NATURAL PREVENTION OF INTERNAL AND EXTERNAL PARASITES IN SHEEP, CASE TAUROA

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ABSTRACT

The goal of my work was to examine how effective different kinds of natural sprays are to prevent fly attacks on sheep. I did this research in New Zealand on a biodynamic farm at the request of the farm owner, Heather Smith. We used hydrosols made of artemisia (wormwood), eucalyptus, citrus and a mixture of artemisia and eucalyptus. Hydrosols were diluted with water and sprayed on sheepôs shoulders, backs, loins and butts.

At the same time that we sprayed the sheep we also drenched them with a natural worm medicine made of artemisia, tansy, garlic, vinegar and seaweed, and a little bit of molasses for taste. Drenching and spraying were done once a month between November and March two days before the full moon, because at that time the wormôs fluid cycle is the most active, and worms are the most vulnerable to the effects of worm medicine. Worm brew and hydrosols were made from plants growing on the farm. The fly prevention sprays work because they adhere to the fat of wool and diminish the smell of the sheep. Lambs were distributed to four different groups, which were separated from each other by different coloured ear tags. Research animals consisted of 200 Romney lambs (born on the farm), 214 organic Perendale lambs (bought later) and 84 conventional Romney-crossbred lambs. All fly preventive sprays were equally effective, but the problem was that fly attacks were targeted to small, infirm individuals who had internal parasites. The problem might be a mineral deficiency of the soil and thus from the grass, too densely grazed pastures, so the amount of parasite larvae on the pastures increase, a breed sensitive to getting parasites and/or a year favorable to parasites.

Keywords Natural prevention of parasites, natural prevention of fly attacks, internal parasites, external parasites, prevention of parasites in sheep

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TIIVISTELMÄ

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TIIVISTELMÄ

Työni tavoitteena oli tutkia erilaisten luonnonmukaisten kärpästorjuntasuihkutteiden tehoa lampaiden kärpästoukkien torjunnassa. Käytimme koiruohosta, eukalyptuksesta, sitruksesta ja koiruohon ja eukalyptuksen sekoituksesta tehtyjä hydrosoleja, jotka laimennettiin vedellä ja suihkutettiin lampaiden lavoille, selkään, lonkkien alueelle ja takamukseen. Tein tutkimusta Uudessa-Seelannissa biodynaamisella tilalla tilan omistajan, Heather Smithin, pyynnöstä.

Samanaikaisesti kärpässuihkutuksen kanssa lampaat myös madotettiin luonnonmukaisella matolääkkeellä, joka oli tehty koiruohosta, pietaryrtistä, valkosipulista, viinietikasta ja merilevästä sekä maustettu pienellä määrällä melassia. Madotus ja kärpässuihkutus tehtiin kerran kuukaudessa marraskuun ja maaliskuun välisenä aikana kaksi vuorokautta ennen täysikuuta, koska tällöin loisten nestekierto on vilkkaimmillaan ja ne ovat altteimmillaan matolääkkeen vaikutuksille. Sekä matolääke että hydrosolit tehtiin tilalla kasvavista kasveista. Kärpästorjuntasuihkutteen teho perustuu siihen, että kasvien eteeriset öljyt sitoutuvat lampaan villan rasvaan ja vähentävät siten lampaan omaa hajua. Karitsat jaettiin neljään eri ryhmään, jotka erotettiin toisistaan erivärisin korvamerkein. Tutkimuseläimet koostuivat 200 omasta romney-rotuisesta karitsasta, 214 ostetusta luomuperendalekaritsasta ja 84 tavanomaiselta tilalta ostetusta romney-risteytyskaritsasta. Kaikki kärpästorjuntasuihkutteet olivat yhtä tehokkaita kärpästen torjunnassa, pikemminkin ongelmana oli se, että kärpäshyökkäykset kohdistuivat pienikokoisiin, heikkokuntoisiin yksilöihin, joilla oli sisäloisia, ja jotka siten olivat alttiita kärpästen hyökkäyksille. Ongelmana saattaa olla jonkin mineraalin puute maaperästä ja siten kasvavasta ruohosta, liian tiheään laidunnetut laitumet, jolloin loistoukkien määrä laitumilla kasvaa, loishyökkäyksille altis rotu ja/tai loisille edullinen vuosi.

Avainsanat Luonnonmukainen loistorjunta, luonnonmukainen kärpästorjunta, sisäloiset, ulkoloiset, lampaiden loistorjunta

Sivut 24 s. + liitteet 4 s.

CONTENTS

1 INTRODUCTION

New Zealand is a land of intensive agricultural production, and that can result in some trouble, like challenges how to prevent internal and external parasites. I got an opportunity to examine how effective different kinds of natural fly preventive sprays are in sheep. I was also interested in natural prevention of internal parasites, and because we drenched the sheep at the same time that we sprayed, I wanted to expand my report to include worms. I made the examination on a biodynamic farm called Tauroa in New Zealand, Hawkeôs Bay. The farm area is 275 hectares, and there are sheep, cattle, dairy cows, chickens, horses and wild turkeys. Most of the land is pasture, but also barley and wheat are grown for the chickens, hay for the winter, and there is in addition a big garden with fruit trees, two feijoa orchards and a trufferie with hazelnuts.

There are no harsh winters in New Zealand, so different parasite species are thriving. In spite of rotational grazing with cattle and sheep, the grazing pressure is too high. Internal parasites are resistant to chemical drenches, and chemical dips used to prevent and treat attacks of ectoparasites. They can also leave residues on wool, and they are harmful to the environment.

Animals with internal parasites are prone to attacks of flies, which is another reason, why I examined also endoparasites, not just the prevention of flies. Endoparasites cause imbalance of minerals, which weakens the sheep, and flies seem more likely to attack small and infirm individuals. Flies lay their eggs to moist and warm wool or skin, so dirty wool and wounds attract them. In addition flies lay their eggs on carcasses.

The research took place between November and March, and we drenched and sprayed the sheep every month two days before the full moon. We drenched all sheep with the same worm medicine, but sprays changed depending on the group. We separated lambs to four different groups and examined how different sprays effect fly attacks.

2 INTERNAL PARASITES

2.1 Parasite species

There are several different internal parasite species that impact sheep in New Zealand. Especially on farms where sheep stocking rates are high, there are a lot of internal parasites. Parasites cause a loss of production through sickness and weight loss. (West et *al*. 2002, 166.) That is the reason why it is really important to control internal parasites.

Changes in the environment, for example rainfall or drought, or lowering of sheep immunity and anthelmintic resistant parasite species, are affecting the parasite status on the farm. Because of the moist and moderate

climate of New Zealand, there are good conditions especially for the free-living parasite stages on pasture. The most ideal temperature for larvae to develop fluctuates between 15 and 30°C. There are several different internal parasite species, for example Nematodes include *Haemonchus contortus*, *Ostertagia circumcincta*, *Trichostrongylus axei*, *T. colubriformis*, *T. vitrinus* and *T. capricola*, *Cooperia curticei*, *Nematodirus spathiger* and *N. filicollis*, *Trichuris ovis*, *Oesophagostomum venulosum*, *Chabertia ovina*, *Dictyocaulus filarial* and *Muellerius capillaris*. There are also Trematodes, like liver fluke, and Cestodes, also called tapeworms. (West et *al*. 2002, 166-167, 180, 193, 196.)

2.2 Larvae development

It takes normally 2-3 weeks or a bit more for Nematode larvae of L_3 stage (third larvae development stage) to develop on pasture. Larvae can survive on pasture for 3-6 months, species of *Nematodirus* for 18 months. Infective larvae (L_3) can also survive cool conditions and frosts, so they are capable to stay alive also in wintertime. Usually the percentage of eggs that will develop to L_3 stage is lower than one per cent. If the weather conditions are very favorable for larvae, typically in late summer or early autumn, over 10 per cent of eggs can reach the infective stage. (West et *al*. 2002, 167-168.)

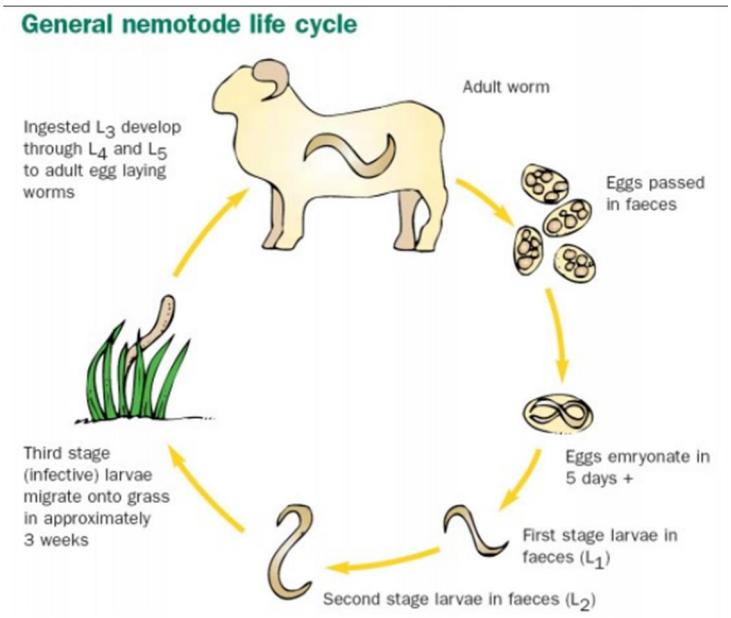

Figure 1 Development of Nematode larvae

There is a remarkable rise in the load of internal parasites in March, April and May. Annually there are two generations of parasites: from overwintered larvae and from the lamb contamination. *Nematodirus* species have only one generation annually, so those species are an exception. *Nematodirus* are a predominant species in spring, *Trichostrongylus* in autumn

and winter, *Haemonchus* in summer and autumn and *Ostertagia* in spring and summer. (West et *al*. 2002, 170-171.)

Liver flukes (Trematode, *Fasciola hepatica*) are common in New Zealand, especially on the North Island. Liver flukes need an intermediate host, a snail. There are three different snail species in New Zealand, which act as intermediate hosts: *Lymnaea tomentosa*, *L. truncatula* and *L. columella*. When the snail is dying, fluke wormôs cercariae leave the snail host and form encysts to grass blades, from where animals eat them and get infected. Snail populations diminish during winter and get bigger in early summer. (West et *al*. 2002, 193.) Liver flukes have a life cycle of six weeks (Coleby 2000, 160).

Liver flukeôs larvae (miracidia) have to reach the host snail within 24 to 30 hours to survive. Larvae need temperatures above 5°C to stay alive. The larval stages are multiplying within the snail, and after five to eight weeks depending on the temperature, tadpole-like larvae (cercaria) emerge from the snail. Cercaria form cysts (metacercaria) on herbage, where they can live for months if moisture and temperature are favorable. After a host animal has ingested young flukes, they penetrate the hostôs intestinal wall and enter the peritoneal cavity. From the peritoneal cavity flukes penetrate the liver, where they mature. Liver flukes are very long-lived, usually for the length of the hostôs lifetime. (Liver fluke in Western Australia 2014.)

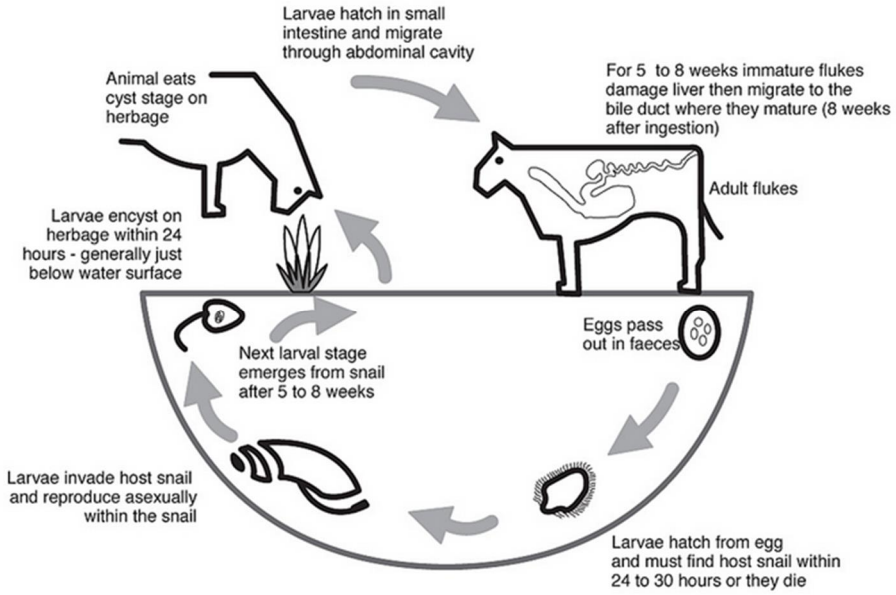

Figure 2 Life cycle of a liver fluke

Also tapeworm *Moniezia expansa* needs an intermediate host, a free-living oribatid mite. Mites can stay alive on pasture up to 22 months. Dogs can carry tapeworm species *Echinococcus granulosus*, *Taenia hydatigena* and *T. ovis*, but in New Zealand there is only the hydatid cyst, *Cysticercus ovis*, which cause lesions to sheepôs meat. (West et *al*. 2002, 196-197.)

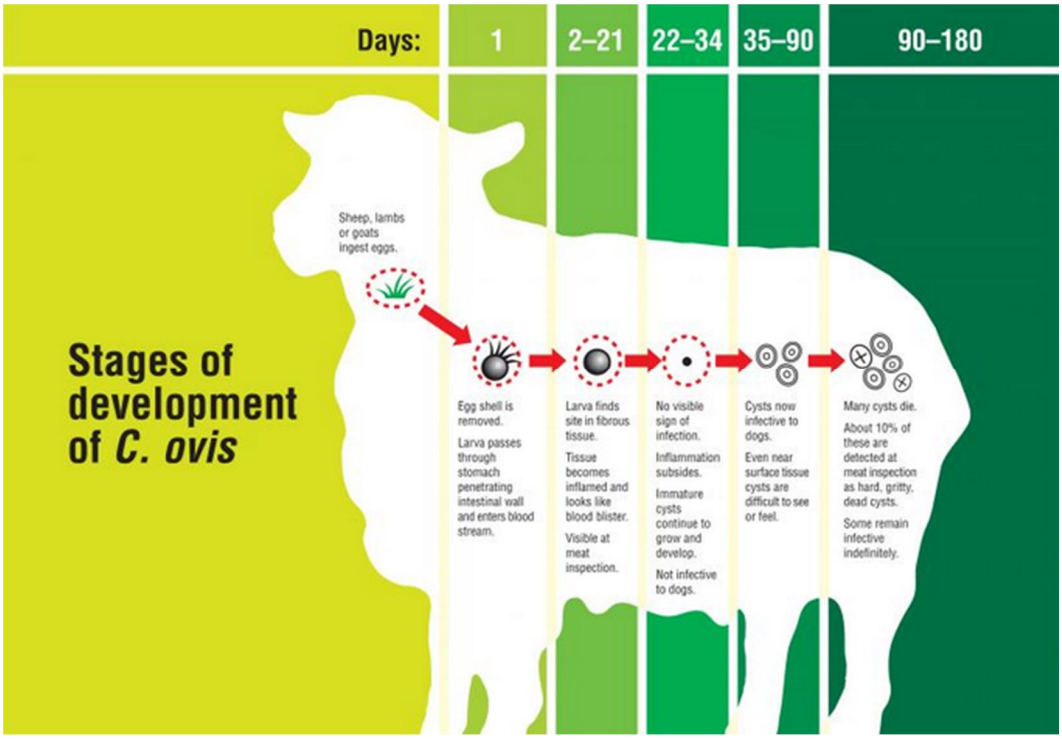

Figure 3 Development of *Cysticercus ovis*

2.3 The effects of internal parasites on sheep

Nematodes reduce haemopoiesis, protein and mineral metabolism, appetite, wool production and skeletal growth. Results can be weight loss, loss of appetite, dark coloured diarrhea and anemia in case of *Haemonchus*. In young lambs there might be watery diarrhea and sticky mucus when they are infected by *Nematodirus*. In severe Haemonchosis ewes or lambs may die suddenly without any previous warning signs. The adult liver fluke, *Fasciola hepatica*, causes severe interference of liver function and hepatic fibrosis. (West et *al*. 2002, 173, 181, 193.) Ewes with liver flukes are prone to have ovine pregnancy toxaemia, they have poor colostrum stores and they give birth to lambs with a low birth weight. Weak, small lambs are susceptible to environmental pathogens and starvation. (Scott 2010, 307.)

Depression of appetite caused by worm infestation can reduce food intake 25 per cent or even more. Loss of tissue and blood protein reduces the energy and amino acids available for example for the muscles. Diarrhea causes functional and structural damage to the gut lining, which results in a loss of water and dissolved materials. As a result of this the sheep becomes dehydrated. Worm infections can also interfere with mineral metabolism and skeletal development. (McCutcheon et *al.* 1986, 214-215.)

Based on New Zealander research, lambs with intestinal worms and who grow only 100 grams per day comparing to healthy lambs, who are growing 300 grams per day, are consuming 13 kilograms more dry matter per kilogram of carcass weight. From weaning to slaughter total feed of lambs, who have intestinal worms and who grow slowly, is 102 kilograms of dry matter more than healthy and normally growing lambs. That is a major expense, because healthy lambs consume 114 kilograms of dry matter from weaning to slaughter. (Sargison 2008, 143.)

2.4 Making a diagnosis

When making a diagnosis of internal parasite levels, counting worm eggs is really useful. It can be done in the laboratory. Also slaughtered sheep can be investigated to determine what kind of parasites they have and how many. For example *Haemonchus* are large red and white worms that can be found in the abdomen. *Ostertagia* worms are smaller and brown and can be seen in abdominal mucosa. (West et *al*. 2002, 175.)

2.5 The control of internal parasites

The base of controlling internal parasites lies on limiting larvae on pasture. In addition the animals need to have good nutrition. Very important is to make a grazing system plan, alternate animal species that are grazing, and the possibility to keep more parasite resistant stock. All farms are different, so every farm has to find its own way to fight parasites. If a farmer wants to reduce the use of anthelmintics or be totally without chemical products, it is essential to give attention to pasture management. (West et *al*. 2002, 179.)

Rotational grazing can be an answer to some farms, but the resting periods have to be long enough, in autumn and winter 4-5 months and in spring and summer 2-3 months. Otherwise pasture infestation can be very high and animals will be contaminated by parasites. It would be useful to graze both cattle and sheep on the same areas, because cattle and sheep usually donôt have the same internal parasites. The exceptions are *Fasciola hepatica, Trichostrongylus axei* and *Trichuris ovis*. Cattle can also trample the ground, so snail populations, which are spreading liver flukes, can reduce. Lambs and hoggets are typically the main contributor to pasture contamination, so reducing the proportion of those animals helps to keep the parasite levels down. (West et *al*. 2002, 179-180, 193.)

To guarantee a safe pasture for animals there should be at least 350-400 cattle for 2000 ewes. Using alteration of cattle and sheep it is possible to raise them without anthelmintics. Cattle can graze a pasture 10-14 days, then there should be break of 30 days, and then lambs can graze the pasture, then cattle again after 30 days rest. There must be enough pasture to do this rotation. (West et *al*. 2002, 180-181.)

Some plants, like lotus (*Nelumbo nucifera*), chicory (*Cichorium intybus*), sainfoin (*Onobrychis viciifolia*) and sulla (*Hedysarum coronarium*) have

bioactivity against nematodes. These effects are from plantsô secondary metabolites, such as flavonols, tannins and cysteine proteases, or from optimized rumen-degradable protein nutrition because of enhanced host immunity. (Sargison 2008, 166.) Adding protein to sheepôs diet has been proven to decrease the number of parasite eggs (Navarre & Pugh 2002, 89).

Adult sheep are usually more resistant to parasites than lambs, and they have less worm eggs in their feces. So it is possible to graze both ewes and lambs when there is a delay of 30 days between the grazings. This alteration is not as good as with cattle, because adult sheep can contaminate pastures with larvae. Lambs should be moved in late February or early March to pasture where lambs havenôt been grazing since weaning. (West et *al*. 2002, 181-182.)

Some sheep breeds are more resistant to parasites than others. In addition some sheep can improve a natural resistance to the parasites. It is possible to measure the parasite resistance by the anti-parasite antibody levels in blood. Sheep donôt develop resistance to liver fluke. There might be a possibility to drain typical snail habitats or fence them, so grazing stock doesnôt go there. (West et *al*. 2002, 186, 194-195.) Also putting 0,5 kilograms of copper sulphate into a dam about of one half hectare could eliminate flukes. Soil should have good nutrient amounts, especially lime, so snails that act as a mediate host are not living on the area. (Coleby 2000, 161.)

Doctor William A. Albrecht found out that copper is preventing worm infestations. Especially tapeworms are susceptible to copper. It would be appropriate to give copper included licks to sheep for their health, fertility and prevention of worms. Copper should be given as a copper sulphate, because it is not as strong as copper carbonate. Giving an overdose of copper carbonate can kill an animal. Dark colored sheep need about six times as much copper as white sheep. Also merino sheep need more copper than other breeds, because their wool is very fine and dense. (Coleby 2000, 82, 84, 116, 158.)

To find out how resistant sheep are against parasites, it is possible to use tests, like WormFEC (Morris 2002, 101). The heritability of worm resistance is 32 per cent. (Morris et *al*. 2001, 93).

It is possible to make a test of a DNA marker for a gene which influences parasite resistance and also productive traits (growth, wool and carcass meat yield). The test is called WormSTAR, and animals can get zero, one or two stars, depending on DNA types which reduce fecal egg count and have a positive effect to production. Every lamb has two DNA types (one from the dam and one from the sire), so if both parents have reduced fecal egg count and both of them are productive, the lamb gets two stars. If only one parent has reduced fecal egg count and is productive, the lamb gets one star. If either of the parents do not have reduced fecal egg count and are not productive, the lamb gets zero stars. When 847 sires were tested with WormSTAR, the increase in overall production index of those rams

who had one star, was 0,51-3,22 dollars, and rams who had two stars, 1,22-5,70 dollars. To get animals with reduced fecal egg count and good productive traits will take years, but will probably be worth it. (Tate 2008, 104-106.)

3 EXTERNAL PARASITES

3.1 Ectoparasite species

External parasites include blowflies, lice, mites, cattle tick and sheep ked. Ectoparasites are causing huge production losses annually in New Zealand. In conventional production wool can be contaminated with dip residues, and parasites can create resistant strains to chemicals. (West et *al*. 2002, 358.)

Flystrike can cause a sheepôs death or at least it damages the wool and causes serious weight loss. There are three blowfly species in New Zealand attacking the sheep: brown blowfly, *Calliphora stygia*, common green blowfly, *Lucilia sericata* and Australian green blowfly *L. cuprina*. After these have attacked sheep, there might be secondary invaders, like *Calliphora* spp. and *Chrysomya rufifacies*, also called as hairy maggot fly. (West et *al*. 2002, 358.) Flies are 1 centimeter long or longer, and they have a metallic sheen on their bodies. Maggots are 2-16 millimeter long, depending on the stage. Fly eggs are cream colored and clustered on the wool or skin. Adult flies can fly large distances, and a female fly can lay up to 3000 eggs during its life, which lasts about 30 days. (Sargison 2008, 375-376.)

Figure 4 Calliphora stygia

Figure 5 *Lucilia sericata*

Figure 6 *Lucilia cuprina*

In New Zealand there are three louse species: *Bovicola ovis*, *Linognathus ovillus* and *L. pedalis*. *Linognathus* species are sucking lice, when *Bovicola* is a body or biting louse. Sheep ked *Melophagus ovinus* isnôt a big problem in New Zealand anymore because of annual treatment. It was an issue before in fine wooled sheep, because its feces stain the wool. The cattle tick *Haemaphysalis longicornis* can affect clinical disease. Ticks like especially unimproved pasture and secondary regrowth of scrub. (West et *al*. 2002, 360, 362.)

Adult *Bovicola ovis* lice are about 2 millimeter long, red-brown colored, and their nymphal stages are smaller and have a whitish body. *Linognathus ovillus* and *pedalis* are about 2,5 millimeter long and they have red-blue blood-filled body. *L. pedalis* can survive without a host up to 20 days, *L. ovillus* for 2 days. *L. pedalis* lives typically on hindlimbs, scrotum and belly. *L. ovillus* is found on the ears, neck, cheeks and face of the sheep. (Sargison 2008, 389, 393.)

Itchmites (*Psorergates ovis*) are most abundant in winter, and they transfer mainly from sheep to sheep. Itchmites have a long generation and they donôt produce a lot of eggs. Itchmites thrive especially on Merino and Merino-crossbred sheep. It is possible to find itchmites by using skin scrapings. In lightly infested animals that may be difficult, and scrapings must be taken from a large area. (West et *al.* 2002, 362-363.)

3.2 Ectoparasitesô development

Flystrike typically occurs between November and March, when weather is humid and warm. Blowflies can spend their winter as pupae or adults. When it gets warmer in spring and soil temperature is about +12 degrees, pupae hatch and adult flies become active. Flies lay their eggs on warm and moist parts of sheep, and after about 12 hours these eggs hatch. The first stage maggots eat the skin surface of sheep and moult to second stage maggots, which secrete enzymes that liquefy the skin. Maggots are feeding on the skin and developing to third stage maggots. After that they drop onto pasture and burrow into soil. In soil the maggots pupate, and after 1-2 weeks they are adult flies. (West et *al.* 2002, 358.) Blowflies mate after they have had enough protein from dung or a carcass (Sargison 2008, 377). Female blowflies need two or three protein meals for ovarian development and the first egg batch maturation (Bates 2012, 85).

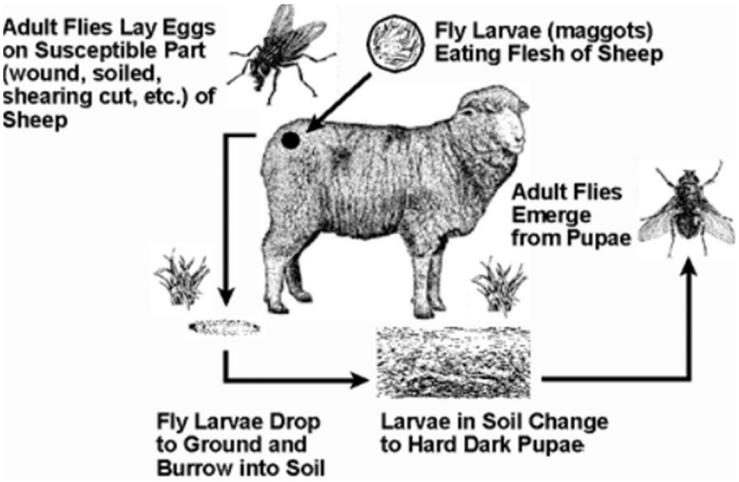

Figure 7 Development of a blowfly

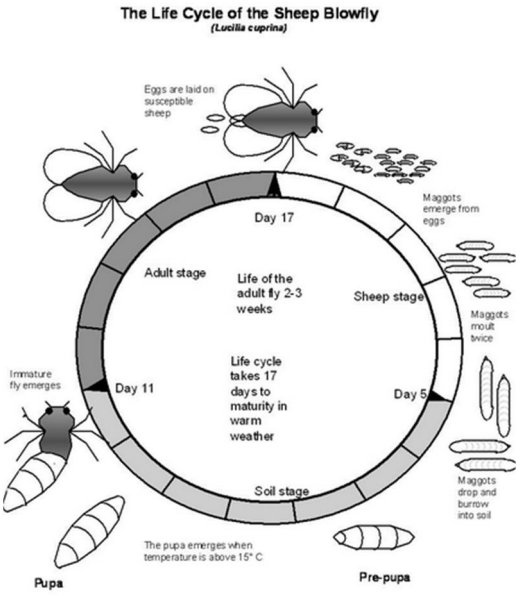

Figure 8 Life cycle of a blowfly Lucilia cuprina

Lice spend their whole life on the sheep, and they eat the skin surface by biting. Lice spread when sheep are in close contact with each other. Lice are the most abundant in autumn and winter, and populations are declining in spring and summer. The development from an egg to an adult through three nymph stages will take 22 days. Female lice can lay 10-30 eggs during their lifetime, which is up to 30 days. (West et *al*. 2002, 361.)

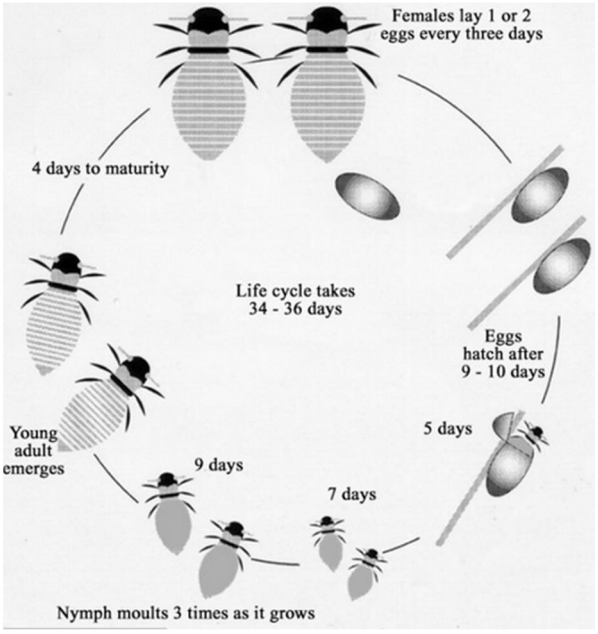

Figure 9 Development of a lice

Ticks have four different stages: egg, larva, nymph and adult. Adult ticks lay their eggs on the ground, and the hatched larva climbs up to the vegetation, from where it transfers to a host animal. Larva eats blood from its host, and after five days it drops back to the ground and moults to the nymphal stage. The nymph repeats the same process as the larva. Nymph moults to the adult stage, which also needs to eat blood. After digesting its blood meal, the adult female tick lays its eggs. Adult ticks are most numerous from November to January on animals, larvae from January to March and nymphs from August to September. All tick stages can be found on animals at the same time through most of the year, except in mid-winter. In New Zealand ticks donôt carry important diseases, like Lyme disease, Q fever or louping ill. (McCutcheon et *al.* 1986, 241.)

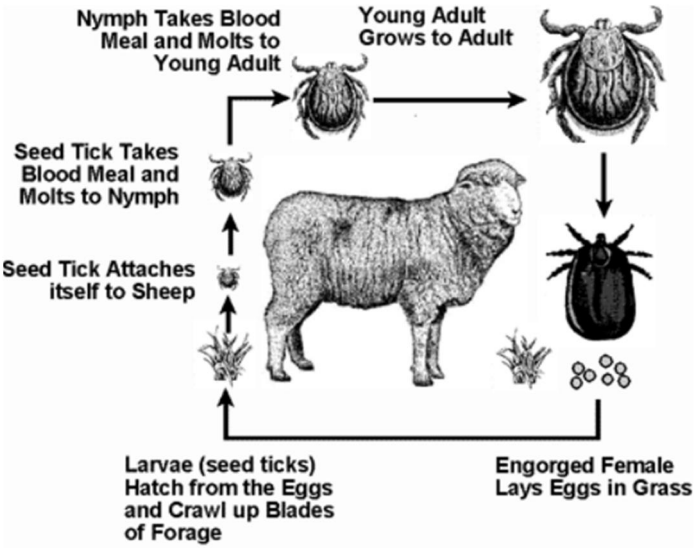

Figure 10 Development of a tick

3.3 The effects of ectoparasites on sheep

Blowfly maggots are causing remarkable damage to the sheep when they are eating the flesh, and the open wound attracts even more flies, which exacerbate the problem. When flies attack, sheep are rubbing, twitching their tails, stamping and biting the area affected. After a couple of days the sheep become depressed, stop eating and seek a shady place. The sheep become dehydrated because of the open wounds where fluid is lost. The sheep will die if they are not treated, because of the loss of protein, electrolytes and fluid and toxaemia. After the sheep are treated, it may take up to 6 weeks until their weight is normal again, and up to 8 months before the fleece has recovered. (West et *al.* 2002, 358-359.)

Open wounds can get bacterial infections, and toxins, released by decomposing tissues and ammonia that maggots are secreting, are absorbed through lesions into the blood, which cause systemic illness, and usually leads to sheepôs death (Sargison 2008, 377). Especially *Lucilia* flies excrete lipid-soluble ammonia, which affects an animalôs heart, lungs and brain (Bates 2007, 334).

Flies attack easily to sheepôs crutch area, especially if it is stained by urine and feces. If the fleece is rotting and there is a dermatophilus infection in the wool, that also attracts flies to lay their eggs onto the sheep. Wherever sheep have injuries, flies may attack there. In addition some Merino sheep have wrinkled skin on their crutch area, and that may attract flies. Sometimes flies attack other parts of sheep without any reason. (West et *al.* 2002, 359.)

Figure 11 Maggots eating a lambôs flesh

Figure 12 Partly healed fly attack on a lamb

Bovicola louse can seriously reduce the fleece quantity and quality. Lice are also causing cockle, which defects sheepôs pelts and reduces their quality. Itchmites (*Psosergates ovis*) cause skin irritation and fleece damages, because sheep are nibbling their skin. (West et *al*. 2002, 360, 363.)

3.4 Treatment of effects of ectoparasites

If flies have attacked the tail and crutch, the wool should be removed around these areas. The clippings should be destroyed, so the maggots canôt crawl away and pupate. It is important not to clip to skin, otherwise skin may get sunburn and healing is much slower. Preventing a flystrike is a better choice compared to treatment. (West et *al*. 2002, 359.)

Shearing can prevent flystrike effectively for a couple of weeks, unless there are cutting wounds. Lambsô tails can be docked to the correct length. It might be beneficial to use some flytraps and get rid of the dead sheep carcasses before flies lay their eggs. In Australia it is typical to mules (surgically amputate the wrinkled skin from the perineum and the breech) Merino sheep, and some farms have tried that also in New Zealand. It is typical to use some dips to prevent flystrike, but they might have harmful effects to the environment and they can leave residues on the wool. (West et *al*. 2002, 358, 360.)

In addition to preventing flystrike, shearing decreases the amount of lice, because lice donôt like light; especially exposing to sunlight and rain and loss of humidity is deleterious to them. When treating animals against ectoparasites, it is important to treat all animals at the same time. Also boundary fences should be in good condition, so neighborôs sheep wonôt contaminate oneôs own sheep. Maybe all neighbors can treat their sheep at the same time. When buying animals for the farm, they should be free from ectoparasites. (West et *al*. 2002, 362.)

Some sheep attract flies more than other individuals. Those sheep should be culled, because some of these attraction factors are hereditary. Also ewes with narrow breeches that favour soiling and deformed genital openings, in which urine drips to the fleece, should be culled. Soiled fleece with ammoniacal decomposition induce flies to lay their eggs. Woolless sheep breeds are relatively resistant to flystrikes. Sheep with a dark colored fleece are also less prone to flystrikes. (Bates 2012, 86, 88.)

Taking care of adequate amount of sulphur in animalsô diet helps to prevent strikes of external parasites. Sulphur can be used also externally if sheep have a lice problem, by sprinkling it along shorn sheepôs back. (Coleby 2000, 94, 117.)

Because blowflies breed in dead carcasses, dead animals should be buried or burned. There is a possibility to reduce the amount of blowflies by using traps, electrified screens or baits. (Ensminger 2002, 206.) Taking care of general animal health, effective control of internal parasites and crutching can aid in the control of flystrikes (Sargison 2008, 379).

There are some natural ectoparasiticides, which have been successful on tests, like neem oil and lavender. In addition garlic and cedar have shown some efficacy against ectoparasites. (Bates 2012, 185-186.)

4 NATURAL PREVENTION OF PARASITES

4.1 Effective substances of plants

Plants produce and accumulate a huge variety of different secondary metabolites for example for defense and interactions with other organisms.

For example over 25 000 terpenes, over 2000 alkaloids and about 8000 phenolic derivatives are known. (Lewinsohn 2004, 435.)

There are several plants that can be used to prevent different kinds of parasites. Especially effective is garlic, which has powers of pulmonary penetration, and worms commonly live in lungs of the sheep (de Bairacli Levy 1991, 192). Unlike Anne Tuomivaara (2009, 183-184) states, garlic can be given at the same time with other worm preventive herbs, like artemisia (wormwood). Worm preventive mixtures should be given when animals are fasting. Lambs can suckle milk from their mothers, otherwise no food allowed. (de Bairacli Levy 1991, 194.)

Garlic (*Allium sativum*) includes diallyldisulphide, which is a pungent constituent (Mills & Bone 2000, 42), diallyltrisulphide, alliin, allypropyl and disulphide (Li 2000, 4, 113). Garlic also includes allicin and saponins, vitamins A, B1 and C, different flavonoids and minerals (Kress 2012, 145). Saponins are effective insecticides and pesticides; they have in addition a strong toxicity regarding to the mammals, which makes the usage a bit difficult (Chaieb 2012, 177, 181). Garlic is antibiotic. Except for using it as a worm medicine, garlic can be used for infections, colic, tumors and to strengthen the heat. (Tuomivaara 2009, 158, 201.) Garlic has been found to be effective against gram-negative and gram-positive bacteria, including multiresistant bacteria strains. It has in addition antiviral and antifungal activity. (Braun & Cohen 2010, 469.) Garlic has been proven to cause anemia to dogs (Poppenga 2007, 186), so raw garlic doesnôt work as a worm medicine for dogs.

Eucalyptus (*Eucalyptus* spp.) includes different monoterpenes with antimicrobial potency. Essential oil of eucalyptus is effective at least against *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli* and *Listeria monocytegenes*, and showed some effectiveness against *Salmonella anatum* and *S. enteritidis*. (Hassine et *al*. 2012, 79-80.) Essential oils of eucalyptus are citronellal, isopulegol, pinene, eucalyptol, neoisopulegol, limonene, linalool, alpha-terpineol, geraniol, pinocarvone, carvone, citral, myrtenal, cuminaldehyde, globulol, cineole, aromadendrene, eudesmol and eudesmyl acetate (Li 2000, 127). Eucalyptus has been proven to be effective against insects (Khemira et *al*. 2013a, 201-203; Khemira et *al*. 2013b, 207, 209), so it works very well as a fly preventive spray. Eucalyptus can on the other hand cause skin irritation or allergic reactions (Braun & Cohen 2010, 406).

Wormwood (*Artemisia absinthium*) is antiparasitic and anthelmintic, and it has been used also in humans in cases of nematode infestation (Ebadi 2002, 335; Bone 2003, 469). Wormwood includes an essential oil called thujone, which is neurotoxic. One ingredient is a bitter called sesquiterpene lactone. (Mills & Bone 2000, 30, 38; van Wyk & Wink 2004, 54.) Other major constituents are absinthol, tannins, flavonoids and phenolic acid. Essential oils of wormwood are phelladrene, pinene, artabsin, anabsinthin azulenes and thujyl alcohol. (Li 2000, 7, 115.) Other artemisia species, besides *A. absinthium*, have also been proven to be effective against mosquito larvae, and in addition to being antifungal and antimi-

crobial (Javadi 1989, 265; Mamedov & Craker 2009, 278-279). Wormwood is toxic (Li 2000, 72). Itôs essential oil thujone is one of the most toxic oils (orally LD_{50} 0,96 gram/kilogram) (Wynn & Fougère 2007, 191).

Tansy (*Tanacetum vulgare* L.) is moderately bioactive against insects because of its terpenoids. Tansyôs related species, pyrethrum (*Tanacetum cinerariifolium*) contains pyrethrin, which is an effective insecticide and pesticide. (Keskitalo 2002, 197-199, see also appendix 1.) Tansy is effective against worms, and its major component is thujone, like wormwoodôs. A betathujone concentration can be as high as 80 per cent, but it depends on genetic variations. (Crellin & Philpott 1990, 424-425.) Essential oils of tansy include also camphor, limonene, artemisia ketone, borneol, chamazulene, gamma-terpinene and dihydrochamazulene. Tansy is toxic. (Li 2000, 46, 104, 149.) Tansyôs essential oil thujone is toxic (oral LD_{50}), when the dose is 0,73 gram/kilogram (Poppenga 2007, 191).

There are seasonal changes on effective substances of plants. The effects can vary depending on the geographical region, soil, climate and weather. If growing medicinal plants in oneôs own garden, it should be noticed, that effects of plants can be different in different years.

4.2 Dosing

Animals can have different reactions to treatment. It depends on the weight, age, life stage and individual traits how treatment is affecting. Herbs active in the pelvic area shouldnôt be given during pregnancy. Herbs can have interactions between each other, and there might be also drug-herb interactions. The user must know if a herb is neutralizing or overpowering the effect of other herbs or drugs. (Fougère & Wynn 2007, 236.)

For example wormwood is abortifacient, emmenagogue and possibly uterine stimulant. Large doses of garlic serve as uterine stimulant, and it can have emmenagogue affects. (Harman 2007, 417.) No matter what herbs you use, still the most important thing fighting against parasites is to guarantee well-managed pastures, high quality nutritious food, fresh water and shelter from the weather (Karreman 2007, 442).

5 CASE TAUROA

Tauroa is a biodynamic farm in Havelock North, Hawkeôs Bay, New Zealand. There are approximately 400 (-700 when buying lambs to grow) sheep and 350 cattle animals. I was researching how different kinds of natural sprays are effective in preventing flystrikes. We used four kinds of hydrosols: eucalyptus, wormwood (artemisia), citrus and mixture of eucalyptus and wormwood. The research started in November 2014 and continued until March 2015. At the same time we also drenched the sheep with a natural drench made from artemisia, tansy, garlic, seaweed, vinegar and molasses. All sheep were drenched with the same drench.

To make a drench 1/3 garlic, 1/3 artemisia and 1/3 tansy are needed. Garlics are chopped and artemisia and tansy are cut to a kettle which will be filled with water. Substances are simmered gently and let stand until the next day. It would be good to blend a brew with a blender and then strain the mixture. In the ready brew there canôt be any plant parts; otherwise a drench gun will clog. The mixture is mixed with molasses, seaweed and vinegar. Herb mixture is needed ½, vinegar ½, seaweed 1/20 and molasses a little bit for taste and trace elements, minerals and vitamin B.

Figure 13 Middle of the drenching, drench gun is stuck

Lambs were separated to four different groups and were identified by ear tags of different colors. Pink color was for wormwood, blue color was for eucalyptus, and lambs with no tags were sprayed with a mixture of wormwood and eucalyptus. Conventional lambs bought to the farm in November were sprayed with citrus hydrosol. Drenching and spraying was done two days before the full moon. That is because wormsô liquid cycle is greatest over that time, and they are more vulnerable to the effects of

worm medicine. Adult sheep were drenched with 40 milliliters of drench and lambs with 20 milliliters of drench.

Figure 14 Drenching gear

Figure 15 Spraying gear

Different hydrosols were mixed with water; ½ liters of hydrosol to 6 liters of water. Then it was sprayed on the sheepôs backs, shoulders, loins and buttocks. We also used homeopathic Tuberculinum 200c to prevent pneumonia (3 caps to 7 liters of water). That was sprayed to the nose area of the sheep.

Figure 16 Drenching a worm medicine and spraying a fly preventive spray and a homeopathic Tuberculinum 200c to prevent pneumonia

Sheep were shorn on the 11th of October and drenched and sprayed the first time on the 5th of November. Drenching and spraying were repeated on the 5th of December, 3rd of January, 2nd of February and 4th of March.

On the 10th of December the first lamb was crutched and treated because of maggots. She belonged to the artemisia-eucalyptus -group. The used treatment was insecticide called PyGanic (see appendix 1), which includes pyrethrum (chrysanthemum), mixed with Tea Tree oil. The sheep must be checked several times a week, especially when it is moist and warm.

On the 23rd of January one of the conventional lambs sprayed with citrus -hydrosol was crutched and treated with PyGanic and Tea Tree oil. Unfortunately he died on the next day. On 24th of December we treated 11 lambs (five from the artemisia -group, one from the eucalyptus -group and five from the artemisia-eucalyptus -group). Three lambs of the artemisia -group and four lambs of the eucalyptus-artemisia -group were drenched with a synthetic drench called Cydectin (moxidectin, see appendix 2). Those lambs were very little and skinny. The lambs drenched with Cy-

dectin lost their organic status and were marked with green ear tags. Cydectin prevents also ectoparasites.

On the 30th of December we crutched and treated with PyGanic and Tea tree oil 14 lambs, five of them from the artemisia -group, five from the eucalyptus -group and four from the artemisia-eucalyptus -group. Especially the smallest lambs had large quantities of maggots on their skin.

Figure 17 Crutching a lamb with a fly attack and maggots

On the 3rd of January we drenched and sprayed the sheep. All lambs were shorn, and three lambs from the artemisia group, two lambs from the eucalyptus group and two lambs from the artemisia-eucalyptus group were treated with PyGanic-Tea tree oil mixture. Two lambs from the artemisia group, one lamb from the eucalyptus group and one from the eucalyptus-artemisia group were treated before. All conventional lambs looked really good, no flystrikes there. When lambs are shorn, they are easier to check in case of the flystrikes and also easier to spray with the hydrosols. And it takes a while for wool to grow back, which also prevents fly from attacking and laying their eggs. All sheep were moved to the new pastures to prevent the contamination of internal parasites. The lambs were also weaned on the 3rd of January, after shearing and treating.

Three weakest lambs (two from the artemisia -group and one from the artemisia-eucalyptus -group) died on 7th-8th of January. They were in a really bad condition and couldnôt handle the infection after flystrike.

On the 2nd of February we drenched and sprayed the sheep. Some of the lambs and ewes were coughing quite badly. We decided to treat the new organic lambs (Perendales) at the same time that they are shorn. The sheep looked quite good this time, no maggots or very sick individuals.

A new group of organic lambs arrived on 22nd of January, and we drenched and sprayed that group of Perendale lambs with wormwood spray on 14th of February after shearing.

Figure 18 New organic Perendale sheep 2.2.2015

On 4th of March we drenched and sprayed all sheep once again. Overall the sheep looked pretty good, unless there were some smaller and weaker individuals within the groups. Later some of the smallest and weakest lambs died, and we needed to drench some of the lambs (mainly our own organic ones) with a synthetic drench (Cydectin). We lost several lambs because of worm infestation and fly attacks during the research project (2.4. the amount was 71 dead lambs, and we still have some weak lambs left).

6 CONCLUSIONS

Sizes of the groups of examination were too small, there wasnôt a control group, and time was limited, so it is hard to make any universal statement of the effectiveness of fly preventive sprays. Years are different, growing conditions are different and the amounts of internal parasitesô larvae and ectoparasites change yearly.

Because flies seem to attack the weakest and smallest lambs, it would be vital to take care of the nutrition of lambs (what kind of mineral amounts there are in the soil, what kind of minerals there are in the grass and if the lambs got enough colostrum from their dams). Because intestinal parasites cause mineral deficiency, all animals need to be treated against worms regularly. When grazing cycles are too short, there are always worm larvae waiting for host animals. Pastures should be completely without animals at least 4-5 months in autumn and winter and 2-3 months in spring and summer. In case of *Nematodirus* species a resting period should be at least 18 months. It can be impossible to leave pastures without grazing for that long time because of the amount of animals, but it would cut the life cycle of worms.

Carcasses should be removed from pastures, so they are not attracting flies to lay their eggs. When crutching and shearing sheep the wool of sheep with maggots should be collected separately and maybe burned right away, so maggots cannot crawl to the ground and pupate.

The most important thing fighting against parasites is to guarantee well-managed pastures, high quality nutritious food, fresh water and shelter from the weather. Good nutrition is the base for everything; it builds an immunity system of an animal. A healthy, well-nourished animal has a better chance to resist parasites and the damage they are causing.

It would be vital to know, what parasite species sheep have, and based on that fact decide what to do. Different parasite species have different life cycles, and knowledge of what parasite species there is on the farm, would help to solve the problem.

On the farm sheep are shorn and tails are docked with a rubber band. That decreases possibility to fly attacks. It could be possible to add some sulphur to sheepôs diet and examine how it works as a fly attack preventive. In addition it would be interesting to test animalsô mineral reservoirs if they are lacking some vital minerals.

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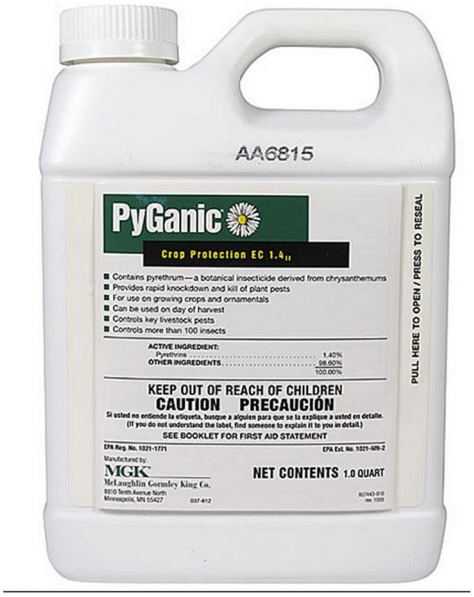
Appendix 1

PyGanic



For Livestock:

When there is an insect infestation on your horses, other livestock or poultry use PyGanic® in a fogger or as a spray. PyGanic® has been approved for use in livestock premises and on livestock.

PyGanic® is a broad-spectrum insecticide and will kill beneficials, including honey bees. To minimize impact, It is advisable to apply it early in the morning or at dusk to avoid killing bees.

- Fly Eliminators are nocturnal, so applying PyGanic® as a fog in the morning will not harm them.
- If other beneficial's have already been put in place, plan to reapply them. Beneficial's can be applied 1 - 2 days after PyGanic®.

PyGanic® is most effective when applied in a final mixed solution that is 5.7 to 7.0 pH. When the solution falls outside this range it is recommended that a buffer (such as Citric Acid) should be mixed with Pyganic to optimize the pH for application.

Adding a surfactant (like Therm-X) will improve coverage by acting as a spreader/sticker.

Pyganic can be tank-mixed with other pest control products including: *Bacillus thuringiensis*, Azadirachtin, Spinosad based products, Neem Oil, and more. It may be applied through irrigation systems or by compressed air or pump sprayers or a fogger.

Suggested Uses: There are no restrictions concerning number of applications per season, because PyGanic® rapidly breaks down in the environment, and there is no residual buildup. Resistance is not an issue.

Source: PyGanic Crop Protection EC 1.4. 2015. Quoted 21.3.2015 http://www.arbico-organics.com/product/omri-listed-pyganic-ec-insecticide-pyrethrin/organic-insecticides

Appendix 2

Cydectin

Cydectin Oral Drench for Sheep

This treatment applies to the following species:

- Sheep

Manufacturer: Boehringer Ingelheim

(moxidectin)

Oral Drench for Sheep

Antiparasitic

NADA 141-247, Approved by FDA

Contains 1 mg moxidectin/mL

For Treatment and Control of Infections Due to Internal Parasites of Sheep.

Consult your veterinarian for assistance in the diagnosis, treatment, and control of parasitism.

PRODUCT DESCRIPTION: CYDECTIN Oral Drench for Sheep is a ready-to-use solution containing 0.1% moxidectin. Moxidectin is an endectocide in the milbemycin chemical class which shares the distinctive mode of action characteristic of macrocyclic lactones. Moxidectin acts by interfering with chloride channel-mediated neurotransmission in the parasite. This results in paralysis and elimination of the parasite.

Cydectin Oral Drench for Sheep Indications

CYDECTIN Oral Drench for Sheep, when administered at the recommended dose level of 0.2 mg moxidectin/2.2 lb (0.2 mg/kg) body weight, is effective in the treatment and control of adult and larval (L_4) stages of the following internal parasites of sheep:

Parasites

Haemonchus contortus - Adult and L_4

Teladorsagia circumcincta - Adult and L_4

Teladorsagia trifurcata - Adult and L_4

Trichostrongylus axei - Adult and L_4

Trichostrongylus colubriformis - Adult and L_4

Trichostrongylus vitrinus - Adult and L_4

Cooperia curticei - Adult and L_4

Cooperia oncophora - Adult and L_4

Oesophagostomum columbianum - Adult and L_4

Oesophagostomum venulosum - Adult and L_4

Nematodirus battus - Adult and L_4

Nematodirus filicollis - Adult and L_4

Nematodirus spathiger - Adult and L_4

ADMINISTRATION: CYDECTIN Oral Drench is ready-to-use. Administer 1 mL per 11 lb (1 mL per 5 kg) body weight into the mouth of the sheep, using any standard drenching equipment. Check dose rates and equipment before drenching. Do not over-dose. Do not mix with any other products before administration. Avoid contaminating the drench solution.

DOSAGE: The recommended rate of administration for CYDECTIN Oral Drench for Sheep is 1 mL per 11 lb (5 kg) body weight to provide 0.2 mg moxidectin/2.2 lb (0.2 mg/kg) body weight. The table below will assist in the calculation of the appropriate volume of drench in 1.0 mL increments and it must be administered based on the weight of animal being treated.

Body Weight		**Dose**
11 lb	5 kg	1 mL
22 lb	10 kg	2 mL
33 lb	15 kg	3 mL
44 lb	20 kg	4 mL
55 lb	25 kg	5 mL
66 lb	30 kg	6 mL
77 lb	35 kg	7 mL
88 lb	40 kg	8 mL
99 lb	45 kg	9 mL
110 lb	50 kg	10 mL
121 lb	55 kg	11 mL
132 lb	60 kg	12 mL
143 lb	65 kg	13 mL
154 lb	70 kg	14 mL
165 lb	75 kg	15 mL

HUMAN WARNINGS: Not for use in humans. Keep this and all drugs out of the reach of children. To obtain a copy of the material safety data sheet (MSDS) which

provides more detailed occupational safety information or to report adverse reactions attributable to exposure to this product, call 1-866-638-2226 FREE.

RESIDUE WARNINGS: Sheep must not be slaughtered for human consumption within 7 days of treatment. Because a withholding time in milk has not been established for this product, do not use in female sheep providing milk for human consumption.

ENVIRONMENTAL WARNINGS: Studies indicate that when moxidectin comes in contact with the soil, it readily and tightly binds to the soil and becomes inactive. Free moxidectin may adversely affect fish and certain aquatic organisms. Do not contaminate water by direct application or by improper disposal of drug containers.

ANIMAL SAFETY WARNINGS: CYDECTIN Oral Drench for Sheep has been formulated specifically for oral use in sheep and should not be given by any other route of administration. Do not use in sick, debilitated, or underweight animals. This product should not be used in other animal species as severe adverse reactions, including fatalities in dogs, may result.

ANIMAL SAFETY: A well-controlled U.S. study has demonstrated an adequate margin of safety to allow treatment of sheep four months of age and older with Cydectin Oral Drench. In this study no signs of toxicity were seen in sheep given up to 5 times the recommended dose. Reproductive safety studies evaluating the use of Cydectin Oral Drench in breeding ewes and rams have not been conducted in the U.S.

Source: Cydectin Oral Drench for Sheep. n.d. Drugs.com. Quoted 21.3.2015
http://www.drugs.com/vet/cydectin-oral-drench-for-sheep.html