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Review on the importance of pasture and grazing management in the control of internal parasites of livestock

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Abstract

Pastures serve as reservoirs and provide suitable environment for the survival and development of internal parasites of animals. Warm and moist pasture environment is very conducive for the survival and development of parasite larvae. Based on the amount of moisture, parasite larvae could be distributed horizontally and vertically on the pasture in order to reach to grazing animals. Managing pasture and animals to provide adequate nutrition for each stage of production and to avoid contact with infective internal parasite larvae will result in improved health and production for grazing animals. There are many strategies that help to make the pasture free from parasitic infestation and safeguarding the health of grazing animals. The strategies are preventive, evasive and diluting strategies. Anthelmintic drugs cannot be used as the only method in cure, control and prevention of parasitic infection without a proper pasture and grazing management. Having a very programmed pasture management helps to control and prevent parasitic infection, to minimize antihelmentic drug use, ensure animal health and increase economic growth by preventing mortality and morbidity domestic animals. Pasture treatment approaches involves **b**iological control of Endoparasites, controlling helminthes through proper pasture and grazing managements by using an important tool such as pasture management calendar which is a guide line for managing pasture without any missing throughout the year. In line with this, even though grazing system is traditional in Ethiopia, proper pasture and grazing management do have a great impact to improve livestock health, production and economy of the country at large.

Keywords: Pasture, Grazing, Endoparasites, Anthelmintic, Management.

Introduction

Pasture is a field covered with grass or herbage and suitable for grazing by livestock. Despite of its benefit pastures it also provides the environment for the survival, development and hatching of parasite eggs and larvae as well as the intermediate hosts. Therefore, the scientific management of pasture is an effective way to control internal parasites in grazing livestock since grazing animals are always exposed to parasites and are thus constantly being re-infected in chain reactions mode (Stuedemann *et al*., 2004).

Several worldwide reports have suggested that the parasitic diseases inflict severe economic losses on the livestock industry and adversely affects the health, weight gain, feed conversion efficiency and reproduction of animals, for example, due to fasciolosis in livestock estimated significant economic loss at US $ 3.2 billion per annum worldwide, mainly due to condemnation of livers at abattoirs, mortality in infected flocks, persistently depressed growth and feed conversion efficiency, loss of productivity, impaired fertility and also the cost of treatment (Spithill *et al*., 1999). The internal parasites include flukes, flat worms and round worms, only a few of them account for the majority of problems for grazing animals. In large scale sheep and goat farming systems endo-parasite have been become a major threat, which is reflected in the sales figures of many countries (Coles, 2005).

Anti-parasitic drugs are effective to minimize the internal parasites in grazing herd. However, this does not able to provide a long term solution. Therefore, an integrated approach becomes obligatory to control internal parasites with objective to harvest the optimum productivity from grazing herds (Rahmann and Seip, 2007).

Pasture needs a proper management in order to control parasitic infection which is transmitting during grazing. The main function of pasture and grazing management system is to provide safe/ clean pastures on which animals can safely graze as well as sufficient forage availability for grazing animals (Barger, 1999). In order to control gastro-intestinal parasites through grazing management three strategies can be categorized as measures to minimize new and re-infection. According to Thamsborg et al. (1999), these three categories are ‘preventive strategies (*Turning out parasite free animals on clean pastures)*, ‘evasive strategies (*moving animals from contaminated to clean pasture)*’ and ‘diluting strategies (Mixed grazing with other host species). Futhere more, there are many pasture treatment approaches conducted to control parasite infestation and to have clean pastures. Those approaches are biological control of endoparasite, including condensed tannin plants in to pasture to insure disease resistance of animals, apply mixed grazing, selectively treating areas invaded by intermediate hosts such as snails etc… (Younie *et al*., 2004). The aim of this review paper is therefore to compile available information on the importance of pasture and grazing management in the control of internal parasites of livestock and improvement of animal health and their productivity.

Distribution and migration of parasite larvae on pasture

The base for successful parasite control in small ruminants is, to keep the pasture infection level low so that the animals are not exposed to an excessive larval population on the pasture. A further fact that may be considered in this context is the possible correlation between actual migration height of infective larvae and stocking rate. the majority of larvae usually “crawl only one inch from the ground onto herbage, so not allowing animals to graze below that point will cut down a lot of infestation” (Wells, 1999). Another source writes that about 80% of the infective larvae can be found on the first two inches of vegetation, so avoiding grazing to below this level will reduce problems (Schoenian, 2005).

Larval development on pasture

Most gastrointestinal nematode worms have a direct life cycle, with a parasite phase and a free-living phase. And also, less than 5 % of the parasite population of a sheep flock is in the animals’ gastrointestinal tracts, while the remainder (about 95 %) is on the grasslands (Bowman *et al*., 2003). Therefore, under favorable conditions, infective larvae travel to the tip of forages and enter into grazing animal’s digestive tract along with the forages that animals eat. This is the case of parasites having direct lifecycle (parasites that require only one host to complete their lifecycle) such as most of the roundworms of veterinary importance (Figure 1). For the parasites having indirect lifecycle (parasites that require more than one host to complete the lifecycle) such as liver flukes (snails are the intermediate host) and ruminant tapeworms (pasture mites are the intermediate hosts) (Urquhart *et al*., 1996).

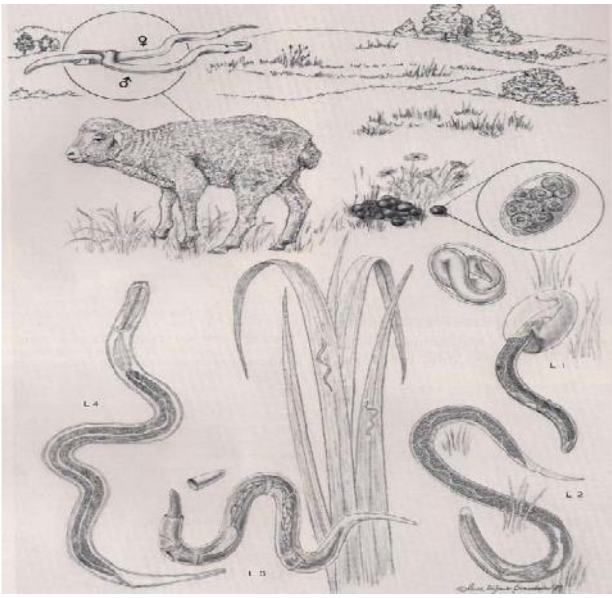

Figure 1. Typical roundworm lifecycle
Source: Bowman and Lynn, (1995)

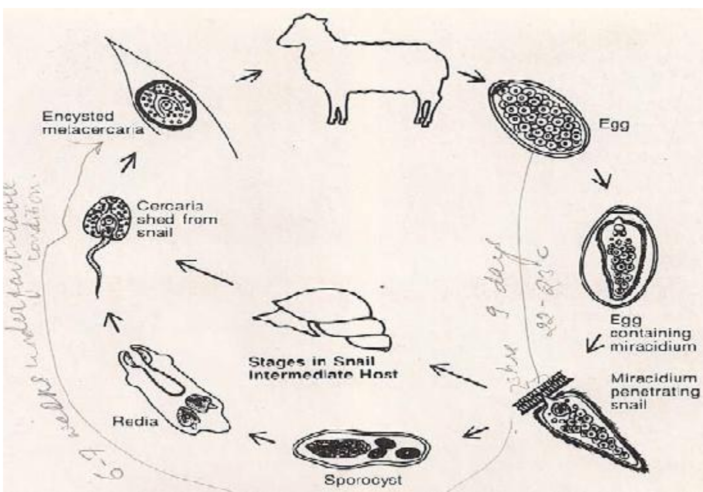

Figure 2. Liver fluke lifecycle and the stages that occur in pasture (indirect life cycle)
Source: Urquhart et al. (1996).

Horizontal distribution of larvae on pasture

Successive harvests of grazable herbage have an effect on the population dynamics of third stage larvae (Boom and Sheath (2008). A number of studies had looked at the development and migration of third stage larvae from animal feces to pasture and that few larvae migrate further than 30 cm from the faecal pats even after significant time and rainfall (Gruner and Sauve, 1982). Herbage was harvested four times (22–248 days) from around the faecal pats in three zones (0–20 cm, 20–35 cm and 35–45 cm from the centre of the faecal pat) and the L_3 remained aggregated close (Boom and Sheath, 2008).

Simulated rainfall on dry pats resulted in dispersal of very few L_3 larvae in contrast to pre-watered pats. In pre-watered pats (equivalent to 1.6 mm of rain) L_3 larvae were stimulated to move to the surface of the pat where they could be hit by rain drops. In the controlled laboratory conditions more than 90% of the larvae were transported passively by splash droplets rather than by active migration. On pasture, faecal pats are often surrounded by tufts of rejected grass and will restrict horizontal movement of splash droplets resulting in larvae falling a few cm from the pat. Where splash droplets could move freely L_3 larvae were found up to 90cm away from the pats (Gronvold et al., 1989). The distribution of L_3 larvae around faecal pats has relation with the grazing behavior of animals and the age of the faecal pat Gruner and Sauve, 1982).

Vertical distribution of larvae on pasture

Moisture also serves as a medium for the travel of larvae. When there is a lot of moisture, larvae travel towards the tip of the forage so that, they can reach to the grazing animals through the forages. Crofton (1948) described the number of L3 larvae (Trichostrongylus retortaeformis) on different portions of herbage across three different plant species: Festuca (fescue), clover and Carex nigris (common sedge). The distribution of larvae on sedge (25cm in height) showed larvae to be limited to the lower 5cm, whilst larvae were evenly distributed vertically over the stems and leaves of clover. The distribution of L3 larvae on Festuca varied with plant height: on grass 13 cm high 90% of the larvae were found in the lower 7.5 cm (and 50% below 3.8 cm) whilst on grass 7.5 cm high 90% of larvae were found below 2.5 cm. In the same study the distribution of larvae in the soil, 'mat' and herbage was measured throughout the year and showed highly seasonal differences. In the summer months (June-August) the majority of larvae were found on the foliage and more were found in the soil than the 'mat'. In the spring and autumn more larvae were found in the 'mat' and fewer in the soil or on the foliage whilst in winter larvae were concentrated in the 'mat'. For example, Silangwa and Todd (1964) carried out laboratory experiments to investigate the ability of L3 larvae (Trichostrongylid) to migrate vertically on grasses under controlled environmental conditions. Even under favorable conditions only a small proportion (2-3%) of larvae applied to the soil actually climbed the foliage. Of these 59% were found in the bottom 2.5 cm, 27% up to 5cm, 10% to 7.5 cm, 3% to 10 cm and 1% above this, supporting the findings of Crofton.

Depending on the species of forage zonal distribution and density (larvae per kg dry matter) of parasitic larvae is varying and plants having chicory has lower larval densities above 75 mm from the base than below this height (Moss and Vlassof, 1993). Herbage with a lower larval density will result in animals taking in fewer larvae overall than herbage with higher densities assuming that daily dry matter intakes are similar on both swards. There is little opportunity to control larval intake by manipulating grazing intensity as the larvae were distributed evenly throughout the sward horizon (Moss and Vlassof (1993).

Factors affecting survival of parasite on pasture

In order to manage internal parasites effectively, it is important to understand the factors affecting the parasite life cycle. The particular climate of an area always influences the grazing management because egg hatching and larval development both depend on prevailing climatic conditions (Barger, 1999). And the Larval survival times can range from some weeks in the wet tropics (Banks *et al*., 1990) to more than a year in temperate climates (Barger 1984).Therefore wet and warm (65oF–85oF; larvae survival and development is arrested beyond this temperature range) environment is favorable for the survival and development of parasite larvae on pasture environment (Miller, 2004).

Parasite larvae remain close to the ground up to a level where there is enough moisture for their survival. Moisture encourages egg hatching and larval development, while long dry periods cause desiccation (drying) and death. A single, heavy rainfall soon after the eggs (in the manure) land on pasture results in more eggs and larvae surviving, and there are more viable eggs in animals manure that has been rained on within four days than in manure that has been dry for eight days or longer (O'Connor *et al*., 2007). Some larvae will go into the soil, creating a "reservoir" that will protect the larvae from weather extremes (Leathwick *et al*., 2011). During development, larvae are vulnerable to prolonged drought and to cold and may also be destroyed by soil organisms, including earthworms (D'Alexis *et al*., 2009).

Pasture and grazing management systems

A. Basic strategies to reduce pasture parasite contamination

1. Preventive Strategy

Animals are prevented from contaminating the pasture. It is achieved by turning out clean animals on clean pasture which involves delayed turnout, changing pastures between seasons, moving at weaning, late lambing, grass reseeds, cultivation of annual forge crops, silage/ hay aftermaths and alternation of different host species **(**Cabaret *et al*., 2002b; Younie *et al*., 2004). It is also flexible to manage as timing of turn out, weaning and housing is not critical (Barger, 1998).

2. Evasive Strategy

This relies on the removal of a moderate existing infection by anthelmintic treatment, allied with a movement of treated animals to a safe pasture. It involves moving to safe pasture within the same season, alternate grazing of different species, hay or silage aftermaths, new grass reseeds, cultivation of annual forage crop and shifting of animals to other safe pasture before PLB (pasture larval burden) rises to dangerous level (Cabaret *et al*., 2002 b, Thamsborg *et al*., 1999; Younie *et al*., 2004).

3. Diluting Strategy

It involves grazing of susceptible animals (source of contamination) with resistant adult animals in order to dilute the feces of susceptible animals which is rich in worm eggs (Waller, 1997; Barger, 1998).This strategies include: avoid stocking rate close to carrying capacity of plant production, reduction of the general stocking rate, mixed grazing with other host species and mixed grazing with other age group (Cabaret *et al*., 2002b, Thamsborg *et al*., 1999; Younie *et al*., 2004).

B. Other strategies involved in grazing management

1. Dose & Move

This strategy involves moving of animals from pasture to pasture after deworming. It requires a clean pasture but is highly selective anthelmintic resistance (Abbot *et al*., 2004). In the Danish experiment the 'dose and move' strategy was compared to a 'move only' strategy (from an infected to a clean pasture) for lambs at weaning time. As a result acute parasitic gastroenteritis could be prevented and weight gains were comparable for all groups, although pasture contamination was higher on the pastures that had been grazed by the 'move only' group (Githigia *et al*., 2001).

2. Stocking rate

High stocking density on pasture increases PLB. On lowering the stocking density there occur reduction in amount of manure in given area and higher height of residual in the pasture grazing forage (Morley and Donald, 1980).

3. Herbage Height and grazing time

According to Jones (1993), new pasture should be grazed closely so that sun rays can dry the faeces and diminishes the chances of larval survival Larva move to the top of herbage when intensity of light is low, limit grazing time to when the sun is strong diminishes the risk of infection since this may limit the grazing in highly contaminated pasture during summer months and put the animals on new pasture during monsoon.

4. Zero Grazing

Keeping sheep and/or lambs in confinement or dry lot i.e. "zero grazing" is a means of reducing parasitism and preventing re-infection. Under a zero grazing situation, sheep and/or lambs do not have access to vegetation for grazing. They are housed in a bedded barn, dirt lot, or facility with slatted floors. Feed should be fed off the ground in feeders. Watering containers should be kept free from fecal matter. Slatted floors offer the best protection against internal parasites because sheep generally do not come into contact with their feces. This system is practiced for fat lamb production and animals are raised in confinement on dry lot (with no grass) without any problem of gastrointestinal nematodes (Singh and Swarnkar, 2005).

Pasture treatment approaches

Biological control of endoparasites

The principle of this strategy bases on the rule that all species of animal are regulated by other living organisms to prevent the uncontrolled increase of one population (Grønvold *et al*., 1996). In the context of parasite control it usually means the use of a naturally occurring antagonist to lower a pest population which would otherwise cause losses to animal production. That of all possible antagonistic organisms for example, nematophagous fungi, earthworms and dung beetles have realistic potential as biological control agents, although there are several species that little or nothing is known about and therefore their potential use for biological control cannot be assessed/estimated (Grønvold *et al*., 1996).

Earthworms: earthworms are soil inhabitants that live on organic matter deposited on the soil surface. Organic matter gets pulled down below the surface either for food or to plug the earthworms burrows. Therefore the major contribution of earthworms towards the biological control of parasites is seen in the destruction of eggs and larvae by digesting them or transferring them to deeper levels of the soil where chances that they can reach the surface as infective larvae are very low (Grønvold *et al*., 1996). Earthworms reduce the total number of larvae on the pasture by consuming them and in other hand they decrease pasture related parasite infection of livestock's (Waghorn *et al*., 2002).

Dung Beetles: The term 'dung beetle' refers to those beetles that live partly or exclusively on the dung of herbivorous; most species belong to the family Scarabaeidae. Adult beetles use the liquid contents of manure for their nourishment and some species form dung balls which they bury and lay their eggs in, others just live in the manure pats (Thomas, 2001). Although, the activity of dung beetles is being controversial because, they involve in breaking up the pats and partially burying the manure, they enhance the drying up of the dung which deteriorates growing conditions for larvae (Grønvold *et al*., 1996). Dung beetles can reduce larvae on herbage in between 40 to 93%, the percentage of reduction correlated positively with the number of beetles (Waghorn *et al*., 2002).

Nematophagous Fungi: nematophagous fungi are soil inhabitants and can be found in most soil types throughout the world and they are found more frequently in organic production systems than any other (Jansson *et al*., 2004). The biological control with nematophagous fungi are well documented all over the world. The fungus *Duddingtonia flagrans* is relatively easy to culture and can be released in the environment against the targeted parasites in a controlled fashion (FAO 2002; Waller and Thamsborg, 2004). So that, it is widely used to control gastro-intestinal parasites of grazing animals by reducing pasture load (Sanyal *et al*., 2008).

These fungi can be divided into groups depending on their mode of affecting nematodes: there, are nematode trapping, endoparasitic, egg and female parasitic and toxin producing fungi (Jansson *et al*., 1997). The fungi of the nematode trapping group all have in common that they form a vegetative hyphal system that produces trapping organs such as sticky nets, knobs or rings (Hertzberg *et al*., 2002). When for example, a nematode gets trapped, the fungi penetrate the nematode cuticle with their hyphae that then grow out and fill the body of the nematode to finally digest it (Grønvold *et al*., 1996). The idea of using nematophagous fungi is to control parasitic nematodes and which is based on the reduction of the larval level in the faeces before larvae reach the vegetation, which requires a high density of spores in the faeces. There are two possible ways to reach that high spore density, the first is to artificially inoculate the faeces and the second way is to administer the spores orally. Since the first way seems not viable the only possibility was to discover those fungi that are able to survive the gastro-intestinal tract of ruminants. In order to know the effect of nematophagus fungi there was many trials from those, the trials used orally spore numbers in between 3x105 and 5x107 chlamydospores per day, some dosed it per kilogram bodyweight (Faedo *et al*., 2000

Among other funguses, *Duddingtonia flagrans* is a fungus that produces trapping nets and the presence of any nematodes induces the trap production, which lasts for approx. 2-3 weeks and the optimum temperature for the development of trapping nets is 30°C; a rise in temperature to 35°C or more causes any fungus activity to stop and a fall in temperature to below 10°C reduces the trapping ability. Therefore, *D. flagrans* significantly reduces the number of infective larvae that migrate onto the pasture and it also has no effect on larval migration of prior and post deposited faeces (Hertzberg *et al*., 2002).

Controlling parasites through effective pasture management

Understanding the influence of pasture management on the internal parasite control possibly starts with detailed epidemiological knowledge of the development of the parasites in and outside their hosts and the grazing behavior of animals. In context with grazing management and epidemiological knowledge the two terms 'safe' and 'clean' pasture are often referred to and it seems advisable to explain them to avoid misunderstandings. 'Clean' pasture is the expression for a pasture with a nil or very low infection risk when animals are firstly grazed on it

(Younie *et al*., 2004), this is achieved by a three year rotation between a susceptible species, an unsusceptible species and the use of the land for forage or crops (Thamsborg *et al*., 2004). Grazing animals eat an array of plants, but often prefer some and avoid others. These preferences or aversions are responses to certain physical and chemical senses of which touch, smell and taste are of greatest importance for ruminants (Bazelly, 1990). Ruminant are known to avoid grazing herbage which is contaminated with faeces (Hutchings *et al*., 1998). Cattle and sheep will generally avoid grazing near faeces and that sheep were sensitive to both the amount and age of fecal deposition (Hutchings *et al*., 1998). The rejection was most apparent around very fresh faeces that actually pose less of a parasite risk because the L3 larvae had not developed. Sheep generally prefer grazing uncontaminated patches of pasture and that the presence of faeces enables sheep to detect and avoid contaminated patches (Cooper *et al*., 2000). So that, grazing behavior in sheep is varying between 1cm on very short (3 cm) swards up to around 2.5cm on swards of 6cm or over. Meanwhile, cattle grazing swards at 6-8 cm could be taking the top 2-3 cm off the top of the sward as they graze (Bartham, 1981).

1. Condensed-Tannin Containing Forages: the pasture plants containing condensed tannins have anthelmintic properties (Hoste *et al*., 2005a). Those animals grazing tannin rich forages have lower faecal egg counts than animals grazing traditional grass pastures. The tannin may also decrease the hatching rate of parasite eggs and larval development in faeces. Forage plant species which contain high levels of condensed tannins include *Sericea lespedeza* (warm season legume), birds foot trefoil (perennial legume) and chicory (leafy perennial) (Marley *et al*., 2003).Tropical legumes contain more condensed tannins than temperate legumes. Normally trees and shrubs contain higher levels of tannins than pasture grasses (Niezen *et al*., 1998). Therefore planting condensed tannin rich plants help to prevent pasture contamination by shaded larvae Hoste *et al*., 2005a).

There are two main explanations for the mode of action of condensed tannins being observed the, Direct mode of action and Indirect mode of action. The direct mode of action:- is involves that Condensed tannins directly react with the proteins on the surface of the parasites and disturb the normal physiological functions of the parasites like mobility, food absorption or reproduction. The indirect mode of action:- is when tannin-rich forages are consumed, then the released condensed tannins build complexes with proteins and protect these from ruminal degradation (tannins have a higher affinity to proteins then to other substances) and these complexes dissociate in the abomasum and release protein, ready for absorption (Heckendorn, 2005).

Short-term of grazing chicory leads to a reduced adult worm burden but no differences in egg output (Tzamaloukas *et al*., 2005). Grazing chicory may help infected animals to balance weight loss due to parasitic infestation and thereby enhance the buildup of immunity. Therefore, Chicory has strong antihelmentic effect on parasite larvae (Anthanasiadou et al. (2005). For example, In simple experiment by Marley et al. (2003a, 2003b), who found that infected lambs grazing chicory had the highest live weight gain and the scanned faeces had a tendency of fewer larval development.

Figure 1: chicory plant. **Source:** http://www.ediblewildfood.com/chicory.aspx.

2. Birds foot Trefoil: *Lotus corniculatus, L. penduculatus* (Family: Fabaceae): These two lotus species are herbaceous perennial legumes with yellow flowers that are native to Europe and parts of Asia (Lolicato, 1998). Lotus penduculatus is referred to as 'Greater Birdsfoot Trefoil', 'Maku Lotus or 'Greater Lotus' whereas the other species is either called 'Birdsfoot Trefoil' or 'Goldie Lotus'. lotus have Positive results in live weight gain during infections and variable results for the reduction of egg output and worm burden (Rattray2, 003).

Figure 2: Sulla:Hedysarum coronarium (Family: Fabaceae)
Source:
http://www.ediblewildfood.com/chicory.aspx

Sulla is a biennial or short-lived perennial with flowers that can vary from pink to violet originating from the Western Mediterranean and Northern Africa (Frame, 2006). Sulla is highly palatable, nutritious and productive forage for ruminant production (Foster, 2010). It is cultivated throughout the Mediterranean basin, where it is extensively grown as a 2-year forage crop for grazing and/or hay or silage production. The species plays a key role in cereal-based systems of semi-arid regions, particularly in organic and low-input agriculture, and is commonly used to enhance the productivity and sustainability of farming systems (Ruisi *et al*., 2011).

One of the main values of sulla is its water requirement coupled to its ability to provide large amounts of palatable forage in steppe areas (Crocker *et al*., 2003.). Due to its excellent adaptability to marginal and drought-prone environments, versatility as a good quality, high-protein forage crop, and its moderate levels of condensed tannins beneficial to ruminant production and antiparasitic nature (Ruisi *et al*., 2011). The type of CT inside sulla plants have advantages in preventing bloat, improving the efficiency of forage protein utilization in ruminants and also it has potential value of natural anthelmintic effect, as it reduces the establishment of ingested parasite larvae and also reduces the dagginess commonly associated with parasitism, thereby reducing the incidence of fly strike (Niezen *et al.* 1995).

3. Sainfoin: Onobrychis viciifolia (Family: Fabaceae): Sainfoin is a perennial herb which is distributed in Europe, parts of Asia and Northern America (Frame, 2006). Flowers of sainfoin plant are showy and pink, white or purple and tightly arranged in a compact raceme with 20 to 50 flowers per head. The addition of Sainfoin to pasture can reduce faecal egg count and therefore lead to lower pasture contamination (Paolini *et al*., 2003c; Hoste *et al*., 2005a; Lüscher *et al*., 2005). Sainfoin plant has promising potential against pasture parasite contamination but it appears not competitive in leys and has high weed infestation (Sainfoin lack competitiveness to weed invasion) and poor establishment when compared to cultivation of mixed sainfoin/grass stand(Thamsborg, 2001b; Athanasiadou *et al*., 2005b).

Sainfoin is preferred over alfalfa by mule deer and other animals. It greens up earlier in spring than alfalfa and stays green during the summer (Stevens and Monsen, 2004). Its large, deep tap root also makes this species fairly drought tolerant. And it has high protein, high palatability and non-bloating characteristic. Sainfoin is best adapted to soils at least 18 inches deep with a pH of 6.6 to 8.0 (USDA, 2008). It is best adapted to sites receiving at least 14 inches mean annual precipitation (MAP). Rangeland plantings have been successful in sagebrush, pinyon-juniper and mountain shrub areas in deep, calcium based soils (Stevens and Monsen, 2004).

Figure 3: Sainfoin: Onobrychis viciifolia (Family: Fabaceae).
Source:
http://www.ediblewildfood.com/chicory.aspx

4. Quebracho: Schinopsis ssp: In the medical context Quebracho is referred to as an extraction from the bark of one the Schinopsis ssp. which is rich in condensed tannins (Paolini *et al*., 2003a). Quebracho leds to the reduction in FEC, lower female fecundity but it does not seem to lower the adult worm burden and animals receiving quebracho had a lower live weight gain and inferior food conversion, although performance of parasitized animals did not decline to the same extent as control animal (Athanasiadou *et al*., 2000).

For example, to examine and to know the effect of Quebracho two short-term experiments were conducted by Paolini et al. (2003ab), in these experiments previously infected goats were drenched with quebracho extract on a daily basis for 8 days. One group was infected with *Trichostrogylus colubriformis* and *T. circumcincta* (2003a) and the other group was infected with *H. contortus*. In all groups the treatment led to a reduction in egg excretion and female fecundity, with no change in the established adult worm population. This study also tested the effect of quebracho on incoming larvae of both species and a reduction was only observed for *T. colubriformis,* the reduction of *T. circumcincta* larvae was insignificant. There are no verified results available on effect of Quebracho on incoming larvae. However studies on quebracho administration remain scarce and although the available results are relatively clear and indicate anthelmintic properties for quebracho (Hoste *et al*., 2010).

Figure 4: Quebracho: Schinopsis ssp. (Family: Anacardiaceae)
Source:
https://www.grassland.org.nz/publications.

5. Include Browse and Tall Forages into pasture

Goats love browsing as they are browsers originally .Goats prefer a diet composed of 20-30% grass, 10-30% broadleaf weeds and legumes, and 40-60% browse and they will also consume a wider range of plants than will cattle (Ball, *et al.*, 2007). Goats have a different strategy for avoiding infection: a preference for browse (brush, vines and trees) and for wandering great distances, thus leaving areas of contamination (Hoste *et al*., 2010). Since parasite larvae are concentrated under the pasture canopy, parasite infection of goats can be significantly lowered keeping the goats' head up such as when browsing.

6. Apply Mixed-Species Grazing

Multi-species grazing have been utilized for many different reasons. It is primarily touted as a means to maximize both animal and pasture production and it is also ideal for vegetation management, especially for invasive, noxious, or unwanted species (Animut *et al*., 2005; Hart; Luginbuhl, 1996). Additional and very vital benefits of mixed species grazing include pasture parasite control in grazing animals (Walker *et al*., 2006).

Before mixing different species of animals for grazing the different grazing behavior of animals has to be known. Each species has different grazing behavior that complements one another. For example, sheep prefer to eat weeds (Whittier *et al*., 2003), short tender grasses and clover, while cattle prefer to eat taller grasses thus allowing the sun light to reach the ground to kill many parasites. Applying sequential grazing is also very important for pasture parasite control. For example, allowing cattle's for grazing before goat or other small ruminants, decrease parasite infection and decrease the use number of antihelmentic treatment for parasite control (Walker *et al*., 2006).

Mixed species grazing is used to control parasite in different species of animals because several parasite species on pasture cannot infect two different animal species. Parasites which are affecting and causing clinical disease on one species can't cause disease on the other species which are grazing together (Walker *et al*., 2006). Therefore, Sheep and goats are generally not affected by the same internal parasites (Christensen, 2005); similar condition with cattle and horses. Consequently, pastures grazed by large ruminant and horses are safer for sheep (Hartwig, 2000) or and goats (Luginbuhl, 1998) and conversely. Sheep or goat can be co-grazed with bovine and/or horses because parasite infecting goat or sheep can't infect cattle and vice versa (Burton, 2010).

Applying mixed species grazing help to break the parasites life cycle on pasture (Walker *et al*., 2006). Parasite larval intake by sheep from bovine origin is normally of little consequence because of host specificity. And also there is a beneficial aspect in that larvae consumption stimulates the immune response in sheep to challenge their own parasite species. Resistance was also found in cattle, though to a lesser extent, as a result of intake of larvae from ovine origin (Barger 1999). A mixed grazing of cattle and sheep has been shown to improve livestock productivity of one or both species involved but it has been suggested that this is due to the complementary grazing leading to improved pasture utilization (Jordan *et al*., 1988).

Based on the condition of the pasture it is better to mix 1-3 goat per cow without a change in the stocking rate in order to decrease pasture parasite contamination and transmission and grazing goats with cattle using the highest stocking rate possible without exceeding the carrying capacity of the land could be beneficial in more effectively renovating the pasture (Animut *et al*., 2005). Cattle and goats complement each other by minimizing the parasitic larva of the other species as they do not share most of the gastrointestinal parasites with major pathogenic importance (Miller et al., 2004). When grazed together, each species dilute the parasite larvae of another species and there by minimize the chance of infection. If co-grazing of cattle and goats is not possible or preferred, each species can be allowed to graze the pasture alternatively. However, one must be careful if there are young calves, which can be infected with *Haemonchus contortus* larvae, although the risk of parasite problem in calves is much less than in goats. Other than benefits of parasite control, mixed species grazing also offers higher forage utilization. Co-grazing of cattle and goats can maximize forage utilization and reduce weed problem because each species has different forage preferences (Abaye *et al*., 2008; Coffey, 2001).

7. Pasture rotation and rest

Pasture rotation, or intensive grazing is optimum use of grass by distributing the pastures into parcels of land of varying sizes called paddocks and frequently moving the livestock from one paddock to another (Johns *et al*., 2004). The main objective of pasture rotation is not to put the animals back into the same field until the risk of infection has diminished. Accordingly, pasture rotation with optimum rest period is an important component to minimize internal parasites in grazing animals. Pasture land can be tilled and used for crop production while crop field can be developed into pasture. All these conversion and tilling operation kill parasite eggs and larvae there by greatly lowering the parasite burden (Colvin *et al*., 2008).

From a parasite control point of view it is important to keep pasture larval population as low as possible. Within a rotational grazing program the longer the rest period the lower the pasture larval population when animals return but the length of the total rotation may expose animals to infective larvae when they return to re-graze. For example, under optimum conditions, *Haemonchus contortus* completes a life cycle in 21 to 25 days. However, animals that already have mature worms will be shedding eggs on Day 1, and those eggs can hatch and have infective larvae by Day 4 or 5. This is the rationale for moving just before Day 4 (Burke *et al*., 2009c). So that, moving goats after five days was adequate to escape parasitism over the summer (Hart, 2012). With time, larvae will naturally die if they are not ingested. However, pastures may have to rest a very long time to allow this natural cleaning: this L_3 can survive for one to three months in tropical or subtropical areas, but in temperate zones they may survive for six months to a year or more (Torres-Acosta and Hoste, 2008).

Achieving parasite control through rotational grazing would probably not be achievable in temperate climates because decline in pasture infectivity could take 3 to 9 months (Barger (1999). Pasture resting requires preventing of animals from grazing in the same paddock for longer time. The resting period varied from 2 months (Semi- arid) to 6 months (Cool Moist Climate).

Rotational grazing can optimize pasture growth and productivity and lead to an increased carrying capacity. The effectiveness of intensive rotational grazing for a cool temperate environment with summer rainfall is that the grazing period of 5 days followed by a rest period of 103 days was found to reduce worm egg counts and was particularly effective in controlling H. contortus populations(Colvin et al.,2008). The short grazing period prevents infection with larvae from the current grazing cycle. It can also be predicted that rotational grazing systems would work particularly effectively in wet tropical climates where although development of the L3 larvae is faster and more successful, their longevity is much shorter (Waller 1997).

In conclusion, parasites continue to plague many animal producers throughout the grazing season. Internal parasites decrease growth rates and in high levels can even cause death. However, animal producers can follow several practices to minimize the impacts to their flock or herd. These practices center on grazing management, but can also include genetic selection principles. Internal parasites are limiting factors for profitable livestock farming by affecting animal's performance. In most of parasitism the economic loss are actually not attributable to mortality but due impaired productivity of animals. Therefore, the proper pasture and grazing management for parasite control is extremely important for successful livestock farming especially in grazing condition. The single control measure will not give long term solution, but integration of more than one measure like pasture rotation, cleaning pastures from intermediate host, including medicinal and nutritious plant to the pasture, biological control of parasite, apply mixed species grazing, don't overstock and include browse and tall forages in to the grazing systems are very important measures to prevent infection with parasite on pasture.

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