolism of calcium. Calcium is relatively high in milk and lactating goats need adequate levels of calcium for milk production. Does can get hypocalcemia (milk fever) while lactating due to a metabolic disorder which results in a shortage of calcium in the blood due to calcium being used for milk production. Urinary calculi is a condition brought about in part by an imbalance in the calcium to phosphorus ratio in the diet. Generally, twice as much calcium as phosphorus should be in the diet of ruminant animals. An excess of calcium can cause abnormal bone growth. Major common dietary sources of calcium include limestone and dicalcium phosphate.

Phosphorus (P) 0.25 - 0.4%

Approximately 80% of the body's phosphorus is found in bones, with the remainder in the blood and other tissues. In addition to skeletal structural functions, phosphorus is essential in energy metabolism, acid-base balance, and is a constituent of enzymes and genetic material. The major symptoms of phosphorus deficiency include reduced growth, listlessness, unkempt appearance, depressed fertility, pica (depraved appetite-eating wood, rocks and bones), and decreased serum phosphorus. Phosphorus is the most commonly encountered mineral deficiency and also the most expensive macromineral. Sources of phosphorus include protein supplements, cereal byproducts, mineral supplements, and dicalcium phosphate.

Sodium (Na) 0.2%
Potassium (K) 0.8 - 2.0%
Chloride (Cl) 0.2%

All three of these minerals function as electrolytes in the body. Electrolytes are mineral ions, carrying a positive or negative charge that the body uses for osmotic balance, pH balance, and water movement. They are also essential in transmission of nerve impulses. These minerals are highly water soluble and are easily lost with diarrhea. Electrolyte solutions used to treat animals with diarrhea contain all three of these minerals. A deficiency of potassium could occur on high concentrate diets, with symptoms including poor appetite, urinary calculi, body stiffness progressing from front to rear, and pica (depraved appetite as described above). A deficiency of chloride depresses growth. A deficiency of sodium causes reduced growth and feed efficiency. Salt provides both sodium and chloride. Most forages have adequate levels of potassium.

Sulfur (S) 0.2 - 0.32%

The major biological function of sulfur is as a component of sulfur-containing amino acids. Therefore, sulfur is important in protein synthesis, milk and hair production, enzymes, hormones, hemoglobin, and connective tissue, and is a component of the vitamins biotin and thiamine. The major deficiency symptoms include poor animal performance, hair loss, excessive salivation, tearing of eyes, and weakness. Major source of sulfur is protein which contains sulfur as a component of some of the amino acids. Therefore, sulfur is important in diets where nonprotein nitrogen (e.g., urea) is used to substitute for some protein. Sulfur-containing mineral

blocks are often used for control of external parasites in goats. Excessive sulfur in high concentrate diets can contribute to polioencephalomalacia as discussed for the water soluble vitamin thiamine.

Magnesium (Mg) 0.18 - 0.4%

Magnesium is found in bones (60 to 70% of that in the body), liver, muscle, and blood. It is required for normal skeletal development, and nervous and muscular system functions, as well as for enzyme systems. It is also closely associated with metabolism of calcium and phosphorus. In ruminants, a major magnesium deficiency disease is grass tetany, often seen on fast-growing, lush, cool season pastures. Affected animals have low blood magnesium levels, exhibit a loss of appetite, are excitable, stagger, have convulsions, and may die. High fertilization rates, cool temperatures, and high levels of plant potassium and(or) rumen ammonia may contribute to the disease. A major supplemental source of magnesium is magnesium oxide. It is often supplemented on winter wheat pasture and mixed with a protein source to encourage consumption.

Micro or trace elements

The first level after the mineral name is what is thought to be the minimum requirement in the diet, while the second is the value above which the element can become toxic. Most supplemental trace minerals are provided by trace mineralized salt or mineral mixes that are designed to provide 25 to 50% of requirements. This is adequate if the animal's diet is marginal in a mineral but inadequate if that mineral is severely deficient. Unless a documented deficiency exists, it is best not to provide 100% of a trace mineral, because an excess of one mineral may depress the absorption of another creating a deficiency. Excess supplementation of some minerals can cause toxicity problems, especially with copper and selenium.

Iron (Fe) 50 - 1000 ppm

The major function of iron is as a component of hemoglobin, required for oxygen transport. It is also a component of certain enzymes. The major iron deficiency symptom is anemia. Anemia can also be caused by blood loss due to several factors, including injury, internal parasites (barberpole worm or liver fluke), and a bad case of external parasites such as lice. Iron is stored in the liver, spleen, and bone marrow. Milk is very low in iron; therefore, kids raised for a long time on milk alone will develop anemia. Soil contamination on forages can provide significant levels of dietary iron. Iron sulfate is a common means of adding iron to the diet. Forages in some areas have excessively high levels of iron that suppress utilization of other trace minerals.

Copper (Cu) 10 - 80 ppm

Copper is essential in formation of red blood cells, hair pigmentation, connective tissue, and enzymes. It is also important in normal immune system function and nerve conduction. Deficiency symptoms include anemia, "bleached" looking (lighter color) and rough hair coat, diarrhea, and weight loss. Young goats may experience progressive incoordination and paralysis, especially in the rear legs. High dietary molybdenum can depress absorption of copper and cause a deficiency. There should be at least four times as much copper as molybdenum in the diet.

Sheep (both hair and wool types) are sensitive to copper toxicity, whereas goats require copper levels similar to beef cattle. Angora goats may be more sensitive to copper toxicity than meat and dairy goats. There are differences in copper requirements for several sheep breeds, and this could be true for meat goats, but no data are available. Although most of the United States has adequate copper levels (Figure 7), many areas have high levels of molybdenum (Figure 6) due to soil geology and, therefore, require copper supplementation. The liver stores copper, which can protect against toxicity in the short term. However, when liver capacity is exceeded, animals can die rapidly from a hemolytic crises caused by stress, such as being chased.

Cobalt (Co) 0.1 - 10 ppm

The only well accepted biological function of cobalt is as a component of vitamin B12. Rumen microbes utilize cobalt for growth and produce vitamin B12. Cobalt deficiency symptoms include loss of appetite, anemia, decreased production, and weakness. Most natural feedstuffs contain adequate levels of cobalt. There are cobalt-deficient areas in the United States (Figure 1).

Zinc (Zn) 40 - 500 ppm

Zinc is found in all animal tissue and is required by the immune system and for normal skin growth. Zinc is also essential for male reproduction. Deficiency symptoms include dermatitis (thick, dry patches of skin), hair loss, skin lesions, swollen feet, and poor hair growth. The bran and germ of cereals contain high levels of zinc.

Manganese (Mn) 40 - 1000 ppm

Manganese is important for bone formation, reproduction, and enzyme functioning. Deficiency symptoms include a reluctance to walk, deformity of forelegs, delayed onset of estrus, poor conception rate, and low birth weight. It is unusual to have a manganese deficiency.

Selenium (Se) 0.1 - 20 ppm

Selenium functions with vitamin E as an antioxidant, protecting cell membranes from oxidation. Selenium also affects reproduction, metabolism of copper, cadmium, mercury, sulfur, and vitamin E. Deficiency symptoms include poor growth rate, kids being unable to suckle, white muscle disease (cardiac and skeletal muscles have white spots), sudden death by heart attack, progressive paralysis, and retained afterbirth. Selenium is deficient in many areas because of low soil levels (geological factors; Figure 8); however, there are a few regions of high selenium soils leading to high to toxic levels in plants. Toxic levels of selenium cause shedding of hair, diarrhea, and lameness. Most plants that are not grown in selenium deficient soils will have adequate selenium levels. It is more effective to provide selenium supplementation through feed than by injection.

Molybdenum (Mo) 0.1 - 3 ppm

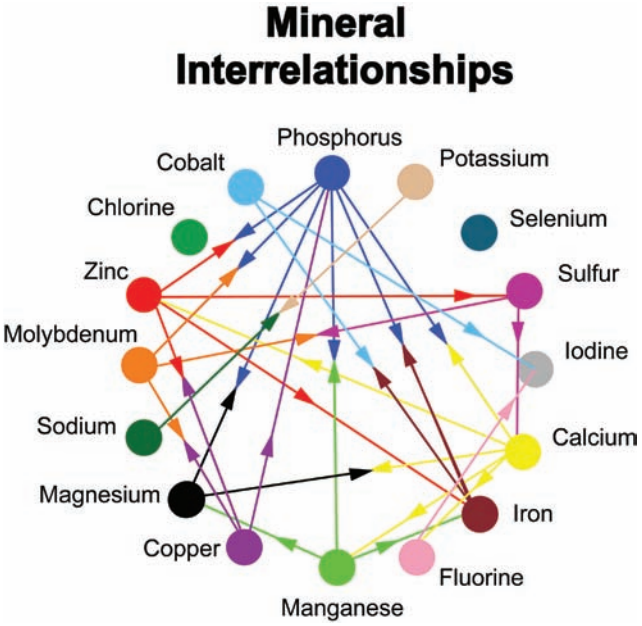
Molybdenum deficiencies are very rare. Toxicity occurs above 3 ppm due to reduced copper absorption, resulting in a copper deficiency. The copper level must be four times the molybdenum level to overcome this effect. High dietary levels of molybdenum are usually related to soil content. Molybdenum (as ammonium tetrathiomolybdate) is often used to treat copper toxicity in animals (Figure 6).

Iodine (I) 0.5 - 50 ppm

The only proven biological function of iodine is as a component of thyroid hormones that regulate energy metabolism and reproductive function. The major iodine deficiency symptom is goiter - a swelled or enlarged thyroid gland in the neck. This should not be confused with the thymus gland in the neck on young animals (the thymus gland is especially pronounced in Nubian kids, but shrinks after several months of age). Also, iodine deficiency causes reduced growth and milk yield, pregnancy toxemia, and reproductive problems such as late term abortion, hairless fetus, retained placenta, and weak kids. Most of the southern U.S. has adequate iodine in the soil and most minerals and trace mineralized salts contain iodine. A number of areas in the northern U.S. are deficient in iodine due to soil geology.

Mineral nutrition considerations

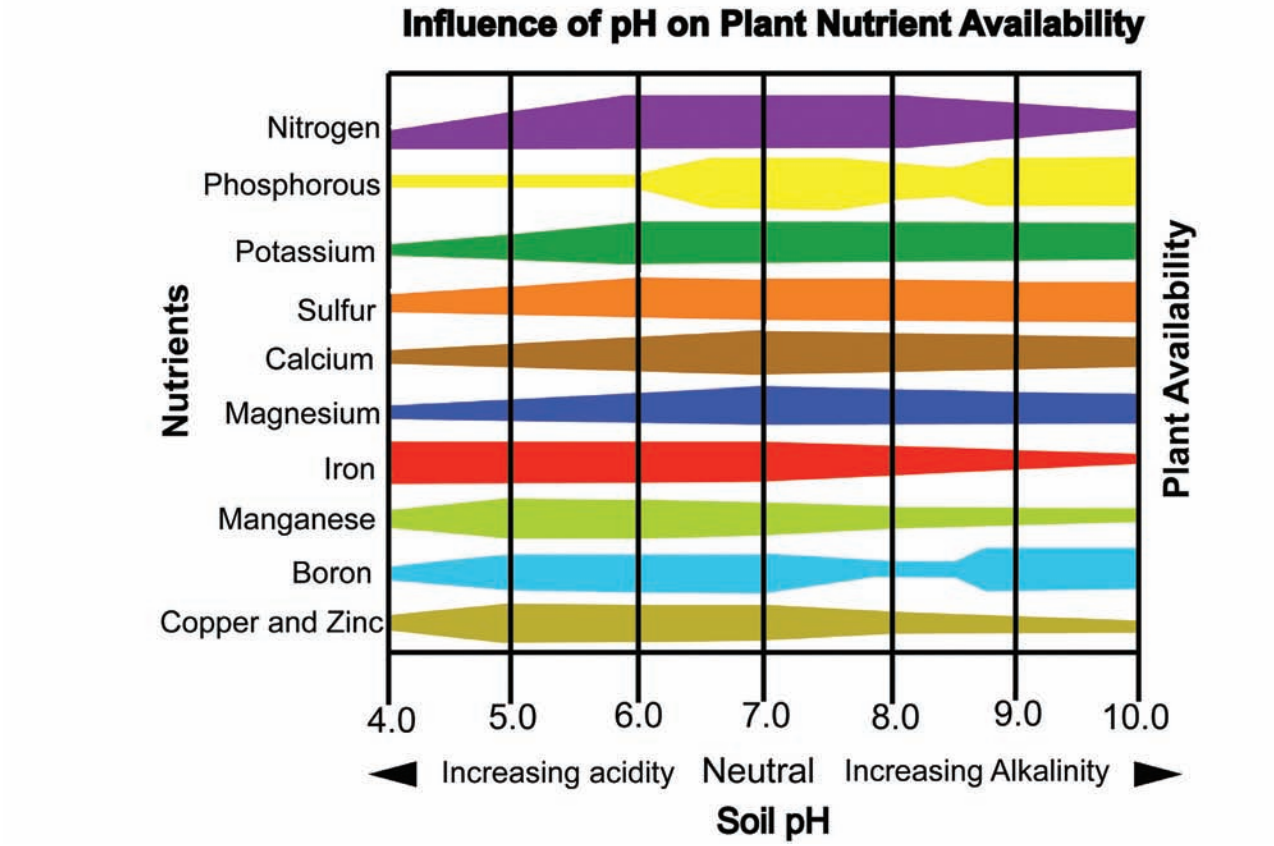
Plants are a major source of minerals for the goat, requiring all minerals that goats require except iodine. However, plant requirements for minerals, such as cobalt and selenium, may be much lower than the level required for animals. Some soils are inherently deficient in some minerals such as iodine and selenium due to soil geology. Plants grown on soils deficient in a mineral are likely to be deficient in that mineral. However,



Drawing by K. Williams.

some plants have an ability to concentrate the minerals available in the soil. Maps of mineral deficient areas of the U.S. are available. However, consulting local extension agents is a better method of determining soil mineral deficiencies or toxicities that could affect mineral levels in local forages. Soil maps showing deficient areas of selenium, copper, molybdenum, and cobalt are located at the end of this article.

Various factors other than soil mineral level can interact to influence the mineral content of forages. Soil pH is one factor that affects mineral uptake by plants. Under acidic soil conditions, many trace minerals are less available for plant uptake. Environmental temperature at certain times of the year may also affect mineral uptake. Interactions among minerals after soil fertilization can also affect their availability for incorporation into plant material. Season of the year affects plant mineral concentrations, mainly due to a



Influence of pH on availability of plant nutrients.
Redrawn from S.S.S.A.P., 1946. 11:305 by K. Williams.

dilution effect, with decreasing mineral levels as plants mature. Different plant species will also have varying contents. Browse and forb plant species may have higher mineral concentrations than do some grasses. As goats eat a variety of plants, they are less likely to have mineral deficiencies than other species of animals that eat predominantly one plant species.

To determine plant mineral content a producer can collect and send samples for analysis. Parts of plants that are being consumed throughout the day and growing season should be sampled. Analysis of a sample will cost a minimum of $25.00. To obtain enough data to formulate a custom mineral supplement would require sampling several times over a growing season and over more than 1 year if possible. This could be worthwhile for a large goat herd but too expensive for most producers. The alternative is to use a commercially prepared mineral block or loose supplement. Some mineral mixes are formulated for regions and are more appropriate to use than a mineral formulated for the whole United States. Many state extension specialists know what minerals are likely to be deficient in given areas of a state and know what levels of calcium and phosphorus are appropriate for beef cattle production. Those recommendations are a good place to start for goat mineral nutrition.

Mineral supplements should not be overfed. Mineral supplements are formulated for goats to consume a sufficient quantity. Many minerals interact with one another (interactions shown on following page) and excess consumption of one mineral may decrease absorption and(or) utilization of another. For example, it is well known that excess iron depresses absorption of zinc, copper, manganese, and selenium. There are several regions of the United States that have high enough levels of iron to depress absorption of these other minerals, requiring them to be supplemented. Feeding a regional mineral with no supplemental iron would be preferable to feeding an all-purpose mineral containing high levels of iron that would further depress absorption of these minerals.

The range between safe supplementation and toxic levels is narrow for many of the trace minerals. Do not overfeed trace minerals or mix additional minerals in a diet if another source of trace minerals, such as a trace mineral block, is present. Formulation of mineral supplements requires considerable expertise since the addition of high levels of one mineral may depress the utilization of another, causing a deficiency. Also, some trace minerals can be toxic in excess.

Calculation of supplemental levels for feed formulas requires a certain amount of technical expertise and specialized scales for weighing, along with sophisticated mixing equipment. Most common farm mixing methods are inadequate, resulting in “pockets” of dangerously high mineral levels in a batch of feed.

Choosing a mineral supplement

The most important consideration in choosing a mineral supplement is the level of calcium and phosphorus. Some mineral mixes are designated 12 - 8, which means they contain 12% calcium and 8% phosphorus. The levels of these two minerals should be the same that is being fed to cattle in your area (contact your county agent or livestock extension specialist). Phosphorus is expensive, so a 12 - 12 mineral will cost more than one that is 12 - 8. However, most forages are low in phosphorus, making it the most common mineral deficiency.

The mineral supplement should also contain trace minerals that are deficient in the area. Levels of trace minerals used in local cattle supplements can provide a guide for goats. Most mineral supplements are formulated to provide less than half the trace mineral requirements due to toxicity concerns. A mineral supplement should be provided in the loose form to maximize consumption. The salt level in the mineral drives intake; therefore, no other sources of salt should be available. A mineral feeder should be used to protect from rain and keep the supplement clean. Replenish minerals frequently to keep them fresh.

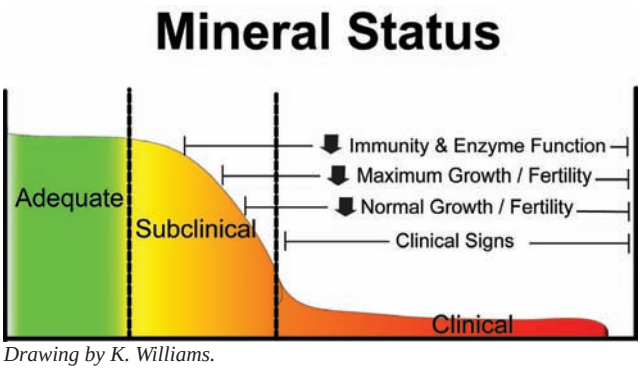
Current approximate wholesale costs for supplying 100% of mineral needs of a 150 lb goat for various minerals in 1 year are as follows:

Calcium	$1.15
Phosphorus	$4.50
Salt	$0.40
Magnesium	$1.11
Potassium	$1.50
Trace minerals	$0.45
Other minerals	$0.65
Total	$9.70

Feedstuffs will normally provide at least half of all minerals and in some cases all required. It should be noted that phosphorus alone accounts for half the mineral cost.

Diagnosing mineral deficiencies or toxicities

The proper procedure for diagnosing a mineral deficiency or toxicity depends on which mineral is being considered. Secure the assistance of a local veterinarian and extension animal nutritionist in the state who are familiar with minerals in the region.



Drawing by K. Williams.

1. Deficiency or toxicity symptoms usually provide initial indications of mineral status (e.g., manganese and "knuckling over"). However, deficient animals do not always show classic symptoms and the major symptom may only be a 'poor doing' animal.
2. Blood tests are adequate for some minerals such as magnesium, calcium, and phosphorus, and for other blood factors that give an indication of mineral status. Examples of these factors include: glutathione peroxidase for selenium, hemoglobin for iron, zinc binding protein for zinc, and thyroid hormones for iodine.
3. Hair analysis has been used for zinc and selenium but in general is a poor diagnostic test.
4. The liver is a good tissue to test for iron and copper adequacy. Liver samples can be obtained via biopsy or from animals that are slaughtered or die.

Take home lessons on mineral nutrition

1. The diet should contain adequate levels of calcium and phosphorus and have close to a 2:1 calcium to phosphorus ratio.
2. Provide a free-choice loose mineral supplement with appropriate levels of calcium and phosphorus that contains trace minerals deficient in the region.
3. Monitor intake of the mineral to make sure the animals are eating an appropriate amount.
4. Avoid excessive feeding of any supplementation.

Body Condition Scoring

The adequacy of a nutritional program can be assessed by observing changes in body weight and condition of the animal. If animals lose weight, body condition will be reduced (animal is thinner), alerting an observant manager to a problem. Body condition is particularly responsive to energy and protein adequacy.

Body condition scoring is a system of assigning a numerical score based on physical characteristics indicative of fatness. These include the amount of muscle and fat covering the spine in the loin area and ribs and fat pad at the sternum. Body condition scores range from 1 (very thin) to 5 (obese) in one-half score increments. Langston University has information on the American Institute for Goat Research website describing Body Condition Scoring of Goats (see following section on BCS or http://www2.luresext.edu/goats/research/bcshowto.html) and Examples of Body Condition Scores in Goats (see following section on BCS or http://www2.luresext.edu/goats/research/bcs.html).

Animals should achieve a certain body condition during specific periods of the production cycle. For example, animals should have a body condition of at least 2.5 but no more than 4.0 at the beginning of the breeding season. Prior to entering the winter a minimum score of 3.0 is desirable. Also, if body condition score is 4.5 or greater, pregnancy toxemia prior to kidding is likely, as also is the case with a score of 2.0 or less.

Using the Langston Interactive Nutrient Calculator

Practical goat nutrition involves providing sufficient nutrients for a desired level of productivity (milk, meat, or kids) at a reasonable cost. Nutrients are supplied via a combination of pastures, supplements, and other feedstuffs; adequate amounts are required for animals to produce at an economically viable level. For commercial meat goat production, the economics of nutrition are of paramount importance due to their great impact on cost of production and subsequent profit. For show, purebred, and companion goats, the economics of nutrition may be of lesser importance.

Applied nutrition involves determining nutrient requirements and then working with available feedstuffs, including pasture, hay, or supplemental feeds, to provide the required nutrients in proper amounts. Nutrient requirements are affected by an animal age, weight, and production type and stage. For example, pregnancy, number of fetuses, etc. will affect the amount of nutrients needed by a doe.

Calculating nutrient requirements by hand can be difficult, but the Langston Interactive Nutrient Calculator (LINC) makes the task easy, only requiring answering several questions. In addition, it is linked to a nutrient balancer program that allows selection and use of pastures and feeds to meet the requirements. The calculator will determine not only protein and energy requirements, but also calcium and phosphorus needs.

Getting started

To teach you to use LINC, we will go through an example. Here is the assignment, calculate the nutrient requirements for a nonpregnant 3 year old mature ½ Boer cross doe that had twins 6 weeks ago. The doe has a 32 inch heartgirth and is under intensive grazing management. Her body condition score is 2.5.

First, go to the Langston web site http://www2.luresext.edu/goats/research/nutritionmodule1.htm.

Question 1 asks the biotype of goat. A drop down menu will give the choices of Boer, Boer cross, Spanish or indigenous (native) goat, dairy goat, or Angora goat. For Kiko goats, use the selection for Spanish and indigenous. Select “Boer cross.”

Question 2 asks the class of goat, and selections include suckling, growing goat less than a year and a half of age, mature goat including late gestation, and lactating goat including meat and dairy goats. If a lactating goat is selected, another drop down menu asks information needed to predict milk production. This information includes litter size (number of kids), week of lactation (weeks since she kidded), and age of doe at kidding in years. Milk production, along with fat and protein percentages, are then predicted. These figures can be edited, which is useful for dairy goat producers who are more likely to know the amount of milk produced and its fat and protein contents.

For the example, select “lactating goat”. Then in the subsequent menu, select the number of kids (twins) and input week of lactation (6) and age at kidding (2 - 3 years). The program predicts that the doe will produce 3.6 lbs of milk containing 3.6% fat and 3.3% protein.

Question 3 asks the gender of the goat, and the drop down menu has choices of doe, buck, and wether. Select “doe.”

Question 4 asks the body weight of the goat. If the weight is known or a good estimate is available, it should be entered in the box. If the weight is unknown, the heartgirth (chest circumference) can be measured to predict body weight. Check the box to estimate weight via heartgirth and enter heartgirth in inches. A menu will appear with choices of genotype (breed) of goat (Alpine, Angora, Boer, ½ or less Boer, ¾ or ⅞ Boer, La Mancha, Nigerian dwarf, Oberhasli, Saanen, Toggenberg, and Spanish). Some breeds require input of body condition score. Body weight is then estimated. Input “32” inches for a “½ or less Boer” and the estimated weight of the doe is 105 lbs. This can be used for estimating bodyweight for medicine dosage or weights for management purposes.

Question 5 asks the desired amount of weight gain or loss expected in a 1 month period, with selections ranging from losing 5 pounds (-5) to gain of 30 pounds. This gain is in addition to any pregnancy weight gain. Select 0 lbs per month.

Question 6 adjusts nutrient requirements for the energy expended during grazing if goats have access to pasture. The drop down menu includes choices of stable feeding, intensive management, semi-arid grazing (goats on extensive ranges), and arid (desert) grazing. For the sample calculation select “intensive management, temperate or tropical range.” This selection will be used in all the examples that follow.

Question 7 asks the percentage TDN of the diet being fed and uses a default value of 60. If the TDN level in the feed is known, this value can be adjusted. For dairy goats, the default value is 65%. Use the default of 60%. If you know the value of the feed you plan to use put it in here. This value is important in prediction of intake.

Question 8 asks the percent protein in the diet and the default is 10%. For dairy goats, the default is 14%. Use the default of 10%. If you know the value of the feed you plan to use, put it in here. This value is used to help predict intake.

Click on the “Calculate Requirements” button to calculate the energy and protein requirements, estimated dry matter intake, and calcium and phosphorus requirements. In this example, the requirements should be 2.5 lbs of TDN for energy, 0.34 lbs of crude protein, 6.65 grams of calcium, and 4.65 grams of phosphorus, with a predicted intake of 3.65 lbs of dry matter.

Providing needed nutrients

After calculating the nutrient requirements for goats, those nutrients must be provided using feedstuffs such as pasture, hay, concentrate, and minerals. For most goats throughout much of the year, nutrient requirements can be met by available pasture, a mineral supplement, and water. During times of limited forage availability or quality such as winter, or feeding poor quality hay or stockpiled forage, a supplement will be needed to supply deficient nutrients. The level of supplemental feeding should be adjusted with changes in animal requirements, such as increased needs of late pregnancy. Sometimes it may be preferable to put an animal in a lot and feed a complete diet or one high in concentrate such as with dairy goats.

There may be periods when nutrient requirements cannot be met, resulting in loss of body weight. This is acceptable at certain times in the production cycle if body condition is sufficient for the animal to draw upon body reserves and maintain the desired production level. An example would be weight loss during early lactation because sufficient nutrients cannot be consumed. However if the doe is in poor body condition, is a growing yearling, or has severe weight loss during this time, milk production will be depressed. During a

drought, it may be acceptable for open or early pregnant animals that are not lactating to lose weight. During late pregnancy, inadequate nutrition can have adverse effects on pregnancy outcome and subsequent lactation. We can estimate what the projected bodyweight losses would be by reducing the bodyweight gains in question five and then calculating nutrient requirements until the energy and protein requirements match intake of those nutrients. Severe undernutrition can cause abortion, reduced livability of the kid(s), reduced milk production and adversely affect maternal behavior.

Feeding Different Classes of Goats

The feeding suggestions that follow are oriented to commercial goat producers. Purebred, show, and companion animals are often fed more for larger frames and better body condition, but excessive body condition can be deleterious to the animal health.

Feeding bucks

Mature bucks can obtain most of their nutrients from pasture. However, yearling and 2 year old bucks have greater nutrient requirements since they are still growing. Bucks need to be in good body condition (BCS greater than 3) before the breeding season because feed intake may be relatively low during that time, with loss of body weight. Thus, body condition should be evaluated 3 months before the breeding season. Decisions can then be made on the supplemental nutrition needed for the buck to achieve the desired BCS.

Whenever bucks cannot meet nutritional needs from pasture, supplementation is necessary. Under most conditions, whole shelled corn or sweet feed at 0.25 to 0.5% of body weight will be adequate (0.5 to 1 lb of feed for a 200 lb buck). Feeding bucks high levels of grain (greater than 1.5% of body weight) for a long period of time makes them prone to urinary calculi. The levels of grain recommended above are safe for bucks. When pasture is scarce, bucks can be fed medium quality hay free-choice (all they can eat).

Using LINC, calculate the nutrient requirements for a 3 year old, 200 lb Boer cross buck, gaining no weight, and on pasture (intensive management). The calculated requirements are 2.39 lbs of TDN, 0.26 lbs of crude protein, 5.05 grams calcium, and 4.09 grams phosphorus, with predicted dry matter intake of 3.55 lbs. However, it is important to note that the estimated dry matter intake is influenced by the dietary TDN and CP concentration inputs. Therefore, if the default values are used and a forage, which makes up all or most of the total diet other than a mineral supplement, has different levels, then the predicted dry matter intake may not be close to the actual amount. In the example above, default values were assumed. To determine if these nutrient requirements can be met by native range with a mineral supplement, click on “Select Feed Ingredients” at the bottom of the page. A page listing different feeds will appear. In the “Forages” section below “Concentrates,” click on “range, early summer,” and under “Minerals” choose a 12-12 mineral supplement. Go to the bottom and click on “Input These Feed Ingredients into the Ration.”

The ration window will appear that lists each ingredient chosen. Intake figures should be entered in the column labeled “Amount, lbs as fed.” The estimated intake for this buck is 3.55 lbs dry matter (lbs of diet not including the water content of the feedstuffs), whereas in this window the consumption amount is entered as the “as fed” form. Because feedstuffs vary in water content (compare the water content of fresh, green pasture to the same forage dried and harvested as hay), nutrient requirements and intake estimations are calculated on a “dry matter basis.” Dry matter basis means that all water has been removed. However, animals eat feed in an “as-fed” form. This calculator will determine the amount of dry matter intake for each ingredient from the as-fed figures entered. This relieves the producer from having to estimate dry matter, allowing the amount fed to the animal to be entered, with the program performing the needed dry matter calculations.

The mineral supplement bag label predicts intake of 0.5 to 1 lb/month/hundred lbs of body weight. At that rate, the 200 lb buck will consume 2 lbs/month or 0.067 lbs/day (2 lbs ÷ 30 days), roughly 1 ounce. Some supplements estimate an intake such as 1 to 1.5 oz/day, but this can vary with the size of the goat. Enter 0.07

lbs for the mineral. Therefore, in this example it can be assumed that forage dry matter intake is 3.55 lbs. The value of 3.55 is entered into the "Amount, as-fed" column for range forage. Clicking in the "Amount, lbs DM" column will calculate the amount of DM and nutrients provided (Running total) compared with the Requirements. The amount of as-fed native range grass provided should be increased until the forage dry matter provided equals the 3.55 lbs previously calculated. This is done by trial and error method until a correct answer is found. In this case, the correct amount is 3.95 lbs of as-fed native range, which will provide 3.55 lbs of dry matter. Therefore, the estimated daily ration for this buck is 3.95 lbs of native range grass hay, or an equivalent amount of pasture, on a dry matter basis plus 0.07 lbs of mineral per day.

Comparing the Running total with the Requirements shows that this diet did not meet the requirement for TDN (2.12 lbs provided vs a requirement of 2.39; 89%). Crude protein, calcium, and phosphorus are supplied in excess of requirements. Because the equations used in these predictions include a small safety margin (i.e., requirements are most likely slightly greater than actual), if the deficiency is not marked the diet could be used as is with careful monitoring of performance measures, most notably BCS. In addition, one should consider that the diet actually consumed could be higher in quality than the 'book' composition values used. In this regard, when taking plant samples, plants are often cut at the ground level, such as for hay. Conversely, goats select certain plant parts (especially leaves) that have higher nutrient contents. Therefore, the composition analysis used in the calculations might not have matched what was actually eaten. For example, if a TDN concentration in consumed forage of 65% and a crude protein level of 12% are assumed, the predicted TDN intake is 95% of that necessary to satisfy the TDN requirement.

Accurate and abundant data on the nutrient content of plant parts consumed by goats are lacking. When hay is fed and animals are 'forced' to consume most of it, the hay analysis will closely match what is consumed. The same applies to supplemental feeds that are totally consumed. One way to more accurately determine the true composition of diets of grazing goats is to follow the animals for a couple of hours and hand pluck the portions of plants consumed and send the sample in for analysis. However, plant composition and plant parts selected vary over time, making it desirable to sample plants monthly or more frequently.

In the absence of feed nutrient analysis, it is important to try to match the description of feeds or pasture as closely as possible to that in the LINC feed tables. If actual analysis has been determined, it can be entered into LINC at the bottom of the feed library. Information required includes concentrations of TDN, crude protein, calcium, and phosphorus. Hopefully in the future, more applicable data will be available for herbage grazed by goats.

Feeding replacement bucks and does

Replacement bucks and does must gain sufficient weight from weaning to breeding to be adequately large and sexually mature. A Spanish doe weaned at 12 weeks of age would be expected to weigh 40 lbs and gain 5 lbs per month to achieve a minimum breeding size of 60 lbs at 7 months of age. A Boer doe weaned at 12 weeks of age would be expected to weigh 50 lbs and would need to gain 7.5 lbs per month to be 80 lbs at breeding. These are minimum weights, and it is advantageous for animals to be slightly heavier. Some purebred breeders wait to breed their doelings at 19 months of age because a doe with a bigger frame size is desired. Most commercial goat producers cannot afford the cost of an extra year of maintaining an animal with no production.

Does will generally gain sufficient weight if an adequate amount of a moderate quality forage is available. If doelings are not gaining adequate weight (as measured by a scale or through the heartgirth conversion program), they could be supplemented with whole shelled corn at 0.5 to 1% of body weight per day (¼ to ½ lb of corn per head per day for 50 lb doeling). Feeding excessive grain to does causes an overly fat condition. Fat may be deposited in the udder, leading to reduced formation of milk secretory tissue. The doe is also more likely to have pregnancy toxemia and birthing problems. If sufficient good quality pasture is not

available, growing doelings will need good quality hay and a supplement such as whole shelled corn, sweet feed, or range cubes or pellets at 0.5 to 1.0% of body weight.

Bucklings must gain more weight than doelings to reach puberty. While there are no available recommendations for weight of meat goat bucklings at first breeding, these animals need to reach an adequate size to achieve puberty. Like doelings, body condition should be monitored and supplemented at 0.5 to 1% of body weight per day (¼ to ½ lb of corn per head per day for 50 lb buckling). Most bucks do not let a lack of body weight interfere with breeding, but some body reserves are necessary to maintain fertility and mating activity throughout the breeding season.

Feeding does throughout their life cycle

The four production periods of does are dry nonpregnant, pregnant, late gestation, and lactating. Does that are open (nonpregnant) or in the early stage of pregnancy (< 95 days) have fairly low nutrient requirements. For open does, the goal is to gain a little weight to be in good condition for breeding. A medium quality pasture, such as in late summer, or a medium quality hay is sufficient to prepare for breeding and the early stage of pregnancy. However, adequate quantities of feed are necessary.

Use the LINC to calculate the nutrient requirements for a 130 lb nonpregnant, mature Boer doe without change in body weight and with intensive pasture grazing. The requirements are 1.50 lbs of TDN, 0.18 lbs of crude protein, 4.03 grams of calcium, and 2.82 grams of phosphorus, with an estimated dry matter intake of 2.31 lbs (based on the composition of fall bermudagrass; 50% TDN and 9% CP). Feeds used are fall bermudagrass and a mineral supplement. A 130 lb doe is expected to consume the mineral at 0.1% of body weight per month = 1.3 lbs/30 days = 0.04 lbs of mineral per day. The estimated 2.27 (2.31-0.04 = 2.27) lbs dry matter intake of fall bermudagrass (3.25 lbs as-fed) provides 1.14 lbs of TDN (76% of requirement) and 0.20 lbs of crude protein (111% of requirement). In this example, it appears questionable as to whether or not body weight of the doe could be maintained with this forage (i.e., 50% TDN). The goat's ability to select higher quality plant parts, as noted above, might enable them to maintain their body weight. In this regard, if they are able to select a diet with a TDN concentration of 60% rather than 50% then the amount of TDN supplied is (2.27 × 0.60 = 1.36 lbs) which is 91% of the required amount, somewhat close to her requirements. Again, it is important to monitor body condition.

Calculate the nutrient requirements for a Boer doeling weighing 70 lbs, gaining 5 lbs per month, and with intensive pasture grazing, using LINC. The requirements are: 1.3 lbs TDN, 0.25 lbs crude protein, 2.98 grams of calcium, and 2.08 grams of phosphorus with a dry matter intake estimate of 2.06 lbs. If we adjust estimated TDN and estimated protein for the forage (questions 7 and 8 in LINC) since the 50% TDN of fall Bermudagrass is different than the 60% assumed, and use 9% CP instead of the 12% assumed, predicted dry matter intake is 2.32 lbs. Using the same feeds, fall bermudagrass and mineral, with a mineral consumption of 0.02 lbs (1% of body weight /month, divided by 30) and using fall bermudagrass for the remainder of her intake (3.3 lbs as fed), both TDN (1.16 lbs intake, 89% of requirement) and crude protein (0.21 lbs intake, 84% of requirement) are inadequate. To achieve the desired growth rate, supplementation may be necessary. By trying sweet feed as a third feedstuff it is determined, through trial and error, that 0.75 lbs of sweet feed along with 2.0 lbs of fall pasture will provide most of the energy requirement but only 0.19 lbs of crude protein (76% of requirement), which is inadequate. By deleting the sweet feed and changing to a 16% dairy ration to supply the needed crude protein, it is finally determined that 0.75 lbs of a 16% crude protein dairy ration, 2.0 lbs pasture, and 0.02 lbs of mineral will provide 1.3 lbs of TDN (100% of requirement) and 0.25 lbs of protein (100% of requirement). The weight gain to achieve adequate breeding size should continue to be monitored with possible feeding adjustments made. The lesson here is that this doeling, because of the need for growth, has higher requirements than a mature doe and needs extra nutrition.

Flushing meat goats

Some people advocate "flushing" of meat goats prior to breeding. Flushing refers to the practice of providing extra nutrition to does approximately 2 weeks prior to breeding and for a variable portion of the breeding period (e.g., 1-2 weeks) to increase the number of ovulations and have a greater proportion of twins and triplets. This is widely advocated with sheep producers and Angora goat producers. Producers have extrapolated the practice to meat goats. However, several controlled studies with Spanish goats in reasonable body condition (BCS 2.5 – 3.5) have shown no response in kidding or conception rate of meat goats to flushing with extra protein, energy, or both. The practice may have utility for meat goats in poor body condition, but there does not appear to be justification for flushing does in acceptable body condition.

Winter feeding of does

Early to mid-winter is a time when does should be in early pregnancy. The goal of a wintering program is to economically provide the necessary nutrients to maintain a reasonable body condition, lose no weight, and keep them warm. In general, most wintering programs consist of both forage and supplement components. The forage component can consist of hay, stockpiled forage, or a cheap byproduct roughage feed. The supplement usually contains energy, protein, and often vitamins and minerals, although these may be provided separately as a mineral mix. Commonly utilized supplements include whole shelled corn (inexpensive source of energy), range cubes (inexpensive source of energy and protein), sweet feed, protein blocks, molasses blocks or tubs, and liquid feed.

Stockpiled forage is forage that is grown during the summer or fall upon which animals are not allowed to graze, reserving it for the winter months. In drier areas, the forage is well preserved, but in a more humid climate quality declines rapidly, making the practice less satisfactory. Stockpiled forage is a very inexpensive forage source since it does not have to be mechanically harvested (baling forage doubles the cost of forage); animals harvest stockpiled forage by grazing. Animals make much more efficient use of stockpiled forage when strip grazed (using temporary electric fence to limit animal access to an area containing a 1 to 3 day supply of forage) to minimize trampling. Fescue is used in many temperate regions for stockpiling and retains its quality well into late winter even in humid areas. Most recommendations for stockpiling fescue include late summer fertilization, clipping, and deferred grazing. Warm season grasses such as native range and bermudagrass can be stockpiled. The amount of deterioration is dependent on grass species and rain. If local cattlemen are using stockpiled forage it will probably work for certain classes of meat goats. Consult your state forage extension specialist for further information.

Calculate the requirements for wintering a 95 lb mature Kiko doe (use Spanish biotype) in early pregnancy gaining no weight and with intensive pasture grazing, using LINC. The requirements are 1.19 lbs TDN, 0.14 lbs protein, 3.13 grams of calcium, and 2.19 grams of phosphorus, with 1.86 lbs of dry matter intake estimated (based on default dietary TDN and CP levels). Feedstuffs that can be used include stockpiled (winter) bermudagrass and a 16% molasses lick. The estimated intake from the molasses lick label is 4 ounces or 0.25 lbs. Assume the remainder of dry matter intake is from the stockpiled bermuda pasture.

The molasses lick is not in the feed library so must be entered manually as a new feedstuff. Click on "Add/ Delete Ingredient to Feed Library," to bring up a table to be filled out. First, the feedstuff class is selected. This molasses lick is in the "concentrate" class. Then the name "16% molasses lick" is entered, and remaining values are entered. These values can be obtained from the feedstuff tag or label or by calling the manufacturer. If a value is unknown, leave it blank. For this example, enter dry matter of 85%, 16% crude protein, 75% TDN, 2.8% calcium, and 0.45 % phosphorus. Click on "Add Feed Ingredient to Library" and the Select Feed Ingredient page appears. If needed, click on refresh feed library and 16% molasses lick appears under "Your Feed Ingredient Library." If you have a dry hay or feed, 85% dry matter is a good assumption.

To continue formulating the ration, select the 16% molasses lick and winter bermudagrass, then click on "Input these Feed Ingredients to the Ration." Enter 0.25 lbs for the 16% molasses lick under the "Amount, as-fed" column and guess at 1.5 lbs of winter bermudagrass. Through trial and error a total of 2.0 lbs bermudagrass is selected to fulfill intake requirement. The table shows that this diet provides 0.91 lbs of TDN (76% of requirement), 0.12 lbs CP (86% of requirement), 4.74 grams of calcium, and 1.52 grams of phosphorus (deficient). The diet is quite deficient in energy. To provide additional energy, add whole shelled corn. The diet is then reformulated to contain 0.6 lbs whole shelled corn, 1.4 lbs winter bermudagrass, and 0.25 lbs of lick molasses. This provides 1.15 lbs TDN (97% of the energy requirement) and meets the CP needs. Phosphorus is slightly deficient (13%), but if the bermudagrass is better than average the requirement can be satisfied. Mineral supplements vary in their phosphorus levels as phosphorus is an expensive ingredient. If a mineral supplement with a high phosphorus level is selected for feeding, the requirement would be met but likely at a high monetary cost.

Feeding does in late gestation

Energy requirements increase dramatically in late pregnancy (Figure 4). Using LINC, calculate the nutrient requirements for a 130 lb mature Boer doe, 140 days pregnant (10 days from kidding), gaining no weight, other than that due to pregnancy, and carrying twins. Under question 3, after clicking on the box for greater than 95 days pregnant, a form drops down for pregnancy number (twins), breed (predicts birth weight, can enter yours if known), and days of pregnancy (140). The requirements are 2.45 lbs TDN, 0.45 lbs crude protein, 3.97 lbs intake, 6.03 grams calcium, and 4.22 grams phosphorus.

A ration can be balanced using bermudagrass hay and 20% range cubes to meet the requirements by feeding 1.5 lbs of range cubes and 3.0 lbs of bermudagrass hay. This illustrates the high level of nutrition that is needed, especially in the last 3 weeks of pregnancy. High quality hay as well as supplementation is usually required. The range cubes contain a mineral supplement so no additional mineral mixture is needed.

Doelings require more supplementation than mature does, as the doelings are still growing. The nutrient requirements for a 95 lb growing Boer doeling with a predicted intake of 3.37 lbs, gaining 1 lb per month in addition to pregnancy weight gain and 140 days pregnant with a single kid are 1.77 lbs TDN, 0.36 lbs CP, 5.23 grams calcium, and 3.66 grams of phosphorus. If the same ingredients are used as those for the mature doe, how much of each will be required? The doeling could be fed 3.8 lbs of bermudagrass hay alone to meet the nutrient requirements for pregnancy with a single kid. However, if the doeling is carrying twins and is 140 days pregnant, her requirements are 2.27 lbs TDN and 0.47 lbs CP. This doeling will require 1.0 lbs of range cubes and consume 3.3 lbs of hay. If an abundance of high quality pasture is not available, the doeling will need some type of supplementation. If the forage (or hay) of adequate quality is available, only 1 to 1.5% of body weight of whole shelled corn may be needed as an energy supplement. This is important in that feed intake may be reduced in the last 4 to 6 weeks of gestation by the growing kids that reduce available abdominal space.

Feeding the lactating doe

The lactating doe has very high nutrient requirements. Calculate the requirements for a 4 year old 110 lb Boer cross doe nursing twins in week 4 of lactation. When lactating is selected under question #2 on LINC, a form drops down. Select litter size (twins), week of lactation (4), and age at kidding (4). The program then predicts production of 4.5 lbs of milk per day with 3.6% fat and 3.3% crude protein. Nutrient requirements are 2.8 lbs of TDN, 0.41 lbs of protein, 7.61 g of calcium, and 5.33 grams of phosphorus, with 4.14 lbs of dry matter intake predicted (based on default dietary TDN and CP concentrations). During lactation, the doe can consume nearly enough nutrients if an abundant supply of high quality pasture is available, such as in spring or early summer. However, does will likely lose some bodyweight due to the high demands of peak lactation (weeks 3 to 8 of lactation) and an inability to consume an adequate quantity of feed. Kidding

should take place when there is an adequate supply of high quality pasture. If there is not adequate pasture, supplemental feed will be required. Inadequate nutrition will decrease body condition, reduce milk production, reduce kid weaning weight, and increase kid mortality.

If feeding bermudagrass hay and a 16% dairy ration, 2.6 lbs of hay and 2.0 lbs of the ration are required to fulfill requirements. However, the doe will still lose 2.0 lbs of bodyweight per month. When feeding high levels of grain such as the amount in this example, the animal should go through an adjustment period of two to three weeks during which time the grain portion of the diet is gradually increased to prevent digestion and other problems from occurring. Feeding a dairy ration and hay to a doe during late gestation and the lactating period will cost approximately $30 per animal. Utilizing available pasture as a feed source is a much cheaper alternative.

Kids are usually weaned at about 12 weeks of age. Milk production of the doe begins to decrease after the 6th week of lactation and is quite low by the 12th week. Nutrient requirements decline as stage of lactation advances, enabling the doe to maintain body condition or even increase it on pasture alone. Kids may be creep fed while nursing to increase growth rate of the kids and reduce nutrient demands on the doe for milk production.

Creep feeding

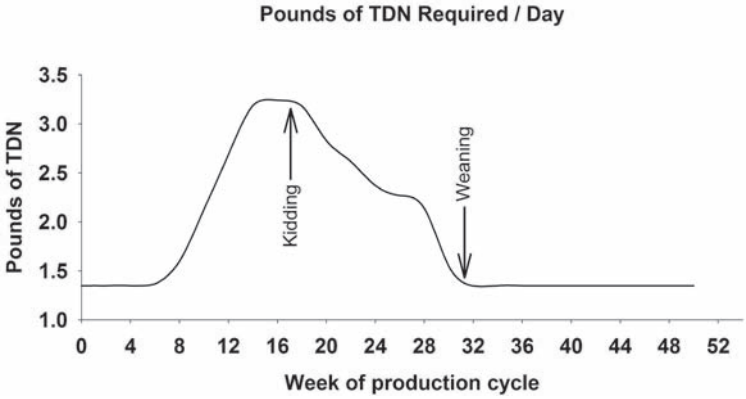
Creep feeding is a method of providing feed for the kids only. This is accomplished by fencing around a feeder and using a creep gate that has holes about 5 inch wide by 1 ft high. These holes are small enough so that kids can enter the feeder, but adults are excluded because they are too big to go through the hole. Creep feeding will provide extra growth for the kids and train them to eat feed, facilitating weaning. A commercial creep feed with at least 16% crude protein that is medicated with a coccidiostat should be used. It requires about 6 lbs of feed to produce 1 lb of animal gain. The more rapid growth from creep feeding may be beneficial for producing show prospects.

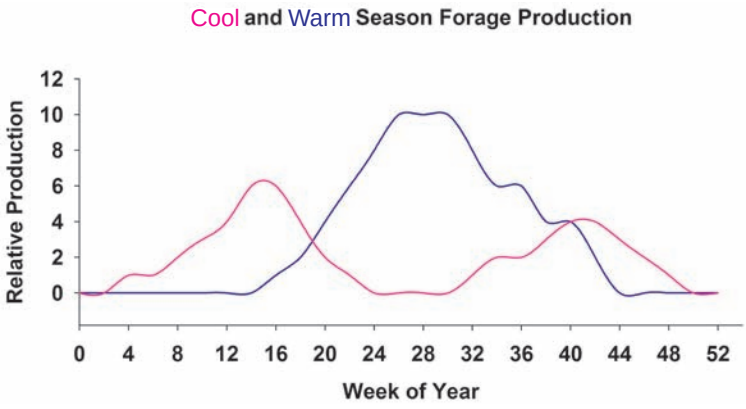
An alternative to grain-based creep feeds that is used in the beef cattle industry is to creep graze calves, using a creep gate that allows calves access to ungrazed high quality pasture. This may have application for goats using high quality pastures (crabgrass or sudangrass that is planted for the kids). In rotational grazing of cattle, the calves are often allowed to creep graze the next pasture before cows so that they have relatively high nutrient intake. Those pastures often have less parasites and disease organisms because of the time since last grazing.

Effect of Kidding Season on Nutrient Requirements

Nutrient requirements of does change dramatically with stage of production. Requirements increase dramatically the last 6 weeks of gestation due to increasing fetal growth and remain high in early lactation (kidding occurred on week 20 in chart). During the month prior to kidding and for the following 3 months (assuming weaning at 12 weeks of age), the doe will consume nearly as much nutrients as in the remaining 8 months of the production cycle. Thus, during that time it makes sense to supply nutrients from an inexpensive source, typically pasture. The cost of providing the same nutrients as hay is more than twice that of pasture, and supplying through purchased feeds may be four to five times greater than for pasture.

Kidding should be planned for a time when pasture is rapidly growing. This period corresponds to late spring for pastures comprised of warm season forages such as bermudagrass or native range, browse, and forbs, but could be either fall or early spring for cool season grasses such as ryegrass, wheat, orchardgrass, and fescue. Cool season grasses usually produce less forage per acre than warm season forages, but generally are higher in energy and protein. The accompanying figure shows the relative production of cool and warm season forages for central Oklahoma. Consult a local pasture extension specialist or livestock extension specialist for local forage growth patterns. Rapidly growing pasture is high in protein and energy. A major consideration in





determining the date to kid is level of forage production at that time. However, there are other considerations in selecting kidding date, such as parasites and market opportunities. Some markets provide a substantial price premium from kidding at a specific time of the year, such as producing prospect show wethers or registered animals. However, it may take a considerable market premium to cover the cost of purchased feed, so general reliance on pastures and forages is best.

Artificial Raising of Kids

Sometimes it is necessary to bottle feed young kids due to death of the mother or the mother refusing to take them. Milk feeding of commercial meat goats is usually not economical. It may be avoided by cross-fostering kids onto another doe as described under the goat management section. If a bottle raised kid is with other kids and does, they may learn to 'steal' sufficient milk to raise themselves. Kids can be raised on cow milk replacer, goat milk replacer (expensive) or, if none is available, cow milk from the store may be used.

It is very important that kids receive colostrum within 12 hours of birth. After 12 hours, antibodies absorption decreases. Colostrum may be milked from another doe that recently kidded. Colostrum contains antibodies that strengthen the immune system for the first months of life. A kid should be fed one ounce of colostrum per lb of weight (average birthweight 7 lbs, therefore, 7 ounces of colostrum) at each of three feedings in the first 24 hours. If the kid is too weak to nurse, it is appropriate to provide the colostrum via stomach tube. This does take some practice, but obtaining colostrum is critically important to kid survival.

Initially kids can be fed using a baby bottle or a nipple such as the Pritchard teat which fits on a plastic soda bottle. Kids can be bottle fed twice a day, although three times a day the first 4 to 6 weeks of life may increase growth rate. Kids are very susceptible to bloating and other gastrointestinal problems from milk replacers that contain a high level of lactose due to use of dried whey in their formulation. Reduced lactose milk replacers will reduce bloating problems.

A calf starter feed (with a coccidiostat such as Rumensin or Deccox, sometimes called medicated) and high quality hay should be made available the second week of life. Deccox can be used in the milk from week 2-6 to prevent coccidiosis. After 4 weeks of life, kids can be limit fed milk at one pint in the morning and also in the afternoon. This will stimulate consumption of starter feed and facilitate weaning.

Kids can be weaned after 8 weeks of age if they are consuming 2 ounces of starter per day and weigh two and a half times their birth weight (about 18 lbs). Weaning shock can be reduced by going to once a day milk feeding for several days to encourage consumption of the starter.

Considerations in Ration Formulation

Rations should be balanced not only for protein and energy, but calcium and phosphorus contents should be calculated, macrominerals supplemented, and a trace mineralized salt used to provide microminerals. A vitamin premix should be used to provide at least vitamin A and E.

If the diet is being fed at high levels to bucks or wethers, there is risk of urinary calculi. To prevent urinary calculi, the ration should be formulated with a minimum of phosphorus, over twice as much calcium as phosphorus, and a urine acidifier such as ammonium chloride at 0.5-1.0 % of the diet. Salt can also be included in the diet, such as at 1%, to reduce incidence of urinary calculi.

If the ration is being fed at high levels, sufficient fiber should be included in the diet to prevent acidosis. Dried brewers yeast and probiotics are often used in rations fed to animals at high levels to help prevent them from going off feed.

Feeds may have a coccidiostat included in the formulation to prevent coccidiosis. There are a number of coccidiostats, but Food and Drug Administration approved drugs commonly used include Deccox and Rumensin. Since goats are very susceptible to coccidiosis when stressed, such as at weaning or shipping, many starters and show feeds contain coccidiostats and have the term 'medicated' on the feed tag. Management considerations to reduce coccidiosis incidence include sanitation, cleanliness, and dry housing.

Feeding Systems

There are many methods of feeding goats. Feeds should be offered in such a way to minimize mold growth or fecal contamination that reduces intake. Mineral mixes must remain dry and should be replenished at 2 week intervals to avoid caking. Feed troughs should be designed to facilitate removal of feces and leftover feed. Troughs generally require a bar running above the length of the trough to keep goats from defecating in them.

Self feeders can be used for feeds containing sufficient roughage for use as a complete feed or for feed that has a built-in intake limiter. For large range operations, feeds such as whole shelled corn or range pellets or cubes are often fed on the ground. The feeding area is moved each day to have clean ground upon which to feed.

Hay should be fed in a rack off the ground. Feeding hay bales on the ground results in hay wastage and leaves a mess that is difficult to clean. Hay can be fed in a manger or hay feeder with keyhole slots, but horns may cause problems preventing access to feed. For large operations, unrolling round bales on the ground works well.

Nutritional Disorders

There are several diseases associated with nutritional management. These include acidosis, founder, enterotoxemia, pregnancy toxemia/ketosis, polioencephalomalacia, and urinary calculi.

Acidosis, founder, and enterotoxemia are all related to either feeding high levels of grain or a rapid increase in the level of grain in the diet. Acidosis is associated with the production of high levels of lactic acid in the rumen from a large supply of starch that the animal consumed. Endotoxins may also be produced by ruminal bacteria that exacerbate the problem.

Founder refers to problems that occur with the feet of the animal as a consequence of acidosis. The blood vessels in the hoof constrict and in the long-term cause the hoof to grow rapidly, necessitating weekly hoof trimming.

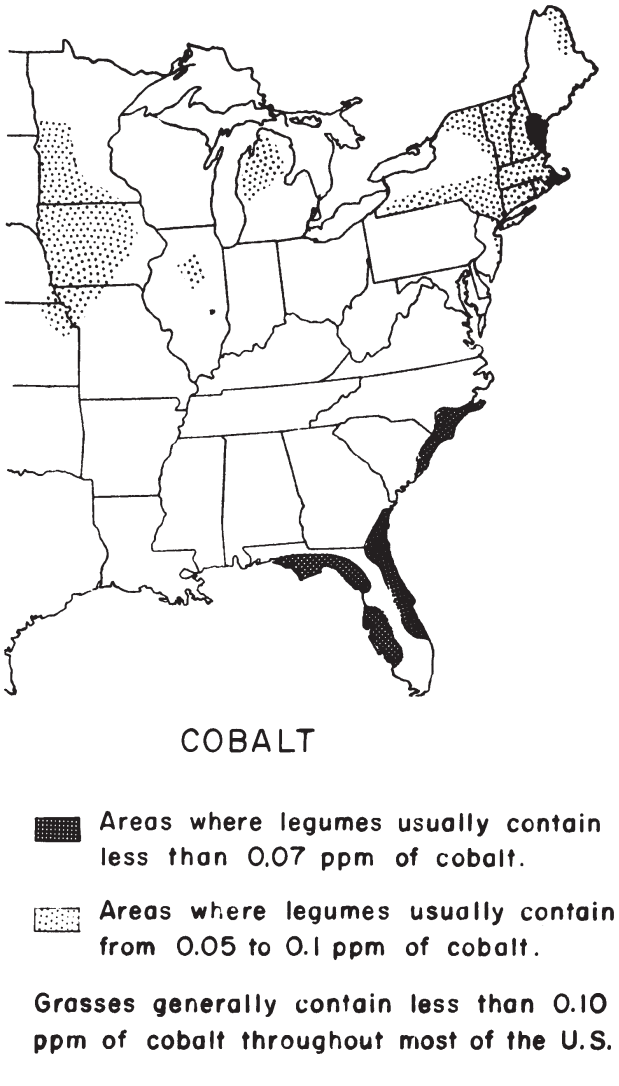
Enterotoxemia is caused by bacteria in the intestine that grow rapidly and produce an endotoxin in response to high levels of starch (grain) in the diet. Animals are in extreme pain from the effect of the endotoxin and often die quickly. Vaccination will help prevent this disease.

High levels of grain in the diet and stress are associated with polioencephalomalacia, which is a thiamine deficiency. High dietary levels of sulfur (such as from molasses in the diet) can increase incidence of the condition. The animals appear drunk, may not be able to stand, become blind, and slowly die. There is often a dramatic response to a large dose of thiamine (5 mg/lb), which may need to be repeated. These diseases can be best prevented by increasing the grain level in the diet slowly and maintaining 50% forage in the diet. Thiamine can be added to high concentrate diets at 0.25 lb/ton to aid in the prevention of polioencephalomalacia.

Pregnancy toxemia is a metabolic disease usually caused by animals being too fat (body condition score greater than 4) prior to kidding; although very thin animals (body condition score less than 2) are subject to the disease also. It is caused by a high demand for nutrients by the growing fetus in late pregnancy that is not being met (excess fat in the body and the growing fetus limit room in the stomach for food, reducing intake of the diet). This unmet nutrient demand causes a rapid breakdown of fat reserves, forming ketone bodies at high levels which are toxic. Treatments include administration of propylene glycol, large doses of B vitamins, glucose given intravenously and possibly Caesarian-section (to remove the fetuses and immediately reduce energy demand; see the Goat Health section). Prevention of the disease is far easier and more effective than treatment. Simply monitor animal body condition and adjust nutrition, especially energy, to manipulate body condition. Do NOT sharply reduce feed in late gestation as this may cause pregnancy toxemia. Also, pregnant goats in the last third of pregnancy will need a more nutrient dense diet (higher quality) due to fetal growth and reduced intake because of reduced stomach capacity. Exercise will help. Does can be encouraged to exercise by separating hay, feed and water at a substantial distance, forcing them to walk more.

Soil-Related Nutritional Problem Areas for Grazing Animals

Figure 1. Geographical distribution of Co-deficient areas in the eastern United States (ppm = 1 $\mu g/ g^{-1}$). From Kubota and Allaway, 1972, by permission Soil Science Society of America.



All soil maps were taken from Kubota, Welch, and Van Campen. 1987. Adv. Soil Sci. 6:189-215.

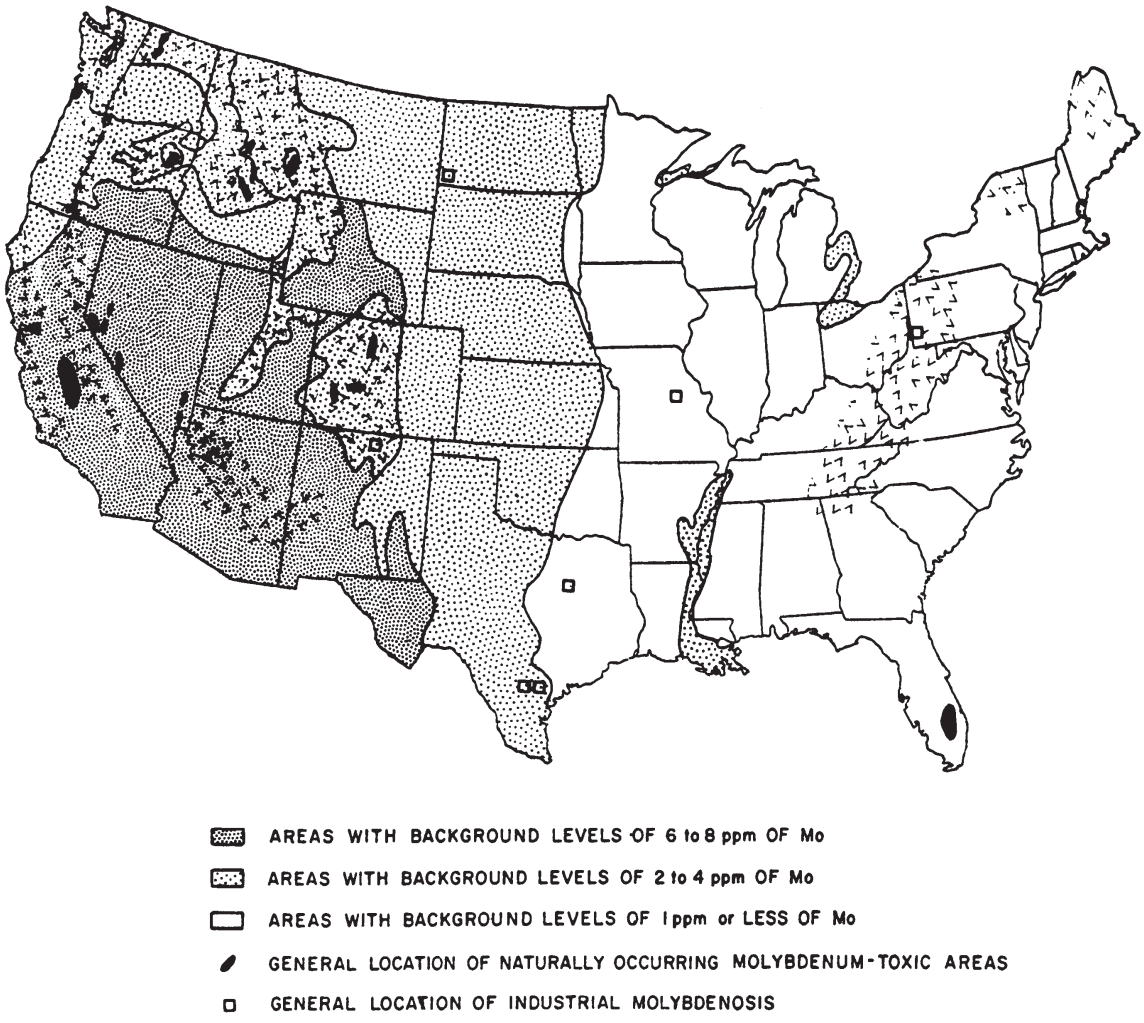


Figure 6. Generalized regional pattern of molybdenum concentration in legumes of the United States (ppm = 1 $\mu g/g^{-1}$). From Kubota, 1977, by courtesy Marcel Dekker, Inc.

All soil maps were taken from Kubota, Welch, and Van Campen. 1987. Adv. Soil Sci. 6:189-215.

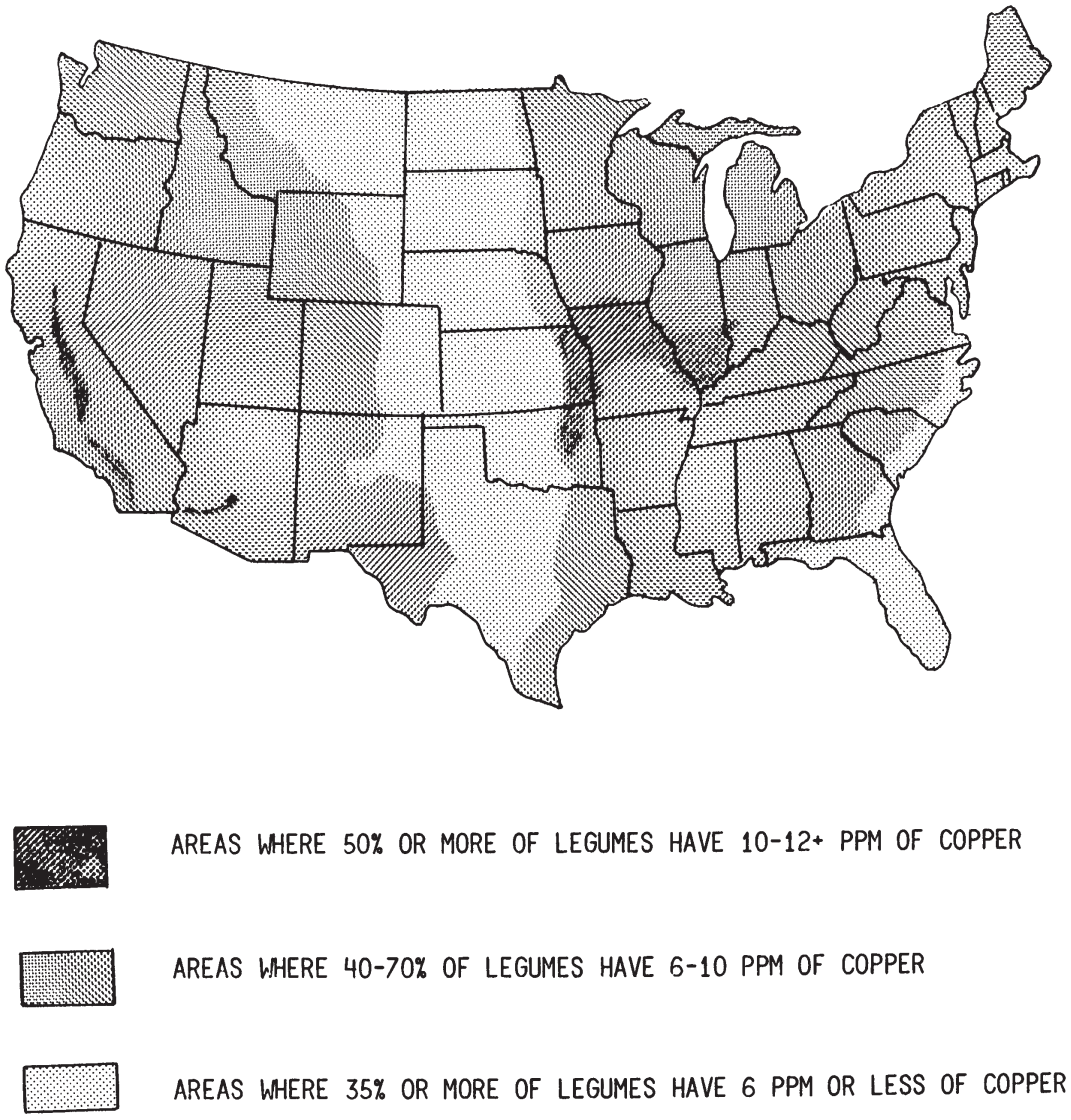


Figure 7. Generalized distribution of copper concentration in legumes of the United States (ppm = 1 $\mu g/ g^{-1}$). From Kubota, 1983a, by permission Amer. Society of Agronomy.

All soil maps were taken from Kubota, Welch, and Van Campen. 1987. Adv. Soil Sci. 6:189-215.

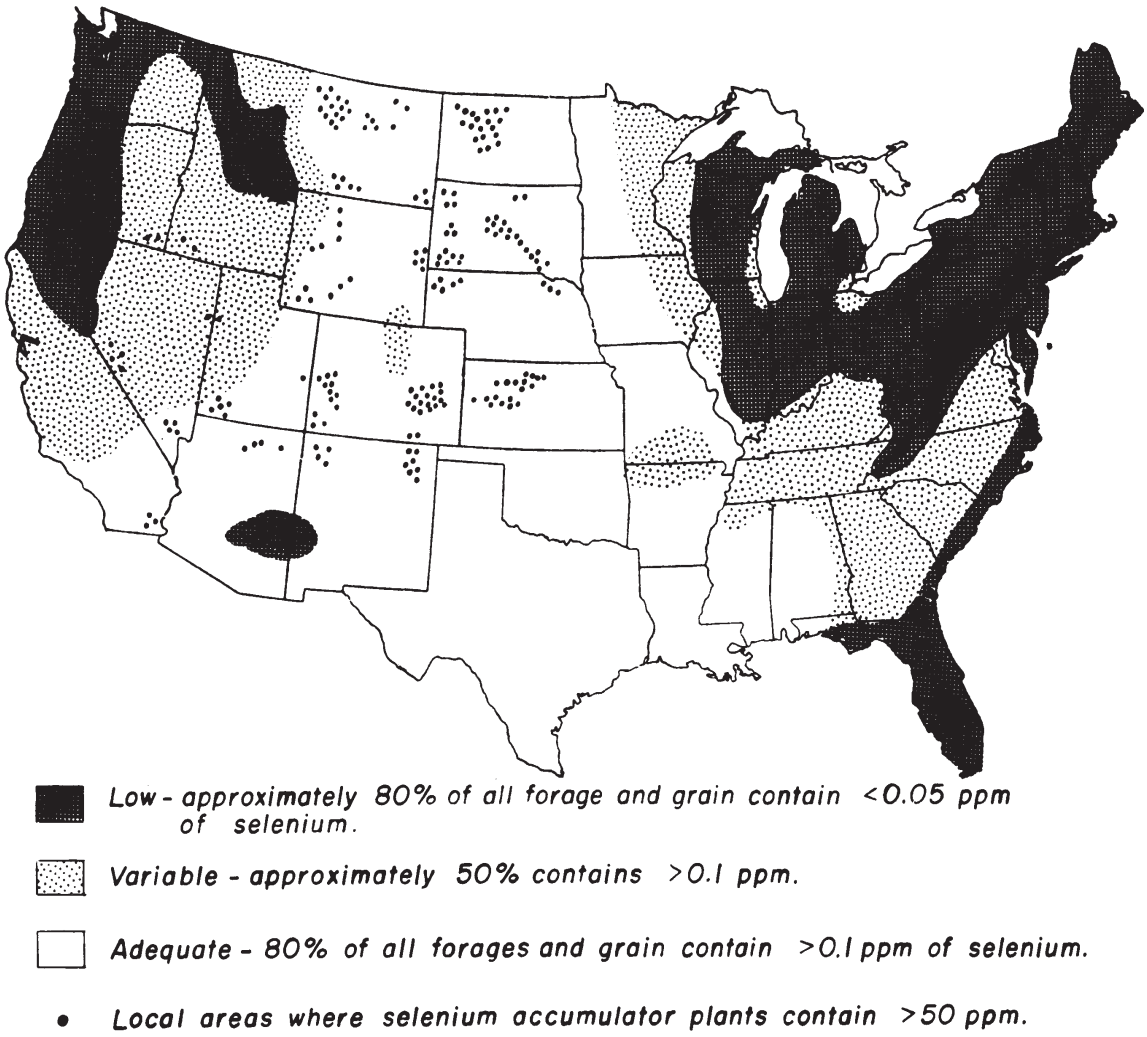


Figure 8. Geographical distribution of low-, variable-, and adequate-Se areas in the United States (ppm = 1 μg/g). From Kubota and Allaway, 1972, by permission Soil Science Society of America.

All soil maps were taken from Kubota, Welch, and Van Campen. 1987. Adv. Soil Sci. 6:189-215.

Definitions useful for this section

Acidosis - A disease usually caused by feeding too much grain or increasing the level of grain in the diet too rapidly. It results in the rumen having very acid conditions, and endotoxins may be produced that adversely affect various parts of the body.

Body condition score - Abbreviated BCS. Applying a numerical score to describe the amount of muscle and fat cover on an animal. Usually performed by feeling along the backbone in the loin area, over the ribs, and at the breastbone (sternum). Scores range from 1 (extremely thin) to 5 (extremely obese).

Browse - Vegetative parts of woody plants, primarily leaves and twigs, that typically contain high levels of tannins.

Carbohydrates - The major energy source found in most feedstuffs. Carbohydrates contain twice as many hydrogen atoms as carbon and as many oxygen atoms as carbon, commonly designated as CH_2O. They include substances such as sugar, starch, fiber, cellulose, and hemicellulose.

Cellulose - A major structural carbohydrate in plants. A component of fiber that is poorly digested by nonruminant animals. Cellulose is composed of glucose molecules chemically linked by a "beta" linkage that is only digested by bacteria such as those in the rumen and(or) cecum.

Coccidiosis - An infectious intestinal disease caused by protozoan organisms (coccidia). The disease causes diarrhea and damages the lining of the intestine. Moisture, stress, and unsanitary conditions are conducive to coccidiosis.

Concentrates - A feed with less than 20% crude fiber and usually more than 60% TDN on an as fed basis. Often a mixture of feedstuffs with added minerals and vitamins.

Crude fiber - The more fibrous, less digestible portion of a plant primarily consisting of cellulose, hemicellulose, and lignin. A method of estimating the fiber content of a feedstuff through sequential extraction with acid and alkaline solutions.

Enterotoxemia - A disease caused by an overgrowth of bacteria (*Clostridia perfringens*) in the intestine usually due to fermentation of a large quantity of starch, with production of endotoxin. Usually causes rapid death of animals.

Fiber - A component of the feed that consists of cellulose, hemicellulose, and lignin. It is necessary for normal rumen health.

Forage - The edible part of the plant, other than separated grain, that can provide feed for grazing animals.

Founder - Refers to a consequence of acidosis, resulting in rapid growth of the hoof.

Mineral - The inorganic group of nutrients including elements such as calcium, phosphorus, copper, etc.

Nutrient - One of six classes of chemical compounds having specific functions in the nutritive support of animal life.

Nutrient requirements - The level of specific nutrients required to keep an animal healthy and productive.

Nutrition - The study of nutrients, determining what nutrients are required, what levels of nutrients are necessary for various levels of productivity, and how to provide those nutrients.

Polioencephalomalacia, PEM, or 'polio' - A neurological disease of goats caused by thiamine deficiency. The rumen normally produces adequate levels of thiamine, but under some conditions such as a high grain diet, high sulfur in the diet, stress, or being 'off feed,' the thiamine is degraded, thus causing the disease.

Stockpiled forage - Forage that is allowed to accumulate for grazing at a later time.

Supplement - A feed designed to provide nutrients deficient in the animal's main diet.

TDN - Total Digestible Nutrients, a measure of digested energy. A lb of TDN equals 2,000 Calories (kilocalories).

Vitamins - Specific organic substances required for various metabolic functions.

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Tanning Goat Hides

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Introduction

Recently, there seems to be a renewed interest in tanned hides for use in the home as decoration, rugs, or coverings for chairs or other uses. A local farm supply store has even begun to carry tanned calf and cow hides. While attractive, the cost of purchasing a professionally tanned hide may be prohibitive for many people. Tanned sheep hides have been commonplace for years. Why not a tanned goat hide? Many goats have attractive hides that could be tanned and used in many ways. Learning the art of tanning hides can be very rewarding, through acquisition of new skills and the attractive products resulting from the endeavor. Tanning at home is also less costly than purchasing a tanned hide. When sending hides to a tanner, costs may be on a per hide or per square foot basis. Deer hides generally range from $45 - $60 unless it is exceptionally large. Calf, cow, and other larger hides will be on the square foot basis. Kits, some designed to tan up to 20 pounds of hide or the equivalent of two deer skins, can be purchased for between $15 and $35. The other equipment needed to tan hides can be purchased or much of it can be fashioned from items found around most households or farms. Although home tanning may not match the quality of a professional tannery, good quality, long-lasting products can be made. However, if you do have a special hide, it is best to send it to a professional rather than attempting it yourself. This is particularly true if you are new to the art of tanning.

Where to Find Information

The Internet is good place to begin learning about tanning hides. Much information will be found in conjunction with taxidermy or taxidermy supply companies. Skins and hides must be tanned before being mounted and the tanning methods used in taxidermy are very appropriate for home use. There are tanning chemical suppliers, taxidermy supply companies, and other outdoor sporting goods companies that sell tanning chemicals, supplies, and kits on-line or via catalogs. Some of their web pages and catalogs have very informative “How to” sections that provide excellent information on hide handling and newer tanning methods. Visit some of these sites (listed at the end of this article) to learn about products and techniques and also to purchase kits and supplies[1].

A local taxidermist or sporting goods store is another potential source of information and supplies. Books on home tanning and leathercraft are available but most were written between twenty and thirty years ago and do not contain information on newer tanning methods. One recent book, “The Ultimate Guide to Skinning and Tanning” by Monte Burch, 2002, does contain information on new techniques and chemicals (see the book list at the end of the article). Finally, the directions for use included with many tanning chemicals provide good detail and instruction on hide preparation and chemical usage.

When searching for tanning information on the Internet one will come across the art of “brain tanning.” This is the traditional method used by Native Americans and other cultures of using animal brains to make buckskin. This can certainly be done with goat hides. In addition to websites dedicated to “brain tanning,” several good texts have been written on the subject.

[1] Mention of trade names, proprietary products, or vendors does not imply endorsement by Langston University or the E (Kika) de la Garza American Institute for Goat Research of the products or vendors named or criticism of similar products or vendors not mentioned.

Different Tanning Processes

Before selecting a particular type of tanning method to try, it is best to familiarize yourself with some of the tanning processes available. Tanning methods can be vegetable, mineral, aldehyde, or synthetic. Oil tanning methods are used in the production of chamois leather. Vegetable tanning is the oldest method and uses tannins found in the bark and other parts of certain trees and shrubs. Extracts from oak, sumac, chestnut, and quebracho are a few of the "vegetable" tanning materials available. Vegetable tanning is used to produce heavy leathers, such as harness or sole leather, and the material used gives leather its characteristic color. It is not suitable for hair-on tanning and can result in stiff leather. Vegetable tanning can be tried at home by grinding bark, leaves, twigs, seeds, and other parts of tanning-containing plants into a solution into which small hides could be immersed. The tanning process is slow and thick hides can take months to finish. To test if the tanning process is complete, cut a thin strip of the hide and see if the color is the same throughout without a lighter middle layer indicating incomplete tannin penetration. The ultimate test of a properly tanned hide is to put a small piece into boiling water. If incompletely tanned, the piece will curl up; a properly tanned hide should be unaffected by boiling water (Hobson, 1977) or withstand at least two minutes of boiling before it begins to curl (G. Dimaio, Industrial Specialist, USDA-ARS Hides, Lipids, and Wool Research Unit, Eastern Regional Research Center, Wyndmoor, PA, personal communication).

Of the mineral tanning methods available, chrome tanning is the most common and uses chromium sulfate as the tanning agent. It is mainly an industrial process used for leather production on dehaired hides. It can be tried at home and chrome tanning agents are available from taxidermy supply stores. However, the chemicals need to be used with care and the spent solutions require proper disposal. There are other methods more suitable for home tanning. Aluminum salts are another mineral tanning method. Alum tanning is a method described in many texts. A disadvantage of alum tanned hides is that they may "sweat" if atmospheric humidity becomes too high. Additionally, inadequate washing of the hide after tanning to remove excess chemicals may leave acid residues that could react with moisture and damage the hide. Lutan F, made by BASF and available from many suppliers, is a mineral powdered tanning agent that is very popular in tanning hides for taxidermy and can be used at home with good results.

Synthetic tanning agents or syntans have been developed as a result of advances made in the chemical industry. Syntans are man-made tanning agents that are highly reactive, form strong bonds, and when used properly result in well-tanned, long-lasting hides. Syntans may be used by commercial tanneries in conjunction with mineral tans as they improve the dyeing ability of leathers (Rittel, 1994a). For home tanning, syntans are usually used alone. One example of a syntan is EZ-100 by Rittel. EZ-100 is administered as a soak or bath in which the hides are placed after pickling and neutralizing. EZ-100 touts itself as environmentally safe by using acids and tanning agents that are biodegradable. However, the salt used in the tanning solution still means that careful disposal is warranted. Hides tanned with EZ-100 can be washed in lukewarm water. Other tanning products, including many of the "paint-on" tans discussed in the following section, may also contain synthetic tanning agents (Rittel, 1994a).

Aldehyde tanning uses formaldehyde or glutaraldehyde. Information exists on tanning hides at home with glutaraldehyde but newer tanning methods, many using syntans, are safer for home use. Oil tanning is a means of preservation and not a true tanning method. A warm oil is brushed into the hide and the hide is left in a warm place for the oil to soak in. Several applications are needed and this method is not suitable for hair-on tanning.

Selecting a Tanning Method

A final consideration in selecting the tanning method is the form of the tanning agent and its ease of use. Tanning agents are available in powder, liquid, or cream form. The powdered forms, and some liquid forms

(such as Krowtann 2000), require the mixing of the chemical into a water and salt solution and immersing the prepared hide for the specified time period. Most liquid and cream tanning agents are designed to be applied directly to the prepared hide using a paint brush or by hand wearing gloves. There are advantages and disadvantages to both systems. While paint-on tans mean one less solution to make and dispose, they require careful application. They may stain the fur or hair of the hide so care is needed around hide edges; however, all areas of the skin must be covered for absorption of the tanning agent. The amount to use may be difficult to gauge. If too heavy an application is used on thin skins the tanning liquid may be absorbed through the skin resulting in potentially discolored and(or) greasy, oily feeling fur. While the greasiness can sometimes be washed out with detergent or a solvent, the stains remain. However, paint-on tans are easy to use, result in a well-tanned hide, and are preferred by many tanners and hobbyists. Examples of paint-on tans include: Liqua-Tan, made by Knobloch's and available through many distributors; Kwiz-n-Eze by Rittel's; McKenzie Tan, available from McKenzie Taxidermy Supply; Tannit Solution, offered by Tandy Leather Co.; Bollman's Mammal Tanning Cream; and Trapper's Hide Tanning Formula. Others are also available.

Use of immersion tanning methods negates problems with discolored or greasy hair sometimes encountered with paint-on tans. However, there is a need to make solutions, monitor pH, and properly dispose of solutions. Through soaking, the tanning agent has access to both sides of the hide, although the hide should be moved occasionally while in the tanning solution to ensure that there are no folds in the hide preventing adequate chemical penetration. This can be done with the blunt end of an old wooden broom or shovel handle. Professional tanneries use rotating drums containing tanning solution and hides. Please note that the hair of deer is hollow and deer hides will float so stirring may need to be more frequent. If tanning is done correctly, weighting a deer hide to keep it submerged in the solution is not necessary. Goat hides do not have this problem. There are many kinds of immersion tanning agents. Two examples are EZ-100 from Rittel's and Lutan F.

For initial attempts at tanning, it is beneficial to purchase a kit complete with tanning chemicals, instructions, and a list of the needed equipment. Rittel's manufacturers many types of kits available from various distributors including EZ100 Kit, Trapline Tanning Kit and Rancher's Tanning Kit that both utilize Rittel's Kwik-Tan, and Dehairing and Leather Tanning Kit. Kits using other chemicals, e.g., Liqua-Tan, Para Tan, Krowtann 2000, Lutan F, etc., are also available or one can also purchase tanning chemicals individually. Authentic Taxidermy Supply Company sells a product called "One Hour Tan" that requires hides to soak for only one hour in the tanning solution. Finally, while not covered in this article, chemicals and kits are available for tanning birds and reptiles.

Basic Tanning Steps

Whatever method is chosen to use in tanning a hide - immersion or paint-on, kit, or purchase of separate chemicals - many of the basic steps are the same: skinning the animal; preserving the hide; fleshing the hide; pickling and neutralizing; the actual tanning process; oiling; drying and softening; and finishing. As with any craft there are many variations on the main themes and different texts will provide different tanning recipes, order of steps, chemicals to use and tips on how to successfully follow their method. It is a good idea to read through several methods and speak with someone knowledgeable on tanning hides before selecting a particular one. As each method or tanning recipe is slightly different, it is best to follow the instructions and learn the basics. One can then experiment in the future.

It is not the goal of this paper to present all of the tanning variations available. Rather, some pertinent information on each of the basic steps will be given. More detailed information can be found in the texts listed at the end of this paper or one of the other information sources previously mentioned. Further, the information presented is designed for the hobbyist tanner and, as such, no use of tanning machinery is required.

Skinning

Most people who want to tan a hide will also use the carcass for meat and will take the animal to a meat locker or abattoir where it will be expertly skinned. If you wish to skin an animal for its hide, be sure the carcass is fresh as putrefaction and decay begin immediately upon death. Bacteria become active breaking down tissue, damaging the hide, and causing hair slippage. Also, ligaments under the skin can shrink as the carcass cools making skinning more difficult. If you do your own butchering ensuring that a carcass is fresh is no problem; however, if an animal is found dead caution is warranted. In addition to possible problems with skinning and hair loss you may be in danger of contracting a disease. Some animal diseases, such as rabies, tetanus, and anthrax, can be transmitted to humans through contact with infected animals. If an animal is seen to be ill, acting strangely, or found dead for an unknown cause it should be buried or disposed of and not skinned, even with gloves on (Hobson,1977).

For those people who hunt or raise deer and elk and wish to tan their hides, Chronic Wasting Disease (CWD) is of concern. CWD is a transmissible spongiform encephalopathy (TSE) of which bovine spongiform encephalopathy, BSE or Mad Cow disease, is the most well-known. Scrapie in sheep and goats is also a TSE. There is currently no evidence that CWD can be transmitted to humans but wearing gloves when skinning and butchering deer has been recommended. Hunters are advised not to consume meat from suspect animals. As the disease agent is found in central nervous tissue, the practice of brain tanning has been discouraged in some areas. More information on CWD can be found at the USDA Animal Plant Health Inspection Service CWD website, http://www.aphis.usda.gov/vs/nahps/cwd; the Chronic Wasting Disease Alliance Website, http://www.cwd-info.org/; and state wildlife departments and websites.

Many people who hunt or butcher at home have experience skinning and have their own favorite tools and methods. Skinning can be done with the carcass hanging or lying. Initial cuts should be made down the midline of the belly from the anus to neck and from the legs inwards. Cuts on the legs should be done on the side where the hock and knee bend, the rearmost portion of the hind leg and the foremost portion of the front leg. This will result in a more rectangular shaped hide. It is easier to skin a hanging carcass as the skin can be pulled downwards and "fisted" away from the body, thereby lessening the need to use a skinning knife. A skinning knife should be very sharp and used sparingly to decrease the chance of cutting the skin which mars the hide. Hides can also be removed using mechanical means. No matter how the hide is removed, large amounts of fat or meat should not be taken with the skin as this material will have to be removed later and can impede salt penetration when preserving (see following section). Any obvious blood spots or dirt should be washed off. A good job in skinning will make tanning easier.

Preserving

If the hide is not to be tanned immediately it must be preserved. The goal of preservation is to stop the putrefaction and decay begun by bacteria immediately upon death. Never leave fresh hides rolled up or stacked. The heat remaining in them will encourage bacterial growth and the possibility of hair slippage increases. If skinning takes place in a different location than preservation, try to cool the hide as quickly as possible by laying it open. While plastic garbage bags are useful in handling a wet, bloody hide, do not leave hides in a closed bag. This traps the heat allowing decay to start. Begin your preservation technique as quickly as possible.

The main methods of preservation are salting, freezing, and drying. In any method, the first step is to remove any large amounts of meat or fat remaining on the hide. Salting the hide to remove moisture and create an unfavorable climate for bacterial growth is the most common preservation method. In salting a hide use only non-iodized salt such as non-iodized table salt or pickling and curing salt. Rock salt should never be used as it has impurities. A fine grain salt is preferred as large grain salt does not penetrate the hide well.

To salt a skin, lay it flat and pour a generous amount of salt, approximately one pound salt per pound hide, down the middle of the hide and rub it in thoroughly covering every portion. Fold the hide flesh to flesh, roll it up and place it on a slanting board to drain. The following day shake off the wet salt and resalt with new salt. Once the skin has finished draining it can continue in the tanning process or be laid flat to dry which may take several days or longer depending upon the weather. Hides should not be dried in direct sunlight or where temperatures are very high. Dried skins can be stored in a dry place until tanning.

Salting a hide.

Salted hides draining on a slanted board.

When preserving by freezing, the goal is to reduce the hide temperature quickly. To best do this, lay the hide flat in the freezer and when it begins to stiffen fold it flesh to flesh, roll and place inside a plastic bag. A frozen hide will last for months or even years with no damage to the hide (G. Dimaio, Industrial Specialist, USDA-ARS Hides, Lipids, and Wool Research Unit, Eastern Regional Research Center, Wyndmoor, PA, personal communication). Air drying, also called flint drying, is a less effective preservation method than salting. It is extensively used in developing countries where hides are stretched and staked to the ground or tied in frames to air dry (Kniefel, 1991).

Once you are ready to begin the tanning process, the preserved skin must be rehydrated in preparation for fleshing. Frozen hides should be soaked in water to thaw. Soak salted hides in a brine solution of one to two pounds salt for each gallon of water needed to completely cover the hide. Hides should be soaked for 24 hours or until they are like a wet dishrag. If a hide is very dry care must be used in getting it into the solution so it does not crack upon bending. Additionally, very dry hides may have to be soaked for longer than 24 hours. Relaxing agents are available that can assist in preparing the hide for tanning.

Dirty hides need to be washed. This can be done by hand prior to or following fleshing after the hide is rehydrated or fully thawed. Use mild detergent and plunge the hide in soapy water and rinse thoroughly. If slaughtering one of your own animals, you can minimize hide dirt by care prior to slaughter and during the slaughter process. Angora hides can be a problem if excessively dirty and have hay or grass matted in the mohair.

Fleshing

To flesh a hide means to scrape all fat, meat and membranes off the skin in preparation for the actual tanning process. This can be done before the hide is salted to allow easier salt penetration. Fleshing is most easily accomplished through the use of a fleshing beam and a fleshing knife. A fleshing beam is a piece of

Fleshing beam.

Fleshing knife.

wood over which the hide is draped for scraping. A common type of fleshing beam can be fashioned out of a 2″× 6″ or 2″ × 8″ board five or six feet long. One end should be cut to a blunt point and all edges rounded and smoothed. Legs are attached near the pointed end so that the fleshing beam slants upward from the ground to waist level. While this is the most common type of beam, others such as rounded logs or large PVC pipes are used.

A fleshing knife is a blade with a handle on both ends allowing even pressure to be exerted as the blade is pushed down the hide. Blades should be dull as the goal is to push and scrape all fat, meat, and membranes off the hide, leaving only the skin. A blade that is too sharp can cut the hide exposing hair roots leading to subsequent hair loss. Fleshing knives are available from many taxidermy supply stores at a reasonable cost. Alternatively, a dull draw knife or butcher knife driven into a block of wood for a second handle can be used. Churchill (1983) describes methods to make fleshing knives and other knives from used industrial hacksaw blades. Mill planer blades from logging mills can also be fashioned into fleshing knives and these types of knives are available on the Internet.

To flesh a hide, drape it over the pointed end of the fleshing beam and let it drain briefly. Push the fleshing knife down the hide scraping off unwanted material. To make fleshing easier and lessen the chance of cutting the hide, flesh with the lay of the hair. The legs should be fleshed towards the belly and the hide from the tail pushing towards the neck (Rittel, 1994b). Fleshing takes practice and initially can be time consuming but must be done properly, removing even the thin membrane held tightly onto the skin. Once a hide is fleshed any remaining dirt or blood should be removed from the coat in preparation for the next step.

Flesh down the hide, scraping off unwanted tissue.

Electric fleshing machines, found in taxidermy supply catalogs, are available for fleshing and shaving hides. The cost is usually prohibitive for the hobbyist tanner as the least expensive handheld models cost approximately $200 and bench models cost over $600. Even with machines, many professionals still do initial fleshing with a traditional fleshing knife and beam. Fleshing machines do have distinct advantages in shaving hides. Shaved hides are thinner, use less tanning chemicals due to reduced weight and result in a softer finished product. This is especially true for hides from thick-skinned species. While shaving can be accomplished using a very sharp knife, it is very difficult to produce a consistent thickness and to avoid cutting the hide. Generally, goat hides can be tanned and softened without shaving.

Pickling and Neutralizing

Pickling, as described by Rittel (1993), is the use of an acid solution to acidify and temporarily preserve a skin while physically and chemically preparing it for tanning. Most tanning recipes will call for an acid pickle, though it may be included in the tanning process itself and not a separate step. Some paint-on tans, such as Tannit solution and Liqua-Tan, are applied directly to the fleshed hide without the skin undergoing a pickle.

Pickling solutions are mixtures of water, salt, and acid made in a plastic barrel. Enough solution should be made to completely submerge the hide while not resulting in overcrowding if several hides are done together. If in doubt about proper quantity, Rittel (1993) suggests making two quarts of pickling solution for every pound of wet, drained hide. The pH must be carefully checked and proper precautions, i.e., use of eye protection, a protective apron, and rubber gloves, should be followed when using acids. Monitoring pH can be done using simple pH paper and adjustments made using acids or alkaline substances such as sodium bicarbonate. Acids should be added slowly to the pickle, pouring them along the side of the container so as to run gently into the solution. Use a wooden stick and mix slowly, but well. There are a number of acids and formulas that are used in pickling and the tanning recipe one follows will have specific instructions. As one example of a pickling solution, the EZ-100 tanning kit recommends 0.5 fluid ounces Saftee Acid (included in the kit) and 1 pound salt per gallon water.

Skins are usually left in the pickling solution for a minimum of three days after which time they must be neutralized. Neutralizing raises the pH of the skin through the use of a solution containing an alkaline substance such as sodium acetate, sodium formate, sodium bicarbonate, or other similar compound. Neutralization is generally brief, 15 to 20 minutes, after which the skins should be rinsed with clean water, drained, and put into the tanning solution (Rittel, 1993). Again, the tanning recipe or kit should have complete instructions on the neutralization method. After draining and prior to tanning, any holes in the hide should be sewn closed. This will prevent further ripping the hide during softening.

Care should be taken in disposing of the pickling and neutralizing solutions. Acid pickles should be raised to a pH of 6.5 to 7.0 before dumping. Rittel (1993) states that sulfates are considered hazardous materials and if an acid is used in which sulfates are formed local health authorities should be contacted concerning proper disposal. Do not dump or dispose of solutions where they can contaminate streams or ground water. If no other disposal means is available, neutralized solutions should be dumped in a driveway or other area where vegetation does not grow. Chemical and salt water solutions should never be put into septic systems as these can kill the microflora needed to break down waste. Contact local authorities about proper disposal methods.

Tanning

To describe the varying tanning recipes and methods is beyond the scope of this paper and those can be found in various texts, taxidermy supply, or tanning chemical dealer catalogs and in the instructions included with tanning kits or chemicals. The main tanning process may be as simple as one of the paint-on tans mentioned earlier or more complex entailing the application of chemicals in a tanning soak or bath. If making a tanning solution, the pH needs to be monitored and the solution neutralized prior to safe disposal. Hides should be stirred while in the solution to ensure proper tanning. Remove hides after the specified time length and drain and rinse prior to oiling. Do not overtan as this can result in a stiffer hide.

Powdered tanning agents will be mixed into a salt:water solution at the recommended rates. The skin is drained and weighed after neutralizing and draining. That weight is used to calculate the amount of tanning agent needed. As an example, Rittel's EZ-100 instructions state that for every pound wet, drained hide use 4 ounces salt, 0.5 ounces EZ-100, and 2 quarts lukewarm water. The solution pH should be 4.0 and skins tan

in 16 to 20 hours. Alternatively, one could mix enough solution to completely submerge the hide, though this is wasteful of chemicals.

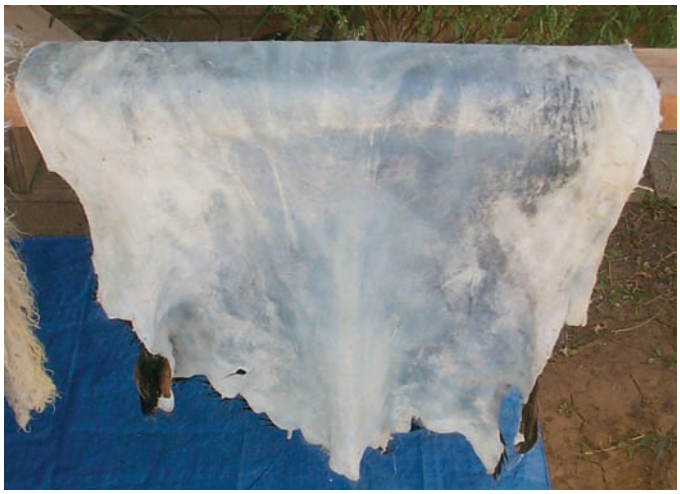
Paint-on tans that call for pickling and neutralizing also require draining before tanning. Others, such as Liqua-Tan that do not require pickling, call for the hide to be washed and drained well prior to application. The well-drained hide is laid flat on a plastic tarp and the tanning agent applied. After several hours, the excess is worked into the skin. Oiling may or may not be included in the instructions. Some paint-on tans state that oils are included in the tanning liquid, others suggest use of a separate oil for optimum softness. As an example, Knobloch's recommends applying Liqua-Soft tanning oil the day following application of Liqua-Tan if the tanned hide will be used for a flat skin or rug.

Oiling

Oiling is done to increase the softness of the finished product and many oils are available in the marketplace. If a tanning kit is purchased, the recommended oil will be included. To oil the hide, lay it flat with the flesh side up. One part oil is mixed with one to two parts hot water and liberally applied to the skin. The hide is folded in half skin to skin and again hair to hair. The folded hide should then be allowed to "sweat," or absorb oil, for approximately 4 to 6 hours. After that time, open the hide up and begin the drying process.

Drying and Softening

Drying methods can range from simple hanging or laying flat to tacking on wood or tying in a frame. Artificial heat should not be used in the drying process. Check the hide frequently to determine when softening should begin. If the hide is stretched and pulled while it is too wet it can become misshapen. If one waits too long the hide stiffens and becomes difficult to soften. If a white line appears when the hide is folded it is dry enough to begin softening. The thinner hide edges will dry out more quickly than the thicker center line and edges are usually worked first. If a hide does become too dry to soften adequately it can be rewetted using damp towels and the softening process begun again.



The white drier areas mean this skin is ready to soften.

Softening, referred to as staking, involves stretching and bending the hide to break up fibers in the skin. The time and effort spent in staking directly determines the suppleness of your final product. A common method involves use of a staking beam. This is a 2″ × 6″ board cut and fashioned in the shape of a braced, inverted T with the upright end rounded to a blunt edge. The flesh side of the damp hide is rubbed across the edge in much the same way as one shines shoes to pull, stretch and break up skin fibers. A highly effective method involves stretching and pulling the hide around a cable. Regular rope can be used but aircraft cable clamped around a pole works very well and can result in an extremely soft hide.

Commercial tanneries use equipment for softening such as large, rotating drums that tumble the hide, generally with sawdust, as it dries. In addition to softening the hide, a solvent may be added to the sawdust to help clean hair or fur. Some texts recommend using an old laundry dryer with the holes plugged for tumbling hides. Whereas this will help clean the hair, it will not help significantly in softening the hide. To do this requires a tumbler with at least a six foot drop along with 100 pounds of hardwood sawdust (P. Helms, McKenzie Taxidermy Supply, personal communication).

Staking beam.

Finishing

Finishing the softened hide entails cleaning or brushing the hair, sanding or rasping the skin side, and trimming off rough or uneven edges. The hair on some hides may only need combing or brushing whereas the hair on other hides may need a deeper cleaning. Cleaning the hair can be done with a tumbler or by simply rubbing sawdust or corn cob grit into the hair. Rittel (1994a) recommends that local sawdust not be used as it may contain pitch and be unevenly grained. Taxidermy or tanning chemical supply houses sell sawdust and solvents to be used in cleaning. Hobson (1977) explains how to use cleaning substances such as cornmeal, oatmeal, bran, chalk and plaster of Paris.

Once the hair is clean and brushed, the skin side can be sanded or rasped. This helps to remove rough spots and further soften the hide. Some staking methods can make the hide appear brown and dirty and sanding or rasping will make it look cleaner and more professional. Hide edges are usually uneven and may be stiffer than inner portions and trimming these results in a more attractive product.

Optional Steps

When reading about tanning, additional steps such as dehairing and degreasing will be found. Dehairing is accomplished by soaking the hide in a lime or caustic lye solution after which the hair is scraped off. The hide is then tanned for leather using the same or similar methods as those described. Degreasing is done on hides with large amounts of oil, such as raccoon, bear, and the like. It is unlikely that goat hides would need degreasing.

Use of Tanned Hides

Tanning is not easy and some difficulties can be expected. But, through practice and experimentation the techniques can be learned and good quality hides produced. The uses for tanned goat hides are limited only by the quality of the finished product and the imagination of the tanner, or purchaser. Rugs, seat covers, decorative wall hangings, or other handicrafts are possible.

References

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Hobson, P. 1977. Tan Your Hide! Storey Communications, Inc., Pownal, VT. 135 pp.

Kneifel, E. 1991. Goat skins supply, demand and utilization. In: T.H. Teh (Editor) Proceedings of the National Symposium on Goat Meat Production and Marketing. pp. 42-47. Langston University Agricultural Research and Extension Program and E (Kika) de la Garza Institute for Goat Research, Langston University, Langston, OK.

Rittel, B. 1994a. Syntans as a tanning agent. Breakthrough 38:26-31.

Rittel, B. 1994b. When fleshing or shaving- the only way is the right way. Breakthrough 36:22-24.

Rittel, B. 1993. The basic principles of pickling and neutralizing. Breakthrough 33:48-52.

Partial list of supplies needed to tan hides

- skinning knife if needed
- sharpening stone
- non-iodized salt, not rock salt
- fleshing knife
- fleshing beam
- plastic garbage can or barrel (metal containers should never be used)
- wooden pole or paddle to stir tanning solutions
- tanning kit or chemicals
- rubber gloves, protective apron, and eye protection for handling chemicals and solutions
- pH paper if pH of solutions must be checked
- staking beam, cable or other softening device
- comb or brush for hair
- suitable place for tanning, not too hot or cold
- area where hides can be laid upon wood or a bench, not concrete floors
- scale to weigh hides and chemicals
- source of hot water to mix solutions

List of some available books on tanning and taxidermy

Deerskins into Buckskins: How to Tan with Brains, Soap or Eggs. 2004. 2nd Ed. Matt Richards. Backcountry Publishing, Cave Junction, OR. 240 pp.

The Ultimate Guide to Skinning and Tanning: A Complete Guide to Working with Pelts, Fur, and Leather. 2002. Monte Burch. The Lyons Press. Guilford, CT. 240 pp.

Buckskin: The Ancient of Art of Braintanning (Originally titled "Wet-Scrape Braintanned Buckskin). 2001. Steve Edholm, Tamara Wilder and Jim Riggs. Paleotechnics, Boonville, CA. 307 pp.

How to Tan Skins the Indian Way. 1991. Evard H. Gibby. Eagle's View Publishing, Liberty, UT. 28 pp.

Outdoor Life Complete Home Taxidermy. 1987. Tim Kelly. Outdoor Life Books, Danbury, CT. 271 pp.

Home Tanning & Leathercraft Simplified. 1984. Kathy Kellogg. Williamson Publishing Co., Charlotte, VT. 192 pp.

The Complete Book of Tanning Skins and Furs. 1983. James E. Churchill. Stackpole Books, Harrisburg, PA. 197 pp.

The Complete Book of Taxidermy. 1979. Nadine H. Roberts. TAB Books, Blue Ridge, Summit PA. 351 pp.

Tan Your Hide! 1977. Phyllis Hobson. Storey Communications, Inc., Pownal, VT. 135 pp.

Home Book of Taxidermy and Tanning. 1969. Gerald J. Grantz. Stackpole Books, Harrisburg, PA. 160 pp.

Where to find tanning supplies and chemicals

The following is a partial list of companies and dealers that sell tanning supplies and chemicals. Other companies, dealers, or distributors can be found on the Internet at http://taxidermy.net or through using any Internet search engine. Local taxidermists and tanneries can also be a source of information and(or) supplies.

Adirondack Outdoor Company
P.O. Box 86
Elizabethtown, NY 12932
Phone: 518-873-6806
http://www.adirondackoutdoor.com/tanning.htm

Jonas Supply Company
1850 Dogwood St.
Louisville, CO 80027
Phone: 800-525-6397
http://www.jonas-supply.com

Knobloch's
1850 Dogwood St.
Louisville, CO 80027
Phone: 303-666-9045
http://www.knoblochs.com/

McKenzie Taxidermy Supply
P.O. Box 480
Granite Quarry, NC 28072
Phone: 800-279-7985
http://www.mckenziesp.com/

Rittel's Tanning Supplies
51 Summer Street
Taunton, MA 02780
Phone: 508-822-3821
Fax: 508-828-3921
http://rittelsupplies.net/

Tandy Leather Co.(Locations throughout the U.S.)
1339 SW 59th Street
Oklahoma City, OK 73119
Phone: 877-428-5754
http://www.tandyleather.com/

Van Dyke Supply Co. Inc.
Phone: 800-737-3355
http://www.vandykestaxidermy.com/

WASCO
1306 West Spring Street
P.O. Box 967
Monroe, GA 30655
Phone: 800-334-8012
http://www.taxidermy.com/

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Internal Parasite Control for Meat Goats

Dr. Dave Sparks

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Introduction

Two of the most common questions on the minds of many goat producers are; "when should I deworm my goats?", and "what should I use to do so?". Unfortunately, there are no simple answers to these questions because all production programs differ in many ways. Therefore, we will look at some of the factors that affect these answers so you can better make the decisions for your herd.

When it comes to internal parasites, goats have special problems. In cattle, roundworms are usually an economic problem in that they waste feed inputs and decrease growth and production. In goats, these same considerations are valid, but the very life and health of the animal may be threatened by *Haemonchus contortus*, or the "barber pole worm." It bleeds the goat and causes death by anemia. In addition there is a serious lack of parasiticide drugs that are labeled for legal use in goats. Only two such drugs exist at this time and research has shown that neither is very effective on Oklahoma goat farms. While there is a strong temptation to use drugs labeled for cattle or sheep according to the dose and route of administration for these species, goats are actually very different. Using cattle or sheep doses and routes will likely not be effective and can lead to resistance problems.

The reason for the lack of research and availability of legal drugs for use in goats is simple economics. A market of one million goats just can't support the research and development costs that a market of 100 million cattle can. For this reason, many of the drugs used today are used "off-label". This means that in order to be legal they must be prescribed by a licensed veterinarian who has first hand knowledge of the animals. Because all goat operations are different and any effective program will probably involve usage of off-label drugs, your local veterinarian is the best source for helping you set up a comprehensive treatment and management parasite control protocol for your farm.

Life Cycle of Roundworms

Although there are many different roundworms that live within livestock, they all have very similar life cycles. A common characteristic is that part of the life cycle takes place inside the host animal and part of it is lived in the environment. Although details will vary between parasites, the cycle can be broken down into three stages: a developmental period, a prepatent period, and a patent or adult period. Understanding what happens in each period will help to understand how management practices can reduce parasite burdens.

The developmental period is the time that the parasite lives in the environment. This period starts when the eggs passed in the host animal's manure hatch and the larvae crawl away into the grass. In the environment the larvae undergo several maturation changes, until the infective larvae (also called L3 or 3rd stage larvae) are able to climb up vegetation, on films of moisture, to await ingestion by a grazing animal. The rate at which this period progresses is determined by environmental conditions. Parasites prefer warm, wet conditions, so the cycle progresses faster and survivability is greatest in the early summer. This is the time of greatest pasture contamination. L3 can survive freezing conditions, but are very susceptible to drying. The eggs do not handle freezing well, but can survive drought conditions.

The prepatent period is extends from the time the L3 are ingested by a grazing animal until the mature worms start to lay eggs in the digestive tract. During this period the parasite develops through the L4 and

L5 or young adult stages, and may migrate through various tissues of the body during these stages before taking up residence inside the digestive tract. The preferred area of residence in the gut will vary with the species of worm. The prepatent period usually lasts from 2 to 3 weeks in young animals. Due to the higher level of immunity in adults, the prepatent period may last longer. This is important in timing parasite control program as this is how long it takes from ingestion until that animal starts contributing to pasture contamination. It is also possible for the L4 to enter an arrested development phase by burrowing into the wall of the gut if environmental conditions are not conducive to starting another generation. This allows the parasite to over-winter in the goat as well as in the environment.

The adult or patent period is the time when adult worms are present in the gut and shedding eggs into the environment via the stool. This is the time when the worms are most susceptible to control by parasiticide drugs. In the case of Haemonchus, this is also the time that the adult worm is attached to the gut wall and sucking blood from the host. Adult Haemonchus females can produce up to 5,000 eggs per female per day, and go through as many as 4 generations in one season. The adult barber pole worm population in the digestive tract of the goat can consume up to 1/10th of the goat's total blood per day.

Deworming Programs

Parasite control programs can be categorized as either therapeutic, tactical or strategic. Implementing the right program will have a tremendous impact on the level of rewards you reap from your goat operation.

Years ago all parasite programs were therapeutic programs. These involved treating the animals only when the condition progressed to the point where it caused clinical disease. At this point the program becomes an effort to salvage the affected animals. Therapeutic programs do nothing to address the subclinical losses such as decreased performance, nor do they address the problem of pasture contamination.

Tactical parasite control programs involve treating all animals in the population, often when it is convenient for the herdsman. Tactical programs help to minimize subclinical losses, but they probably do not minimize recontamination and may, in fact, contribute to parasite drug resistance problems.

Strategic parasite control programs involve a combination of management, responsible drug usage, and proper timing to ensure that animals are grazing "parasite safe" pastures for most or all of the year. Strategic programs usually take less drug inputs but require more in management, observation and herdsmanship. They address all the issues of clinical disease, subclinical losses, and contamination of the environment with subsequent reinfestation.

Parasite Control Drugs

Drugs available today for parasite control fall into four classes. It is important to know which active ingredients are in which classes because usually, when resistance occurs to one drug it confers to other drugs within that class. The main concern with parasite resistance to drugs that we have today is due to the fact that there are no new drugs on the horizon. It takes up to 10 years to get approval for a new drug and there are currently no parasite control drugs in development. Most of the drugs on the market today still work very well in cattle. Since this is the major market for food-animal drugs, there is no incentive for drug companies to undertake the massive cost of getting new drugs on the market at this time.

Only two of the drugs in the table above, albendazole and morantel, are labeled for legal use in goats. All other parasite control drugs, when used in goats, constitute "off label use" which is the domain of licensed veterinarians. As stated above, goat dosages are not the same as for sheep and cattle because their metabolism is not the same. Goats have larger livers as a percent of their body weight so they clear the drugs faster. The route of administration may also be different. Goats do not absorb drugs as easily through their skin as do other food animals. In addition to providing the correct dosage and route of administration instructions,

the prescribing veterinarian must also address the correct withdrawal time requirements for goats. Goats, when slaughtered, are randomly sampled for drug residues, and any violations are attributed to the producer who originally marketed the goat. Violations can lead to federal prosecution, stiff penalties, and for repeat offenders even incarceration.

Examples of active ingredients in the different classes of de-wormer medications.			
Benzimidazoles	*Imidazothiazoles*	*Macrocylic Lactones*	*Tetrahydropyrimidines*
Albendazole	Levamisole	Doramectin	Morantel
Fenbendazole		Eprinomectin	
Oxfendazole		Ivermectin	
		Moxidectin	

Drug Resistance

Not many years ago we began to hear of farms in Australia and New Zealand where they could no longer graze small ruminants because of the resistance of the parasites to parasite control drugs. Today we have farms in the Southeast United States that have the same problem. A recent study done by Langston University shows that serious resistance to parasiticides is developing on most goat farms in Oklahoma. Although there is nothing we can do to completely eliminate this resistance, today's parasite control programs must be designed to slow and delay it as much as possible. We can achieve this by proper use of the drugs we have, incorporating management practices into the plan, and selecting the right individuals to build our future herds on.

The following chart shows the degree of resistance found on several Oklahoma farms to Ivermec, Valbazin, Levisole, and in one case Cydectin. The numbers in the respective columns represents the percent kill the drugs achieved based on the results of fecal egg count reduction tests.

FARM	IVM	VAL	LEV	CYD
1	12	87	98	
2	37	88	99	
3	7	67	99	
4	63	85	92	
5		55	99	100
6	46	42	98	
7	41		91	
8		0	97	
9	69	74	94	

We get drug resistance because we select for it, or because we pay good money for it and bring it home in animals we purchase from other farms who have selected for it. When we deworm using drugs that are not completely effective, or when we use dosages that are too low, we kill the more susceptible worms and leave the more resistant worms. These resistant worms then become the parents of the next generation of worms. Over time as our program selects for more and more resistant worms, the drugs are less and less effective.

When deworming, it is important to leave some susceptible worms to provide competition for the resistant ones. It is also important to know what drugs are or are not effective on your farm. When half of the worms are killed you will see a good clinical response, but it will be short lived and deworming will get more and more frequent. If anything less than 95% of the worms are killed, resistance is developing. This means that by the time that you are aware clinically that the drug you are using is no longer effective, the kill rate has dropped to less than 50% and the use of this drug is lost to you. Once parasites are resistant to a drug, the resistance lasts for many years. A means to measure the effectiveness of parasiticide drugs is discussed later in this paper.

Newly purchased animals should be quarantined and aggressively dewormed in a dry lot until stool samples are shown to be clean. This prevents introducing someone else's resistance problems into your goats and across your pastures.

Management as a Parasite Control Tool

There are several ways that proper management and grazing techniques can help to control parasite problems on Oklahoma goat farms. When goats are allowed to browse as they do in nature they have few parasite problems. When we mold them to domestically managed situations we often cause these problems. Grazing and browsing systems that mimic nature as closely as possible will usually reduce the degree of parasite problems experienced.

One management technique that helps is to closely monitor the grazing height. This is not the same as the height of the vegetation. You need to actually watch and see at what level the goats are eating when they select their plants to consume. As previously stated, the L3 climb on a film of water up the vegetation so that they can be ingested. Their ability to climb, however, is not limitless. Eighty percent of the infective larvae are located in the lower 2 to 3 inches of vegetation. The goats will get almost no infective larvae if they are grazing at or above the 4 to 5 inch level. Time of grazing also is important. The film of water is vital for the larvae to climb. Producers with heavily contaminated pastures during warm and wet times of the year may consider confining the goats at night and turning them out to graze after the dew is off the plants. This greatly reduces the infestation rate.

Pasture rotation is beneficial to improve pastures and maximize utilization of the forage. It is commonly thought that this practice also reduces parasite problems, but this may or may not be true. In order to be effective as a parasite control technique, rotational grazing must be timed to break up the life cycle of the roundworms. If the animals stay in one paddock long enough for the eggs to hatch and mature to the L3 stage, or if they go around the system and return as the larvae mature to the L3 stage, the rotation doesn't help with control. Additionally the timing will change as the season, and thus the maturation process, changes.

Perhaps the most important management tool in controlling parasites is to treat only the individual goats that need help. This helps to maintain a base population of susceptible worms to compete with resistant worms. It is equally important to identify and cull those animals that repeatedly have problems. Eighty percent of the eggs that contaminate the pastures are passed by 20% of the goats. There is a good economic reason for culling these problem individuals as well. A culled goat is worth a lot more than a dead goat.

Larger commercial producers should consider a multiple species grazing program, usually involving goats with cattle or, less frequently, horses. Although all domestic animals have roundworms that are closely related, the actual species of worms are host specific. This means that cattle worms cannot develop in goats and goat parasites cannot develop in cattle. When one type of animal ingests the infective larvae of another type of animal, those larvae are essentially cleaned up or eliminated. There are economic benefits as well because cattle are grazers and prefer grass, while goats are browsers and prefer weeds, shrubs, and brush.

There is limited overlap of their preferred food supplies and it is possible to realize two income streams from one land resource, which is usually one of the highest input costs for the operation.

Parasite Resistance and Parasite Tolerance

Some goats have more problems with parasites than others, while some goats are relatively problem free under proper management. There are actually two phenomena at play here, parasite resistance and parasite tolerance. Parasite resistance is the goat's ability to suppress the population of worms that is trying to develop in the digestive tract. This is a function of the individual goat's immune system. Some individuals may have stronger specific immunity to the worms while others just have stronger ability to respond to any immunological challenge. Both genetics and nutrition play a roll here. Parasite tolerance is the individual goat's ability to carry a given parasite load with minimal impact on the goat's system. Again, both genetic and nutritional factors come into play.

These characteristics are very desirable in Midwestern goats. Researchers at Tennessee State University have shown that there are definite differences expressed between breeds. In general, breeds that were developed in wet, rainy climates have an advantage over breeds that were developed in hot, arid climates for production of goats in areas of significant rainfall. Differences between individuals within a given breed exist as well. Record keeping is important to eliminate genetics that are predisposed to parasite problems while propagating genetics associated with fewer problems.

Evaluating Parasite Problems

In order to tailor a parasite control program for your herd, it is necessary to be able to quantify what problems you are having, how serious they are, and which individuals are having the problems. Some of the tools that facilitate this quantification are fecal egg counts, fecal egg count reduction tests, DrenchRite test, and the FAMACHA system.

Fecal egg counts are conducted by mixing a known quantity of stool into a known quantity of flotation solution and examining the resulting mix microscopically in a special egg counting slide. The result is the number of worm eggs per given quantity of stool and serves as a measure of the number of adult egg laying worms that are present in the animal. This is also an indicator of how much pasture contamination is occurring, but it doesn't give any indication of the health status of the animal.

The fecal egg count reduction test measures the effectiveness or resistance to specific parasiticide drugs. To conduct this test a sample containing at least 10 randomly selected animals serves as a control, while 10 other animals are treated with a given drug. It is important that all animals in the test be of similar age, sex, and condition. After 10 to 14 days, pooled stool samples are taken from both groups and fecal egg counts are done on both. If the drug is effective the treated group will have at least a 95% reduction in fecal egg count as compared to the control group. Reductions less than 95% indicate the severity of the resistance of the parasites on your farm to that drug. It is possible to test several drugs simultaneously with the addition of more animal groups. Once you have the required equipment, consisting of a microscope and McMasters counting slide, the test is very inexpensive. You can either have it performed by any veterinary clinic or do it yourself with minimal training. This test will help you determine which drugs to avoid, which to use, and which to save for the future.

The DrenchRite test was developed in Australia and is currently being conducted at the University of Georgia, College of Veterinary Medicine. For this test a pooled stool sample is collected from a minimum of 10 animals and sent to the lab. There the parasites are hatched and the efficacy of the various drugs is measured on the worms in a laboratory environment. The results are then reported back to you for all the various drugs tested. This is an accurate and simple measure of the parasiticide resistance status of your

herd. The lone drawback is that it is somewhat expensive, but it may well save significant losses and wasted drug expense in the long run.

The FAMACHA system was developed in South Africa as a way to determine which individuals needed to be treated for parasites. It compares the color of the animal's mucous membranes, such as the inside of the eyelids, to a standardized color chart. By detecting anemia in the individual you can treat only those animals that are in danger of clinical disease or death. By keeping a record of the findings on the individuals within the herd you can recognize which goats are perpetual problems and should be culled, and which goats are relatively trouble free and should be perpetuated. This is a good test for the barber pole worm, but doesn't address the problem of other worms which do not suck blood, but may be lesser problems by robbing the goat of nutrition.

Conclusion

Today's major challenge for goat producers is to provide a parasite safe environment for their goats while minimizing the development of parasiticide resistance. Achieving these goals requires an understanding of the parasites, selection of the right goats, and incorporating the right management practices. Your local veterinarian can be your ally in combining these considerations into the right program for your operation.

The proper citation for this article is:

Sparks, D. 2007. Internal Parasite Control for Meat Goats. Pages 119-124 in Proc. 22nd Ann. Goat Field Day, Langston University, Langston, OK.

Body Condition Scores in Goats

Dr. Mario Villaquiran, Dr. Terry Gipson, Dr. Roger Merkel, Dr. Arthur Goetsch, and Dr. Tilahun Sahlu

Langston University

Introduction

Every goat producer has animals that are either too thin (under-conditioned) or too fat (over-conditioned). Failure to recognize these animals and take corrective actions will cost dearly in terms of decreased fertility, increased disease or internal parasite incidence, decreased milk production, and increased operating costs. Thus, goats need to be maintained with a moderate amount of body condition. When overall body condition starts to decrease in the herd, it is a sign that managerial intervention is needed such as supplemental feeding, deworming, pasture rotation, etc. Conversely, when overall body condition starts to increase in the herd, it is a sign that the producer should reduce supplemental feeding. Ignoring an animal's body condition and waiting to intervene until goats become either too thin or too fat may result in production and(or) animal losses or decreased profits from overfeeding. Therefore, producers need to develop skills in assessing body condition of their goats so that a desired moderate body condition can be maintained.

Body condition score (BCS) has been shown to be an important practical tool in assessing the body condition of cattle, sheep, and goats because BCS is the best simple indicator of available fat reserves which can be used by the animal in periods of high energy demand, stress, or suboptimal nutrition.

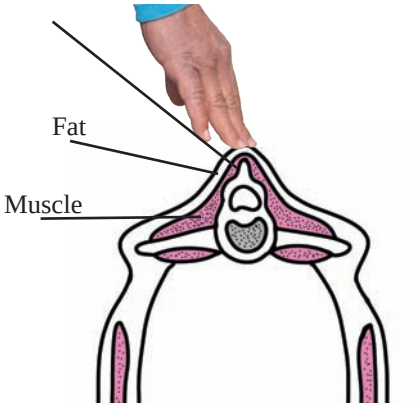
Scoring is performed in goats using a BCS ranging from 1.0 to 5.0, with 0.5 increments. Examples of BCS of 1.0, 2.0, 3.0, 4.0, and 5.0 are given using photographs and written descriptions. Assigning the 0.5 score increment is done when the animal being evaluated is intermediate to the BCS described. A BCS of 1.0 is an extremely thin goat with no fat reserves and a BCS of 5.0 is a very over-conditioned (obese) goat. In most cases, healthy goats should have a BCS of 2.5 to 4.0. BCS of 1.0 , 1.5, or 2.0 indicate a management or health problem. A BCS of 4.5 or 5 is almost never observed in goats under normal management conditions; however, these BCS can sometimes be observed in show goats.

It is important to note that BCS cannot be assigned by simply looking at an animal. Instead, the animal must be touched and felt. The first body area to feel in determining BCS is the lumbar area, which is the area of the back behind the ribs containing the loin. Scoring in this area is based on determining the amount of muscle and fat over and around the vertebrae. Lumbar vertebrae have a vertical protrusion (spinous process) and two horizontal protrusions (transverse process). Both processes are used in determining BCS. You should run your hand over this area and try to grasp these processes with your fingertips and hand. The second body area to feel is the fat covering on the sternum (breastbone). Scoring in this area is based upon the amount of fat that can be pinched. A third area is the rib cage and fat cover on the ribs and intercostal (between ribs) spaces.

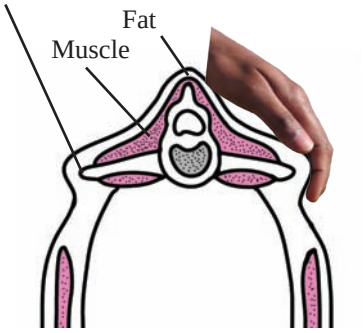
With practice, evaluating the BCS of an animal will only take about 10-15 seconds. By adding BCS as a regular part of

Lumbar Region

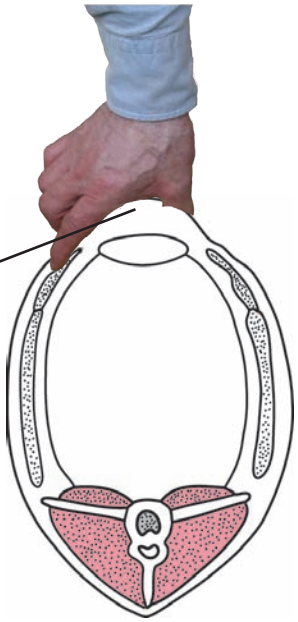
Spinous process



Transverse process



Sternum



Fat

BCS 1.0

Visual aspect of the goat: Emaciated and weak animal, the backbone is highly visible and forms a continuous ridge. The flank is hollow. Ribs are clearly visible. There is no fat cover and fingers easily penetrate into intercostal spaces (between ribs).

The spinous process of the lumbar vertebrae can be grasped easily between the thumb and forefinger; the spinous process is rough, prominent, and distinct giving a saw-tooth appearance. Very little muscle and no fat can be felt between the skin and bone. There is a deep depression in the transition from the spinous to transverse process.

The hand can easily grasp the transverse processes of the lumbar vertebrae which are very prominent. Clearly half of the length of the transverse process is discernible.

Diagrams adapted from Edmonson, et. al, 1989. J. Dairy Science, 72:68-78. Used with permission from the American Dairy Science Association.

Sternal fat can be easily grasped between thumb and fingers and moved from side to side. The cartilage and joints joining ribs and sternum are easily felt.

BCS 2.0

Visual aspect of the goat: Slightly raw-boned, the backbone is still visible with a continuous ridge. Some ribs can be seen and there is a small amount of fat cover. Ribs are still felt. Intercostal spaces are smooth but can still be penetrated.

The spinous process of the lumbar vertebrae is evident and can still be grasped between the thumb and forefinger; however, a muscle mass can be felt between the skin and bone. There is an obvious depression in the transition from the spinous to transverse process.

The hand can grasp the transverse process but the outline of the transverse process is difficult to see. About one-third to one-half of the length of the transverse process is discernible.

Sternal fat is wider and thicker but can still be grasped and lifted by the thumb and forefinger. The fat layer can still be moved slightly from side to side. Joints are less evident.

BCS 3.0

Visual aspect of the goat: The backbone is not prominent. Ribs are barely discernible; an even layer of fat covers them. Intercostal spaces are felt using pressure.

The spinous process of the lumbar vertebrae cannot be easily grasped because the tissue layer covering the vertebrae is thick. When running a finger over the spinous process, a slight hollow is felt. There is a smooth slope in the transition from the spinous to transverse process.

The outline of the transverse process of the lumbar vertebrae is slightly discernible. Less than one-quarter of the length of the transverse process is discernible.

Sternal fat is wide and thick. It can still be grasped but has very little movement. Joints joining cartilage and ribs are barely felt.

BCS 4.0

Visual aspect of the goat: The backbone cannot be seen. Ribs are not seen. The side of the animal is sleek in appearance.

It is impossible to grasp the spinous process of the lumbar vertebrae, which is wrapped in a thick layer of muscle and fat. The spinous process forms a continuous line. There is a rounded transition from the spinous to transverse process.

The outline of the transverse process of the lumbar vertebrae is no longer discernible. The transverse process forms a smooth, rounded edge, with no individual vertebrae discernible.

Sternal fat is difficult to grasp because of its width and depth. It cannot be moved from side to side.

BCS 5.0

Visual aspect of the goat: The backbone is buried in fat. Ribs are not visible. The rib cage is covered with excessive fat.

The thickness of the muscle and fat is so great that reference marks on the spinous process are lost. The spinous process forms a depression along the backbone and there is a bulging transition from the spinous to transverse process.

The thickness of the muscle and fat is so great that reference marks on the transverse process are also lost. It is impossible to grasp the transverse process.

The sternal fat now extends and covers the sternum, joining fat covering cartilage and ribs. It cannot be grasped.

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Fitting and Grooming for Youth Market Doe Shows in Oklahoma

Ms. Kay Garrett and Mr. Jim and Mrs. Mary Daniel

Blue Ribbon Boers

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- **Remember** – ***ALWAYS SAFETY FIRST*** – Never use anything that does not appear safe. If you don't think something is right, stop and ask someone before you do it. Better to be safe than sorry.
- Never leave an animal tied up alone or on the stand alone. Learn how to tie a quick release knot. We suggest the slip knot.
- Never wash an animal in cold weather without the ability to dry them and warm them up quickly. Always wash and completely dry your animal before you start clipping to preserve the life of your clipper blades and a smoother clipping job.
- Until you feel confident in your ability to trim, never start out on your show animal, practice on an older animal or an animal that won't go to the show ring.
  - Equipment: Foot trimmers, clippers and shampoo. The rest of what we use is nice to have.
    * Halter
    * Grooming Stand
    * Clippers with #10 blade and 5/8" blade (Andis or Oster blades. I think Wahl's are coming out with a line comparable to the Andis and Oster)
    * Brushes and shedding comb
    * Coat finisher
- Start about 6 weeks out before your first show to get your animal into condition.
  - We condition our animals by worming, vaccinating, treating with a parasite control and good feed and hay. We suggest worming with Cydectin (1 cc per 10 pounds), vaccinating (CDT – Covexin 8, follow label), parasite control (Cylence 1 cc per 25 pounds along the back). We recommend and use Honor Show Feeds and high quality alfalfa hay.
- About a week before the show, wash your animal and trim it's feet. This will give the animal time to adjust to it's new "shoes" (feet). A couple of days before the show, rewash and finish trimming.
- A rule of thumb, if you cut long at first, then you can trim out faults. If you start short, you have no way to correct mistakes.
- We start with a # 10 and trim the wild hairs on the following places:
  - Ears
  - Chest floor
  - Front legs, dew claw, pasterns and hoof band
  - Belly
  - Tail
  - Hip
  - Hock
- We will change blades and use the 5/8 blade on the belly and hip depending on the hair length, type and quality. We will also use the shedding blade along the neck, topline and hip to smooth it out.

The proper citation for this article is:

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Fitting and Grooming for Youth Market Wether Shows in Oklahoma

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- **Remember** – ***ALWAYS SAFETY FIRST*** – Never use anything that does not appear safe. If you don't think something is right, stop and ask someone before you do it. Better to be safe than sorry.
- Never leave an animal tied up alone or on the stand alone. Learn how to tie a quick release knot. We suggest the slip knot.
- Never wash an animal in cold weather without the ability to dry them and warm them up quickly. Always wash and completely dry your animal before you start clipping to preserve the life of your clipper blades and a smoother clipping job.
  - Equipment: Foot trimmers, Lister Stablemate clippers and shampoo. Some other equipment that we like to use:
    - Halter
    - Grooming Stand
    - Slick sweater
    - Body blanket
    - Small clippers with #10 blade for small areas
      - Head, Feet, Trim legs, Horn base, Tail
- The wethers are completely slick shorn above the hocks. It is not wise to leave hair on the wethers. Leaving lots of hair on wethers make the wethers to appear fat and overly conditioned and finished when the judge handles them and analyzes them at a show.
- To trim below the hocks and tail, be very careful. You do not want to slick shear the legs. You only need to trim up the wild hair. You want to leave as much hair on as possible. You do not want the animal to appear "deer like". You will want to trim the hoof band and slick up the tail. The head needs to be slick sheared paying special attention under the chin and around the horns. Leave no hair on in the head area. I suggest using a small clipper such as the doe clippers around the head, leg and tail area with a number 10 blade. The tail should be trimmed up close but not completely sheared.
- Keep the blades oiled every 10 minutes or every time you switch sides on an animal.
- If the weather is cold, be sure to cover up your animal with blankets and slickies and use a heat lamp if necessary.
- Never, Never, Never, Never, Never, Never, Never, Never, Never, Never, Never, Never trim a doe in this fashion unless you plan on showing her with wethers for her show career. She will not compete in a regular doe show if she is slick sheared.
- Some suppliers that we use and are reputable dealers.
  - Outback Laboratories - www.outbacklabs.com - 405-527-6355
  - Hoegger Caprine Supply - 1800-221-4628 – www.thegoatstore.com
  - Jeffers – 1800-533-3377 – www.jefferslivestock.com
  - Mid-State – 1800-835-9665 – www.midstatewoolgrowers.com

The proper citation for this article is:

Garrett, K., J. Daniel, and M. Daniel. 2007. Fitting and Grooming for Youth Market Wether Shows in Oklahoma. Page 133 in Proc. 22nd Ann. Goat Field Day, Langston University, Langston, OK.

Extension Overview

Terry A. Gipson

Goat Extension Leader

The year 2006 was a busy year for the Langston Goat Extension program. The goat extension specialists have answered innumerable producer requests for goat production and product information via the telephone, letters and e-mail, have given numerous presentations at several state, regional, national and international goat conferences for potential, novice and veteran goat producers, and have produced a quarterly newsletter. They have also been busy with several major extension activities. These activities include the annual Goat Field Day, Langston Goat Dairy Herd Improvement (DHI) Program, grazing demonstrations, the eighth annual meat buck performance test and various goat workshops on artificial insemination and on internal parasite control.

Goat Field Day

Our annual Goat Field Day was held on Saturday, April 29, 2006 at the Langston University Goat Farm. This year's theme was Organic Goat production.

Our featured speakers were Rev. Dr. Lisa Waltz, who spoke on organic meat goat production, and Ms. Nancy Coonridge, who spoke on organic dairy goat production.

Rev. Dr. Lisa Waltz, is a Naturopathic Doctor, Certified Traditional Naturopath, Certified Nutritional Consultant, ordained minister, and holds a Doctorate of Divinity. Dr. Waltz is also the author of "The Herbal Encyclopedia - a Practical Guide to the Many Uses of Herbs" and owns and operates The Natural Wellness Center. She has been raising meat and dairy goats the natural way, free of chemical intervention, for over 15 years. The herd consists of paint, solid, and traditional Boers, colorful Nubians, and percentages of the two breeds. Performance bred American Quarter Horses are raised alongside the goats at her small all-natural ranch known as Waltz's Ark, located near Delta, Colorado.

Nancy Coonridge has been making her living from her goats "in the Wilds of New Mexico" since 1982. Her Alpine, Nubian and LaMancha does graze the dry high desert range daily. Nancy's Grade A Dairy, Coonridge Organic Goat Cheese has been certified organic by the New Mexico Organic Commodities Commission since 1998. Before moving to New Mexico Nancy produced milk for an evaporated milk co-op, and two goat cheese co-ops. She managed a Grade A Dairy in California for a short time. She also edited the "Goat Products" newsletter for two years.

Mr. Bryan Buchwald of the Oklahoma Department of Agriculture spoke on rules and regulations for organic certification and production.

In the afternoon session, participants broke into small-group workshops. The afternoon workshops included:

1. Natural Medicine for Organic Goat Production,
2. Regulations and More Regulations,
3. Organic Cheesemaking Overview,
4. Basic Goat Husbandry - hoof trimming, farm management calendar, disbudding, etc.,
5. Basic Herd Health - herd health program including vaccinations and other approved drugs,
6. Nutrition for Production,
7. Legal Aspects of Goat Production,
8. Livestock Guardian Dogs,

9. Goat Budgets,
10. Predator Control,
11. Introduction to Artificial Insemination,
12. Benefits of Government Programs - overview of USDA Natural Resource Conservation Service's work and its cost-sharing program and of the Farm Service Agency's work with loans for farming activities,
13. General Youth Activities - fun activities for younger youth, and
14. Fitting and Showing for Youth and Adults - full day workshop.

Ms. Sheila Stevenson hosted a full day of activities for youth ages 5-12. This allowed parents and older teens to enjoy the workshops knowing that their little ones were having fun in a safe environment. Some activities included pony rides, PYOP (pot your own plant), Okalahoma mobile educational unit, wood turning, face painting and many other activities.

Other youth and interested adults were able to participate in a full-day clipping, fitting, and showing workshop conducted by Ms. Kay Garrett of the Oklahoma Meat Goat Association. Participants had the opportunity to have hands-on practice of clipping and fitting a goat and then show it before a judge in the show ring.

Attendance at the Goat Field Day increases every year. This year 527 people pre-registered; 169 by mail and 358 by the web site. Of the 527 pre-registered individuals, 422 actually attended the Goat Field Day. In addition, 104 people registered on-site. The total number of participants for the 2006 Goat Field Day was 526.

The breakdown of participants by state of residence is:

State	Pre-registered by mail	Pre-registered by web	On-site registration	Total
Arkansas	2	3	?	5
Illinois	0	1	?	1
Kansas	6	12	?	18
Missouri	2	9	?	11
Oklahoma	133	240	?	373
Tennessee	0	1	?	1
Texas	1	10	?	11
Virginia	0	1	?	1
Wisconsin	0	1	?	1
Total	144	278	104	526

Goat DHI Laboratory

The Langston Goat Dairy Herd Improvement (DHI) Program is housed at the dairy farm, west of campus, operates under the umbrella of the Texas DHIA. In February 1998, the Langston DHI program became the first DHI program to introduce forms and reports in goat terminology to dairy goat producers in the United States. A national Dairy Herd Improvement Association (DHIA) has been in existence for a number of years. However, until 1996 DHIA catered only to cow dairies. The Langston DHI program has been very popular with dairy goat producers and has grown significantly since its establishment in 1996. Goat producers are now able to get records for there animals that reflect accurate information with the correct language. Currently

we are serving a 27 state area that includes a majority of the eastern states. We have over 100 herds in these 27 states enrolled in the Langston Goat Dairy DHI Program. Langston University continues to serve the very small-scale dairy goat producer. The average herds size on test with Langston University is 10 animals. This is significantly smaller than the herd size average for the five other processing centers.

For those interested in becoming a Langston goat DHI tester, training is available either in a formal classroom setting or through a 35-minute video tape. Every tester is required to attend the DHI training session or view the tape and take a test. Upon completion of the DHI training, the milk tester can start performing monthly herd tests.

Goat Newsletter

The Goat Extension program published four issues of the 8-page Goat Newsletter in 2006. Interest in the newsletter has grown and we currently have over 3400 subscribers to our free quarterly Goat Newsletter and the subscription list continues to increase every year. The Goat Newsletter is mailed to every state in the nation and to 10 countries overseas. Ninety-seven percent of the mailings go to American households. At least one newsletter is mailed to a household in every state in the nation. Fifty percent of the newsletters are mailed to Oklahoma households. An additional thirty percent of the newsletters are mailed to households to state adjacent to Oklahoma.

Artificial Insemination Workshop

The use of superior sires is imperative in improving the genetic composition of breeding stock. Artificial insemination has long been used in the dairy cattle industry and is a simple technology that goat producers can acquire. However, opportunities for goat producers to the necessary skills via formal and practical instruction are not widespread. Langston University has instituted a practical workshop for instruction in artificial insemination in goats. Producers are instructed in the anatomy and physiology of the female goat, estrus detection and handling and storage of semen. Producers participate in a hands-on insemination exercise. An understanding of the anatomy and physiology enable the producer to devise seasonal breeding plans and to troubleshoot problem breeders. An understanding of estrus detection enables the producer to effective time inseminations for favorable conditions for conception and to effectively utilize semen. An understanding of semen handling and storage enables the producer to safeguard semen supplies, which can be scarce and costly. The experience of actually inseminating a female goat enables the producer to practice the knowledge that they have gained. The acquisition of these inseminating skill will allow producers the use of genetically superior sires in their herds that they normally would not have access to. It also allows producers to save money by conducting the inseminating themselves instead of hiring an inseminator. In 2006, AI workshops were held in September at the Langston University campus and in October at the county fairgrounds in Tahlequah and the county fairgrounds in Antlers.

Controlling Internal Parasites Workshop

In 2006, Langston University conducted several workshops on controlling internal parasites. Controlling internal parasites is the number two cost of production for goat producers. Many of the anthelmintics on the market are not labeled for goats and there is considerable confusion about effective control programs among goat producers. Goat producers tend to underdose and overuse anthelmintics; both hasten anthelmintic resistance. Langston University initiated a workshop to help goat producers develop a sustainable control program for internal parasites. In the workshops, goat producers learn about the life cycles of the most common and the most pathogenic parasites, various families of anthelmintics, correct dosage and dosing procedures and how to collect fecal samples and how to conduct fecal egg counts. An understanding of life cycles enables the goat producer to devise seasonal control strategies. An understanding of anthelmintics

enables the goat producer to rotate anthelmintics for more efficacious control and to follow withdrawal times. An understanding of correct dosage and dosing procedures enables the goat producer to administer anthelmintics to achieve optimal efficacy. The ability to conduct fecal egg counts allows producers to deworm their goats on an as-needed basis instead of a calendar or other equally unreliable bases. A decrease of just one deworming will save the goat producer $1.20 per goat, slow anthelmintic resistance and better ensure a wholesome product.

Nutrient Requirements of Goats

Under a research project which developed equations for energy and protein requirements for goats, as well as prediction of feed intake, an extension sub-project developed a website calculation system for "Nutrient Requirements of Goats" (http://www2.luresext.edu/goats/research/nutreqgoats.html). Most calculators were based on studies of the project reported in a Special Issue of the journal Small Ruminant Research. For calculators with score inputs (i.e., grazing and body conditions), pictures are available to aid in determining most appropriate entries. Realistic examples are given, as well as discussion of appropriate and inappropriate usage. However, for the experienced user there is an option to hide text and examples and to view only inputs and outputs.

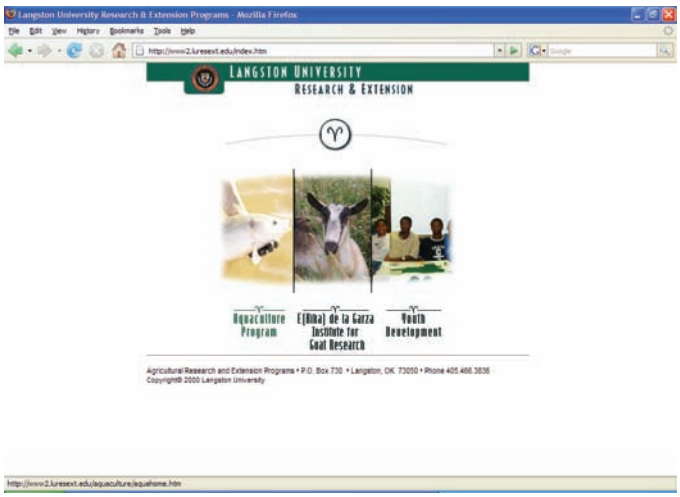
In 2005, a calculator for calcium and phosphorus requirements was added to the existing calculators for metabolizable energy, metabolizable protein, and feed intake. for suckling, growing, mature, lactating, gestating, and Angora goats. Also in 2005, the interface of the calculators was unified into a single calculator with the English measurement system used. This will encourage the use of the calculators by American producers. The least-cost ration balancer was modified so that it incorporates the least-cost feed percentage into the diet. Also, calculators are equipped with printable version commands to obtain inputs and outputs in hard copy format.

In summary, for nutrient requirement expressions to be of value, they must be readily accessible and reasonably simple. Therefore, a web-based goat nutrient requirement system was developed based on findings of a recent project. It is hoped that this system will enjoy widespread usage and enhance feeding practices for goats.

Internet Website

http://www2.luresext.edu

The Agricultural Research and Cooperative Extension program of Langston University recently unveiled a new and improved Internet web site. The Internet address (URL) of the new web site is http://www2.luresext.edu.



Capabilities of the new web site include a document library with the complete proceedings of the annual Goat Field Day for the past three years and the quarterly newsletter for the past several years. Both the proceedings and newsletters are also available in portable document format (pdf), which allows for the viewing and printing of documents across platform and printer without loss of formatting.

Information, recent abstracts and scientific articles of completed and current research activities in dairy, fiber and meat production are available for

online viewing and reading. Visitors will be able to take a Virtual Tour of the research farm and laboratories, complete with digital photos and narrative. Visitors will also be able to browse a digital Photo Album. Visitors will also be able to subscribe to our free quarterly newsletter online. Visitors will be able to test their knowledge of goats with the interactive goat quiz which covers nearly all aspects of dairy, fiber and meat goat production. For those questions that are lacking in the interactive quiz database, visitors will be able to submit a question to be included in the database. Visitors will be able to read about research interests of faculty and will be able to contact faculty & staff via email.

Web-based Training for Meat Goat Producers

Meat goat production is one of the fastest growing sectors of the livestock industry in the United States. New producers, as well as some established ones, have an expressed need for current, correct information on how to raise goats and produce safe, wholesome products in demand by the public. As the meat goat industry grows and evolves, a quality assurance program is essential. Such a QA program ensures the production of a wholesome product that satisfies consumers and increases profit for the meat goat industry.

Langston University was awarded funding by the Food Safety and Inspection Service of USDA to develop training and certification for meat goat producers. Langston University organized and led a consortium of 1890 universities and producer associations in this project. The consortium identified the subject topics most pertinent and pressing for the instructional modules. The consortium then identified experts on the selected subject topics and pursued these experts as module authors. These authors represent the most qualified persons in their field in academia as well as in the industry. Langston University translated the sixteen instructional modules into web pages with accompanying images, and pre- and post tests for those producers wishing to pursue certification. All modules are also available in pdf for easy printing and the introductory module is available as a podchapter for downloading and listening on your favorite mp3 player. The web-site (http://www2.luresext.edu/goats/training/qa.html) was unveiled in late 2005.

Even though this web-site (http://www2.luresext.edu/goats/training/qa.html) was only unveiled in 2006, 289 producers have enrolled for certification and 11 have completed the certification process. These instructional materials will best serve meat goat producers in assisting them to produce a safe, wholesome, healthy product for the American consumer. Funding source for this project was USDA/FSIS/OPHS project #FSIS-C-10-2004 entitled "Development of a Web-based Training and Certification Program for Meat Goat Producers."

Body Condition Score Pamphlets

Every goat producer has animals that are either too thin (under-conditioned) or too fat (over-conditioned). Failure to recognize these animals and take corrective actions will cost dearly in terms of decreased fertility, increased disease or internal parasite incidence, decreased milk production, and increased operating costs. Thus, goats need to be maintained with a moderate amount of body condition. When overall body condition starts to decrease in the herd, it is a sign that managerial intervention is needed such as supplemental feeding, deworming, pasture rotation, etc. Conversely, when overall body condition increases excessively in the herd, it is a sign that the producer should reduce supplemental feeding. Ignoring an animal's body condition and waiting to intervene until goats become either too thin or too fat may result in production and(or) animal losses or decreased profits from overfeeding.

Producers need to develop skills in assessing body condition of their goats so that a desired moderate body condition can be maintained. Body condition score (BCS) has been shown to be an important practical tool in assessing the body condition of cattle, sheep, and goats because BCS is the best simple indicator of available fat reserves which can be used by the animal in periods of high energy demand, stress, or suboptimal nutrition. Langston University has developed two educational tools for assisting goat producers with body

condition scoring in goats. The first is a BCS pamphlet and the second is a web site (http://www2.luresext.edu/goats/ research/ bcs.html).

These educational resources for assessing BCS should enable the goat producer to evaluate management direction and to correct deficiencies or excesses in management; thus, improving productivity and profitability of the enterprise. More than 4,000 BCS pamphlets have been distributed.

Tulsa State Fair

At the 2006 Tulsa State Fair, Langston University participated in the Birthing Center program with twelve pregnant Spanish does. Dr. Hellwig of the Oklahoma Department of Agriculture coordinated the birthing center and said that the goats were the highlight of the center. This was a huge success and plans are underway to provide pregnant does for 2007.

Meat Buck Performance Test

Meat goat production represents the most rapidly growing animal industry in the US today, and is becoming a mainstream livestock enterprise. To further genetic progress through the identification of superior sires in the industry, Langston University and the Oklahoma Meat Goat Association established a meat goat performance test in 1997.

Entry

The tenth annual meat buck performance test started May 13, 2006 with 56 bucks enrolled from 16 different breeders. Geographical distribution is given in the table below.

State	Bucks
KS	5
MO	12
OK	9
TX	30
Total	56

Bucks were given a physical examination by Dr. Lionel Dawson, dewormed with Cydectin (moxidectin), deloused with Atroban De-Lice, given a preemptive injection of Nuflor for upper respiratory infections, and those bucks that needed booster or initial vaccinations for enterotoxemia and caseous lymphandinitis. Four weeks after check-in, all bucks were given a booster vaccination for enterotoxemia and caseous lymphandinitis.

Half of the bucks were randomly assigned within breeder to either Calan feeders or Feed Intake Recording Equipment (FIRE) system.

Average age in days and entry weight are detailed in the table below.

Type	Data	Total
Calan	Average of Entry Weight (lbs)	58.3
Fire	Average of Entry Weight (lbs)	55.8
	Total Average of Entry Weight (lbs)	57.0

Adjustment Period

The performance-testing facility only has 53 Calan feeders but 56 bucks enrolled. To accommodate all animals, the new Feed Intake Recording Equipment (FIRE) system was used. The FIRE system is a

completely automated electronic feeding system, which was developed for swine but we have adapted it to goats. Animals wear an electronic eartag, which is read by an antenna in the feeder. The FIRE system automatically records body weight and feed intake. This year, half of the bucks are in the FIRE system and half are in the Calan feeders. For producers, who enrolled more than one buck in the Buck Performance Test, the test supervisor randomly assigned half of their bucks to the FIRE system and half to the Calan feeders. The training period was much shorter for the FIRE system than for the Calan feeders. However, the bucks on the Calan feeders mastered the Calan feeders and are doing quite well. With the combined FIRE system and Calan feeders, the Oklahoma Buck Performance Test Buck now has a capacity of 100 bucks.

Because the FIRE system has not previously been used with goats, Langston University determined the appropriate stocking density per FIRE feeder. As many as 10 young goats can share a FIRE feeder and have similar performance to goats in the Calan system. Langston University also compared the FIRE system with the Calan feeders. We found no differences in average daily gain or feed intake of growing goats on the FIRE system and the well-established Calan feeders.

All bucks underwent an adjustment period of two weeks immediately after check-in. During the adjustment period, bucks were acclimated to the test ration and to the Calan feeders or to the FIRE system. For the Calan feeders, each buck wears a collar with an electronic "key" encased in hard plastic. The key unlocks the door to only one Calan feeder, thus enabling the buck to eat out of his individual feeder. Each morning, yesterday's feed that remains in the Calan feeder is weighed and removed from the Calan feeder. Fresh feed is weighted and placed into the Calan feeder. The difference in weights between the fresh feed place in the Calan feeder one morning and the remaining feed the next morning is the amount consumed. Because only one goat is capable of opening the Calan door and eating, it is possible to calculate the feed intake of the individual bucks. For the FIRE system, feed intake is automatically recorded every time a buck enters into the FIRE system to eat.

The area immediately around the Calan and FIRE feeders and waterers is concrete, however, the large majority of the inside pen is earth and is covered by pine shavings. Pine shavings were periodically added as needed to maintain fresh bedding. Bucks had free access to water provided by float-valve raised waterers. Whenever the weather was permitting, the bucks had access to the outside pens as well as the inside pens.

There were three bucks that did not finish the test. One buck weighed only 22 lbs at entry, refused to eat despite veterinary inventions and died within several days. We had two goats from the same farm that had similar problem, septic arthritis of bacterial origin. The organism was Staphylococcus auricularis. It was resistant to most common antibiotics, but sensitive to a few specialized antibiotics. The veterinarians theorized that the organism probably gained entry through the navel at birth and resided in the joint until the joint was damaged by another buck beating on them and the organism grew and destroyed the joint. We had one hernia which was repaired and one abscess problem.

Thisyear we were fortunate to hire a second year veterinary student from Oklahoma State University, Ms. Rebecca Whittington. Rebecca has done a wonderful job with the bucks.

Ration

Nutritionists at Langston University formulated the following ration. In 1999, the amount of salt and ammonium chloride was doubled due to problems with urinary calculi the previous year. Except for the increase in salt and ammonium chloride, the ration was unchanged from that which was used in the first two meat buck performance tests. The ration was fed free-choice during the adjustment period and during the 12-week test.

Ingredient	Percentage (as fed)
Cottonseed hulls	29.07%
Alfalfa meal	19.98%
Cottonseed meal	15.99%
Ground corn	15.99%
Wheat midds	9.99%
Pellet Partner (binder)	5.00%
Ammonium chloride	1.00%
Yeast	1.00%
Calcium Carbonate	0.95%
Salt	0.50%
Trace mineral salt	0.50%
Vitamin A	0.02%
Rumensin	0.01%
TOTAL	100.00%

The crude protein content of the ration is 16% with 2.5% fat, 20.4% fiber and 60.6% TDN. Calcium phosphorus and sodium levels are .74%, .37% and 1.07%, respectively. Zinc concentration is 33.04 ppm, copper is 17.15 ppm and selenium is .21 ppm. In 2003, competitive bids were sought for the buck-test feed and Bluebonnet Feeds of Ardmore, OK was awarded the contract to supply feed for the buck performance test for 2003, 2004, 2005, and 2006.

ABGA Approved Performance Test

In early 2000, the Oklahoma performance test was designated by the American Boer Goat Association Board of Directors as an ABGA Approved Performance Test. Qualified fullblood or purebred Boer bucks will be eligible to earn points towards entry into the "Ennobled Herd Book". Candidate bucks must pass a pre-performance test inspection conducted by one (1) or more ABGA approved breeders. Ten (10) points will be awarded a Boer buck who shows an average daily weight gain (ADG) in the top five percent (5%) of the animals on test. Five (5) points will be awarded a Boer buck who shows an average daily weight gain (ADG) in the next fifteen percent (15%) of the animals on test. All bucks must gain at least three-tenths (.3) pounds per day to be awarded any points.

International Boer Goat Association, Inc. Sanctioned Test

In 2003, the Oklahoma buck performance test was sanctioned by the International Boer Goat Association, Inc. The Oklahoma performance test continues to grow and to serve the meat goat industry.

Gain

The official performance test started on May 31 after the adjustment period was finished. Weights at the beginning of the test averaged 67 lbs with a range of 39 to 112 lbs. Weights at mid-point averaged 94 lbs with a range of 70 to 139 lbs. Weights at the end of the test averaged 122 lbs with a range of 94 to 162 lbs. Weight gain for the test averaged 55 lbs with a range of 33 to 76 lbs.

The type of feeder (Calan or FIRE) had no significant effect upon gain. Figure 1 shows the weekly body weight gains for both feeder types over the course of the performance test.

Average Daily Gain (ADG)

For the test, the bucks gained on averaged 0.65 lbs/day with a range of 0.39 lbs/day to 0.90 lbs/day.

Feed Efficiency (Feed Conversion Ratio)

For the test, the bucks consumed an average of 358 lbs of feed with a range of 250 to 537 lbs.

The type of feeder (Calan or FIRE) had no significant effect upon intake. Bucks on the Calan system averaged 352 lbs intake and bucks on the FIRE system averaged 363 lbs, which is a difference of 11 lbs. over the 12-week period. Figure 2 shows the average daily intake for both feeder types over the course of the performance test.

For the test, the bucks averaged a feed efficiency of 6.66 (feed efficiency is defined as the number of lbs. of feed needed for one lbs. of gain), with a range of 4.84 to 11.11.

Muscling

The average loin eye area as determined by ultrasonography was 1.82 square inches with a range of 1.38 to 2.78 square inches and the average left rear leg circumference was 16.4 inches with a range of 15.0 to 18.5 inches.

Index

For 2006, the index was calculated using the following parameters:

- 30% on efficiency (units of feed per units of gain)
- 30% on average daily gain
- 20% on area of longissimus muscle (loin) at the first lumbar site as measured by real time ultrasound adjusted by the goat's metabolic body weight:

$$\frac{\text{area of longissimus muscle (loin)}}{BW^{0.75}}$$

- 20% circumference around the widest part of the hind left leg as measured with a tailor's tape adjusted by the goat's metabolic body weight:

$$\frac{\text{circumference of hind left leg}}{BW^{0.75}}$$

The adjustment to metabolic body weight gives lighter weight goats a fair comparison of muscling to heavier goats.

The deviation from the average of the parameters measured from the goats in the performance test was used in the index calculation. Thus, the average index score for bucks on-test was 100%. Bucks that are above average have indices above 100% and those below average have index scores below 100%.

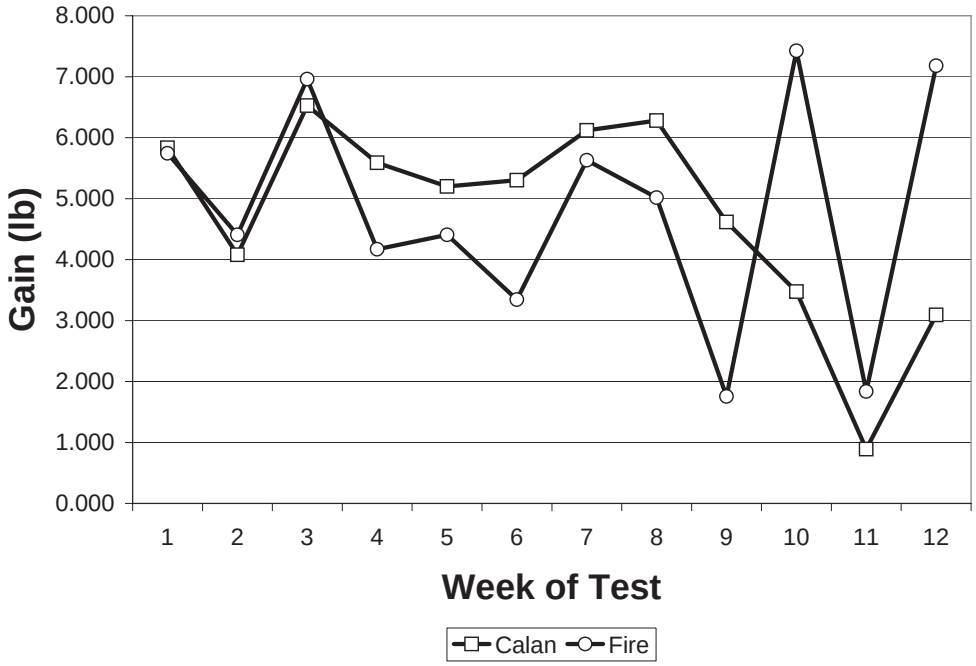


Figure 1. Calan vs. FIRE - weekly body weight gains

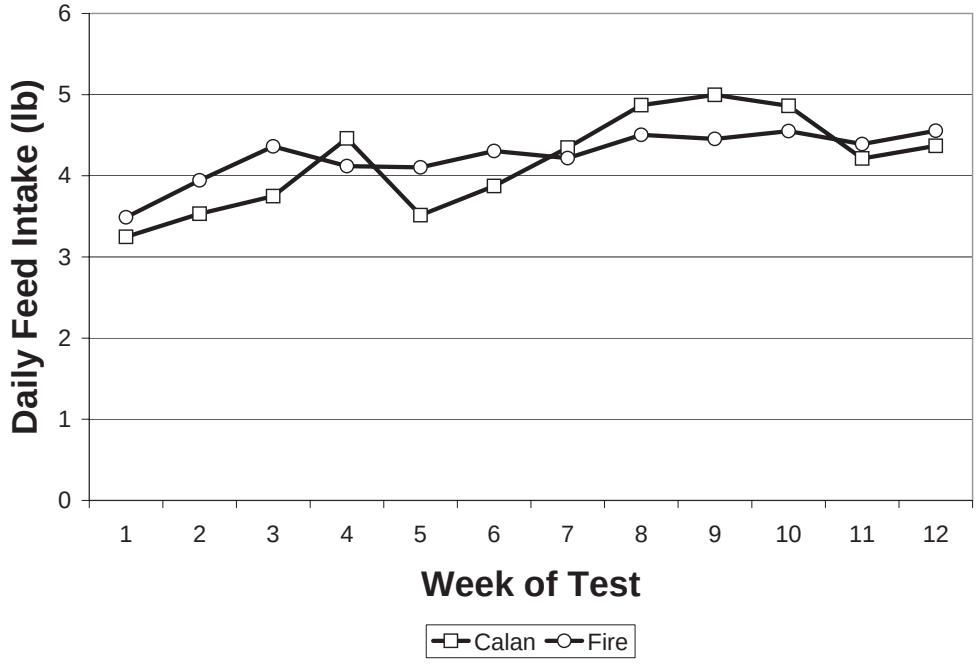


Figure 2. Calan vs. FIRE - daily feed intake

Congratulations

The Oklahoma Meat Goat Association and the Agricultural Research and Extension Program at Langston University congratulate:

- Mr. Orlin Scrivener of Cabool, MO
  for having the Top-Indexing buck
  in the 2006 Oklahoma Meat Buck Performance Test

Also, deserving congratulations are:

- Mr. Orlin Scrivener of Cabool, MO
  for having the #1 Fastest-Gaining buck

- Mr. Orlin Scrivener of Cabool, MO
  for having the #2 (tie) Fastest-Gaining buck

- Mr. Dan Wagner of Sonora, TX
  for having the #2 (tie) Fastest-Gaining buck

- Ms. Paula Lane of Shady Point, OK
  for having the #2 (tie) Fastest-Gaining buck

- Mr. Dan Wagner of Sonora, TX
  for having the #5 Fastest-Gaining buck

- Mr. Martin Peters of Barksdale, TX
  for having the Most-Feed-Efficient buck

- Mr. Marvin Shurley of Sonora, TX
  for having the Most-Heavily-Muscled buck

Acknowledgments

The Buck Test supervisor wishes to acknowledge Dr. Lionel Dawson of Oklahoma State University for his contributions as the admitting and on-call veterinarian, Ms. Rebecca Whittington for their management and oversight of the day-to-day activities, Mr. Jerry Hayes and Mr. Erick Loetz of Langston University for aid and supervision, Mr. Les Hutchens and his associates at Reproductive Enterprises, Inc. for conducting the ultrasound measurements for the loin eye area and the breeding soundness exams, and Bluebonnet Feeds of Ardmore, OK for custom mixing the feed.

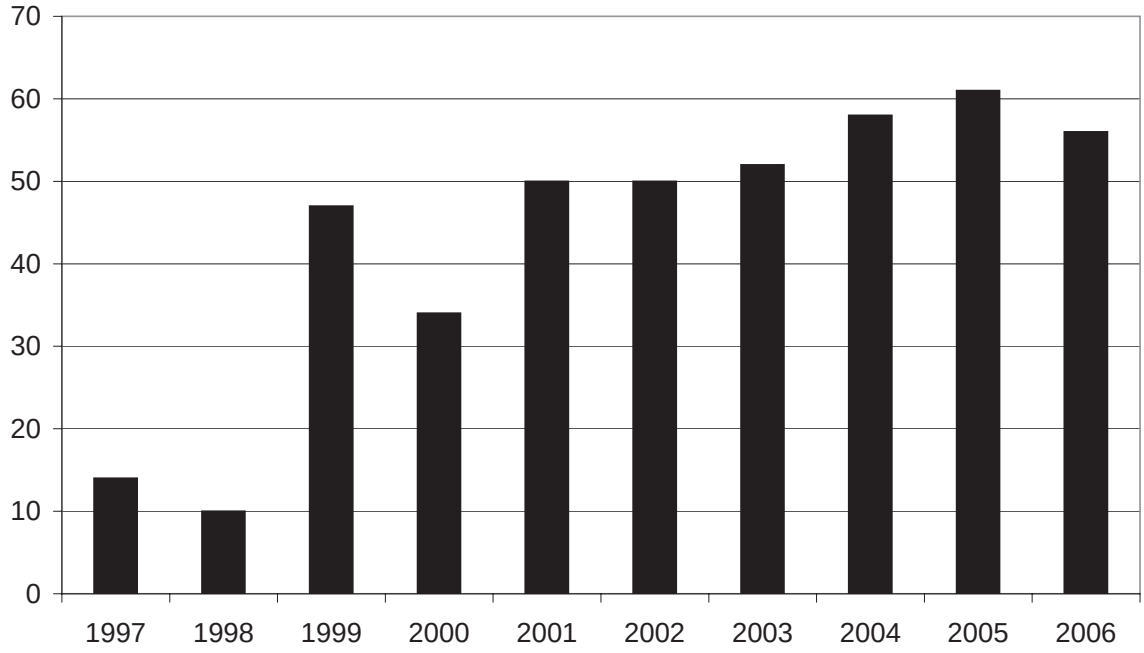
Table 1. Bucks sorted by Index score.

ID	Owner ID	Breed	Birth date	Weights (lbs)			Gain	ADG	Intake		LEA	RLC	
				Entry	Start	End	(lbs)	(lb/d)	(lb)	FE*	(in2)	(in)	Index
28	Wht ear	Boer	02/06/06	56.2	52.9	123.3	70.5	0.84	352.8	5.00	1.76	16.0	101.04
59	605	Boer	01/15/06	46.3	49.6	118.9	69.4	0.83	362.9	5.23	1.70	16.0	100.97
29	106	Boer	01/26/06	45.2	48.5	124.4	76.0	0.90	418.5	5.51	1.52	15.5	100.96
66	697	Boer	01/15/06	45.2	52.9	123.3	70.5	0.84	355.4	5.04	1.58	16.0	100.95
75	4	Boer	01/29/06	47.4	63.9	132.2	68.3	0.81	400.9	5.87	2.11	17.0	100.82
49	174	Boer	01/23/06	44.1	52.9	118.9	66.1	0.79	351.1	5.31	1.70	16.0	100.80
35	44	Boer	02/10/06	35.2	38.5	100.2	61.7	0.73	306.5	4.97	1.49	15.5	100.80
31	133	Boer	01/31/06	57.3	50.7	113.4	62.8	0.75	315.0	5.02	1.58	16.0	100.75
50	191	Boer	02/07/06	33.0	46.3	101.3	55.1	0.66	289.5	5.26	1.86	16.5	100.73
60	218	Boer	12/30/05	45.2	55.1	112.3	57.3	0.68	277.0	4.84	1.84	16.5	100.73
70	32	Boer	02/02/06	50.7	52.9	115.6	62.8	0.75	333.4	5.31	1.76	16.0	100.73
33	24	Boer	01/20/06	46.3	58.4	118.9	60.6	0.72	310.1	5.12	1.84	16.5	100.71
55	201	Boer	02/11/06	41.9	49.6	107.9	58.4	0.69	325.1	5.57	1.81	16.5	100.62
22		Boer	01/20/06	55.1	66.1	128.9	62.8	0.75	370.2	5.90	2.01	17.0	100.59
37	47	Boer	01/17/06	60.6	74.9	145.4	70.5	0.84	446.4	6.33	1.99	16.5	100.57
58	200	Boer	02/11/06	37.4	45.2	98.0	52.9	0.63	311.2	5.89	1.92	16.5	100.54
44	168	Boer	01/23/06	40.7	49.6	106.8	57.3	0.68	326.4	5.70	1.76	16.0	100.50
68	189	Boer	02/07/06	40.7	44.1	99.1	55.1	0.66	291.8	5.30	1.52	15.5	100.49
69	110	Boer	01/18/06	41.9	48.5	109.0	60.6	0.72	359.1	5.93	1.58	16.0	100.45
51	177	Boer	01/22/06	49.6	56.2	111.2	55.1	0.66	295.1	5.36	1.72	16.0	100.43
34	43	Boer	02/10/06	38.5	45.2	101.3	56.2	0.67	350.8	6.25	1.78	16.0	100.41
32	35	Boer	02/10/06	38.5	41.9	95.8	54.0	0.64	310.7	5.76	1.51	15.5	100.34
43	603	Boer	02/10/06	38.5	46.3	102.4	56.2	0.67	345.0	6.14	1.59	16.0	100.32
38	126	Boer	01/03/06	54.0	52.9	102.4	49.6	0.59	281.5	5.68	1.66	16.0	100.19
54	126	Boer	01/20/06	76.0	78.2	136.6	58.4	0.69	345.2	5.91	1.79	16.5	100.15
65	28	Boer	01/15/06	61.7	72.7	131.1	58.4	0.69	375.9	6.44	1.81	16.5	100.07
23	V20	Boer	02/26/06	58.4	76.0	132.2	56.2	0.67	375.4	6.68	2.01	17.0	100.04
36	39	Boer	01/04/06	51.8	62.8	114.5	51.8	0.62	300.7	5.81	1.53	16.0	100.02
52	4	Boer	01/25/06	50.7	63.9	117.8	54.0	0.64	360.5	6.68	1.84	16.5	100.00
46	166	Boer	01/22/06	68.3	87.0	146.5	59.5	0.71	412.5	6.94	2.04	17.0	99.98
24	V21	Boer	03/06/06	52.9	62.8	111.2	48.5	0.58	294.1	6.07	1.60	16.0	99.89
40	3	Boer	01/21/06	67.2	81.5	146.5	65.0	0.77	527.3	8.12	2.00	17.0	99.85
63	14	Boer	01/15/06	59.5	73.8	130.0	56.2	0.67	396.8	7.07	1.84	16.5	99.85
48	180	Boer	01/25/06	52.9	63.9	113.4	49.6	0.59	338.9	6.84	1.61	16.0	99.68
42	2	Boer	01/12/06	67.2	82.6	138.8	56.2	0.67	426.0	7.58	1.92	16.5	99.65
57	172	Boer	01/23/06	55.1	65.0	111.2	46.3	0.55	329.3	7.12	1.84	16.5	99.65
39	41	Boer	01/17/06	51.8	61.7	107.9	46.3	0.55	321.1	6.94	1.53	16.0	99.55
41	6	Boer	01/26/06	65.0	76.0	125.6	49.6	0.59	364.8	7.36	1.83	16.5	99.53
27	120	Boer	02/04/06	63.9	73.8	137.7	63.9	0.76	536.9	8.41	1.51	15.5	99.51
26	514	Boer	01/10/06	74.9	88.1	138.8	50.7	0.60	317.1	6.26	1.49	15.5	99.51
30	115	Boer	01/31/06	61.7	73.8	123.3	49.6	0.59	379.0	7.65	1.87	16.5	99.49

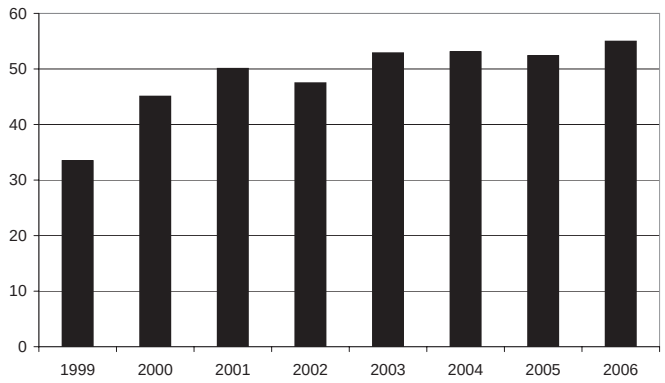
ID	Owner ID	Breed	Birth date	Weights (lbs)			Gain	ADG	Intake		LEA	RLC	
				Entry	Start	End	(lbs)	(lb/d)	(lb)	FE*	(in2)	(in)	Index
74	3	Boer	01/12/06	49.6	54.0	93.6	39.6	0.47	249.7	6.30	1.38	15.0	99.49
45	118	Boer	01/19/06	68.3	84.8	137.7	52.9	0.63	412.7	7.81	1.94	16.5	99.46
53	130	Boer	01/20/06	56.2	66.1	114.5	48.5	0.58	365.7	7.55	1.61	16.0	99.44
56	5	Boer	01/19/06	62.8	66.1	104.6	38.5	0.46	272.7	7.08	1.76	16.0	99.35
47	156	Boer	01/21/06	58.4	70.5	112.3	41.9	0.50	346.4	8.28	2.20	17.0	99.35
71	136	Boer	01/01/06	90.3	92.5	138.8	46.3	0.55	370.9	8.02	2.30	17.5	99.32
20	Wh 14	Boer	12/24/05	99.1	112.3	161.9	49.6	0.59	417.5	8.42	2.48	18.0	99.22
72	138	Boer	01/01/06	90.3	105.7	153.1	47.4	0.56	438.9	9.27	2.34	17.5	98.88
25	511	Boer	01/10/06	77.1	100.2	145.4	45.2	0.54	416.9	9.23	2.02	17.0	98.73
73	134	Boer	01/01/06	89.2	103.5	136.6	33.0	0.39	334.8	10.13	2.78	18.5	98.46
67	183	Boer	01/24/06	72.7	90.3	128.9	38.5	0.46	367.2	9.53	1.70	16.0	98.32
21	V0006	Boer	01/16/06	79.3	103.5	145.4	41.9	0.50	464.9	11.11	2.08	17.0	98.09

* lbs of feed for one lb. of gain.

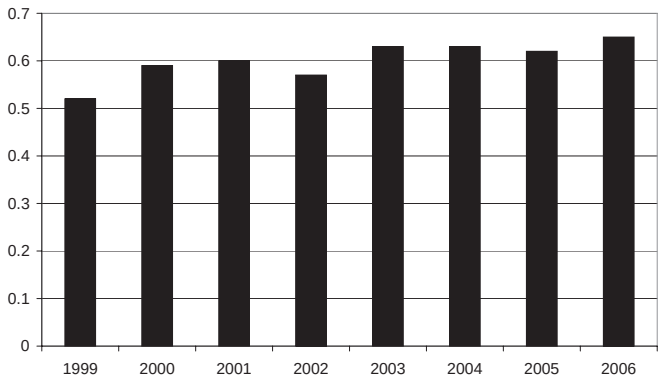
Bucks enrolled



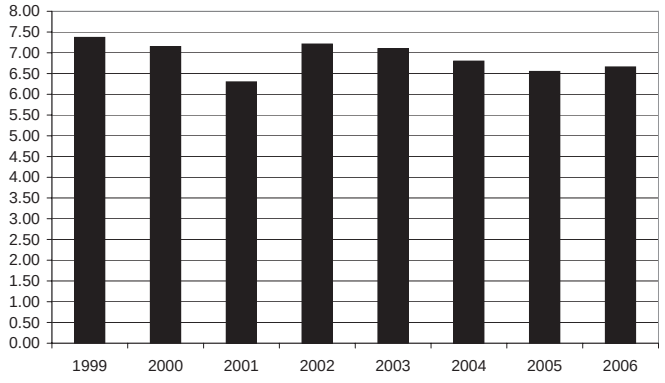
Gain (lb)



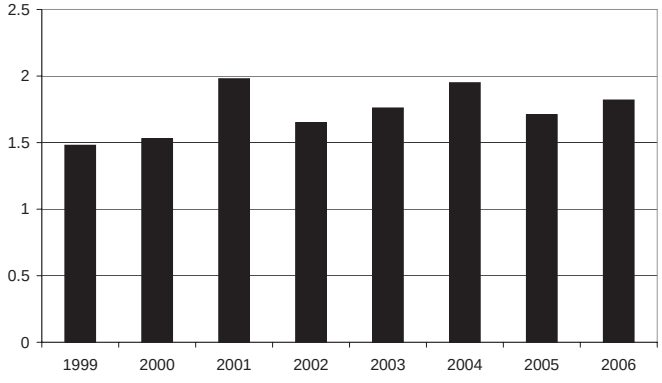
ADG (lb/day)



Feed Efficiency



Loin Eye Area (sq. in)



The proper citation for this article is:

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International Overview

Roger Merkel
International Program Leader

Objectives

Of the 767 million goats in the world, less than 0.2% reside in the United States, while over 90% can be found in countries of Asia and Africa. Goats and goat products are part of the livelihood of a majority of the world's population and are an important resource for poor farmers in many countries of the world. Part of the mission of the American Institute for Goat Research is to effect positive change in goat production throughout the world. To fulfill this aspect, the Institute has developed and maintains many strong ties with research and academic institutions around the world. Collaborative research projects, along with academic and research training, have been the traditional modes of collaboration. Recently, the Institute has increased its activities in the area of agricultural development with the goal of enhancing food security and income generation for many of the world's poor.

In addition to collaborative work with foreign institutions, the Institute has hosted visiting scientists from over 20 foreign countries to conduct research. Training for foreign livestock workers and scientists as well as for U.S.-based persons who will travel and work overseas are other ways in which the Institute is active in the international arena.

International research and training, hosting foreign scientists, and teaching those who will teach others are internationally-focused activities that give the Institute unique opportunities to not only increase knowledge of foreign production systems and constraints, but also to positively impact agricultural development in foreign countries and help alleviate poverty and hunger. General objectives of the Institute's international program are to: 1) increase our knowledge of goat production systems worldwide and current constraints to increased production; 2) build human capacity through training foreign scientists and agricultural workers in goat production thereby allowing them to more effectively carry out their missions of teaching, research, and extension; 3) increase Langston University and the Institute's involvement in agricultural development and impact on human welfare; and 4) enhance the Institute's knowledge of development and development issues.

International Research

The American Institute for Goat Research has expanded its international research activities to include countries in the Middle East, Africa, and Asia. While most international projects conducted by the Institute have aspects of research, training, and extension, some are more research oriented. Many of these types of grants are typified by a number of projects with countries in the Middle East.

Egypt, Israel, Jordan, Al-Quds University in the West Bank (Palestinian Authority)

The grant "Multinational Approaches to Enhance Goat Production in the Middle East" promotes collaborative research, training, and extension activities among Langston University, the Desert Research Center of Egypt, the Volcani Center in Israel, Al-Quds University in East Jerusalem working in the West Bank, and the Jordan University of Science and Technology. The objective of this grant is to revitalize and develop the Middle East goat industry via research and technology transfer to increase income and improve the standard of living. Specific goals of the grant include the characterization of current goat production systems,

distribution of improved goat genotypes, development of new technologies for production of milk products, and the transfer of appropriate technologies to Middle Eastern households.

One of the activities underway at each Middle Eastern location is the characterization of chemical and bacteriological status of goat milk. Israeli scientists are focusing on effects of subclinical intramammary infection on milk production and quality. Goat production practices have been evaluated through use of a questionnaire in the West Bank, Jordan, and Egypt, including the identification of major constraints to high levels and efficiencies of production. Technology transfer is a major part of the project, particularly in Egypt, Jordan, and the West Bank. Training areas include use of byproduct feedstuffs and crop residues, goat herd health, manufacture of traditional and alternative cheeses, milk product hygiene, and use of improved genotypes.

Within the past year, three additional grants have been awarded to the American Institute for Goat Research for research collaboration in the Middle East. The first of these establishes collaboration with the Newe Ya'ar Research Center of the Agricultural Research Organization in Israel on a grant entitled "Energy Expenditure for Activity in Free-Ranging Ruminants: A Nutritional Frontier." The second grant continues the collaborative research relationship between the Institute and the Desert Research Center of Egypt through researching "Effects of Acclimatization on Energy Requirements of Goats." Both of these research grants deal with important aspects of energy expenditure by goats.

Jordan, China, Mexico, Rwanda, Ivory Coast

A third grant involving a Middle Eastern institute also includes institutions in three other regions of the world. The grant "International Collaboration in Goat Research and Production Web-based Support Aids" partners the American Institute for Goat Research with Jordan University of Science and Technology, Northwest Science-Technology University in China, National University of Rwanda, Centre National Recherche Agronomique in Cote d'Ivoire, and University of Chapingo in Mexico. This grant expands usage of the interactive, web-based nutrient calculator for goats and the goat production simulation program developed by Institute scientists through translation into Arabic, Chinese, French, and Spanish. Having the web-based nutrient calculator in these languages will increase the number of producers and scientists who will be able to utilize the unique features of the calculator and enhance its usefulness.

Training and Program Support

Liberia

In July/August 2006, the United States Agency for International Development (USAID) Mission in Liberia invited Institute scientists to travel to Liberia to assess the small ruminant industry in the country. Liberia is recovering from over 15 years of civil strife that decimated traditional society and killed over 250,000 people. The Liberian small ruminant population has been reduced by up to 80% of pre-war numbers. In addition to the loss of stock, the loss of human life and the large number of people who fled Liberia have reduced the animal husbandry knowledge in the country. As a result of the visit, Institute scientists submitted a plan to work with Liberian universities and government agencies on training Liberian scientists, extension personnel, and farmers in small ruminant production while working to restock and revitalize the small ruminant industry. Currently, the Institute is waiting for USAID's response.

Iraq

Recently, the American Institute for Goat Research collaborated in a University of Oklahoma-led project with Oklahoma State University and Cameron University and five Iraqi universities (Salahaddin University, Basrah University, Al-Anbar University, University of Technology, and Babylon University). This grant "Al-Sharaka Program for Higher Education in Iraq" supported USAID activities to upgrade and revital-

ize the higher education system in Iraq. The role of the Institute and Langston University was to provide training in small ruminant production to Iraqi scientists and to establish a ruminant nutrition laboratory at Salahaddin University.

To accomplish the former goal, a three-week training was held in Cairo, Egypt in September 2004. This training, "Updating and Enhancing the Skills of Iraqi Scientists in Small Ruminant Production," provided information on computer technology, herd health and reproduction, statistical analysis, nutrition, and manuscript preparation to seven Iraqi scientists. To accomplish the establishment of a ruminant nutrition laboratory, analytical equipment and associated chemicals and supplies were purchased for Salahaddin University. Textbooks on various topics in animal science as well as laboratory procedure manuals were purchased. The equipment, supplies, and books were sent to Salahaddin University in the summer of 2005.

Democratic People's Republic of Korea

In addition to providing program support to government-funded programs, the American Institute for Goat Research also conducts training and support activities for projects funded by non-government organizations. In November 2004, the Institute conducted an eight-day training program for five persons from the Democratic People's Republic of Korea (DPRK). This training was supported by Global Resources Services, Inc., an organization that has a history of working in the DPRK and that has established a goat dairy in the southern region of the country. The Korean personnel received training in animal management, artificial insemination, semen collection and freezing, nutrition, herd health, milking procedures and mastitis prevention, and cheese making.

As an extension of this work, Dr. Roger Merkel of the Institute traveled to the DPRK in June 2005 with representatives of Global Resources Services, Inc. to provide training and technical assistance to the dairy in the areas of nutrition, forages, and internal parasite control.

Argentina

Dr. Steve Zeng was invited as a Keynote Speaker to the Argentine Consortium of Goat Milk Cheese Plant Internationalization in Buenos Aires, Argentina. Dr. Zeng gave two one-hour presentations to an audience of goat producers, cheese makers, dairy researchers, cheese traders and health regulators. He introduced the U.S. dairy import and export regulations to the Argentines and discussed the quality standards of goat milk and cheeses in the U.S. with Argentine goat cheese makers. Dr. Zeng also visited several commercial goat cheese plants and helped them manufacture high quality goat cheeses for export to the U.S. In addition, he participated in a cheesemaking workshop at the University of Buenos Aires.

China

In October 2006 Dr. Zeng was invited to China as an Adjunct/Visiting Professor at Harbin Institute of Technology in Heilongjiang Province. Dr. Zeng and three cheese experts from France conducted a week-long cheese manufacturing workshop for dairy technologists, industrial leaders and university professors. Mozzarella cheese, cream cheese, processed cheese and hard and semi-hard cheeses from both goat and cow milk were demonstrated and evaluated. In addition, dairy manufacturing classes were instructed to graduate students at the university.

Agricultural Development

The Institute is proud of its activities in the area of agricultural development. Partnerships with foreign institutions have led to the opportunity to impact the lives of poor farmers. While many of Institute's international grants have aspects of direct development, the succession of grants with Ethiopian institutions have had the most direct development activities.

Ethiopian Connection

Langston University and the Institute have had a long and fruitful relationship with universities in Ethiopia. This relationship began with research grants awarded in the 1990's and expanded to include more aspects of training, research, and development through university partnerships and other grants awarded to Langston University. In 1998, a three-year institutional partnership was formed with Awassa College of Agriculture of Debub University (now Hawassa University) in Awassa, Ethiopia. In 1999, another three-year university partnership was formed with Alemaya University in eastern Ethiopia. Both grants were designed to enhance the research, teaching, and extension capabilities of all institutions involved through a program of collaborative research, training of Ethiopian scientists at LU, and the establishment of village development projects designed to enhance household food security, income generating potential, and family health status through increased goat productivity. Increased goat production was accomplished via the provision of goats and appropriate technology to women's groups for goat production in villages near both universities.

In 2000, Langston University was awarded a grant entitled "Enhanced Education and Computer Capabilities: The Foundation for Sustained Collaboration" for further activities with Hawassa University and a new institution, Oklahoma State University was added to the partnership. Further, Langston University was awarded a companion Technology Enhancement grant to establish a student computer laboratory on the Hawassa University campus, an activity completed in 2001.

Two additional grants were awarded in 2002 for continued work with these two Ethiopian universities. A new partner, Fort Valley State University, became the lead institution in a grant furthering activities with Hawassa University while the Institute and Oklahoma State University continued activities with Alemaya University. These grants had a similar focus to the original projects with the addition of training and research in reproduction, artificial insemination, and herd health.

In 2005 the American Institute for Goat Research of Langston University and Prairie View A&M University, Prairie View, TX were awarded a $7 million grant from the USAID Mission in Ethiopia for a project entitled "Ethiopia Sheep and Goat Productivity Improvement Program." This 5-year program entails collaboration with the Ministry of Agriculture and Rural Development of the Government of Ethiopia. The overall goal of the program is to conduct research and extension activities in the areas of production and marketing that will result in a sustainable increase in small ruminant productivity in Ethiopia to improve food and economic securities. The project will work in six regions of Ethiopia (Tigray, Amhara, Oromia, Southern States, Afar, and Somali), and address a number of factors including human and institutional capacity building, research and technology transfer, introduction of improved animal genetics, and determining appropriate utilization of indigenous breeds.

In 2006, the Institute was awarded a grant to work with Hawassa University on increasing the attendance of children in schools and reducing dropout rates, particularly in rural Ethiopia. Poverty and the need for children to work to support their families and assist in farming activities are main factors that prevent children from obtaining an education. This is particularly true for young girls. This grant works with two schools to conduct surveys to determine the cause of low attendance and high dropout. Facilities at these schools will be upgraded and interventions developed as a model for other Ethiopian schools to use to increase the rate of child education.

The End Result

The American Institute for Goat Research is proud of its international activities and the impact they have on strengthening human and institutional capacity of foreign institutions, providing important and relevant research results on local issues of importance, and in the assistance provided to small farmers, and particu-

larly women, in enhancing family nutrition and income generation. These are unique activities that support the mission of the Institute and the goals of its personnel.

Through these activities, Institute personnel learn about goat production throughout the world and are exposed to foreign cultures and customs. The knowledge gained through these activities is put to use by personnel in their research, extension, and teaching duties.

The foreign scientists who come to conduct research at the Institute also bring with them a wealth of information that is imparted to Institute scientists. The results of the research conducted by those scientists can be used to improve goat production both here and abroad. Foreign institutes with whom the Institute collaborates gain from the training functions and research trials conducted and become better equipped to perform their missions of teaching, research, and extension.

Most importantly, though, is the satisfaction that through its efforts, the American Institute for Goat Research is having a positive impact on goat production throughout the world and assisting village parents in lesser developed countries of the world to better provide for their families.

Recent International Grants

Years	2006-20/7
Title	Sustainable Interventions to Increase Child Education in Ethiopia: Models for Poverty Reduction and Overcoming Child Labor Constraints
Collaborators	Langston University; Hawassa University, Hawassa, Ethiopia
Funding source	United Negro College Fund Special Programs
Funding amount	$25,000

Years	2005-2010
Title	Ethiopia Sheep and Goat Productivity Improvement Program
Collaborators	Langston University; Prairie View A & M University, Ministry of Agriculture and Rural Development of the Government of Ethiopia
Funding source	USAID Ethiopia
Funding amount	$6,999,998

Years	2005-2008
Title	International Collaboration in Goat Research and Production Web-Based Decision Support Aids
Collaborators	Langston University; Jordan University of Science and Technology; Northwest Science-Technology University, China; Département des Sciences Animales of Institut National Agronomique, France; University of Chapingo in Mexico
Funding source	USDA International Science and Education Competitive Grants Program
Funding amount	$99,959

Years	2005-2008
Title	Energy Expenditure for Activity in Free-Ranging Ruminants: A Nutritional Frontier
Collaborators	Langston University; Newe Ya'ar Research Center of the Agricultural Research Organization, Israel
Funding source	United States – Israel Binational Agricultural Research and Development Fund
Funding amount	$310,000

Years	2005–2007
Title	Effects of Acclimitization on Energy Requirements of Goats.
Collaborators	Langston University; Desert Research Center, Egypt
Funding source	U.S. – Egypt Joint Science and Technology Fund
Funding amount	$58,500

Years	2003 - 2006
Title	Al-Sharaka, The Partnership. Revitalizing the Higher Education System in Iraq
Collaborators	Langston University, University of Oklahoma; Oklahoma State University; Cameron University, Lawton, OK; Al Anbar University, Ramadi City, Iraq; Babylon University, Hilla City, Iraq; Basrah University, Basrah, Iraq; Salahaddin University, Erbil, Iraq; University of Technology, Baghdad, Iraq
Funding source	USAID
Funding amount	$4,988,569

Years	2000 - 2008
Title	Multinational Approaches to Enhance Goat Production in the Middle East
Collaborators	Langston University; Desert Research Center, Cairo, Egypt; Volcani Center, Bet Dagan, Israel; Al-Quds University in East Jerusalem working in the West Bank; Jordan University of Science and Technology, Irbid, Jordan
Funding source	USAID/Middle East Regional Cooperation Program
Funding amount	$1,199,725

The proper citation for this article is:

Merkel, R. 2007. International Overview. Pages 150-155 in Proc. 22nd Ann. Goat Field Day, Langston University, Langston, OK.

Research Overview

Arthur Goetsch

Goat Research Leader

There has been and is a wide array of research areas addressed by our program. All major types of goats produced in the US are considered, i.e., ones raised for meat, milk, and(or) fiber, both cashmere and mohair. The increasing demand for goat meat and decline in the mohair industry in recent years have resulted in an expansion of research topics with meat goats, but because the future is unknown, all goat industries will continue to receive attention. The Institute has and will in the future conduct research to increase levels and efficiencies of goat production, enhance utilization of goat products, and improve use of goats for specific purposes such as vegetation management. There is intent to increase economic returns to those raising goats or processing their products, as well as providing other benefits such as enhanced sustainability of livestock production systems.

A large proportion of the Institute's research program is made possible by grants, many of which are through USDA programs. Although dissemination of information generated from all of these projects occurs, some entail strong extension components. Likewise, there are projects listed in our international section that entail significant research components.

To provide an idea about our research program since the last Field Day, listed below are research projects and experiments we have been involved with in 2006, abstracts for 2007, and summaries of scientific articles that were ublished in 2006, 2007, or currently are "in press" to appear in 2007 journals.

Standard Abbreviations Used

BW = body weight
CP = crude protein
dL = decaliter
DMI = dry matter intake
kg = kilogram
M = mole
MEI = ME intake
mm = millimeters
ng = nanogram
OM = organic matter
SE = standard error
wt = weight
vs = versus
cm = centimeters
d = day
DM = dry matter
g = gram
L = liter
ME = metabolizable energy
mL = milliliter
mo = month
NDF = neutral detergent fiber
P = probability
TDN = total digestible nutrients
vol = volume
µ = micro

Research Projects

Title:	Enhanced Goat Production and Products in the South-Central U.S.
Type:	CSREES project
Project Number:	OKLX-SAHLU
Period:	2006-2011
Investigators:	T. Sahlu, A. L. Goetsch, R. Puchala, R. C. Merkel, T. A. Gipson, S. P. Hart, S. Zeng, and Z. Wang
Institution:	Langston University
Objective:	Study goat feeding and management, relevant health issues, and milk product technologies in order to increase the level and efficiency of goat productivity for increased profitability from goat production and lower costs to consumers of goat products.

Title:	Characterization of the Energy Requirement for Activity by Grazing Ruminants
Type:	USDA 1890 Institution Research Capacity Building
Project Number:	2005-38814-16352
Period:	2005-2008
Investigators:	T. Sahlu[1], R. Puchala[1], A. L. Goetsch[1], T. A. Gipson[1], K. E. Turner[2], and B. Kouakou[3]
Institutions:	[1]Langston University, [2]Applachian Farming Systems Research Center, and [3]Fort Valley State University
Objectives:	• Develop and evaluate a system to predict the grazing activity energy cost for ruminants by determining effects of animal and dietary conditions on energy expenditure, metabolizable energy intake, the grazing activity energy cost, grazing and walking times, and horizontal and vertical distances traveled.

Title:	The Ability of Goats to Withstand Harsh Nutritional Environments
Type:	USDA 1890 Institution Research Capacity Building
Project Number:	2005-38814-16353
Period:	2005-2008
Investigators:	A. L. Goetsch[1], R. Puchala[1], T. Sahlu1, and H. C. Freetly[2]
Institutions:	[1]Langston University and [2]Meat Animal Research Center
Objectives:	• Determine if there are differences between goats and sheep and between meat goat species of the US in the ability to utilize diets with limited supplies of nitrogen and energy and to characterize the physiological bases of any such differences.

Title:	International Collaboration in Goat Research and Production Web-Based Decision Support Aids
Type:	USDA International Science and Education Competitive Grants Program
Project Number:	2005-51160-02281
Period:	2005-2008
Investigators:	A. L. Goetsch and T. A. Gipson
Institution:	Langston University
Goal:	Facilitate future collaborative research between the American Institute for Goat Research (AIGR) and institutions in Arabic-, Chinese-, French-, and Spanish-speaking countries, as well as to gain knowledge of goat research and production practices in other areas of the world.
Objectives:	• Translate and adapt two web-based goat production and research decision-support tools developed at the AIGR (goat nutrient requirements and feed intake; goat production system simulation model) for use and future collaborative research in the Middle East, China, France and other French-speaking countries, and Central and South America.

Title:	Energy Expenditure for Activity in Free-Ranging Ruminants: A Nutritional Frontier
Type:	United States - Israel Binational Agricultural Research and Development Fund
Project Number:	US-3694-05 R
Period:	2005-2008
Investigators:	A. L. Goetsch[1], Y. Aharoni[2], A. Brosh[2], R. Puchala[1], T. A. Gipson[1], Z. Henkin[3], and E. Ungar[4]
Institutions:	[1]Langston University, [2]Newe Ya'ar Research Center, Agricultural Research Organization, [3]MIGAL-Galilee Technology Center, and [4]Agronomy and Natural Resources, Agricultural Research Organization
Objectives:	• Develop and evaluate a system(s) to predict the grazing activity energy cost of ruminants by determining effects of stocking rate (influencing available forage mass and forage quality) and animal production state and season (affecting energy demand) on energy expenditure, metabolizable energy intake, energy expended in grazing activity, grazing and walking times, horizontal and vertical distances traveled, and diet quality with grazing females of two breeds of cattle and goats.

Title:	Effects of Acclimatization on Energy Requirements of Goats
Type:	United States - Egypt Joint Science and Technology Fund Program
Project Number:	BIO9-017
Period:	2005-2007
Investigators:	A. L. Goetsch[1] and H. El Shaer[2]
Institutions:	[1]Langston University and [2]Desert Research Center
Objective:	• Develop a means of adjusting the maintenance energy requirement of goats for acclimatization.

Title:	Decreased Methane Emission by Ruminants Consuming Condensed Tannins
Type:	USDA 1890 Institution Research Capacity Building
Project Number:	2004-38814-02606
Period:	2004-2007
Investigators:	R. Puchala[1], A. L. Goetsch[1], C. R. Krehbiel[2], and V. H. Varel[3]
Institutions:	[1]Langston University, [2]Oklahoma State University, and [3]USDA ARS Meat Animal Research Center
Objectives:	• Determine effects of consuming different condensed tannin sources on the ruminal microflora and methane emission, digestibility, nitrogen and energy balance, and energy expenditure by goats. • Determine effects of consuming diets with different levels of a forage containing condensed tannins on the ruminal microflora and methane emission, digestibility, nitrogen and energy balance, and energy expenditure by goats. • Determine effects of different frequencies of consumption of a forage containing condensed tannins on the ruminal microflora and methane emission, digestibility, nitrogen and energy balance, and energy expenditure by goats.

Title:	Evaluation and Modeling Extended Lactations in Dairy Goats
Type:	USDA 1890 Institution Research Capacity Building
Project Number:	2004-38814-02579
Period:	2004-2007
Investigators:	T. A. Gipson[1], A. Capuco[2], T. Sahlu[1], L. J. Dawson[3], and S. Ellis[4]
Institutions:	[1]Langston University, [2]USDA ARS Gene Evaluation and Mapping Laboratory, [3]Oklahoma State University, and [4]Clemson University Research Center
Objectives:	• Compare extended versus standard lactations with reference to milk, fat, and protein yield, reproduction and health issues . nitrogen and energy balance, and energy expenditure by goats. • Mathematically model the lactation curve for extended lactations in dairy goats, with particular emphasis on the effect of extended lactations has upon the shape and scale of the lactation curve. • Examine the physiological changes in the mammary gland over the course of an extended lactation.

Title:	Quality, Safety, and Shelf-Life of Dairy Goat Products in the U.S. Market
Type:	USDA 1890 Institution Research Capacity Building
Project Number:	2004-38814-02587
Period:	2004-2007
Investigators:	S. S. Zeng[1], M. Perdue[2], and S. E. Gilliland[3]
Institutions:	[1]Langston University, [2]USDA ARS Environmental Microbial Safety Laboratory, and [3]Oklahoma State University
Objectives:	• Establish a comprehensive database of dairy goat product safety, quality and shelf-life on the store shelves. Identify the unique values such as CLA of dairy goat products. • Develop and implement biological, biochemical and/or physical interventions to control undesirable microbes. • Enhance the marketability and profitability of goat milk and dairy products by improving product microbiological and sensory quality, and by prolonging shelf-life of finished products. • Assist store managers and personnel handling goat milk and dairy products by providing information and techniques to maximize product quality and shelf-life.

Title:	Nutrient Requirements of Goats: Composition of Tissue Gain and Loss
Type:	USDA 1890 Institution Research Capacity Building
Project Number:	2003-38814-13923
Period:	2003-2007
Investigators:	T. Sahlu[1], A. L. Goetsch[1], C. L. Ferrell[2], and C. R. Krehbiel[3]
Institutions:	[1]Langston University, [2]USDA ARS Meat Animal Research Center, and [3]Oklahoma State University
Objectives:	• Determine the composition of tissue gain by growing Boer crossbred and Spanish meat goats consuming different quality diets from weaning to 1 year of age. • Determine the composition of tissue loss and gain by mature meat goats. • Determine the composition of tissue loss and gain by lactating dairy goats. • Develop equations to predict body composition of growing and mature meat goats and lactating dairy goats based on shrunk body weight and urea space.

Title:	Tethering for Detailed Study of Grazing Ruminants
Type:	USDA-CSREES-NRI 03-03289
Project Number:	OKLX-GOETSCH
Period:	2003-2006
Investigators:	A. L. Goetsch[1], R. Puchala[1], T. Sahlu1, and C. R. Krehbiel[2]
Institutions:	[1]Langston University and [2]Oklahoma State University
Objectives:	• Validate use of tethering to study responses of meat goats to grazing conditions by investigating effects of grazing unrestrained versus tethered on grazing behavior, energy expenditure, forage intake, and composition of forage selected by meat goats on pastures with low and high forage quality and available mass.

Title:	Enhanced Goat Production Systems for the Southern United States
Type:	USDA Initiative for Future Agriculture and Food Systems
Project Number:	2011-52101-11430
Period:	2001-2006
Investigators:	T. A. Gipson[1], A. L. Goetsch[1], S. P. Hart[1], L. J. Dawson[2], Harvey Blackburn[3], Stephan Wildeus[4], Joseph Tritschler[4], Jean-Marie Luginbuhl[5], Matt Poore[5], Marcos Fernandez[6], Will Getz[7], Tom Terrill[7], Mack C. Nelson[7], and Ken Turner[8]
Institutions:	[1]Langston University, [2]Oklahoma State University, [3]National Seed Storage Lab Animal Germplasm, [4]Virginia State University, [5]North Carolina State University, [6]Louisiana State University, [7]Fort Valley State University, and [8]USDA ARS Appalachian Farming Systems Research Center
Objectives:	• Develop a vehicle to appraise use of available resources and production conditions with goat production systems. • Project most appropriate production systems for goat-producing regions based on compatibility with presently available resources and production conditions, and evaluate changes in resources or production conditions necessary for employment of alternative, preferred systems. • Disseminate and provide training in use of the developed-decision support vehicle.

Title:	Effect of somatic cell count levels of goat milk and lactation stage on sensory quality, texture profile, proteolysis, and free fatty acid profiles of goat semi-hard cheese
Experiment Number:	SC-06-01
Project Number:	2004-38814-02587
Investigators:	S. Chen, S. Zeng, B. Bah, and K. Tesfai
Objectives:	1) Determine effects of goat milk SCC levels on the composition and cheese yield, FFA profiles, protein hydrolyzation, and texture profiles of semi-hard cheese 2) Provide information for payment-by-quality schemes, and assist goat cheese producers controlling goat cheese quality

Title:	Evaluating and modeling extended lactations in dairy goats
Experiment Number:	MR-06-02
Project Number:	2004-38814-02579
Investigators:	M. Rovai, T. A. Gipson, T. Sahlu, L. J. Dawson, S. Chen, S. Zeng, A. V. Capuco, and S. E. Ellis
Objectives:	1) Compare extended versus standard lactations with reference to milk, fat, and protein yield, reproduction and health issues 2) Mathematically model the lactation curve for extended lactations in dairy goats, with particular emphasis on the effect of extended lactations has upon the shape and scale of the lactation curve 3) Examine the physiological changes in the mammary gland over the course of an extended lactation

Title:	Effects of CLA supplementation and lactation parity on goat colostrum profile (composition, physicochemical properties, and immunocompetence) and development of probiotic goat colostrum cheese
Experiment Number:	SC-06-03
Project Number:	2004-38814-02587
Investigators:	S. Chen, S. Zeng, M. Rovai, T. A. Gipson, and B. Bah
Objectives:	1) Determine effects of rumen-protected trans-10, trans-12CLA supplementation and lactation parity on goat colostrum composition, immunocompetence, and free fatty acids profile. 2) Determine eEffects of CLA and colostrum on the growth of Bifidobacterium in semi-hard cheese 3) Determine effects of CLA and colostrum adjunct in goat milk on composition and quality of goat cheese.

Title:	Effects of age upon repeated measurement and level of body conditions on time of infused urea equilibration with body water in meat goats
Experiment Number:	AP-06-04
Project Number:	2003-38814-13923
Investigators:	A.K. Patra, A. Asmare, R. Puchala, A. L. Goetsch, T.A. Gipson, L.J. Dawson, G. Detwelier, and T. Sahlu
Objective:	Assess the time of plasma urea equilibration at different times on different nutritional planes and to ascertain the relationship between heart rate and time of plasma urea equilibration in goats

Title:	Methane emission by goats consuming a condensed tannin-containing forage at different frequencies
Experiment Number:	GA-06-05
Project Number:	2004-38814-02606
Investigators:	G. Animut, R. Puchala, A.L. Goestch, T. Sahlu, V. H. Varel, and J. Wells
Objective:	Determine effects of consuming condensed tannin-containing forage at different frequencies on the ruminal microflora and CH4 emission, digestibility, nitrogen and energy balance, and energy expenditure by goats

Title:	The energy cost of grazing activity in goats grazing fescue/bermudagrass pastures at high and low stocking rates
Experiment Number:	AB-06-06
Project Number:	US-3694-05 R
Investigators:	A. Beker, A. L. Goetsch, A. Askar, A. Asmare, R. Puchala, T. A. Gipson, T. Sahlu, G. Detweiler, and K. Tesfai
Objectives:	Overall objective: Develop and evaluate a system(s) to predict metabolizable energy (ME) use for grazing activity (MEa) of goats grazing pastures at high and low SR Specific objectives: 1) Determine effects of stocking rate and season on available forage mass and forage quality; and 2) Determine effects of stocking rate, animal genotype and season on ME intake, energy expenditure, MEa, average daily gain, and grazing behavior of goats

Title:	Effects of stocking rate and physiological state on energy balance and the energy requirement for grazing activity of goats
Experiment Number:	AR-06-07
Project Number:	2005-38814-16352
Investigators:	A. Askar, A. L. Goetsch, A. Asmare, A. Beker, R. Puchala, T. Sahlu, T. A. Gipson, G. Detweiler, and K. Tesfai
Objectives:	Overall objective: Develop and evaluate a system to predict the energy cost for grazing activity for ruminants. Specific objectives: Determine effects of stocking rate (affecting forage mass and possibility nutritive value) and physiological state of meat goats on energy expenditure, metabolizable energy (ME) intake, ME used for grazing activity, grazing and walking times, and horizontal and vertical distances traveled

Title:	The ability of goats to withstand low protein intake
Experiment Number:	AA-06-08
Project Number:	2005-38814-16353
Investigators:	A. Asmare, A. L. Goetsch, R. Puchala, A. Askar, A. Beker, T. A. Gipson, L. J. Dawson, T. Sahlu, H. C. Freetly, and K. Tesfai
Objectives:	Determine potential differences between goats and sheep and between two goat genotypes in the ability to utilize low-nitrogen diets by measurements, made with nitrogen-adequate and -limiting forage-based diet, of: total urea synthesis in the body, the rate at which urea enters the gastrointestinal tract, and urinary urea excretion; net flux across splanchnic tissues of nitrogen-containing metabolites as well as other metabolites such as glucose, volatile fatty acids, and oxygen to assess gut and liver energy use; whole body nitrogen and energy balances; extra-splanchnic tissue energy use; and whole body energy expenditure as the feeding period progresses

Title:	The ability of goats to withstand low energy intake
Experiment Number:	AA-06-09
Project Number:	2005-38814-16353
Investigators:	A. Asmare, A. L. Goetsch, R. Puchala, A. Askar, A. Beker, T. A. Gipson, L. J. Dawson, T. Sahlu, H. C. Freetly, and K. Tesfai
Objectives:	Determine potential differences between goats and sheep and between two goat genotypes in the ability to utilize low-energy diets by measurements, made with energy-adequate and -limiting forage-based diet, of: net flux across splanchnic tissues of nitrogen-containing metabolites as well as other metabolites such as glucose, volatile fatty acids, and oxygen to assess gut and liver energy use; whole body nitrogen and energy balances; extra-splanchnic tissue energy use; and whole body energy expenditure as the feeding period progresses

Title: Effects of ginger and garlic on nematode infection in goats
Experiment Number: ZW-06-10
Project Number: OKLX-SAHLU
Investigators: Z. Wang, S. P. Hart, L. J. Dawson, A. L. Goetsch, and T. Sahlu
Objectives: Determine effects of garlic and ginger on: 1) fecundity of Haemonchus contortus and other parasites in the gastrointestinal tract of goats; 2) immune responses of goats, measured by concentrations of antibodies (IgA, IgM, and IgG); and 3) cytokine gene expression

Title: Methane emission by goats consuming a condensed tannin-containing lespedeza with or without PEG compared with a legume and grass with little or no condensed tannins
Experiment Number: GA-06-11
Project Number: 2004-38814-02606
Investigators: G. Animut, R. Puchala, A.L. Goestch, T. Sahlu, V. H. Varel, and J. Wells
Objectives: Determine effects of consuming CT-containing forage (Sericea lespedeza) with or without PEG, compared with a legume (alfalfa) and grass (sorghum-sudangrass) with little or no CT on the ruminal microflora and CH4 emission, digestibility, nitrogen and energy balance, and energy expenditure by goats

Title: Methane emission by goats consuming hay from a condensed tannin-containing lespedeza with or without PEG compared with a legume and grass with little or no condensed tannins
Experiment Number: GA-06-12
Project Number: 2004-38814-02606
Investigators: G. Animut, R. Puchala, A.L. Goestch, T. Sahlu, V. H. Varel, and J. Wells
Objectives: Determine effects of consuming hay from a CT-containing forage (Sericea lespedeza), with or without PEG, compared with a legume hay (alfalfa) and grass hay (sorghum-sudangrass) with little or no CT on the ruminal microflora and CH4 emission, digestibility, nitrogen and energy balance, and energy expenditure by goats

Title: Healing characteristics of a full thickness tenectomy lesion in the caprine superficial digital flexor tendon
Experiment Number: HJ-06-13
Collaborating Institution: Oklahoma State University College of Veterinary Medicine
Investigators: H. Jann, C. Baumwart, J. Ritchey, L. Dawson, and A. Goetsch
Objective: Document the healing time of a surgically created lesion in the caprine superficial digital flexor tendon

Title:	Naturally occurring precocious udder enlargement in Alpine maiden ddoelings and its association with body growth and udder development, milking traits, and reproductive and productive performance
Experiment Number:	EL-06-14
Project Number:	OKLX-SAHLU
Investigators:	E. Loetz, M. Rovai, L. J. Dawson, J. Hayes, and T. A. Gipson
Objectives:	1) Determine the correlation and nature of the relationship between PUE and response variables describing body growth, reproductive performance, milk production, and milking traits; 2) Characterization of mammary tissue parenchyma accretion and reduction (e.g., cell proliferation, differentiation, and apoptosis) during mammogenesis, lactogenesis, galactopoiesis, and mammary gland involution of events leading to and during the first and second lactation of normal and PUE-affected goats; 3) Document and quantify udder morphology dynamics by means of digitized visual information (pictures and ultrasound images) during development, lactation, and regression of the mammary gland of normal and PUE-affected goats; 4) Ascertain which of the common health parameters monitored in a dairy goat operation (i.e., somatic cell counts, mastitis, dystocia, abscesses, caprine arthritis encephalitis, and internal gastrointestinal parasite load) are associated with PUE; and 5) Establish whether PUE has a temporary or permanent effect on the selected response variables and determine the correlation of the trait with their mother's milking ability

Title:	Oregano oil dose response to control of gastrointestinal nematodes in goats
Experiment Number:	SH-06-15
Project Number:	OKLX-SAHLU
Investigators:	S. P. Hart, Z. Wang, and T. Sahlu
Objectives:	Iinvestigate the dose response of oregano oil on fecal egg hatching and larval development in goats and to monitor its effect on rumen microorganisms

Title:	The energy cost of grazing activity in goats grazing fescue/bermudagrass pastures at high and low stocking rates
Experiment Number:	AB-06-16
Project Number:	US-3694-05 R
Investigators:	A. Beker, A. L. Goetsch, A. Askar, A. Asmare, R. Puchala, T. A. Gipson, T. Sahlu, G. Detweiler, and K. Tesfai
Objectives:	Overall objective: evaluate a system(s) to predict the energy cost for grazing activity for different breeds of goats and a breed of sheep that are grazing together Specific objectives: Determine effects of goat breed (Angora, Boer, and Spanish) and species (goats vs Rambouillet sheep) on metabolizable energy intake, energy used for grazing activity, grazing and walking times, and horizontal and vertical distances traveled, under varied pasture conditions

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Abstracts

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Methane emission by goats consuming different sources of condensed tannins

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Boer × Spanish (7/8 Boer; initial BW of 37.5 ± 0.91) wethers (24) were used to assess effects of different condensed tannin (CT) sources on methane emission. Diets were Kobe lespedeza (Lespedeza striata; K), K plus quebracho providing CT at 5% DMI (KQ), Sericea lespedeza (Lespedeza cuneata; S), and a 1:1 mixture of K and S (KS). Forages harvested daily were fed at 1.3 times the maintenance energy requirement. The experiment was 51 d divided into two phases. In phase 1 forage diets were fed alone, and in phase 2 25 g/d of polyethylene glycol (PEG) was given mixed with 50 g/d of ground corn. Adaptation periods were 28 and 7 d in phases 1 and 2, respectively. N concentration was 2.28 and 2.36%, in vitro true DM digestibility was 69.8 and 64.8%, and the level of CT was 14.0 and 15.1% for S and K, respectively. DMI was similar among treatments (776, 717, 806, and 800 g/d for K, KQ, S, and KS, respectively; SE = 51.7) and lower ($P < 0.05$) in phase 1 vs 2 (699 vs 851 g/d). OM digestibility was similar between phases and averaged 47.8, 45.1, 40.1, and 43.7% for K, KQ, S, and KS, respectively (SE = 2.37). Treatment and phase interacted ($P < 0.05$) in N digestibility (phase 1: 51.4, 49.1, 28.0, and 41.3%; phase 2: 68.3, 65.0, 63.8, and 66.2% (SE = 3.02) for K, KQ, S, and KS, respectively). Methane emission was 14.3, 11.7, 16.2, and 14.1 l/d for K, KQ, S, and KS, respectively (SE =1.25), and in phase 2 PEG markedly increased ($P < 0.05$) methane emission (9.0 vs 19.1 l/d). There was a substantial difference ($P < 0.05$) between phases in in vitro methane release by ruminal fluid incubated for 3 wk with conditions promoting activity by methanogens (11.5 and 22.9 ml in phases 1 and 2, respectively). Counts of total bacteria and protozoa were similar among treatments but considerably greater ($P < 0.05$) in phase 2 vs 1 (bacteria: 1.9 and 19.7 x 1011/ml; protozoa: 9.3 and 18.9 x 105/ml). In summary, CT from different sources had disparate influence on N digestion but similar effects on ruminal microbial methane emission by goats, possibly by altering activity of ruminal methanogenic bacteria though change in actions of other bacteria and(or) protozoa may also be involved.

Effects of genotype and diet on growth and mass of organs and tissues of growing meat goats

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Young 3/4 Boer x 1/4 Spanish (BS) and Spanish (S) wethers were used to determine influences of diet and genotype on growth and mass of organs and tissues. A 50% concentrate pelleted diet (C) and one based on grass hay (H) were fed free-choice. Six wethers of each genotype were harvested at 0 wk as well as six of each diet and genotype at 14 and 28 wk. Initial BW was 21.6 and 18.8 kg for BS and S, respectively (SE = 0.67). The only genotype difference in initial organ or tissue mass relative to empty BW (EBW) was a tendency (P < 0.09) for skin (10.38 vs 9.79% EBW for BS and S, respectively). Average daily gain during the entire experiment was influenced by an interaction (P < 0.05) between genotype and diet (199, 142, 44, and 50 g for BS-C, S-C, BS-H, and S-H, respectively). Likewise, average (mean of wk 14 and 28) EBW was greater (P < 0.05) for BS vs S with C and similar between genotypes with H (45.6, 34.8, 19.1, and 17.1 kg for BS-C, S-C, BS-H, and S-H, respectively). Carcass mass was greater (P < 0.05) for C vs H (56.2, 56.2, 53.2, and 54.0% EBW for BS-C, S-C, BS-H, and S-H, respectively). Mass of the liver (2.11, 1.92, 2.00, and 1.98% EBW; SE = 0.048) and gastrointestinal tract (5.50, 4.83, 8.43, and 8.36% EBW for BS-C, S-C, BS-H, and S-H, respectively; SE = 0.158) tended (P < 0.07) to be influenced by an interaction between genotype and diet. Mass of internal fat (12.16, 12.09, 3.36, and 3.37% EBW; SE = 0.364) and skin (9.55, 9.77, 11.97, and 11.27% EBW for BS-C, S-C, BS-H, and S-H, respectively; SE = 0.281) differed (P < 0.05) between diets but were not affected by genotype. In conclusion, growth advantages of growing Boer crossbred goats compared with Spanish realized with diets of high nutritive value may not be accompanied by differences in mass of organs or tissues other than relatively small ones for the liver and gastrointestinal tract in accordance with growth rate.

Effects of dietary concentrate level on tissue and organ mass of Alpine does at different stages of lactation

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Multiparous Alpine does (42) were used to determine how dietary concentrate level and stage of lactation affect mass of organs and tissues. Measures were made with six does a few days after kidding (0 wk). Eighteen does were fed a 60% concentrate diet (C) and 18 received one based on forage (20% concentrate; F) for 8, 16, or 24 wk of lactation. Intake of DM was greater (P < 0.05) for F vs C (2.23, 2.14, 2.10, 2.42, 2.81, and 2.55 kg/d), ADG was affected (P < 0.07) by an interaction between diet and time (0, 24, 121, -61,

46, and 73 g), and 4% fat-corrected milk was less ($P < 0.05$) in wk 17-24 than earlier (3.60, 2.78, and 2.45 kg/d for C and 3.02, 3.00, and 2.14 kg/d for F in wk 1-8, 9-16, and 17-24, respectively). Measures at 0 wk in % empty BW (EBW) included 51.1% carcass, 2.01% liver, 14.88% internal fat, and 6.57% gastrointestinal tract (GIT). Carcass mass was greater ($P < 0.05$) for F vs C and similar among times (50.8, 52.1, and 51.2% EBW for C and 52.6, 53.0, and 52.2% EBW for F at 8, 16, and 24 wk, respectively). Liver mass was similar between diets ($P = 0.13$) and greatest among times ($P < 0.05$) at 8 wk (2.87, 2.46, and 2.23% EBW for C and 2.81, 2.63, and 2.58% EBW for F at 8, 16, and 24 wk, respectively). Internal fat mass was greatest among times ($P < 0.05$) at 24 wk and greater for C vs F (11.40, 14.27, and 18.59% EBW for C and 9.39, 11.43, and 13.70% EBW for F at 8, 16, and 24 wk, respectively). Mass of the GIT was less ($P < 0.05$) for C than for F and decreased ($P < 0.05$) with increasing time in lactation (9.26, 7.56, and 6.21% EBW for C and 9.24, 8.50, and 7.87% EBW for F at 8, 16, and 24 wk, respectively). In conclusion, though milk production was not affected by diet partially because of greater DMI for F vs C, based on tissue mass more energy was expended by the GIT of F vs C does. In this regard, it appears that considerable internal fat is mobilized in early lactation particularly with forage-based diets, with more rapid and a greater magnitude of repletion by does consuming diets with high vs moderate or low concentrate levels.

Effects of feed restriction and subsequent realimentation on tissue and mohair fiber by growing Angora goats

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Forty-eight Angora goat wethers (16.7 ± 0.43 kg initial BW and 6 mo of age) were used in a 24-wk experiment to evaluate effects of level of feed intake on current and subsequent tissue (non-fiber) and mohair fiber growth. In Phase 1, 12 wk in length, different amounts of dehydrated alfalfa pellets were fed to provide ME according to NRC requirements adequate for tissue and mohair fiber growth (g/d) of 0 and 0 (0L), 15 and 1.5 (15L), 30 and 3.0 (30L), 45 and 4.5 (45L), 60 and 6.0 (60L), and 75 and 7.5 (75L), respectively. Alfalfa pellets were consumed ad libitum in Phase 2. Digestibility of OM was similar among treatments in both phases. In both phases ME intake (MEI) increased linearly ($P < 0.05$) with increasing level of DMI in Phase 1 (Phase 1: 5.40, 5.24, 6.00, 7.15, 7.89, and 8.04 MJ/d; Phase 2: 10.93, 11.00, 12.02, 13.50, 13.59, and 16.32 MJ/d for 0L, 15L, 30L, 45L, 60L, and 75L, respectively). Energy expenditure in Phase 1 increased linearly ($P < 0.05$) with increasing level of DMI (3.67, 3.87, 3.91, 4.18, and 5.20 MJ/d for 0L, 15L, 30L, 45L, 60L, and 75L, respectively) and was similar among treatments in Phase 2 (6.45 ± 0.40 MJ/d). Tissue growth increased linearly ($P < 0.05$) with increasing DMI in Phase 1 (15.3, 30.9, 49.2, 58.9, 62.5, and 72.1 g/d) and was similar among treatments in Phase 2 (105.6, 108.3, 91.9, 81.9, 76.0, and 97.0 g/d for 0L, 15L, 30L, 45L, 60L, and 75L, respectively). Mohair fiber growth was similar among treatments in Phase 1 (6.6, 6.6, 6.0, 6.2, 7.8, and 7.0 g/d) and in Phase 2 (6.6, 6.8, 5.5, 6.1, 9.2, and 7.3 g/d for 0L, 15L, 30L, 45L, 60L, and 75L, respectively). Mohair diameter increased linearly ($P < 0.05$) with increasing DMI in Phase 1 (21.7, 21.8, 22.1, 23.4, 23.8, and 23.0µm) and in Phase 2 (25.4, 25.5, 26.0, 27.1, 27.0, and 27.1µm for 0L, 15L, 30L, 45L, 60L, and 75L, respectively). In conclusion, growing Angora goats partition nutrients to maintain mohair fiber growth with limited MEI and decrease ene rgy expenditure to lessen the ME requirement for maintenance, resulting in compensatory tissue growth upon realimentation.

Short-term trends of performance test traits of young meat bucks in a central performance test

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Increasingly meat goat producers are basing selection decisions upon performance traits, which impact the profitability of the enterprise, and are relying upon central performance tests to objectively select breeding males. Since 1999, the Langston University central performance test (LUCPT) has evaluated 398 bucks representing 70 breeders and 8 states. Two breeds have been tested, Boer and Kiko, the former accounting for 95% of the bucks enrolled. Therefore, the objective of this study was to evaluate the temporal trends of the performance traits over the last 8 years (1999 to 2006) of bucks enrolled in the LUCPT. Traits evaluated were ADG, feed:gain ratio (FE), loin-eye area (LEA), and residual feed intake (RFI). An analysis of covariance was conducted with performance traits as the dependent variables, breed as the independent variable, and linear and quadratic effects of year as covariates. Over the 8 years, ADG increased linearly (yearly rate =7.3 (g/d)/yr ± 1.25); FE decreased linearly (yearly rate = -0.08/yr ± 0.029); LEA increased quadratically (linear yearly rate = 1.15 cm2/yr ± 0.223; quadratic yearly rate = -0.10 (cm2)yr2 ± 0.024); and RFI increased quadratically (linear yearly rate = 0.039 (g/d)/yr ± 0.0162; quadratic yearly rate = -0.005 (g/d)/yr2 ± 0.0017). The two latter traits increased then decreased overtime so that the traits in 2006 were virtually the same as in 1999. Breed has affected ($P < 0.05$) all performance traits: ADG averaged 277 ± 2.9 for Boer and 206 ± 13.8 g/d, for Kiko; FE averaged 6.8 ± 0.07 for Boer and 7.6 ± 0.32 for Kiko; LEA averaged 11.4 ± 0.11 for Boer and 9.2 ± 0.53 cm2 for Kiko; and RFI averaged -0.03 ± 0.008 for Boer and 0.04 ± 0.038 g/d for Kiko. Phenotypically, FE was positively correlated ($P < 0.05$) with LEA ($r = 0.18$) and with RFI ($r = 0.41$) but negatively correlated with ADG ($r = -0.49$). ADG was positively correlated ($P < 0.05$) with LEA ($r = 0.24$). Generally, ADG increased and FE decreased in desirable directions indicating that meat goat producers may be basing selection upon economically important traits, especially ADG which is easily measured on-test and on-farm. The change in FE may not be due to direct selection but to indirect selection. LEA and RFI remained unchanged, indicating that producers may not be considering these traits in their selection decisions because they do not consider them important or they do not understand them.

Participant demographics of a web-based certification program for meat goat producers

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In 2006, a Langston University-led consortium of 11 universities and 5 meat goat producer groups unveiled an on-line training and certification program (http://www2.luresext.edu/training/qa.html). The program consists of 22 learning modules. Participants take pre- and post-tests to pass the 16 required and a minimum of 3 elective modules for certification. As of February, 2007, 256 participants from 9 countries (US – 245, Canada – 3, India – 2, Australia, Jamaica, Malaysia, Nigeria, Pakistan, Romania – 1 each) have registered for the program. Thirty-nine states are represented with the top 5 states representing 55% of total participants (OK – 59, MO – 24, TX – 20, TN and KS – 16 each). Sixty-five percent of respondents classified

themselves as part-time farmers/ranchers, 19% full time, and 16% no response. Fifty-one percent classified farm size as less than 40 acres and only 16% > 160 acres. Average herd size for 54% of respondents was 49 or fewer animals (34% < 25 goats). Only 13% of respondents owned >100 goats. Males comprised 56% of participants and females 37%, with the remainder not responding. Sixty-three percent of respondents reported membership in the American Boer Goat Association; 16% American Meat Goat Association; 13% American Kiko Goat Association; 6% U.S. Boer Goat Association; and 4% International Kiko Goat Association. Demographic data suggest that an on-line certification program is an acceptable method to provide information to smallholder meat goat producers.

Effectiveness of a web-based certification program for meat goat producers

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In 2006, a Langston University-led consortium of 11 universities and 5 meat goat producer groups unveiled an on-line training and certification program (http://www2.luresext.edu/training/qa.html). The program consists of 22 learning modules in which participants take pre- and post-tests (requiring a score of ≥ 85%) to pass the 16 required and a minimum of 3 elective modules for certification. As of February, 2007, 256 participants have registered for the program. Least square means were lower for pre- vs post-tests (68 vs 90% ± 1.53; P < 0.001) with an average increase in score of 22 percentage points. Largest increases in pre- vs post-test scores were seen in the Reproduction (48 vs 89% ± 3.7) and Nutrition (54 vs 90% ± 3.0) modules with lowest increases in test scores seen in the Livestock Guardian Dogs (77 vs 91% ± 5.4), Herd Health Procedures and Prevention (73 vs 90% ± 4.6), and Marketing (75 vs 87% ± 2.7) modules. Knowledge transfer was evident through the increases in test scores. These data suggest that an on-line testing and knowledge dissemination program is acceptable for many goat producers as a means to increase knowledge of goat production practices.

Validation of Petrifilm plates for enumeration of total bacteria, psychotropic bacteria, and coliforms in goat milk

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PetrifilmTM Aerobic Count (AC) and Coliform Count (CC) plates were validated against standard methods for enumeration of coliforms, total bacteria, and psychrotrophic bacteria in raw (n = 39) and pasteurized goat milk (n = 17) samples. All microbiological data were transformed into log form and statistically analyzed using paired comparison t-test of SAS. There were no significant differences (P < 0.01) between PetrifilmTM CC and the standard Violet Red Bile Agar Petri dish method. PetrifilmTM AC was as accurate (P > 0.05) as the standard Petri dish methods for both total bacteria and psychrotrophic bacteria when the total bacteria count was less than 1x106 CFU/ml. Correlations between PetrifilmTM plates and the standard Petri dish agar methods were high (r = 0.992, 0.997, and 0.974 for coliform, total bacteria, and psychro-

trophic bacteria, respectively). In conclusion, PetrifilmTM AC and CC plates can be used as alternatives to standard methods for enumeration of total bacteria, psychrotrophic bacteria, and of coliforms, respectively. Advantages of PetrifilmTM plates include rapidity, ease of performance, labor saving, and no need for agar preparation or autoclaving. This validation is of practical importance to goat milk producers and processors because of the limited numbers of goat milk samples available daily and the lack of advanced laboratory facilities on most goat farms and in most goat milk processing plants.

Fertility of bucks in the Langston buck performance test

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The objective of this study was to determine the incidence of infertility (based on a breeding soundness examination) in young bucks that completed the Langston Buck test. Data was collected from each buck test from 1999 to 2006 (7 tests, 392 bucks). Semen was obtained by electroejaculation and concentration and motility evaluated immediately by microcopy. A semen sample was spread on a slide for determination of morphology. The breeding soundness examinations were conducted by a commercial semen processor (Reproduction Enterprise). Few bucks failed to pass the breeding soundness examination (15, 3.8%). Eleven goats failed to pass because of low sperm concentration or no sperm and four bucks failed to pass because of low motility which often was associated with abnormal morphology. Some of the bucks with low sperm concentration had droplets indicating that animals had not really reached sexual maturity despite being more than 6 months old. Only 5 of the 15 bucks failing to pass the breeding soundness examination had scrotal circumferences less than 24 cm. The average scrotal circumference on all animals was 26.3 cm (SD 2.63) and the average sperm concentration was 1.59 billion sperm /ml (SD 0.90). There is a low rate of infertility in well managed buck kids older than 6 months.

Methane emission by goats consuming a condensed tannin-containing lespedeza, alfalfa and sorghum-sudangrass

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Twenty four Boer × Spanish (1/2 Boer; initial BW of 38.3 ± 0.69) wethers six per treatment were used to assess effects of a condensed tannin (CT)-containing forage (sericea lespedeza, Lespedeza cuneata; S) with or without polyethylene glycol (PEG), a legume (alfalfa, Medicago sativa; A), and grass (sorghum-sudangrass, Sorghum bicolor; G) on ruminal methane emission. Treatments were S, S plus 25 g/d of PEG mixed with 50 g/d of ground corn (P), A, and G. Forages harvested daily were fed at 1.3 times the maintenance energy requirement. The experiment lasted 15 d, 7 d for adaptation and 8 d for measurement. Digestibility of DM differed ($P < 0.05$), whereas digestible DMI and energy expenditure (EE) were similar among treatments (DM digestibility: 49.5, 52.1, 60.9, and 66.5% (SE = 2.22); digestible DMI: 415, 448, 442, and 475

g/d (SE = 26.3); EE: 462, 456, 509, and 476 kJ/kg BW0.75 (SE = 17.0) for S, P, A, and G, respectively). Methane emission was 15.8, 20.9, 21.3, and 21.6 l/d for S, P, A, and G, respectively (SE =1.25), and was lower for S compared with other treatments ($P < 0.05$). There was also a difference ($P < 0.05$) among treatments in in vitro methane release by ruminal fluid incubated for 3 wk with conditions promoting activity by methanogens (12.9, 21.8, 25.3, and 28.5 ml for S, P, A, and G, respectively; SE = 2.73). In summary, CT-containing forage S decreased methane emission by goats, possibly by altering activity of ruminal methanogenic bacteria, and it did not appear that dietary differences of forages other than CT level might play a significant role in reducing ruminal methane emission.

Summaries of Recent Journal Articles
(2006, 2007, and In Press)

Performance by goats and sheep consuming a concentrate-based diet subsequent to grazing of grass/ forb pastures at different stocking rates

Animut, G., A. L. Goetsch, G. E. Aiken, R. Puchala, G. Detweiler, C. R. Krehbiel, R. C. Merkel, T. Sahlu L. J. Dawson, Z. B. Johnson, and D. H. Kiesler

Small Ruminant Research. 66:92-101. 2006

A study was conducted to determine effects of grazing of mixed grass/forb pastures at three stocking rates (SR) on subsequent performance of goats and sheep fed a concentrate-based diet. Experimental periods, in 2002 and 2003, were 15 weeks in length, following 16 weeks of grazing (May to September) of pastures with warm season grasses and various forbs. Sheep (Katahdin) and goat (75% Boer blood) wethers were 4 to 5 months of age when grazing began. Stocking rates were four (SR4), six (SR6), and eight (SR8) animals per 0.4-ha pasture, with equal numbers of sheep and goats and three pastures per SR. Two sheep and two goats from each pasture were used in the subsequent confinement period, with initial BW of 25 0.6 and 23 0.5 kg, respectively. Average daily gain by all animals during grazing tended to decrease linearly ($P < 0.10$) with increasing SR (61, 51, and 47 g/day for SR4, SR6, and SR8, respectively). In the period after grazing, DM intake tended ($P < 0.10$) to be affected by an interaction between SR and year (year 1: 958, 966, and 1011 g/day; year 2: 1109, 904, and 930 g/day for SR4, SR6, and SR8, respectively (SE = 56.8)). There was a tendency ($P < 0.07$) for an interaction between SR and year in overall ADG (year 1: 172, 160, and 177 g; year 2: 193, 135, and 141 g for SR4, SR6, and SR8, respectively (SE = 12.6)). Sheep had higher overall ADG than goats (193 vs 133 g; SE = 7.9). Gain efficiency (ADG:DMI) was not influenced by SR ($P > 0.10$). Energy expenditure (EE) measured in weeks 3 and 9 via heart rate increased linearly ($P < 0.05$) with increasing SR (562, 589, and 628 kJ/kg BW0.75 for SR4, SR6, and SR8, respectively; SE = 16.4). In conclusion, SR had no impact on ADG of sheep and goat wethers consuming a concentrate-based diet subsequent to the grazing period, which may involve effect of prior SR on subsequent EE.

Change in energy expenditure by meat goats with varying levels of feed intake near maintenance and below

Asmare, A., R. Puchala, R. C. Merkel, T. Sahlu, T., and A. L. Goetsch

Journal of Applied Animal Research 29:81-89. 2006

Eleven yearling meat goat wethers (7/8 Boer and 1/8 Spanish) were used in a 16-week experiment to determine effects of different levels of nutrient restriction and a maintenance level of intake after a severe restriction on energy expenditure (EE). Dehydrated alfalfa pellets were fed throughout the experiment. During the first 4 weeks for adaptation, wethers were fed near maintenance. In weeks 5 to 10, six wethers were fed at approximately 60% of the maintenance level and in weeks 11 to 16 were again fed near maintenance

(L-H). The other five wethers were fed at approximately 80 and 60% of maintenance in weeks 5 to10 and 11 to 16, respectively (M-L). Body weight and EE were measured on the last day of most weeks, with EE determined from heart rate and the previously determined ratio of EE to heart rate for each wether. Body weight differed among weeks but not between treatments (41.0, 41.5, 39.7, 39.5, 38.0, 37.2, 38.0, 37.5, 37.8, 38.8 and 30.3 kg for L-H (SE=1.29), and 38.6, 38.2, 37.2, 37.2, 36.6, 35.0, 36.6, 36.7, 35.9, 35.7 and 36.9 kg (SE=1.41) for M-L in wk 4, 5, 6, 7, 9, 10, 11, 12, 13, 15 and 16, respectively). Energy expenditure, expressed relative to BW at the end of the adaptation period, was 362, 366, 322, 280, 262, 260, 259, 331, 331 and 335 kJ/kg BW0.75 (SE=11.4) for L-H, and 342, 378, 306, 301, 282, 276, 288, 263, 253 and 254 kJ/kg BW0.75 (SE=14.8) for M-L in weeks 4, 5, 6, 7, 9, 10, 11, 12, 13 and 15, respectively. Retained or recovered energy was different ($P<0.05$) from 0 for L-H in weeks 4, 5, 6, 11, 12, 13 and 15 (65, -101, -56, -14, 4, 6, 192, 120, 121 and 117 kJ/kg week 4 BW0.75; SE=15.7) and for M-H in weeks 4, 5, 9 and 10 (92, -47, 25, 29, 49, 55, -14, 11, 21 and 20 kJ/kg week 4 BW0.75 in weeks 4, 5, 6, 7, 9, 10, 11, 12, 13 and 15, respectively; SE=17.3). In conclusion, meat goats can markedly reduce EE in response to limited feed intake, with nonlinear change as time advances.

Effects of walking speed and forage consumption on energy expenditure and heart rate by Alpine does

Berhan, T., R. Puchala, A. L. Goetsch, and R. C. Merkel

Small Ruminant Research 63:119-124. 2006

Eight nonlactating Alpine does (2.5 to 6.5 yr of age; 46 ± 2.9 kg BW) were used to determine effects of standing vs. walking at different speeds and interactions between walking speed and forage ingestion on energy expenditure (EE), heart rate (HR) and their ratio. Coarsely ground alfalfa hay was fed at a maintenance level of intake, and measures were performed in a head-box respiration calorimetry system. In experiment 1, measures occurred at least 3 h after feeding for 20 min after the plateau in EE sequentially, while standing (0 m/s) on a treadmill and thereafter walking at 0.14, 0.28 and 0.42 m/s at a +5% slope. HR and EE ranked ($P < 0.05$) $0 < 0.14 < 0.28 < 0.42$ m/s (HR: 79, 95, 108, and 125 beats/min; EE: 20.6, 25.8, 29.6, and 34.1 kJ/(kg BW0.75 × h)). The ratio of EE:HR was lowest among treatments ($P < 0.05$) for 0 m/s (6.26, 6.54, 6.58, and 6.56 (kJ/(kg BW0.75 × day)/(beats/min) for 0, 0.14, 0.28, and 0.42 m/s, respectively). In experiment 2, EE and HR were first determined while standing, followed by measures when walking at 0.07, 0.14 or 0.21 m/s at a +5% slope; measurements also occurred while consuming 50% of the daily allocation of forage when standing or walking at the different speeds immediately after measures without forage ingestion. Differences between values for forage consumption plus walking or standing and walking or standing without forage were calculated to determine the origin of, or factor responsible for, change in EE (i.e., walking (W) vs. forage consumption (F)), with the previous standing estimate without forage used as a covariate. There was an interaction ($P < 0.05$) between walking speed and origin of EE. EE due to W ranked ($P < 0.05$) $0 < 0.07 < 0.14$ and 0.21 m/s (-0.3, 3.4, 4.8 and 5.9 kJ/(kg BW0.75 × h)). Conversely, EE attributable to F was lower ($P < 0.05$) for 0 than for 0.07 and 0.21 m/s (9.0, 10.7, 10.3, and 10.7 kJ/(kg BW0.75 × h) for 0, 0.07, 0.14, and 0.21 m/s, respectively). Differences in HR were generally similar in magnitude to those in EE (-1, 9, 17 and 20 beats/min for W, and 35, 51, 40 and 42 beats/min for F, at 0, 0.07, 0.14, and 0.21 m/s, respectively (SE = 2.1)). In summary, these results suggest potential use of HR to predict EE while grazing.

Forage consumption increased EE to a greater extent than walking and may lessen effects of walking and walking speed on the grazing activity energy cost.

Effects of the number of yearling Boer crossbred wethers per automated feeding system unit on feed intake, feeding behavior and growth performance

Gipson, T. A., A. L. Goetsch, T. A. Gipson, G. Detweiler, R. C. Merkel, and T. Sahlu

Small Ruminant Research 65:161-169. 2006

Thirty-six growing Boer x Spanish wethers (initial BW of 30 ± 0.7 kg) were used in an 82-day experiment to determine effects of the number of animals per automated feeding system (NPF; 6, 8, 10 and 12), allowing consumption by only one animal at a given time, on intake of a 50% concentrate pelletized diet (9.2 MJ/kg ME, DM basis), feeding behavior and growth performance. During the entire experiment DM intake (1454, 1513, 1596 and 1374 g/day) and BW gain (156, 167, 181 and 136 g/day for 6, 8, 10 and 12 NPF, respectively) were affected by NPF quadratically ($P < 0.05$), although gain efficiency (ADG:DM intake) was similar among NPF. The number of feeder visits (17.5, 17.1, 17.9 and 18.7) and meals (8.9, 9.0, 9.3 and 8.9) were similar among NPF, although feeder occupancy per day (97.8, 73.2, 83.0 and 71.7 min), visit (5.8, 4.4, 5.0 and 3.8 min) and meal (11.2, 8.2, 9.2 and 8.1 min for 6, 8, 10 and 12 NPF, respectively) decreased linearly with increasing NPF ($P < 0.05$). The rate of DM consumption relative to feeder occupancy time plateaued as NPF increased to 8 (linear and quadratic changes, $P < 0.05$; 14.6, 24.9, 21.5 and 23.1 g/min for 6, 8, 10 and 12 NPF, respectively). In conclusion, with these diet and animal characteristics, 8 or 10 wethers per automated feeder appear appropriate for achieving unrestricted growth performance.

Effects of feeding system on growth performance of Somali and Arsi-Bali goats

Legesse, G., G. Abebe, and A. L. Goetsch

Journal of Applied Animal Research 30:5-12. 2006

Forty-eight intact male goats, approximately 9 months of age, were used in an 84-day experiment to determine effects and interactions of genotype (27 Arsi-Bale and 21 Somali, with mean initial body weight (BW) of 14.1 and 15.9 kg, respectively (SE = 0.39)) and feeding system (intensive, semi-intensive, and extensive) on growth performance and harvest measures. Goats on the intensive (I) treatment were confined in individual pens and fed Rhodesgrass hay supplemented with 300 g/day (air-dry) of a concentrate mixture; semi-intensive (S) goats grazed grass pasture for 7 h/day and were supplemented with 300 g/day of concentrate; and goats on the extensive (E) treatment grazed grass pasture for 8 h daily. There were no significant interactions between genotype and feeding system. Average daily gain (ADG) ranked ($P < 0.05$) S > I > E (54, 32, and 5 g) and was greater ($P < 0.06$) for Somali than for Arsi-Bale goats (34 vs 27 g). Hot carcass weight was 7.34, 8.21, and 5.21 kg (SE = 0.28) and hot carcass dressing percentage was lowest among feeding systems ($P < 0.05$) for E (42.6, 43.3, and 38.8% for I, S and E, respectively). Carcasses of Somali goats were lower ($P < 0.05$) in separable lean tissue (55.3 vs 58.9%) and higher in fat ($P < 0.05$; 14.0 vs 11.0%) compared with Arsi-Bale carcasses. Carcass separable lean concentration ranked ($P < 0.05$) S (62.2%) >

I (57.5%) > E (51.6%), fat was greatest among feeding systems (P<0.05) for I (15.3, 11.2, and 10.9% for I, S, and E, respectively), and bone was greatest (P<0.05) for E (27.3, 26.6, and 37.5% for I, S, and E, respectively). In conclusion, ADG of male Somali and Arsi-Bale goats was similarly affected by the different feeding systems, with Somali goats yielding greater final BW than Arsi-Bale as a function of both greater initial BW and ADG during the experiment. Feeding system can impact not only growth performance but also carcass characteristics that may influence consumer appeal.

Effects of level and source of supplemental protein in a concentrate-based diet on sites of digestion and small intestinal amino acid disappearance in Boer × Spanish wether goats

Soto-Navarro, S. A., A. L. Goetsch, T. Sahlu, and R. Puchala

Small Ruminant Research 65:85-100. 2006

12 yearling Boer × Spanish wether goats fitted with ruminal, duodenal and ileal cannulae (34.5 ± 1.39 kg average BW) were used in an experiment with two simultaneous 6 × 6 Latin squares to determine effects of different supplemental protein sources on sites of digestion and small intestinal amino acid disappearance with concentrate-based diets moderate or high in CP concentration. Diets were formulated to be 13 or 19% CP (DM basis), with supplemental protein provided by blood (BLM), corn gluten (CGM), cottonseed (CSM), feather (FTM), fish (FIM) or soybean meal (SBM). Small intestinal disappearance of the sum of essential amino acids measured (i.e., histidine, threonine, arginine, valine, methionine, isoleucine, leucine, lysine and phenylalanine) was greater for BLM vs. SBM (39.0, 33.4, 28.7, 33.1, 33.3 and 20.5 g/day for BLM, CGM, CSM, FTM, FIM and SBM, respectively). Small intestinal disappearance of some essential amino acids was similar among CP sources with 13% CP but different with 19% CP. With 19% CP, small intestinal disappearance of histidine and valine was greatest (P < 0.05) among sources for BLM (histidine: 6.1, 1.8, 2.1, 1.9, 1.5 and 1.1 g/day; valine: 7.1, 3.6, 3.0, 4.3, 4.7 and 2.1 g/day), for leucine was greater (P < 0.05) for BLM and CGM than for CSM, FTM and SBM (13.2, 13.1, 5.8, 8.5, 9.3 and 4.4 g/day), of lysine was greater (P < 0.05) for BLM vs. CGM, CSM, FIM and SBM (8.2, 3.2, 3.9, 5.5, 4.1 and 2.9 g/day) and of phenylalanine was lowest among sources for SBM (6.6, 5.2, 3.8, 3.9, 3.7 and 2.2 g/day for BLM, CGM, CSM, FTM, FIM and SBM, respectively). Essential amino acids with small intestinal disappearance not influenced by protein source within CP level were threonine, methionine and isoleucine. However, small intestinal disappearance of threonine (2.5 and 3.8 g/day) and methionine (1.1 and 1.9 g/day for 13 and 19% CP, respectively) was greater (P < 0.05) for 19 vs. 13% CP diets. In conclusion, use of different feedstuffs high in protein not extensively degraded in the rumen and with unique amino acid concentrations in diets of goats may have little influence on small intestinal absorption of select amino acids with dietary CP levels such as 13%, although effects may occur with much higher levels of CP (e.g., 19%).

Effects of dietary ratios of fish and blood meals and level of crude protein in a concentrate-based diet on sites of digestion, small intestinal amino acid disappearance and growth performance of meat goat wethers

Soto-Navarro, S. A., R. Puchala, T. Sahlu, and A. L. Goetsch

Small Ruminant Research 64:255-267. 2006

Six yearling Boer x Spanish wether goats (37 ± 1.6 kg initial live weight; LW) and 24 growing Boer x Spanish and 24 Spanish wethers (21 ± 3.1 and 20 ± 2.6 kg initial BW, respectively) were used to determine the effects of total CP and two supplemental protein sources (fish meal, FIM; blood meal, BLM) in a 70% concentrate diet on sites of digestion, small intestinal amino acid disappearance and growth performance. Diets were formulated to be 12% or 15% CP (DM basis), with predicted ruminally undegraded intake protein (UIP) from FIM and BLM of 1.2 and 3.0% DM, respectively, achieved from FIM supplying 100, 67 and 33% and BLM 0, 33 and 67%, respectively (100F, 67F and 33F, respectively). True ruminal OM and N digestibilities were greater ($P < 0.05$) for 12% vs. 15% CP and decreased linearly ($P < 0.05$) as level of FIM decreased. Duodenal flows of both microbial and nonmicrobial, nonammonia (feed plus endogenous) N were greater ($P < 0.05$) for 15% than for 12% CP and increased linearly with decreasing FIM level in the diet. Correspondingly, small intestinal disappearance of essential amino acids was greater ($P < 0.05$) for 15% vs. 12% CP and increased ($P < 0.05$) with decreasing FIM. In an 18 week growth experiment, DM intake (935 vs. 783 g/day), average daily gain (ADG; 145 vs 108 g) and ADG:DM intake (155 vs. 138 g/kg) were greater ($P < 0.05$) for Boer x Spanish compared with Spanish wethers. Regardless of genotype, neither level of total CP nor of FIM influenced growth performance. In conclusion, with diets relatively high in concentrate and a CP level of 12%, amino acid requirements of common genotypes of growing meat goats in the US may be satisfied by basal dietary ingredients, with little or no potential to enhance performance by addition of feedstuffs high in UIP regardless of amino acid profile.

Evaluation of melatonin and bromocryptine administration in Spanish goats. III. Effects on hair follicle activity, density, primary and secondary follicle ratio and relationships between follicle characteristics

Wuliji, T., A. Litherland, A. L. Goetsch, T. Sahlu, R. Puchala, L. J. Dawson, and T. Gipson

Small Ruminant Research 66:11-21. 2006

Melatonin treatment for out of season breeding in goats may also affect skin hair follicle activity, thereby influencing the spring growth phase and yield of cashmere. Female Spanish goats (15 does and 65 kids) were allotted to 5 treatments: control (C), melatonin implant (MI; 18 mg, 42-day release); melatonin and bromocryptine implants (225 mg, 60-day release period; MIB); oral administration of melatonin (MO; 3 mg/day); and oral administration of melatonin and bromocryptine implant (MOB). Treatments began March 1 (spring), and hair follicle characteristics were monitored monthly from February to May. Mean initial and final body weights were 27.9 ± 1.2 and 35.3 kg ± 1.2, respectively. Total follicle number was greater ($P < 0.05$) for the MOB group compared to the C group in April, while in May the total follicle number was greater ($P < 0.05$) for the MIB group compared to the C and MO groups, whereas secondary follicle

numbers were greater (P < 0.05) for MIB than for C and MO and for MOB (P < 0.05) vs. C, MI and MO groups. The primary active follicle percentage was correlated (P < 0.001) with the secondary active follicle percentage (r = 0.32), and the correlation (P < 0.01) between secondary active follicle percentage and mean cashmere fiber diameter was r = 0.31. Primary active follicle ratio did not differ between treatments, but the secondary active follicle ratio was greater (P < 0.01) for treatments with melatonin administration, compared to the control in March, April and May. Primary follicle number, secondary follicle number, total follicle number, secondary to primary follicle ratio, primary follicle diameter, secondary follicle and primary to secondary follicle diameter ratio averaged 3.9/mm2 (SE = 0.15), 26.8/mm2 (SE = 1.22), 30.8/mm2 (SE = 1.31), 7.0:1 (SE = 0.23), 74.0 m (SE = 2.87), 15.6 m (SE = 0.19) and 4.7:1 (SE = 0.18), respectively. There were positive correlations (P < 0.001) for follicular characteristics, such as secondary follicle number with total follicle number (r = 0.99), secondary to primary ratio (r = 0.68), group follicle number (r = 0.63) and group secondary to primary follicle ratio (r = 0.63), and primary follicle diameter with primary secondary diameter ratio (r = 0.96). There were also negative correlations (P < 0.01), such as primary follicle number with primary follicle diameter (r = -0.42), secondary follicle diameter (r = -0.33) and secondary and primary follicle ratio (r =-0.48), and primary follicle number with primary and secondary diameter ratio (r= -0.33). 90% of follicular groupings were of the trio primary follicle type, whereas the remaining 10% were of solo, duo and quartet primary follicular group formations. All primary follicles possessed medullae and some secondary marginal follicles (intermediate type) were medullated, but few follicles of the pure cashmere follicle type had medullae. Hair follicles varied from low, moderate to high density in Spanish goats. Fiber growth rate, fiber diameter and extended follicular activity rate during the spring months suggest that an accelerated breeding program for Spanish goats by melatonin treatment for breeding in the spring could be also profitable by extending the spring cashmere growth phase into a commercially harvestable cashmere length.

Effects of pasture inclusion of mimosa on growth by sheep and goats co-grazing grass/forb pastures

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Effects of mimosa alley-cropped in grass/forb pastures on growth performance of co-grazing sheep and goat wethers were determined. Eighteen sheep (Katahdin) and eighteen goats (> 75% Boer blood), with BW of 22 ± 0.3 and 21 ± 0.2 kg, respectively, and age of 4 to 5 months were used. Wethers grazed 0.4-ha pastures of grasses and forbs for 16 weeks. Three pastures with alley-cropped mimosa (W) and three without (WO) were divided into four paddocks for 2-week rotational grazing. Based on mimosa leaf mass at the beginning of grazing periods and animal days, daily consumption of mimosa leaf DM averaged 47 g per animal, although mimosa leaf harvest was complete long before the end of the grazing periods. Mimosa leaf samples averaged 2.81, 37.8, and 85.9% N, NDF and in vitro true DM digestibility (IVDMD), respectively. Forage mass (grass and forbs) was similar between treatments before (2928 and 2695 kg/ha) and after grazing (1507 and 1452 kg/ha for WO and W, respectively). Pre-grazed forage concentrations of N (1.25 and 1.24%) and NDF (64.5 and 63.8%) and IVDMD (52.9 and 56.2% for WO and W, respectively) were similar between treatments, as was also true post-grazing. ADG was numerically greater (P=0.17) for W vs. WO (70 vs. 51 g/d; SE = 7.7). In summary, alley-cropped mimosa increased nutritive value of the forage avail-

able for consumption. Nonetheless, mimosa had limited effect on growth performance of co-grazing sheep and goats perhaps because of decreasing mimosa leaf availability as 2-week grazing periods advanced or overall relatively low intake of mimosa leaf.

Factors influencing urea space estimates in goats

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Small Ruminant Research In Press; available on-line. 2007

Female Alpine goats, 18 approximately 17 mo of age (yearling) and 18 5-mo-old (growing), were used in an experiment to determine effects of animal age, urea dose (100, 130, and 160 mg/kg BW), and time without feed and water (shrink; 0, 16, and 24 h) on urea space estimates. A 20% (wt/vol) urea solution was infused into a jugular vein, with blood sampled before infusion and every 3 min to 21 min. BW was 49.8, 47.4, and 47.0 kg for yearlings and 26.1, 24.6, and 23.9 kg for growing animals after 0, 16, and 24 h shrinks, respectively (SE = 0.80). Time of urea equilibration with body water, determined by a grafted polynomial quadratic-linear model, was affected by a dose x age x shrink interaction ($P < 0.05$); yearling means did not differ (ranging from 7.3 to 10.8 min), although those for growing animals were greater ($P < 0.05$) for 0 h:130 mg (13.0 min) and 24 h:130 mg (13.2 min) compared with 24 h:100 mg (7.6 min) and 16 h:130 mg (7.1 min). Based on these times, 12-min samples were used to determine urea space. Urea space was influenced by an age x shrink interaction ($P < 0.05$), being similar among shrink times for yearlings (17.8, 18.8, and 18.9 kg) and greater ($P < 0.05$) for growing animals after 0 than 24 h shrink (12.9, 11.3, and 10.0 kg for 0, 16, and 24 h, respectively). Hemoglobin concentration in plasma, as an index of hemolysis, was lower ($P < 0.05$) for growing than for yearling animals (1.16 vs. 1.86%), lowest among doses ($P < 0.05$) for 100 mg (1.05, 1.74, and 1.75% for 100, 130, and 160 mg, respectively), and highest among shrink times ($P < 0.05$) for 24 h (1.46, 1.42, and 1.61% for 0, 16, and 24 h, respectively). In conclusion, effects of and interactions involving some of the factors studied and high variability in the time of urea equilibration with body water indicate that, regardless of the particular urea space procedures chosen, relatively high numbers of observations are warranted.

Effects of feeding method, diet nutritive value, and physical form and phenotype on feed intake, feeding behavior, and growth performance by meat goats

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Thirty-two F1 Boer x Spanish (28.7 ± 0.49 kg) and 40 3/4 Boer-1/4 Spanish (31.9 ± 0.47 kg) wethers, approximately 5 months of age, were used to compare feeding systems with different dietary treatments. Feeding systems were Calan gates and automated feeding units allowing one animal to consume feed at a time. Two diets included concentrate (C) and two were dehydrated alfalfa (A), fed pelletized (P) or loose (L). The main effect of feeding method was not significant for any variable. There was an interaction in DM intake (DMI) involving feeding method, diet, and genotype, which indicated that with a concentrate

diet, regardless of physical form, DMI was not influenced by feeding method. Main effect dietary treatment means (1.78, 1.67, 2.04, and 1.70 kg for C-P, C-L, A-P, and A-L, respectively; SE = 0.030) indicated that pelletizing had a slightly greater effect on DMI with A vs. C. ADG was lowest among treatments for A-L (212, 205, 190, and 157 g for C-P, C-L, A-P, and A-L, respectively; SE = 8.9), and ADG:DMI was greater for C vs. A (127, 120, 94, and 94 g/kg for C-P, C-L, A-P, and A-L, respectively; SE = 7.8). For wethers subjected to automated feeding units, the number of feeder visits was lowest among diets ($P < 0.05$) for C-P (23.1, 31.2, 35.7, and 35.7 per day; SE = 2.00); total feeder occupancy time per animal ranked ($P < 0.05$) C-P < A-P < C-L and A-L (74, 130, 105, and 122 min/day; SE = 6.8), and rate of DMI was greater for P than for L diets (24.6, 12.9, 22.0, and 13.7 g/min for C-P, C-L, A-P, and A-L, respectively; SE = 3.89). In summary, meat goats can markedly vary feeding behaviors in response to different diet types and forms; however, there appear limits to such changes, as exemplified by lowest ADG for A-L. Calan gates and automated feeding systems appear similar in the ability to compare growth performance with treatments such as the concentrate-containing diets and genotypes of this experiment. Most performance benefit in growing progeny from Boer crossbreeding may be achieved in F1 animals, with little further improvement realized from the first backcross of F1 females. Pelletizing does not seem to affect on growth performance with diets consisting of appreciable concentrate. Effects of pelletizing on growth performance of meat goats consuming forage diets may be attributable to change in level of feed intake, without impact on efficiency of feed utilization.

Effects of fertilization, leguminous trees, and supplementation on performance of meat goat does and their kids grazing grass/forb pastures

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Thirty-nine Spanish does and their twin kids, approximately 4-wk old initially, were used in a 112-d experiment. Twelve grass/forb 0.4-ha pastures were subdivided into four paddocks and rotationally grazed for 2-wk periods in two 8-wk phases. Treatments were Control, Fertilization, Mimosa, and Supplementation, with three pastures per treatment. Three does with six kids grazed each of the Control, Supplementation, and Mimosa pastures, and four does with eight kids grazed Fertilization pastures. Fertilization pastures received a N, P, and K application 3 weeks before the experiment, and Supplementation animals received ad libitum access to a commercially available block containing 20% CP, with DM consumption averaging 116 g/d on a per doe basis. Mimosa leaf DM available at the beginning of each 2-wk period averaged 174 and 139 kg/ha in phase 1 and 2, respectively, although consumption was complete within the first few days of grazing periods. Fertilization increased prevalence of bermudagrass at the beginning of grazing periods (23.2, 43.6, 20.3, and 28.2% before grazing and 63.5, 58.9, 42.9, and 55.8% after the experiment for Control, Fertilization, Mimosa, and Supplementation, respectively; SE =5.70). Forage DM mass (excluding mimosa leaf DM) was similar among treatments (1,491, 1,554, 1,386, and 1,430 kg/ha; SE = 69.0); the concentration of CP in hand-plucked forage samples was 12.9, 14.7, 14.3, and 13.1% for Control, Fertilization, Mimosa, and Supplementation, respectively (SE = 1.12). Doe ADG was similar among treatments (-55, -56, -29, and -59 g/d; SE = 10.9), and kid ADG was greater ($P < 0.05$) for Mimosa vs. Supplementation (133, 130, 146, and 118 g/d Control, Fertilization, Mimosa, and Supplementation, respectively; SE = 5.8). In conclusion, a supplemental protein block may not be beneficial for grazing meat goat does with nursing

twin kids unless forage is very low in protein. Fertilization can allow an increased stocking rate to elevate production per unit of land area. Leguminous trees in grass/forb pastures deserve further study as a means of nutrient supplementation, although methods of management to facilitate leaf availability throughout the grazing period or on most days should be given attention.

Performance of Spanish and Boer x Spanish doelings consuming diets with different levels of broiler litter

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Sixty Spanish (S) and 40 Boer x Spanish (BS) doelings (14.9 ± 3.8 and 21.9 ± 3.8 kg initial BW, respectively, and approximately 6 months of age) were used in an experiment with four 3-week periods to determine effects of dietary broiler litter (L) level on growth performance. There were two groups per treatment with six S and four BS doelings in each. Dietary treatments were 20% coarsely ground millet hay and 80% concentrate, which consisted of 0 (0L), 20 (20L), 40 (40L), or 60% L (60L; total dietary level). An additional treatment was 80% hay and 20% concentrate (80F). Concentrate (primarily corn and L when included) DM intake (DMI) was 700, 593, 652, 387, and 165 g/d (SE = 20.3) and total DMI was 883, 755, 825, 490, and 696 g/d (SE = 35.5) for 0L, 20L, 40L, 60L, and 80F, respectively. There was a dietary treatment x period interaction in ADG (period 1: 104, 29, 36, -44, and 47 g; period 2: 124, 102, 53, -74, and 12 g; period 3: 175, 126, 126, 87, and 80 g; period 4: 161, 151, 136, 66, and 51 g for 0L, 20L, 40L, 60L, and 80F, respectively (SE = 12.2)). Treatment and genotype also interacted in ADG (S: 107, 85, 72, 8, and 36 g; BS: 174, 118, 103, 10, and 60 g for for 0L, 20L, 40L, 60L, and 80F, respectively (SE = 9.2)). ADG:DMI ranked ($P < 0.06$) 0L > 20L > 40L > 80F > 60L (152, 130, 102, 18, and 65 g/kg for 0L, 20L, 40L, 60L, and 80F, respectively; SE = 6.12). The acetate:propionate ratio in ruminal fluid was greater ($P < 0.05$) for 60L and 80F than for other treatments (1.60, 1.73, 2.18, 3.80, and 3.67 for 0L, 20L, 40L, 60L, and 80F, respectively; SE = 0.27). Liver Cu concentration at the end of the experiment was influenced by dietary treatment (88, 275, 478, 286, and 47 ppm for 0L, 20L, 40L, 60L, and 80F, respectively; SE = 53.2). In conclusion, L can be effectively used in diets for growing meat goats, but high levels, such as above 40% of dietary DM, may restrict performance primarily via limited feed intake. However, the level of L below this threshold impacts efficiency of feed utilization.

Effect of initial body condition of Boer x Spanish yearling wethers and level of nutrient intake on body composition

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Yearling Boer x Spanish goat wethers were used to assess effects of initial body condition and subsequent level of feed intake on body composition. Before the experiment, 21 wethers were fed to achieve high body

condition score (BCS; 1 to 5, with 1 = extremely thin and 5 = extremely fat) and BW (initially fat; I-F) and 27 were fed for low BCS and BW (initially thin; I-T). During the experiment, I-F wethers were fed low amounts of a pelletized diet and I-T wethers received high amounts. Harvest measures were determined before the experiment (wk 0) and after 12 and 24 wk, with seven animals per initial body condition and time. BCS in Experiment 1 was 3.8, 3.2, 2.6, 1.9, 2.8, and 3.5 (SE = 0.11) and live BW was 53.3, 46.2, 42.4, 36.6, 40.1, and 48.2 kg (SE = 2.03) for I-F:wk 0, I-F:wk 12, I-F:wk 24, I-T:wk 0, I-T:wk 1, and I-T:wk 2, respectively. There were substantial declines in mass of many internal organs with advancing time for I-F compared with relatively small change for I-T. Examples include the reticulo-rumen (1.03, 0.59, 0.52, 0.87, 0.78, and 0.73 kg; SE = 0.041), small intestine (0.59, 0.27, 0.23, 0.55, 0.33, and 0.36 kg; SE = 0.021), large intestine (0.40, 0.24, 0.24, 0.33, 0.33, and 0.26 kg; SE = 0.017), and liver (0.86, 0.45, 0.42, 0.56, 0.60, and 0.67 kg for I-F:wk 0, I-F:wk 12, I-F:wk 24, I-T:wk 0, I-T:wk 12, and I-T:wk 24, respectively; SE = 0.031). Conversely, change in internal or non-carcass fat mass was much greater for I-T vs. I-F (5.7, 3.9, 2.8, 0.6, 2.5, and 5.1 kg for I-F-wk 0, I-F-wk 12, I-F-wk 24, I-T-wk 0, I-T-wk 12, and I-T-wk 24, respectively; SE = 0.33). Changes in carcass mass of protein (-5.9, -5.3, 7.0, and 5.8 g/day; SE = 0.89) and fat (-1.9, 0.2, 21.4, and 26.6 g/day; SE = 2.35) were greater ($P < 0.05$) for I-T vs. I-F, as was also true for non-carcass protein (6.1, 0.0, 14.5, and 6.3 g/day; SE = 0.91) and fat (-16.3, -10.4, 13.6, and 26.3 g/day for for I-F:wk 1-12, I-F:wk 1-24, I-T:wk 1-12, and I-T:wk 1-24, respectively; SE = 2.49). Based on energy concentrations in empty body tissue lost or gained in wk 1-12 and 1-24 (14.8, 12.1, 19.9, and 26.4 MJ/kg for I-F:wk 1-12, I-F:wk 1-24, I-T:wk 1-12, and I-T:wk 1-24, respectively; SE = 2.13), the energy concentration in wk 13-24 was 9.4 and 32.9 MJ/kg for I-F and I-T, respectively. In conclusion, the energy concentration in tissue mobilized or accreted by yearling meat goats within certain body condition ranges may not necessarily be the same and appears influenced by initial animal characteristics and subsequent feeding conditions.

Urea space and body condition score to predict body composition of meat goats

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Yearling Boer x Spanish goat wethers (40) were used to develop and compare body composition prediction equations for mature meat goats based on urea space (US) and body condition score (BCS). Before the experiment, one-half of the animals were managed to have high BW and BCS (1-5, with 1 being extremely thin and 5 very fat) and the others were managed to have low BW and BCS. During the 24-wk experiment, initially fat wethers were fed to lose BW and BCS and initially thin wethers were fed to increase BW and BCS. BCS, US, and whole body chemical composition were determined after 0, 12, and 24 wk. Mean, minimum, and maximum values were 42.1 (SE = 1.12), 24.5, and 59.0 kg for shrunk BW; 3.0 (SE = 0.11), 1.5, and 4.0 for BCS; 61.3 (SE = 1.01), 53.7, and 76.5% for water; 20.2 (SE = 1.11), 4.7, and 29.7% for fat; 15.6 (SE = 0.19), 13.3, and 18.1% for protein; and 2.9 (SE = 0.062), 2.2, and 3.7% for ash, respectively. For water, fat, and ash concentrations and mass, simplest equations explaining greatest variability (with independent variables of US, BCS, and(or) shrunk BW) based on BCS accounted for more variation than ones based on US, although in some cases differences were not large (i.e., water and ash concentrations and mass). Neither US nor BCS explained variability in protein concentration. Equations to predict protein mass based on shrunk BW and US or BCS were nearly identical in R2 and the root mean square error. A 1

unit change in BCS corresponded to change in full BW of 8.9 kg (full BW, kg = 17.902 + (8.9087 × BCS); R2 = 0.653), fat concentration of 7.54% (% fat = -5.076 + (7.5361 × BCS); R2 = 0.612), and energy concentration of 3.01 MJ/kg (energy, MJ/kg = 0.971 + (3.0059 × BCS); R2 = 0.615). In summary, BCS may be used as or more effectively to predict body composition of meat goats than US. The primary determinant of BCS, within the range of BCS observed in this experiment, was fat content.

The relationship between heart rate and energy expenditure in Alpine, Angora, Boer and Spanish goat wethers goats consuming different quality diets at level of intake near maintenance or fasting

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Small Ruminant Research. In Press; available on-line. 2007

Six Alpine (AL; 38.4 ± 3.0 kg), Angora (AN; 23.1 ± 2.7 kg), Boer (BO; 40.8 ± 4.5 kg) and Spanish (SP; 33.6 ± 2.2 kg) wethers (1.5 yr of age) were used to determine the effects of time of the day and potential interactions between time, genotype and diet quality on energy expenditure (EE), heart rate (HR) and EE:HR when fed near maintenance and fasting. The experiment consisted of four simultaneous crossovers, with 21 d for adaptation before measures. Diets were 60% concentrate
(CON: 15% CP) and ground alfalfa hay (FOR: 23% CP), offered in two meals at 8:00 and 16:00 h. Energy expenditure was determined from O2 consumption and production of CO2 and CH4 over 2-day periods in fed and fasting states (total 4-day fasting period). Fasting EE was higher during the day than night, with values generally highest at 16:00-17:00 h. Animal within breed affected EE, HR and EE:HR ($P < 0.05$). The diurnal pattern in EE varied with diet ($P < 0.05$), although total daily EE was not different be tween diets. Before the morning meal, there were a number of hours during which EE was greater for CON than for FOR. However, at both meals the rise in EE was considerably greater for FOR versus CON, lasting for 3–4 h. The same general pattern in HR was observed, although the period of time when there was a dietary difference after the afternoon meal was shorter. For both fed and fasted goats, EE:HR differed among hours of the day ($P < 0.05$). EE:HR tended ($P < 0.09$) to differ between diets (5.99 and 6.21 for CON and FOR, respectively) and to be affected ($P < 0.09$) by an interaction between breed and diet (AL: 5.84 and 6.38; AN: 5.91 and 5.73; BO: 6.05 and 6.58; and SP: 6.17 and 6.15 kJ/(kg BW0.75 × day):heart beats/min) for CON and FOR, respectively. In conclusion, for use of HR to predict EE by goats, it appears desirable to determine the ratio of EE:HR with a diet similar to that consumed during prediction and over an extended period of time.

Energy utilization by mature goats. 1. Effects of feed restriction on energy expenditure by 2 year old crossbred Boer goats

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Fourteen Boer (75%) x Spanish wether goats (51 ± 1.8 kg BW and 23 months of age) were used to determine effects of a moderate degree of nutrient restriction on heat production or energy expenditure (EE). The experiment consisted of a 26-day period (P1) followed by one of 50 days (P2). Wethers were fasted on the final 4 days of each period, with gas exchange measured on the last 2 days. Fasting was preceded by collection of feces and urine for 7 days, with the final 2 days for gas exchange. All wethers were fed a 60% concentrate diet at a level of intake near maintenance in P1 (P1-100 and P1-80 treatments). In P2, six wethers continued on this level of intake (P2-100 treatment); eight wethers also were fed at this level for 15 days but then had ME intake sequentially reduced by approximately 10 and 20% for 10 and 21 days, respectively (P2-80 treatment). Intake of ME was lowest ($P < 0.05$) for P2-80 (529, 535, 552 and 474 kJ/kg BW0.75 (fasted) for P1-100, P1-80, P2-100, and P2-80, respectively). Fed EE was lowest ($P < 0.05$) for P2-80 (495, 505, 467, and 406 kJ/kg BW0.75), whereas that while fasting was similar among treatments (287, 279, 273, and 253 kJ/kg BW0.75 for P1-100, P1-80, P2-100, and P2-80, respectively). The ME requirement for maintenance (MEm) was greater ($P < 0.05$) in P1 than P2 (477, 487, 421, and 376 kJ/kg BW0.75 for P1-100, P1-80, P2-100 and P2-80, respectively), and when analyzed for P2 separately MEm was lower ($P < 0.10$; 374 vs 425 kJ/kg BW0.75) and the efficiency of ME use for maintenance was greater ($P < 0.08$) for P2-80 than for P2-100 (0.689 vs 0.625). In conclusion, moderate feed intake restriction impacted EE and MEm by mature meat goats largely via decreasing EE associated with or responsive to nutrient intake or workload rather than physiological processes responsible for fasting EE.

Energy utilization by mature goats. 2. Effects of diet quality on energy expenditure by 20-month old Alpine, Angora, Boer and Spanish wethers

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Small Ruminant Research. In Press; available on-line. 2007

Six Alpine (47.7 ± 1.36 kg initial BW), Angora (28.8 ± 1.11 kg), Boer (87.5% Boer and 12.5% Spanish; 49.3 ± 2.17 kg), and Spanish (38.7 ± 0.51 kg) wethers (initial age of 19 months) were used to determine effects of genotype and diet quality on energy expenditure (EE) when fed near maintenance and fasted. The experiment consisted of four simultaneous crossovers, with 21 d for adaptation before measures. Diets were 65% concentrate (CON) or coarsely ground alfalfa hay (FOR). EE was determined from O2 consumption and production of CO2 and CH4 with a head-box respiration calorimetry system, along with urinary N excretion, over 2-day periods in fed and fasted states (4-day fast). EE was expressed on the basis of average BW during the fasted measurement period. There were only significant interactions between genotype and diet in DM and gross energy intakes, which were due to differences in magnitude. Intake of ME was similar among genotypes and slightly greater ($P < 0.05$) for CON than for FOR (450 vs. 424 kJ/kg BW0.75). Neither diet (373 and 371 kJ/kg BW0.75 for CON and FOR, respectively; SE = 5.9) nor genotype (377,

377, 361, and 373 kJ/ kg BW0.75 by Alpine, Angora, Boer, and Spanish, respectively; SE = 9.3) influenced fed EE ($P > 0.10$). Fasted EE was similar between diets but was greatest among genotypes ($P < 0.05$) for Alpine (251, 224, 217, and 225 kJ/ kg BW0.75 by Alpine, Angora, Boer, and Spanish, respectively; SE = 7.2), which may have been due to a greater level of activity exhibited by Alpine than other genotypes when fasted. Efficiency of utilization of ME for maintenance was similar ($P > 0.10$) between diets (0.685 and 0.657 for CON and FOR, respectively; SE = 0.0134). The ME requirement for maintenance was similar ($P > 0.10$) between diets (342 and 352 kJ/kg BW0.75 for CON and FOR, respectively; SE = 7.9) and among genotypes (353, 349, 326, and 362 kJ/kg BW0.75 for Alpine, Angora, Boer and Spanish, respectively; SE = 11.1). In summary, with a level of intake near maintenance, the maintenance energy requirement appears similar for Alpine, Angora, Boer and Spanish goats near 2 yr of age regardless of diet quality.

Energy expenditure by growing crossbred Boer and Spanish wethers consuming different quality diets ad libitum and near maintenance and while fasting

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Small Ruminant Research. In Press; available on-line. 2007

Eight Boer (75%) x Spanish (BS) and eight Spanish (S) wether goats (155 ± 8 days of age and 19.2 ± 2.3 kg BW, initial) were used in a replicated crossover design experiment with a 2 x 2 factorial arrangement of treatments to determine effects of genotype and diet quality on heat production with ad libitum, near maintenance and fasting levels of feed intake. Diets were 65% concentrate (CON; 15% CP, DM basis) and coarsely ground alfalfa hay (FOR; 23% CP). There were no significant interactions between genotype and diet. ME intake was similar between genotypes and greater ($P < 0.05$) for CON vs. FOR both when intake was ad libitum (7.60 vs. 5.43 MJ/day) and near maintenance (4.31 vs. 4.09 MJ/day). DE concentration was greater ($P < 0.05$) for CON than for FOR with ad libitum (74.4 vs. 55.5%) and restricted intake (77.0 vs. 59.6%). Energy expenditure (EE), determined by respiration calorimetry, at all levels of intake was similar between genotypes. EE was greater ($P < 0.05$) for CON than for FOR at each of the three levels of intake, ad libitum (573 and 521 kJ/kg BW0.75 while fasting), near maintenance (426 and 400 kJ/kg BW0.75) and fasting (280 and 255 kJ/kg BW0.75). Efficiencies of ME utilization for maintenance (km) and gain (kg) and the ME requirement for maintenance (MEm) were similar between genotypes. km was similar between diets (0.705 and 0.690 for CON and FOR, respectively), although kg was greater ($P < 0.05$) for CON than for FOR (0.603 vs. 0.387). MEm was numerically greater ($P < 0.17$) for CON than for FOR (407 vs. 379 kJ/kg BW0.75), which may have involved higher ME intake with CON. In conclusion, under the conditions of this experiment energy requirements and efficiency of utilization were not different between growing Boer crossbred and Spanish goats regardless of diet quality.

Energy expenditure by crossbred Boer x Spanish does with litter size of one, two, or three

Tovar-Luna, I., A. L. Goetsch, R. Puchala, T. Sahlu, G. E. Carstens, H. C. Freetly, and Z. B. Johnson

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Twenty-four Boer x Spanish does (3 yr of age, having kidded once previously and with an initial BW of 42.7 ± 1.2 kg) were used to determine the efficiency of ME utilization for pregnancy (kpreg). Six does were nonpregnant and, based on ultrasound determination on day 45 of gestation, six had a litter size (LS) of 1, 2, and 3. However, only 10 of the pregnant does delivered the expected number of kids (three, four, and three with LS of 1, 2, and 3, respectively). Does were fed a diet of approximately 50% concentrate in accordance with assumed maintenance plus pregnancy energy requirements based on estimated nonpregnancy tissue BW and LS. Recovered energy (RE) was determined by subtraction of energy expenditure (EE; respiration calorimetry) near day 80, 100, 120, and 140 of gestation from ME intake (MEI). RE was assumed attributable to pregnancy tissues (fetus, fetal fluids and membranes, uterus, and mammary gland), and ME used for pregnancy (MEpreg) was estimated by subtracting MEm determined with nonpregnant goats from MEI by those pregnant. For does with actual LS equal to that expected, the no-intercept equation for the regression of RE against MEpreg was: RE = MEpreg x 0.252 (SE = 0.030; R2 = 0.64), indicating a kpreg of 25%. Although, a regression including LS (1 vs. 2 or 3) suggested greater kpreg for LS of 1 (40.2% ± 5.6) vs. 2 or 3 (20.5% ± 3.2). Regressions for goats with LS different from expected suggested positive effects of use of energy mobilized from nonpregnancy tissues on kpreg and of use of dietary ME for energy accretion in nonpregnancy tissues on the efficiency of whole body ME utilization. In conclusion, the average efficiency of ME use for pregnancy regardless of LS in goats was near 25%, which when considering the expected proportion of all pregnancy tissues attributable to fetal or conceptus tissues implies an energy requirement for pregnancy of goats similar to common recommendations for sheep and cattle.

Effects of stocking rate and creep grazing on performance by Spanish and Boer x Spanish does with crossbred Boer kids

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26 Spanish does with twin Boer x Spanish kids and 26 Boer x Spanish does with twin 3/4 Boer-1/4 Spanish kids were used in a 76-day experiment to determine effects of stocking rate (SR) and creep grazing on pre-weaning performance. The study commenced approximately 2 months after kidding. There were four treatments, three involving SR and one creep grazing, with two animal groups or replicates for each treatment (consisting of both genotype sets) per treatment. Groups had 4 does with 8 kids for the low SR (L), 6 does with 12 kids for a moderate SR (M), and 8 does with 16 kids for both the high SR (H) and creep grazing treatment (C). Groups grazed 0.4-ha pastures of various grasses and forbs, with the most prevalent forb being ragweed (Ambrosia artemisifolia L.). Kids of C groups also had access to similar 0.4-ha pastures that contained the tree legume mimosa (Albizia julibrissin Durazz). All pastures consisted of four equal size paddocks that were sequentially grazed twice by the same animal groups (i.e., phases 1 and 2 were 48 and 28 days in length, respectively). Post-grazing forage mass decreased linearly with increasing SR (P <

0.01) (1902, 1454, 928, and 1150 kg/ha; SE = 51.2), and change in forage mass during the phases linearly increased ($P < 0.05$) (1078, 1247, 1746, and 1493 kg/ha for L, M, H, and C, respectively; SE = 120.6). Change (pre-grazing - post-grazing %) during the experiment in the contribution of ragweed to the sward increased linearly with increasing SR ($P < 0.05$) (-6, 12, 33, and 9% for L, M, H, and C, respectively; SE = 4.5). ADG by does (47, -16, -54, and -2 g/day; SE = 21.8) and kids (76, 61, 37, and 81 g/day; SE =6.7) linearly decreased with increasing SR ($P < 0.03$); however, kid BW gain per unit land area was similar among treatments (115, 138, 113, and 124 kg/ha for L, M, H, and C, respectively; SE = 21.7). Kid ADG was similar between genotypes but doe ADG differed ($P < 0.05$) (-47 and 34 g/day for Spanish and Boer x Spanish, respectively; SE = 11.5). In conclusion, creep grazing with high SR for does can increase ADG of does and kids but not relative to lower SR for both does and kids. Spanish does with Boer x Spanish kids may be less able to maintain or increase BW while supporting kid growth compared with Boer x Spanish does.

Effect of extended storage on microbiological quality, somatic cell count and composition of raw goat milk on farm

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Dairy goat herds in the U.S. are small scale, scattered around and distant from processing facilities. It is not cost-effective to collect goat milk everyday or every other day as it is with cow milk. In some areas goat milk is collected only once a week, which is in violation of regulations specified in the Pasteurized Milk Ordinance (PMO) for Grade A milk. This study was conducted to determine the effect of extended storage time up to seven days over a lactation on composition, somatic cell count (SCC), pH and microbiological quality of goat milk in refrigerated storage tank on farm. Duplicate samples were taken daily, after the morning milking, for seven consecutive days each month of the lactation season. Samples were analyzed immediately for all variables except free fatty acids (FFA). There were no significant changes ($P > 0.05$) detected in milk fat, protein, lactose, solids-non-fat, SCC or pH during the extended storage period, although effects of stage of lactation ($P < 0.05$) were observed. Mean standard plate count (SPC) in goat milk increased to 1.8x105 CFU/ml on the 6th day of the extended storage, exceeding the Grade-A limit (i.e., 1.0x105 CFU/ml). Mean psychrotrophic bacteria count increased steadily to 1.5 x 104 CFU/ml at 6 days of storage. Mean coliform count was approximately 500 CFU/ml for the first 3 d and fewer than 2,500 CFU/ml throughout 7 days of storage. No significant changes ($P > 0.05$) in FFA concentrations except for butyric and caprylic acids were observed as storage of goat milk advanced. In conclusion, when stored under refrigerated and sanitary conditions, goat milk in bulk tank on the farm could meet the Grade-A limits of both SPC and SCC within 5 days of storage but would have low quality due to growth of psychrotrophic bacteria thereafter.

Proteolytic and rheological properties of aging cheddar-like caprine milk cheeses manufactured at different times during lactation

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The effects of 24 wk of aging on the proteolytic and rheological properties of Cheddar-like cheese made from caprine milk collected at different lactation periods were evaluated. Cheddar cheese was made weekly using whole milk from Alpine goats and cheeses manufactured at wk 4, 5, 12, 14, 15, 21, 22, and 23 of lactation were evaluated for proteolytic and rheological properties at 5 d after manufacture and after 8, 16, and 24 wk of aging at 4 °C. Rheology results indicated that a minimum of 8 wk of aging was needed to stabilize the texture of the cheese and that the most uniform cheeses were made from mid lactation milk. Cheeses manufactured at wk 12-15 of lactation were the firmest, had the least flexible protein matrix (highest values for hardness, chewiness, and shear stress and rigidity at point of fracture), and the lowest degree of proteolysis. Understanding the factors that impact the texture of cheese, such as aging and the period of lactation that cheesemilk is obtained, will help develop guidance for maintaining the production of high quality and uniform caprine milk cheeses.

Yield predictive models for goat milk cheeses using compositional variables

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Prediction of the yield and quality of different types of cheeses that could be produced from a given type and/or amount of goat milk is of great economic benefit to goat milk producers and goat cheese manufacturers. Bulk tank goat milk was used for manufacturing hard, semi-hard and soft cheeses (N = 25, 25 and 24, respectively) to develop predictive formulae of cheese yield based on milk composition. Fat, total solids, total protein and casein contents in milk and moisture-adjusted cheese yield were determined to establish relationships between milk composition and cheese yield. Soft, semi-hard and hard cheeses in this study had moisture contents of 66, 46 and 38%, respectively, which could be used as reference standards. In soft cheese, individual components of goat milk or a combination of two or three components predicted cheese yield with a reasonably high correlation coefficient (R2 = 0.73-0.81). However, correlation coefficients of predictions were lower for both semi-hard and hard cheeses. Overall, total solids of goat milk was the strongest indicator of yield in all three types of cheeses, followed by fat and total protein, while casein was not a good predictor for both semi-hard and hard cheeses. When compared with moisture-adjusted cheese yield, there was no difference ($P > 0.05$) in predicting yield of semi-hard and hard goat milk cheeses between the developed yield formulae in this study and a standard formula (the Van Slyke formula) commonly used for cow cheese. Future research will include further validation of the yield predictive formulae for hard and semi-hard cheeses of goat milk using larger data sets over several lactations, because of variation in relationships between milk components due to breed, stage of lactation, season, feeding regime, somatic cell count and differences in casein variants.

Effects of aging on functional properties of caprine milk made into Cheddar- and Colby-like cheeses

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Small Ruminant Research. In Press. 2007

The effects of cheese milk obtained at three times during lactation (weeks 4–5, 12–15, and 21–23) and cheese storage (up to 16 or 24 weeks) on meltability, sliceability, and color changes upon heating (232 °C for 5 min, high baking temperature, HT, or 130 °C for 75 min, low baking temperature, LT) of caprine milk cheeses were evaluated. The cheeses were manufactured from milk from Alpine goats and based on the procedures of Cheddar and Colby cheese manufacture. In Cheddar-like cheese, the sliceability (force required to slice sample) was at its highest when the cheese was made with milk from weeks 12–15 into lactation. Color change was variable although it tended to be lowest in cheese made at weeks 4–5 into lactation. In Colby-like cheeses, meltability was at its highest and sliceability was very poor (after 8 weeks of aging) when made with milk obtained later in lactation. Color changes were variable at the two different baking temperatures. As expected during aging, the meltability of the cheeses increased and the force required to slice the cheeses decreased with the significant changes occurring within the first 16 weeks for Cheddar-like and the first 8 weeks for Colby-like cheeses. The color changes upon heating were variable for aged Cheddar-like cheeses and did not change significantly for aged Colby-like cheeses. Color changes were highly correlated with proteolysis occurring during storage. Cheese milk obtained at different times of lactation and aging of the cheese impact the functional properties of caprine milk cheeses and will affect their optimal utilization

Visiting Scholars (2006/2007)

Mr. Getachew Animut
Native of Ethiopia
Research Project: Decreased Methane Emission by Ruminants Consuming Condensed Tannins 2004-38814-02606)
Experiments: GA-06-05, GA-06-11, GA-06-12

Dr. Asefa Asmare
Native of Ethiopia
Research Project: The Ability of Goats to Withstand Harsh Nutritional Environments (2005-38814-16353)
Experiments: AA-06-07, AA-06-08

Dr. Amlan Patra
Native of India
Research Projects: Tethering for Detailed Study of Grazing Ruminants (USDA-CSREES-NRI 03-03289) and Effects of Acclimatization on Energy Requirements of Goats (BI09-017)
Experiment: AP-06-04

Mr. Sean Chen
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Research Project: Quality, Safety, and Shelf-Life of Dairy Goat Products in the U.S. Market (2005-38814-02587)
Experiments: SC-06-01, SC-06-03

Dr. Maristela Rovai
Native of Brazil
Research Project: Evaluation and Modeling Extended Lactations in Dairy Goats (2004-38814-02579)
Experiment: MR-06-02

Dr. Adnan Beker
Native of Ethiopia
Research Project: Energy Expenditure for Activity in Free-Ranging Ruminants: A Nutritional Frontier (US-3694-05 R)
Experiments: AB-06-06, AB-06-16

Dr. Ahmed Askar
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Research Project: Characterization of the Energy Requirement for Activity by Grazing Ruminants (2005-38814-16352)
Experiment: AAR-06-08