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Review article

Managing helminths of ruminants in organic farming

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Abstract – The use of anthelmintics is strongly limited in organic farming. This may induce a change in the intensity (no of worms) and diversity (proportions of species) of helminth infection. Helminths remain a major preoccupation in organic sheep farming: high levels of infection have been recorded on several farms and helminth diversity is always higher. The helminth infection in milk cattle of northern Europe is controlled and diversity is higher in organic farms, as recorded in sheep. The role of helminth diversity on intensity is still unclear. Grazing management is one of the means to controlling helminths. The use of safe pastures for calves and sheep after weaning is one of the major components of control. The use of alternate or mixed grazing is common for cattle in northern countries but is uncommon for sheep in France. Grazing management is not sufficient to controlling infection in sheep and conventional anthelmintic treatments are performed. Additionally, alternative treatments are used. The alternative therapies based on phytotherapy or homeopathy are largely recommended in organic farming but do not have any demonstrated efficacy. More research is needed to evaluate such therapies.

ruminant organic farm / helminth / grazing management / anthelmintic / phytotherapy

Résumé – Gestion des helminthes de ruminants en agriculture biologique. L'emploi des anthelminthiques est fortement limité en élevage biologique. Cette diminution de leur utilisation peut conduire à des changements en ce qui concerne l'intensité (nombre de vers) et la diversité (proportion des espèces) des parasites. Les helminthes sont une préoccupation majeure en élevage biologique ovin : les infestations sont très fortes dans certaines fermes et la diversité est plus élevée que dans les élevages conventionnels. L'infestation des bovins laitiers par les helminthes dans les pays du nord de l'Europe est assez bien contrôlée et la diversité est plus forte également en élevage biologique. Le rôle de la diversité sur l'intensité n'est pas encore clair. La gestion des pâturages est l'un des moyens de contrôler l'infestation. L'utilisation de pâtures saines pour les veaux ou les agneaux après le sevrage est l'une des composantes essentielles de la gestion des parasites. L'utilisation de pâturage alterné ou mixte avec des espèces différentes est commun dans les régions nordiques pour les bovins mais n'est

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presque pas recensé chez les ovins en élevage biologique en France. La gestion des pâturages n'est pas suffisante pour assurer le contrôle de l'infestation des ovins et l'emploi d'anthelminthiques synthétiques est usuel. À ces traitements chimiques classiques s'ajoutent des traitements dits alternatifs. Ils sont fondés sur l'utilisation de préparations phytothérapeutiques ou homéopathiques, et sont recommandées en agriculture biologique bien que leur activité n'ait pas été évaluée. Un effort de recherche important est à faire pour apprécier le bien-fondé de telles thérapies.

élevage biologique des ruminants / helminthe / pâturage / anthelminthique / phytothérapie

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1. INTRODUCTION

During recent years organic farming has grown rapidly: it represented 1% of the total utilisable agricultural area in 1985 and reached 2.1% in 1998 in the European Union [32]. Most expansion in the land area has taken place since the implementation in 1993 of EC regulation 2092/91 [2] defining organic crop production and the application of policies to support conversion to organic farming as a part of the agri-environmental programme (EC reg. 2078/92). Many of the investigations in the past were dedicated to crops and organic animal breeding was not studied much. The situation has changed and products from livestock bred organically are available on the market. In contrast to conventional livestock production, organic livestock farming is defined by basic guidelines, involving a decreased use of chemotherapy and a different way of thinking in relation to production processes, as integrative and holistic features are placed in the forefront [56]. Organic farming encompasses a vision of a more sustainable approach to animal production. The aim is to maintain soil fertility, environmental protection, animal welfare, and the production of good quality animal products based on nonchemical prevention of diseases. Among the main problems in French organic farming of ruminants, the control of parasitism and mastitis, reproduction organisation, and grazing management are considered of high importance [5]. An examination of papers that appear mostly in extension journals referenced in the database of the French Centre for documentation on organic agriculture in Brioude [12], gives an idea of the preoccupations on diseases. Diseases represent 16.8% of 350 references on animal breeding in the last ten years. Parasitic diseases are recorded in 22.2% of these papers giving an estimate of the concern for parasite management. Organic farmers in the United Kingdom list the following diseases as research priorities in sheep: flukes, digestive-tract worms, fly strike, footrot and mastitis [47]. Gastrointestinal nematodes, flukes, and the *Moniezia* cestode are then one of the major preoccupations for organic ruminant breeders.

Their control can occasionally rely on anthelmintic drugs, or more frequently on authorised drugs based on phytotherapy or homeopathy. In agreement with the organic farming rules, parasite control procedures based on grazing management may be grouped as preventive, evasive or diluting [4]. Preventive procedures include the introduction of uninfected ruminants to a parasite free pasture. The evasive strategies are aimed at avoiding disease producing infections of a contaminated pasture: the infected ruminants are moved to a clean pasture. Dilution strategies rely on mixing susceptible with resistant stocks, or by reducing stocking rate or the duration of the grazing period. The present review will focus on the following points: (i) Are helminths an important preoccupation in organic farming? (ii) Can we achieve an efficient control using grazing management? (iii) Can we wisely use anthelmintics in pathological cases? (iv) Can we rely on alternative treatments founded on phytotherapy or homeopathy?

2. HELMINTHS: SHOULD WE BE AFRAID, AND OF WHAT?

The majority of studies are focused on digestive-tract strongyles. Although Trematodes or Cestodes might represent a real problem in organic farming, they are poorly studied and are thus under-represented in our review.

Good levels of performances of breeding stock are possible under a chemical-free livestock system [37]. The between-year variation can, however, be important [18] and the insidious nature of strongyle infections should be accurately studied. Many investigations comparing untreated and treated stocks have demonstrated the importance of strongyle infections on the performances of sheep, goats and young cattle in a large array of environmental conditions. Digestive-tract strongyle infection in set stock conditions for lambs may even lead to an absence of growth during the whole grazing season under a temperate climate [33]. Strongyle infection is thus to be taken into account in all ruminant production. Digestive or pulmonary strongyles [10] in goats may also play an adverse effect on milk and kid production. This detrimental effect will be more important in high milk producing goats [21].

Conversion from conventional to organic farming affects management procedures that depend on the host species. Dairy production is the least affected by conversion and consequently little to no change is expected in the intensity and spectrum of internal parasites [58] since grazing (source of helminths) in dairy cows is limited. The increased use of the deep litter barn system has resulted in cocciodiosis but has not modified helminth infection. A survey of Danish organic farms indicates that strongyles markedly infected 7–32% of heifers on 5 farms out of 11 and the *Dictyocaulus viviparus* lungworm was detected on three farms [60]. In Sweden, faecal egg counts over 500 were only observed in 2.2 to 0.6% of the calves, and only 1% of the serum samples had pepsinogen values exceeding 3.6 U tyrosine, indicative of subclinical *Ostertagia ostertagi* infections [28]. The difficulty in conversion is probably higher in meat lambs. In meat sheep of the centre of France, infection is slightly higher (although much variability was recorded) in certified organic farms compared with conventional ones [11].

The most striking fact is that organic farms clearly have a more diverse helminth fauna, e.g. more species are well represented. A decrease in helminth diversity could be related to increasing anthelmintic treatments in dairy-goats [52], in sheep [11] and in meat cattle (Costa, personal communication, 2001). We also noted from Swedish cattle data [18] that cattle treated with boluses (continuous release of anthelmintics) have one or two species whereas untreated cattle harbour three species. The organic farms, since they use a lower number of treatments, may then present higher species diversity, preserving the chance to be infected by rarer species. This was shown in meat sheep when 7 conventional farms were compared to 5 organic ones [11]. Conventional farms had higher proportions of a few species: (1) *Nematodirus* and *Cooperia* (two farms), (2) *Haemonchus* and *Chabertia* (two farms), or (3) *Teladorsagia circumcincta* and *Trichostrongylus* in the abomasum (two farms) whereas organic farms harboured all the species in balanced proportions. Increased helminth diversity might be a result of lower pressure from anthelmintic treatments and it could possibly seed the predictability of the intensity of helminth infection. Several researchers of free-living organisms or plants have linked diversity to the predictability [26] or sustainability of populations [59], in populations that do not increase or decrease enormously. Predictable or sustainable parasitic helminth communities should have low or medium intensity, depending on pathogenicity, so that helminth infections do not alter the host populations. Helminth diversity has been related to a lower intensity of infection in extensive goat breeding [52] and in meat cattle [50] and it corresponds to the diversity-sustainability hypothesis. This hypothesis has not been clearly demonstrated in all cases and more investigations should be undertaken if one wants to assess the respective role of treatments and diversity itself on the intensity of strongyle infections.

3. GRAZING MANAGEMENT AND THE CONTROL OF GASTRO-INTESTINAL HELMINTHS

The methods of parasite control in organic dairy cattle of Sweden were extensively studied on 162 farms [57]. In these cattle, digestive-tract strongyles represented the main parasitological problem. The organic farmers have significantly larger areas of cultivated lands, due mainly to a greater access to pastures and ley. They also rely on (1) preventive grazing management such as delayed turn-out, change of pastures between seasons, and the use of more aftermath, (2) diluting grazing management: mixed or alternate grazing with other host species, (3) evasive grazing management like changing the pasture within the season, (4) supplementary feeding in the spring. In Denmark [58], cattle are moved to new pastures several times during the season and feed supplementation is given. Parasite control is obviously based on grazing management in these dairy cattle-farms.

In French sheep meat farms [38], parasite management still strongly relies on anthelmintics within the frame of the organic constraint, and pasture management (mostly evasive, like changing the pasture within the season). We will focus on grazing management in organic meat sheep, since it is probably a production where parasitism has much importance. The breeding strategy is summarised as follows in meat sheep of the centre of France [38]: (1) ewes and lambs graze together on permanent pastures up to mid-June, and then lambs are placed on safe pastures; lamb production is economically satisfying; (2) ewes and lambs are grazed together on permanent pastures from turn-out to the beginning of July and the lambs graze alone on safe pastures; lamb production is poor; (3) ewes and lambs graze together on permanent pastures up to the end of July-mid August, and then lambs graze on safe and infected pastures; lamb production is very poor. The duration of lambs common grazing with ewes is then the main factor leading to poor production results of the lambs growth. These previous investigations on less than 10 organic meat sheep farms of the centre of France in 1998 were continued on a larger sample of 34 organic meat sheep farms in the same region, and the records of lamb sales and real infection (necropsies and helminth faecal egg output) were undertaken. Three types of management were then evidenced (Bouilhol and Mage, unpublished data). They encompass a larger variety of breeding managements and are probably more representative of the organic farm practices. The first breeding strategy was based on continuous grazing all year round and the lambs grazed on their own pastures from July on (Fig. 1). This system had high infection (over 5000 strongyles, mostly *Teladorsagia circumcincta* and *Nematodirus* sp. in July and multispecies infections in September) and poor lamb growth (lambs sold in July and August represented only 10%). The lambs that remained after September could not be bred organically since several treatments were needed. In breeding management 2 (Fig. 2), lambing and early growth of the lambs indoor, and the use of the lambs on safe pastures from July to the end of the grazing season was favourable to low infection (mostly *T. circumcincta*, less than 1000 worms per lamb in July or September) and there was a high level of lamb growth (40% of the lambs were sold in July and August). Breeding system 3 (Fig. 3) had lambing in pens and outdoors, and lambs and ewes were grazed together until the end of July–beginning of August. The infection level remained low (1500 and 1200 strongyles, mostly *T. circumcincta*, respectively in July and September) and the lamb production remained very poor (only 5% of the lambs were sold in July and August). The main differences in breeding management were the date of lamb birth, its indoor occurrence or not and the use of pastures. Poor production results were probably due to strongyle infection in strategy 1 (ewes and lambs grazed the longest time together compared to the other systems) and to late lambing and strongyle infections (after lambs grazed previously contaminated pastures) in strategy 3. The importance of pasture management has been outlined recently in sheep in Denmark: weaning lambs at the beginning of July and moving them before the expected mid-summer rise of infection to a clean pasture will prevent parasitic gastroenteritis and achieve good production whether the move is accompanied by anthelmintic treatment or not [23]. In the same way, in the temperate Pampas of Argentina, it was shown that calf infection depended mostly on the initial contamination of pastures by cows [55].

Other proposals including more resistant sheep and mixed grazing were tested for four years in New-Zealand [45]. No farm could eliminate the use of anthelmintics completely, but drenching concerned 24% and 6% of the lambs, on the first and second grazing season of the conversion to organic practices, respectively. On one of the farms where experiments were done, the average lamb faecal egg counts (three year monthly averages) was approximately 1250 in organic compared to 400 in conventional breeding management. The average lamb live-weight advantage (kg) in conventional management was 1.9 in the 4 year experiment, with much variation (–1.7 vs. 4.9 kg). These trials were conducted with mixed grazing using a cattle: sheep ratio of 42: 58 in organic (no drenching) and conventional (5 drenches) management. Rams selected for resistance to nematodes were also used in both sheep flocks. The use of pastures was highly organised: the grazing area was divided into two-blocks. From weaning until lambing the ewes were set-stocked on 1 block and the cattle and lambs grazed the other. At lambing, the ewes were shifted to the block grazed by cattle and vice versa. Ewes and lambs were shifted monthly between paddocks from lambing until weaning when lambs entered a grazing rotation with finishing cattle. Lambs grazed on the regrowth of the cattle pasture and were shifted every 7–14 days and did not regraze on paddocks for at least 60 days and in the interval, the paddocks were grazed by cattle. The greatest problem to be overcome on the chemical-free farm is to generate strongyle-clean

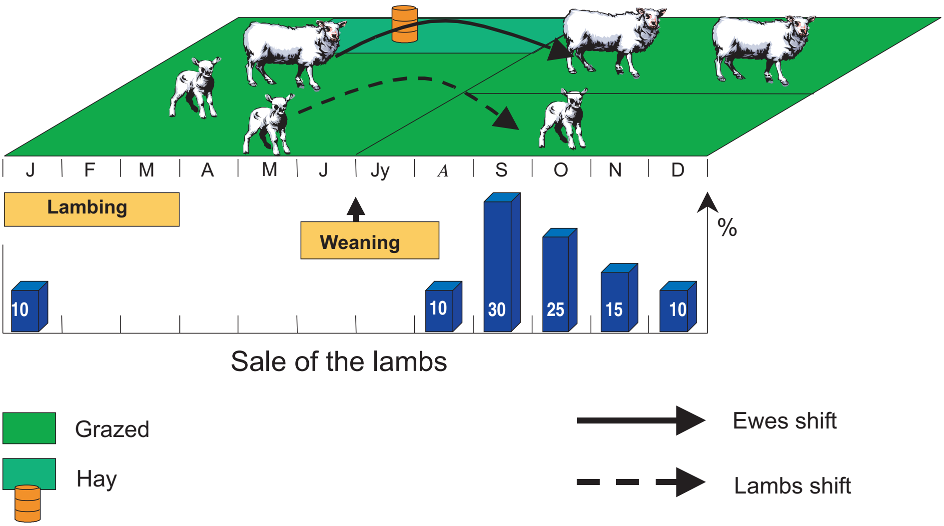

Figure 1. Continuous grazing all year round of meat sheep in the centre of France: general characteristics of management with regards to lamb production and digestive tract-strongyle infection. Poor growth of lambs. High level of infection: 7000 (July) and 19000 (September) strongyles per lamb.

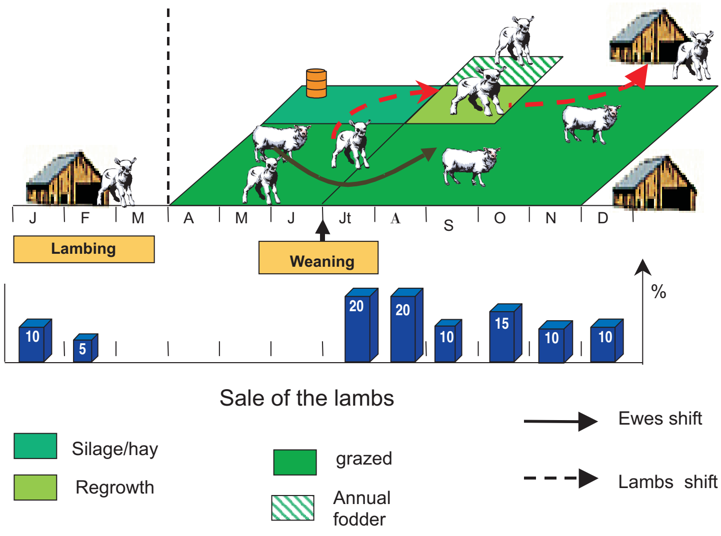

Figure 2. Grazing from April to November of meat sheep in the centre of France with lambs grazing safe pastures after weaning: general characteristics of management with regards to lamb production and digestive tract-strongyle infection. Good growth of the lambs. Low level of infection: 1000 (July) and 1000 (September) strongyles per lamb.

pastures. The strategy in the Romney sheep was effective in reducing infective larvae of *Trichostrongylus*, *Haemonchus* and *Cooperia* but not of *Nematodirus* on pastures as shown in tracer lambs [37]: the number of worms recovered in the organic system was 3670

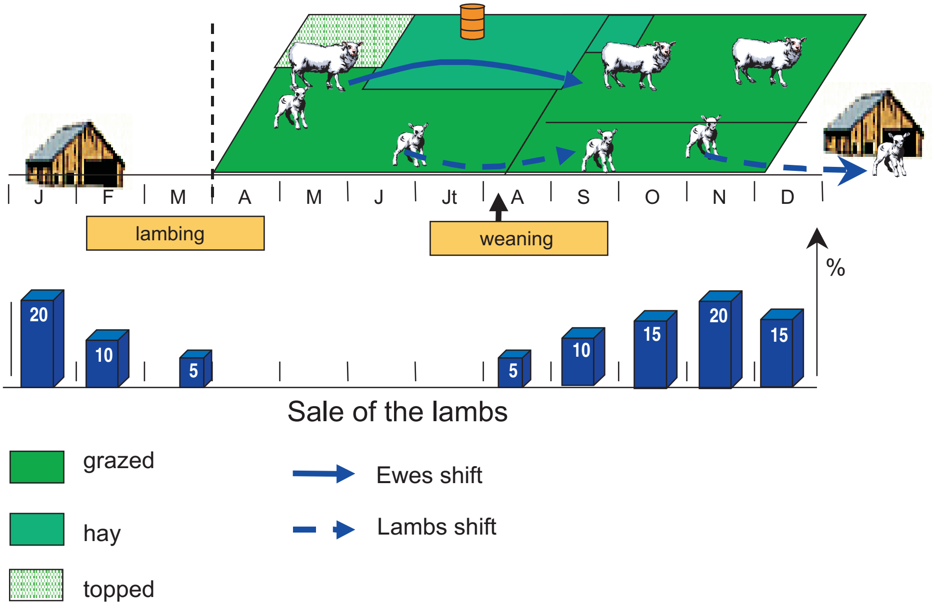

Figure 3. Grazing from April to November of meat sheep in the centre of France with lambs grazing unsafe pastures after weaning: general characteristics of management with regards to lamb production and digestive tract-strongyle infection. Poor growth. Low level of infection: 1500 (July) and 1200 (September).

worms of which 2400 *Nematodirus,* whereas the mean burden was 265 worms in the conventional system. The liveweight gains in the lambs were 139 and 115 g/day, the average carcass weight 17.7 and 13.6 kg (25% less) in March in conventional and organic management respectively, whereas the difference was 37% in June. Average fat depth was greater in conventional (5.2 mm) than in organic (3.8 mm) lambs. Wool production remained similar in organic and conventional lambs. The liveweight of cattle was reduced in first-year grazing animals (steers and heifers) by 10 to 15% depending on the year. Mixed grazing resulted in acceptable production results either in conventional or organic management in these experiences. Weed management (mostly gorse, *Ulex europeaus*) was a major problem in the chemical-free farm. This weed presents a greater production constraint and long-term threat than parasitic problems: only sheep grazing may reduce its extension. The sustainability for parasitic control of small ruminant-cattle mixed grazing remains a question: in desert areas of Mauritania, the mixed grazing for centuries of cattle, sheep, goats and dromedary has led to the maintenance of a species of cattle helminth (*Haemonchus placei*) in sheep and goats, and similarly *Haemonchus longistipes* of dromedary is harboured by goats [31]. The prevalence of *Ostertagia ostertagi* in goats, a typical parasite of cattle, is high in some investigations [13] and indicates that an unusual parasite might become more frequent, probably due to common grazing between the host species. The less frequent mixed grazing of ruminants with pigs or horses has to be evaluated.

Grazing of pastures that may counter parasite-induced losses has also been proposed. Forage crops that contain condensed tannins (Sulla: *Hedysarium coronarium*, Maku Lotus *Lotus pedunculatus* and Goldie Lotus *Lotus corniculatus*) [45] may partly provide a solution to parasitic control. They must be grown as specialist crops since they do not compete well in a mixed grass environment. The interest of such crops in breeding management is still to be evaluated.

Grazing management is important in controlling helminth infection. It can be sufficient to controlling infection in dairy-cattle, particularly in Nordic countries where the grazing period is relatively short and cattle are able to build up a protective response. Conversely, grazing management can hardly be implemented as the only means to controlling helminths in areas where grazing occurs all the year long and when the hosts are less able to build a protective response (lambs and goats). Other means for control are then needed and anthelmintics (synthetic or based on herbal medicine) are one of the most practised.

4. WHICH DRUGS MAY WE USE WHEN NEEDED?

4.1. Use of synthetic anthelmintics

The use of synthetic antiparasitic drugs is strictly regulated in organic farming. One of the main differences between European and national regulations is the more liberal use of anthelmintics and vaccinations. The French regulations [2] are more strict than European ones and are a source of concern for controlling helminth infections in ruminants. The rules are also stringent in organic certified farms in Denmark: oral anthelmintics are preferred, preventive use of anthelmintics is prohibited, a specific diagnostic by a veterinarian is necessary before treatment and withdrawal time following treatment is three times the statutory time [1]. The *per os* is preferred to the injection formulations (boluses being forbidden), and molecules that are environmentally friendly are also preferred (most macrocylic lactones are then bad candidates [36, 54]). According to the present regulations, ewes, adult goats and cows can be treated twice a year for parasites, and when ectoparasites are to be controlled, exceptionally an additional external antiparasitic treatment is allowed. Withdrawal time is twice the statutory time and when there is no withdrawal time, a minimum of two days is required. Three antiparasitic treatments may be performed in lambs and young goats, and one in calves. This means that the allocation of anthelmintics is even more limited since antiparasitic drugs may concern coccidia and helminths (two different treatments). Helminth control is based on drugs designed against intestinal nematodes, small and large lungworms, *Moniezia*, *Fasciola* or *Dicrocoelium*. Although anthelmintics have a large array of parasitic targets, none are efficient at usual or even at higher doses on all these parasites. Several benzimidazole drugs are efficient against gastro-intestinal nematodes and small lungworms [17] and *Moniezia* (fenbendazole at 3 times the ordinary dosage), nematodes and flukes (albendazole) when used at higher dosages. Three groups of anthelmintics are available: benzimidazoles (albendazole, cambendazole fenbendazole, flubendazole, mebendazole, oxfendazole) and probenzimidazoles (febentel), imidazothiazoles (levamisole, tetramisole), and macrocyclic lactones (ivermectin). The imidazothiazoles are not as efficient on lungworms and are inefficient on *Moniezia* or flukes: tetramisole at 15 mg/kg of bodyweight in sheep did not reduce the larval excretion much ([17]: 60% of faecal larval counts were reduced on day 7 after treatment). The tetrahydropyrimidines are highly similar to imidazothiazole regarding their efficacy on digestive-tract strongyles but are totally inefficient on lungworms. Benzimidazoles and macrocyclic lactones are highly efficient on lungworms when evaluated 7–15 days after treatment but their efficacy is not as good on the long term [40]. Benzimidazoles are efficient against *Moniezia* when used at high dosages but macrocyclic lactones remain inefficient. The choice of the anthelmintic is complicated when resistance to benzimidazoles (a highly frequent phenomenon in sheep and goats: [9, 14, 52]) has been evidenced: the use of two different drugs to control either nematodes and *Moniezia,* or nematodes and fluke infections is required. This means then that the control is based on one type of anthelmintic for each group of helminths in situations where *Moniezia*, flukes and nematodes are found in lambs: three different treatments are then needed. The threshold for the treatment is either therapeutic, production-based or preventive as described in cattle [62] and may then promote a more appropriate use of anthelmintics, although the limitations of organic farming may render such a strategy highly difficult. Thus the farmer cannot rely only on anthelmintics for treatments in ruminant organic farming and they may find other alternatives. Monthly monitoring of production (daily weight gains) and infection (average value of faecal egg counts) for determining the urge of all herd treatment have been proven efficient in controlling the infection of young meat cattle in Argentina [16]. The treatments may be applied selectively to the most susceptible group of hosts as proposed in dairy-goats [29] or to the individually most susceptible hosts in conditions where they can readily be identified [61]. Most of the indicators for gastrointestinal parasites are efficient for groups (faecal egg counts, plasma pepsinogen, or antibody response: [22]) but they remain poor on an individual basis. Indirect evaluation based on bodyweight and body condition score has not yet been proven useful for managing the control of parasites on an individual scale. The only widely tested individual method is the clinical anaemia index (Famacha: [61]) in conditions where *Haemonchus contortus* is the predominant nematode in sheep. A reasonable use of efficient anthelmintics on hosts at risk deserves further studies either in organic or sustainable breeding, since it will permit the control of infection on the most susceptible hosts which may then be run under non-organic rules whereas the majority of hosts would be managed organically.

4.2. Use of phytotherapy and homeopathy

Many resources in complementary and alternative medicine (CAM) are available: phytotherapy (or herbal medicine) and homeopathy are among the most documented both in men and animals. They are widespread but remain controversial. Evidence based medicine (EBM) is founded on scientific evidence established on large randomised trials and remains the core of drugs used in classical medicine. CAM advocates have sometimes argued that EBM will prevent a clinician to adapt treatment to meet individual needs, which is not true [63]. In fact EBM provides an opportunity for CAM to find an appropriate place in health care.

A recent review on herbal medicine in humans only found 58 plants that meet the criteria for consideration e.g. where methods and effects are described explicitly. The most important plants mentioned are *Ginkgo biloba*, *Hypericum perforatum*, *Allium sativum*, *Vaccinium macrocarpum*, *Echinacea purpurea*, *E. angustifolia*, *E. pallida*, *Mentha piperata*, and *Serenoa repens*, of which none have an evaluated anthelmintic activity [34]. Many plants have been listed as having anthelmintic activity in animals [20] but very few have been subjected to scientific validation. Moreover, the technology for preparing these herbal remedies has often been overlooked and it is well known that water, alcohol (most of the stock solutions in homeopathy or phytotherapy) or glycerine extracts (used in gemmotherapy based on maceration of plant buds in glycerine) will

Table I. Veterinary anthelmintic phytotherapy in Europe (from Cabaret, 1986).

Plant	Recipe	Target parasite	Host species	Comments
Dryopteris filix-mas	Ether extract with 16 to 19% of filicine	*Fasciola hepatica*	Ruminants	Used in Wales (on 30000 sheep in 1925, 1926), also in Ireland.
	Dried plant (5 g) and other compounds, given for 5 days	*Ascaris equinum*	Horses	Possibly toxic
Bryona alba, B. cretica subsp. *dioica*	20 g dried powder/ horse	No	Horses	Possibly toxic
Nicotiana tabacum	10 g	Worms	Sheep	Possibly toxic
Asarum europaeum	20–30 g dried powder	Worms	Cattle	Possibly toxic
Pinus maritima	Therebentina 50–10 mL/host	*Fasciola he*patica Roundworms	Cattle Horses	
Tanacetum vulgare	Many variations	Worms	No	Possibly toxic
Allium sativum	Many variations	Worms	No	

not harbour the same products although they originate from the same plants. These plants may be from temperate (Tab. I) [7] or tropical origins [25]. Several plants are proposed to counter the effects of internal parasites in cattle such as diarrhoea or constipation [19]. The ethnoveterinarian practices are probably a source of valuable drugs, and Africa is likely to be a major resource for phytotherapy, as well as South America and Asia. In Africa, the high cost and unpredictable value of commercial anthelmintics [42] have aroused a renewed interest in traditional veterinarian remedies. African herders are generally very knowledgeable about plants for the most common diseases and ailments [43] affecting their livestock like gastrointestinal nematodes. Similarly, in the Chiapas region in Mexico, herders are knowledgeable of local plant use: *Chenopodium ambrosoides* and to a limited extent *Allium sativum* are used to control gastrointestinal helminths in sheep. Sheep organic farming has been proposed to farmers in the Chiapas in relation with agriculture (potatoes and maize principally), sheep being a source of manure, the only fertiliser available in these Indian communities of poor resources. Several measures have been taken [49]: the building of a corral for collecting sheep faeces, reduction of the number of animals based on selection of the best producers, better feeding on local products, improved surveillance at lambing, use of monthly treatment with *Chenopodium ambrosoides* for internal parasites and extracts of coffee leaves for external parasites. Among the 50 farmers involved, the results were good since mortality decreased from 15% to 2%, and from 18% to 8% in ewes and lambs, respectively. In this example, we do not know if the results were due to better control of parasites (this was not evaluated) or to the set of measures proposed to the farmers. There is hardly any scientific basis to confirm allegations on the value of anthelmintic properties of plants in the ethnoveterinarian practices: only a few evaluations on their short term efficacy are available [30, 39, 44]. The last of the above mentioned work is a good example of the confirmation of ethnoveterinarian medicine efficacy. Four African plant extracts were tested: *Terminalia glaicescens*, *Vermonia amygdalina*, *Solanum aculeastrum*, *Khaya anthotheca* and the control was treated with levamisole. The efficacy of the usual drug (Levamisole) was 97% (at day 10 and 14 after treatment) whereas *T. glaucescens*, *V. amygdalina*, *S. aculeastrum*, and *K. anthotheca*, has efficacies on digestive-tract strongyles of 45, 38, 15, and 71% respectively. In this study the preparation of the drugs (infusion or decoction of herbal medicines) are clearly stated, two doses were evaluated in calves and the efficacy of the evaluation procedures were standard. The Neem tree (*Azadirachta indica*) used in ayurvedic medicine (Indian traditional medicine) provides a wide range of efficacy on ectoparasites, coccidia and digestive-tract strongyles [46]. Many other evaluations are needed worldwide on plants based on ethnoveterinarian medicine, and the necessity of a standard procedure for evaluating this type of drug (efficacy, toxicity and environmental sustainability) is really necessary.

The commercial preparations derived from plants available in France (and probably elsewhere) are not attractive since all the ones tested do not decrease the worm burdens or the faecal egg excretions (except possibly a preparation intended against the tapeworm *Moniezia* in sheep). Homeopathic drugs based on plants are used and have been tested extensively for a few diseases, exclusive of parasitism, and with limited success [51]. Plant homeopathic drugs are not intended to reduce the worm burden or egg output but are meant to build a better response to helminth infection but most of the evaluation trials were organised to demonstrate a reduction of helminth eggs in faeces. Cina, a plant (*Artemisia cina*) most used in homeopathic drugs or compounds for regulating worm infections, is exemplary [8]. When tested in natural (most strongyle species) or in nematode experimental infections (*Teladorsagia circumcincta*, *Trichostrongylus vitrinus*, *Nematodirus filicollis* or *Chabertia ovina*) no effect on egg output was detected. A trial in cattle from three farms in Dordogne in southwestern France [41] gave similar information for a homeopathic complex based on plants (*Filix mas, Allium sativum, Kamala, Areca catechu, Solidago*): no reduction in egg counts was evidenced. Several homeopathic products clearly indicate that they have no anthelmintic effect and that they only possibly help the host to support the helminth infections. We do not have any evaluation procedure for this type of claim and in the future helminthologists should have. Allopathic phytotherapy has a large array of drugs that may reduce the infestation level or effect of worms on production. The distributors of such drugs do not claim real effects on helminths since they should have to obtain an authorisation to distribute anthelmintic drugs. Drugs tested [6] in sheep and [41] cattle have not then clearly been identified as anthelmintics although they were evaluated as such. In the Bouilhol et al. study [6], five drugs were tested against most prevalent parasites. No efficacy of these drugs was demonstrated in sheep against digestive-tract strongyles, *Strongyloides*, *Nematodirus*, *Trichuris*, *Dicrocoelium* or *Moniezia*. In cattle [41], the efficacy of a commercial drug was nil against digestive-tract strongyles or *Nematodirus*. We come to a very important point: How can we evaluate phytotherapy when no accurate therapeutic effect is targeted? What should we evaluate exactly? Better production or better welfare of the hosts? A concerted array of evaluation of methods and goals is really needed and should be established in the future.

4.3. Use of acupuncture

A review on human uses does not give any indication on worm control [35]. Rubin (1976) [48] provides a manual of veterinary acupuncture for several species among which figure cattle (but not sheep and goats). No indication is given for digestive-tract nematodes, although several acupuncture points are proposed against intestinal disorders.

5. DISCUSSION AND CONCLUSION

The intensity and diversity of helminth infections are modified in organic farming [11]. Intensity is very variable from one farm to another in meat sheep. It could be much higher or similar to that found on conventional farms, which is in relation to grazing management and treatment practices. One general question remains unanswered: What is the role of species diversity in maintaining low levels of infection? Are diverse infections better controlled than one species infection? Besides their theoretical implications, such questions have direct practical consequences: conversion to organic breeding of herbivores harbouring resistant strongyles (then with fewer species: [52]) would less easily control these worms. In this study we did not pay much attention to parasites with intermediate host cycles (*Moniezia* spp., *Fasciola hepatica*, *Paramphistomum daubneyi*, *Dicrocoelium dendriticum*, Protostrongylids). This was due to the fact that very few data are available, and in future investigations on organic farming these parasites should be studied. In the meat sheep farms studied, *F. hepatica* was hardly present, *D. lanceolatum* was present at several sites at low levels, and protostrongylid infections were low. The main bias in our sheep studies was the absence of an evaluation of *Moniezia.*

In the organic farming examples we presented, grazing management procedures to control digestive-tract strongyle infections are grouped as preventive (change of pastures between seasons, delayed turn-out, use of aftermath), diluting (mixed or alternate grazing with less susceptible groups of hosts) or evasive (change of pasture within season) strategies. In Nordic countries, dairy cattle, preventive (change of pastures between seasons) and diluting strategies (mixed or alternate grazing with other species) are the selected means for control [57, 58]. Mixed or alternative grazing of sheep and cattle has been studied on several occasions and reduced infection of sheep [53] was observed. The study of mixed or alternate grazing with sows and heifers resulted in a reduction of *Ostertagia* burden in heifers [58]. Such good results are not always obtained: it has been reported that mixed /alternate grazing may in some conditions favour sheep infection with *Nematodirus battus* in the field [15] or induce incidents of severe diarrhoea in calves [3]. No strategy is available for meat calves in organic farming. Several indications are available from conventional farms from temperate areas in Argentina [55] where preventive (change of pastures between seasons, use of aftermath) or evasive (change within season) may strongly alter the pattern of infection. The grazing management associated with a reduced number of treatments based on indicators of infection and calf growth is efficient for meat calve producers in the same area [16]. These results are promising for conversion in meat production in the Argentinean conditions (a large number of cattle per farm and a high soil fertility). Many adaptations are required in the most diverse (from breeds to products) European meat cattle production conditions (intensive, extensive lowland or mountain meat production). The meat sheep farms we presented [11, 38] use preventive (changing of pasture between the seasons, delayed turn-out, use of aftermath), diluting (mixed grazing with less susceptible host of the same species-ewes) or evasive (change of pastures within the season) strategies. They do not rely on mixed or alternate grazing (one of the diluting strategies). The efficacy of their worm control and feeding strategies is unequal, and lambing from January to March is associated with high production only when lambs are kept indoors longer during the winter. Many combinations of pasture use and general breeding management need to be evaluated. No information on milk sheep or goats is available.

Pasture management is not sufficient to prevent the outburst of strongyle infections in all situations. The recourse to drugs either synthetic or derived from plants is still needed. Plant-derived or homeopathic preparations are preferred to synthetic drugs in organic farming. Commercial plant preparations only show an anthelmintic activity in only a very few cases, and up to now they have not proven their efficacy. Homeopathic drugs are not claimed as having an anthelmintic efficacy but rather promote the resilience of hosts to infections. When a drug claims an anthelmintic activity, it must be evaluated by standard methods, but when increased resilience is the drug target, new procedures need to be made. These "resilience helpers" are not legal drugs and legal control is not needed. We come to a situation in which we do not have methods for control and that control is not legally needed, although these drugs represent an important market. To overcome this critical situation it is suggested that resilience evaluation methods (for flock/herd or individual) should be proposed (based on flock evaluation such as the numerical production per ewe or cow, weight gains of lambs of lambs fertility, mortality, or individual evaluation), validated by organic farming institutions and then applied to the marketed "resilience helpers". It is also surprising that plant extracts, when given to animals, are not submitted to the regulations on residues as any other drug. It is well known that a plant or a plant extract may: (1) vary in its concentration of efficient constituents (menthone in *Mentha piperata* ranges from simple to double depending on its origin, (2) also be toxic to animals (*Taxus baccata* among others) or men consuming animal products (ingested *Taxus baccata* – meat, or *Colchicum autumnale* – milk) or (3) alter the quality of products (*Trigonella foenum-graecum* in meat and milk) [7]. These examples show that the control of the use and residues in phytotherapy should be expected in the future. The use of synthetic drugs is available in organic farming in a limited number of treatments and on a curative basis. In several countries, prevention is the rule: all animals are treated during risk periods. Herbivores are then treated within the limits of the number of permitted treatments: for example in sheep the average number of treatments is lower than the limit for organic sheep but the treatments are given to all sheep on a preventive basis. This explains that the number of anthelmintic treatments is not enormously reduced in organic sheep farming [11]. The rational use of anthelmintic treatments on group or individual bases has been promoted [29, 61] but is not yet in practice in conventional nor in organic farms. We are still in the need of efficient and low cost group/individual indicators for treatment, not only in organic farming but for all sustainable production systems. Research in this area will be profitable for all herbivore production, organic or not. In this review, we did not develop alternatives for controlling helminths such as the use of ruminants genetically selected for resistance [24], vaccination (although protection remains apparently modest) or biological control based on nematophagous fungi [27]. This was due either to the fact that the demonstration of sustainable field efficacy has not yet been fully demonstrated or to an uncertain feasibility. They should probably be considered in the future as useful tools in integrated/biological control of parasites [58] in a post-anthelmintic era.

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