RUNNING HEAD: PARASITES AND ORGANIC LIVESTOCK

PARASITE PROBLEMS IN ORGANIC LIVESTOCK PRODUCTION SYSTEMS AND OPTIONS FOR CONTROL

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ABSTRACT: Organic livestock production has increased dramatically in recent years in Europe and other parts of the world. The aim of producing livestock under more natural conditions has led to a reversion to primarily outdoor production systems and less intensive housing when indoor, more forage-based diets, and a reduced reliance on external inputs like antiparasiticides. These major changes in livestock production systems may potentially result in re-emergence (or emergence) of parasitic infections. The basic objective of this paper is to give an overview of the available information on parasitic problems in organic livestock production with a focus on northern temperate regions. Furthermore, options for control that target these problems and are acceptable within the framework of organic farming will be discussed. The large majority of conventional pigs and poultry are raised in highly intensive production systems which differ dramatically from organic housing systems and especially outdoor runs and pastures. A comparably pronounced difference between conventional and

organic systems is not found for ruminants. Thus, organic rearing may be a higher risk factor for pigs and poultry than for ruminants, however this may partly be counteracted by the fact that pigs and poultry never rely on pasture vegetation for feeding, while ruminants do so with associated potential problems of insufficient nutritional status and increased parasite transmission. Several studies have indicated higher parasite infections rates in organic herds vs. and conventional herds, and many of these differences may be explained by environmental factors favourable to the development of parasite oocysts/eggs/larvae and perhaps for intermediate hosts, while fewer differences may be due to the lack of chemical intervention. However, parasite species have to overcome many very diverse constraints in their attempts to complete their life cycles and it may therefore be risky to generalize. Thus, helminths and *Eimeria* sp. infections are most prevalent in organic swine herds whereas infections with *Isospora suis* seems less common than in intensive herds. A higher risk of helminth infections has also been documented in organic poultry. In organic dairy production, gastrointestinal parasites may pose a problem, and lungworm infection remains a major problem, not only in grazing heifers and steers but also in adult milking cows. This is not different from conventional herds but control measures are restricted. Many problems can be controlled by appropriate management routines, e.g. pasture management. However, avoiding chemotherapeutics for control in certain regions, e.g. in relation to ectoparasitic infections, remains a major challenge. Future research has to actively exploit new, promising avenues for control like forages or diets with anti-parasitic activities, biological control and selection for resistance, using approaches compatible with organic farming principles.

ORGANIC LIVESTOCK PRODUCTION

Organic livestock production has increased dramatically in recent years in Europe and other parts of the world but it still relatively small. In the EU, organic products had a market share of about 1.5-2.0 % of the total food consumption in 1996-1998 (Wier and Calverley, 2001). Within the organic market, livestock products like milk, beef and eggs were amongst the five highest ranking products in 14 out of 18 European countries (Michelsen et al., 1999). Products from small ruminants have only a small market share overall. Only few countries have a net export of organic products.

Organic farming is based on sets of explicit goals of which most countries or organisations adhere to the principles and basic standards laid down by International Federation of Organic Agricultural Movements (IFOAM, 2000). The principles express a strive towards closed nutrient cycles and sustainability, minimal external input, prevention rather than treatment, local production, high level of animal welfare through more natural housing systems and application of the precautionary principle, as discussed by Thamsborg (2001). Organic farming thus represents an alternative and more holistic view of agriculture and food production compared to conventional (i.e. non-organic) production. It must, however, be emphasized that although based on common concepts, national standards may differ markedly. The EU-regulation 1804/99/EC (CEC, 1999) in effect from August 2000 stipulates the minimum requirements for organic livestock production within the EU. Although the regulation is very detailed, there are many examples of different national interpretations. In the US, common standards were laid down by USDA in 2001.

With regard to pigs and poultry of which the large majority is raised in highly industrialized conventional herds, the aim of producing livestock under more natural conditions has led to a change from indoor to primarily outdoor production systems. When indoor housing remains, the conditions have changed from cage (or pen) systems with net or perforated/slatted floors without bedding to modern versions of traditional systems with group housing in large pens with plenty of bedding material. Conventional and organic ruminant production systems do not differ to the same extent. Organic production also includes more forage-based diets and a reduced reliance on external inputs like anti-parasiticides for prophylaxis. In the EU the preventive use of veterinary medicine, including antibiotics and anti-parasiticides is banned. This does not preclude the use of these medicines for curative or pre-emptive purposes but it does imply that parasite control in organic production systems is largely synonymous with non-chemical control. The ban on the preventive use of chemotherapy should not be considered a risk factor *per se* - but rather as a limitation in the spectrum of control options. Preventing disease should always be the aim. There may be cases where introduction of other external “agents” than chemical parasiticides may also be questionable in organic farming, e.g. genetic modified organisms (GMOs). Vaccines based on GMO products are presently allowed in the EU but e.g. Sweden has banned the use in the national standards.

The access to the outdoors, the change in housing conditions and abstaining from medical prevention in organic pig and poultry production result in breaking existing biosecurity barriers both between and within farms. In most cases, the outdoor environment is considered more conducive of parasitic infections than the indoor environment and even indoor, organic housing systems with deep litter greatly facilitate transmission in comparison to intensive indoor systems. In both cases the closer contact between faeces, parasites and hosts may increase the incidence of existing infections, and potentially result in emergence (or re-emergence) of new parasitic infections. Pastured ruminants rely on the vegetation for feeding, wherefore they may face potential problems of insufficient nutrition combined with high parasite transmission. In contrast, the greater transmission risk of outdoor reared pigs and poultry may partly be counteracted by the fact that these two livestock species are normally through-fed with non-infective feed, while they become infected only during their additional searching behaviour. In comparison to ruminants, this fact automatically secures a sufficient nutritional level and a lower parasite transmission, although the latter may be increased by high stocking rates. Despite outdoor rearing is a significant risk factor for parasite infection of pigs and poultry, one should not forget that several countries have a long tradition for a substantial conventional, outdoor production of livestock, e.g. pigs in the UK, without documented major parasitic problems.

OBJECTIVES

Several authors have in recent years reviewed available literature on health and disease in organic livestock production e.g. Sundrum (2001), Athanasiadou et al. (2002; ruminants only) and Hovi et al. (2002). A first description of parasitic infections and organic farming can be found in Thamsborg et al. (1999). The basic objective of this paper is to present the available new information on parasitic problems in organic livestock production with a focus on northern temperate regions, in particular Europe. Furthermore, available options for control that target these problems and are acceptable within the framework of organic farming will be discussed. There will be no or little focus on breeding for resistance to parasites, use nematophagous fungi and zoonotic infections because these areas are covered in other papers in this volume. Lastly, it has to be emphasized that the large differences between countries, due to traditionally different management systems and production conditions and not least different standards, make comparisons difficult and in some cases invalid.

ENDOPARASITIC INFECTIONS IN ORGANIC LIVESTOCK

Pigs

Several clinical and parasitological surveys in European countries have identified endoparasites as a common, and most likely a major, problem to organic pig production (Roepstorff et al., 1992 (12 farms); Leeb and Baumgartner, 2000 (30 farms); Vermeer et al., 2000 (10 farms); Carstensen et al., 2002 (9 farms)). The range of commonly occurring endoparasite species within conventional indoor production is restricted to *Ascaris suum* and the coccidia *Isospora suis* in the most industrialized herds, supplemented with *Oesophagostomum* spp., *Trichuris suis, Strongyloides ransomi*, and *Eimeria* spp. in the more traditionally managed herds (reviewed by Nansen & Roepstorff, 1999). All of these parasites, perhaps with the exception of *I. suis* which tends to cause problems in all intensive herds, have solid floor, straw bedding, infrequent dung removal, high humidity foci as risk factors for a high incidence (Roepstorff & Nilsson, 1991). Thus, any deep litter system, which combines several of these risk factors, may be of particularly high risk (e.g. Holmgren & Nilsson, 1998). Many surveys have shown that access to outdoor runs is another important risk factor for these parasites. In addition, there are parasites which are almost exclusively transmitted outdoor. *Hyostrongylus rubidus* belong to the latter category together with parasites with indirect life cycles such as *Metastrongylus* spp., *Ascarops strongylina*,and *Physocephalus sexalatus*, not to forget the species with a wider host spectrum like *Fasciola hepatica*, *Dicrocoelium dendriticum*, and *Trichostrongylus axei* that are not normally regarded as pig parasites (Nansen & Roepstorff, 1999). Recently, also the fibre-rich diets have been shown to strongly favour helminth infections, particularly *Oesophagostomum* spp., not only in experimental studies (Petkevicius et al., 1999) but also at farm level (Pearce, 1999). This is an extremely important observation in relation to organic farming, as roughage/forage has to be offered to pigs on a daily basis in most countries.

It is clear from the above that there are very good reasons why organically reared pigs may have considerably higher endoparasite infection levels than conventional pigs, as documented by Nansen & Roepstorff (1999). It is also interesting to note that the epidemiology of infections is different between the production systems e.g. piglets get infected with *A. suum* at an earlier stage in organic systems and patent infections are heavier. Two Danish surveys carried out in 1990-91 and 1999, respectively (Roepstorff et al., 1992; Carstensen et al., 2002), surprisingly revealed a 50% reduction in overall prevalence of *Ascaris* and *Oesophagostomum* over the period of 8-9 years. The first survey included newly established herds, in which the pigs only to a limited extent had returned to previously used pastures during a pasture rotation strategy. It was therefore proposed that helminth problems would increase in the future organic herds (Roepstorff et al., 1992). This was, however, not the case when a new group of farms was examined in 1999. The relatively low helminth prevalences found in 1999 may be due to better overall indoor facilities (indoor facilities in the early survey were in many cases extremely old and could not be cleaned properly), better incorporation of the pigs in the crop rotation and thus less use of permanent pastures. Furthermore, the herds in 1999 were still relatively newly established and had not reached “parasitological stability”. It was, however, thought-provoking that the two oldest herds of the 1999 study had the highest *Trichuris* infection levels. One of these farms had produced organically for 8 years with a stringent 3-year pasture rotation, and in this herd also *Ascaris* was found with a prevalence of up to 90% in the weaners and fatteners. Thus, the problems with both parasites may indicate a failure in the management of the scheme or simply that 3 years are not sufficient rest period to reduce pasture contamination. Due to the relatively young age of the herds in both surveys, it is still not possible to conclude anything on ‘re-emergence’ of parasite infections, like *Hyostrongylus* and *Metastrongylus* spp.

The impact of these infection levels on health is largely unknown. Clinical trichuriosis has been observed in pigs under poor hygienic conditions with access to out-door yards (Jensen & Svensmark, 1996) and has also been reported from an organic farm (Carstensen et al., 2002).

Reduced production levels have been observed in sows and suckling piglets (3% lower body weight at weaning) with mixed infections under experimental conditions (Thamsborg et al., unpublished data) but the situation is by no means comparable to the heavy production losses seen in infected ruminants. *Isospora suis* is the most pathogenic coccidia, causing severe diarrhoea in piglets within the first weeks of life in many intensive indoor herds. These problems are not observed in organic herds when the piglets are born in farrowing huts that are being routinely moved before farrowing (Roepstorff et al., 1992).

The information on whether the levels of control achieved in private farms are acceptable is scarce, and few experimental studies have been conducted on potential control strategies. Pasture rotation is likely to play a central role in control. On pasture, infective larvae of *Oesophagostomum* sp. and *H.rubidus* may be able to survive for a maximum of one year (Larsen, 1996). Several Danish studies have shown that even pastures heavily contaminated in autumn may be totally clean the following spring. *Ascaris* and *T. suis* eggs may survive for 5-11 years on pasture. However, recent studies have shown a high mortality rate of the eggs even within the first 6-12 months (Larsen & Roepstorff, 1999), indicating that a shorter rest period may still serve to reduce the transmission. It is presently unknown whether pigs should be moved to clean pasture one or two times per year, and when it is safe to re-utilize a previously contaminated pasture. The effects of nose ring and stocking rate on uptake of infections are not clearly described (Mejer et al., 2000; Thomsen et al., 2001).

Other control measures include mixed (or alternate) grazing and strategic feeding. When sows have nose-rings, it is possible to have cattle (or potentially other ruminants) and sows together on the same pastures. In a 3-year study with heifers and dry sows, mixed grazing has been shown to increase the performance of the sows, although the most important effect was to reduce *Ostertagia* infection levels of the heifers and increase their weight gain (Roepstorff et al., unpublished). The effect was attributed to better utilization of pasture, and disruption of cattle faecal pats and the surrounding tussocks. As argued by Barger (1997), there is a potential risk in mixed systems that previously host specific helminths get adapted to other hosts. In relationship to pigs and ruminants, we have first indications of low level establishment of patent *Ascaris* infections in the small intestine of lambs grazing old pig pastures and of *Teladorsagia* spp. and *Trichostrongylus vitrinus* in pigs (H. Mejer, personal communication, 2002). Feeding infected pigs with easily digestible carbohydrates has been shown to reduce the worm burdens and female fecundity of *O.dentatum* significantly (five fold decrease or more)(Petkevicius et al., 1999). This promising principle is currently being investigated using inulin-rich diets for pigs under conditions close to the organic farming situation.

Poultry

Coccidiosis caused by *Eimeria* spp. is probably the most important parasitic poultry disease in most production systems but poultry reared on litter and with out-door access is particularly at risk. In Austria, considerable problems of coccidiosis have been reported in pullets for egg production (Zollitsch et al, 1995). In table bird (broiler) production, flock mortality rates ranging from 2.5% to up to 30% have been reported from the UK (Lampkin, 1997), the high mortalities most likely being attributable to coccidiosis. In a Danish survey, severe problems of coccidiosis as indicated by need of medication were observed in only 3 flocks of organic table birds out of 24 flocks surveyed and the average mortality was 2-4% in all flocks (about 34,000 birds) (Fisker, 1998). However, several of the 9 farmers were producing table birds for the first time, and areas were unlikely to be heavily contaminated. Based on this information it is difficult to assess whether coccidiosis will be major threat to the long term sustainability of the organic systems.

Free range egg production is also likely to increase the risk of helminth infections compared to intensive production in battery cages. A study of Danish organic egg layers showed high prevalences of infection with the nematode species *Ascaridia galli*, *Heterakis gallinarum* (vector of *Histomonas meleagridis*). and *Capillaria* spp. (Permin et al., 1999). The risk of endoparasitic infection was about 7 times higher in organic compared to conventional systems (Permin & Nansen 1996). However, the implications of these findings for production and health are largely unknown. Recent experimental studies have indicated that eggs of *A. galli* is capable of transmitting *Salmonella enterica* to hens (Chadfield et al., 2001). Preliminary experiments have shown that *A. galli* infection can influence the testosteron blood levels and the behaviour of the hens towards more male character, resulting in more pecking (Roepstorff et al., 1999).

In conventional herds, control of coccidiosis is achieved by strict hygienic measures, all in-all out production and in-feed medication with coccidiostats for pullets and broilers. Until now hens for egg-laying in organic systems have been reared conventionally but in a few years time in the EU, the rearing has to be organic. This change may potentially result in more problems with coccidiosis in the future. A vaccine based on live, attenuated coccidia is available today and is considered as reasonable safe and effective (Berg, 2001). It is used extensively in pullets for organic egg production in Sweden and other countries but may not be appropriate for the much faster rearing of broilers.

At present, management practices like pasture rotation is the only way to prevent the building up of coccidia and helminth infections in the outdoor environment. In organic broiler flocks, the allocation of new pastures for each batch is the most rational solution. It does, however, create problems of accessibility of these areas when the housing facilities are permanent, and use of mobile hen houses is an option for smaller flocks. Organic standards stipulate the requirement for resting of poultry runs between batches for 1 or 2 years. This period of rest may be (almost) sufficient for coccidia, with a survival time of up to two years (Sainsbury, 2000), but we do not know whether this is sufficient time for long term reduction in helminth populations. Furthermore, the farmer has to adhere to good management practice like cleaning, disinfection, avoiding water spillage and prompt medication if needed. Breeds have recently been shown to respond differently to experimental *A. galli* infections (Schou et al., 2002), and the future control options may include selection of appropriate breeds and perhaps breeding within breeds for resistance to parasites.

Dairy cattle

Most parasite problems are observed in recently converted herds (Vaarst, 1998), perhaps due to lack of plans for surveillance and pasture rotation in this phase. Diarrhoea or ill-thrift amongst calves in deep bedding systems and in association with turnout have been described as a problem in Danish organic farms (Jensen, 1998; Vaarst et al., 2002). *Eimeria* spp. infections are considered a contributory causative factor but this has not been supported by sufficient diagnostic work. Some of the problems are related to the turnout of calves at a young age (3 months) without adequate feed supplementation and on pastures used repeatedly year after year. It may be a transitional problem until the farmers become experienced in managing young calves on pasture.

Only few studies report systematic clinical and parasitological findings from organic farms. A Danish survey (1992) reported that in 5 of 11 farms 7-32% of heifers showed clinical signs of parasitic gastroenteritis during the grazing season (Vaarst & Thamsborg 1994). Loss-producing subclinical infections, as judged by level of serum-pepsinogen, were seen amongst 10-15% of the first year heifers. Persistent infections with both gastrointestinal worms and lungworms from one season to the following were observed. Clinical signs suspect of lungworm disease resulted in anthelmintic treatments on several farms. Similarly, a more recent Swedish study showed that lungworm infection continues to be a significant problem in organic herds (Höglund et al., 2001). The heifers on the 15 farms examined for two seasons by Höglund and coworkers, only had moderate to low levels of gastrointestinal parasites (all means below 250 epg). Prophylactic treatments were not applied, and control relied on a combination of management procedures, particularly late turnout, low stocking densities and supplementation (early/late season) were significantly reducing the levels. Interestingly, the use of paddocks previously grazed by older cattle came out as a highly significant risk factor, as two such farms reported diarrhoea in the first year and one farm in second.

A Swedish questionnaire survey of parasite control methods in 162 organic and a similar number of conventional dairy herds, showed that chemoprophylaxis, mainly controlled release devices, was used on 58% of the conventional farms (Svensson et al., 2000). The methods used on organic farms included change of pasture between seasons, late turnout and use of aftermath. Despite this apparent awareness of non-chemical control methods, organic farmers more frequently than conventional farmers reported lower weight gains in calves in the first grazing season compared to their weight gain in the previous winter: 17% versus 5% (Svensson et al., 2000). Although the answers may reflect different production goals in the two groups of farmers, it may indicate more parasitic problems in organic farms. This was substantiated by 14% organic herds reporting diarrhoea in first grazing season calves versus 6% in conventional.

It can be concluded that endoparasitic infections may pose a problem in organic dairy production but the variation between farms is large. Some farmers do apparently control infections by appropriate management routines. Regarding nematode infections, the available options for control by grazing management and other non-chemical means have recently been reviewed by Thamsborg et al. (1999) and Athanasiadou et al. (2002). These options have in experimental studies been shown to be efficacious against gastrointestinal nematodes, while options for control of lungworm are few. The remaining question is how these measures are implemented in practice on a farm and whether acceptable levels of long term control can be achieved completely without any preventive use of anthelmintics. Of course, widespread clinical disease is unacceptable but what is the yard-stick for subclinical disease? At present, clinical lungworm disease is a recurrent problem in grazing heifers, steers and milking cows, and anthelmintic treatments are often needed. This situation is not acceptable but far from different from conventional herds (Ploeger, 2002). For measuring productivity, it may not be relevant (or acceptable) for the organic farmer to use suppressively treated animals (e.g. bolus treated) as a reference. These animals may be totally free of nematodes but with possible negative long term effects on development of immunity in the treated animals and in the herd as a whole. A balance has to be achieved between sufficient exposure to develop immunity and production losses. The finding of persistent infections in second year grazers after winter housing may have important implications for transmission if young and old stock are mixed. This route of transmission is abrogated on many conventional farms if deworming takes place during winter.

Small ruminants

Despite widespread problems of anthelmintic resistance, the regular use of anthelmintics is still the cornerstone of helminth control in most conventional small ruminant enterprises. With the ban on preventive use of anti-parasiticides, parasite infections have been recognized in several reviews as a serious threat/constraint to organic sheep health and production (e.g. Keatinge, 1996; Mage et al., 1998). However, although it may intuitively be true, few surveys support this view at present.

Haemonchosis, diarrhoea, high lamb mortality and lean ewes were listed as the most commonly health problems in Swedish organic sheep flocks, but it was concluded that the problems were not more extensive or different from conventional flocks (Lindqvist, 2001). A survey of organic farmers in UK reported internal parasites and fly strike as the highest ranking health problems in both ewes and lambs, although animal health generally was not a major concern of farmers (Roderick and Hovi, 1999). The same survey indicated that the majority of UK organic producers use clean or mixed grazing practices as a means of control, frequently in combination with strategic anthelminitic use. A recent, large-scale 3-year survey in 152 organic sheep farms in Sweden showed low to moderate faecal egg counts in both ewes and lambs (Lindqvist et al., 2001). A management factor such as new grazing area at turnout was linked with low faecal egg counts in lambs in early season. Low egg counts in lambs in late season were linked with provision of new autumn grazing area and resulted in a larger proportion of lambs being slaughtered before December. It was concluded that nematode infections in organic sheep flocks were relatively well controlled by current organic farming practices. However, about 20% of the ewes were treated with anthelmintics each spring.

In recent years research has been initiated in order to improve parasite control in organic sheep and goat production. The investigated novel approaches to non-chemical control of nematode infections include selection for genetic resistance, bioactive forages, biological control and vaccination, of which the latter two options may become commercially available in the near future. Selection for genetic resistance in sheep is practised in commercial farms in the southern hemisphere. The approach conforms closely with the intentions of organic farming, and may be very useful in large flocks. Also the selection of best suited breed should always be kept in mind in organic farming. Bioactive forages can be characterised as forages containing metabolites that may reduce the establishment of incoming nematodes or reduce existing worm burdens. Initial work has focussed on plants with a high content of condensed tannins, like sulla (*Hedysarum coronarium*) and the trefoils (*Lotus* spp.) (Niezen et al., 1995). Studies in UK using quebracho as a model condensed tannin in the diet have confirmed a 50-60% reduction in establishment of *Trichostrongylus colubriformis* in penned lambs and a 30% reduction in established infections (Athanasiadou et al., 2000a, b). These preliminary results have been promising, although levels of reductions under practical conditions are low ($<50\%$) but much further work is needed before implementation at farm level. Suitable forages species for different regions have to be identified, and the seasonality of the forages has to match the epidemiology of nematode infections, if conserved forage cannot be used. Even if a direct effect on nematode worm burdens cannot be shown, it is most likely that several of these forages can be used to alleviate the detrimental effects of nematode parasitism. The use of bioactive forages easily incorporated in the crop rotation for grazing animals or in the diet of housed animals is highly compatible with principles of organic farming. However, if possible active compounds are isolated (or chemically synthesised) they may be regarded as medicine and the use may be questionable.

Today most organic sheep farmers have to rely on grazing management procedures, like turn-out on clean pasture, applying low stocking rates or repeated moves to clean pastures. Securing the availability of sufficient herbage at all times is imperative. Operation of clean grazing as the sole control policy is restricted by factors such as farm layout, size of fields, ratio of sheep:cattle and timing of forage conservation and furthermore the efficacy of clean grazing in practice entirely without anthelmintic treatments remains to be documented, particularly in areas where *Haemonchus contortus* is endemic. Niezen et al. (1996) pointed to the considerable practical problems of running a mixed sheep-cattle enterprise relying on grazing management and resistant rams, without the use of anthelmintics. Regular use of anthelmintics has been part of the control in several places in Europe (e.g. surveys of Roderick et al., 1996; Lindqvist et al., 2001), despite preventive medication was discouraged and later prohibited. Contamination of spring pastures with *Nematodirus battus* often makes a treatment of lambs in early season necessary to avoid disease. *N. battus* can survive up to two years on a pasture and the infection can be propagated by calves in alternate grazing systems. In Sweden, drenching of ewes infected with *H. contortus* around lambing is recommended, even on organic farms, in order to avoid transmission to lambs later in the season, and about 20% of organic farmers in the above survey did this (Lindqvist et al., 2001).

Infection with the liver fluke *(Fasciola hepatica*) may cause sporadic disease problems, mainly in sheep. It is generally a problem of a specific farm or region. Whilst the condition in conventionally managed flocks may be controlled by frequent use of flukicides, this is not compatible with organic production. This may be part of the explanation for the observed difference in prevalence of fasciolosis in slaughtered sheep reported from Sweden: 1.7% and 1.3% ($p<0.05$) in organic and conventional sheep (Hansson et al., 2000). Control can perhaps be achieved through pasture management, in particular avoiding grazing of specific pastures or areas of pastures in certain periods but to our knowledge there is no documentation on successful control on infected farms without any use of flukicides. The use of meteorological fluke forecasts may be used to time pre-emptive treatments correctly but this forecasting is no longer in use in the UK (Douglas Gray, pers. comm., 2002).

ECTOPARASITIC INFECTIONS IN ORGANIC LIVESTOCK

It is evident from several surveys, questionnaires and reviews that ectoparasitic infections often can be a major problem in organic livestock, and thus represent a serious welfare issue. The most relevant infections include mange in pigs (*Sarcoptes suis*)(Roepstorff et al., 1992; Leeb and Baumgartner, 2000), the red poultry mite (*Dermanyssus gallinae*) and poultry lice (*Menacanthus stramineus*)(Permin & Nansen 1996), blow-fly strike in sheep (myiasis) and sheep scab (*Psoroptes ovis*) (Roderick and Hovi, 1999; Keatinge, 2001).

Sarcoptes infections had a high prevalence in Danish organic pig farms in early 90'ties and one farmer had even got several pigs totally condemned due to mange (Roepstorff et al., 1992). Surprisingly, Carstensen et al. (2002) found no clinical indication of mange nor lice in 9 organic Danish farms. If new breeding material is required or when a new herd is established, it is thus a reasonable option to buy pigs from a mange-free indoor herd (this will also reduce the introduction of other parasites). If the parasites are present within a herd, it should be considered to eradicate them totally by 2-3 treatments with an effective drug administrated simultaneously to all animals, just like the common and successful eradications in many conventional herds. Such intensive treatment may seem unacceptable to organic farmers (and a violation of standards), however, unless other effective strategies are identified, the only ethically acceptable alternative is regular medication, which may be even more unacceptable.

In Sweden, 27% of 56 organic egg producers (12-10,000 hens per farm) reported in a questionnaire the presence of the red hen mite (*D. gallinae*), mainly in the summer (Berg, 2001).

A survey of organic farmers in UK identified blow-fly strike as a prominent health problem afflicting their sheep flocks (Roderick and Hovi, 1999), and Keatinge (2001) has highlighted sheep scab as presenting particular problems on organic farms. Much of this concern is probably related to the restrictions on the preventive use of medicines, and e.g. organophosphates are banned in organic farms in the UK. Control in conventional production relies mainly on the topical application of long-lasting insecticides. However, regarding fly strike there is anecdotal evidence from New Zealand that organic sheep farmers can avoid major problems, even in larger herds, by frequently observing and care-taking, and on one farm, by large scale non-chemical trapping when fly numbers increase (Morris, 2000). Low stocking rates may lower the risk of fly strike but this may, on the other hand, make frequent observations more cumbersome. Modelling of infections may in the future serve to optimize the timing of observations. The feeding of forages with a high content of condensed tannins (e.g. *Lotus corniculatus* or sulla) has been shown to reduce the formation of dags dramatically (faeces less soft), and thus reduce fly strike (reviewed by Waghorn et al., 1999). Other non-medical options for fly strike control include non-insecticidal trap-and-bait systems, vaccination against fleece rot and breeding for resistance (Morris, 2000) but to our knowledge these measures have not been applied in Europe. Crutching (removing the fleece around the breech) or dagging to prevent fly strike is performed on farms in endemic areas of New Zealand, estimated 50% of the national flock annually (Waghorn et al., 1999) and some parts of Europe. Mulesing (retraction of the skin by inducing scar formation around anus) is not compatible with organic principles, and tail docking is also banned. Alternative approaches to control of sheep scab are less well documented but control by fungus is currently being investigated.

Ectoparasitic infections can also constitute a problem in cattle e.g. biting insects and ticks, not least in relation to vector-borne infections. Svensson et al. (2000) reported that organic cattle farmers more frequently encountered ectoparasites than conventional (62% versus 42%). Hammarberg (2001) stated that biting insects can cause serious welfare problems in organic cattle in northern Sweden if they cannot be protected with topical antiparasiticides as practiced in conventional cattle. Similarly, the author stated that the vector-borne infection *Parafilaria bovicola* transmitted by flies and parasitising the subcutaneous tissues of cattle, cannot be controlled without preventive use of parasiticides (Hammarberg, 2001). This may create a long term problem for regional control if organic farmers do not treat. Ticks and tick-borne infections are becoming increasingly important in NW Europe, and control of the infections may be a future requirement. It is unknown whether the commercial vaccine developed against *Boophilus microplus* (Tick-guard®) will offer protection to *Ixodes ricinus*, the prevailing tick species in this region (P. Willadsen, 2002, personal communication).

In summary, the best way to handle infections with ectoparasites in organic livestock production seem to be avoiding the introduction from start and then try to keep the infections off the premises. This approach may be feasible for non-flying arthropods with a narrow host spectrum like mange in pigs and sheep. It may be impossible if e.g. common grazing is used, unless all participating farmers are free of the infection. Regarding other ectoparasites, like ticks and flying insects, avoidance of grazing in certain periods or areas should be considered as a control measure, besides the occasional use of medicines. In Denmark, a derogation from the required 150 days summer grazing has recently been implemented to accommodate for problems of summer mastitis in cattle transmitted by *Hydrotea irritans*. Biological control of flies by means of parasitic wasps seems to offer some prospects of control of the stable fly (*Stomoxys calcitrans*) and house fly (*Musca domestica*) in confined environments (stables, feed lots) (Hogsette, 1999) but control in free range or pastured systems is not available. Lastly, it should be emphasized that whenever possible it is important to use a breed (or strain) of livestock with a low infection risk. Scientific information is presently limited in this area.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

It is evident from the available literature that parasitic infections in organic livestock create problems of animal welfare and economic concern of farmers, and potentialy food safety. It is, however, clear that some farmers are able to manage their herds without significant problems. It is our task to describe measures applied, to provide basic understanding of the problems, and to develop new methods of control compatible with organic farming principles. Several questions remain open:

1. Grazing management: it has not been documented whether control in practice can be achieved in ruminants, particularly sheep, without any preventive use of anthelmintics. Information on grazing management as a means of control of cattle lungworm infections is inadequate, and in the monogastrics, the pasture management and rotation time is largely unknown.
2. Vaccination against poultry coccidia seems to be applicable in pullet production but it is not clear whether it can prevent serious outbreaks in organic broilers.
3. How do we handle ectoparasite infections with minimum use of antiparasiticides ?
4. It is stipulated in the EU-directive that alternative treatments have a preference to commercial drugs but it has to be ensured that at least the alternative products are not potentially harmful! Furthermore, it may for welfare reasons in a longer term be

questionable and unacceptable if products with undocumented efficacies are in widespread use.

5. Selective breeding for resistance to parasites is solidly documented with regards to small ruminants and to some extent cattle, but much more work is needed in poultry and pigs. This approach is highly compatible with the principles of organic animal husbandry and should play a major role in the future control.

The future control of ectoparasites will continue to rely heavily on the use of chemical antiparasiticides. More options for non-chemical control of ectoparasites are needed, and this will also be relevant in a tropical context. New avenues of control of endoparasites include bioactive or specialized forages, biological control and vaccination. The introduction of bioactive forages, particularly leguminous plants, may be highly relevant in organic farming also from an agronomic point of view by adding to the diversity of crops. But, as mentioned, presently this approach suffers from low levels of reduction of infection, and perhaps the use of these forages as a supplement or adjunct therapy in affected animals may be more appropriate. Testing of different medicinal plants may provide new ideas along this line.

Parasite control in organic farming represents to our opinion the ultimate challenge to veterinary parasitologis where the key question for most infections will be: how do we achieve sufficient levels of immunity with acceptable levels of production loss without chemotherapeutics? The production losses will inevitably be higher than in conventional farming but welfare should not be compromised in any way. Similarly, the present state of food safety with regard to important food-borne parasitic zoonosis, like toxoplasmosis and trichinosis, should be monitored and maintained. A close collaboration with farmers is a necessity to achieve these goals and to secure integration of parasite control with other operations. The years to come will judge our success!

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