Bioactive forage and phytotherapy to cure and control endo-parasite diseases in sheep and goat farming systems - a review of current scientific knowledge

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Abstract

Infestation with gastro-intestinal nematodes (GIN) in small ruminants can cause server economic losses and endanger animal welfare. The development of organic farming systems, the increased public awareness for drug residues in agricultural products and the development of resistant strains of parasites have enforced the search for sustainable alternatives.

The aim of this review is to summarise the current scientific knowledge of alternative strategies to prevent and control endo-parasitic diseases in organic sheep and goat farming systems. The conducted literature evaluation has revealed the major potential to be within the field of bioactive forages, phytotherapy, homeopathy and copper-oxide wire particles. Alternative management pattern like grazing management, nematophagous fungi, improved fodder and breeding are not considered.

The administration and cultivation of bioactive forages and phytotherapy are displaying promise potential for endo-parasite control in organic sheep and goat farming. Scientific research has mainly concentrated on the extracts of the plant species chicory, Birdsfoot trefoil (*Lotus corniculatus*), Sainfoin (*Onobrychis viciifolia*), Sulla (*Hedysarum coronarium*) and Quebracho (*Schinopsis ssp.*). The analysis of these plants showed all plants to have some positive potential, but also highlighted individual limitations in application. However from the results of this literature review none of the investigated plants have been researched sufficiently in on farm experiments to recommend any for implementation at this stage.

No concrete recommendation for a single plant can be given, further research on promising species for the commercial use is strongly recommended, as is the review of the law concerning the appliance of plant based remedies.

Keywords: endo-parasite, bioactive forage, phytotherapy, organic farming, small ruminants

Zusammenfassung

Stand des Wissens über bioaktives Futter und Phytotherapie zur Behandlung und Kontrolle von Endoparasitosen in der Schaf- und Ziegenhaltung

Infektionen mit Endoparasiten - insbesondere den Magen-Darm-Strongyliden (MDS) - sind eine der bedeutendsten Probleme in der Schaf- und Ziegenhaltung. Ziel dieser Literaturstudie war es, den Stand des Wissens über alternative Methoden zur Reduzierung bzw. Kontrolle von MDS festzustellen. Dabei wurden besonders bioaktives Futter, Phytotherapie, Homöopathie und Kupferoxide betrachtet. Alternative präventive Managementmethoden wie optimiertes Weidemanagement, nemathophage Pilzsporen, verbessertes Futter und Zucht wurden hier nicht betrachtet.

Die Anpflanzung von bioaktivem Futter in die Grünlandnarbe (Weide, Wiese) und die Phytotherapie zeigen ein Potenzial für die Kontrolle von Endoparasiten in der Schaf- und Ziegenhaltung. Wissenschaftliche Arbeiten haben sich besonders mit Gewöhnlichem Hornklee (*Lotus corniculatus*), Esparsette (*Onobrychis viciifolia*), Alpen-Süßklee (*Hedysarum coronarium*) und Quebracho (*Schinopsis ssp.*) - einer südamerikanischen Baumart - befasst. Alle zeigten eine gewisse Wirkung, die jedoch nicht überwältigend war. Auch für diese am intensivsten untersuchten Pflanzen sind bislang keine Praxisversuche durchgeführt worden und können damit nicht empfohlen werden. Auch für andere Pflanzen kann bislang keine Empfehlung ausgesprochen werden. Hier fehlen weitergehende Studien, die phytotherapeutische Wirkung belegen. Das Problem besteht auch in der Deklaration, ob es sich um einen Futterzusatzstoff oder ein Medikament handelt. Heilstoffe auf Ganzpflanzen oder Pflanzenteile werden in der Regel nicht mehr als Medikament anerkannt.

Schlüsselwörter: Endoparasitosen, bioaktives Futter, Phytotherapie, Ökologischer Landbau, Kleine Wiederkäuer

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1 Introduction

Parasitic nematodes remain a major threat to the health and welfare of small ruminants all over the world and the demand for alternative control measures has constantly increased during the last years. 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. Increased public awareness of drug residues in animal products, the increased resistance of parasites to modern anthelmintics, combined with the wish for a more sustainable way of farming has resulted in an intensified effort to find alternative endo-parasite control options (Rahmann et al., 2002). This has triggered the evaluation of some of these traditionally applied plants for their anthelmintic properties with a view to finding out more about them.

Nevertheless, from the scientific point view little has been done in this area, even though a lot of plants are currently used in third world countries (Hördegen, 2005). They are not only dealing with helminth infections but also have to be able to treat a whole range of other diseases with often successful outcomes (Nfi et al., 2001).

The problem is that science has to deal with at the huge variety of plants that may or may not be suitable for the development of alternative anthelmintics. There is also the current lack of verified information to contend with. For these reasons effective plants need to be divided from ineffective ones and the quickest means of achieving this is with in vitro methods. Once a plant has proven its efficiency in vitro, further in vivo testing will be necessary to confirm the obtained results and evaluate risks, side-effects and future applicability (Hounzangebe-Adote et al., 2005a). At this stage it seems a long way off from the discovery of a potential plant to the release of a commercially viable product for use on farms.

The literature review will help researchers, adviser and farmers to get an overview about the state of the art from scientific point of view. Particularly organic farmers are in need to get information about possibilities and limitations of phytotherapy for endo-parasite control.

2 Bioactive forages

Plants contain more than energy and protein for animal nutrition but possibly also anti-parasitic 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 (Rahmann, 2004).

In this context a certain group of SPS, the condensed tannins (CT) have been investigated. CT are not only included in certain plants, a lot of plants have CT content but only those with higher levels are referred to as ‘bioactive forage’. As opposed to the application of medical plants, these forages are generally non-toxic and can consequently not be overdosed and the idea is to integrate them into the normal diet of ruminants (Thamsborg, 2001a).

There seem to be several options for feeding tanniferous plants. An example of this is the cultivation of arable crops that can be integrated in the normal rotation (Niezen et al., 1998), these can then be used for either de-worming paddocks, or the plants can be preserved and fed as hay or silage at a later date.

Feeding bioactive forages is not only associated with positive effects but also with some negative consequences (Coop and Kyriazakis, 2001) and this may be the reason why plants with high tanniferous content have not been used earlier. High concentration of CT is known to lead to reduced feed digestibility, feed intake and consequently lower productivity (Aerts et al., 1999; Dawson et al., 1999). Coop and Kyriazakis (2001) therefore conclude that the intake of tanniferous plants will only be preferred by grazing small ruminants “if the negative consequences are offset by the positive effects attributed to their anti-parasitic properties”.

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:

- First theory: Indirect mode of action: When tannin-rich forages are consumed, the then released condensed tannins build complexes with proteins and protect these from ruminal degradation (tannins have a higher affinity to proteins then to other substances). These complexes dissociate in the abomasum and release protein, ready for absorption. Since nematode parasitism leads to a loss of protein and decreased protein absorption, the intake of tanniferous forages may balance the protein loss and thereby increase resilience. (Min et al., 2003)
- Second Theory: Direct mode of action: Condensed tannins directly react with the proteins on the surface of the parasites and disturb the normal physiological functions of the nematodes like mobility, food absorption or reproduction (Heckendorn, 2005)

For the successful performance a certain CT-content (35 g d^{-1}) of the applied plants seems to be necessary (Athanasiadou et al., 2005). Alternatively Min and Hart (2003) suggest that beneficial effects of CT in plants only occur within the concentration range of 45 to 55 g of CT kg^{-1} of DryMatter (DM), levels below and above this range lead to inconsistency.

There is evidence that results obtained in studies with sheep can be transferred to the application on goats (Paolini et al., 2003c; Paolini et al., 2005b). Hoste et al. (2005b) state that data obtained in goat experiments is in agreement with those in sheep. Basic physiological processes are alike indeed but it should be kept in mind that goats are more susceptible than sheep and they take longer to acquire immunity (Thamsborg et al, 2004).

A number of plants have been investigated in the last years and it was found that the CT-content of most grasses is < 1 %, (in DM) most temperate forage legumes have about 5 % and some tropical plants contain up to 40 % (Thamsborg, 2001a).

2.1 Chicory (Chicorium intybus, family: Asteraceae)

Chicory is a bushy perennial herb that has light blue to lavender coloured flowers, which is originated in the Mediterranean climate. Forage chicory is known to improve the live weight gain in lambs and to lead to lower pasture contamination because "larval survival on chicory is lower then on grasses" (Rattray, 2003). Similar results were achieved 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.

Anthanasiadou et al. (2005) proved strong anthelmintic activity in their in vitro studies. In this study extract from rumen material of sheep that previously grazed pure stands of chicory was analyzed, former studies had tested extracts of plant material. The subsequent in vivo study on chicory showed that feeding chicory was indeed effective against adult *T. circumcincta* but not on incoming larvae.

These results were confirmed by a five week grazing trial (Marley et al., 2003a) and two recent studies that investigated that short-term of grazing chicory leads to a reduced adult worm burden but no differences in egg output (Athanasiadou et al., 2005; Tzamaloukas et al., 2005).

These experiments provide evidence for the ability of chicory to reduce the adult worm burden in infected sheep but they also prove the incapacity of chicory to reduce faecal egg output and prevent incoming larvae from settling. Consequently grazing chicory may help infected animals to balance weight loss due to parasitic infestation and thereby enhance the buildup of immunity. It certainly neither appears suitable to decrease pasture infectivity nor does it show the ability to protect sheep from further infestation.

Unfortunately no reports were found regarding the effectiveness of chicory on goats, so no secured conclusion can be drawn and no recommendation given in this area.

2.2 Birdsfoot 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'.

Rattray (2003) reviewed quite a few of studies on lotus that had been conducted up until 2001. Positive results were found for performance and live weight gain during infections and variable results for the reduction of egg output and worm burdens.

The results of Marley et al. (2003a; 2003b) lead to opposing conclusions. In the feeding trial (Marley et al., 2003a) with lambs carrying mixed infections, they found that the lotus fed group had the lowest weight gain and overall showed no significant positive effect. The impact of different forages on development and survival were explored in their other study (Marley et al., 2003b) and resulted in no effect on hatchability but the highest larval development (L3) on birdsfoot trefoil. Two short-term grazing studies had similar results were no direct effects of birdsfoot trefoil could be investigated, although both authors wondered whether the lack of effect might have been due to a minor dosage (Anthanasiadou et al., 2005; Tzamaloukas et al., 2005).

Greater birdsfoot trefoil has also been investigated by Athanasiadou et al. (2005b) within the scope of the wormcops project but the in vitro experiments could not demonstrate any anthelmintic properties. But the in vivo trials measured a substantially declined egg excretion for *T. cirumcincta* and *Trichostrongylus spp.*

These results were less clear then those for chicory. Marley et al. (2003a) suggest that inconsistent findings could be related to the fact that different cultivars have varying CT contents. Athanasiadou et al. (2005) and Tzamaloukas et al. (2005) both wonder whether their dosage had been insufficient. Unfortunately no other study has been conducted with different cultivars and levels of CT, to either confirm, or disprove this explanation.

Judging the current stage of experiments, no recommendation for the application in practise can be given; results are inconsistent and controversial and indicate an exploratory need to finally determine the potential of birdfoot trefoil species.

2.3 Sulla (Hedysarum coronarium, family: Fabaceae)

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; Frame et al., 1998).

Niezen et al. (1998) found in their six week grazing trial that lambs that had grazed Sulla, had a lower FEC, reduced worm burdens and intestinal parasite density, had good live weight gain, despite infection, and were less affected by parasites.

Molan et al. (2000a) tested the effects of Sulla extract on larval development and found that the genus *T. colubriformis* was more resistant to the inhibitory effects than the other tested species. Further in vitro tests were undertaken within the scope of the WORMCOPS project by Hoste et al. (2005b) who observed reduced in vitro egg hatchability but no difference in larval development. The subsequent in vivo study on lambs infected with *H. contortus* grazing Sulla showed reduced FEC and worm burdens.

Similar results were obtained by Niezen et al. (2002) who discovered that the consumption of Sulla reduced faecal egg output substantially but it also accumulated further evidence for the inefficiency of Sulla on *T. colubriformis*.

The short-term feeding trials of Athanasiadou et al. (2005), Tzamaloukas et al. (2005) and Pomroy and Adlington (2006) do not support any of the previous evidence, both trials show no positive results for Sulla consumption. The former two studies both argue that the lack of effect could be due to insufficient levels of CT, Pomroy and Adlington state similar level of CT in their diet like Niezen et al. (2002) and conclude that the lack of effect must have another reason.

The presented research results indicate that there is a discrepancy between longer and short-term experiments. The administration of Sulla seems to have no effect when applied for a short period of time but if fed for longer, it may reduce FEC and have a positive effect on animal performance.

A further question that should be considered is if it is possible to integrate the cultivation of Sulla into the farming routine. Pomroy and Adlington (2006) state that "Sulla is a difficult herbage to manage agronomically" and they further quote that the provision of a substantial amount of Sulla for an extended period of time for all animals on a farm seems difficult to achieve. Information about Sulla in the FAO-database indicates that weeds can affect Sulla at establishment, as well as after cutting, and that it is not suitable for intensive grazing (Frame, 2006; Frame et al., 1998).

These aspects need to be considered and indication is given that further research is necessary to find out more about the cultivation attributes of Sulla, particularly for organic agricultural systems. Moreover it seems advisable to establish the period of time required for the successful reduction of FEC.

2.4 Sainfoin (Onobrychis viciifolia, family: Fabaceae)

Sainfoin is a perennial herb which is distributed in Europe, parts of Asia and Northern America (Frame et al., 1998; Frame, 2006).

Barreau et al. (2005) showed in their in vitro experiments the activity of Sainfoin extract against *H. contortus* nematodes and therefore confirmed the results of Paolini et al. (2004) who had demonstrated the inhibitory effect of Sainfoin extracts on L3 of *H. contortus* and *T. colubriformis* and on adult *T. circumcincta*.

Positive in vivo results have been shown in several studies. Thamsborg et al. (2001) observed in an in vivo study normal growth rates for lambs on Sainfoin, a more than 50 % reduced faecal egg output of infected animals and the tendency of lower establishment of incoming larvae and expulsion of adult worm burdens. Recently there have been many studies on the possible effect of Sainfoin with all confirming the significant reduction of FEC after the consumption of Sainfoin (Paolini et al., 2003c; Thamsborg et al., 2003; Athanasiadou et al., 2005b; Hoste et al., 2005a; Lüscher et al., 2005; Paolini et al., 2005b).

There were two short-term trials conducted on the effect of Sainfoin consumption on establishment of incoming larvae in which no evidence for any significant effects could be found (Athanasiadou et al., 2005; Paolini et al., 2005a). These findings are supported by Thamsborg et al. (2003) who showed that the consumption of Sainfoin previous to infection did not influence establishment. The only study on Sainfoin without any significant effects remains the one of Athanasiadou et al. (2005) but they cite that the concentration of CT in the Sainfoin swards might have been insufficient.

The reviewed research results provide evidence that the administration of Sainfoin can reduce faecal egg count and therefore lead to lower pasture contamination. Lüscher et al. (2005) continue to research the potential for the practical integration of tanniferous plants into agricultural practise in their large-scale project and argue that first results in particular on Sainfoin show that this plant has promising potential. In fact not all studies display the same optimism when it comes to the cultivation of Sainfoin. Thamsborg (2001b) states that Sainfoin appears not competitive in grassland swards. Athanasiadou et al. (2005b) also mention poor establishment of Sainfoin in UK.

Frame (2006) writes in about Sainfoin that "monocultures lack competitiveness to weed invasion" when compared to cultivation of mixed Sainfoin/grass stands.

This indicates the need for further research particularly on the cultivation side of feasibility. No recommendation can be given as long as it is not clear how suitable Sainfoin is for different climates and especially for the non chemical methods of organic agriculture.

2.5 Quebracho (Schinopsis ssp., family: Anacardiaceae)

Quebracho is the Spanish name for a group of similar species of trees that are originated in tropical South America

(Wikipedia, 2006). 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).

The first study to be considered in this context in an extensive long-term (10 weeks) feeding study on sheep by Athanasiadou et al. (2000) with several interesting results: the administration of quebracho led to a reduction in FEC and later to lower female fecundity and adult worm burden, however the observed differences were not always significant. During the trial it was also noticed that the 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 animals.

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 *T. 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.

The following conclusions can be drawn from the above experimentation: the administration of quebracho extract appears to lead to a reduction of egg excretion and female parasite fecundity but it does not seem to lower the adult worm burden. There are no verified results available on effect of incoming larvae. However studies on quebracho administration remain scarce and although the available results are relatively clear and indicate anthelmintic properties for quebracho, more studies are required to confirm the existing results.

A further critical point that needs to be proved is the availability of quebrancho extract, which is certainly also a question of costs. It needs to be estimated whether farms can afford to purchase the delivery of this extract, or whether the application of quebracho will be limited to areas where *Schinopsis ssp.* are naturally grown.

2.6 Other plant species with high tanniferous contents

Apart from the above described plants, a range of grasses, shrubs and bushes have been chemically analysed for their CT-content and anthelmintic activity in vitro. Some have shown promising results when tested in vivo however not with the same benefits shown as the previously examined plants (Table 1).

The following list shows tanniferous plants that have been the item of scientific consideration, either in in vitro, or in vivo studies, or both. The list is not exhaustive with research in this field an ongoing process.

Table 1:
Studies on the anthelmintic effect of different plants/herbs

Scientific name	Traditional name	Studies
Forage plants:		
Dorycnium pentaphyllum	Socarillo	Molan et al., 2000b; Niezen et al., 2002b
Dorycnium rectum	No common name	Molan et al., 2000b; Niezen et al., 2002b; Waghorn et al., 2006
Lespedeza cuneata	Chinese Lespedeza	Min and Hart, 2003; Min et al., 2005
Rumex obtusifolius	Dock	Molan et al., 2000b; Thamsborg, 2001a
Shrubs and trees:		
Acacia karoo	Wattle (leaves)	Kahiya et al., 2003
Calluna vulgaris	Heather	Hoste et al., 2005b
Castanea sativa	Chestnut Tree (fruit)	Hoste et al., 2005b
Cornus sanguinea	Common Dogwood	Athanasiadou et al., 2005b
Corylus avellana	Hazel tree	Paolini et al., 2004; Rahmann et al., 2007
Erica ssp.	Erica	Athanasiadou et al., 2005b
Pinus sylvestris	Pine tree (leaves)	Hoste et al., 2005b
Punica granatum	Pomegranate	Athanasiadou et al., 2005b
Quercus ssp.	Oak	Paolini et al., 2004; Hoste et al., 2005b; Athanasiadou et al., 2005b
Robinia pseudacacia	Black Locust	Athanasiadou et al., 2005b
Rubus fructicosus	Blackberry bush	Paolini et al., 2004; Hoste et al., 2005b
Salix ssp.	Willow	Barry et al., 2005; Diaz-Lira et al., 2005
Sarothamnus scoparius	Genista (leaves)	Hoste et al., 2005b
Vitis ssp. extract	Grape Seed extract	Waghorn et al., 2006

Shrubs and trees are of particular interest because of the alimentary spectrum of sheep and goats and their ability to browse a wide range of plants. In this context the nutritional consequences of goats browsing rangeland environments has been extensively studied, but it has taken longer to focus research on the correlation between browsed plant species and parasite infection status. Despite the scarcity of studies there is evidence of a positive effect on parasitism (Hoste et al., 2001; Hoste et al., 2005c). Although sheep are generally categorized as grazers, they still browse trees and shrubs to some extent and as current research results from New Zealand indicate this can have beneficial effects on the resilience to parasitic nematodes (Diaz Lira et al., 2005).

3 Phytotherapeutical measures against internal parasites

Phytotherapy is either prophylactical or therapeutical use of plants, their plant components or their preparations, and can be divided into allopathic and traditional phytotherapy (Hördegen, 2005). The allopathic phytotherapeutical approach uses scientific testing to verify the anthelmintic effectiveness of a plant or preparation, and in contrast to that the use of traditional products is based on handed down knowledge (Anonymous, 2005 in: Hördegen, 2005).

The evaluation was focused on possible risks and side-effects of plants, and on scientific verification. Listed are herbs and preparations that have either proved to have an anthelmintic efficacy (scientifically tested) or that are traditionally associated to help against internal parasites (Table 2). The criterion for inclusion into the table was the frequency in which plants were mentioned in coherence with anthelmintic activity. It is important to keep in mind when considering alternative options in this area that there still remain a lot of plants not evaluated.

At the current stage veterinarians that are willing to work with phytotherapy have to deal with two basic problems. First of all effective plants have to be divided from ineffective ones, and secondly the physiological consequences of herbal administration need to be determine, including possible risks and side-effects. Preparations derived from plants are often thought to be harmless and widely associated to have fewer side effects and are therefore considered easier to apply, however reality shows that plants and plant extracts can be as toxic as allopathics, that they can have side effects, and if applied inappropriately they can cause severe damage and even lead to death (Reichling and Saller, 2001).

A further problem that has been explained and discussed by Häublein (2005) is the legal requirements for the use of homeopathical and phytotherapeutical remedies in the EU. These remain restrictive and discouraging for both veterinarians and farmers, with no change in the foreseeable future. For further information on this matter refer to Häublein (2005). So before advising or suggesting anything to practically working people, these aspects should be well thought of.

Table 2:
Plants and plant preparations used as alternative anthelmintics

Botanical & Common Name	Scientific Verification & Comment	Prime Source
Allium sativum (Garlic)	Traditionally applied. In vivo trial showed no effect of garlic administration contradicting statements of the effectiveness	Allen, 1998; Duval, 1994; Cabaret et al., 2002b; Meat New Zealand, 1998; Perezgroves, no date; University of Aberdeen, no date
Annonum senegalensis (Custard tree)	Traditionally used by Nigerian farmers In vitro test showed promising potential	Alawa et al., 2003
Artemisia abrotanum (Southern Wormwood)	Although traditionally used, activity seems reliable	Hoffmann, 1995; FAF, 2002
Artemisia absinthium (Common Wormwood)	Reputation of anthelmintic effect in trad. medicine In vitro tests showed barley sign. reduction of Trichstrongylus	Bara et al., 1999; Duval, 1994
Artemisia cina (Eurasian Wormwood)	It is used for the fabrication of Santonin which is used in human medicine	PFAF, 2002; Duval, 1994
Artemisia dracunculus (Tarragon)	Is known to have vermifuge properties in the traditional medicine	Duval, 1994; PFAF, 2002
Artemisia herba-alba	Powder was used in a trial with goats infected with *H. contortus* and worked successfully	Idris et al., 1982
Artemisia vulgaris (Common Mugwort)	No reliable source could be found that confirms the unobjectionable efficacy	Duval, 1994; PFAF, 2002 www.feenkraut.de
Asarum canadense (Wild Ginger, Snakeroot)	Is known to work as an anthelmintic, traditionally used in Africa, no conducted trial could be found	Duval, 1994; PFAF, 2002
Azadiracta indica (Neem tree)	Results are scientifically verified but vary	Costa et al., 2006; Githiori, 2004 Thomas et al., no date www.neem-foundation.org

Botanical & Common Name	Scientific Verification & Comment	Prime Source
Carica papaya (Papaya)	In vitro trials have confirmed anthelmintic activity. Used traditionally in the Philippines and other countries. In vivo trials with papaya seeds in sheep showed 80 % reduction in FEC In vivo trial with calves show reduction of 60 %	Animal Science at Cornell University, 2001; Hoste et al., 2005d; Hounzangbe-Adote et al., 2005a; Ronoredjo and Bastiaensen, no date; Stepek et al., 2004
Chenopodium mbrosioides (Goosefoot, Wormseed)	Internet database and Cornell University seems to have investigated thoroughly	Animal Science at Cornell University, 2001; PFAF, 2002
Chrysanthemum cinerariifolium (Pyrethrum)	It has been discussed for years but two in vivo trials found no and very low anth. efficacy	Duval, 1994; Hammond et al., 1997; Mbaria et al., 1998
Crucifers (There are several species of the family cuciferae that are used as anthemintics)	All traditional plants with anthelmintical reputation, no in vivo experiments could be found	Duval, 1994; PFAF, 2002
Curcurbita pepo (Pumpkin)	Activity scientifically researched, reliable sources	Anonymus, 2003; Duval, 1994; Hoffmann, 1995; PFAF, 2002
Daucus carota (Wild carrot)	Plant can not be recommended because of missing scientific verification	Duval, 1994; PFAF, 2002
Dryopteris ssp. (Fern) (*D. filix-mas* quoted the most)	Popular and effective against tapeworms	Cabaret et al., 2002b; Duval, 1994; PFAF, 2002
Eucalyptus grandis (Eucalyptus)	In vivo test in goats led to 90 % reduced FEC on *H. contortus* but none on Ostertagia	Animal Science at Cornell University, 2001; Bennet-Jenkins and Bryant, 1996
Ferula conocaula, F. gigantea, F. narthex (Fennel)	Traditionally used, no scientific tests available	Duval, 1994
Fumaria parviflora (Small-flowered/ Fine-leaved Fumitory)	Extract had the same efficiency as common anthelmintic control product Promising alternative	Hördegen et al., 2003; FIBL activity report, 2004
Juglans regia (English Walnut, Black Walnut)	Long history of medical use Traditional anthelm Known to expel worms	Edward, no date
Khaya senegalensis (Gambian Mahagony)	Traditionally used as a vermifuge In vitro and in vivo tests confirmed anthelmintic potential	Ademola et al., 2004
Mallotus philippensis (Kamala tree)	Scientific trials confirmed in vitro and in vivo anthelmintic activity	Akhtar and Ahmad, 1992; Singh et al., 2004
Melia azedarach (Chinaberry tree) Indian Lilac	Trial with goats was successful and showed virtually no side-effects.	Akhtar and Riffat, 1984; PFAF, 2002
Melinis minutiflora (Panicum minutiflora) (Panicum melinis)	Traditionally used in the Dominican Republic as a de-wormer. Cornell University did in vitro tests on *H. contortus* that indicated some effect.	Animal Science at Cornell University, 2001
Newbouldia laevis Boundary Tree	Traditionally used by farmers in W.-Africa Confirmation of anthelm. Activity through in vitro testing	Brown, 1992; Hounzangbe-Adote et al., 2005a
Nigella sativa (Black Cumin)	Traditionally used as a anthelmintic, in vivo trial with Monezia confirm effect on tapeworms	Iqbal et al., 2005b; PFAF, 2002
Ocimum sanctum (Sacred Basil) *Ocimum gratissimum* (Basil)	Confirmation of in vitro testes with *H. contortus*	Anthony et al., 2005; Asha et al., 2001 Pessoa et al., 2002
Spigelia marilandica (Pinkroot, Indian Pink)	Especially effective with tape- and roundworms, treatment should always be followed by a saline laxative	University of Aberdeen, no date; PFAF, 2002
Tanacetum vulgare (Tansy)	Traditionally applied, no in vivo results available. In vitro testing showed effectiveness. Other species seem to possess anthelm. properties as well	Duval, 1994; Gadziev and Eminov, 1986; PFAF, 2002
Zanthoxylum zanthoxyloides (Fagara)	Traditionally applied in Western Africa In vitro tests confirmed activity In vivo tests showed that regular feeding is better then a single cure	Hounzangbe-Adote et al., 2005a; Hounzangbe-Adote et al., 2005b

4 Copper-oxide wire particles

The basic principal of this treatment is that the availability of macro-minerals and trace elements influences the host-parasite relationship (Suttle and Jones, 1989 in: Chartier et al., 2000). When copper-oxide wire particles (COWP) are administered they remain in the rumen and release free copper into the abomasum which creates an environment that affects *H. contortus* ability to remain established (Burke et al., 2004).

Bang et al. (1990) found that the administration of copper-oxide wire particles led to a good reduction of parasite burden of *H. contortus* but the impact on other species was very average. Further research proved the efficiency of (COWP) on *H. contortus* in goats but also showed that it does not influence greatly on other species (Chartier et al., 2000).

Other research come to similar conclusions, the treatment seems to successfully reduce FEC and the number of established adults of *H. contortus* but does not work effectively on other species (Watkins, 2003). Burke et al. (2004) evaluated to optimal dosage for administration and found 2g as a single dose to be sufficient to result in reduced FEC and worm burden but not enough to lead to toxicity or predispose lambs to disease which higher concentrations do.

5 Homeopathy

Homeopathy will not be discussed in detail for two reasons. The first is that the last paper that has been written about alternative helminths control a year ago has already dealt with homeopathy sufficiently and the report on homeopathy can be recommended (Häublein, 2005). The second reason is that according to the findings of the last paper homeopathy is considered unsuitable to treat acute helminthosis in most cases. This is due to several circumstances, amongst them the lack of veterinarians that have an additional homeopathic qualification and that the application of homeopathics requires detailed knowledge as incorrect dosing rates can lead to overreaction and worsen the condition.

Despite the above findings it still cannot be generally claimed that it is impossible to de-worm with homeopathic remedies, good results have been obtained in the past in independent reports (Gibbons, 2002).

The mode of action of homeopathy is based on a thorough anamnesis and on the provision of adequate animal husbandry. It requires time and the will of the farmer to think over the whole farming process in order to detect the source of susceptibility.

In conclusion, it can be ascertained that homeopathy has the potential to help the animal to overcome its deteriorating condition caused by parasitic infection but it is currently considered unsuitable as a short-term measure to treat intestinal nematodes on organic farms (Cabaret et al., 2002b; Humann-Ziehank and Ganter, 2005).

6 Conclusions

In conclusion future research in this area seems promising, there remain a lot of plants to be tested but it is possible that there are some plants that possess a high anthelmintic effectiveness and cause no side-effects.

In the retrospection of the literature research it has been concerning to discover the incomplete and possible misleading information that is available on the internet and in other sources. The information published by Duval (1994) and the University of Aberdeen is possibly well meant but it can not be considered sufficient to only occasionally and briefly mention possible risks of plants and their preparations. This information may be misinterpreted, with people applying the information in a belief that they are doing their animals a favour by not using common anthelmintics but ending up doing severe damage to their stock.

Some preparations like copper sulphate should actually not even be mentioned as an alternative treatment. So one needs to be very careful before giving any advice to practically working farmers and only introduce plants and preparations with reference to risks and side-effects.

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