

Beth Lamp  
Northeast High School  
Goose Lake, Iowa  
Ethiopia: Animal Health

### **Tick Infestations in Camel Populations in the Southern and Eastern Regions of Ethiopia**

Ethiopia, located on the eastern side of Africa is home to 2.4 million camels; (Rirash, Wakayo, & Abdi, 2007, p. 1) the third largest population of camels in the world (Getahun & Belay, 2002, p. 158). Camels serve as a source of both meat and milk and are often used to transport individuals and goods to different regions of the country. They are also a significant source of income for pastoral communities that receive little rainfall to grow traditional crops (Simenew et al, 2012, p. 16). According to an article in the *Journal of Environmental and Analytical Toxicology*, “the importance of camels as a source of livelihood for pastoralists in Eastern Ethiopia cannot be overemphasized” (Awoke K & Ali, 2015, p. 1). While camels can be viewed as a boon to the Ethiopian economy, raising them is not without its problems, especially in the areas of disease and illness. One problem that camel producers face are ticks. Research emphasizes that “Ticks are one of the most important parasites among the factors affecting the health, productivity, and performance [of] camels” (Kiros, Awol, Tsegaye, & Hadush, 2014, p. 151).

Before discussing the problem of ticks, it is important to first establish background information about the country. While Ethiopia does have some urban areas, it is predominantly a rural country well suited for raising camels. In the rural areas of the country, these animals allow for a higher standard of living because they generate income. For this reason, large swaths of land are devoted to camel husbandry. Yet even with this land, pastoralists are still facing issues with pasture and grazing. According to the “World Climate Guide”, the Southern and Eastern parts of Ethiopia fall into region two, or the arid region (“Climates to,” n.d., p. 1). This region averages less than 31.5 inches of rain each year with most of the rainfall occurring during July and August (“Climates to,” n.d., p.1). That means the rest of the year is typically dry, which can strain grass production on the plateau. These dry periods are also one of the factors that limits the production of large quantities of extra income generating crops. While cereal grains are popular in other areas, families typically use these grains for consumption within their own households. The grain that is most exported throughout the country tends to be corn, while the most imported crops are sorghum and wheat (GAIN Report, 2018, p.1-2). Because there is only a limited amount of money to be made in grain and its production is heavily dependent on the weather, farmers often look to livestock such as camels to enhance their economic security.

The domestication of camels has been around for decades, but their populations have doubled over the past 60 years (Faye, 2013, p. 74). This expansion is due in part to “the increasing human population pressure and declining per capita production of food in Africa” (Abdisa, Wubishet, & Etsay, 2017, p. 1). Populations in Ethiopia are almost 80% rural (CIA World Factbook, 2018, p.1), and much of the populations diet consists of grains and produce (Nutrition Consumer, 2010, p. 1). Even though a portion of the population raises livestock, the livestock is mostly used for milk (Nutrition Consumer, 2010, p. 1). Camels help provide owners with milk for their children and cash resources from sales of younger stock. With camels being an important source of income for rural populations, keeping them healthy is essential to their value and the success of the local economy, yet ticks pose a significant health risk for camels.

According to an article in the *Journal of Health, Medicine and Nursing*, Ethiopia has the largest population of livestock in all of Africa and because of the livestock, they also have one of the highest concentrations of ticks (Walelign, & Mekuriaw, 2016, p. 13). In fact, “of the major parasitic diseases, ticks...rank third... in causing economic losses of the country” (Walelign, & Mekuriaw, 2016, p. 13). While little is known about the exact location of where ticks came from, one of the reasons they are so devastating is because evolution has granted them a longer than normal lifespan. While most animals that

feed on blood have a relatively short life expectancy, hard-backed ticks typically live between one and three years, while soft-backed ticks can survive 10 to 11 years, often outliving their hosts (Waleign, & Mekuriaw, 2016, p. 15). Ticks can also adapt to extreme weather conditions, including both heat and cold. In Ethiopia, ticks can handle the arid climates where little rainfall occurs. Some ticks can go the other way and tolerate extreme cold including conditions in Antarctica (Scallen, 2015, p. 5). Another adaptation ticks have is an organ that allows them to smell a potential host when it walks by (Scallen, 2015, p. 4). Because ticks do not jump or run quickly, the ability to smell an animal such as a camel, gives them the ability to track the animal and eventually hitch a ride. Lastly, and perhaps most importantly, ticks “outwit the host immune response” (Scallen, 2015, p. 3). They do this by releasing immunosuppression agents into the skin, including anti-coagulants, which prevent blood from clotting (Scallen, 2015, p. 3). By tricking the animal’s immune system into not producing a response to their bite, ticks can often feed for days completely unnoticed.

What happens is this, ticks attach themselves all over the camel and burrow into the camel’s skin. Once they are firmly attached, they proceed to draw blood out of the camel to feed upon. This can leave the camel weak from blood loss depending upon the number of ticks found. Ticks are also known for carrying diseases, which can be passed on to the camel and can wear down the camel’s immune system. According to the *Journal of Dairy and Veterinary Sciences*, parasites make up 50% of the reported diseases in camels and were cited for producing “decrease[d] body condition, decrease[d] meat/milk yield, and growth retardation” (Abdisa, Wubishet, & Etsay, 2017, p. 4). A decrease in meat and milk yield means a loss of food for the pastoralists who raise these animals. It also means they have less product readily available for export.

If pastoralists are not making money when they sell the products from their camels, it means they will not have extra money to spend in either further developing their herd, or within the community purchasing goods and services. They may no longer buy extra items from the market, which puts a strain on other producers who rely on these sales to provide for their own families. Ticks have the potential to cause a significant economic impact on the community if they cause a drop in camel production and prices, which can be devastating to individuals trying to feed their families.

An article put out by the University of Gondar in Ethiopia says, camels represent a vital contribution to food security and human welfare in vulnerable households of the dry area. They are important for milk and meat production, transportation, draft power and household income generation. (Taddese & Mustefa, 2013, p.66).

The article goes on to say despite the camel’s importance, their health is not being maintained. A study found that of the 384 camels looked at, 94% of them were infested with ticks (Taddese & Mustefa, 2013, p. 66). Eleven thousand seven hundred and seventy-four ticks were collected from these camels, a number that is higher than previous reports (Taddese & Mustefa, 2013, p. 68). One of the major contributing factors to this trend is due to the ticks “geographical distribution in savanna, steppe and desert climatic regions” (Taddese & Mustefa, 2013, p. 68). These regions are also where camels tend to live, especially on the savanna where they have access to grass.

Families using the camels for milk may see a decrease in production rates due to the tick infestation because the ticks wear down the camel’s bodies by introducing infection and draining them of blood. A decrease in milk may cause the families to experience food insecurity, especially if they rely on the milk as a part of their daily diet. If others in the community are also purchasing the milk, they may have a reduction in food security.

Another study was done using the same number of camels, 384, and it was found that 100% of those camels were infested with ticks and most with other parasites such as mites (Regassa, Awol, Hadush,

Tsegaye, & Sori, 2015, p. 2). This study was done at an Ethiopian slaughter facility where the animals were brought to be processed. Camels that are slaughtered for meat further see a decline in production rates because of ticks. An article in the *Journal of Veterinary Medicine and Animal Health* say, “Tick infestation also causes loss of appetite, leading to a reduction in growth rate and decreased productivity” (Regassa, Awol, Hadush, Tsegaye, & Sori, 2015, p. 6).

If the camels are not eating and growing, they will produce less meat at harvest which can contribute to food insecurity for the families who depend on that meat to survive throughout the year. It also creates food insecurity within the community because it means that less meat is available for sale forcing people to either find alternative food sources or try to import costly animal protein from other countries. Finally, the ability to export camel meat to other parts of the country is drastically reduced if the camel is in poor condition when it is harvested. The inability to export means less money for the farmers raising the camels, which could create food insecurity in their families and the community at large. The Agriculture and Consumer Protection Department cites evidence that Ethiopia is already one of the poorest countries in the world and if their camel population continues to suffer because of ticks; the people living there will further experience high levels of food insecurity (Nutrition Consumer, 2010, p. 1).

To combat the growing tick population without the use of expensive chemicals, camel producers may want to consider is the use of a product containing the fatty acid complex C8910 (E. Machtinger, personal communication, January 14, 2019). Email messages from Dr. Erika Machtinger Department of Entomology at Penn State University explain that these fatty acids are found in various products including coconut oil (E. Machtinger, personal communication, January 14, 2019). Coconut oil has long been used as the natural tick repellent of the ancient world in the countries of “China, Egypt, and India” (Zue et al, 2018, p. 2). It is also used in modern day all-natural products for dogs and cats and can be used by working it into the animal’s coat. Coconut oil is a heavy substance and working it into the coat smothers the ticks and suffocates them (Ticks, H., 2018, p. 2). The coconut oil also helps sooth the bites the animal may have sustained from the ticks and promotes healing (Ticks, H., 2018, p. 2). Coconut oil can be diluted with mineral oil or acetone and poured over the back of the camels, like the process of using a chemical pour-on. To do this, the coconut oil should be mixed at a ratio of one-part mix and two parts coconut oil. The next step is to dip the coconut and oil mixture out of the mixing container using a cup or ladle or pour the liquid directly from the container onto the animals back. Once the coconut oil is poured over the camel’s coat, it should be rubbed into the hide to make sure the existing ticks are covered.

Research could not be found to say if coconut oil had been used as a solution to the tick problem occurring in camels in Ethiopia, but it was discovered that coconuts are produced in the neighboring country of Kenya (Mumero, 2013, p. 1). Having coconuts produced close by would eliminate the need to ship in the oil from other places around the world and should help to reduce the costs for camel producers in Ethiopia. Another positive to this method is it can help producers in Kenya use crops that may have molded due to wet conditions (Corpa Meal, 2019, p. 1). Once coconuts are harvested, they should be left to dry for a week at a time in the sun, but if rainy weather occurs, this can be a problem (Corpa Meal, 2019, p. 1). Damaged coconut oil cannot be sold because the mold makes it unsafe for humans to consume. There is a possibility however that it could still be used externally on camels to help combat ticks, thus creating a mutual benefit for both countries.

Coconut production and sales in Kenya are currently regulated by the Kenya Coconut Development Authority or KCDA (Mumero, 2013, p. 1). Camel producers in Ethiopia could benefit from working with this organization to discuss options for purchasing damaged or low-quality coconut oil that cannot be sold for human consumption. If negotiations between the KCDA and pastoralists in Ethiopia are successful, the next step would be to look at import taxes for the product. Pastoralists would need to consider import taxes on all coconut oil into their expenses and may consider talking to government agencies about creating an exemption on the damaged coconut oil (Custom Duty, 2019, p.1).

Packaging, storage, and transportation must also be factored in when considering the use of coconut oil as a preventative. The packaging of coconuts is relatively simple. The guidelines put out by the International Transportation Information Service say that coconuts themselves can be placed in “coconut fiber netting bags” and transported either in refrigerated containers or in ventilated containers (Transportation Information Service, 2019, p. 4). When transporting coconuts, their natural respiration process must be taken into consideration meaning that accommodations should be made for heat, water vapor loss, and CO<sub>2</sub> emissions (Transportation Information Service, 2019, p. 6). If too much CO<sub>2</sub> builds up during the storage process, it can cause a shortage in oxygen, which may be potentially hazardous to individuals working with the product. To prevent this, it is important to make sure adequate ventilation is available both in the storage container and in the bags containing the coconuts (Transportation Information Service, 2019, p. 8).

Pastoralists and coconut producers should consider working with the International Livestock Research Institute, which has locations in both Kenya and Ethiopia (International Livestock Research Institute, 2019, p.1). The goal of this organization is to “improve food security and reduce poverty in developing countries through research for better and more sustainable use of livestock” (International Livestock Research Institute, 2019, p. 1). Because the reduction of ticks would help in retaining the number of healthy camels in Ethiopia, the International Livestock Research Institute may help in covering the initial research costs of the project.

Importing coconut oil could still be a problem for pastoralists in terms of costs. Using coconut oil requires them to have the extra income for the purchase, which is not feasible in all situations. In this case, a healthy relationship with the International Livestock Research Institute and coconut growers could prove advantageous. If the use of coconut oil plays into the mission statement of the International Livestock Research Institute, perhaps a grant might be established to help offset the costs of accessing this commodity. The next step to determining if this was indeed feasible would be to contact the institution directly.

It may also be difficult for those living in the Eastern regions of Ethiopia to receive the same amount of coconut oil as those in the Southern regions because of the proximity of the borders of Kenya and Ethiopia. One solution to this is to transport the oil by railway. Ethiopia is rapidly expanding their rail systems; most recently through foreign investments from China (Ethiopia-Road and Railway, 2018, p. 2). Using railways may be more reliable than trying to transport via road and would deliver the product faster.

A final issue pastoralists and coconut producers may encounter is the political unrest that sometimes happens in both countries. According to Stratfor Worldview, Kenya and Ethiopia sometimes experience power struggles for control of regions around them including Somalia (Understanding East Africa’s, 2018, p. 3). If a power struggle is taking place, it may be difficult to get the coconuts from Kenya. To help balance this problem, a similar product can be used in place of coconut oil and in some areas is even produced right in Ethiopia, although much of it is still imported.

Another potential alternative to using coconut oil is the use of red palm oil. Palm oil is the largest import into Ethiopia, ranked number one in 2017. (Addis & Tedrick, 2017, p. 4). Palm oil can be traced to two categories: palm oil, which comes from the flesh of the palm fruit and palm kernel oil, which comes from the internal seed or kernel (Palm Oil Investigations, n.d., p. 1). The red palm oil comes from the fruit of the plant and is red in color. Oil palms, the trees that produce palm oil, are one of the most productive crops in the world and are capable of producing “more oil from less land than any other vegetable oil in existence. One oil palm tree will produce ongoing fruit for up to 30 years deeming the crop as high yielding and sustainable.” (Palm Oil Investigations, n.d., p. 1). Red palm oil is like coconut oil in that it is

a solid at or below room temperature and turns into a liquid once it is heated. Thus, it can be smeared over the backs of the camels and worked into the skin, smothering the ticks and conditioning the camel's hide.

To obtain red palm oil, the flesh of the fruit is used and not the kernel. Red palm oil is most like coconut oil when it is in its natural state and has not been put through the refining or heating process (Wylde, 2019, p. 1). Instead, the fruit is extracted from the seed and then cold pressed without heat to extract the oil. This gives a pure product that maintains a solid or semi-solid shape at room and is ideal for spreading over the camel's skin. Once the red palm oil is collected, it is stored in holding tanks and then packed for distribution (Poko, 2002, p. 9).

Oil palms are typically raised on large plantations in Indonesia and Malaysia and imported into Ethiopia (*Capital*, 2019, p. 1). In 2019, the Ethiopian government opened import markets to more producers keep up with the growing demand for palm oil (*Capital*, 2019, p. 1). According to the Embassy of the Republic of Indonesia in Ethiopia, Indonesia and Ethiopia have one of the most important relationships in the region (Embassy of the Republic of Indonesia in Addis Ababa, Ethiopia, 2018, p. 1). Because trade agreements are strong between the two nations and because palm oil is one of the main exports from Indonesia to Ethiopia, it is reasonable to assume that pastoralists in Ethiopia would have access to this commodity, if they have the income to purchase it. It should be noted that the Ethiopian government does not charge an import tax on palm oil according to a report put out by the USDA's Foreign Agricultural Service Global Agricultural Information Network (Tefera, 2015, p. 2).

In order to develop a better understanding of how coconut oil and red palm oil might work on tick infestations, I reached out to Dr. Susan Paskewitz at the University of Wisconsin at Madison. She referred me to Dr. Joel Coats at Iowa State University. Dr. Coats routinely uses ticks in his research to conduct repellency trials. Dr. Coats was kind enough to connect me with his graduate student Colin Wong, who invited my sponsor and I out to his lab at Iowa State University to do preliminary research on the use of these oils on live ticks. Trials were conducted on July 28, 2019 and data from those tests is recorded below.

To create an accurate trial, the same brand of coconut oil and red palm oil was used. The brand is Nutiva and they specialize in organic products in an unrefined state. An additional red palm oil found in Indonesia was also tested. Its brand name was Omni Red Palm Oil. When conducting the experiment, the first step was to put on protective gear. I was given safety goggles, a lab coat and gloves. Once I had those items on, Colin showed me the acetone, which would act as a diluent for the oils. Acetone was selected because it can dilute the oil, but then it evaporates out, leaving a pure product once again. Diluted oil is used because labs typically start with smaller quantities of the active ingredient and add more as necessary. This is the most cost-effective method and ensures that the lowest amount of product possible is used for the situation.

After taking protective measures, I then mixed up two different sets of trials, the first to measure repellency and the second mortality. For the first trial, 5% oil was used and mixed with the acetone. Three graduated glass containers of solution were created, one for each type of oil. Once an accurate amount of oil was placed in each tube, the acetone was mixed in to dilute it down. For the second trial, a mixture of 50% oil and 50% acetone was used. Three sets of this were also created for the three oils. Warm water was then applied to the outside of the glass to ensure that the coconut oil and red palm oils maintained a liquid state during the mixing process. Once the solutions were completely mixed, the vials were taken across the street to a different lab where live tick samples were located. Inside of this lab there were two jars of American dog ticks, one of males and one of females. Colin sorted the ticks for us before we came into the lab.

The first test we started was the mortality test. Clean sets of glass containers were selected and labeled with each type of oil and concentration of the solution. After the containers were labeled, a pipet was used to extract the previously mixed solution from the 50% mixture. The ticks were then taken out of the jars one at a time using a small pair of soft tweezers. Holding the tick with the tweezers, the solution was directly applied to the outside of the tick, covering the body and the head. It was then placed in one of the labeled containers and covered with a mesh netting to allow air flow to continue. Five males and five females were used for each oil resulting in ten ticks per trial. A control test using just acetone was also conducted. A timer was then set for one hour and after the hour was up, I counted the number of ticks still active in the containers. The one-hour test is known as the knockdown test and is designed to see how many ticks are either dead or weakened from the oil's application. To do this, I breathed into the top of the containers because ticks are attracted to carbon dioxide and it wakes them up. While none of the ticks had died from the diluted solution, several of them appeared sluggish, especially in the container with the Indonesian red palm oil and the coconut oil. The control did not appear to have any adverse effects on the activity level of the ticks. Another measurement of the ticks was taken at 2:00 pm on Monday, July 29th, twenty-four hours after the initial test. Results of this showed that the ticks were still alive, but those that had been covered in the coconut and palm oils were lethargic and slower to respond than those found in the control group. This result was encouraging and shows promise for success in future studies with different concentration levels.

In addition to the mortality tests, a repellency test was also conducted. The goal of this test was to see if the oil worked at repelling the ticks rather than killing them. To conduct this test, circles of filter paper were covered with the 5% solutions and an acetone control. 5% is the standard amount of a chemical that would be used in many commercial repellency products. The center of each paper was cut out and the paper was placed inside of a lid containing plain white paper. A tick was selected from the jar and placed in the center of the paper. A stopwatch was then used to calculate the number of seconds it took for the tick to move from the center of the circle across the barrier of the paper that had been covered in the oil mixture. To qualify as crossing the barrier, ticks had to have all their legs across the edge of the paper.

Five males and five females were again used for the test and the control. The amount of time was recorded for each mixture with the longest single amount of time being 19.16 seconds for a male tick exposed to the organic red palm oil. Coconut oil came in second with 13.85 seconds. The acetone control was also measured and showed at the high end 7.14 seconds and on the low end only 2.38 seconds of repellency. While none of the three oils created an impenetrable barrier for the ticks, they do show promise over the control at repelling the ticks. It should also be noted that the papers appeared most effective with the first ticks placed inside of the barrier. This could be because the paper was most saturated at that point, but more research is needed to say for certain if that is true.

All in all, promise is shown in using these products to either repel or kill the ticks. The next step in the research would be to look at pure oil substances as opposed to diluted in the mortality test. This test was not conducted because of time constraints within the lab. I would also like to do additional testing on the repellency percentages to see if adding a larger amount of pure oil worked better at repelling the ticks.

In addition to pure oil testing, testing should also be done to see if the palm and coconut oil could be used as a diluent or carrier oil and combined with an additional product such as the chemical repellent Flumethrin. According to Colin, right now most natural repellents use a mineral oil base, but it is possible that either coconut or palm oil could be used as a carrier oil. Mineral oil is a by-product of petroleum whereas coconut and palm oils are plant-based, renewable products that are more easily accessible to pastoralists in Ethiopia. Research could not be found to say if mineral oil itself worked as a tick repellent, but my initial trials show that coconut and red palm oil does have some powers at repellency. This could mean that if they were used as a delivery system for a chemical form of treatment that less chemical would be necessary because of the natural properties found in these two products.

Once an accurate percentage has been established, I would then test the hypothesized delivery method to see if a pour on system would be effective or if the oil solution would need worked into the skin in a different manner. Interviews with local Ethiopian pastoralists would also be necessary to see if they had the materials required for the delivery system and to see if they had the ability to get close enough to the camels to employ the delivery system. Trials need to be done to measure the effectiveness of the solution in the field and how long each application lasted. Finally, a cost analysis needs to be completed to see if preventing the ticks using natural products or product delivery methods is indeed economically beneficial for camel owners.

Overall, camels make up a portion of the livestock owned by pastoralists in the Southern and Eastern regions of Ethiopia. These camels are used primarily as sources of meat and milk, but they can also be used for transporting goods. One of the primary issues facing camels in this part of the world is a large infestation of ticks which burrow into their skin and can cause infection and decreased body condition. This directly impacts food security because the ticks cause the camels to produce less meat and milk meaning there is less product to be consumed or sold. Preliminary research trials using natural tick repellent including coconut and red palm oils show promise that these products can either kill the ticks without added chemicals, or more likely that they be used as a delivery vehicle for other products. Because of the promise they show by themselves, it is likely that pairing them up with another product would be that less of the chemical would need to be used to achieve the same result. As populations continue to increase, the camel market in Ethiopia will also continue to grow. It is important to help pastoralists find solutions to the ticks, so they can take advantage of expanding markets.

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