The demand of livestock products is increasing at a dramatic rate because of the increase in human population and income growth. In order to satisfy this huge demand, livestock productivity has to be enhanced. However, apart from feed scarcity and its nutritional fluctuation, livestock productivity is highly influenced by parasitic diseases. Gastro-intestinal nematodes (GIN) infection is a major constraint of livestock production particularly production of small ruminants. In order to control GIN, the development of effective drugs capable of controlling a number of parasite species has, apparently, been one of the most impressive technological achievements of the twentieth century. However, parasitic resistance to chemical drugs, poor availability and affordability of chemical drugs to resource poor farmers and fear of the residual effects of chemical drugs on animal products fuel increased interest in the use of medicinal plants to control parasites. The goal of this paper is to provide an overview of plant metabolites in controlling internal parasites of small ruminants and their efficacy.

Key words: Drug resistance, GIN, Phenolic compounds, Small ruminants.

INTRODUCTION

Livestock farming is crucially important for provision of animal-based food products for the population, and as a source of income for many resource-poor farmers in developing countries. They have a special role to play in the conversion of feed that is unsuitable for humans into food and other useful products. Small livestock, especially sheep and goats are important for the poorest livestock keepers and for the landless that could start to raise livestock. However, the major constraints to livestock development in these countries are the scarcity and fluctuation in the quality and quantity of the year-round animal feed supply and the heavy internal parasitic load in livestock.

Globally parasitic diseases continue to be a major constraint for poor developing countries. Gastrointestinal nematode (GIN) infection is a major cause of wastage and decreased productivity in livestock worldwide (Waller et al., 1996). This parasitism is particularly a major constraint of grazing livestock in the humid tropics (Sani and Gray, 2004). Infestations caused by gastrointestinal parasites are major drawbacks hindering livestock productivity worldwide (Gill and Le Jambre, 1996). Control of helminthiasis is mainly by chemotherapeutic means, with best results being obtained when this is integrated with grazing management, resistant animals and worm vaccines.

Infestation with endo-parasites can have severe consequences for the animal as well as for the livestock farmers leading to economic loss and restricted productivity. The need for alternative means of parasite control is urgent, because of the serious problems associated with parasites, the availability of sub-standard anthelmintics, and sometimes also because of high levels of anthelmintic resistance (Hood, 2004).

Therefore the objectives of this review were:

a. To determine the impact of nematode parasites on livestock production
b. To determine the need of biological control of parasitic nematodes

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c. To identify current knowledge on the role of plant phenolic compounds in controlling parasitic nematodes of small ruminants

Impact of Nematode Parasites on Livestock Production

Nutrient Utilization/Requirements

A) Feed intake

In general GINs reduce nutrient availability to the host through both reductions in voluntary feed intake and/or reductions in the efficiency of utilization of absorbed nutrients (Dynes et al., 1998). A reduction in voluntary feed intake of up to 50 % is commonly observed during infection with GIN, and can severely influence the protein economy of the host by substantially reducing the total nutrient availability for anabolic processes (Sykes and Greer, 2003).

B) Gut function

Gastro-intestinal parasitism may have an overall effect on gut functions, including a depressed feed digestion, as well as an abnormal absorption and rate of digesta passage. Rowe et al. (1988) reported a reduction in apparent digestibility of organic matter across the whole digestive tract, but particularly in the abomasum of sheep infected with *H. contortus*. Reduction in energy digestibility has been observed in relation to both abomasal (Coop et al., 1982) and intestinal parasitism (Sykes et al., 1979) in sheep. In the small intestine, nematode worms interfere due to damage of the epithelium lining with the secretion of enzymes, which contributes to depressing the ability to absorb amino acids (Symons and Jones, 1975).

C) Nutrient requirement

Nematodes in the gastro-intestinal tract often deplete body proteins and increase the animal’s need for absorbed amino acids, which will increase the requirements of protein relative to energy (Preston and Leng, 1987). Koski and Scott (2001) suggested that infection with GIN in livestock both increases the protein needs of the host at the same time as they reduce the effectiveness of the immune response.

D) Nutrient metabolism

Gastrointestinal nematode may redirect protein synthesis away from skeletal muscle growth to repair of gut tissues, leading to reduced nitrogen retention (MacRae, 1993). Kyriazakis et al. (1994) found that sub-clinical gastro-intestinal parasitism in growing sheep was associated with an impairment of protein metabolism. Loss of plasma protein through the faeces and/or urine is a common feature in sheep heavily infected with *H. contortus* (Rowe et al., 1988). An impaired energy metabolism is another concern in the GI parasitized host. MacRae et al. (1979) found that lambs infected with *T. colubriformis* showed a decrease of 17 % in metabolizability of dietary energy by the fourth week of infection compared with pair-fed controls.

Effects on Production

As discussed earlier, GIN both cause disorder of gut functions and impair the nutrient metabolism. The most common and primary losses are due to endogenous protein in the form of whole blood, plasma and mucus (Coop et al., 1982). Extreme protein deficiency results in severe digestive disturbances, weight loss, anemia, edema, and sometimes also reduced resistance to arrange of other diseases.

A) Growth performance

The slow rate of attaining maturity in ruminants, due to chronic sub-clinical parasitism in combination with malnutrition and poor management, will have a major impact on the overall performance. Information on the impact on production caused by gastro-intestinal parasites in humid tropical climates is described by Sani and Gray (2004). The growth depressions induced by gastro-intestinal parasites are easily eliminated when infected animals are offered supplementation, particularly if the diet is enriched in protein.

B) Reproductive performance

The most important determinant of the efficiency of livestock production system is the females’ reproductive age (Sani and Gray, 2004). In Maharashtra, India, Ghalsasi et al. (2002) compared flock productivity after using an intra-ruminal capsule containing macro cyclic lactones that prevented incoming larvae from establishing with others treated every three months with albendazole, and other flocks left untreated. It was shown by complete suppression of the worm population that the annual off take per female in the flock increased by 22 %. Similarly, a reduction (46 %) in off take and mortality (6 %) was reported in groups of grazing goats dewormed 3 times per month compared to untreated goats (Osaer et al., 2000).

C) Morbidity and mortality

In highly pathogenic nematode parasites of small ruminants, *H. contortus* is capable of causing acute disease associated with high mortality in all age classes. Studies of helminthes in small ruminants in South East Asia have indicated high incidence and mortality in...
situations where grazing is the predominant husbandry practice (Dorny et al., 1995).

**Economic Losses**

The greatest losses associated with GIN are sub-clinical, and economic assessments have shown that the financial costs are enormous. Annual treatment costs due to this parasite alone have been recently estimated to be $46 million and $103 million in South Africa (Waller and Chandrawathani, 2005) and India (McLeod, 2004), respectively.

**The Need of Biological Control of Parasitic Nematodes**

1) **Drug Resistance of Nematodes**

Chemical dewormers are losing their effectiveness, with parasites developing resistance to them at an alarming rate. The situation is particularly serious in sheep and goats, but also occurs with cattle. There are some parts of the country where the internal parasites of sheep and goats have developed resistance to all commercially available dewormers. The surviving worms pass that genetic resistance on to offspring. Drug resistance has become an important issue in small ruminant husbandry when anthelmintics are applied at high levels and increasing frequency and with inappropriate doses (Chartier et al. 2001).

The use of medicinal plants to control parasitic infections in animals is a common practice with resource-poor farmers in Africa, India, Asia, and other regions. In areas where chemical anthelmintics are readily available, there has been a world-wide increase in anthelmintic resistance in sheep and goats, and this is fueling increased interest in use of medicinal plants to control parasites. There is a growing realization that chemical anthelmintic treatment, on its own, may not provide a long term strategy for managing parasites in grazing animals. The widespread development and prevalence of resistant strains of nematode parasites have stimulated efforts to identify and use of plant based anthelmintic compounds (Michel, J.F., 1985).

2) **Cost of the Chemotherapeutic Drugs**

Nematode control has traditionally been through using synthetic anthelmintics. However, over-dependency and even misuse of the anthelmintics has resulted in the emergence and spread of nematode populations that are resistant to most anthelmintics. Moreover, anthelmintics are expensive and not affordable to many resource-poor farmers in the developing countries. Therefore, on top of the anthelmintic resistance, poor availability and affordability of anthelmintics to resource-poor farmers in developing countries have compounded the problem (Hammond, et al., 1997). There is, therefore, a need to search for cheap and sustainable nematode control alternatives. One such alternative could be the use of plants.

3) **Search of Organic Products and Fear of Residual Effects**

The widespread development of anthelmintic resistance, particularly in nematode parasites of small ruminants, and the trend towards nonchemical (ecological, organic, green) farming of livestock has provided an impetus for the research and development of alternative parasite control methods that have a great role either in organic farming or in other low-input farming systems. Certified organic livestock producers face an additional challenge as they are limited to use chemotherapeutic drugs. Routine use is prohibited, and it also can never be used in animals raised for meat. This also helps the organic producer who is even more in need of alternative management strategies and products (Peter et al., 2004).

In recent years there has been an increasing demand by consumers that agricultural products should be “clean and green”. Impetus for this has been the contamination of human food products with substances that had tragic adverse embryogenic effects, and the development of super-resistant human microbial pathogens. The threat of adverse effects on the environment on the use of any chemicals in agricultural production has also driven this agenda. Legislation now proclaims that for organic farming, the prophylactic use of drugs (including of course, anthelmintics) is prohibited. As a consequence, new and serious animal welfare issues are starting to emerge throughout Europe, that are caused by distress suffered by animals due to uncontrolled parasite infections (FAO, 2002).

**Plants and their secondary compounds**

**Plants that contain Secondary Compounds**

Plants contain more than energy and protein for animal nutrition but possibly also antiparasitic compounds, or nutraceuticals. Both terms refer to crops that contain secondary plant substances (SPS) and metabolites which are considered to be beneficial for the animal health rather than having an optimized nutritional value (Anthony J-P and Smith H, 2005). According to Max R. A. et al (2007), leaves of different browse species were assayed for condensed tannin (CT) content using a calorimetric method as indicated in table 1 and the concentrations and seasonal variation on CT content in table 2. Although there are numerous compounds that are thought to have beneficial effects on parasite loads,
Table 1. Description of species of browse trees containing CT

<table>
<thead>
<tr>
<th>Species</th>
<th>Family name</th>
<th>Common name (Swahili)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia mearnsii</td>
<td>Mimosoideae</td>
<td>Black wattle (Muwati)</td>
</tr>
<tr>
<td>Acacia polyacantha</td>
<td>Mimosoideae</td>
<td>Falcon’s claw acacia (Mgunga)</td>
</tr>
<tr>
<td>Acacia tortilis</td>
<td>Mimosoideae</td>
<td>Umbrella thorn (Mgunga)</td>
</tr>
<tr>
<td>Albizia lebbek</td>
<td>Mimosoideae</td>
<td>East Indian walnut (Mkingu)</td>
</tr>
<tr>
<td>Azadirachta indica</td>
<td>Meliaceae</td>
<td>Neem tree (Mwarobaini)</td>
</tr>
<tr>
<td>Gliricidia sepium</td>
<td>Papilionoideae</td>
<td>Mexican lilac (Grisidia)</td>
</tr>
<tr>
<td>Moringa oleifera</td>
<td>Moringaceae</td>
<td>Horse-radish tree (Mlonge)</td>
</tr>
<tr>
<td>Persea americana</td>
<td>Lauraceae</td>
<td>Avocado tree (Mparachichi)</td>
</tr>
<tr>
<td>Morus alba</td>
<td>Moraceae</td>
<td>White mulbery (Mforosadi)</td>
</tr>
<tr>
<td>Psidium guajava</td>
<td>Myrtaceae</td>
<td>Guava (Mpera)</td>
</tr>
<tr>
<td>Tamarindus indica</td>
<td>Caesalpinoideae</td>
<td>Tamarind (Mkwaju)</td>
</tr>
</tbody>
</table>


Table 2. Concentration of extractable condensed tannins (g CT/kg dry matter [DM]) in the leaves of different browse species (preliminary study; NA = not analyzed)

<table>
<thead>
<tr>
<th>Browse Species</th>
<th>CT (g/kg DM)</th>
<th>Dry season</th>
<th>Wet season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia mearnsii</td>
<td>122.6</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Acacia polyacantha*</td>
<td>NA</td>
<td>229.0</td>
<td></td>
</tr>
<tr>
<td>Acacia tortilis</td>
<td>NA</td>
<td>307.4</td>
<td></td>
</tr>
<tr>
<td>Albizia lebbek</td>
<td>8.3</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Azadirachta indica*</td>
<td>50.3</td>
<td>48.5</td>
<td></td>
</tr>
<tr>
<td>Gliricidia sepium</td>
<td>7.5</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Moringa oleifera</td>
<td>NA</td>
<td>17.9</td>
<td></td>
</tr>
<tr>
<td>Persea americana*</td>
<td>93.9</td>
<td>50.1</td>
<td></td>
</tr>
<tr>
<td>Psidium guajava*</td>
<td>136.6</td>
<td>70.1</td>
<td></td>
</tr>
<tr>
<td>Tamarindus indica*</td>
<td>NA</td>
<td>429.7</td>
<td></td>
</tr>
<tr>
<td>Morus alba</td>
<td>5.7</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

* = selected species.

Table 3. Condensed tannin (CT) content of different forage species.

<table>
<thead>
<tr>
<th>Forage species</th>
<th>CT, g/kg of DM</th>
<th>% DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birdsfoot trefoil</td>
<td>48</td>
<td>4.8</td>
</tr>
<tr>
<td>Big trefoil</td>
<td>77</td>
<td>7.7</td>
</tr>
<tr>
<td>Sanfoin</td>
<td>29</td>
<td>2.9</td>
</tr>
<tr>
<td>Sulla</td>
<td>51-84</td>
<td>5.1-8.4</td>
</tr>
<tr>
<td>Lucerne(alfalfa)</td>
<td>0.5</td>
<td>0.05</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>1.8</td>
<td>0.18</td>
</tr>
</tbody>
</table>

(Source: Min etal., 2003)

condensed tannins have gained some attention recently. The compound can be found in leguminous plants like leucena and mimosa in addition to other plants like oak trees.

**Effects of Plant Secondary Compounds on Nematode Parasites**

Many studies have been undertaken to find out more about the anthelmintic effects of condensed tannins, with two main explanations for the mode of action of condensed tannins being observed. The first theory describes about indirect mode of action—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 than to other substances). These complexes dissociate in the abomasum and release protein, ready for absorption. Condensed tannins have been shown to reduce gastrointestinal parasite loads in goats by reducing worm fertility, eliminating adult worms, and retarding the establishment of incoming larvae (Waller,
Tannins are polyphenolic compounds widely distributed in the plant kingdom. Field studies have established that nematode-infested sheep fed tannin-rich fodder performed better than those receiving tannin-free fodder (Niezen et al., 1993). Some on-station trials showed significant decreases in fecal egg count (FEC) and worm burdens when a commercially available quebracho tannin preparation was included in the diets of sheep infested with *Trichostrongylus colubriformis* (Butter et al., 2000) and *Haemonchus contortus* (Max et al., 2005b). *In vitro* studies with commercial tannin forages preparations have also demonstrated significant anthelmintic activity against goat nematodes (Max et al., 2005a).

According to the research done on the anthelmintic plant *Viscum verrocosum* in reducing fecal egg count on goats in Botswana, the pattern of fecal egg count (FEC) over the sampling period showed a decrease in the treatment group while the control registered an increase in FEC as indicated in the figure 1.

According to Max R. A. et al. (2007), the mean FEC and worm burden of acacia meal supplement fed group were respectively 27% and 13% lower than in the control group as indicated in figure 2 and 3 below. The result
substantiated previous reports of suppressing effects of CT on GIN of small ruminants. The first and second arrows indicate onset of supplementation and increment points of AMS respectively. EPG=eggs per gram

Conclusion and Recommendation

The demand of livestock products is increasing at a dramatic rate because of the increase in human population and income growth. In order to satisfy this huge demand, livestock productivity has to be enhanced. However, apart from feed scarcity and its nutritional fluctuation, livestock productivity is highly influenced by parasitic diseases. GIN infection is a major constraint of livestock production particularly production of small ruminants. In order to control GIN, the development of effective drugs capable of controlling a number of parasite species has, apparently, been one of the most impressive technological achievements of the twentieth century. However, parasitic resistance to chemical drugs, poor availability and affordability of chemical drugs to resource poor farmers and fear of the residual effects of chemical drugs on animal products fuel increased interest in the use of medicinal plants to control parasites.

Plants with anthelmintic characteristics, containing CT, by disturbing the normal physiological functions of the nematodes and balancing the protein loss of the animal, they are effective in increasing livestock productivity.

Based on the above conclusion the following recommendations are forwarded:

i. Proper grazing management for animals entirely grazing need to be implemented

ii. Plants with better tannins and metabolite need to be identified

iii. Use of these plants by farmers need to be initiated and encouraged

iv. The effect of higher level consumption need to be researched.

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