Condensed Tannins

- Condensed-tannin (CT) forages
  - Leaves and stems of plants contain CT (proanthocyanidin)
  - CTs increase nitrogen utilization in ruminants
  - CTs have a complex structure
  → formation of rumen bypass protein, less ammonium released into the environment, higher milk solids, anti-bloat.
Condensed Tannins

• Grazing the forage legume, Sericea lespedeza, reduces round worm populations in sheep and goats. Attributed to its condensed tannins.

• Not all condensed tannins work – Oak, peanut skins, grape pulp?

• Promising studies with cranberry leaves, pine bark

• SL not winter hardy in Northeast. Potential for Birdsfoot trefoil?
As part of the OREI USDA grant on “Forage-Based Parasite Control in Sheep and Goats in the Northeast US”, 11 Northeast farms established birdsfoot trefoil pastures.

2015 - 6 farms conducted grazing trials
2016 – 4 farms conducting grazing trials
Forage samples were taken every two weeks from the paddocks to estimate the total amount of forage dry matter and percentage of it that is Birdsfoot Trefoil.
Sampling included FAMACHA scoring by same person each time.
AND Fecal Sampling!
Animals were weighed at the beginning and end of the grazing trials.
2 Acre Field Birdsfoot Trefoil
Marathon, NY
Cortland County

- Soil Type: Volusia
- Soil pH: 5.3
- Buffer pH: 5.2
- P: 2 lbs/acre
- K: 147 lbs/acre
- Ca: 1,372 lbs/acre
- Mg: 148 lbs/acre
- % OM: 6.8
Soil Preparation and Planting

• Plowed in 2012 with horses

• Disked in 2014 with horse teams

• Cultipacked with horses

• On May 20\textsuperscript{th}, 2014 BFT (17 lb. per acre) planted along with millet nurse crop (20 lb. per acre) using handheld broadcast spinner.

Cultipacked again after seeding
Disked with horse team
Cultipped with horse team
Bruce variety of BFT planted at ~17 lbs/acre and Japanese millet at 20 lbs/acre
Cultipacked again after planting
Millet harvested for hay on Aug 11th
Millet/trefoil regrowth, millet will winter die

<table>
<thead>
<tr>
<th># of Plants of:</th>
<th>Birdsfoot Trefoil</th>
<th>Broadleaf Weeds(^1)</th>
<th>Grass Weeds</th>
<th>Forage Legumes(^2)</th>
<th>Forage Grasses(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>25</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>118</td>
</tr>
<tr>
<td>3</td>
<td>51</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>85</td>
</tr>
<tr>
<td>4</td>
<td>31</td>
<td>17</td>
<td>2</td>
<td>3</td>
<td>79</td>
</tr>
<tr>
<td>5</td>
<td>67</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>64</td>
</tr>
<tr>
<td>6</td>
<td>27</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>76</td>
</tr>
</tbody>
</table>

\(^1\)Broadleaf weeds very small with exception of Sample #5 where they were small bracken ferns

\(^2\)Forage legumes were all clovers

\(^3\)Vast majority of forage grasses were millet
Hoped to lime and manure in the fall or winter – made a decision not to
Lamb management

• Lambs born Apr 9\textsuperscript{th} - 30\textsuperscript{th} and raised on their dairy ewe dams.
• Lambs happened to be given 2 g Copper Oxide Wire Particles on May 23\textsuperscript{rd} . (Tis is more than Cornell studies indicate are needed when COWP works especially if you think you might repeat it. Please check with your veterinarian.
• Weaned on June 1\textsuperscript{st} and put out to conventional pastures with maiden yearling ewes
• Preliminary fecal samples on subset of lambs about 3 weeks before the study started indicated about 100 to 3200 round worm eggs per gram with about 0 to 9 % of them being barber pole worm (Haemonchus contortus).
• Grazing trial started July 15\textsuperscript{th} (1 ½ months after weaning)
Treatments

• 8 lambs and 2 maiden yearling ewes were on the Birdsfoot Trefoil Treatment. Birdsfoot Trefoil (BFT) group got 12’ * 164 ′ of BFT pasture per day, i.e. 1968 sq. ft of BFT daily or 196.8 sq. ft. per animal per day.

• Eight lambs and 2 maiden yearling ewes in the Control group on unimproved pasture were also tracked. The entire control group consisted of 62 lambs and 4 maiden Yearling ewes. The Control group got 120’ * 150 ft of unimproved pasture per day, i.e. 18000 sq.ft daily or 272.7 sq. ft. per animal per day.

• Fences were moved daily. However, animals could backtrack for up to 3 days.
Both groups got free choice minerals - Fertrell Nutrient Balancer, Kelp and Redmond Salt
Control group was on unimproved pasture in same highly acidic field as the BFT
Some spots had very unpalatable weeds
Most were better but still quite unimproved
Birdsfoot Trefoil Paddocks
7/15/2015 = 72% BFT
7/29/2015 = 78% BFT
8/12/2015 = 86% BFT
Animals were sampled approximately every two weeks
Very very preliminary results

• Please note these are just raw means and there may be no true differences between the groups!!!
Animals seemed to undergo some stress first 2 weeks – or at least coccidia count went up and then back down.
On average, the Birdsfoot trefoil group had better FAMACHA scores (lower is better) on week 4 & 6 – almost one whole point better.
Fecal egg counts were similar between the two groups until week 6 when the average egg count for the BFT group increased (at 2 weeks it appeared that very few of the roundworms were barber pole worms).
Birdsfoot trefoil group gained substantially more

<table>
<thead>
<tr>
<th>Date</th>
<th>Birdsfoot Trefoil Lambs</th>
<th>Unimproved Pasture Lambs</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/15/2015</td>
<td>57.1</td>
<td>60.8</td>
</tr>
<tr>
<td>8/24/2015</td>
<td>70.3</td>
<td>65.5</td>
</tr>
<tr>
<td>Gain (lb)</td>
<td>13.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Days</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>DailyGain (lb)</td>
<td>0.33</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>1/3 lb</td>
<td>&lt; 1/8 lb</td>
</tr>
</tbody>
</table>
Birdsfoot trefoil regrowth
Examples of unimproved pasture regrowth
1.6 Acre Field Bruce BFT
Germantown, NY
Colombia County

• Soil Type: Raynham
• Soil pH: 6.0
• Buffer pH: 6.0
• P: 4 lbs/acre
• K: 249 lbs/acre
• Ca: 2,706 lbs/acre
• Mg: 351 lbs/acre
• % OM: 3.9
Soil Preparation and Planting

• Pasture limed in 2013

• Fall 2014 - Pasture mowed close and plowed next day

• 6 days later on Aug 6th, 2014 disked and planted Bruce BFT at 12 lb. per acre

• 400 lb. bone char per acre (65 lb. P^{2}O^{5}) banded in at planting
1 in. rain on the day before planting, emerged ~Aug 15, 2014 then drought – Velvet leaf may have provided shade
Was mowed to control velvet leaf on Oct 2\textsuperscript{nd} after rains finally came.

Frost seeded additional BFT in March 2015.
Lamb Management

• Grass fed flock
• Flock was originally FinnDorsets. Had been bred to Icelandic rams for the last few generations. This lamb crop was sired by one Dorset ram and one Icelandic cross ram.
• Used only ram lambs for the study. Lambs were born late April/early May.
• Ram lambs weaned on July 29th.
• Grazing trial started July 30th.
Treatments

• Nine ram lambs on Birdsfoot Trefoil Treatment. Birdsfoot trefoil group got about 3000 sq. ft. of BFT pasture every 3 days (~108 sq.ft. per lamb per day). Birdsfoot trefoil had been mowed high once or twice during the spring to control weeds and try to keep it from getting too mature.

• Ten ram lambs tracked on Conventional Pasture Treatment. Entire Conventional Pasture Group consisted of 30 ram lambs and one mature ram. Control group got about 8320 sq. ft. of conventional pasture every 2.5 days (~111 sq. ft. per lamb). Conventional pasture had been harvested for hay in the spring.

Both groups got free choice minerals (Heinhold sheep minerals and livestock kelp).
Both groups got free choice minerals (Heinhold sheep minerals and livestock kelp).
On July 13, 2015

Field biomass averaged about 65% BFT. Mugwort was the 2nd most common plant in the pasture with regard to biomass. Queen Anne’s Lace was also prominent. Biomass yield in dry matter per acre was ~ 2900 lb./acre and BFT yield was about 1900 lbs. of dry matter per acre.
Lambs had just been weaned - coccidia egg counts rose next 2 weeks and then dropped sharply by Week 4.
On average, the FAMACHA scores were the same for both groups until Week 6 when the BFT group averaged better FAMACHA scores by one whole point.
Fecal egg counts for both groups rose sharply after weaning but were similar for the two groups until Week 6 when the average egg count for the BFT group was substantially less. Spot checks indicated that most of the roundworms were barber pole worms.
Weight Gain (lb.) by Treatment during 41 d. Grazing Trial

<table>
<thead>
<tr>
<th>Date</th>
<th>Birdsfoot Trefoil</th>
<th>Conventional Pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/30/2015</td>
<td>45.8</td>
<td>44.4</td>
</tr>
<tr>
<td>9/9/2015</td>
<td>65.9</td>
<td>60.9</td>
</tr>
<tr>
<td>Gain (lb)</td>
<td>20.1</td>
<td>16.5</td>
</tr>
<tr>
<td>Days</td>
<td>41</td>
<td>41</td>
</tr>
<tr>
<td>Daily gain (lb)</td>
<td>0.46</td>
<td>0.38</td>
</tr>
</tbody>
</table>
St. Lawrence County Extension Learning Farm
Canton, NY

- Compared grazing a 3 acre field of Pardee Birdsfoot Trefoil (planted in Spring 2014)
- To grazing a conventional pasture (renovated in 2014)
  - Worm counts
  - FAMACHA Scores
  - Weight gain
- Also compared effect of administering 1 gram of COWP 2 weeks pre-weaning to giving no COWP
St. Lawrence County Extension Learning Farm
3 Acre Field Birdsfoot Trefoil
Canton, NY

• Soil Type: Muskellunge
• Soil pH: 5.9
• Buffer pH: 6.0
• P: 2 lbs/acre
• K: 75 lbs/acre
• Ca: 1,932 lbs/acre
• Mg: 300 lbs/acre
• % OM: 2.9
Soil Preparation and Planting

• Plowed in 2013
• Disked 2 or 3 times for weed suppression in 2014
• Planted with no till seeder June 4th, 2014
• Pardee BFT seeded at 7-8 lb per acre with Sunset II Timothy at 4 lb per acre
• BFT emerged June 18th
• Mowed for weeds Aug 6th, 2014
• Fertilized Oct 15th, 2014
• Manure spread October 21st, 2014
Inorganic plots (1 & 2) got 0-0-60 and 11-52-0 (MAP)
Organic plots (3 & 4) got bone char and sulfur of potash
Frost seeded additional Birdsfoot Trefoil seed with broadcast seeder in early Spring 2015
Copper Oxide Wire Particles”
given 2 weeks prior to weaning
Copper Oxide Wire Particles

- Copper oxide wire particles (COWP) were developed as a slow release source of copper for cattle on copper deficient soils.

- 12.5 and 25 gram boluses for calves and cows need to be repackaged into far smaller doses suitable for growing sheep and goats!

- COWP particles must be retained in the abomasum long enough to permit acid solubilization of the copper. The stomach acids are responsible for this. If the pH of the stomach is not acidic enough, the copper will not go into solution and will be ineffective.

- Acid solubilization results in gradual release of copper from the COWP which reduces risk of copper toxicity.
Copper toxicity in sheep

• Sheep are ten times more susceptible to copper toxicity than cattle.

• When consumed over a long period of time, excess copper is stored in the liver.

  – No damage occurs until a toxic level is reached → hemolytic crisis with destruction of red blood cells.
  – Copper is closely related to molybdenum, and copper toxicity occurs when the dietary ratio of copper to molybdenum increases about 6-10:1.
  – Affected animals suddenly go off feed and become weak. Mucous membranes and white skin turn yellowish brown color. Urine red-brown color due to hemoglobin in the urine.
Copper Oxide Wire Particles

- Works only on round worms in stomach, not worms in intestines. Damages barber pole worm but not brown stomach worm.

- If there are too many brown stomach worms, the copper will not be available, why?

- SE researchers said - worked poorly in animals that were stressed or run down. Did not appear effective in just weaned kids or lambs – instead give 2 weeks before or after weaning

- When it worked → Quite effective, killing 75-95% of Barber pole worms
Illustrates the fate of COWP boluses in the animal. (adapted from www.animax-vet.com)

ATTRA Tools for Managing Internal Parasites in Small Ruminants: Copper Wire Particles
After weaning, 16 lambs grazed on birdsfoot trefoil paddocks. Half of these lambs received 1 gram of copper oxide wire particles (COWP) 2 weeks prior to weaning.
After weaning, 16 lambs grazed on conventional pastures. Half the lambs received 1 gram of COWP 2 weeks prior to weaning.
8 lambs were tracked in a Control group fed 2\textsuperscript{nd} cut hay (12\% CP) and grain (16\% CP). Each lamb received 1 gram COWP 2 weeks prior to weaning.
On June 8\textsuperscript{th}, total BFT dry matter in biomass averaged about 27.5\%.

However, during the grazing trial (\`July 25\textsuperscript{th} to Sept 16\textsuperscript{th} ) the percentage of BFT in the biomass dry matter ranged from \(~42.8\%\) to 57.5\%. 
Both the BFT Pasture and Conventional Pasture had not been grazed yet that year and were pretty mature.
• Lambs were weighed
  • 2 weeks pre-weaning (start of the COWP study)
  • At weaning (start of the grazing trial)
  • 8 wks. post weaning (end of the grazing trial)
During the grazing trial, the lambs on conventional pasture w/o COWP averaged the highest FAMACHA scores (lower is good)

Figure 1. FAMACHA Scores by Treatment

- 4 lambs had to be dewormed and no longer included
- 2 lambs had to be dewormed and no longer included
- COWP given

Lambs weaned

2 lambs had to be dewormed and no longer included
Treatments that got COWP appeared to have lower worm egg counts throughout the study. We were excited by the dip in worm egg counts for the two BFT groups at 6 wks. although it was temporary.

Figure 2. Roundworm Egg Count by Treatment

[Graph showing egg count over time for different treatments, including BFT, BFT/COWP, CP, CP/COWP, and HG, with key events such as deworming and weaning marked.]
The treatments on BFT appeared to gain weight similarly to the treatment on hay and grain while the treatments on conventional pastures appeared to grow slower.

**Figure 4. Weight Gain over 70 days**
## Table 1. Weight Gain by Treatment during 70 d. Grazing Trial

<table>
<thead>
<tr>
<th>Date</th>
<th>Birdsfoot Trefoil + COWP</th>
<th>Birdsfoot Trefoil</th>
<th>Conventional Pasture + COWP</th>
<th>Conventional Pasture (4 lambs dewormed)</th>
<th>Hay &amp; Grain + COWP (2 lambs dewormed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/08/2015</td>
<td>46.4</td>
<td>49.0</td>
<td>45.5</td>
<td>43.9</td>
<td>46.9</td>
</tr>
<tr>
<td>7/22/2015</td>
<td>49.0</td>
<td>53.3</td>
<td>50.9</td>
<td>53.3</td>
<td>52.5</td>
</tr>
<tr>
<td>9/16/2015</td>
<td>67.6</td>
<td>64.3</td>
<td>56.9</td>
<td>56.3</td>
<td>64.3</td>
</tr>
<tr>
<td>Gain (lbs.)</td>
<td>21.3</td>
<td>15.3</td>
<td>11.4</td>
<td>12.4</td>
<td>17.4</td>
</tr>
<tr>
<td>Days</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
</tr>
<tr>
<td>Daily gain (lbs.)</td>
<td>0.304</td>
<td>0.218</td>
<td>0.163</td>
<td>0.178</td>
<td>0.248</td>
</tr>
</tbody>
</table>
Asgaard Goat Dairy
AuSable, NY

• Compared
  – grazing a 3 acre field of Pardee Birdsfoot Trefoil (planted in Spring 2014)

• To
  – grazing a conventional pasture

• Soil Type: Adams
• Soil pH: 7.2
• P: 511 lbs/acre
• K: 675 lbs/acre
• Ca: 5,494 lbs/acre
• Mg: 808 lbs/acre
• % OM: 5.2
Dairy x Kiko goat kids that had been taken from dairy dams shortly after birth and raised on separate property.

**Fecal Samples** - Sadly (for us), round worm eggs were absent from all fecal samples throughout study!!!

**Bulk samples** from conv. pasture group (but not BFT group) did grow a few round worm larvae in weeks 6 and 8.
Kids in both treatments also received 1 pound of grain each per day.

Unable to weigh at beginning of study.

Weights taken
Weeks 2, 4 and 8
Weight Change Over 42 Days by Treatment (does not include first 14 days of study)

Birdsfoot Trefoil
Conventional Pasture
Conclusions on COWP in NE US

- .5 gram per head dosages appears to be as effective as 1 gram per head for lambs. More uncertain on goat kids.

- Why do results vary widely across different farms? Diarrhea, diet, exposure of earlier generations of worms to other sources of copper, timing of infection, acidity of true stomach?

• Need more studies to identify why.
Copper Oxide Wire Particles

• Researchers in SE US who have studied it the most recommend using it in combination with FAMACHA – give COWP to your vulnerable “3s” (lambs, kids, lactating or late pregnant females) rather than giving a commercial dewormer.

• Follow up with regular FAMACHA scoring, fecal egg sampling, to see if it actually works in your herd or flock.
In summary

- When animals have worm loads, animals on BFT appear to be more resilient
  - Is this simply due to better nutrition?
  - Or are there compounds in BFT that boost their immune systems and make them more able to cope?
- Grassfed lambs appear to grow well on lush BFT pastures
- Will grazing BFT for at least 4 weeks help to control strongyle worms (roundworms)?
  - Jury is still out
- In grassfed flocks where COWP is effective and barber pole worms are present, dosing with COWP and feeding BFT appear to improve performance (better FAMACHA scores and weight gains) as compared to doing only one of these treatments or neither.
Problems encountered growing BFT

• Good germination requires excellent soil to seed contact without seed being too deep – very small seed

• Most problems centered around competition from other plants
  – Lodging
  – Shading and rotting
Lodging of grasses followed by severe mowing
July 19th
Shading/rotting after mowing weeds at 8 inches and then getting lots of heat & rain
August 26th
Research sponsored by

- USDA Organic Research & Education Initiative
- Northeast Sustainable Agricultural Research & Education Program
- Federal Formula Funds
- Northern NY Agricultural Development Program
- With staff from Cornell Sheep & Goat Program, St. Lawrence County CCE, Dr. Dwight Bowman’s Parasitology Lab at Cornell and Dr. Anne Zajac’s Parasitology Lab at Virginia Tech
- Outreach: tatiana Stanton (Cornell) & Holly Burdett (URI)