Grazing and Browsing Behavior, Grazing Management, Forage Evaluation and Goat Performance: Strategies to Enhance Meat Goat Production in North Carolina

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ABSTRACT

Goats (*Capra hircus hircus*) offer an opportunity to more effectively convert pasture nutrients to animal products as milk, meat and fiber which are currently marketable and in demand by a growing segment of the US population. With the introduction of the Boer breed and the upgrading of meat-type goats with Boer genetics, research focusing on forage evaluation, feeding strategies and the development of economical grazing systems was urgently needed to meet the needs of this emerging industry. The first part of this paper focuses on the description of grazing/browsing behavior of goats and grazing management, and grazing strategies such as control and strip grazing, differences between control and continuous grazing, forward creep grazing, limit grazing and co-grazing and multi-species grazing. The second part reports on results from research conducted at North Carolina State University, the objective of the program being the development of year-round grazing systems. Studies were conducted with winter and summer annual forages, cool-season perennials in spring and fall, weaning age in spring on perennial forages, summer perennial forages including gastrointestinal parasite control, evaluation of fodder trees, and finally a demonstration with a volunteer stand of a mixture of a summer annual forage and a broadleaf plant.

Key words: meat goat, annual and perennial forages, fodder trees, grazing systems.

INTRODUCTION

Feeding may be the highest expense of any meat goat operation. Goats (*Capra hircus hircus*) raised for meat need high quality feed in most situations and require an optimum balance of many different nutrients to achieve maximum profit potential. Because of their unique physiology, meat goats do not fatten like cattle (*Bos Taurus*) or sheep (*Ovis aries*), and rates of weight gain are smaller, ranging from 0.1 to 0.8 lb/day. Therefore, profitable meat goat production can only be achieved by optimizing the use of high quality forage and browse and the strategic use of expensive concentrate feeds. This can be achieved by developing a year-round forage program allowing for as much grazing as possible throughout the year.

Some people still believe that goats eat and do well on low quality feed. Attempting to manage and feed goats with such a belief will not lead to successful meat goat production. On pasture or rangeland, maximum goat gains or reproduction can be attained by combining access to large quantities of quality forage that allow for selective feeding.

Goat Brazing/Browsing Behavior

Goats are very active foragers, able to cover a wide area in search of scarce plant materials. Their small mouth, narrow muzzle and split upper lips enable them to pick small leaves, flowers, fruits and other plant parts, thus choosing only the most nutritious available feed. As natural browsers and given the opportunity, goats will select over 60% of their daily diet from brush and woody perennials (black locust [*Robinia pseudoacacia*], brambles [*Rubus spp*.], honeysuckle [*Lonicera japonica*], multiflora rose [*Rosa multiflora*], privet [Ligustrum vulgare], saplings, small deciduous trees, sumac [*Rhus typhina*], etc.), and broadleaf plants (dock [*Rumex spp*.], dog fennel [*Eupatorium capillifolium*], horseweed [*Conyza Canadensis*], lambsquarter [*Chenopodium album*], pigweed [*Amaranthus spp*.], plantain [*Plantago spp*.], poison ivy [*Toxicodendron radicans]*, sedge [*Carex aurea*], etc.) over herbaceous species such as bluegrass [*Poa pratensis*], tall fescue [*Festuca arundinacea*], orchardgrass [*Dactylis glomerata*], annual ryegrass [*Lolium multiflorum*], crabgrass [*Digitaria sanguinalis*], bermudagrass [*Cynodon dactylon*], cereal grains, and others. The ability to utilize browse species, which often have thorns and an upright growth habit with small leaves tucked among woody stems, is a unique characteristic of the goat compared to heavier, less agile ruminants. Goats have been observed to stand on their hind legs and stretch up to

browse leaves from trees such as several oak species (*Quercus spp*.), walnut (*Juglans nigra*), sweet gum (*Liquidambar styraciflua*), etc. or throw their bodies against saplings to bring the tops within reach. Goats even sometimes climb into trees or shrubs to consume the desired forage.

Because of their inquisitive nature and tolerance of "bitter" or high tannin material, goats may eat unpalatable weeds and wild shrubs that may be contain poisonous compounds, such as pokeweed (*Phitolacca Americana*) or milkweed (*Asclepias syriaca*). The absence or the severity of poisoning is related to the quantity of material consumed, the portion and age of the plant eaten, the season of the year, the age and size of the animal, whether the leaves are wilted or not as in the case of black cherry, and other factors. Goats are often not affected by poisonous compounds or anti-nutritional factors if a sufficient number of other plant species are available. Because goats prefer to consume a very varied diet, the detrimental effects of poisonous compounds found in certain plants are diluted.

In spite of their grazing preferences, goats can be grazed on pasture alone. The feeding strategy of goats appears to be to select grasses when the protein content and digestibility are high, but to switch to browse when the latter overall nutritive value may be higher. This ability is best utilized under conditions where there is a broad range in the digestibility of the available feeds, giving an advantage to an animal which is able to select highly digestible parts and reject those materials which are low in quality.

In a pasture situation, goats tend to graze from the top to the bottom of plants and do not like to graze near the soil surface. Therefore, goats will more uniformly graze a canopy than other ruminants. This behavior results in even grazing and favors a first grazer-last grazer system. This might consist of using a goat herd as the first group and cattle as the last group. This management is most appropriate with lactating does or growing kids whose nutrient requirements are high.

In summary, goats have been observed to:

1. Select young grass over white clover (*Trifolium repens*).
2. Prefer browsing over grazing pastures, and eat more browse than do other domestic ruminants.
3. Eat a wider range of plant species than do sheep or cattle.
4. Prefer foraging on rough and steep land over flat, smooth land.
5. Graze along fence lines before grazing the center of a pasture.
6. Graze the top of pasture canopy fairly uniformly before grazing close to the soil level.
7. Will travel longer distances in search of preferred forage than will other domestic ruminants.

Explanation of Plant Terms

Annual: A plant that germinates, grows, reproduces only by seed, and dies in one year or growing season.

Perennial: A plant that persists for several years with new growth from a perennating part, and can live indefinitely. Often a combination of diseases and/or insects will cause a perennial to be short lived.

Cool Season Perennial: Perennial plant species that is usually seeded in late summer or early fall (may be seeded in late winter or early spring, resulting in less growth the year of establishment). The major proportion of its growth is during the cool season in the spring with a lesser peak growth in the late summer and early fall. For example, in the piedmont of North Carolina a mixture of tall fescue-ladino clover will produce about 55% of its total production in March, April and May, and about 20% in August, September and October. Cool season grasses usually flower profusely in mid-spring and, if permitted, seeds will mature by late spring. Cool season legumes vary greatly in their periods of floral production. For example, alfalfa (*Medicago sativa*) will usually produce some flowers after every harvest. In the year of establishment, the seedling growth of perennials is less vigorous than winter annuals.

Warm Season Perennial: Perennial plant species that is usually seeded or planted vegetatively in late winter or spring and produces the major proportion of its growth during the warmer months, June, July and August in the Piedmont of North Carolina. For example, hybrid bermudagrass will produce about 70% of its total production in June, July and August in the piedmont of North Carolina. Bermudagrass completely ceases growth at frost. Warm season grasses vary greatly in their period of floral production. A warm season perennial legume such as sericea lespedeza (*Lespedeza cuneata*) produces a seed crop every year in early to mid fall.

Warm Season Improved Grasses: Warm season grasses are often of tropical or subtropical origin and grow mainly during late spring, summer and early fall. Frost will kill warm season annual grasses, whereas warm season perennial grasses become

dormant and unproductive during the winter months. With adequate fertilization, some of the warm season grasses have very high forage yields. However, forage quality of warm season grasses, especially perennials, is generally much lower than that of cool season grasses.

What is a Good Stand? In general, a good stand provides 90 to 100% ground cover and will produce high yields when managed properly. The clover part of mixtures should make up to 30% of the stand on a weight basis for it to significantly contribute to the mixtures and forgo nitrogen fertilization.

Grazing Management for Goats

Grazing of forage generally provides the least expensive way of supplying nutrients to animals. Therefore, it is advantageous to develop a year round forage program which allows for as much grazing as possible every month of the year. However, good pasture management involves much more than simply turning the animals to pasture. The principles of controlled grazing of goats are similar to those used for cattle or sheep. The primary goal is to have control of the animal's grazing pattern so that one can dictate the degree of defoliation and the frequency of defoliation. To obtain efficient animal production over a number of years, the needs of the plants as well as the needs of the animals must be taken into consideration. The development of a successful forage systems/grazing management entails:

1. Adjusting the number of animals grazing a certain area (stocking density) of pasture because some forage must be left at the end of the grazing period to maintain adequate plant production. Otherwise, overuse will weaken the plants and regrowth will be slower. Adjusting the stocking rate require experience because forage growth is not uniform throughout the year or from year to year.

2. Harvesting ungrazed forages as hay or silage at an immature stage of growth when forage growth is more rapid than it can be grazed. This will provide high quality feed when grazing is not available. Cross fencing will keep animals concentrated on small areas while excess growth accumulates on other paddocks. Under those circumstances, short duration rotational grazing through a series of paddocks, or strip grazing a rapidly growing pasture by allowing animals access to only enough forage to carry them for one day using a movable fence, are alternatives to consider.

3. Overseeding bermudagrass pastures with legumes, ryegrass, cereal grains, or brassicas such as turnip, mustard and rape, to extend the grazing season and to provide some high quality feed during the winter and spring.

4. Restricting the use of high quality forage, when in short supply, for the supplementation of other low quality pastures, hay or silage. This can be achieved by letting goats graze high quality forage a few hours at the end of each day, or by grazing the limited high quality supply every other day.

5. When the aim is to kill or reduce the amount of unwanted vegetation, then greater severity and frequency of grazing is necessary. Goats will actively select major weeds at particular stages of growth. As a rule, effective control of unwanted vegetation can be achieved in two years. Therefore, the advantages of the goat in feeding strategy must be weighed against its disadvantages. Being a browsing animal, the goat stunts tree growth and prevents the regeneration of forests and thus should be managed carefully in areas desired for forests. Goats could be very useful, however, in areas where regrowth of brush and trees is not desirable.

Grazing Strategies

Control Grazing and Strip Grazing

The basic principle of control grazing is to allow goats to graze for a limited time leaving a leafy stubble, and then to move them to another pasture or paddock (a subdivision of a pasture) or sub-paddock. Smaller paddocks are more uniformly grazed and surplus paddocks can be harvested for hay. The pasture forage plants, with some leaves still attached, can then use the energy from the sun through photosynthesis to grow back without using up all of their root reserves. Even brush will need a recovery time if it is being used as forage for goats. Without this rest period, the goats can kill the brush through continuous browsing.

Under control grazing, legumes and native grasses may reappear in the pasture, and producers often report that the pasture plant community becomes more diverse. Control grazing can be used to improve the pasture, extend the grazing season, and enable producers to provide higher quality forage at a lower cost with fewer purchased inputs. Control grazing can also be useful in controlling internal parasite problems, if meat goat producers are careful

to move the goats to a new pasture before the forage plants are grazed too short (less than about 4 inches).

Strip grazing can be easily superimposed on control grazing in large paddocks by placing movable electric fences ahead and behind the goats, giving them sufficient forage for 2 to 3 days. Strip grazing is very effective and results in high pasture utilization because otherwise goats will not graze soiled forage well. Strip grazing results in high average daily gain, increased gain per acre, and in rapid improvement of body condition when pasture is vegetative and of excellent quality such as during cool weather when plant quality declines only slowly. Strip grazing is very effective with stockpiled fescue during late fall and early winter. Strip grazing is not recommended when pasture is of low quality because of reduced goat selectivity.

Control Grazing Versus Continuous Grazing

Control grazing allows the manager a better utilization of the forage at hand because this grazing method gives more control over grazing animals. During periods of fast growth, the excess forage can be harvested for hay. Control grazing can stretch forage availability and the grazing season as spring forage growth slows during the hot summer months. It also slows the gradual predominance of less palatable and less nutritious plants because goats are forced to consume all plants before moving on.

Another level of managerial control is achieved by having more than one pasture. Under a control grazing system a) goats are easier to handle and more docile because they are in frequent contact with humans when fences, water tanks and mineral troughs are moved, b) plants that are sensitive to close and continuous grazing will persist longer and producer better, c) less forage is wasted by trampling and soiling, d) urine and dung are distributed more uniformly, e) producers' managerial and observational skills will improve because goats will be observed more frequently, and pasture species and productivity will be evaluated more carefully. Conversely, control grazing may not be beneficial because of a) unsatisfactory layout such as long, narrow paddocks or wet and dry areas within the same paddock, b) overstocked pastures, c) rest period is too long between grazing such that the available forage becomes mature and of low nutritive value with a lesser amount of young green leaves, d) pastures dominated by low forage quality.

Continuous grazing or stocking means that goats are maintained on one pasture for the entire grazing season. Therefore, the goat makes the decision as to where to graze, when to graze, where to congregate and to selectively graze unless the stocking rate is too high. Goats may overgraze the plants they prefer and undergraze other, less preferred plants if the stocking density is not adjusted as conditions change. Forage availability may be ideal, too high or too low during different periods of the same grazing season. Therefore, adjusting the stocking density as needed greatly improves forage utilization. Temporary fences can be used to fence off portions of the pasture and harvest surplus forage for hay. Finally, certain forage species such as switchgrass (*Panicum virgatum*), gamagrass (*Tripsacum dactyloides*), big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*) and johnsongrass (*Sorghum halepense*) are not suitable for continuous grazing unless the stocking rate is low enough to maintain a 6 to 8 inch leafy stubble.

Forward Creep Grazing

Installing an opening in the fence with a small gate allows animals with the highest nutritional requirements such as kids, to have first access to fresh, high quality, ungrazed forage ahead of their mothers. Forward creep grazing can be easily used in a control/strip grazing system.

Limit Grazing or Supplementation with other Crops

Limit grazing is a strategy used to meet goat nutritional requirements with grasses of differing nutritive values, or with a cool-season grass and legumes sown in separate pastures. Adult does could be maintained on a low quality warm-season bermudagrass or switchgrass pasture after frost, but allowed to strip graze a high quality winter annual forage such as cereal rye)*Secale cereale*], annual ryegrass, wheat)*Triticum aestivum*], or oat)*Avena sativa]* as a protein supplement for only a few hours each day or every few days. The same principle can be used with a low quality cool-season grass grazed during the hot summer months, and warm-season legumes such as soybean)*Glycine max*] or the fodder trees black locust or mimosa)*Albizia julibrissin*]. The foliage quality of these legume plants change little throughout the growing season, thus they are referred to as protein banks.

Co- and Multi-Species Grazing

The differences in feeding behavior among cattle, sheep and goats uniquely fit each species to the utilization of different feeds available on a farm. These differences should be considered in determining the best animal species to utilize a particular feed resource. Feeding behavior is also important in determining whether single or multi-species will best utilize available plant

materials. Most studies indicate greater production and better pasture utilization are achieved when sheep and cattle or sheep, cattle and goats are grazed together as opposed to grazing only sheep, goats or cattle alone. This is especially true where a diverse plant population exists.

Because of the complimentary grazing habits, the differential preferences and the wide variation in vegetation within most pastures, one to two goats can be grazed with every beef cow without adversely affecting the feed supply of the beef herd. The selective grazing habits of goats in combination with cattle will eventually produce pastures which are more productive, of higher quality, and with little weed and brush problems as a result of mixed-species grazing.

Judicial mixed-species grazing can have additional benefits. Because gastrointestinal parasites from goats or sheep cannot not survive in the stomach of cattle, and because gastrointestinal parasites from cattle cannot survive in the stomach of goats or sheep, mixed-species grazing will decrease gastrointestinal parasite loads and slow resistance of gastrointestinal parasites to conventional dewormers. Several strategies can be used to one's advantage. In fields with a low parasite load, animals can be grazed together (co-grazing) or animals with the highest nutritional requirements can have access to the field first, followed by the animal species having lower nutritional requirements (first grazers, last grazers). A variation of co-grazing with nursing animals is to have openings in the fence giving forward access to ungrazed pasture to young stock. Alternatively, in a field infected with a high load of goat or sheep parasites, cattle should be grazed first, followed by goats or sheep.

FORAGE EVALUATION AND ANIMAL PERFORMANCE: RESULTS FROM NORTH CAROLINA

This section focuses on research results from the NCSU Meat Goat and Forage Program toward the development of year-round grazing systems. The methodology used is described in sufficient detail to guide producers interested in developing their own grazing systems or adapt what is presented herein to their own farm situation.

Winter Annual Forages

A 3-year study was conducted to evaluate the performance of crossbred (50 to 75%) Boer replacement does and castrated males control-grazed on cereal rye, annual ryegrass and triticale, a cross between rye and wheat. The forage species were sod-drilled in late September or early October and seeding rates averaged 111 lb per acre for cereal rye, 31 lb for annual ryegrass, and 108 lb for triticale. All forages were fertilized each year with ammonium nitrate at a rate of 50 lb nitrogen per acre in November and February. The grazing area consisted of a total of 4.5 acres, divided into 9 plots measuring 0.5 acre each. Each forage species was seeded in 3 different plots. Goats averaged 64 lb at the start of the study, and 6 goats were grazed in each plot. Goats were moved to a fresh strip of grass 3 to 4 times per week and back fenced immediately. In addition, they had access to a free choice goat mineral, water and movable shelters. Additional goats were used as put-and-take animals to keep up with forage growth.
During the first year, grazing periods ranged from 28 February – 19 May for ryegrass, 25 February – 14 April for cereal rye, and 28 February – 21 April for triticale. During the second year, grazing started on 22 January for all 3 forages, and ended on 4 May for ryegrass, 8 April for cereal rye and 23 April for triticale. During the last year of the study, grazing started from 9 to 28 December for each forage species. All goats were removed from the experimental plots on 28 December due to lack of forage, with the exception of the ryegrass plots, on which three goats/plot were left grazing until 18 January. For triticale, three goats/plot were grazed from 11 to 20 January, at which date 20 inches snow fell in 24 hours. Grazing resumed on each plot on 24 February and ended on 10 May for ryegrass, 31 March for cereal rye and 20 March for triticale.

Protein and cell-wall concentrations (Table 2) indicate that these forages were of excellent quality. Protein concentrations were more than sufficient to meet the nutritional requirements of any class of goat from mature dry does, does in early gestation and mature bucks, to yearlings and weanlings and does lactating and in late gestation.

Forage species had no effect on average daily gain but castrated males gained more weight than does. Total gain per acre was greater for ryegrass than for cereal rye or triticale because cereal rye and triticale were grazed for shorter periods and thus had a lower number of total grazing days per acre. In conclusion, growing goats achieved satisfactory weight gains when fed only on these forages under controlled rotational grazing management, but ryegrass resulted in superior per acre live weight gains.

Summer Annual Forages

An experiment was conducted over 3 summers and designed to evaluate grazing soybean, cowpea and pearlmillet for summer grazing by weanling doe kids and to determine animal performance. The grazing area consisted of a total of 1.53 acres, divided into 9 plots measuring 0.17 acre each. Each forage species was planted in 3 different plots. All 3 forage species were no-till drilled and immediately cultipacked in mid-May. Corrected for germination, grazing soybean, variety Johnston, was seeded at 97 lb/acre, prostrate cowpea , variety Pinkeye Purplehull BVR, at 115 lb/acre and pearlmillet, variety Tifleaf II Hybrid, at 21 lb/acre. The pearlmillet plots were fertilized with ammonium nitrate at a rate of 50 lb N/acre approximately one month after planting. In year 1, grazing started 48 d after planting, and plots were grazed 34 d for cowpea and 57 d for pearlmillet and soybean. In year 2, grazing started 39 d after planting, and plots were grazed 44 d for cowpea, 51 d for soybean, and 72 d for pearlmillet. In year 3, grazing started 37 d after planting for pearlmillet and 56 d after planting for both cowpea and soybean, and all forages were grazed for 63 d. The length of time from planting to the start of grazing and the length of grazing differed between forage species and years due to the large variation in rainfall.

Doe kids (50 to 75% Boer) used in this study were born in March-April and weaned at 10 weeks of age. Their average live weight at the start of the experiment was 35 lbs. Each plot was divided into 6 equal subplots and doe kids were controlled-grazed among the subplots. Additional goats were used as put-and-take animals to keep up with forage growth. Water was available on each subplot, goats had access to a free-choice goat mineral but no shade was provided. Goats were moved to a new subplot before they had eaten all the leaves of the soybean and cowpea plants to ensure faster regrowth. Using this strategy, each soybean and cowpea plot was grazed 3 times during the growing season. Cowpea attracted a lot of bees, and kids and goat keepers were stung several times. It is perhaps for that reason that doe kids grazed cowpea better once the pods developed.

Protein and cell-wall concentrations (Table 3) show that these summer annual forages were of excellent quality, and more than sufficient to meet the nutritional requirements of any class of goat. Forage species did not have a large effect on average daily gain. Nevertheless, gains were low but were not unexpected as these doe kids were in a post-weaning slump, and were grazed in a rather hot environment. The number of grazing days per acre for the cowpea and the soybean were less than half and a third less, respectively, than for the pearlmillet because pearlmillet was stocked more heavily and in general had a longer grazing season. Therefore, total gain per acre was greater for pearlmillet than for cowpea and soybean. Gain per acre for soybean, however, was only 61 lb less than pearlmillet, because doe kids grazing soybean gained better.

In conclusion, doe kids average daily gain was disappointing but not unusual when fed only on these forages under controlled rotational grazing management. Nevertheless, total gains per acre were satisfactory. Pearlmillet and soybean should be considered as summer annual forages in year-round forage systems as they provide forage of excellent quality during a part of the year when perennial forages are usually of low quality.

Volunteer Stand of Summer Annual Plants

At times, producers should take advantage of opportunities that arise, even if that means grazing unconventional forages. One dry spring followed by a very rainy period, 4.6 acres that had were to be planted with pearlmillet for summer grazing became covered with a solid stand of volunteer crabgrass and pigweed. As an environmentally-friendly alternative to using herbicides, the area was further partitioned into 11 0.4 acre plots with 3 strands of braided wire and temporary posts, and grazed with 90 adult does from the NCSU breeding herd. Grazing started when the forage had reached an average height of 10 to 12 inches. Each plot was grazed for 1/2 to 3 days, depending on forage availability. Grazing lasted 44 days for 3 grazing cycles, meaning that each plot was grazed approximately every 12 or 13 days. The strategy used in this instance was mob-grazing young plants of high quality at a high stocking density (90 does in 0.4 acre paddock = 225 goats/acre) for a short period. Samples showed crabgrass averaged 17^{+}% protein and pigweed ranged from 20 to 27% protein. Forage availability ranged from 900 to 3000 lb dry matter per acre. Goats readily ate these two plant species, even young pigweed stems, even though pigweed is considered a poisonous plant to ruminants on some websites because of it produces a toxin and oxalic acid.

Cool-Season Perennials Forages

A 3-year study was conducted to evaluate a) the performance of suckling kids (75 to 100% Boer) and nursing does in spring and b) the performance of replacement does in fall, control-grazed on 3 tall fescue cultivars, namely Kentucky 31^{+} endophyte-infected, $Jesup^{-}$ non infected and MaxQ variety Jesup novel endophyte. In Kentucky 31^{+} endophyte-infected fescue, the fungal endophyte produces ergot

alkaloids that can result in poor gains, unthrifty appearance, rough hair coat, reproductive problems, low milk production, and many other symptoms. Nevertheless, no toxic effects have been observed in goats. The forage species were sod-drilled in September at a seeding rate of 23 lb/acre corrected for germination. Lime was applied according to soil test and all forages were fertilized each February and early September with ammonium nitrate at a rate of 50 lb nitrogen per acre. The grazing area consisted of a total of 4.5 acres, divided into 9 plots measuring 0.5 acre each. Each forage species was seeded in 3 different plots. Goats were moved to a fresh strip of grass 3 to 4 times per week and back fenced immediately. In addition, they had access to a free choice goat mineral, water and movable shelters. No additional animals were needed to keep up with forage growth.

Spring study

Grazing periods ranged from 16 April to 26 May in year 1, 29 March to 25 May in year 2, and 4 April to 16 May in year 3. In year 1, we grazed 45 does and 70 kids (56 days old and weighing 28 lb at the start), in year 2, 36 does and 63 kids (18 days old and weighing 16 lb at the start), and in year 3, 36 does and 72 kids (24 days old and 19 lb at the start). All kids were mostly twins and a mixture of female and castrated males).

Throughout the study, the number of infected stems and stems producing alkaloids averaged 97% for Kentucky 31^+ and 2% for Jesup $^-$, whereas for MaxQ novel endophyte, the number of infected stems ranged from 82 to 92%, but only 1% of those stems were producing alkaloids. Protein and cell-wall concentrations averaged 20 and 56%, respectively, across cultivars, and available biomass (biomass when goats entered paddocks or sub-paddocks) and residual biomass (biomass left immediately after goats were moved to a new paddock or sub-paddock) averaged 1460 and 760 lb/acre across cultivars (Table 4). An average of 700 lb/a of residual biomass is considered a target to aim for that will promote fast regrowth. Average daily gain was lower in suckling kids on Kentucky 31^+, which resulted in lower total gains per acre (Table 4). Nursing does on Kentucky 31^+ were unable to maintain body weight whereas the weight of does on Jesup$^-$ and MaxQ remained constant. Loss of some weight while nursing kids is physiologically normal in meat goats and other lactating livestock. As weaning takes place in early June, these does will have ample time to regain sufficient body condition before the start of the next breeding season in late September-early October if grazed on a medium quality pasture or woodlot during the summer. Blood serum prolactin levels decreased 85% in does on Kentucky 31^+, whereas levels increased by 23 and 31% in does on Jesup$^-$ and MaxQ, respectively. In summary, these results indicate that suckling kids performed well although those on Kentucky 31^+ gained less weight. The dramatic decrease in serum prolactin levels observed in does grazing Kentucky 31^+ could have important reproductive implications. Nevertheless, we could not detect any differences in reproductive performance in those does bred the following fall. Does control-grazed on Jesup- and MaxQ fescue consumed most of the plant seed heads, and also portions of the stems, whereas close to 75% of the Kentucky 31^+ plant seed heads remained untouched. As Jesup$^-$ and MaxQ are readily consumed by goats, these cultivars require a higher level of management, otherwise goats will graze them to the ground and drastically decrease stand persistence.

Fall Study

Grazing periods ranged from 8 November to 16 January in year 1, 17 October to 2 December in year 2, and 27 September to 30 November in year 3. Fescue was stockpiled before grazing in year 1 only. In year 1, we grazed 72 replacement does weighing 65 lb at the start, in year 2, 45 replacement does weighing 67 lb at the start, and in year 3, 54 replacement does weighing 57 lb at the start of grazing.

Cell-wall concentrations averaged 50% across cultivars stockpiled in year 1, with similar values observed in year 2 and 3. Conversely, protein concentrations averaged 11% across cultivars stockpiled in year 1, but averaged 18 and 20% in year 2 and 3, respectively. Average daily gain of replacement does control-grazed on Kentucky 31+ was almost nil (Table 4), and resulted in very poor total weight gain per acre, whereas gain of replacement does grazing Jessup- and MaxQ, although still low, were acceptable as those animals had already passed their peak growth rate period. The replacement does grazing Kentucky 31^+ were very reluctant to consume Kentucky 31^+ regardless of the grazing management strategies we tried, as evidenced by the residual biomass (Table 4). This grazing behavior could be related to the levels of alkaloids produced in Kentucky 31^+ in fall.

In another 3-year study, the performance of suckling kids (75 to 100% Boer) and nursing does control-grazed on MaxQ variety Jessup novel endophyte tall fescue and orchardgrass (variety Persist) were compared as the seed cost in $ per acre is more than double for MaxQ tall fescue ($64.20) than for orchardgrass ($30.80). Seeding rates were 14

and 15 lb/acre for orchardgrass and fescue, respectively. Planting method, fertilization and grazing management were similar as in the previous experiment. The grazing area consisted of a total of 2.4 acres, divided into 6 plots measuring 0.4 acre each. Each forage species was seeded in 3 different plots. We started each grazing season with 24 does and 48 kids, all twins. Depending on forage availability, we had to reduce the number of animals to 3 does and 6 kids on certain plots. Grazing periods ranged from 10 April to 22 May in year 1, 25 March to 13 May in year 2, and 25 March to 10 May in year 3. Protein and cell-wall concentrations averaged 21 and 57%, respectively. Average daily gain for suckling kids control-grazed on orchardgrass and MaxQ fescue averaged .30 and .27 lb, and total weight gain 263 and 232 lb/acre. Nursing does maintained their weight during year 1 and 3 of the study, but lost an average of .26 lb/day during year 2.

In summary, these two forages are excellent for spring grazing. Nevertheless, producers should consider the following: a) goats grazed orchardgrass closer to the ground than MaxQ fescue and therefore orchardgrass requires a higher level of grazing management, 2) despite our efforts, one plot of orchardgrass did not subsist after 2 years due to a combination of being grazed to close to the ground and 3) excess water washing over the plot from a nearby road, 4) another plot has thinned considerably and is being colonized by other plants, 5) the third plot, which always produced more forage because it is located on better soil, still has a good stand, 6) orchardgrass persists better at higher elevations, 7) conversely, the MaxQ plots are still in good condition after 4 years of grazing and this factor could offset seeding costs in some situations.

Effects of Weaning Age and Pasture Species on Weight Gain

An experiment was conducted at the Mountain Research Station in Waynesville, located in the western mountains of North Carolina, to evaluate the effects of weaning age on kid growth rates when grazed on pasture. A group of 52 halfblood Boer males and female kids were divided into four equal groups according to sex and type of birth. Early-weaned twins of the same sex were separated and grazed either on alfagraze alfalfa or Kentucky 31^{+} (endophyte infected) tall fescue. Kids from 2 groups were weaned at 10 weeks of age (*May 17, early weaning*) and kids from the two other groups grazed with their mothers until reaching 16 weeks of age (*June 27, late weaning).* One group of early-weaned and one group of late-weaned kids (*nursing kids with does*) were controlled-grazed on alfalfa using electronetting, and the two other groups (one early-weaned, the other nursing kids and does) were grazed on tall fescue. Following weaning at 16 weeks of age (*June 27, late-weaned kids*), all kids remained on their respective paddocks until reaching 20 weeks of age.

From week 10 to 16, kids grazed on alfalfa and weaned at 16 weeks of age gained more weight (0.43 lb/day) than kids grazed on alfalfa and weaned at 10 weeks of age (0.33 lb/day). Conversely, weaning age had no effect on growth rate of kids grazed on fescue (late weaning: 0.29 lb/day; early weaning: 0.26 lb/day) during that same period.

From week 16 to 20 (late-weaned kids were weaned at week 16), early-weaned kids gained less (.34 lb/d) than late-weaned kids (.41 lb/d) while grazing alfalfa. These gains were similar to those reported for week 10 to 16 above. During that same period (week 16 to 20), early-weaned kids grazed on fescue gained much less weight (0.08 lb/d) than late–weaned kids (0.19 lb/d), representing respective decreases of 69 and 34% compared to gains reported for week 10 to 16. Protein and cell-wall concentrations for alfalfa and fescue averaged 30 and 49, and 20 and 74%, respectively, during the period of the study. The fescue cell-wall concentrations did not fluctuate much, with a narrow range of 72 to 75%. Differences in cell-wall concentrations between fescue and alfalfa could account in part for gain differences. The presence of fungal alkaloids in Kentucky 31^{+}, however, could be mostly responsible for the drastic decrease in gains observed in kids during week 16 to 20, as alkaloid levels increase during the summer months.

Under the conditions of this study, late weaning offered some advantages, but the response differed according to forage species, linked to plant maturity, and thus plant quality. If nursing does are grazing a good quality pasture in spring, and will have access to a summer pasture allowing them to regain sufficient body condition before the start of the next breeding season, it does not make sense to wean early because kids will achieve the highest growth rate of their productive life while suckling.

Summer Perennial Forages

In the hot and humid southeast, it is challenging to grow high quality perennial forage during the summer months for meat goats, especially for growing weanlings.

Bermudagrass

A study was conducted over two years to determine the influence of supplementation with pelleted soybean hulls (SBH) or whole cottonseed plus corn (WCS) on the post-weaning growth rate and carcass characteristics of Boer-cross wether kids grazed on Tifton-44 and Coastal bermudagrass pastures. Kids were born mid February to mid-March, and were weaned in mid-May at 10 to 14 weeks of age. Five or six weaned kids weighing 46.7 lb at the start of the study were grazed on paddocks averaging 0.067acres each. Each pasture was divided into 5 sub-paddocks and kids were rotated to a fresh paddock each 3 to 5 days. Pastures were clipped behind the kids as necessary to maintain forage quality. Kids had free access to minerals, water and shade. Kids were either not supplemented, supplemented with soybean hulls at 1% of their body weight, or supplemented with a grain mix (65% corn, 33% whole cottonseed and 2% limestone) also at 1% of their body weight.

Average forage biomass was 3217 lb/acre in year 1 and 1735 lb/acre in year 2. Supplementation at 1% body weight improved post-weaning growth and carcass characteristics of kids grazing bermudagrass pastures, but supplement type had little influence on growth or carcass characteristics. Average daily gain increased from 0.11 to 0.19 lb/day, carcass weight from 23 to 28 lb, dressing percent from 43.3 to 47.4%, pelvic fat from 0.20 to 0.46 lb, and loin eye area from 1.20 to 1.5 square inch.

In conclusion, gains were low even when kids were supplemented when compared to gains reported earlier in this article for weaned doelings control-grazed on soybean, cowpea and pearlmillet without addition of concentrate. Nevertheless, supplementation of weaned kids on bermudagrass offers producers another alternative for the summer months.

Sericea lespedeza

A warm-season perennial legume that has elicited a lot of interest from researchers and meat goat producers because of its effect of gastrointestinal nematodes is sericea lespedeza. Sericea lespedeza variety AU Grazer was no-till drilled at a rate of 35 lb/acre on March 22, 2007. Following emergence and a height of approximately 2 inches, annual weeds covered the entire field and shaded the young plants, followed by the severe drought of summer 2007. The field was flailed off in October but surprisingly a very good stand emerged the following year. Three studies were conducted in 2008, 2009 and 2010 to evaluate the effect of sericea lespedeza on natural gastrointestinal nematode infection in young weanling goats. Each year, 72 to 81 crossbred Boer weanling goats were strip-grazed on either sericea lespedeza or pearlmillet. In 2009, a third group of weanlings was switched from grazing sericea lespedeza to grazing pearlmillet and back to grazing sericea lespedeza every two weeks, and in 2010 the third group had access to both pearlmillet and sericea lespedeza at the same time

In 2008, fecal egg count of weanlings grazed on sericea lespedeza decreased from 1479 to 490 within one week and then progressively decreased to 21 by day 49. In 2009, weanlings grazed on sericea lespedeza started with a low fecal egg count of 255 that stayed low throughout the study period, only averaging 194 egg per gram of feces, while fecal egg count of weanlings grazed on pearlmillet increased from 178 on day 0 to 2867 by day 46. Conversely, fecal egg count decreased from 2855 at day 0 to 568 and 59 within 7 and 14 days of grazing sericea lespedeza, and then increased from 59 to 1065 and 1967 within 7 and 14 days of being switched back to grazing pearlmillet. In 2010, fecal egg counts of kids grazing sericea lespedeza and of kids having free access to both sericea lespedeza and pearlmillet at the same time showed similar patterns. Fecal egg counts decreased within 7 days (1688 to 178 for sericea lespedeza and 1525 to 493 for free access to both sericea lespedeza and pearlmillet) and stayed low from day 7 through 35 (average 218 for sericea lespedeza and 503 for free access to both sericea lespedeza and pearlmillet). Conversely, fecal egg counts of kids grazing only pearlmillet increased from 2010 to 3052 within 7 days of grazing and averaged 3033 from day 7 to 35. In 2009, larval culture and identification indicated that in kids grazed only on sericea lespedeza, barber pole nematodes were being progressively replaced by tricostrongylus species. Finally, fecal egg counts of kids previously grazing sericea lespedeza or having free access to both sericea lespedeza and pearlmillet at the same time increased drastically within one or two weeks of being housed off pasture on a dry lot.

Daily gains were similar across treatments averaging 0.22 lb/day in 2008 and 0.15 lb/day in 2009, whereas in 2010, kids daily gains were highest for kids having free access to both sericea lespedeza and pearlmillet (0.26 lb/d), intermediate for sericea lespedeza (0.22 lb/d) and lowest for pearlmillet (0.14 lb/d).

These results look very promising but additional research is warranted to determine optimal grazing

strategies to control gastrointestinal parasites and simultaneously increase goat growth rate.

Switchgrass and Secondary Photosensitization in Grazed Goats

A herd of 15 nursing Boer cross does and their respective 30 suckling kids were control-grazed on three Alamo switchgrass plots starting on April 26th to determine pre- and post weaning performance. Two other groups of does and their respective kids were control-grazed on either gamagrass or sericea lespedeza. At weaning on May 28th, the does were moved back to the breeding herd pastures while the weaned kids were kept on these same plots. Fifty-one additional weaned kids from the breeding herd were added to the switchgrass plots on two separate occasions (May 22nd and June 11th) to control pasture growth. As the switchgrass stubble (mainly stems) grew taller during the grazing season, it was cut to promote leaf growth. The litter was left to decompose on the field.

Following a period of rainy weather, 24 (30%) of the weaned kids developed swelling/thickening of the ears, and swelling around the eyes. In some affected kids, the eyes would almost close shut overnight due to the swelling. These first signs of photosensitization were followed by clinical signs of lethargy, poor body condition, and skin ulcerations with crusting on the face, ears, the dorsal midline, left and right flank, lateral aspect of the limbs, and dorsal pinnae, followed by the development of secondary infections. Essentially all areas of skin exposed to sunlight, especially lightly pigmented areas, could be found to be affected. Blood serum chemistry showed elevated levels of liver enzymes. Other serum abnormalities included elevated blood urea nitrogen and total bilirubin. The experiment was terminated on August 6, the weaned kids were removed from these plots, and the remaining forage was harvested as hay.

Affected kids were kept out of the sunlight and secondary skin infections and pain were managed with appropriate therapy. Six severely affected goats had to be humanely euthanized at the NCSU College of Veterinary Medicine. Necropsies revealed hepatic and renal abnormalities as well as skin pathology. Hepatic lesion severity appeared to correlate with increased switchgrass exposure time.

The following summer, the switchgrass hay harvested from the grazed plots was barn-fed once a day in the afternoon from July 8th to August 8th to a group of weanlings while another group of weanlings was fed fescue hay. Both groups spent the entire day outdoors without having access to shade. No animal of either group developed any problem of photosensitization. During the same period, a third group of weanlings was grazed on the regrowth of one of the switchgrass plots grazed the previous year. The first cut had been harvested for hay, which meant that dead material was present in the field. This group of animals did not develop any problem while the weather was dry. But, approximately 10 days after several good rain showers, some weanlings started to show swelling/thickening of the ears and around the eyes and signs similar to those previously seen with the secondary photosensitization.

Diosgenin and other steroidal sapinogens are believed to be the principle toxic agents present in *Panicum* species. Ingestion of *Panicum* species, primarily Kleingrass, has been reported to be hepatoxic in sheep and horses but not cattle. According to Dr. Brownie from the NCSU College of Veterinary Medicine, a fungus growing on the decomposing switchgrass litter (hay, cut stubble, dead lower leaves of standing forage) during periods of wet weather, combines with diosgenin, the saponin found in switchgrass. It has been suggested that the resulting complex apparently occludes the bile ducts and phylloerythrin cannot be eliminated into the digestive tract through the bile ducts. Phylloerythrin is derived from the degradation of chlorophyll by microorganisms present in the gastrointestinal tract. As phylloerythrin accumulates in the blood plasma and reaches capillaries in skin areas unprotected by sufficient hair, it can absorb and release light energy, initiating a phototoxic reaction. Older extension publications from Texas warned not to graze sheep on Kleingrass during period of humid and hot conditions. Our experience suggests that *under certain conditions* switchgrass can produce secondary photosensitization in grazed goats.

Fodder Trees for Meat Goats

As goats are selective feeders and have a strong preference for browse, efficient meat goat production systems in the southeastern United States must take advantage of regional pasture ecologies. The inclusion of native or naturalized fodder tree species could contribute to system productivity and efficiency by supplying required nutrients during the seasonal production cycle (mid-late summer) when demand by growing or lactating animals is critical and availability of high quality forage is scarce.

A long-term study was initiated at the Center for Environmental Farming Systems located near Goldsboro, North Carolina. White mulberry and three leguminous tree species, black locust, mimosa and honey locust were evaluated for growth, leaf

biomass, nutritive value, and browsing preference by yearling crossbred Boer goats. The site was first mowed and each row was sub-soiled to a 30-cm depth. Fodder trees were then planted in double rows (12 trees per row, planted 1 m apart within row and 3 m apart between rows) in plots measuring 11 m by 3 m and spaced 6 m apart. One year old bare-root seedlings were planted in March 1995 in an endophyte-infested tall fescue bermudagrass, bahiagrass , crabgrass and white clover pasture. Trees were cut back to a 50-cm height in February 1996, yearly thereafter, and are still being browsed in summer 2010. After planting, a 5-strand high-tensile electrified fence was erected at the perimeter of the experimental site.

Based on data taken in September 1997 and May 1998, black locust (500 and 1,330 lb dry matter[DM]/acre) and mimos*a* (688 and 541 lb DM/acre) produced more leaf biomass than the two other species. White mulberry did not produce as much herbage (217 and 230 lb DM/acre) as the other two species. Although of good quality and readily consumed by goats, honey locust was judged to be a low value browse species due to its slow growth and low biomass production (87 and 153 lb DM/acre). Subsequent leaf production data of black locust by hand defoliation of the same trees twice during the growing season indicated that that species produced large amounts of herbage (June 2001: 1497 lb DM/acre; August 2001: 3613 lb DM/acre; June 2002: 4966 lb DM/acre; September 2002: 1818 lb DM/acre).

Goats exhibited an initial low preference for mimosa but readily consumed that species following defoliation of the other three tree species. Crude protein and neutral detergent fiber concentrations, and *in vitro* DM digestibility of leaf samples averaged, respectively: 23, 31 and 96% for mulberry; 23, 44 and 60% for black locust; 24, 33 and 84% for mimosa; and 18, 43 and 71% for honey locust.

These results indicate that mimosa and mulberry, and especially black locust due to its aggressive growth habit, high biomass production, and very high survival (75% after 15 years) have high potential as silvopastoral species and could potentially play an important role in meat goat production systems as protein and/or energy banks during the summer. In addition, tannins present in black locust may also offer a useful alternative to chemical dewormers to control gastrointestinal parasite loads in goats.

Although slower growing and initially producing less biomass, honey locust had an excellent survival rate (91% after 15 years) and has potential as a shade tree due to the size and shape of its canopy. In addition, the large pods produced by honey locust could be a source of feed for goats once they dry and fall on the ground in late fall. Finally, preliminary observations from another study indicate that switchgrass planted between rows of black locust tolerates shade well, and seems to benefit from nitrogen fixation from black locust by producing large amounts of biomass.

FINAL CONSIDERATIONS

Year-round Grazing Systems

Producers need to be aware that there is no one grazing plan that fits all situations and many factors need to be considered. Soil types, topography, climatic conditions, type of livestock operation, labor resources, capital, available machinery, specific objectives, etc. will define the grazing system to be implemented. Other factors such as control of gastrointestinal parasites of goats will also influence the choice of some forages to incorporate into the grazing system. The seasonal distribution of cool-season and warm-season perennial and annual grasses, cool-season perennial legumes and perennial browse is shown in Figure 1. It can be easily seen that under southeastern conditions, cool-season and warm-season pastures complement each other. As a rule of thumb, only 25% of pasture land should be dedicated to warm-season forages in any grazing system. Grazing systems can include only perennial forages, only annual forages, or a mixture of perennial and annual forages. In general, white clover is the predominant legume found in present grazing systems, but sericea lespedeza, because of its beneficial effect in controlling intestinal parasites of goats, is starting to play an important role in certain areas. Nevertheless, sericea lespedeza is listed as an obnoxious, invading plant is some states.

The seasonal patterns of growth of a fescue (cool-season perennial) and hybrid bermudagrass (warm-season perennial) grazing system is depicted in Figure 2. In Figure 3, the hybrid bermudagrass was overseeded in the fall with a winter annual small grain forage (cereal rye or annual ryegrass or wheat or oat). The winter annual forage will provide feed at both extremes of the bermudagrass growth season with a small peak in November-December and another one in March-April when bermudagrass is mostly dormant. The winter annual forage, however, will reduce the productivity of bermudagrass during the summer, but not necessarily of the combination bermudagrass + winter annual small grain.

Browse should be used as a forage resource during the hot and humid summer months, preferably for goats having high nutritional requirements such as does in late gestation, does in early lactation with

nursing kids and weanlings. One of the beneficial aspects of browse is that it provides shade when the heat index can be an environmental stressor. Keep goats on browse as long as possible is another benefit as the higher the goat grazes/browses, the lower the level of internal parasites will be Leaving trees in both cultivated pasture and cleared rangeland is important for the same reason. In addition, browse foliage nutritive value can be very high and changes little throughout the growing season. Nevertheless, additional research work is needed to assess the chemical composition and nutritive value of many browse plants.

Establishing Mixed-Plant Communities as Pastures

As mentioned previously, if given a choice, the daily ration of a goat is made up of 20% grasses, 20% "weeds" (many are forbs of very high quality) and 60% browse. Thus, plant diversity needs to be optimized to provide goats the forage quality and quantity necessary to meet their nutritional requirements. One approach is to plant a community of high quality perennial forages (a mix of grass, legume and forbs such as orchardgrass or tall fescue with plantain, chicory (*Chichorium intybus*), perennial sericea lespedeza and birdsfoot trefoil (*Lotus corniculatus*). Plant species selection is important as different nutrients (amino acids, fiber and sugars, minerals and vitamins) can be optimized when goats have access to a wider array of plants, and thus will be better able to mount an effective immune response when necessary. In addition, chemicals in certain plants such as condensed tannins have an effect on internal parasites. So far, research conducted at North Carolina State University dealt with the evaluation of pure stands. Future research will focus on the evaluation of mixed-plant communities for the following reasons: a) it should be obvious to anyone that pure stands do not stay pure for very long, not even one growing season as other plants, both preferable and "weeds", colonize empty spots until the plant community reaches an equilibrium, unless gross mismanagement and other circumstances lead to pasture degradation, b) due to their innate grazing/browsing behavior, goat prefer to consume a variety of plant species during a single meal, they prefer "a buffet" to meet their nutritional requirements, c) perhaps they also prefer to consume some plants, considered weeds as they are not consumed by other livestock species, because they may contain compounds that help the goat fight some parasites or diseases, an area we do not know much about besides the beneficial effects of tannins d) inclusion of legumes in pastures will lessen the burden on the environment and decrease nitrogen fertilizer costs to producers.

Renovation of pastures

Given that goats are the most versatile of livestock in terms of the variety of plants it consumes, many of them considered weeds although of extremely high quality, assessing the plant community and its productivity is a "must" before considering and investing the total renovation of a pasture. A pasture considered not sufficiently productive for beef cattle of horses because of "weeds" and brush invasion could be highly productive for goats. Therefore, total pasture renovation should be considered a last resort alternative. Drilling other forage species such as white clover, chicory, plantain or spreading crabgrass or prairie grass seeds on a very short stubble and incorporating them into the soil with a light implement should be sufficient in most cases to thicken a thin stand. In addition, soils samples should be taken to determine chemical composition and possible remediation. Under certain circumstances, adding lime to correct the pH is sufficient to alter the pasture plant community. In other cases, strategic nitrogen fertilization, grazing and or bush-hogging to allow other plants to grow will alter the plant community satisfactorily.

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Table 1. Forage data and performance of crossbred (0.5 to 0.75%) Boer replacement does and castrated males control-grazed on annual ryegrass, cereal rye and triticale.

Item	Ryegrass	Cereal rye	Triticale
Forage quality			
Protein, %	21.5	23.3	23.0
Cell-wall, %	40.3	42.2	41.8
Forage biomass, lb/a	2372	2143	2236
Average daily gain, lb/d			
Female	0.25	0.30	0.28
Castrated male	0.36	0.44	0.42
No. grazing days/a	1402	677	728
Total weight gain/a, lb	365	186	187

Table 2. Forage data and performance of crossbred (0.5 to 0.75%) Boer weanling doe kids control-grazed on pearlmillet, soybean and cowpea.

Item	Cowpea	Pearlmillet	Soybean
Forage quality			
Protein, %	25	19	31
Cell-wall, %	30	59	35
Average pre-grazing height, inch	13	28	25
Average post-grazing height, inch	11	16	14
Average daily gain, lb/d	.19	.15	.19
No. grazing days/a	992	2167	1411
Total weight gain/a, lb	187	316	255

Table 3. Forage data and performance of suckling kids and their dams and replacement does control-grazed on three cultivars of tall fescue.

Item	Kentucky 31[+]	Jesup[-]	MaxQ
Spring			
Available biomass, lb/a	1453	1441	1472
Residual biomass, lb/a	759	790	730
Suckling kid average daily gain, lb/d	.26	.31	.33
Suckling kid total weight gain/a, lb	194	232	247
Doe weight change, lb/d	-.20	0.0	-.02
Doe serum prolactin levels, ng/mL			
Initial level (day 1)	118	124	128
Average level (day 28 + end of study)	18	152	168
Tillers with seedheads following			
Grazing in mid-May, %	74	3	1
Fall			
Available biomass, lb/a	1800	1600	1700
Residual biomass, lb/a	1400	800	1000
Replacement doe avg daily gain, lb/d	.04	.16	.17
Replacement doe total gain/a, lb	24	105	106

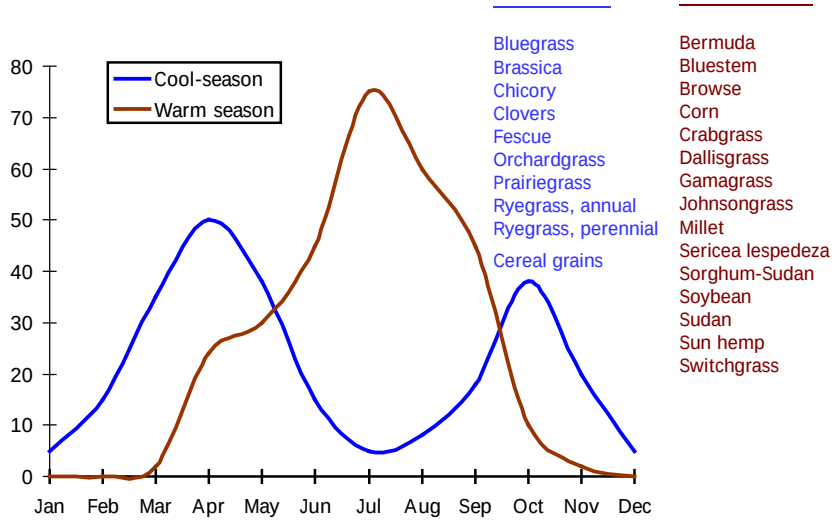

Figure 1. Seasonal distribution of growth (lb/acre/day) of cool- and warm-season plants.

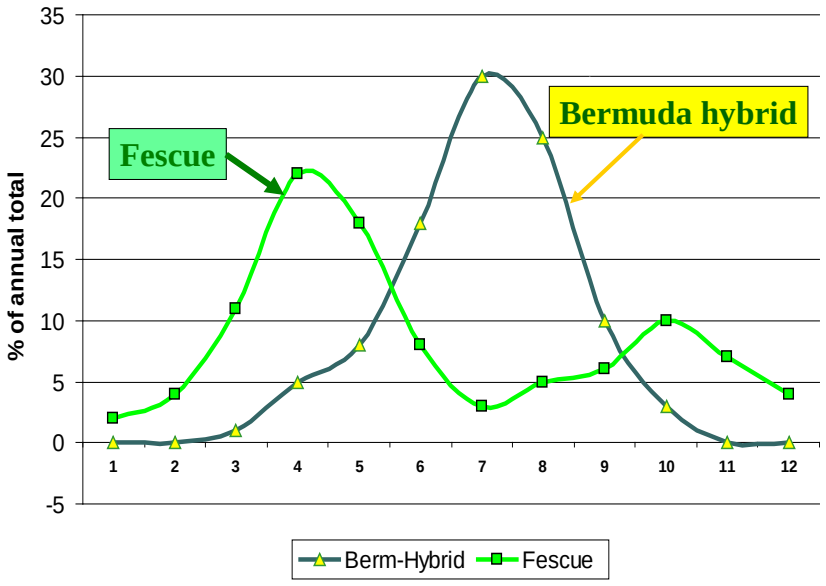

Figure 2. Seasonal growth patterns of a fescue-bermuda system.

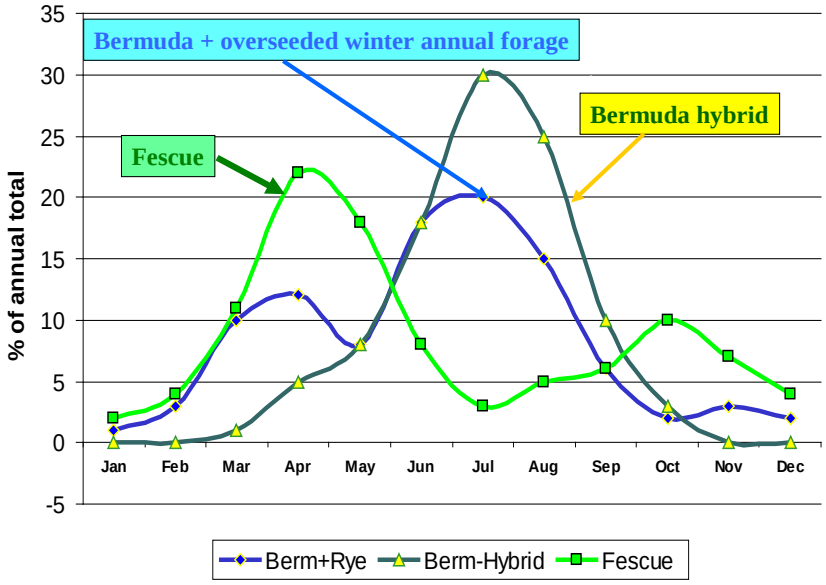

Figure 3. Seasonal growth pattern of a fescue-bermuda system with the bermuda overseeded with a winter annual forage during winter.

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