Plants as De-Worming Agents of Livestock in the Nordic Countries: Historical Perspective, Popular Beliefs and Prospects for the Future

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Introduction

The use of plants, or their extracts, for treatment of gastro-intestinal parasites in humans and livestock is steeped in antiquity. It was Claudius Galénus (AD 130-200), a Greek physician of Pergamon, who received notoriety for applying medicines prepared from vegetable substances by infusion, or decoction. These became known generically as "galenical" drugs, or preparations, and established the foundation for modern veterinary pharmacology. It is with some interest to note that the approach taken by Galénus was in contrast to the Hippocrates / Paracelsus school of thinking which espoused treating "like with like" (similia similibus curantur), that later formed the basis for Hahneman’s concepts of homeopathy (Vaarst 1996). In medieval times, plants with reputed anthel-
mintic properties were often mixed with mineral salts (arsenic, copper etc.), or more esoteric materials (blood, faeces, fluids from reptiles, wild animals etc.) to form quite bizarre and often hazardous concoctions – for both parasites and hosts alike. With time, trial and error, such preparations were refined in an attempt to at least moderate the undesirable consequences to the host, but with the advent of safer and more effective synthetic anthelmintic compounds, they rapidly disappeared from the veterinary anthelmintic market (Gibson 1980). Nevertheless, it is of interest to note that the World Health Organisation has recently estimated that 80% of the population of developing countries rely on traditional medicine, mostly plant drugs, for their primary health care needs (Danoe & Bøgh 2000). Also in a global context, modern pharmacopoeia still contain in the order of 25% drugs derived from plants and many others which are synthetic analogues built on prototype compounds isolated from plants. However, there has been a resurgence of interest in traditional health practices throughout the world. In veterinary medicine, this interest encompasses ethnomedicine and the use of herbal remedies. Workshops, forums and conferences are occurring with increasing regularity, which is obviously being driven by a concomitant increasing level of research activity. The forces responsible for this momentum are manifold. These include the perception that "natural is nice", concerns of synthetic drug residues in the environment and the food chain, and particularly the spectre of rapid emergence of multiple resistant pest organisms through misuse and overuse of these modern drugs. Within the Nordic countries, the same holds true. This region of the world is at the vanguard of the organic farming movement, with major emphasis on livestock production. Many progressive and educated farmers who have chosen to farm livestock organically are well aware of the importance of nematode parasites affecting the productivity of their animals and adopt grazing strategies aimed at evading, or mitigating the effects of parasites in their animals (Svensson et al. 2000). However, others show less awareness and management of grazing livestock is largely determined by herbage supply and not by parasitological considerations (Vaarst et al. 1996). One specific strategy is to graze livestock on plants with purported anthelmintic properties. For example, a survey of Danish organic dairy farmers with 255 respondents, revealed the use of herbs in the leys on 26% of the farms. Of these, caraway (Carum carvi) [56%], parsley (Petroselinum crispum) [20%], chicory (Cichorium intybis) [10%], chervil ( Anthriscus cerefolium) and dill (Anethum graveolens) [14%], used singly or in combination, were the most commonly used plants (Smidt 1997). For the purposes of deworming, the feeding of wormwood (Artemisia absinthium), mugwort (A. vulgaris), chicory (Cichorium intybis) and common tansy (Tanacetum vulgare) were expected by farmers to have anthelmintic properties (Smidt 1997). In addition, there has been a major commitment to the development of sustainable disease control systems, which by definition means the integration of a range of non-chemical methods with the minimal use of drugs, to insure continued effectiveness for the foreseeable future. Control of internal parasites of livestock by these means has been a major focus of research activities in the Nordic countries for several years (Thamsborg et al. 1999). Research in the Nordic countries on anthelmintic properties, or protective effects, of local plants against helminth parasites of livestock is very recent and limited at this stage to studies on tanniferous forages (Kahiya et al. 1999, Bernes et al. 2000). However, many of the earliest written reports of anthelmintic properties of plants originate from this region of the world.
Plants as de-worming agents

Acta vet. scand. vol. 42 no. 1, 2001

(eg., the writings of Henrik Harpestræng in the early 13th century). The purpose of this review is to provide a historical perspective and to present our view of the potential and possibilities for the use of plants that are endemic, or thrive in the Nordic environment, as de-worming agents. Due to the relatively wide variation in climate, soil, altitude etc. within this limited area, the total number of plant species is quite large.

Also, a brief consideration is made of the recent developments in the use of specialized crops, the so-called "nutraceuticals", which are bioactive crops that are either grazed, or fed after preservation, with the main purpose of preventing or curing disease. The ultimate objective would be to use these plants as additional means for the further development and refinement of sustainable parasite control systems of livestock.

Plants and parasites

There is an inextricable association between plants and parasites of livestock. Pastures provide the link between the free-living and the parasitic phases of helminth parasites for all grazing animals. At different stages of growth, pasture species may facilitate or impede the survival of free-living populations, the establishment of parasite burdens and lessen or intensify the effects of parasitism on the host. Competent management of pastures is needed for the twin goals of efficient conversion of herbage to animal products and effective control of gastrointestinal parasites.

Indirect effects of plants on parasites

It is reasonable to assume that the height, density and form of plant growth could affect the micro-environment of the free-living stages of parasites and thus play a role in transmission of infection. Because of the necessity of moisture films for movement of nematode larvae from faecal deposits to herbage, it might be expected that pastures consisting largely of erect, tall growing species would provide less protection from desiccation, and from removal by heavy rain, than those consisting primarily of prostrate species. Indeed, a factor considered to mitigate the high rates of contamination following increased stocking rates is the decreased availability of herbage, which provide conditions less favourable for the development and survival of the free-living stages of nematode parasites (Thamsborg et al. 1996). Although there has been a number of such ecological studies, little has been done in the Nordic countries and this aspect is outside the scope of this review. However, it is important to recognise these indirect effects of herbage when any grazing studies are conducted on plants with purported anthelmintic properties. It must be established that observed effects are directly plant related and not due to effects on development and survival of the free living stages of parasites, or the provision of an enhanced level of nutrition which helps the animal to rapidly mount an immune response against incoming or resident parasite infections.

Direct effects of plants on parasites

This relates specifically to anthelmintic properties of plants. Although there is a large and diverse range of herbal de-wormers that are used throughout the world, particularly in the Asian and African countries, generally there is a lack of scientific validation of the purported anthelmintic effects of these products. Evidence to date is almost entirely anecdotal. This also applies to the reports of de-worming properties of herbal preparations that have either Nordic origins, or a long history of use in this region (for some historical background, see Grove 1990). These can be broadly classified into the following classes (see Table 1):
### Table 1. Plants said to have been used against internal parasites in the Nordic countries; their scientific names and names in English and in the Nordic languages.

| Plant family | Scientific name | English | Swedish | Norwegian | Danish | Finnish | Icelandic | Host | Target | Part used | Reference |
|--------------|-----------------|---------|---------|-----------|--------|---------|-----------|------|--------|-----------|-----------|
| Lichens      | Cetraria islandica | Iceland moss | islandslav | islandslav | lav * | jákálá | fjallagrös * | M | H | W | 8, 9, 33, 36, 37, 41 |
| Ferns        |                  | bracken fern | örnbräken * | einstape * | ornbregne * | sananjalka * | arnarburkni | M | H, C | R | 9, 21, 35, 45 |
|              | Dryopteridaceae  | dryopteris wood fern | skogsbäcken | broddløv | småbladet mangelov | metalsalvejurs * | M | H, C | R | 31 |
|              | D. expansa      | spring wood fern | nordbräken | saueklg | finbladet mangelov | isoalvejuuri * | M | H | R | 31 |
|              | D. filix-mas    | male fern | träjon * | ormetelg * | allmindelig mangelov | kivikkoalvejuur * | störi burkni * | M, A, S, H | H, N, C, T | R | 4, 5, 8, 9, 10, 30, 31, 33, 35, 44, 45, 53, 54, 70 |
|              | Polypodiaceae   | Polypodium vulgare | polypody | stensöta * | aieselrot | engelsad | kallomarre * | köldugras | M | H, C | R | 45, 49 |
| Coniferous trees |                  | Picea abies | spruce | gran | gran * | rodgren | kuusi * | rauögrem | M, A | H | J | 29, 55 |
|              | Pinus sylvestris | pine | tall * | furu | skovfyr | mänty | skogfyr | M | C | H, P, T | 45, 49 |
|              | Cypresseae      | Juniperus communis | juniper | en * | eier * | enebær * | katja * | einir * | M, A, C, H | H, N, C | B, R | 4, 9, 14, 25, 34, 44, 45, 53 |
|              | J. sabina      | saxon | sivenbom | sevenbom * | rohtokatja | sabinminir | C, H, P | W | 9 |
| Trees, shrubs |                  | Populus tremula | aspen | aap | aap * | barsæveaap | haapa * | öap | M, H | H, N, C, L, P | 34, 45 |
|              | Salix spp       | willow | salg | vier | pal * | paju * | vúr * | M, S, J | H, C, T, L, P | 9, 33, 45 |
| Myrtaceae    | Myrica gale     | sweet gale | pors | pors * | porse * | suomyerti | mjuusteling | M, H | H | W, L | 9, 35 |
| Betulaceae   | Alnus glutinosa | alder | al | or | el * | tervaléppä | rauöléri | S | T | H | 9 |
|              | Betula pendula  | silver birch | vårbräken | hengebjörk | vorte-brik | randuskovu * | M | C | L, J, P | 45 |
|              | P. pubescens    | downy birch | glashjörk | björk | dun-brik | hiskuovu * | birki * | M, S, H, C | L, J, P, C | 9, 33, 37, 45, 50 |
| Corylaceae   | Corylus avellana | hazel bush | hassel | hassel | hassel | pälkimänsä | heiliñjät | H | L | 9 |
| Grossulariaceae | Ribes nigrum | blackcurrant | svarta vinbär | solbär | solbär | musta vinimarja | sölberjarummu | M | C | B | 45 |
| Rosaceae     | Prunus padus    | bird cherry | higg | høeg | høeg | tuomi * | heggur | M | C | B, P | 45 |
|              | Pyrus communis  | pear | pärón | pære | pære * | päärynä | periñät | S | N | O | 9 |
|              | Sorbus aucuparia | rowan | rogn | røm | røm | phialja * | reynir | M | C | P | 45 |
| Rosaceae     | Rhus vernicifolia | honeywood | buckthorn | bukthorn | bukthorn | bukthorn | pukapu | H | L | 9 |
|              | Quercus robur   | oak | ask | ask | ask | saarni * | askur | M | H, C | L, P | 45, 49 |
|              | Sambucus nigra  | black elder | flader | svartvlhyld | hyld * | selja * | svartylhr | M, S, C, T | B | 9, 45 |

Host (if specified): M = human, A = animal, C = cattle, S = sheep, H = horse, P = pig.

Target (if specified): H = helminths, N = nematodes, C = cestodes, T = trematodes, P = protozoa.

Part used (if specified): W = whole plant, L = leaves, F = flowers, S = seeds, B = berries, H = shoots or buds, R = root or tuber, J = sap, P = phloem or bark, O = wood, C = charcoal or ashes, T = tar.

* Indicates that the plant is mentioned in literature from that Nordic country.

Note: Plants included in this table are based on generally historical reports. This does not imply endorsement by the authors in either their effectiveness against parasites, or safety for human and/or animal use.
Table 1. Continued

| Plant family | Scientific name | English | Swedish | Norwegian | Danish | Finnish | Icelandic | Host | Target | Part used | Reference |
|--------------|----------------|---------|---------|-----------|--------|---------|-----------|------|--------|-----------|-----------|
| C. brunnescens | C. brunHeatd | good king | høgsko | stort Henrik | giskeflett | pluggut ark | litorina | M | H,C | W | 45, 49 |
| Caryophyllaceae | Cardamine pratensis | hairy bitter- | ängsbräsm | rosettkarse | roset | mäkilitukka | lambaklukka | H | L | 8, 36, 37 |
| Descurainia sophia | D. flexuosa | common | flaxweed | stillfrö | hundesennep | finbladet liitutilli | befjurt | M | H, N, C | S | 22, 45, 49 |
| Lepidium sativum | L. sativum | garden cress | kryddkrasse | matkarse | karse | vihanneskrassi | karsi | M, S | H, T | W, S | 9, 44, 45 |
| Raphanus sativus | R. sativus | garden radish | rättika | rödmålde | rød gåsefod | punasavikka | M | C | H | 9, 44 |
| Sisymbrium officinale | S. officinale | hedge mustard | vägsenap | vegsennep | vejsennep | rohtopernaruoho | götudesurt | M | C | H | 9, 44 |
| Crassulaceae | Rhodiola rosea | roseroot | rosenrot | rosenrot | rosenrod | ruusujuuri | burnirót | C | H | R | 55 |
| Sempervivum tectorum | S. tectorum | house leek | taklök | takløk | husløg | mehitähti | húslaukur | M | C | W | 9, 44 |
| Rosaceae | Agrimonia eupatoria | agrimony | småborre | åkermåne | agermåne | maarianverijuuri | M | H, W | 9, 44, 49 |
| Fragaria vesca | F. vesca | wood | markjordbær | skov mansikka | villijär | jordbær | | M | C | B | 9, 45 |
| Potentilla anserina | P. anserina | silverweed | gåsört | gåsemure | gåse-potentil | ketohanhikki | tágamura | M | H | W | 44 |
| Rubus chamaemorus | R. chamaemorus | cloudberry | hjortron | molte | multebær | lakka | múltuber | M | C | B | 45 |
| Sanguisorba officinalis | S. officinale | great burnet | blodtopp | læge kvæsurt | punaluppio | blókollur | H | H | R | 30 |
| Fabaceae | Vicia sativa | common vetch | fodervicker | fôrvikke | vikke | vikkeri | fóurflækja | H | W | 9 |
| Rutaceae | Ruta graveolens | common rue | vinruta | vinrute | rude | ruutakasvi | ruutakasvi | M | H | W | 9 |
| Clusiaceae | Hypericum perforatum | perforate | äkta prikkperikum | prikbladet | mäkikuisma | jónsmessurunni | M | H, F, H | 9, 49, 51 |
| H. maculatum | H. maculatum | imperforate | fyrkantig | firkant- | kantet | särmäkuisma | flekkjagullrunni | M | C | 45 |
| Violaceae | Viola odorata | sweet violet | luktviol | marsfiol | marts-viol | tuoksuorvokki | ilmfjóla | M | 9 |
| Cucurbitaceae | Cucumis sativus | cucumber | gurka | agurk | agurk | kurkku | agúrka | M | C | S | 45 |
| Plant family | Scientific name | English | Swedish | Norwegian | Danish | Finnish | Icelandic | Host | Target | Part used | Reference |
|-------------|----------------|--------|---------|-----------|--------|---------|-----------|------|--------|-----------|-----------|
| Cucurbitaceae | Cucurbita pepo | pumpkin | pumpa | gressakr | mandel-gressakr | kurtaska | grasker | M | N,C | S | 9, 45 |
| Apiaceae | Anethum graveolens | dill | dill | dild * | till | dill | C | 9 |
| | Angelica archangelica | angelica | kvanne | kvann | vamnpunkki | hvom * | M, H | H | S,R | W | 8, 32, 35, 36, 37, 41 |
| | Anthriscus cerefolium | chervil | dansk-körel * | bagekjørvel | körel * | maustekvikri | garukjerköll | M | H | W | 9, 44 |
| | Apium graveolens | celeriac | selleri | lagese lleri | selleri * | selleri | blaßelja | M | 9 |
| | Carum carvi | caraway | kumin | karv * | kommen * | kuminus * | kümni | M | H, C | W,S | 9, 34, 45 |
| | Coriandrum sativum | coriander | korrajander | korriender | korriander * | korrianti | körjandra | M | 9 |
| Daucus carota | carrot | morot * | gulroter * | gulerod * | porkkana | gurrott | M,P | H,C | R | 9, 35, 44, 45, 49, 55 |
| | Foeniculum vulgare | fennel | fläskul | femnikel | femnikel * | femniki | fennhaka | S | T | 9 |
| | Levisticum officinale | lovage | livsbitiska | livsbitikke | livsbitikke * | liperi | trellatrygg | M | H | S | 9, 44 |
| | Petroselinum crispum | parsley | persilla | persille | persille | persila * | steinselja | C | P | 29 |
| | Valeriana officinalis | valerian | valerian | valerian | valerian | valerian | valerian | C | P | 29 |
| | Hyoscyamus niger | henbane | bolmiört | bulmiort | bulmiort * | hullaali | skollarótt | H | S | 9 |
| | Nicotiana rustica | tobacco | tobak | tobak | tobak * | takalaka | bónsd-tobaksjur | S, T | R | 9 |
| | Solanum dulcamara | woody nightshade | begesöta | sylngsöver | bitterös natskygge | natskygge * | punakoiso | ereturfläcka | M | 9 |
| | S. nigrum | black nightshade | nattsanka | nartstwér | sort natskygge | sort natskygge * | mustakoiso | hünjurt | H | L,B | 9 |
| | S. tuberosum | potato | potatis | potet | kartoefi | perun * | kartufla | M | C | R | 45 |
### Table 1. Continued

| Plant family         | Scientific name | English | Swedish | Norwegian | Danish | Finnish | Icelandic | Host | Target | Part used | Reference |
|----------------------|-----------------|---------|---------|-----------|--------|---------|-----------|------|--------|-----------|-----------|
| Scrophulariaceae     | Rhinanthus spp  | yellow rattle | skältra | kull | skålje | laukku | lóka | M     | H      | W        | 8, 36, 37 |
| Veronica anagallis-aquatica |             | blue water speedwell | vattenveronica | vassveronika | lancettbladet | komnuniTyde | laugadepla | M     | H      | W        | 8, 36, 37 |
| V. chamaedrys        |                 | germander speedwell | teveronica | tveskjevg-veronica | tveskjeget | narmuriTyde | völudepla | M     | H      | W        | 44        |
| Plantaginaceae       | Plantago lanceolata | English plantain | svartkämpar | smålkjörp | lancet-vejbred | hemiråtamo | selgäri | M     | H      | L,R      | 8, 33, 35, 36, 41 |
| **P. major**         |                 | great plantain | groblad | groblad | vejbred | piharatamo | graösiura | M     | H      | W,L,R    | 9, 35, 37, 41, 55 |
| **P. maritima**      |                 | sea plantain | gulmar | strandkomppe | strand-vejbred | meriråtamo | kattarunga | M     | H      | L,R      | 8, 36      |
| Valerianaceae        | Valeriana officinalis | valerian | vänderot | lege-venderot | legebadkramra* | roftovormrajaksi | garastäru | M     | H      | W        | 9, 4, 44, 49 |
| **Asteraceae**       | Achillea millefolium | yarrow | röllika | röllika | sünkarsámö | vallhumall | M     | H      | W,LF    | 9, 5, 35, 38 |
| Artemisia absinthium  |                 | southernwood | åbrodd | åbrodd | ambra | aaprontimarana | M     | N      | W        | 44        |
| **A. absinthium**    |                 | wormwood | malört | ekte malurt | malurt | mali | M,C,S, H | H,C   | W,LS    |           | 5, 9, 25, 34, 44, 45, 49, 53, 55, 58 |
| **A. vulgaris**      |                 | mugwort | gråbo | burott | gråbyröke | puo | M     | H      | W        | 9, 38, 40, 58 |
| Cicuta maculata      |                 | blessed thistle | kardbenedikt* | kardbenedikt* | korbendikt* | karvasohdake* | M     | H      | W,L     | 9, 35, 44, 55 |
| Helianthus annuus    | sunflower | solros | solsikke | solsikke | auringonkakka* | sölfildl | M     | C      | S        | 45        |
| Inula heptaphylla    |                 | sea heptaphylla | alandarot | alandarot | lagealart | lagealart | M     | H      | R        | 9, 55      |
| Matricaria maritima  | sea mayweed | sea mayweed | kustbadbrar* | strand-baldbrar* | kamillke | merisunio | baldursbr* | M     | H,L,F   | 8, 9, 33, 36, 37, 41 |
| Senecio vulgaris     |                 | common groundsel | korsört | åkersvineblom | almindelig brændhedge* | peltoviikko* | krostfildl | M,C    | C      | L        | 9, 22, 45 |
| Silphium marianum    |                 | mariajiestel | mariajiestel | mariajiestel | mariajiestel | mariajiestel | mariajiestel | M     | S      |           | 9, 53      |
| Tanacetum balsamita  | alectros | balsamblad | balsam | okroej | palsempän-pänkakkara | M     | H      | W        | 35        |
| T. parthenium        | feverfew | matram | matrem | matrem | reynup-pin-kakkara | M     | H      | S        | 44        |
| T. vulgare           |                 | common tansy | renfana | renfann | renfann | renfann | pøtaryrt | regfanged | M,A,S,H | H,N,C,T | W,LF,S   | 1, 4, 9, 10, 19, 30, 34, 35, 44, 45, 49, 53, 55, 58, 70 |
| Liliaceae            | Allium cepa     | onion | rödlök | rödlök | rödlag | punasipul | rau-laukur | M     | H      | W        | 9, 35, 44, 55 |
| A. porrum            | leek | purrlokk | purrlokk | purlag | purjo | bladlaukur | M     | H      | W        | 34        |
| A. sativum           | garlic | viitlokk | hvitlokk | hvitlokk | hvitløg | hvitløg | hvitløg | hvitløg | M, A     | W,N,C   | W       | 4, 9, 33, 44, 45, 55, 70 |
| A. asarinum          | ramson | ramskik | ramlokk | rams-lokk | rams-lokk | karhunalaukka | bjarmalaaukka | M     | H      | W        | 34        |
| Asparagust officinalis | asparagus | sparris | asparagus | asparagus | asparagus | ruokaparsa | M     |       |           |           |
| Iris pseudacorus     | iris | svärdjilja | sverdiljhe | gul sverdiljhe | keltakurjemnakka | gula sverdiljhe | M     | H      | R        | 9, 30      |
| Araceae              | Acorus calamus  | sweetflag | kalmus | kalmsrot能够 | kalmsrot | kalmsrot | M     | C      | R        | 45        |
| Grasses              | Poaceae         | Poa annua | couch grass | kvickrot | kvickrot | kvickrot | jouluvehna | húsapintur | M     | H, W    |           | 9, 18      |
| Hordeum vulgare      | barley | korn | bygg | bygg | bygg | orha | bygg | M     |       |           | 9        |
| Secale cereale       | rye | råg | rug | rug | rug | rugin | rugin | M     |       |           | 9        |
Lichens and Ferns: One of the plants most commonly mentioned in the Nordic literature is male fern (*Dryopteris filix-mas*), a common fern that is widespread throughout the Northern hemisphere. Extracts from powdered rhizomes were first used by the Greeks (circa 350-250 BC) to treat tapeworm infections. This product (oil of aspidium) became an established product in many Pharmacopoeia of the Western World and was sold until the end of the 1940s. A number of active compounds have been isolated from this product, but it appears that the anthelmintic constituent is filicic acid.

Trees and Shrubs: Reports are few on the extensive use of trees and shrubs specifically to feed to livestock as treatment against parasites. However, products of willow (*Salix* spp.) have been widely used as analgesics or antipyretics in humans, probably attributable to the content of salicin and derivatives. *Salix* spp. also has a reputation as an anthelmintic for humans and livestock. Horses fed leaves are not supposed to get worms and a decoction of the bark is efficacious against flukes (trematode parasites) and diarrhoea in sheep (*Brøndegård* 1980).

Herbaceous Plants: There is a great variety of these plant types that has been used as deworming preparations. Whilst most of those mentioned in Table 1 thrive in the Nordic environment, many originated from other countries. Possibly one of the most widespread and commonly used herbal anthelmintic is oil of chenopodium, derived from *Chenopodium ambrosoides*, popularly known as American wormseed, or goosefoot. Archeological and ethno-logical studies suggest that this material has been used for many centuries. It is of passing interest that in the early eighteenth century, Peter Kalm (1715-1779), a Swedish botanist and traveller, reported that it was used by both the indigenous inhabitants and European settlers in the American colonies for the treatment of *Ascaris* infections. Plants were taken to Europe, cultivated widely, and were soon in common usage. The active principle, ascaridol, a volatile terpene, was isolated and eventually synthesized. However, in the Nordic countries, *Chenopodium* is not one of the most commonly mentioned plant families.

Some of the plants mentioned are now commonly used as spices eg. caraway (*Carum carvi*), thyme (*Thymus* spp) and mint (*Mentha* spp). These have been found in Russian studies to have effect against *Trichostrongylus* larvae *in vitro* and also in sheep (*Gadzhiev & Eminov* 1986, *Eminov* 1982).

Members of the family *Asteraceae* have also a prominent position in the herbal de-worming literature. The Romans used dried, unexpanded flower heads obtained from several species of the genus *Artemisia* in the first century, for the treatment of *Ascaris, Enterobius* and tapeworm infections. The name given for this herbal preparation was *semen-contra vermes* (semen against worms), apparently because of its superficial resemblance to semen. It became an important member of the European Pharmacopoeia until the early 20th century. The active principle was found to be the sesquiterpene lactone, santonin. More recent pharmacological studies have demonstrated the pharmacological basis of this chemical. Low concentrations of santonin are reported to have a selective toxic action on the ganglion located in the nerve ring of *Ascaris* spp. (*Sollmann* 1957). Against other nematodes, such as *Oxyuris* spp and the cestodes, santonin is not effective (*Steinegger & Hänsel* 1972). Pharmacological studies investigating the specific effects of santonin-containing herbal preparations are not known. This is probably because santonin had been isolated and used as a vermifuge as early as 1830. Due to its narrow therapeutic window (safety index) and toxicity, the crude drug santonin is no longer used (*Reynolds & Prasad* 1982, *Tyler et al.* 1988, *De Smet* 1997).
Another member of the *Asteraceae* family, more widely used in the Nordic countries, is common tansy (*Tanacetum vulgare*). The active component is claimed to be thujon. *In vitro* studies have shown an effect of this plant on *Trichostrongylus* and *Ostertagia circumcincta* spp. (*Gadzhiev & Eminov 1986, Eminov 1982*). Vegetables, such as carrot (*Daucus carota*), brassicas (*Brassica* spp), the onion group (*Allium* spp.), as well as all kinds of berries have had widespread use against parasites in the Nordic as well as most other countries. Seeds of pumpkin and cucumber (Cucurbitaceae) have been used in tropical America for centuries as a treatment of tapeworm infections. From there the popularity of this remedy spread to Europe. The active component, cucurbitine, was identified as an amino acid (3-amino 3 carboxy pyrrolidin). Leaves from another tropical plant, tobacco (*Nicotiana rustica*), have enjoyed universal popularity and latterly notoriety for use in smoking. However, infusions of this plant, or synthetic analogues (e.g. nicotine sulphate) were commonly used as anti-nematode preparations in ruminant livestock up until the advent of the modern broad spectrum anthelmintics in the mid 1950s. Both these plants have also been grown and used as anthelmintics in the Nordic countries.

**Pasture plants:** The possible use of specialised crops to control nematode infections in grazing ruminants has attracted considerable research interest in recent years. Bioactive plants or forages with secondary metabolites, particularly legumes with a high content of proanthocyanidins (condensed tannins) e.g. sulla (*Hedysarum coronarium*) or lotus major (*Lotus pedunculatus*) have been reported to reduce worm burdens in grazing lambs by up to 50% (*Niezen et al. 1995*). An *in vivo* anthelmintic effect has also been observed using quebracho, a condensed tannins extract, as a single high dose against sheep nematodes (*Athanasidou et al. 1999*) and the capacity of purified condensed tannins from Danish legumes to kill nematode larvae *in vitro* has been demonstrated (*Kahiya et al. 1999*). However, in several field studies it has been difficult to relate anti-parasitic effects to the actual amounts of condensed tannins (e.g. *Niezen et al. 1998*). A complicating factor is that condensed tannins are a poorly defined group of compounds (basically polymers capable of covalently binding protein) making standardised determinations in plant material difficult.

It has been postulated that the beneficial effects of tanniferous plants against internal parasites could be due to one, or a combination, of the following factors:

- Tanniferous plants increase the supply and absorption of digestible protein by animals. This is achieved by tannins forming non-biodegradable complexes with protein in the rumen, which dissociate at low pH in the abomasum to release more protein for metabolism in the small intestine of ruminants – in other words, ”natures protected protein.” This indirectly improves host resistance and resilience to nematode parasite infections.
- Tannins have a direct anthelmintic effect on resident worm populations in animals.
- Tannins and/or metabolites in dung have a direct effect on the viability of the free-living stages (development of eggs to infective larval stages).

Although there is some evidence to support each of these above claims (for review, see *Kahn & Diaz-Hernandez 1999*), we believe that the data are by no means clear-cut (*Bernes et al. 2000*).

**Limitations with using plants as natural anthelmintics**

It is not a simple matter of just growing these plants and expecting them to be used in a natural parasite control system. In a longer perspec-
tive, many issues need to be considered. These include, whether the chosen plants are amenable to cultivation and if so by what means (pure stands or as mixed leys), ease of harvesting seeds and thus their commercial availability, and means of use or administration (grazing, or individual stable feeding – short, or long term). In addition, factors such as palatability, stability, biodegradability of active compounds in preserved products, whether these are to be used curatively, or preventively, need to be considered. Finally, dosage may be difficult to control and the possibility of toxic side effects in animals needs to be considered.

Some of the potential candidate plants cannot withstand trampling by livestock, are poor competitors with other pasture species in mixed grazing swards (e.g. *Lotus* spp., Beuselinck & Grant 1995), or they are preferentially sought out by grazing animals and thus easily succumb to even light grazing pressure (e.g. *H. coronarium*, Niezen et al. 1995).

Plants which have a high content of known direct-acting parasiticides (e.g. santonin in wormseed) may be effective for short-term "curative" use eg. a short grazing interval on a "deworming" paddock before a pasture change. In other cases, plants may have to constitute a substantial proportion of the feed and may therefore be used in a preventive fashion mixed with grass and clover in larger grazing areas, or in pure stands for rotational grazing.

A word of warning – plant toxicity

The whole animal kingdom is dependent on the use of plant material. Plants have probably covered much of our planet throughout the history of multicellular life. This implies that herbivores have been too few in number to consume all the food available (Hairston et al. 1960), and probably more importantly, that some plants have evolved defence mechanisms against being eaten by herbivorous animals (Murdoch 1966). One of their defence principles is the production of chemical compounds, which may be harmful or distasteful to potential herbivores. The fact that certain plants could have adverse effects on man and livestock has been known since ancient times. Likewise, it has been recognised that some plants could be of benefit in disease conditions. These two aspects of the plant kingdom, the beneficial and the harmful properties of plants, strongly related to dosage, are described in the early medical literature of classical Greece and Rome (Hippocrates, Theophrastus, Dioscorides).

Modern scientific literature on plant effects on livestock deals mainly with adverse effects, and less attention has been paid to the curative potential of plant material. The complex nature of this discipline is reflected in the difficulties in classification of poisonous plants. Attempts to classify them according to the chemical nature of their active constituents are met with the obstacles that these may be either a single substance or a number of substances with wide differences in chemical properties. Accordingly, a chemical classification will lead to considerable overlapping with some plants featuring in several chemical groups. Albeit these difficulties, the majority of recent textbooks group the poisonous plants according to their known toxic constituents (Cooper & Johnson 1998). These include a vast range of compounds that may be classified as alkaloids, glycosides, nitrates, oxalates, photodynamic substances, thiaminases, local irritants and phytooestrogens. The most reputed plants in the Nordic flora with reported responsibility for livestock poisoning include wolf’s-bane (*Aconitum lycoctonum*) (alkaloids), cowbane (*Cicuta virosa*) (alkaloids), groundsel (*Senecio* spp.) (alkaloids), yew (*Taxus baccata*) (alkaloids), brassicas (*Brassica* spp.) (S-methyl cystein sulphoxide, progoitrin, nitrates, amongst others), foxglove (*Digitalis purpurea*) (digitalis-glycosides), bog...
Plants as de-worming agents

Conclusion

This review provides ample evidence that a considerable amount of information relating to the use of plant material as de-worming preparations for man and his livestock in the Nordic countries, is available. However, almost all of these reports are historical and/or anecdotal. Evidence for effectiveness of plant de-worming preparations has been rarely obtained and little has been made available in scientific publications. With respect to increasing interest in the therapeutic use of natural products, we believe that it is important that a systematic evaluation is made of the botanical resources of the Nordic countries in relation to the purported de-worming properties of those plants that are endemic, or thrive, in this region of the world.

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