

Effect of Copper on Both Wool Color and Parasite Load of Icelandic Sheep

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ABSTRACT

The purpose of this project is to determine the effect of copper on Icelandic sheep. All sheep need some copper; some say Icelandic sheep need more copper than other sheep breeds. Because sheep can be easily poisoned by too much copper, sheep minerals do not contain copper. This project considers the effect of giving higher levels of copper to Icelandic sheep to determine if the added copper will effect the color of the wool and reduce the parasite load from *Haemonchus contortus* worm. We predict that by feeding Icelandic sheep goat minerals containing high levels of copper, the faded black and brown Icelandic sheep will regain the color of their wool. The added copper levels will decrease the amount *Haemonchus contortus* parasites the sheep have. The decrease in parasites will be visible through eye membrane evaluations using the FAMACHA scale. Fifteen ewes were offered loose goat minerals containing a high percentage of copper. Two ram lambs were given loose minerals without copper. Photographs of the wool color were taken and FAMACHA scores were collected to determine anemia levels. 100% of the colored sheep showed improvement in wool pigmentation. 67% of the sheep showed improvement in FAMACHA scores while 27% remained the same. The sheep starting with the highest FAMACHA scores and the most parasite load showed the most improvement in four weeks. Icelandic sheep should receive a mineral containing copper to maintain the wool pigmentation of the black and brown sheep and to fight infestation of the *Haemonchus contortus* parasite.

1.0 Purpose

The purpose of this project is to determine the effect of copper on Icelandic sheep. All sheep need some copper; it is said that Icelandic sheep need more copper than other sheep breeds. Generally most breeds of sheep can not handle high levels of copper; therefore, sheep minerals contain low levels of copper to prevent copper poisoning. The Icelandic Sheep Breeders Association recommends high levels of copper be given to Icelandic sheep for the prevention of parasites and to maintain wool color. This project's primary focus looks at whether giving high levels of copper will affect the color of the wool. The secondary focus looks at the effect of copper on eye membranes to determine if the parasite load from *Haemonchus contortus*, also known as the barber pole worm, is reduced.

2.0 Hypothesis

We own and raise Icelandic sheep. Our flock consists of three black sheep, five moorit (brown) sheep and nine white/spotted sheep. Over time, the wool color of the black and moorit sheep has faded. We predict that by feeding Icelandic sheep goat minerals, which contain high levels of copper, the faded black and brown Icelandic sheep will regain the color of their wool. The added copper levels will decrease the amount of *Haemonchus contortus* parasites the sheep have. The decrease in parasites will be visible through eye membrane evaluations using the FAMACHA scale.

3.0 Background Research

3.1 Copper

Copper is one of the key trace minerals and is critical for life. Copper is needed for a healthy nervous and immune system and healthy wool development and is stored in a sheep's liver. (Schoenian, 2009)

Copper is required for the activity of enzymes associated with iron metabolism, elastin and collagen formation, melanin production, and the integrity of the central nervous system. It is required for normal red blood cell formation by allowing iron absorption from the small intestine and release of iron in the tissue into the blood plasma. Ceruloplasmin is the copper-containing transport protein. The process of normal hair and wool pigmentation requires copper. It is believed that copper is a component of polyphenyl oxidase which catalyzes the conversion of tyrosine to melanin and for the incorporation of disulfide groups into keratin in wool and hair. (Blezinger, 2004)

Copper deficiency is common in sheep when pastures are low in copper and high in iron, molybdenum and sulfur. Signs of copper deficiency include anemia, brittle or fragile bones, loss of hair or pigmentation loss, and poor wool growth. Copper deficiency in ewes during mid-pregnancy may lead to swayback in lambs. (NADIS, 2001) Most sheep get copper from mineral supplements, but it is sometimes absorbed from pastures that have been fertilized with large amounts of poultry manure. Copper is used in the diet at about 8-11 parts per million. It will be toxic to sheep at 15-20 parts per million. Different breeds of sheep respond to copper differently. Finnsheep are the least likely to suffer from copper poisoning. (Bagnall, 2001) Icelandic sheep are part of the North European Short Tailed grouping and are related to Finnsheep, Romanov, Shetland, Spelsau sheep and the Swedish Landrace.

There are two types of copper poisoning: chronic copper toxicity and acute copper toxicity.

Acute copper poisoning occurs when copper is injected in the sheep. Chronic copper toxicity happens when the liver cannot handle all the copper. This causes a release of copper into the blood stream which causes jaundice and destruction of red blood cells. Some breeds get copper toxicity more than others. This can be determined by evaluating the eyelids and mouth, looking for yellow coloring. (Sargison, 2014) A sheep can get copper poisoning by eating trace mineral supplemental salt, that is formulated for cattle or horses, vitamin and mineral supplements for other livestock, or grazing pasture that has been fertilized with swine manure or poultry litter. (Schoenian, 2009) Signs of poisoning include weakness, panting, dull attitude, pale mucous membranes, yellow discoloration of the eyes, or gums. (NADIS, 2001) Copper poisoning can be determined by evaluating the mucus membranes and/or the sclera of the sheep.

3.2 Copper and Wool Pigmentation

Many shepherds in the Icelandic Sheep community feel that it is necessary to feed Icelandic sheep copper. New shepherds are encouraged to use copper to treat for wool discoloration and parasites. Shepherdess Deborah Niemann talks about why she gives her sheep copper. One of her black sheep's face was almost white. Her sheep had all the signs of copper deficiency so she decided to give her a copper bolus. When she did that, within a short time her sheep's face regained its black color and the wool began to grow in normally. (Niemann, 2009)

This anecdotal evidence was confirmed by a study completed in 1999 that reported on a study completed at Leeds University, UK. Black Welsh Mountain sheep “subjected to a low copper diet and basically became white.” (Huchinson and Symington, 2000) It is reported that shepherds competing in colored wool classes in Canadian sheep shows add copper sulphate just a few weeks before show to get the optimal wool pigmentation. (Huchinson and Symington, 2000)

3.3 Copper and Parasite Management

The largest health threat to sheep is the *Haemonchus contortus* parasite, commonly referred to as barber pole worm.



Schoenian, Susan. *Barber Pole Worm*. Digital image. *Sheep 201*. University of Maryland Extension, 8 Dec. 2013. Web. 16 Mar. 2014.

It is the deadliest parasite to sheep. The *Haemonchus contortus* is a stomach parasite residing in the abomasum that sucks up to ten percent of the total blood volume of the sheep each day. (Hutchens, 2004) The parasite has a very short four-stage life cycle and produces thousands of eggs each day. With a parasite load of ten thousand adult worms, the sheep can die. (Burke, 2005) “The eggs are deposited in the feces, hatch on pasture and the life cycle begins again. Outbreaks are worst when warm summer rains break up the fecal pellets and create a moist environment for the hatched larvae.” (Burke, 2005) With wet pastures, the animals are more susceptible to the *Haemonchus contortus* infestation. (Hutchens, 2004)

Although scientists are not sure how copper kills the *Haemonchus contortus* parasite, there have been numerous studies in the last twenty years to show that copper is effective.

“Copper sulphate, a mineral substance that already meets organic farming specifications for plant production, has a strong deworming action against certain parasites, particularly *Haemonchus contortus*.” (Duval, 1996)

Despite the information on copper, it is only in the last few years that farmers have been really encouraged to consider copper as a major part of their parasite management. In Clinton County, the annual sheep and goat producers meeting in 2012 included very little information about using copper as part of parasite management. This fall the main focus of the meeting was to talk about the use of copper as part of parasite management.

Copper oxide wire particles (COWP) capsules were developed to meet the needs of copper deficiency in sheep and cattle without causing copper toxicity. “The form of copper used in COWP is poorly absorbed. The exact mechanism of how copper wire particles control internal parasites is not yet fully understood.” (Hale, 2007) There are many ongoing studies showing the effectiveness of using COWP against the *Haemonchus contortus*.

FAMACHA is a method to determine if your sheep or goat is anemic and therefore has an infestation of the *Haemonchus contortus* worm. FAMACHA stands for FAffa MAlan CHArt. The method was named for its originator, Francois Malan, a South African livestock parasitologist. (Hutchens, 2004) The FAMACHA method is only effective for determining the parasite load of the *Haemonchus contortus* as other parasites do not cause anemia in the same manner as the *Haemonchus contortus*.

In the FAMACHA system the eyelid color is matched up with a scorecard that ranks color on a 1 to 5 scale. A dark red eyelid membrane color is a 1 and indicates no significant anemia. A white color is a 5 and indicates severe anemia. The light red, pink and pinkish white colors in between indicated by scores 2 through 4, indicate increasing levels of anemia that generally correspond to the parasite burden the animal is carrying. (Lewandowski, 2010)

Animals that score 3 should be considered for deworming. If an animal is a 4 or 5, deworming should occur. “By deworming only those animals that need it, selection of drug resistant strains of worms is slowed and the life of a given dewormer on a given farm can be prolonged.” (Hutchens, 2004) For FAMACHA to be accurate, sheep and goat eyelids should be checked at least every 7-10 days at minimum. Because lambs have smaller blood volumes, lambs “with heavy infections can go from apparently healthy to death’s doorstep in 10 to 14 days.” (Lewandowski, 2010) The FAMACHA system must be used correctly to be effective. This requires taking a FAMACHA training course and learning how to compare sheep eye-lids with the laminated color chart. The method is simple to use if two properly trained people work together. (Hutchens, 2004)

4.0 Materials

- Official FAMACHA Anemia Card
- Clipboard with list of sheep to record eye membrane color and sclera color

- Pen/pencil
- Back in Balance Goat Minerals
- Kelp
- Poulin Grain Sheep Minerals
- Mineral feeders
- Camera
- Computer
- Icelandic sheep

5.0 Procedures

5.1 Procedures Background

First we needed to withhold copper from the sheep for a few months to see if it would make a difference. Up until this point we were feeding the sheep ordinary sheep minerals with goat minerals (containing high copper levels) mixed in. Sometimes we would feed straight goat minerals but we would not do it for a long time in large quantities to avoid copper toxicity. We would also offer kelp. The minerals were fed free choice to allow the sheep to get the amount of minerals they needed. For the fall of 2013, we fed only sheep minerals. On 16 November 2013, we took a class to get trained in using the FAMACHA card. You can only get an official card if you are trained and certified. After a three hour class on the science of the parasites, we learned to do fecal egg counts. Then we had a “hands-on” training session, evaluating the anemia status of some sheep using the FAMACHA card.

In January, we ordered goat minerals from Boreal Balance, which operates out of Minnesota. These minerals contain high levels of copper and are formulated to meet the needs of goats. They are also recommended to meet the needs of Icelandic sheep. The sheep ate them right away and in a week had eaten the entire 16 pounds that were purchased. A 25 pound bag was ordered and arrived mid-February. An additional 25 pound bag was ordered in Mid March as the sheep ate all 25 pounds by the second week of March.

5.2 Day-to Day Procedures

Every day, we fed the ewes and ewe lambs the goat minerals. We put the minerals in the mineral feeders that were mounted on the barn wall. The two moorit rams were our control. We fed them sheep minerals (no copper) mixed with kelp. The Back in Balance Minerals contain kelp. We wanted the minerals to be as similar in palatability as possible. (Icelandic sheep like kelp.) Every few days we checked the color of the eye membrane of all the sheep to make sure they did not have copper poisoning which shows up as yellow membranes. We also compared the eye lids to the FAMACHA card to determine the anemia levels. We recorded the FAMACHA number on a chart. We took pictures of the sheep to record wool colors on a regular basis.

6.0 Data

Using the FAMACHA card to evaluate sheep eyelids, we got the following data:



FAMACHA Card. Digital image. *Goat Equipment*. ProProf Quiz Maker, n.d. Web. 16 Mar. 2014.

EYE LID CHECKS: FAMACHA NUMBER

NAME	TAG	2/23	3/1	3/4	3/9	3/13	3/17	3/19
Gilly	1005	3	3 1/2	2	3 1/2	4	4	2
Gracie	1004	4 1/2	4	4 1/2	3	2	3	3 1/2
Bes*	1057	3 1/2	2	3	2 1/2	1 1/2	2	2 1/2
Morning Glory*	1056	2 1/2	3	3	2 1/2	2	2 1/2	2 1/2
Pennyroyal*	1009	3	4	3	3	3	3	3
June*	1020	4	SOLD	SOLD	SOLD	SOLD	SOLD	SOLD
Holstein	1018	4	3	4	4	4	3	3
Jersey	1015	4	4	3	3	2	3	2 1/2
Hyacinth*	1024	4	3 1/2	3	2 1/2	2 1/2	2 1/2	2
Tiger Lilly	1025	2	2	2 1/2	2 1/2	2	3	2
Lilly of the Valley*	1026	2 1/2	3	3 1/2	2	2	2	2
Aster Julia*	1041	1 1/2	2	2 1/2	2	2	1 1/2	2 1/2
Azalea	1045	3 1/2	3	3	1 3/4	1 1/2	2	2 1/2
Almond Blossom	1046	3	3	2	1 1/2	3	2 1/2	2
Apple Blossom	1047	3 1/2	3	3 1/2	3	3	2 1/2	2 1/2
Alyssum	1051	3	2	3	1 1/2	3	2 3/4	3
CONTROLS								
Aspen*	1042	3	3	3	3	2 1/2	3	2 1/2
Asparagus*	10	3	3	3	3	2	3	3

*indicates black or moorit colored sheep

Using the following pictures to evaluate for copper poisoning, none of the sheep showed signs of copper toxicity.



Sargison, Neil, BA VetMB DSHP FRCVS. *Jaundice of the Sclera of the Eye*. Digital image. NADIS National Animal Disease Information Service. National Animal Disease Information Service, UK, 2014. Web. 21 Feb. 2014.



Sargison, Neil, BA VetMB DSHP FRCVS. *Jaundice of the Gums*. Digital image. NADIS National Animal Disease Information Service. National Animal Disease Information Service, UK, 2014. Web. 21 Feb. 2014.

COPPER CHECKS

NAME	TAG	2/23	3/1	3/4	3/9	3/13	3/17	3/19
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Gilly	1005	N	N	N	N	N	N	N
Gracie	1004	N	N	N	N	N	N	N
Bes	1057	N	N	N	N	N	N	N
Morning Glory	1056	N	N	N	N	N	N	N
Pennyroyal	1009	N	N	N	N	N	N	N
June	1020	N	SOLD	SOLD	SOLD	SOLD	SOLD	SOLD
Holstein	1018	N	N	N	N	N	N	N
Jersey	1015	N	N	N	N	N	N	N
Hyacinth	1024	N	N	N	N	N	N	N
Tiger Lilly	1025	N	N	N	N	N	N	N
Lilly of the Valley	1026	N	N	N	N	N	N	N
Aster Julia	1041	N	N	N	N	N	N	N
Azalea	1045	N	N	N	N	N	N	N
Almond Blossom	1046	N	N	N	N	N	N	N
Apple Blossom	1047	N	N	N	N	N	N	N
Alyssum	1051	N	N	N	N	N	N	N
Aspen	1042	N	N	N	N	N	N	N
Asparagus	10	N	N	N	N	N	N	N

N- indicates the sheep showed no signs of yellowing of the sclera of the eye or the mucus membranes.

7.0 Analysis

Mineral blocks containing copper have high amounts of salt. Sheep only need a small amount of salt so they self regulate the intake of the mineral block. This means they do not get all the nutrients they need. Sheep should be fed loose minerals. Chelated minerals are easier to digest and absorb over mineral blocks. (Hatfield, et al, 2001) "Because chelated minerals are so easily digested (sometimes close to 100% usable by the body), they can help offset situations where other minerals cause elimination or poor absorption of the needed mineral." (Kenney, 2013) Molybdenum added to minerals interferes with the absorption of copper. We wanted to ensure there would be no molybdenum in the minerals. Using all this information, we chose to provide copper to our ewes by using Boreal's Back in Balance (loose) Goat Mineral. It does not contain Molybdenum. It has copper amino acid rather than copper sulfate. We had been using Poulin Grain Sheep and Goat mineral mixed, but chose to switch to the Back In Balance Goat Mineral because we wanted to use chelated minerals so that the sheep would be able to absorb them more.

Boreal Balance, LLC

Back in Balance Minerals

Back in Balance Goat Mineral

012014

Back in Balance Goat Mineral to be fed free choice to goats in all life stages. This mineral can be fed to goats on pasture or confined to dry lot feeding.

GUARANTEED ANALYSIS

Calcium (Ca), minimum.....	8.00%
Calcium (Ca), maximum.....	10.00%
Salt (NaCl), minimum.....	1.00%
Salt (NaCl), maximum.....	3.00%
Sulfur (S), minimum.....	10.00%
Magnesium (Mg), minimum.....	4.90%
Potassium (K), minimum.....	.50%
Zinc (Zn), minimum.....	935 ppm
Copper (Cu), minimum.....	325 ppm
Manganese (Mn), minimum.....	521 ppm
Cobalt (Co), minimum.....	100 ppm
Iodine (I), minimum.....	200 ppm
Selenium (Se), minimum.....	25 ppm
Vitamin A, minimum.....	350,000 Int.Units/Lb
Vitamin D3, minimum.....	30,000 Int.Units/Lb
Vitamin E, minimum.....	2,000 Int.Units/Lb

GUARANTEED INGREDIENTS

Magnesium limestone, Kelp Meal, Sulfur, Zinc amino acid complex, Copper amino acid complex, Manganese amino acid complex, Cobalt glucoheptonate, Selenium yeast, Salt, Vitamin A acetate, Vitamin D supplement, Vitamin E supplement, Calcium carbonate, Hydrated sodium calcium aluminosilicate, Diatomaceous earth (flow agent), Origanum oil, Hemicellulose extract, Roughage Products, Cobalt carbonate, Organic soy oil, Organic rose hip powder.

Goat Label/Ingredients. Digital image. *Back in Balance Minerals*. Back in Balance Minerals, 2014. Web. 1 Mar. 2014.

Poulin Grain Goat Mineral:

Ingredients: *Monocalcium Phosphate, Dicalcium Phosphate, Salt, Processed Grain By-Product, Calcium Carbonate, Yeast Culture, Potassium Chloride, Magnesium Potassium Sulfate, Mineral Oil, Zinc Oxide, Copper Sulfate Vitamin E Supplement, Manganous Oxide, DL Methionine, Sodium Selenite, Flavoring, Vitamin D3 Supplement, Calcium Iodate, Cobalt Carbonate, Vitamin A Acetate, Vitamin E (Poulin Grain, 2014)*

Ewes began to receive minerals with copper in the end of January. The rams were given minerals without copper. During the entire study there were no signs of copper toxicity in any of the sheep. There were no yellow scleras nor mucus membranes.

The ewes in the study had access to go in and out of the barn to a large winter pasture. The sun was never strong enough to make a difference in color fading. Some who question the need for Icelandic sheep to need copper have suggested that the sun fades the wool. By performing the study in the winter, we were able to consider the effect of the sun as negligible. When we started the project, the wool pigmentation of the black and moorit sheep was faded. As the copper was fed, all six of the colored ewes began to regain color. Similarly

to the Canadians who fed copper for a few weeks before a show, we noticed the wool color change in just a few weeks. The most obvious sheep was Bes. She started out looking really faded with lots of white in her black coat. She started to get black within a couple of weeks of copper supplementation. By the end of our study, she was really black. It appears that copper does allow Icelandic sheep to regain the color of the wool. Icelandic sheep come in many colors and coat patterns. It is important to know the correct color for registration because sheep are registered by color code. Sometimes it is hard to tell what color they are if they are faded-- are they a gray sheep? Or are they a black sheep that is faded? The two rams that were not fed any copper showed no sign of wool pigmentation change. They were in a barn out of the sun so there was no fading of the wool due to sunlight.

The FAMACHA scores of the sheep generally got better over time with the copper supplementation. Ten of the fifteen ewes (67%) improved their FAMACHA score in only 4 weeks. Four sheep (26%) remained the same. Only one sheep showed an increase in FAMACHA numbers from the first collection to the last collection. This sheep started as a 1.5 and ended as a 2.5. There were 4 sheep (plus one that was sold) that started the study as 4's. All of them should have received a chemical deworming according to FAMACHA. As our farm is attempting to raise the sheep naturally, we chose to provide just copper and monitor the sheep closely to ensure no one was near death. In the fall we had four ram lambs that were 4.5 to 5 on the FAMACHA scale. We lost two sheep to the barber pole parasite even though we chemically dewormed them. The two other ram lambs were given a copper drench. Both rams survived. We used these rams as our control in this project.

The most noticeable positive effect from the copper was on sheep that had the worst FAMACHA scores. The four sheep that had a FAMACHA score of 4 or 4.5 at the beginning of the study ended with scores of 2's and 3's, for a 100% improvement. There were some ups and downs which is to be expected. The copper does not completely eliminate the parasite. Many of the sheep were pregnant. One of the rams got in with the ewe lambs in February so it is possible that all the sheep are pregnant. The closer the sheep were to lambing, which occurs in April on our farm, the worse the FAMACHA numbers were. This is a known factor for sheep. Lambing and the final stages of fetal development puts stress on the ewe. Rises in parasite infestations occur in times of stress when the body needs to focus on other things. We did notice that Gilly's FAMACHA score went up the week that we were waiting for more minerals. Once she was back on daily minerals, her FAMACHA scores were reduced. The rams mostly stayed the same. Each had a slight fluctuation. Because FAMACHA does not involve exact quantitative numbers, the fluctuation was not significant.

8.0 Conclusion

Icelandic sheep should receive a mineral containing copper. The copper is needed to maintain the wool pigmentation of the black and moorit sheep. The copper is also needed to fight infestation of the *Haemonchus contortus* parasite. As adding copper is just one aspect of parasite management, FAMACHA checks should be maintained regularly to ensure the sheep is not infested with parasites. Eyelid monitoring should continue on a weekly basis to look for signs of copper toxicity.

Annotated Bibliography

Bagnall, Alicia, Luke VanNatter, and David Lee. "Copper Toxicity in Sheep." *Sheep Management*. Purdue University School of Agriculture, Spring 2001. Web. 11 Mar. 2014.

This article talks about copper toxicity. Copper is stored in a sheep's liver. Different breeds respond to copper differently. Finnsheep are the least likely to suffer from copper poisoning. Copper is used in the diet at about 8-11 parts per million. It will be toxic to sheep at 15-20 parts per million. The mucus membranes and skin will turn a yellowish brown.

Blezinger, Stephen B. "High Levels of Sulfur in a Cow's Diet Can Affect Copper Absorption." *Cattle Today*. Cattle Today, Inc., 2004. Web. 21 Feb. 2014.

"Copper is required for the activity of enzymes associated with iron metabolism, elastin and collagen formation, melanin production, and the integrity of the central nervous system. It is required for normal red blood cell formation by allowing iron absorption from the small intestine and release of iron in the tissue into the blood plasma. Ceruloplasmin is the copper-containing transport protein. The process of normal hair and wool pigmentation requires copper. It is believed that copper is a component of polyphenyl oxidase which catalyzes the conversion of tyrosine to melanin and for the incorporation of disulfide groups into keratin in wool and hair."

Burke, Joan. *Management of Barber Pole Worm in Sheep and Goats in the Southern U.S.* Booneville: USDA, ARS, Dale Bumpers Small Farms Research Center, Feb. 2005. PDF.

"The adult female can lay thousands of eggs daily and can consume 200 microliters of blood daily. An average of 10,000 adults is enough to kill a sheep or goat. The female's prodigious output of eggs is partly responsible for the explosive nature of outbreaks, especially in favorable weather conditions. The eggs are deposited in the feces, hatch on pasture and the life cycle begins again. Outbreaks are worst when warm summer rains break up the fecal pellets and create a moist environment for the hatched larvae. During drought or very cold conditions, a majority of larvae become dormant or die and transmission to the animal is very low."

Duval, Jean. "The Control of Internal Parasites In Ruminants." *The Ecological Agriculture Projects*. McGill University, 1996. Web. 16 Dec. 2013.

"Copper sulphate, a mineral substance that already meets organic farming specifications for plant production, has a strong deworming action against certain parasites, particularly *Haemonchus contortus*."

"Goat Mineral." *Poulin Grain - Dairy, Equine, Pet, And Livestock Feeds*. Poulin Grain, 2014. Web. 1 Mar. 2014.

This website had the tag information for the Poulin Grain goat mineral. The ingredients list was on the sheep mineral page.

Hale, Margo, Joan Burke, Jim Miller, and Tom Terrill. *Tools for Managing Internal Parasites in Small Ruminants: Copper Wire Particles*. N.p.: ATTRA: National Sustainable Agriculture Information Service, 2007. Print.

This article provided information about parasite management and using copper oxide

wire boluses (COWP). It has been discovered that copper oxide wire particles (COWP) reduce parasite overload in sheep and goats. COWP was developed to meet the needs of copper deficiency in sheep and cattle without causing copper toxicity. "The form of copper used in COWP is poorly absorbed. The exact mechanism of how copper wire particles control internal parasites is not yet fully understood. Researchers believe copper has a direct effect on internal parasites."

Hatfield, P. G., C. K. Swenson, R. W. Kott, R. P. Ansotegui, N. J. Roth, and B. L. Robinson. "Zinc and Copper Status in Ewes Supplemented with Sulfate- and Amino Acid-Complexed Forms of Zinc and Copper." *Journal of Animal Science* 79 (2001): 261-66. Web. 1 Mar. 2014.

This study showed that the chelated mineral form of copper was better absorbed than the sulfate.

Hodge, Betsy. "Integrated Parasite Management and FAMACHA Training." FAMACHA Workshop. Cornell Cooperative Extension of Essex County, Essex. 16 Nov. 2013. Lecture.

Our family took this class to learn how to use the FAMACHA system. We learned all about parasites. We learned how to perform fecal egg counts. We learned to evaluate live sheep using FAMACHA.

Hutchens, Terry, Dr. Monty Chappell, and Dr. Marion Simon. *Kentucky Cooperative Extension Service Evaluates FAMACHA*. Lexington: University of Kentucky Cooperative Extension Services, 2004. Print.

The method was named for the originator- Francois Malan, a South African livestock parasitologist. The method is simple to use if two properly trained people are working together. "10% of the total blood volume may be consumed by the parasites each day." Animals that score 3, the animal should be considered for deworming. If an animal is a 4 or 5, deworming should occur. "By deworming only those animals that need it, selection of drug resistant strains of worms is slowed and the life of a given dewormer on a given farm can be prolonged." With wet pastures, the animals are more susceptible to barber pole worm.

Hutchinson, Tom C., and M. Sheena Symington. "Differences in the Copper Tolerance of British Sheep Breeds and the Possible Relationship to the Soil Chemistry of the Regions of the Origin of the Breeds." Trent University, Environmental and Resource Studies Program, Peterborough. 14 Mar. 2014. Speech.

The speakers think that some sheep developed in areas with high copper in the soil so they are able to tolerate more copper than sheep that developed in areas with low copper soil. "An interesting aspect of copper in wool analysis is that coloured or black wool has been known for at least a century to respond to copper applications. Copper deficient wool loses its crimp while copper deficient black wool loses both its crimp and its colour. It becomes white. In a recent experiment at Leeds University, a number of Black Welsh Mountain sheep were subjected to a low copper diet and basically became white. Shepherds showing sheep in coloured classes at shows in Canada used a potentially lethal mixture of nicotine sulphate and copper sulphate in the diet a few weeks before shows to maximize pigmentation (but, they emphasized that you had to be careful with it.)"

"Icelandic." *Breeds of Livestock*. Oklahoma State University, 2008. Web. 19 Dec. 2013. Icelandic sheep are part of the North European Short Tailed grouping and are related to Finnsheep, Romanov, Shetland, Spelsau sheep and the Swedish Landrace.

Kenney, Alethea. *Restoring and Maintaining Health*. Shevlin: Boreal Balance, 2013. PDF. Sheep that have poor health will have issues like poor wool quality, hoof conditions, low lambing percentages and difficult births, poor weight gain and milk production, diseases and parasites. Many farms are deficient in several key trace minerals. Some trace minerals are needed in small amounts and they may be the limiting factor in life or death. Copper is associated with poor nerve function and swayback disease. Copper is important for immune health and the ability to use iron. You should consider copper first when talking about parasites because of its use as copper oxide wire particles to kill parasites. Mineral blocks contain high amounts of salt. Sheep only need a small amount of salt so they self regulate the intake. This means they do not get all the nutrients they need. Sheep should be fed loose minerals. Chelated minerals are easier to digest and absorb over mineral blocks. "Because chelated minerals are so easily digested (sometimes close to 100% use able by the body), they can help offset situations where other minerals cause elimination or poor absorption of the needed mineral." Molybdenum added to minerals interferes with the absorption of copper.

Lewandowski, Rory. "Use FAMACHA Correctly." *OSU Sheep Team RSS*. Ohio State University Extension, 16 June 2010. Web. 17 Feb. 2014. FAMACHA is a way to determine if your sheep is anemic. An anemic sheep is suffering from an infestation of the barber pole worm. You need to use the system correctly and not guess. FAMACHA is recommended for small to medium herds. If you have a large herd, look at a portion of the sheep rather than all of them. "In the FAMACHA system that eyelid color is matched up with a scorecard that ranks color on a 1 to 5 scale. A dark red eyelid membrane color is a 1 and indicates no significant anemia. A white color is a 5 and indicates severe anemia. The light red, pink and pinkish white colors in between indicated by scores 2 through 4 indicate increasing levels of anemia that generally correspond to the parasite burden the animal is carrying." It is only effective when used on a regular basis. Sheep cannot have barber pole one day and then an infestation a few days later. "Due to their smaller blood volumes, lambs and kids with heavy infections can go from apparently healthy to death's doorstep in 10 to 14 days. This means that animals should be FAMACHA scored every 7-10 days during this period."

McNeil, Lyle G. *Sheep Sheet Wool Faults*. N.p.: Navajo Sheep Project, 1997. Print. This pamphlet talks about wool faults. Copper deficiency wool loses its pigmentation in colored sheep.

Niemann, Deborah. "Another Lamb! and Copper and Sheep." Web log post. *Antiquity Oaks*. Blogger.com, 31 Aug. 2009. Web. 10 Mar. 2014.

Many shepherds in the Icelandic Sheep community feel that it is recessionary to feed Icelandic sheep copper. New shepherds are encouraged to use copper to treat for wool discoloration and parasites. Shepherdess Deborah Niemann talks about why she gives her sheep copper. Her black sheep's face was almost white. Her sheep had all the signs of copper deficiency; she decided to give her a copper bolus. When she did

that her sheep's face regained its color and her wool is growing normally.

Sargison, Neil, BA VetMB DSHP FRCVS. "Copper Poisoning in Sheep." *National Animal Disease Information Service*. National Animal Disease Information Service, UK, 2014. Web. 21 Feb. 2014.

This article talks about the effect of copper poisoning on sheep. There are two types of copper poisoning: chronic copper toxicity and acute copper toxicity. Chronic copper toxicity happens when the liver cannot handle all the copper. This causes a release of copper into the blood stream which causes jaundice and destruction of red blood cells. Some breeds get copper toxicity more than others. It can be determined by evaluating the eyelids and mouth, looking for yellow coloring. Acute copper poisoning occurs when copper is injected in the sheep.

Schoenian, Susan. "Copper Toxicity in Sheep." *Small Ruminant Info Sheet*. University of Maryland Extension, 21 Dec. 2009. Web. 16 Mar. 2014.

This article talks about copper toxicity in sheep. The signs of copper deficiency are: anemia, brittle or fragile bones, loss of hair or pigmentation loss, and poor wool growth. Copper is one of the key trace minerals and is critical for life. A sheep can get copper poisoning by: trace mineral salt formulated for cattle or horses, vitamin and mineral supplements for other livestock, or a pasture that has been fertilized with swine manure or poultry litter.

Schoenian, Susan. "Internal Parasite (Worm) Control." *Sheep 201: A Beginner's Guide to Raising Sheep*. University of Maryland Extension, 8 Dec. 2013. Web. 16 Mar. 2014.

This article talks about internal parasites. They are the biggest threat to sheep health. The barber pole worm sucks blood in the abomasum. The barber pole worm is the deadliest parasite to sheep. It has a very short life cycle and produces lots of eggs. Integrated Parasite Management involves many methods working together to control parasites. Methods include rotational grazing, dry lotting, multi-species grazing, using pasture plants that have anthelmintic properties, nutritional management, anthelmintics, and FAMACHA.

"Trace Element Deficiencies in Sheep." *NADIS National Animal Disease Information Service*. National Animal Disease Information Service, UK, 2014. Web. 17 Feb. 2014.

This article talks about the trace mineral deficiency in sheep. One deficiency is for copper. It talks about the signs and how it can be prevented. Copper deficiency is most common when pastures are low in copper but higher in iron, molybdenum and sulfur. The symptoms of copper depend on where you live. Signs include poor wool quality, anemia, and poor bone mineralization. Copper deficiency in ewes during mid-pregnancy may lead to swayback in lambs.

Van Wyk, Jan A., and Gareth F. Bath. "The FAMACHA System for Managing Haemonchosis in Sheep and Goats by Clinically Identifying Individual Animals for Treatment." *Veterinary Research: A Journal of Animal Infection* 33.5 (2002): 509-29. *National Center for Biotechnology Information*. U.S. National Library of Medicine, 2002. Web. 7 Mar. 2014.

This study proves that the FAMACHA system is very reliable for those who take the class. However, FAMACHA does not work as well with goats as it does the sheep.

Images

Goat Label/Ingredients. Digital image. *Back in Balance Minerals*. Back in Balance Minerals, 2014. Web. 1 Mar. 2014.

This image shows the tag label for the Back In Balance goat minerals.

FAMACHA Card. Digital image. *Goat Equipment*. ProProf Quiz Maker, n.d. Web. 16 Mar. 2014.

This is an image of a FAMACHA card used in determining the eye membrane score of sheep and goats.

Sargison, Neil, BA VetMB DSHP FRCVS. *Jaundice of the Gums*. Digital image. *NADIS National Animal Disease Information Service*. National Animal Disease Information Service, UK, 2014. Web. 21 Feb. 2014.

This is an image of the mouth of a sheep showing jaundice indicating copper poisoning.

Sargison, Neil, BA VetMB DSHP FRCVS. *Jaundice of the Sclera of the Eye*. Digital image. *NADIS National Animal Disease Information Service*. National Animal Disease Information Service, UK, 2014. Web. 21 Feb. 2014.

This is a picture of a sheep whose eye shows jaundice; indicating the sheep has copper poisoning.

Schoenian, Susan. *Barber Pole Worm*. Digital image. *Sheep 201*. University of Maryland Extension, 8 Dec. 2013. Web. 16 Mar. 2014.

This is an image of the barber pole worm.