**SMART MAN'S LUCERNE AND WORM CONTROL**

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## Introduction

Since the 1930's and 1940's, sericea lespedeza (SL; *Lespedeza cuneata*), became a cultivated plant in the USA. SL is a tannin-rich warm-season perennial legume that has been called "Poor Man's Alfalfa/Lucerne" because it can produce forage under poor environmental conditions. It has the ability to tolerate drought, infertile, acidic soils and grow well on sloping land with minimal lime and fertilizer inputs. With recent research on the potential health and environmental benefits of including SL in the diet of ruminant animals, this forage has earned a new nickname. Well-adapated to the warm, moist environment of the southern and eastern United States (U.S.) and the acid velds of southern Africa, this non-bloating forage also lowers ruminal methane production in grazing livestock, reducing the contribution of this powerful greenhouse gas to global warming. However, the main reason that it may be time to change SL's name to "Smart Man's Lucerne" is the effect of its tannins on internal parasites of livestock. In an era when anthelmintic drugs are rapidly losing their effectiveness against gastrointestinal nematodes (GIN), particularly *Haemonchuscontortus*, the infamous blood-sucking GIN commonly known as "wireworm", "red stomach worm", or "barber's pole worm", research over the last ten years has demonstrated excellent anti-parasitic properties of SL in fresh (grazed) or dried (hay, leaf meal, pellets) forms in the diet of sheep, goats, and other ruminants, not only against *H. contortus*, but also against *Eimeria* spp., a protozoan parasite that causes coccidiosis and can have devastating effects on young animals (lambs and kids).

## History of sericea lespedeza

Sericea lespedeza has been used for soil conservation and as forage for livestock in the U.S. for over 100 years and as a grazing and hay crop in South Africa (SA) for over 30 years. Introduced to the U.S. at the North Carolina Experiment Station in 1896, SL was used extensively for reducing soil erosion on disturbed soils and for strip mine reclamation in the 1920's and 1930's, and as a pasture species beginning in the 1940's (Ohlenbusch et al., 2007). The SL cultivars available at the time, Arlington (released in 1939) and Okinawa (available in 1944) had thick stems, which lowered palatability and animal performance. A breeding program to improve this species was initiated at Auburn University in Alabama in the 1950's, resulting in the release of high-tannin cultivars with thinner stems and lower fiber content (Serala and Interstate) in the 1960's, lower tannin concentrations (AU Lotan) in 1980, and improved grazing tolerance (AU Grazer$^{TM}$) in 1997 (Mosjidis, 2001).

In the U.S., older SL cultivars are still used for stabilizing disturbed soils from surface-mined coal sites, road banks, and other disturbed or eroding sites (Mosjidis and Terrill, 2013) and for improving wildlife habitats. AU Grazer$^{TM}$ is the primary cultivar planted as a grazing and hay crop for livestock production in this country.While most productive in the southeastern states, sales of AU Grazer$^{TM}$seed have been increasing throughout the southern, eastern and northern U.S., from Florida to Texas to Minnesota (T. Sims, personal communication).

In SA, while AU Grazer$^{TM}$is being planted and used for pasture and hay on commercial farms, the most widely planted SL cultivar is AU Lotan that has been adapted to SA growing conditions. In a plot trial completed in the 1980s in the lowveld, middleveld, and highveld areas of Swaziland (Mkhatshwa and Hoveland, 1991), several SL cultivars (Interstate 76, Serala, AU Donnelly, and AU Lotan) produced very well in the acidic conditions of the middleveld (950 m elevation) and highveld (1500 m) sites (pH of 4.8 and 4.0, respectively), and produced poorly on the basic soils (pH 8.0) of the lowveld (150 m). Although dry matter production of AU Lotan was lower than Interstate 76 and AU Donnelly in this trial, AU Lotan has become the most widely-utilized cultivar in the summer rainfall regions of SA thanks to the perseverance of pioneering commercial farmers who refused to give up on SL after early planting failures (Fair, 2014).Sericea lespedeza may also have potential as a forage crop in other countries in southern Africa with a similar summer rainfall pattern and acid velds, including Namibia, Botswana, Zimbabwe, Mozambique, and Zambia.

**Agronomic, environmental, and health benefits of sericea lespedeza**

Sericea lespedeza has a number of desirable qualities that make it useful as a forage crop and as a conservation plant. It can be grown on a wide range of soil types, including acidic, infertile sites that will not support growth of other forage legumes (Ball and Mosjidis, 2007). As a legume, it needs no nitrogen (N) fertilization. Because of its tolerance of high free $AL^{+3}$ levels, SL roots grow deeply in acidic soils, making it very drought-tolerant (Hoveland et al., 1990). Deep rooting of SL also reduces its need for phosphorus (P) fertilization, as it is excellent at extracting this element from soil (Joost et al., 1989). Reduced need for lime and fertilization with N and P make SL an inexpensive pasture and hay crop compared to other forages. Sericea lespedeza is also an excellent seed producer and is generally resistant to damage from insects and diseases (Ball and Mosjidis, 2007).With a deep root system, ability to persist under a wide range of soil conditions, and its tendency to shed lower leaves, SL is an ideal conservation plant, building soil fertility, improving soil structure, and reducing erosion. It is also environmentally-friendly as a feed for ruminants, reducing activity of methanogenic bacteria in the rumen (Puchala et al., 2005; 2012; Naumann et al., 2013).

The health benefits of this plant to both animals and humans include its anti-bloat, anti-microbial (including pathogenic bacteria, such as *E. coli*), and anti-parasitic properties (Min et al., 2008; Terrill et al., 2012). All of these characteristics of SL are thought to be related to the high concentration and unique structure of its condensed tannins (CT). Structural analysis has revealed high concentrations of CT compounds of high molecular weight and up to 98% “prodelphinidin-type” tannins in the leaves of SL (Mechineni et al., 2014).These tannins are very reactive with protein, possibly including those on the surface of adult parasites.

**Anti-parasitic properties of sericea lespedeza**

The first reports on the anti-parasitic properties of SL came from grazing work with goats in Oklahoma, with Min et al. (2002) reporting a 57% reduction in GIN egg counts in feces of goats grazing SL compared with similar animals grazing grass pasture. Lower numbers of *H. contortus* (94%), *Teladorsagiacircumcincta* (100%), and *Trichostrongyluscolubriformis* (45%) were observed in ‘tracer’ animals grazing SL compared with tall fescue (*Festucaarundinacea*) pastures in a second experiment (Min et al., 2003). Results of the first trial demonstrating anti-parasitic effects of sun-cured SL (hay) were presented at the International Goat Symposium held in South Africa in July, 2004 (Shaik et al., 2004), with lower GIN egg counts in goats fed ground SL compared with ground bermudagrass (*Cynodondactylon*) hay. In a follow-up study, Shaik et al. (2006) reported an 80% drop in GIN egg counts of goats a week after being fed long (unground) SL hay compared with bermudagrass hay at 75% of daily intake, and these differences remained throughout the 6-week feeding trial. The SL-fed goats also had improved blood packed cell volume (PCV),reduced development of infective ($L_3$) larvae from GIN eggs in feces, and reduced adult worm numbers in their abomasum and small intestines. Total reductions in adult female GIN were 77%, 36%, and 50% for *H. contortus*, *T. circumcincta*, and *T. colubriformis*, respectively, in goats fed SL compared with bermudagrass hay diets (Shaik et al., 2006). In a similar study with sheep fed SL and bermudagrass diets, Lange et al. (2006) reported 67-98% lower GIN egg counts in the SL-fed animals throughout the 49-day trial, and a greater effect of SL on reducing existing *H. contortus* worm burdens (67%) compared with establishment of incoming larvae (26.1%).

Sericea lespedeza can be grazed, fed as hay, ground and fed as whole plant or leaf only meal, processed into whole plant or leaf only pellets, or ensiled. Preserving and processing SL gives farmers greater flexibility in the use of this forage on their farm and facilitates storage and shipping to areas where SL doesn’t grow well. However, any type of drying or processing of SL generates heat, reduces extractable CT, and increases CT bound to protein (Terrill et al., 1992; 2007). Recent work has also demonstrated that sun-curing and pelleting of SL can even change CT structure, increasing the polymer size of CT molecules (Kommuru et al., 2014; Mechineni et al., 2014). The question is how does processing of SL affect its anti-parasitic bioactivity? So far, the answer has been uniformly positive. As previously mentioned, sun-curing and grinding does not significantly change the anthelmintic efficacy of SL compared with grazed forage. This is important because sun-curing reduces extractable CT content of high-tannin SL (Interstate 76) and improves the palatability and digestibility of this forage for sheep (Terrill et al., 1989). Pelleting of AU Grazer SL further reduced extractable CT concentrations, but did not reduce the plant’s anti-parasitic properties in goats, whether fed as the primary diet (Terrill et al., 2007) or as a supplement on grass pasture (Gujja et al., 2013). In a recently-completed study comparing SL hay, ensiled SL, and bermudagrass hay fed to goats as 70% of diets balanced for protein and energy, there was no effect of SL processing method on GIN egg counts and coccidial (*Eimeria* spp.) oocyst counts in feces, but goats on either SL diet reduced counts by 75.5% and 88.6%, respectively, compared with control animals two weeks after initiation of feeding (unpublished data). Other studies have demonstrated very good effectiveness of pelleted SL against *Eimeria* infection (up to 98% reduction compared to non-CT control pellets) in both sheep (Burke et al., 2013) and goats (Kommuru et al., 2014).Promising results of reduced GIN egg counts have also been observed in preliminary studies with beef cattle fed SL as hay or in pellet form (Miller et al., unpublished data) and llamas fed SL in round bales (Gillespie, 2008) compared with non-tannin control forages.

Other research questions with SL that needed to be addressed included 1) how much SL wasrequired to achieve the anti-parasitic effect (what percentage of the diet), 2) can the parasites develop resistance to the effect of CT, and 3) what are the nutritional consequences of including SL in livestock diets. An initial answer to question 1 was provided in a study published by Terrill et al. (2009) in which diets differing in SL content (0, 25, 50, and 75% SL) were fed to parasitized goats. The 50 and 75% SL diets significantly reduced GIN egg counts compared with the control diet (0 % SL), but only the 75% SL goats had lower numbers of adult worms.The conclusion from a second dose titration study with growing meat goat kids comparing pelleted whole plant SL and commercial pellets fed at 0, 20, 40, and 60% of the diet was the more SL the better, as there was a linear reduction in GIN egg counts in feces as the percentage of SL in the diet increased (Burke et al., 2011). In a study comparing ground whole plant SL with ground SL leaf meal fed to goats at 25% of each ration, both diets reduced GIN egg counts from pre-trial levels, but the leaf meal diet reduced egg counts more quickly (Terrill et al., 2008). Retaining leaves is an important consideration when drying and processing SL because the leaves are higher in protein and CT content (16.0 versus 3.3 g/100g dry weight tannin content in leaf and stem SL, respectively; Mechineni et al., 2014).

The answer to the second question is still to be determined. Recent studies with pelleted SL fed to goats and sheep in Arkansas showed no effect on GIN egg production compared with non-CT pellet (control) diets (Burke, personal communication), while the same pellets were effective against GIN and coccidia in both lambs and kids in trials in Georgia (Terrill, unpublished data). So far, SL grazing and confinement feeding trials with both goats and/or sheep have shown fairly consistent anti-parasitic results in work completed in Georgia, Louisiana, and North Carolina with AUGrazer™ (Terrill et al., 2012) and in South Africa with sheep grazing AU Lotan(Botha and Bath, unpublished data). The possibility of regional differences in GIN susceptibility to the effects of dietary SL, particularly with long-term exposure to CT needs to be explored further.

The question of the nutritional value of SL in livestock diets has been debated for a long time. Intake of the older cultivars of SL was low by grazing cattle, with the problem thought to be due to high levels of fiber and CT. Based upon observations that cattle will graze even common SL when it is young, or the top 20 cm of more mature plants, which are just as high in CT as the rest of the plant (Mosjidis et al., 1990), it is now generally accepted that once the animal gets used to the taste of SL, their consumption level is based more on plant maturity than CT concentration (Mosjidis, personal communication). In addition, processing of high-CT SL into hay improves intake compared with fresh forage in sheep (Terrill et al., 1989).Generally, performance (daily gain) of livestock grazing or fed hay of improved cultivars of SL have been comparable to or better than perennial warm-season grasses, such as bermudagrass, which are the mainstay of grazing systems in the southern U.S. (Ball and Mosjidis, 2007; Moore et al., 2008). In a 49-day trial with weaned calves given supplemental soy hulls and either free-choice AU Grazer™ SL hay or bermudagrass hay in round bales, daily gains for the SL and bermudagrass groups were 1.49 and 1.38 lbs/day, respectively (Ball and Mosjidis, 2007). Average daily gains in parasitized and unparasitized goats fed either SL or bermudagrass hay at 75% of daily intake were 104 and 75 g/day, respectively (Moore et al., 2008). In on-farm trials completed in KwaZulu Natal, South Africa, daily gains in beef calves and milk production/day in dairy cows were similar between SL hay and fertilized perennial grass (weeping lovegrass; *Eragrostiscurvula*) diets (Botha, unpublished data), although costs for SL production were 70% lower.

One of the questions about long-term feeding of SL concerns the effect on micronutrient status of livestock. In several recent studies with kids and lambs, long-term SL feeding reduced serum molybdenum (Mo) and cobalt (Co) levels compared with animals fed non-tannin (control) diets, although the effect on animal performance is still unclear (Burke, unpublished data). In other studies, there was no clear effect of SL feeding on blood micronutrient status in lambs (Acharya et al., 2015) and yearling goats (Hamilton, 2015).

**Feeding recommendations for parasite control using Smart Man's Lucerne**

All of the fresh (grazed), dried (hay, leaf meal, pellets), or preserved (ensiled) forms of SL that have been tested so far have showed some level of anti-parasitic activity against GIN, particularly *H. contortus*, and more recent studies, against the protozoan parasites (*Eimeria* spp.) that cause coccidiosis (Terrill et al., 2012; Burke et al., 2013; Kommuru et al., 2014; Hamilton, 2015). Based on this work, our current recommendations for using SL for parasite control in livestock are to feed it in its various forms at 50% or more of the diet (along with other sources of supplemental energy or protein as needed to meet nutritional needs of specific classes of animals). For control of *Eimeria* spp., begin feeding two weeks priorto periods of stress that might lead to outbreaks of coccidiosis, such as weaning of kids or lambs, and then continue for an additional 6 weeks afterwards. For barberpole worm, use a similar approach, feeding prior to and during times of stress, particularly in classes of animals that are most susceptible to parasitic infection, such as kids and lambs at weaning and adult females during parturition and early lactation, particularly if they are suckling twins or triplets. We don't recommend feeding longer than 8 weeks for younger animals, as in some locations/farms, the CT in SL may bind some trace minerals and may slow weight gains (Burke, unpublished data). This does not seem to be a problem with long-term SL feeding in more mature animals (Hamilton, 2015). When SL feeding is discontinued, the animals should be observed closely for signs of parasitic infection using FAMACHA© or the Five Point Check©, and if needed, treated using 0.5 g of copper oxide wire particles (for *H. contortus* infection) or an effective anthelmintic.

## Future of sericea lespedeza

Research is continuing on the unique structure and bioactivity of tannins in different cultivars of SL and the effects of various preservation and processing methods on these properties. With its many agronomic advantages (low-input, tolerant of acidic, infertile soils, drought tolerance, resistant to insect and disease damage, soil-building properties) and animal health benefits (non-bloating, anti-parasitic), as well as its flexibility in form of feeding (grazing, hay, pellets, silage), SL has tremendous potential to improve sustainability of animal-based agriculture both on large commercial farms as well as with small and limited resource farmers. With a source of pelleted SL leaf meal now commercially available in the U.S. and sources of SL seed in both the U.S. and South Africa, the use of this plant as an anti-parasitic forage for both small and large ruminants is likely to continue growing in the U.S., Africa, and other parts of the world.

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