Worm Control Strategies in Development: COWP

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From 2013 until 2017, the Cornell Goat & Sheep Program conducted 13 on-farm trials studying:

The effectiveness of dosing sheep and goats with copper oxide wire particles (COWP) to control *Haemonchus contortus* (barber pole worm).

Funding thru NESARE, USDA OREI, Federal Capacity Fund and NNY Ag Dev. Program.

Copper Oxide Wire Particles

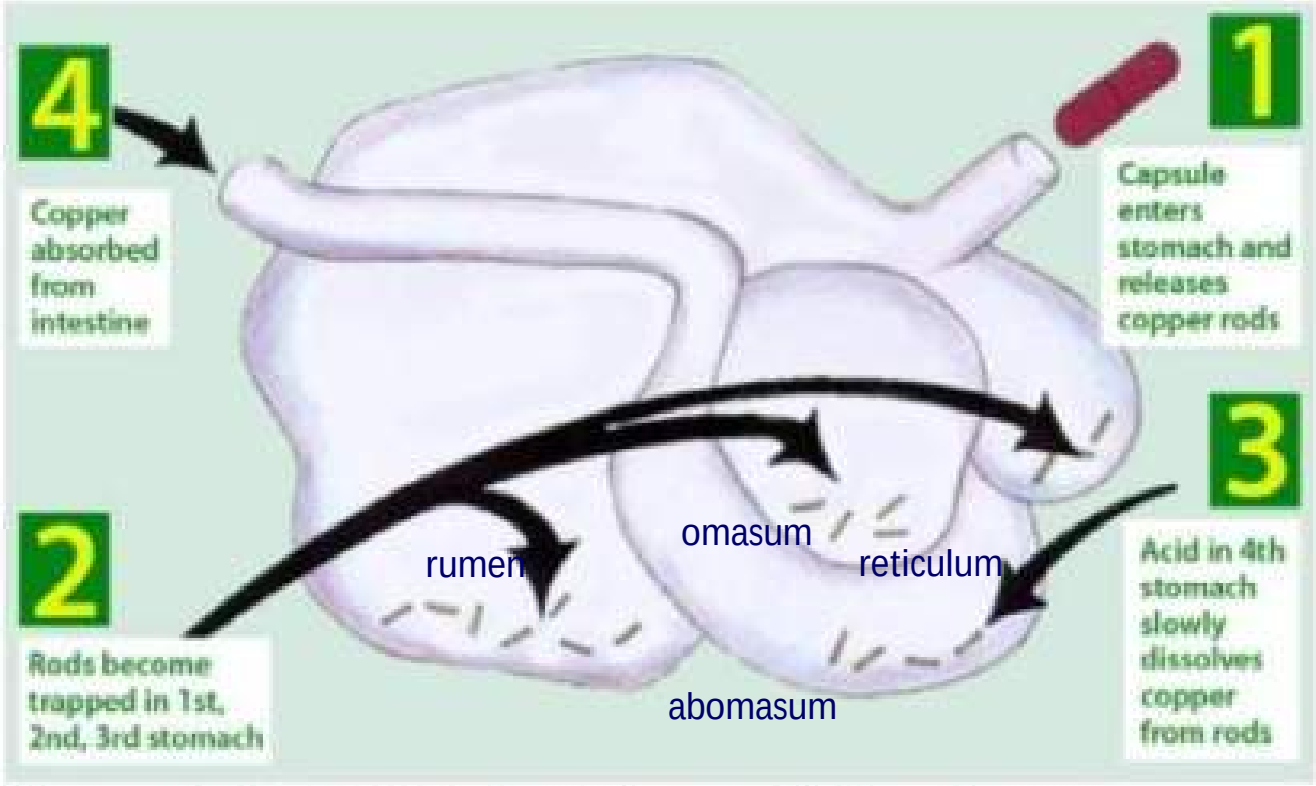
- Copper oxide wire particles (COWP) were initially developed as a slow release source of copper for cattle on copper deficient soils.

- Sheep are ten times more susceptible to copper toxicity than cattle. 12.5 and 25 gram boluses for calves and cows need to be **repackaged into far smaller doses suitable for growing goats and sheep!** Dosages prepared for goats can be toxic to sheep.

- **How do COWP particles work?**

  They need to be swallowed by the animal and deposited in the abomasum (true stomach). There they must be retained 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.** The soluble copper damages the stomach worms and also passes into the small intestines where it is absorbed and helps boost the immune system.

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



Illustrates the fate of COWP boluses in the animal. (adapted from www.animax-vet.com)

Copper Oxide Wire Particles

- Work only on parasitic worms in the true stomach, not worms in the intestines. Damages barber pole worm (*Haemonchus contortus*) but not brown stomach worm (*Ostertagia circumcincta).*

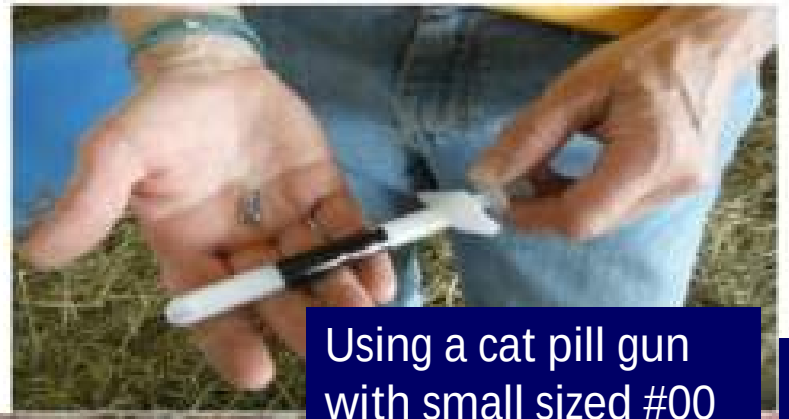
- In fact if there are too many brown stomach worms, the copper will not be available either to act as a copper supplement or to help with parasite control. WHY?
  Brown stomach worms damage the gastric glands à less stomach acids produced à pH of the stomach increases à acid solubilization of the copper fails to occur.
- COWP researchers in other parts of the U.S. found COWP did not work well in animals with diarrhea or in just weaned kids or lambs, instead recommended giving it 2 weeks before or after weaning, and avoiding diet changes right at dosing.
- When it worked à Quite effective, killing 75-95% of barber pole worms

How to administer COWP

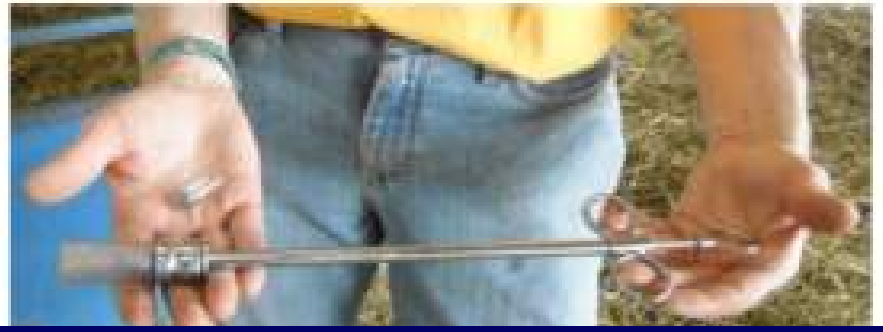
- Give orally using an applicator gun such as a cat pill gun or a balling gun. In most cases, straddle the goat or sheep. Place a hand under its head and tilt slightly to the side. Keep the nose level to the eyes. When you feel the end of the balling gun go over the “bump” at the back of the tongue, eject the bolus. A flexible tip is a nice addition. If using a cat pill gun, you need to go pretty far back into the mouth and may not encounter a “bump”.

- In some cases, an applicator gun suitable for the COWP capsules you are purchasing will accompany the purchase

- If there is no applicator gun or you are making your own capsules (you will need a gram scale to measure dosages), the next slide shows how we orally dosed the goats and sheep on our trials



Using a cat pill gun with small sized #00 (0.95ml) gel capsules



Using a metal bolus or balling gun with flexible plastic head

Large gel capsules #13(3.2 ml) can be used with a balling gun and are easier to see if spit out

Objectives of our COWP studies

- Determine the effectiveness and risks of incorporating COWP into Northeastern goat and sheep parasite management systems
- Observe whether COWP dosing has detrimental effects on the quality of milk or cheese from small ruminants

2013 Study of NEW YORK Goat Dairy

- Treatments consisted of
  - 1 gram COWP/head,
  - 2 gram COWP/head, or
  - 1 gram COWP/22 lb. live weight (a popular online recommendation at the time which was higher than recommended by actual researchers)
- 15 to 16 lactating does per treatment
- Does were fecal sampled every two weeks to determine Strongyle worm egg counts. Special peanut agglutinin (PNA) staining techniques were used to calculate the percentage of these eggs that were *H. contortus* (barber pole worm, a subset of Strongyle) eggs.
- We also looked at FAMACHA scores (color of membrane inside lower eyelid à an indicator of anemia à one of the main signs of barber pole worm infection), curd formation in 4 cheeses, Copper content of milk and aspartate aminotransferase (AST) content of blood.

Effect of copper oxide wire particles (COWP) on the change in fecal egg counts 14 days after dosing. Fecal egg counts were reduced significantly for dairy does receiving either 1 g/22 lb. live weight or 2 g/head of COWP compared to dairy does only receiving 1 g/head.

COWP	Strongyle eggs per gram	Barber pole eggs per gram
1 g / 22 lb. live wt.	-1185	-1153
2 g / doe	-1226	-1191
1 g / doe	107	75
SE	484.6	477.9
P-value for 1 g / doe vs average of 1 g / 22 lb. and 2 g / doe	0.034	0.036
P-value for 1 g / 22 lb. vs 2 g / doe	0.914	0.993

Looked for signs of Copper problems

- Sampled milk on Day 0 (immediately before) of COWP dosing, and on Day 14 and Day 42 after COWP dosing to analyze milk for Copper (Cu) content using plasma-atomic emission spectroscopy

- Cheese maker reported no changes in either time to set curd or in consistency of curd for 4 different cheeses made the first week immediately following COWP treatments

- Blood samples were taken on Day 42. The plasma was then analyzed for aspartate aminotransferase (AST) enzyme activity – an indicator of poor liver function and possible copper toxicity

Changes in Cu Level in Milk after COWP Treatment

Treatment	Day 0 – Immediately before treatment	Day 14	Increase
1 gram/22 lb live wt.	0.105 ppm (0.042 – 0.33)	0.171 ppm (0.083 – 0.322)	0.066 ppm
2 gram/head	0.135 ppm (0.056 – 0.398)	0.161 ppm (0.103 – 0.282)	0.026 ppm
1 gram/head	0.153 ppm (0.043 - 0.551)	0.191 ppm (0.121 – 0.358)	0.039 ppm

Copper levels in milk 14 days after dosing were well below allowable limits. Highest levels in milk (0.398 and 0.551 ppm) were actually recorded in two dairy does prior to dosing and there was no significant difference between the three treatments for copper levels in milk at 14 days after dosing. However, in separate paired t tests, copper concentrations increased significantly ($P = 0.003$) from 0 to 14 days for the 1 g/22 lb. live wt. treatment but not for the two lower treatments.

AST Enzyme Levels (units per liter) in Plasma 42 days after COWP Treatment

Treatment	DAY 42 Average AST (Range in AST)
1 gram/22 lb live wt.	117.9 (89 – 221)
2 gram/head	120.6 (76 – 203)
1 gram/head	112.9 (86 – 138)

Copper toxicity elicits AST enzyme activity values >300 to 400 units/Liter. Only two goats had values >200 units and all values were considered within normal, safe ranges. There was no statistically significant difference between the three treatments.

Summary of the goat dairy trial

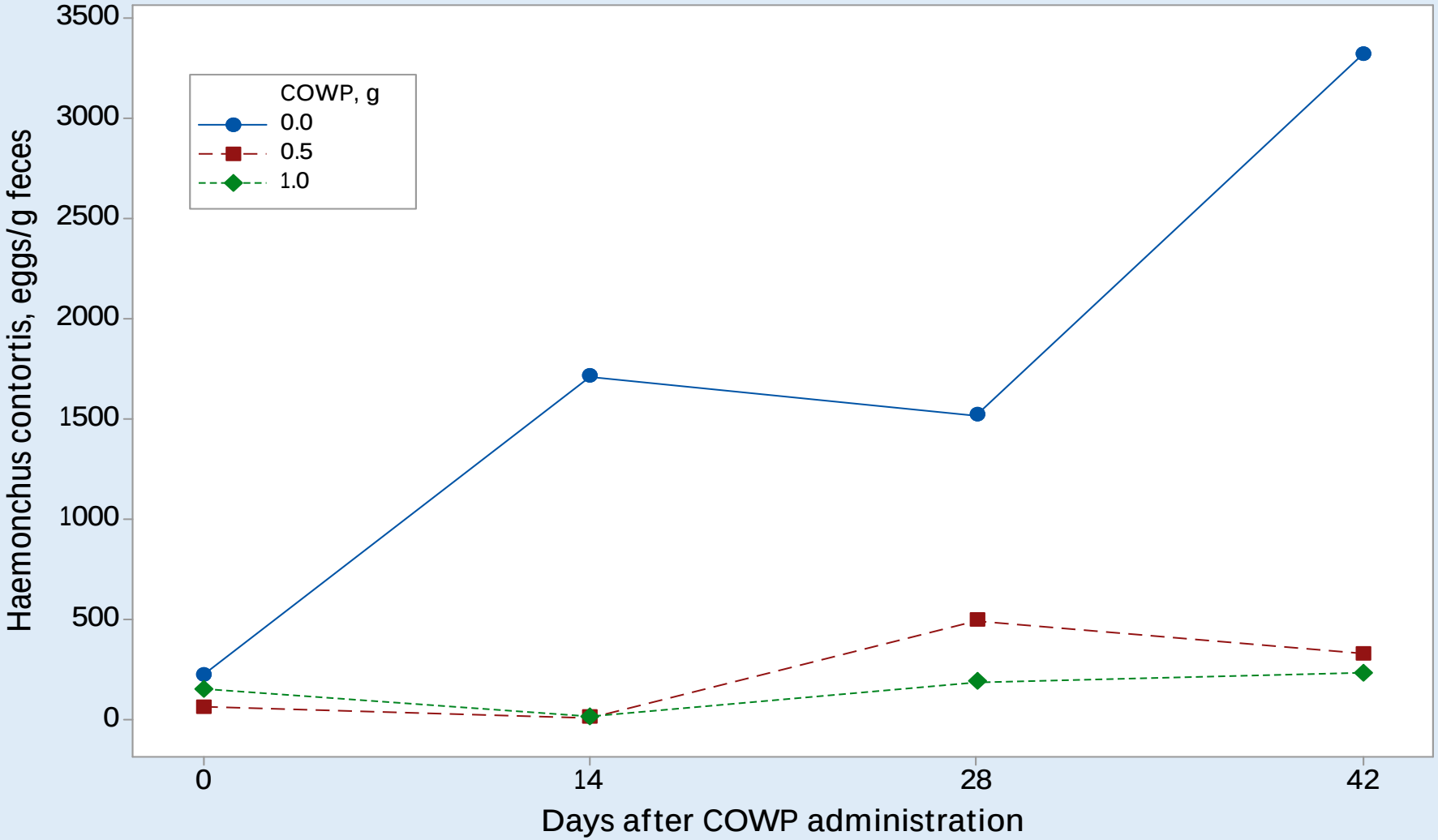
- COWP dosing was not as effective as a chemical dewormer (assuming there is no resistance to the dewormer). However, barber pole worm counts were substantially lower 14 days after dosing for the 1 g/22 lb. live wt. and 2 g/head treatments but not the 1 g/head treatment. No longer term significant effect noted.
- Unlike chemical deworming, no discarding of milk was necessary.
- Curd formation of cheese appeared normal.
- Copper in milk was well below allowable limits. AST levels in blood did not indicate any Copper toxicity.
- **In mature dairy does, 2 grams of COWP per head** appeared to work as well as 1 gram per 22 lb. live weight and unlike the latter dosage did not significantly increase the copper levels in milk

Most of our later studies involved lambs and kids

- Treatment was usually given either 2 weeks before or after weaning unless animals were self weaning
- Treatments usually consisted of dosing animals with
  - No COWP (Control)
  - 0.5 gram COWP/head
  - 1 gram COWP/head

  AND then observing them on pasture for 4 to 8 weeks following treatment
- Animals were weighed at the beginning and end of the trials and fecal samples and FAMACHA scores were taken every 2 weeks.
- Fecal egg counts do not have a normal distribution. Therefore, prior to statistically analyzing the observed change in fecal egg counts over the days of the trial , fecal egg counts were log transformed. However, the fecal egg counts are expressed in their untransformed form (geometric means) in the following tables and graphs.

Effect of COWP level (0, 0.5 or 1 gram) given on Day 0 (2 weeks prior to weaning) on barber pole worm (*Haemonchus contortus*) egg counts in lambs over a 42 day period at the St. Lawrence County Extension Learning Farm (ELF). There was a very significant difference (P=0.051) in worm eggs per gram between lambs getting 0.5 g COWP/head and 1 g COWP/head compared to lambs getting no COWP over the 42 days of the 2013 study.



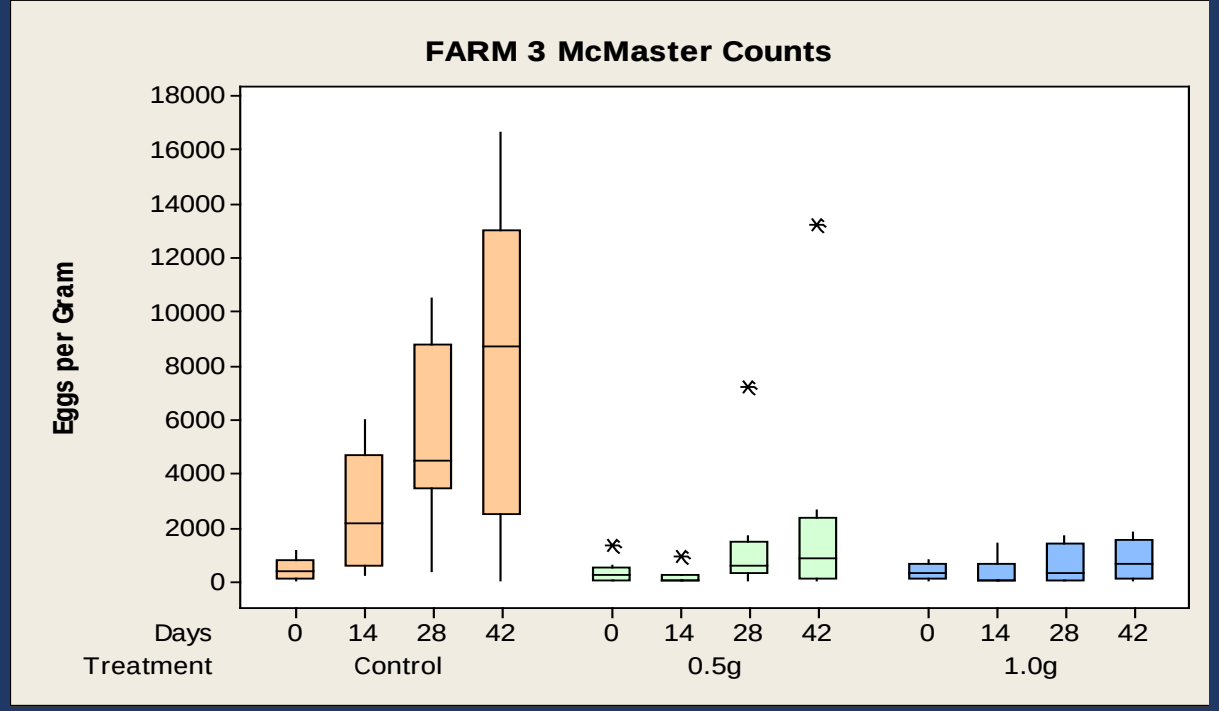
Change in fecal egg counts (eggs per gram) over a 6 week trial for lambs dosed with COWP 2 weeks prior to weaning at the St. Lawrence County Extension Learning Farm (ELF)

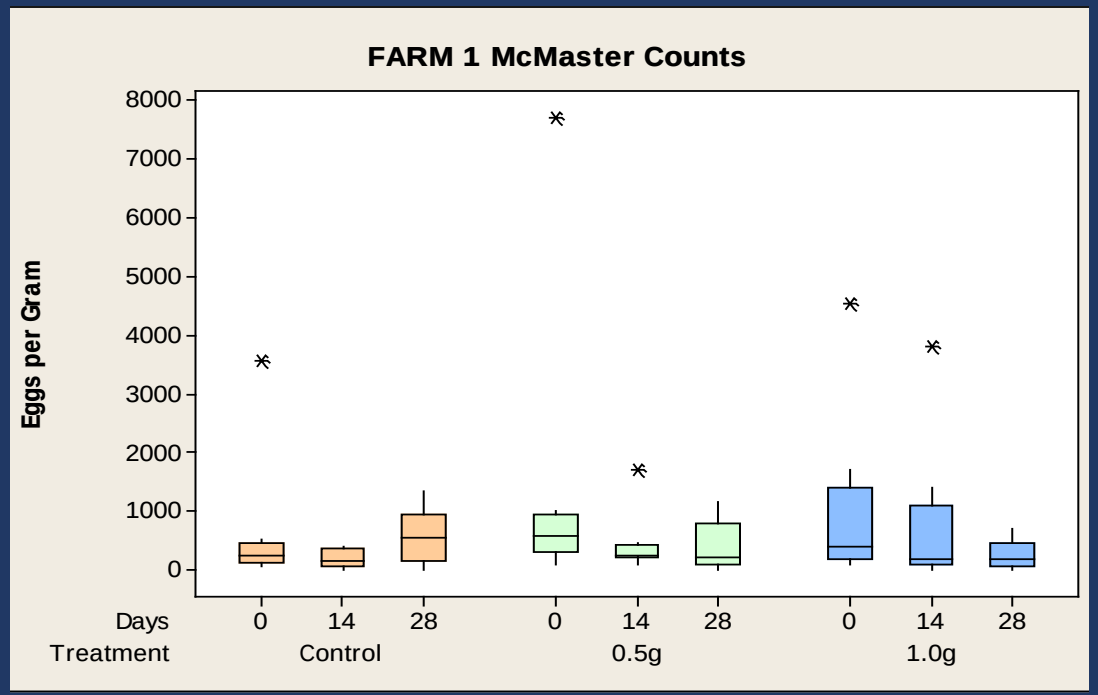
				Total strongyle worm eggs per gram (epg)		Barber pole worm eggs per gram (epg)	
Effect	Level	Weight	FAMACHA	Log10	Geometric mean	Log10	Geometric mean
COWP							
	0.0	64.1	2.2	3.11	1283	3.07	1180
	0.5	60.6	2.3	2.10	124	1.97	92
	1.0	63.5	2.0	2.16	142	1.98	94
	SEM	3.72	0.15	0.240		0.262	
.5 g &1 g vs 0 g	P-value	0.771	0.352	0.012		0.011	
Day							
	0	59.0	1.7	2.15	141	2.10	125
	14	64.0	1.9	1.87	74	1.74	55
	28		2.3	2.85	712	2.71	516
	42	65.2	2.8	2.93	858	2.80	628
	SEM	2.19	0.13	0.223		0.228	
	P-value	<0.001	<0.001	0.001		0.001	
COWP x Day	P-value	0.369	0.079	0.114		**P = 0.051 for 0.5 g/hd and 1 g/hd versus no COWP**	

We did COWP lamb trials at two other farms in 2013.
At FARM 1, COWP was given 5 weeks post weaning.
At FARM 2, COWP was given 2 weeks post weaning.

Effects appeared to be shorter termed at these two farms (see following slide) compared to at the Extension Learning Farm (ELF, Farm 3).

However, if we looked only at the change in barber pole eggs per gram from Day 0 to Day 14 after COWP dosing using a general linear model run on all three farms including the effects of farm, COWP, sex and their interactions, the effects of Farm (P =0.005), COWP (P = 0.003) and Farm*COWP (P = 0.056) were all significant.


FARM 3 McMaster Counts
Eggs per Gram
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Days 0 14 28 42 0 14 28 42 0 14 28 42
Treatment Control 0.5g 1.0g


FARM 1 McMaster Counts
Eggs per Gram
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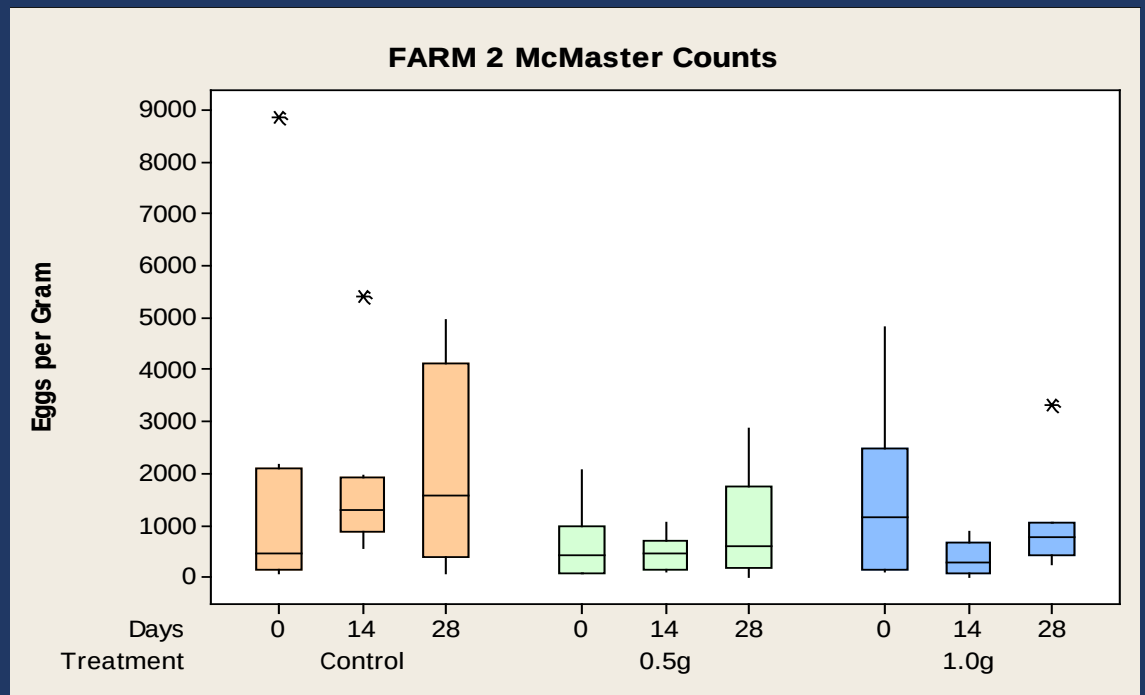
7000
6000
5000
4000
3000
2000
1000
0
Days 0 14 28 0 14 28 0 14 28
Treatment Control 0.5g 1.0g


FARM 2 McMaster Counts
Eggs per Gram
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Days 0 14 28 0 14 28 0 14 28
Treatment Control 0.5g 1.0g

How might suckling lambs differ from weanlings?

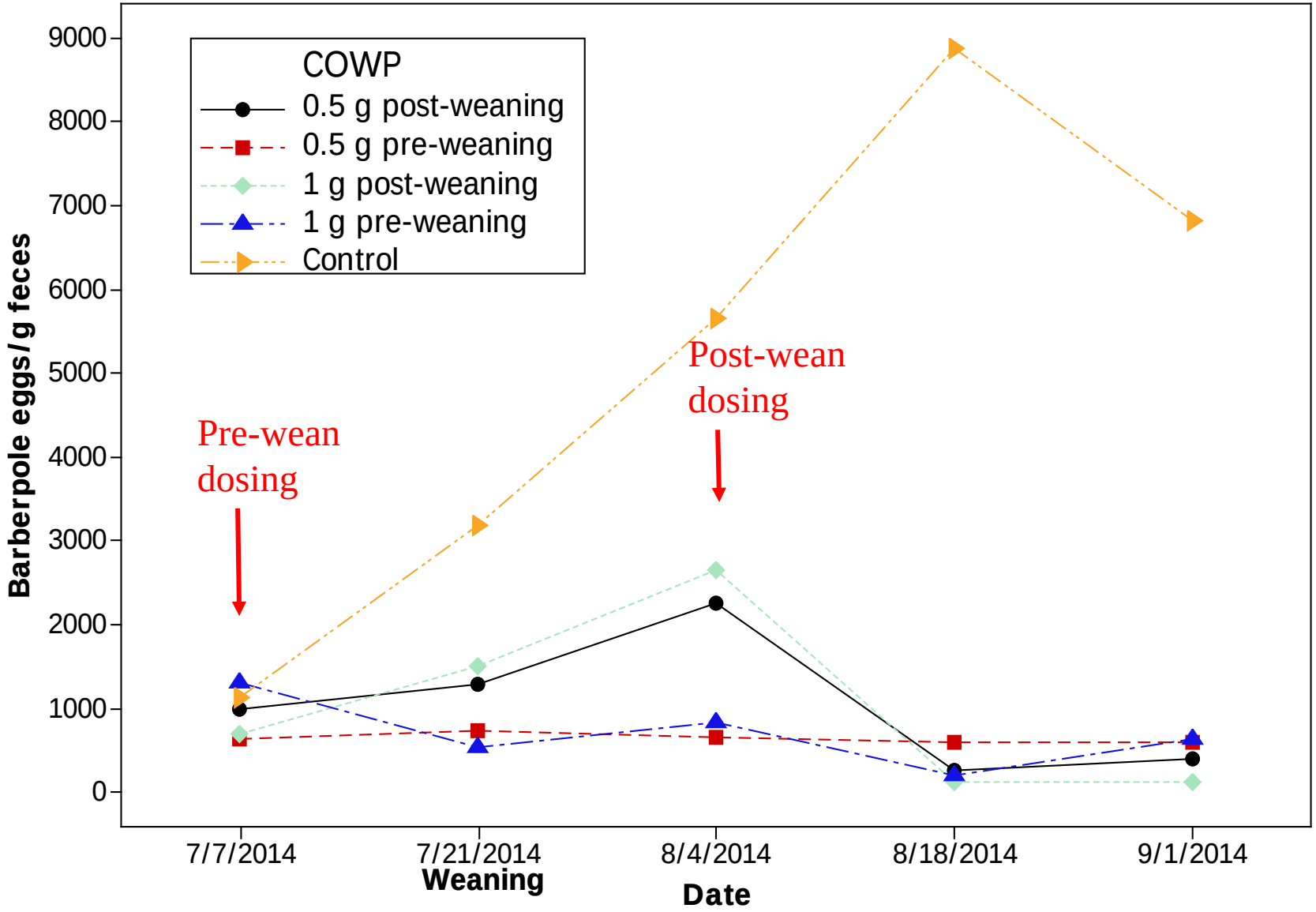
The acidity of abomasum (true stomach)? Maybe acid solubilization is more likely to take place when the true stomach is digesting mostly milk rather than forages/grain?

Less solids in diet so maybe it is easier for the wire particles to get lodged in the abomasum rather than the rumen?

Does the esophageal groove possibly close on young pre-weaning animals when dosed with the balling gun, thus insuring that the COWP goes directly to the abomasum?

Or were differences for another reason?

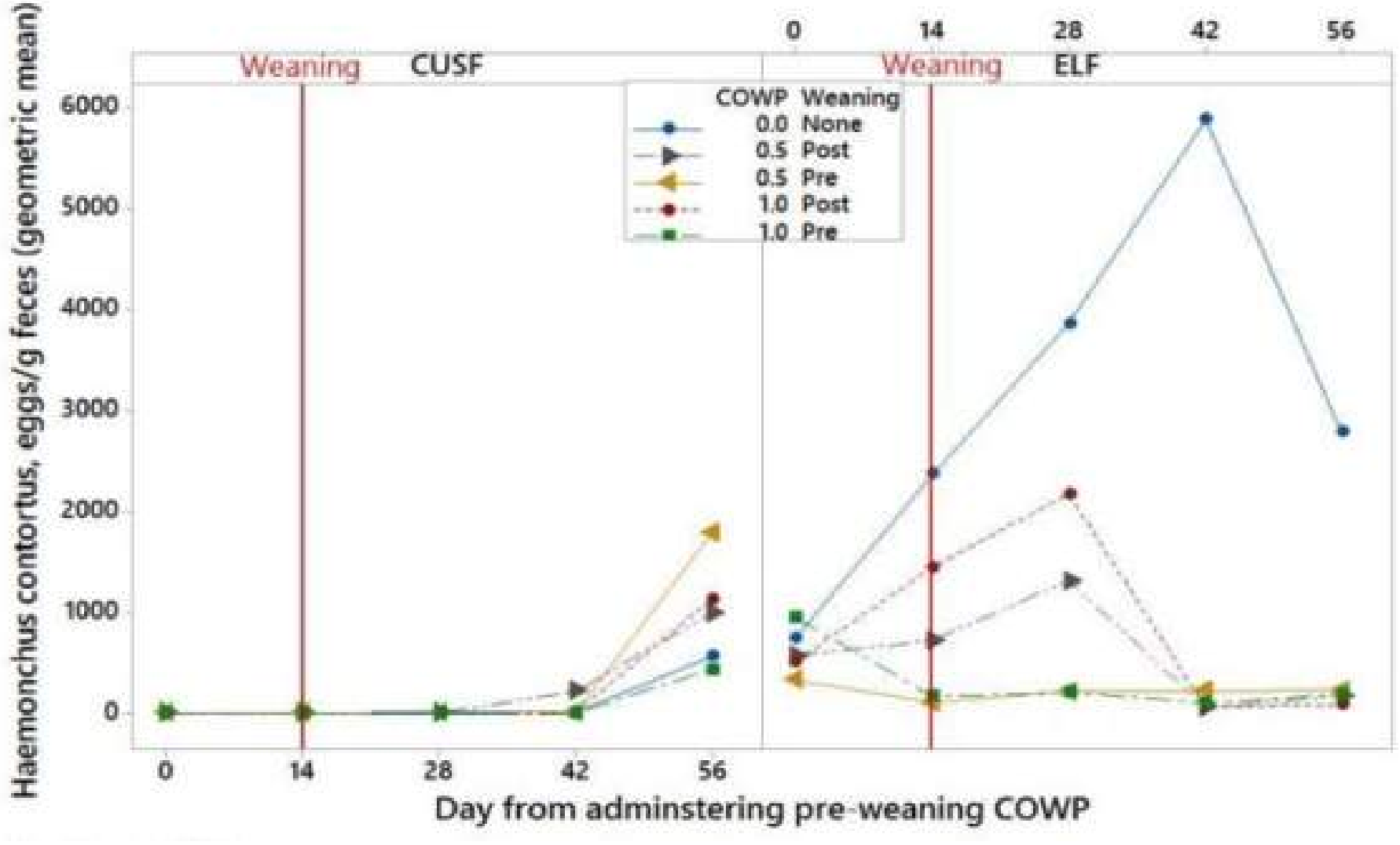
In 2014 we compared the effect of giving COWP at 2 wks. pre OR post weaning and at dosages of 0.5 or 1 gram on barber pole worm egg counts (epg) in lambs over a 56 day period at the St. Lawrence County Extension Leaning Farm (ELF). COWP was effective in both dosages given either pre or post weaning when compared to the Control group given no COWP.



St. Lawrence County Extension Learning Farm – effect of COWP on FAMACHA scores, worm eggs per gram (epg), and weight gain

			All Strongyle Worms		Barber pole worm		
	COWP	FAMACHA	Ln (+1) epg	Geometric mean for epg	Ln (+1) epg	Geometric mean for epg	Weight, lb.
Administration	Control 0 g	2.5	8.05	**3121**	7.85	**2573**	56
Pre-weaning	0.5 g	2.2	6.28	534	5.33	206	53
	1 g	2.2	6.42	613	5.44	230	55
Post-weaning	0.5 g	1.9	6.72	830	5.86	350	54
	1 g	2.2	6.73	835	5.95	385	56
	SEM	0.18	0.29		0.37		2.2
Effect of COWP	P-value	0.323	0.001		<0.001		0.822
COWP*DAY	P-value	0.079	0.114		0.051		0.369

A study using the same COWP dosages given 2 weeks pre-weaning or 2 weeks post weaning was done at the Cornell Univ. Sheep Farm (CUSF) . However, while COWP dosing was very effective at ELF both pre and post weaning, there appeared to be no effect at CUSF. This may have been because worm infection was still very low at the time the COWP was given both pre and post weaning OR it may have been because rather than being on almost entirely pasture like the ELF lambs, the CUSF lambs received a free choice total mixed ration as well as pasture.

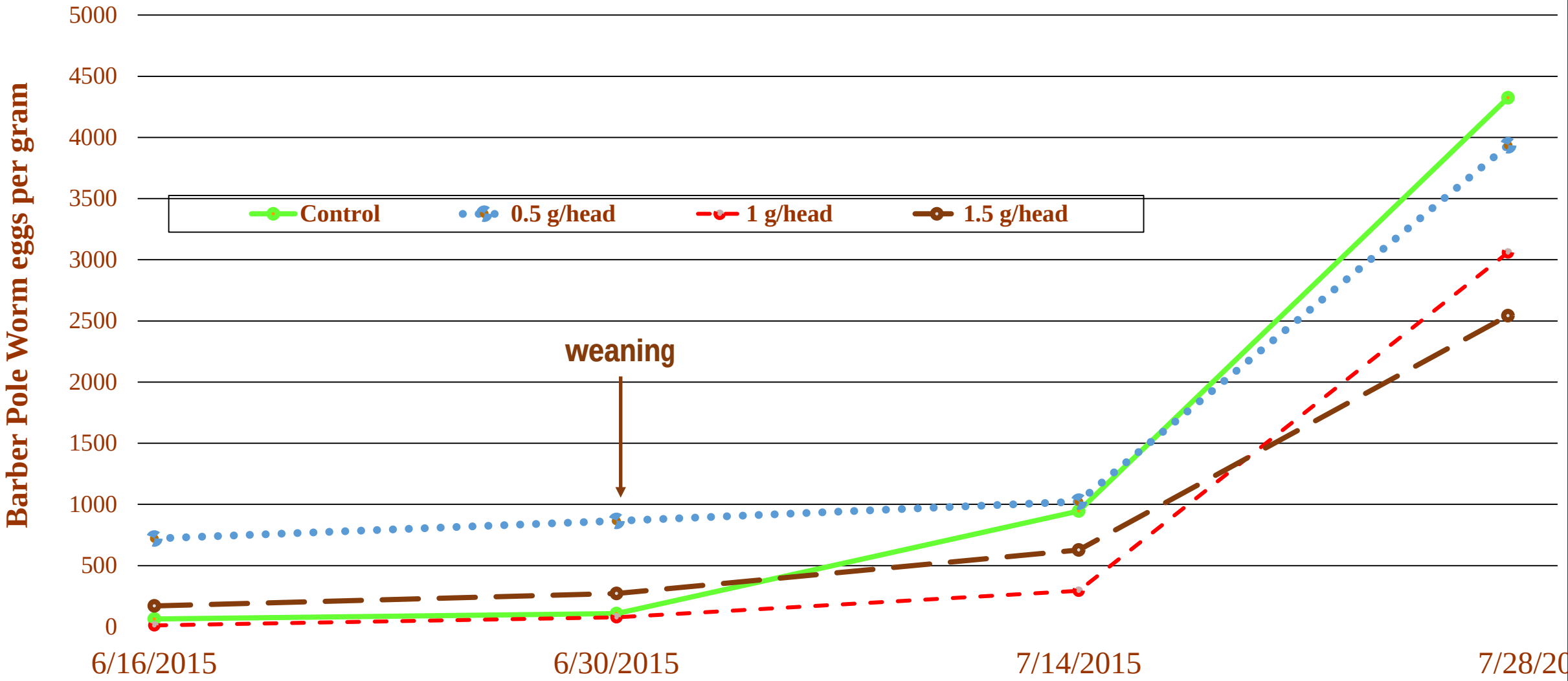


We also did two similar study with Boer goat kids

Effect of copper oxide wire particles (COWP) on the change in fecal egg counts after 14 days in **self-weaning** Boer goat kids under continuous grazing (no pasture rotation) management, **supplemented with concentrate and mineral (both containing copper)**. Egg counts increased for ALL 3 treatments. However, the increase was significantly less for kids receiving COWP than kids who received none. The CONTROL treatment was significantly different (P = 0.005) from the 0.5 and 1.0g COWP treatments but these two treatments were not significantly different from each other (P=0.388).

	All Strongyle Worms	Barber Pole Worm
COWP dosage	**Change in fecal egg counts, g/g feces**	
Control (0 g COWP)	**3156**	**3098**
0.5 g	**1494**	**1472**
1 g	**900**	**864**
SEM	**500**	**486**
P-value	**0.014**	**0.013**

Barber Pole Worm Egg County By Treatment in pastured Boer goat kids receiving ½ lb. grain supplement/head/day where COWP was administered 2 weeks pre-weaning. Although Eggs Per Gram increased most for the Control group (0 COWP) and least for the 1.5 g/hea



Thus, results for goat kids were disappointing in these two studies

- Kids were from farms feeding concentrates or trace minerals supplemented with Copper regularly. Could the worms on these farms be less susceptible to Copper because of previous selection? Could the diets of these goats be interfering with acid solubilization?
- Were the infection levels too low or too high at the time of COWP dosing?
- Were dosages of COWP given not high enough?
- Are there other herd management factors affecting the effectiveness of COWP treatment that we have not discovered yet?

Some forages that are high in condensed tannins appear to decrease strongyle worm infections in sheep and goats.

The most studied of these is *Sericea lespedeza*. However, *Sericea lespedeza* is not winter hardy in NY

- The following 3 NY studies combined
  - Grazing the high tannin forage legume, birdsfoot trefoil

WITH

  - Oral dosing with COWP

A study was conduced at ELF in 2015 combining grazing the high tannin legume forage, Birdsfoot trefoil (variety Pardee), with COWP dosing.

- 40 Lambs in total – Lambs were pasture grazed with their dams prior to weaning
- 3 diets fed after weaning
  - 16 on Birdsfoot Trefoil Pasture (BFT)after weaning
  - 16 on Conventional Pasture (CP) after weaning
  - 8 on 2nd cut Hay and Grain (HG)

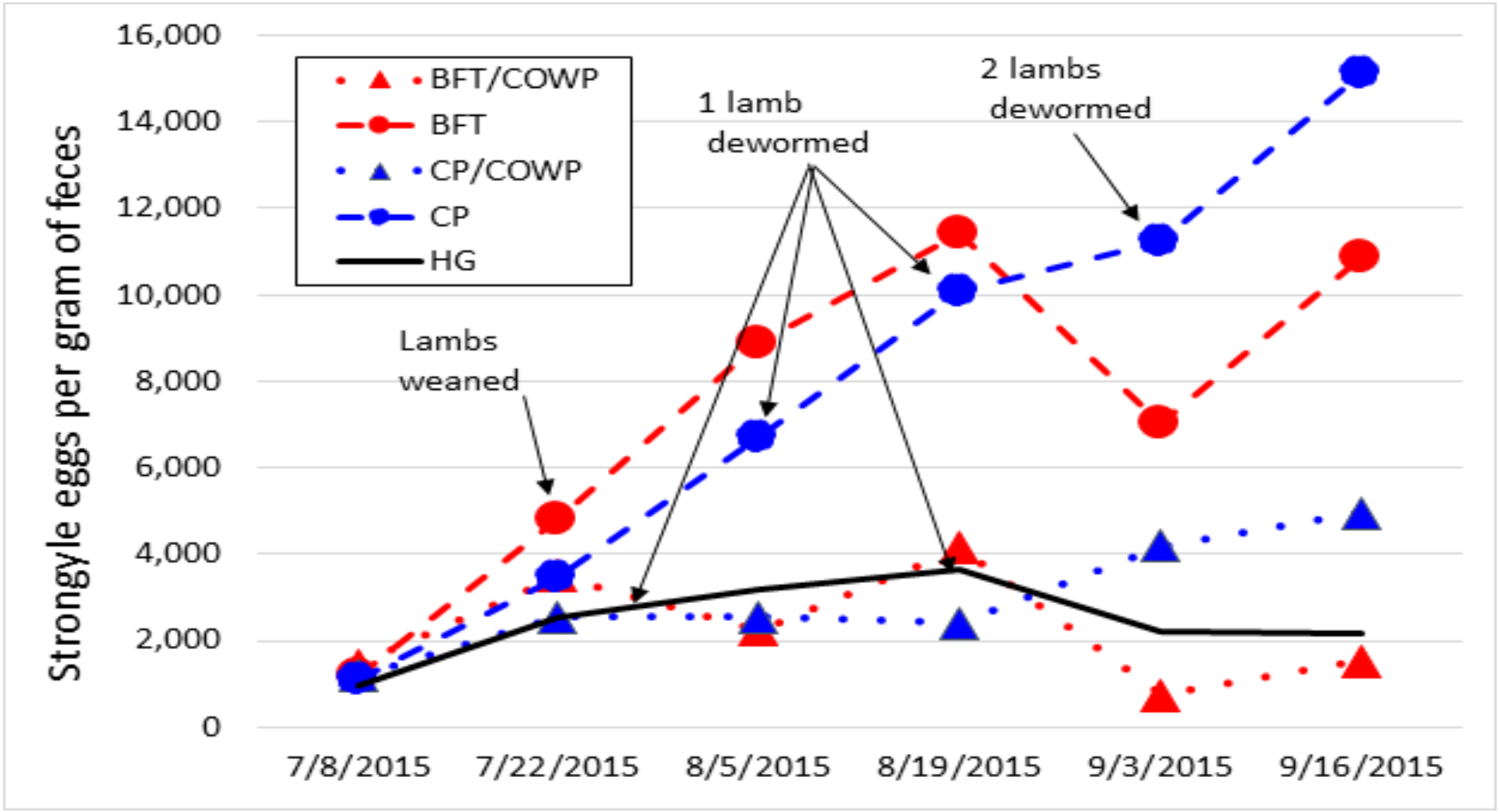
  - All 3 groups got free choice minerals with no added copper (Wight & Patterson Sheep Mineral)

16 lambs grazed on PARDEE birdsfoot trefoil paddocks (43 to 58% BFT). Half of these lambs received 1 gram of copper oxide wire particles (COWP) 2 weeks prior to weaning. 8 lambs designated “BFT”, 8 lambs designated “BFT/COWP”.

16 lambs grazed on conventional pastures
Half the lambs received 1 gram of COWP 2 weeks prior to weaning.
8 lambs designated “CP”, 8 lambs designated “CP/COWP”.

8 lambs were tracked in a Control group fed 2nd cut hay (12% CP) and grain (16% CP).
Each lamb received 1 gram COWP 2 weeks prior to weaning. This group designated as “HG”.

Treatments that got COWP had lower worm egg counts (epg) 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. Treatment*Day was statistically significant (P value < 0.001) for worm egg count. However, when we looked at forage separate from COWP, COWP * Day interaction was statistically significant (P value < 0.001) but Forage*Day interaction was not, nor was the contrast between BFT and CP.



Once a lamb had to be dewormed, its future fecal egg counts (epgs) were not included in the epgs for its treatment although its epgs up until deworming were kept.

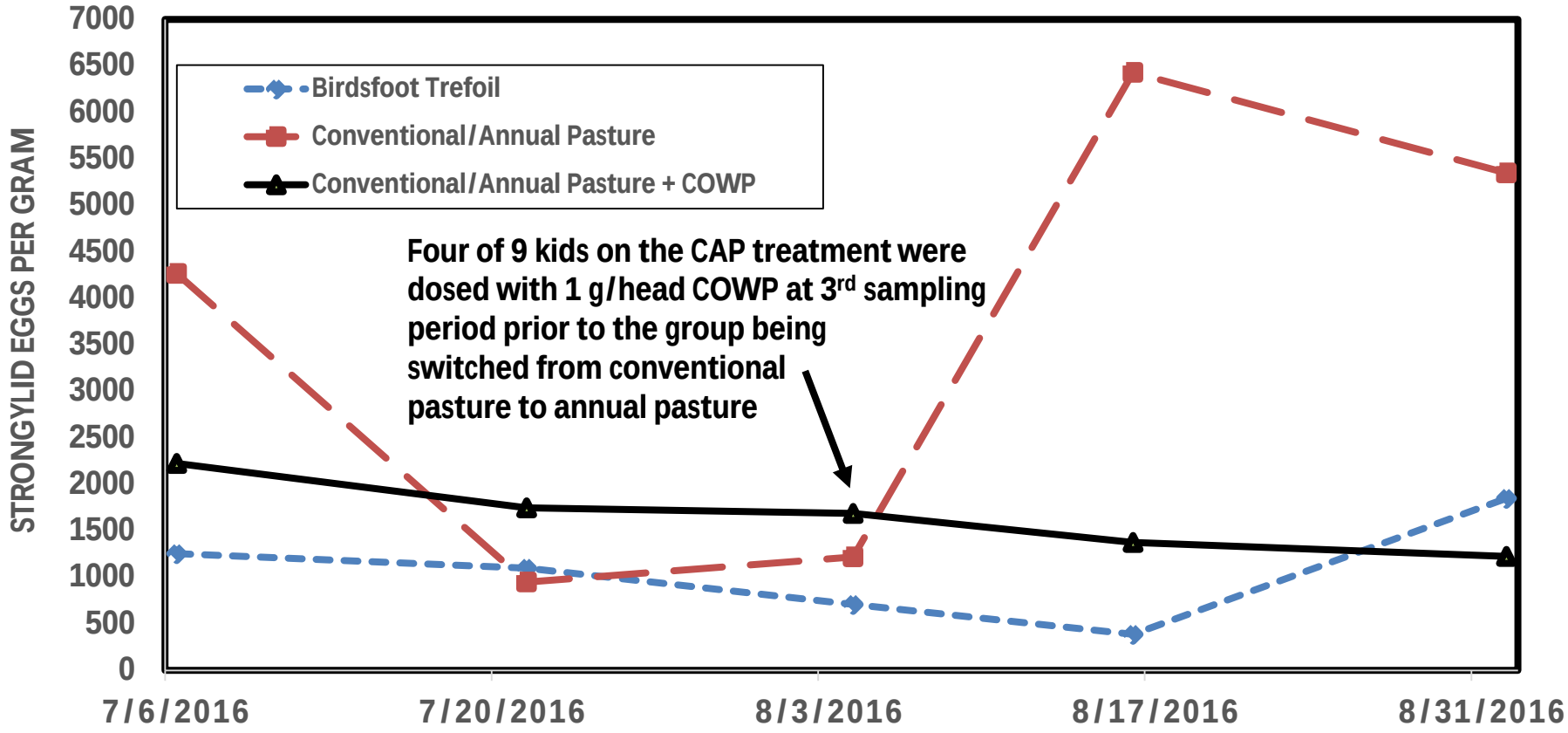
Four lambs on the treatment grazing conventional pastures but receiving no COWP had to be dewormed.

However, two lambs given COWP on the Hay/Grain treatment also had to be dewormed. Could the change in diet from pasture to hay/grain at weaning possibly have disrupted the pH of the stomach and interfered with acid solubilization?

Another study with weaned Kiko goat kids grazing either BRUCE birdsfoot trefoil pastures (BFT) or conventional and annual pastures (CAP). Four of 9 kids on the CAP trial received 1 g COWP/head 4 weeks into the 8 week grazing trial. Kids received no concentrate feeding.

Differences for Strongyle Worm Egg Counts were statistically significant for Forage (BFT vs. non BFT; P=0.007), Day (P=0.000), Forage*Day (P=0.028) and COWP dosing (P=0.005). One kid on the CAP (Conventional/Annual Pasture) treatment had to be dewormed at the end of the study because of FAMACHA score of 4 and very high worm count for last 2 sampling periods.

FIGURE 3. CHANGE IN STRONGYLE WORM EGG COUNT OVER 57 DAYS BY TREATMENT FOR WEANED KIKO KIDS

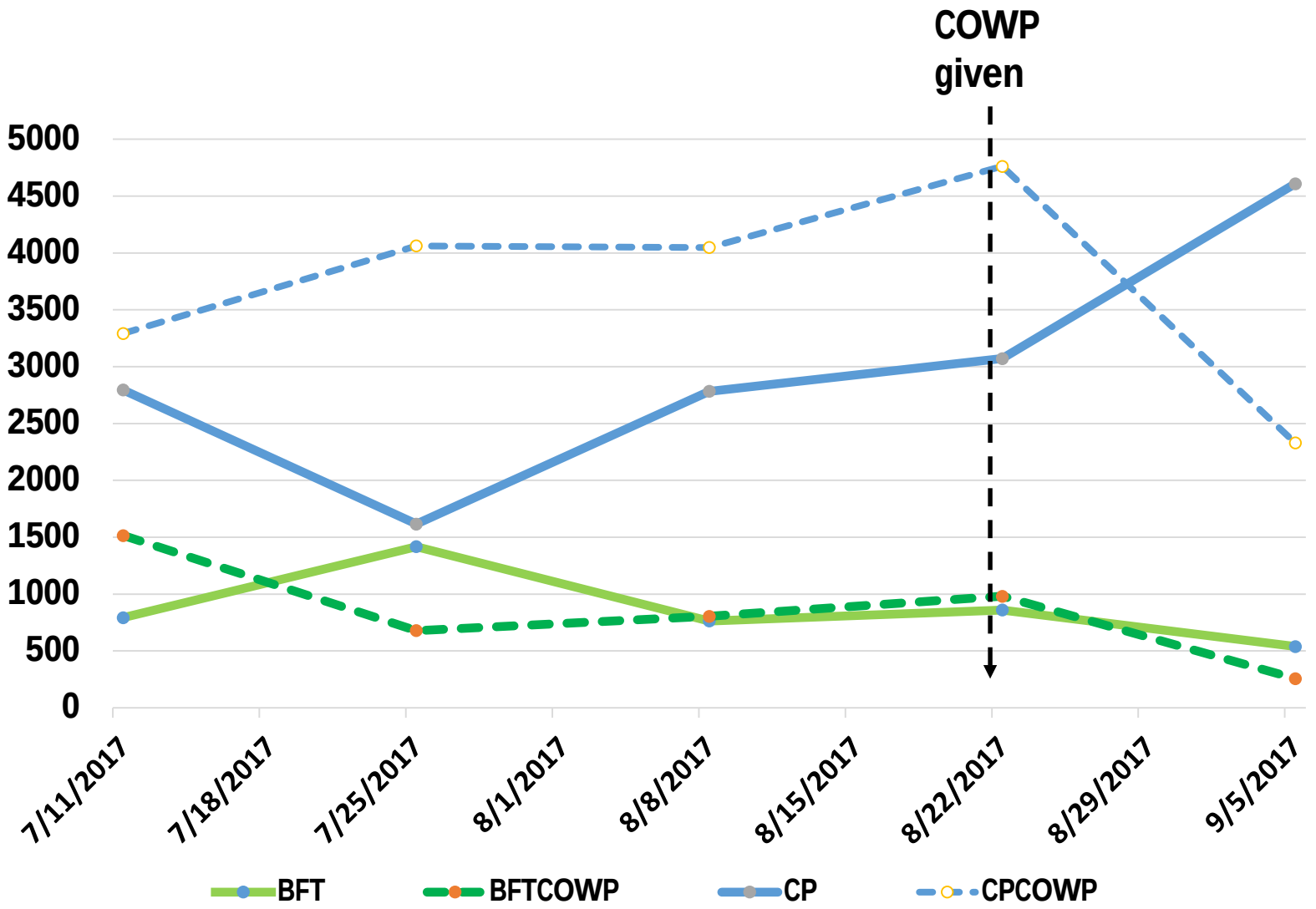


Weaned angora and cashmere kids – 8 kids grazing on BRUCE birdsfoot trefoil and 8 kids grazing on conventional grass/legume pastures. 4 kids on each treatment received 1g COWP/head on day 42 of a 56 day grazing trial

Barber pole worm eggs per gram (epg) by Treatment

for angora and cashmere kids grazing birdsfoot trefoil (BFT) or conventional (CP) pastures and receiving ¼ lb. of grain/head/day.

Dosing with COWP on Day 42 significantly decreased barber pole worm epgs (P = 0.004) on Day 56



Conclusions about possible dosages for COWP

0.5 gram/head dosages appeared to be as effective as 1 gram/head for lambs in flocks where COWP had an effect with the advantage that this dosage can be repeated later in the grazing season if necessary. The Cornell Veterinary Diagnostic Lab has seen Copper toxicity in some lambs approaching weaning age at 2 g dosages.

2 gram/head dosages appear to be as effective as larger dosages for mature goats and sheep.

Our studies were more uncertain on dosages for goat kids. Our first two studies were disappointing and suggested that kids might need larger dosages than lambs. However, results from the later two studies with weaned kids grazing birdsfoot trefoil suggest that 1 g COWP/head is sufficient when management conditions are such to allow COWP to be effective. In these BFT studies, kids were eating a forage diet with little or no concentrate feeding and did not receive COWP until they already showed some worm infection.

Conclusions about effectiveness of COWP

The effect of COWP was very variable among the NY flocks and herds participating in the studies. It was not effective on some farms. It usually had a short term effect of about 14 days when effective on other farms. However, there were some NY farms such as ELF where a long term effect for many weeks was observed for each of 3 years studied.

Why do results vary for different farms? COWP seemed to work best when animals already had some worm load when dosed and when animals were not consuming very much grain.

Animal species (goat versus sheep), diet, weaning status, the extent of barber pole worm infection at the time of oral dosing or past exposure of earlier generations of worms to other sources of copper, could all possibly influence effectiveness.

Need more studies to identify what factors are involved

How to use Copper Oxide Wire Particles and determine if they are effective in your herd

- COWP researchers in the Southeast US recommend using it in combination with a FAMACHA scoring program. During the grazing season FAMACHA score your animals at least every 1 to 2 weeks according to need. Give COWP to your vulnerable “3s” (lambs, kids, lactating or late pregnant females) rather than giving a commercial dewormer. Give an effective dewormer to your animals scoring ≥4.

- BE SURE to follow up with regular FAMACHA scoring and fecal egg sampling to see if Copper Oxide Wire Particles (COWP) actually work in your herd or flock. Discuss with your veterinarian safe dosages and how often they can be repeated during a grazing season.

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