RESPONSIBLE USE OF MEDICINES IN AGRICULTURE ALLIANCE

ruma

GUIDELINES

Anthelmintics in Pigs

A farm health planning initiative by RUMA

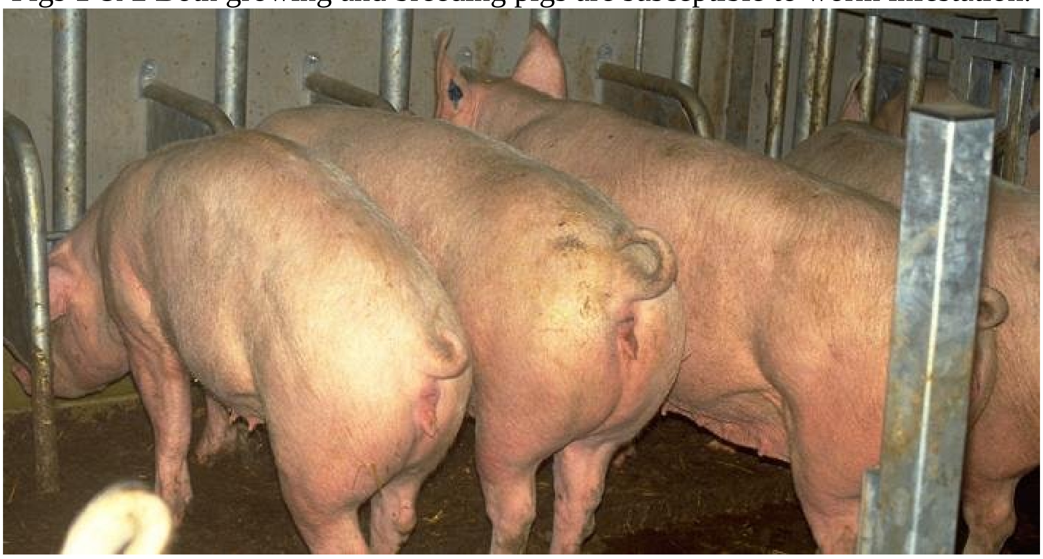
May 2010

CONTENTS

Introduction

The aim of this paper is to provide a complete guide to the use of anthelmintics in pigs within the UK. Helminth parasitism in pigs does not commonly represent the severe clinical disease picture that is often encountered in ruminants but that is not to say that helminths are not important. Whilst in specific circumstances, different worm parasites can cause severe clinical illness and even death in pigs, such parasitism is also important economically as it can restrict growth, affect sow productivity and increase the cost of growth.

Figs 1 & 2 Both growing and breeding pigs are susceptible to worm infestation.



This paper will provide a resumé of the various pharmaceutical products available as anthelmintics in pigs including their mode of action, along with a detailed description of the various helminth parasites relevant to the UK pig. Monitoring techniques and management approaches to control will be addressed before embarking on specific treatment regimes for different parasites and the practical application of general worming programmes for different types of herds and classes of stock.

Practical and potential complications in the use of various products will be addressed before some more general comments on the safe use and disposal of medicines relevant to anthelmintics conclude the paper.

1. Helminth Parasites

The word helminth is derived from the Greek word *hélmins* meaning a worm. The term however applies only to the Phyla platyhelminths (flatworms including fluke) and nemathelminths (roundworms) which include both parasitic and non-parasitic forms (Soulsby 1978).

A parasite is an animal that lives on or in a host animal receiving nourishment and protection whilst causing harm. In the case of UK pigs helminths, we are principally concerned with parasites that live their adult lives in the intestine or pulmonary tissue (lung) but, as will be seen from the detailed description in section 4, each worm has a life cycle that may involve migration around the host body, free living forms and involvement of secondary or intermediate hosts. Some have zoonotic implications.

UK Pig Keeping

In order to understand the biology of helminth parasites in pigs it is necessary to understand in broad terms the types of systems of pig keeping employed.

Within the commercial sector it is normal to divide the pig herd into breeding (gilts, sows plus litters and boars) and feeding (weaned pigs up to sale weight) sectors.

With a relatively short gestation period of 16 weeks, pig production is a year round exercise with each sow capable of producing 2.4 litters per year i.e. a breeding cycle of 152 days. In virtually all farm situations, farrowing occurs throughout the year on a regular weekly or batch basis. Thus a sow herd of 500 sows would be expected to produce 23 litters every week or multiples of this every three to five weeks depending on the system. This means that there is a continual production of young pigs entering the feeding herd.

Fig 3 Young piglets are produced all year round, supplying a source of naive pigs into the growing system.

Breeding herds can be either outdoors or indoors. The UK has one of the largest outdoor commercial pig keeping sectors in the world. In general, sows are kept in paddocks with small moveable huts (arcs) provided for shelter. The paddock may be divided as a grid or a radial system with pregnant sows generally kept in weekly or batch groups before being subdivided into small groups or individuals to farrow.

Fig 4 Outdoors, sows farrow in individual arcs

A typical outdoor farm will move the whole herd every two to three years to clean ground, which has important implications for parasite control, although some occupy land continuously over many years.

Indoor systems are highly variable. Within the UK, close confinement of pregnant sows in stalls or on tethers is prohibited (Figure 5), with all sows loose housed. They may be grouped into large dynamic populations in yards, be split into weekly or smaller stable groups and can be housed on solid floor straw bedded systems or on slats.

Fig 5 Close confinement of sows on tethers is no longer permitted in the UK but still exist in other countries.

Fig 6 All sows in the UK kept indoors are now loose housed, enabling greater spread of potential pathogens and parasites.

Again, the type of system employed has implications for worm control. Base flooring for sows generally is concrete although variations include tarmac (which can be toxic) and earth.

Piglets in the UK suck their mothers for approximately four weeks before weaning, when the sows return to the breeding area for re-mating whilst the piglets are placed in growing accommodation.

Piglets may be grown-on on the same holding on which they were born – either through to slaughter weight or an intermediate weight - or may leave at weaning. Rearing systems are either slatted – in which pigs are kept away from their own faeces and urine on suspended floors - or solid floors with or without bedding.

They can be in small or weekly groups enabling cleaning of buildings between groups or may be kept in buildings which are permanently stocked with a dynamic population – rendering cleaning very difficult.

On straw-based systems, pigs can be kept in small pens (straw flow pens or scrape- through dunging areas) or in large yards which are cleaned out after each batch.

Fig 7 Pigs kept in a series of straw yards.

Growing pigs reach a slaughter weight of 90-110 kg at five to six months of age meaning that there is a constantly renewed young dynamic pig population in which development of immunity to parasites is difficult to achieve. Thus, in continually occupied unwashed buildings a constant cycle of worm and other parasites can be maintained.

A small population of commercial pigs are reared and finished out of doors in paddocks which if continually or repeatedly occupied can have important implications for worm parasitism.

Fig 8 Outdoor finishing of pigs has become more popular in recent years risking lungworm problems and well as enteric worms. (courtesy A E J Waddilove)

In addition to the commercial sector in which 90%+ of all pigs in the UK are kept, there are a huge number of small pig keepers who variably fall into the bracket of smallholders, backyard pig keepers, hobby farmers and pet pig keepers. They may keep a small number of sows or individuals or simply buy young pigs to fatten up. The majority of such holdings will keep pigs outdoors in paddocks, orchards or runs which may be continually or repeatedly occupied over many years. In such situations parasitic worms can be a continual and serious challenge to the pigs.

A proportion of UK pigs are kept and reared to “organic” standards which have implications for parasite control and there are both farmed and feral wild boar populations which potentially can act as reservoirs of worms.

With such variable systems of pig keeping available, it is necessary to tailor any parasite control programme to the specific circumstances whilst following the broad principles outlined below.

It should be noted that in the UK over the last 20 years there has been a drift towards more straw-based and extensive pig keeping system which might be expected to be more favourable to worm parasites and as such control programmes, incorporating the use of anthelmintics, have had to evolve to meet the challenge.

2. UK Pig Helminths

There is a relatively restricted list of helminth parasites found in UK pigs and details of each life cycle are provided in section 4.

The worms with which we are concerned are:-

a) *Ascaris suum* – the large roundworm with a migrating larval stage

Fig 9 *Ascaris suum* worms*

b) *Hyostrongylus rubidus* – the stomach worm seen particularly in outdoor kept sows

Fig 10 Inflamed gastric mucosa as a result of infestion with *Hyostrongylus rubidus***

c) *Oesophagostomum dentatum* - the nodular worm which has been historically associated with the "thin sow syndrome"

d) *Trichuris suis* - the whipworm - residing in the colon (large intestine) and producing colitis in growing pigs

e) *Metastrongylus apri* (aka M. *elongatus*) – the pig lungworm requiring an earth- worm as an intermediate host

f) *Strongyloides ransomi* – rarely reported in the UK but capable of passing through the milk of the sow to infest baby piglets

g) *Fasciola hepatica* – the liver fluke rarely found in pigs

There are two further helminth parasites that are not seen as problems in UK pigs which require brief mention, but are not relevant in the context of this paper to control by anthelmintics in the UK.

1) *Trichinella spiralis* – a helminth which has important zoonotic implications in that the worm produces larvae which migrate to and reside in muscle tissue and are transmitted to man by consumption of raw or uncooked pork. Statutory monitoring programmes are applied in abattoirs throughout the EU and the prevalence of encysted larvae in UK pork is very low. Disease in pigs due to *Trichinella spiralis* is not seen in the UK and no positive tests on slaughtered pigs or horses have been found in the last 30 years in the UK. (FSA 2003 M01024: Survey for *Trichinella* in wild foxes and boar)

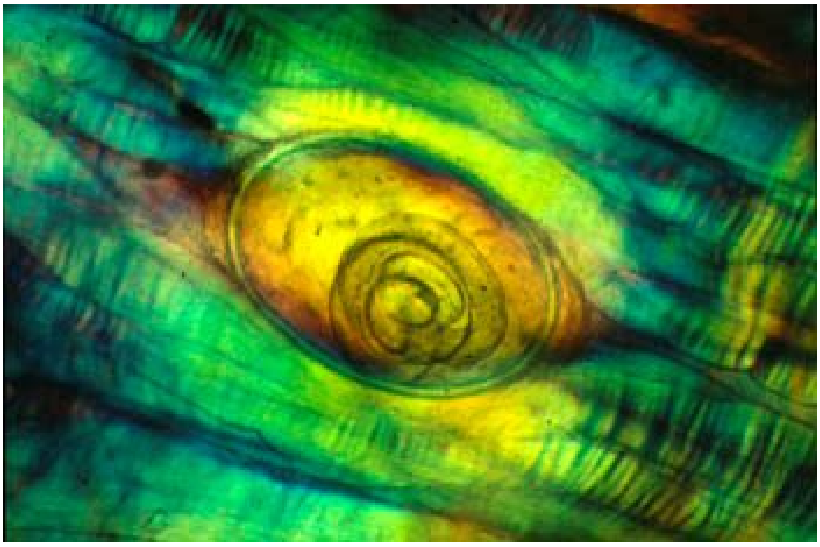


Fig 11 Trichinella spiralis within muscle**

2) *Stephanurus dentatus* – the pig kidney worm – an important pig parasite in North America, Australia ,Asia and parts of Europe but is not seen in the UK

Finally, mention should be made of the platyhelminths cysts, *Cysticercus tenuicollis* and hydatid cysts (cysts of the dog tapeworms *Taenia hydatigena* and *Echinococcus granulosus* respectively) and *Cysticercus cellulosae* (the encysted intermediate form of the human tapeworm *Taenia solium*) all of which can occur in pigs.

Fig 12 *Cysticercus tenuicollis***

3. Anthelmintic Products Available for UK Pigs

There are currently only 2 classes of pharmaceutical products available for use in pigs in the UK to act as anthelmintics – avermectins (first introduced in 1984) and benzimidazoles (available since the early 1960's). Despite the presence of other classes of anthelmintics within the UK, licensed for use in other species and known to be effective against pig helminths, under the cascade system their use is not permitted (e.g. Levamisole, piperazine).

The active chemicals available and licensed for use in pigs are:

Avermectins: - Ivomectin – available for in-feed and injectable use

Doramectin – injectable only

Benzimidazoles: - Flubendazole – available for in feed, top dressing and in water use

Fenbendazole – in feed and direct oral application

Table 1 provides a list of all the various trade products currently available. (May 2010)

Table 1 Anthelmintics currently available in the UK for the treatment of pig parasites (May 2010)

1% Ivermectin injection

Trade Name	Manufacturer
Animec inj	Chanelle Animal Health
Bimectin	Bimeda
Ecomec Inj	Eco Animal Health
Ivomec inj for pigs	Merial Animal Health
Noromectin multi injection	Norbrook Animal Health
Panomec inj for cattle, sheep and pigs	Merial Animal Health
Qualimec 10mg for inj	Janssen Animal Health
Virbamec inj	Virbac

NB Other preparations of 1% Ivermectin inj are marketed outside the UK.

0.6% Ivermectin Premix

Trade Name	Manufacturer
Ecomec 6mg/g Premix	Eco Animal Health
Ivomec Premix for pigs	Merial Animal Health

1% Doramectin Inj

Trade Name	Manufacturer
Dectomax inj for pigs	Pfizer Animal Health

Flubendazole (oral)

Trade Name	Manufacturer
Flubenol	Janssen Animal Health

Flubendazole (water)

Trade Name	Manufacturer
Solubenol	Janssen Animal Health

Fenbendazole (oral)

Trade Name	Manufacturer
Panacur	Intervet Schering Plough
Zerofen	Chanelle Animal Health

All products are licensed in the UK under the category POM-VPS and as such they do not require specific veterinary authority to be used within the terms of the licence.

In addition to the old established anthelmintics such as levamisole and piperazine mentioned above, which are not licensed for use in pigs in the UK, it should be noted that neither Moxidectin (Cydectin: Fort Dodge Animal Health) nor the new generation of amino-acetonitrite derivatives (AAD's) such as Monepantal (Zolvix: Novartis Animal Health) (Kaminski et al 2008) now available for sheep treatment are indicated or licensed for use in pigs. Furthermore, unlike for cattle, vaccines are not available to protect against pig worms.

Modes of Action

Avermectin

The Avermectin group – a class of macrocyclic lactones produced as fermentation products from *Streptomyces avermitilis* and represented in the pig anthelmintic range by Ivermectin and Doramectin – have the dual effect of not only acting against endoparasites (i.e. helminth worms) but also against ectoparasites of which Sarcoptic mange (*Sarcoptes scabei var suis*) and Pig lice (*Haematopinus suis*) are the most important in the UK.

Avermectins work at the cellular level of helminth worms, stimulating the inhibitory neurotransmitter GABA, increasing permeability of the cell to chloride ions leading to paralysis, starvation and death of the worm. (Straw *et al* 1999 and Janssen 2008) As such, avermectins are not effective at killing worm eggs or early stage larvae (see section 5). They are highly effective at killing most adult and stage 4 larvae (L4) although their activity against *Trichuris suis* is poor. (Injectable Ivermectin is only indicated as an 'aid to control' and Doramectin has no indication for *T. suis*). Evidence suggests that oral ivermectin may be more effective at killing *Trichuris* worms and may even inhibit egg viability (Arends *et al* 1996). Equally some trials have shown Doramectin to be effective against *Trichuris* (compare Fujii *et al* 1994 with Stewart *et al* 1994).

Of the two avermectins available for pigs, the reported and observed lesser pain on injection of Doramectin in cattle compared to Ivermectin (Grandin et al 1998) does not appear to be as noticeable in pigs although the fact that Doramectin is indicated for intramuscular administration (compared to subcutaneous administration for Ivermectin) may disguise this difference.

Benzimidazoles

These chemicals act to prevent both cell growth and cell division in helminths by inhibiting the growth of microtubuli within cells (by arresting polymerisation of tubulin) without which cells die. This means that the benzimidazoles are effective at killing all adult and larval stages of worm parasites. In addition, they are capable of killing worm eggs (by interruption of embryonization) although it is claimed that flubendazole is more ovicidal than fenbendazole due to increased binding potency (Janssen Animal Health 2008) (Lacey 1990).

Fig 13 Strongyle egg found in sow faeces

Benzimidazoles are absorbed from the gut and therefore are active against migrating larvae and lungworms even though they are only available as oral preparations.

Compared to ruminants, resistance of pig nematodes to benzimidazoles is not widespread nor viewed to be a major problem. (Kagira *et al* 2003). Resistance has been identified in Denmark and Germany involving *Oesophagostomum* species but reports of pig worm resistance in the UK are sparse (Gerwent *et al* 2002) and within the field there is no evidence of practical resistance.

Neither class of anthelmintic is indicated for the treatment of liver fluke in pigs.

Thus, in summary, to achieve control of all stages of nematode worm parasites in the pig the benzimidazoles are likely to be preferred. However, the fact that avermectins also control the generally far more economically challenging Sarcoptic mange means that where both endo and ecto parasites are a problem, this class of product would be indicated. (The avermectins are currently the only UK licensed products for Sarcoptic mange treatment in pigs).

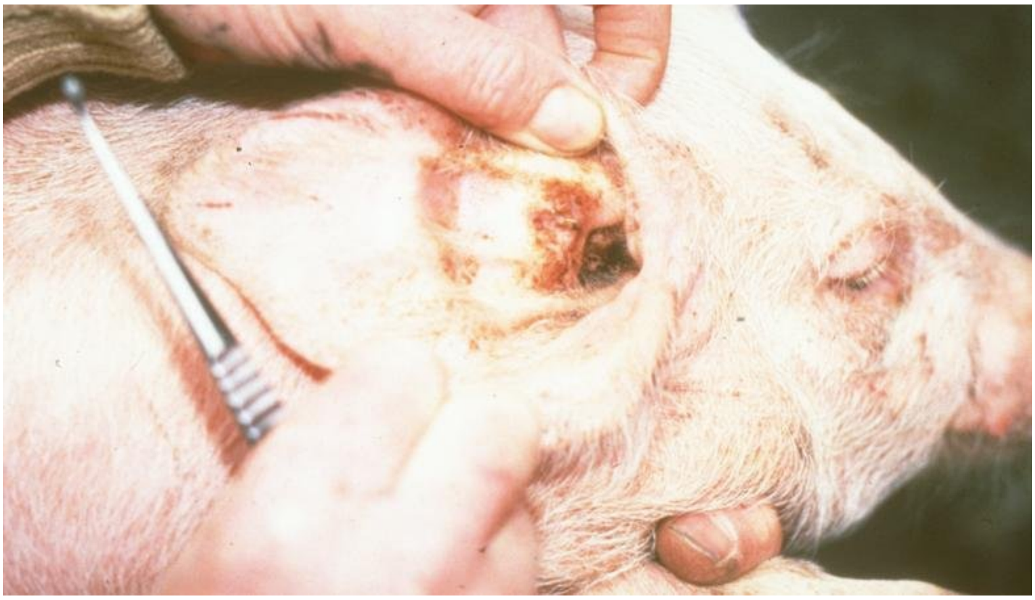


Fig 14 Sarcoptic mange will require use of avermectins for treatment.

The choice of product used will also depend upon the preferred delivery method. If it is required to worm via the feed then either class of anthelmintics can be used. However, if injectable delivery is preferred, only the avermectins are available. Conversely, if treatment via the water system is desired, only flubendazole is available.

With respect to delivery via feed, Ivermectin can only be provided by incorporation into the finished feed by a licensed operative whereas the benzimidazoles are available both for full incorporation in the feed or for direct delivery as a pre-medicated pellet or powder (i.e. top dressing).

4. Nematode Life Cycles

All nematode parasites have a repeatable life cycle in which the eggs are produced by a mature female worm and shed from the host either in a unembryonated, embryonated or larval form. The larvae progress through a number of stages which can occur free living or in different parts of the host body before maturing to adults. However, to understand the pathogenesis of each worm and appropriate methods of control it is necessary to clearly describe the specific life cycles of each of the main nematodes found in pigs in the UK.

Ascaris suum

The mature worm lives in the small intestine and, in the adult pig, which may only be infested with a few worms, they can grow to 40cm or more in length. Eggs are produced from the mature female in huge numbers at a time (200,000 eggs/day) but intermittently. They are therefore not consistently shed or found in the faeces.

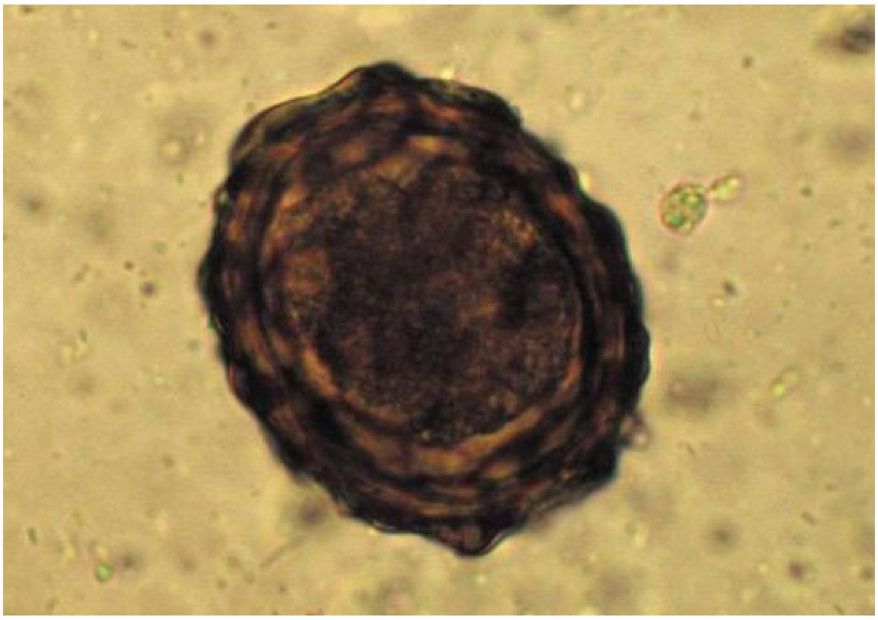


Fig 15 *A suum* egg shed in faeces; note the sticky outer coating**

Once released into the environment the eggs are highly resistant to chemicals and drying – an important feature to remember when controlling disease. The eggs will embryonate and mature through a first and second stage larva – the latter being capable of infesting a new host but retained within the egg shell. This maturation to infectivity is temperature dependent not occurring below 15°C but occurring as quickly as 14 days at 30°C.

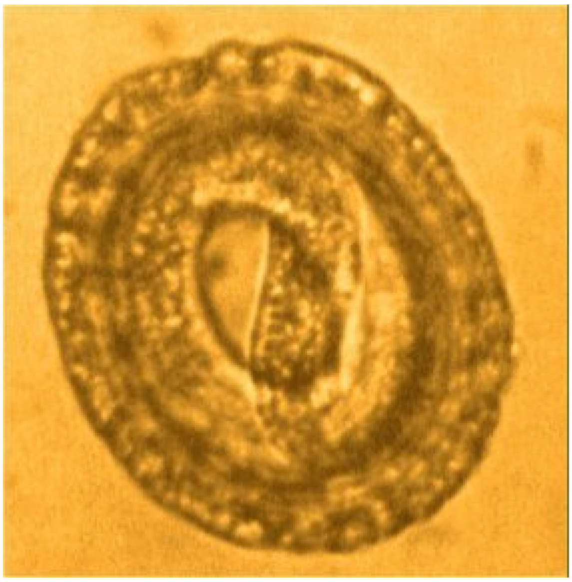


Fig16 Embryonated *A suum* egg containing developing larva**

Once ingested, the egg hatches and 3rd stage larva (L3) released will burrow into the intestinal wall and begin a migration through the liver (causing milk spot damage) over a few days.

Fig 17 *A suum* larva hatching from the egg**

Gaining entry to the hepatic portal blood stream, the larvae reach the heart and then the lungs and they burrow into the airways (alveoli) and from there into the bronchial system where they can induce coughing. They are then coughed up to be swallowed as L3 where they moult twice to L4 and adult stages. In large numbers these can cause intestinal blockage.

Fig 18 *A suum* blocking the intestine

This stage can be reached 3-4 weeks after initial infection but a similar time must elapse further for eggs to be shed by the mature female.

The key points of the life cycle are that:

1) It is direct i.e. no intermediate host is needed
2) The full cycle can be completed in 10 weeks
3) The eggs are almost indestructible in the environment

Details of monitored levels of *Ascaris suum* are provided in section 5 below but a few additional comments are pertinent at this stage. Potential infective eggs can hatch in man allowing L3 larvae to migrate. (This however is far less of an issue as a zoonosis than the larvae of the related dog roundworm *Toxacara canis*).

Milk spot lesions in the liver are initially lymphoid accumulations but mild fibrosis can also occur. The lesions will fade with time such that provided there is no re-infection, the liver will appear clear 6 weeks after last damage. This means that where there is evidence of milk spot affected livers at slaughter, migrating larval damage must have occurred within the previous 6-8 weeks.

Sporadic lesions can occur in the liver due to migrating larvae from both the cat and dog roundworm (T. cati and T. canis respectively) and can be seen where cat populations on farms are high or in small holdings where dog contact occurs. (Roneus 1966)

Fig 19 Classic moderate milk spot liver in a five month old slaughter pig

Because of the indestructible sticky coat of the egg no pig holding can keep free of *Ascaris suum* – eggs are easily transferred by birds, flies and rodents – and the degree of damage done and levels of infestation will depend on hygiene levels within the pig keeping environment.

Enteric Strongyles

Oesophagostomum sp and *Hyostrongylus rubidus* are classified as ‘strongyle’ worms producing very similar and distinctive eggs.

Fig 20 Typical Strongyle egg**

Unlike *Ascaris suum*, the eggs are not particularly resilient in the environment and can be destroyed by good hygiene practice indoors and drying and sunlight outdoors.

Adult *Hyostrongylus* worms live in the stomach and in heavy infestations can cause bleeding and ulceration of the gastric mucosa. The partly digested blood can appear as “coffee granules” in the gastric mucosa.


Fig 21 Coffee granule appearance of gastric mucosa due to partial digestion of blood.

Adult *Oesophagostomum dentatum* lives in the large intestine producing nodules and thickening of the mucosa which impede digestion and feed on blood and nutrients from the host.

Both of these parasites can occur in sows and in heavy infestations can affect body condition causing the “thin sow syndrome”. Very little immunity develops to these parasites.

Eggs released from the adult female worm are shed in the faeces and in warm damp conditions can embryonate to infective L2/3 larvae within seven days for both species. Following ingestion, *Oesophagostomum* 3rd stage larvae burrow into the small intestinal wall where they feed for seven days before re-emerging to pass down to the colon and mature through 4th stage larvae to adults. Eggs are produced from mature females 6 weeks after infection giving a full cycle of seven weeks.

The cycle for *Hyostrongylus* is much shorter with the L3 infective larvae burrowing into the gastric mucosa and developing to adult egg laying females within 3 weeks giving a full life cycle of as short as four weeks.

Whilst pigs kept outdoors are more vulnerable to strongyle infestation, particularly where paddocks become heavily contaminated, these worms are seen in indoor systems and can maintain a cycle particularly in straw based yards with dynamic populations. The boar may also be an important source of infection for sows.

Fig 22 The boar can be a important source of worm eggs

Whilst eggs will die off over time, the permanently occupied outdoor production systems favour survival of the parasite throughout the year.

Egg excretion rates may increase in the two to three weeks prior to farrowing and during lactation providing a rich source of infective larvae into young pigs.

Many pig farms have been set up or restocked over the years with single sourced stock itself derived directly or indirectly from herds set up by hysterectomy techniques or caesarean derivation. As such, whole pyramids of farms can be completely free of strongyle worms and, provided biosecurity remains good, they can remain free of these parasites over many years.

Metastrongylus apri (elongatus)

The pig lungworm is unusual amongst pig nematodes in that it requires an intermediate host – the earthworm - for completion of the cycle.

The adult resides in the main airways of the lung (bronchi and bronchioles). The eggs are shed by the mature female to be coughed up and swallowed by the pig, to then be passed in faeces, by which time the egg will have developed into a 1st stage larvae within the egg shell.

Fig 23 Embryonated egg of *M apri* containing larva**

(As such, the eggs are heavy and do not float in saturated salt making them more difficult to find in faeces). The non-infective larvae can survive in soil for 3 months but at some point – either as hatched larvae or encased larvae – must be ingested by the earthworm (*Lumbricus terrestris* and potentially other species of *Lumbricus*) for the cycle to progress. They develop in the oesophagus of the earthworm into infective L3 larvae in approx 10 days and then infect the host either by the pig eating the earthworm or by ingesting released larvae from dead earth worms.

Fig 24 *Lumbricus terrestris* – the earthworm - is vital for the life cycle of the pig lungworm

The L3 larvae penetrate the intestinal wall and pass via the mesenteric lymph nodes maturing to L4 before reaching the lung where they develop to mature egg laying adults at 24 days post infection. It is possible for the larvae to carry certain viruses (such as Swine Influenza virus) and thus act as a source of infection for other disease.

Thus, in highly favourable conditions the life can be completed in five weeks.

Because of the need for the earthworm intermediate host, lungworm in pigs is not seen in indoor systems (unless concrete is badly broken or earth floors are used) and are in fact very rare in outdoor herds kept commercially - the seedstock keeping free of the parasite.

Fig 25 *M apri* within the airways of the pig*

Disease, in the form of respiratory distress and coughing, that does not respond to antibiotic medication in outdoor kept pigs – including backyard and small holding situations – should always lead to consideration of the possible involvement of *Metastrongylus apri*. It should be noted that earthworms can live for two to three years and as such can remain infective on rested ground.

Trichuris suis – the whipworm

Fig 26 *Trichuris suis* – the whipworm*

The prevalence of the whipworm in pigs at slaughter has historically been quoted at 25% (Taylor 1995) and yet illness associated with infestation is not common (see section 5).

The whipworm is distinctive in shape and the adult resides in the large intestine (colon) where it attaches to the mucosa. In large numbers, the damage and irritation caused can induce a severe colitis, disturbing fluid metabolism and re-absorption causing diarrhoea. In very severe cases, the irritation induces mucus production and occasional blood streaks producing a syndrome that is clinically easily confused with swine dysentery.

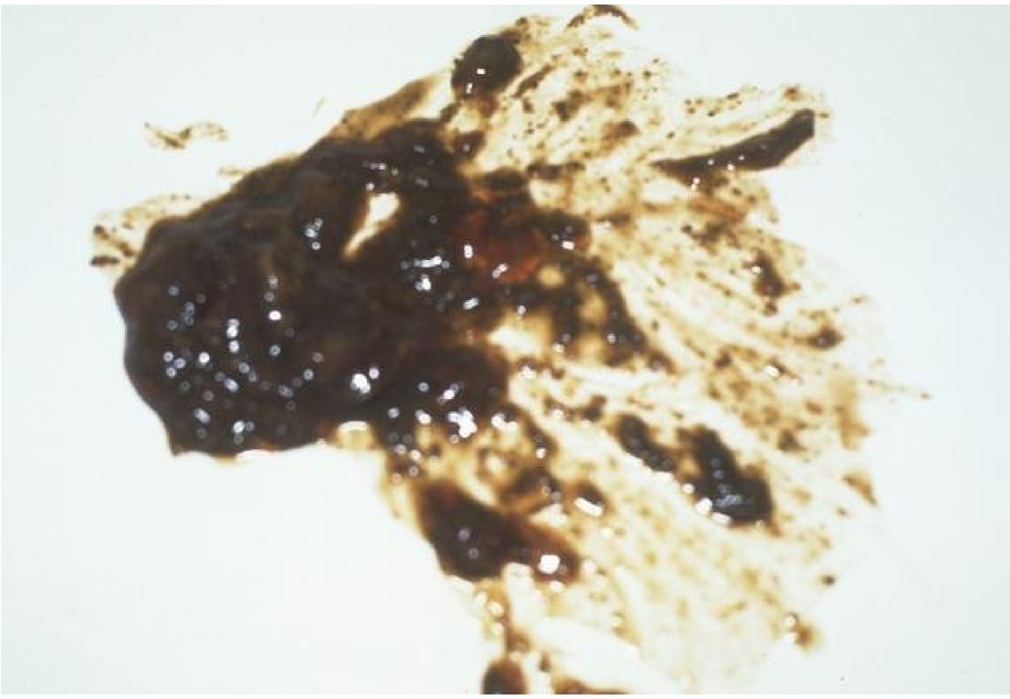


Fig 27 Bloody mucoid scour – Swine dysentery or *Trichuris*?

Eggs are produced from mature females and shed in faeces and very large numbers can be excreted by a mature population. The eggs are highly distinctive containing a ‘cap’ (operculum) at both ends and are very resistant to drying and disinfectants.

Fig 28 *T suis* eggs with typical opercula at both ends**

Embryonization and development to infectious L2/3 stages is temperature dependent (min 6°C) taking 3-4 weeks. The infective larvae remain protected within the highly resistant egg shell and as such can remain viable for many years in the environment. Unlike Ascaris eggs they are not covered in a sticky gel and whilst killing them may be difficult, washing away is more feasible.

Once ingested by the pig, the eggs hatch in the lower small intestine, attaching to the mucosa to continue growth and maturity through to 4th stage larvae. After several weeks they detach and migrate to the colon where they reattach and after six to seven weeks become adult egg layers. Thus the full life cycle takes more than three months but clinical disease will be evident four to six weeks after infective larvae are ingested.

Fig 29 *T suis* attached to the surface of the colon**

Trichuris infection is most important in growing pigs where in addition to causing primary disease it may exacerbate other conditions such as Porcine Intestinal Adenomatosis (Ileitis), *Salmonella* enterocolitis and non specific ‘grower scours’.

Strongyloides ransomi

Whilst this nematode has been reported in UK pigs, it is rare. It is also unusual in that clinical disease associated with infestation is seen in young piglets rather than growing pigs. The sow is the main reservoir of the infection – usually asymptomatically – with adult worms buried in the mucosa of the small intestine. The eggs are shed in the faeces and mature outside the host either to infective 3rd stage larvae (L3) or become free living adults which themselves produce infective larvae. Warm damp conditions favour the latter which obviously increase environmental contamination.

Whilst oral infection of the new host can occur, more importantly the infective larvae attach to and penetrate the skin of the young pig, migrating to the intestine where they rapidly develop.

Fig 30 Small intestine affected by *St ransomi***

Maturation of eggs to L3 in the environment can occur as rapidly as 24 hours. Furthermore infective larvae can 'recirculate' within the sow and pass to the udder where they are shed in colostrum providing a rich source of infestation for the new born piglet. Patent infections of piglets acquiring Strongyloides by this route can be seen within 4 days, inducing depression, anorexia and diarrhoea with mortality rates capable of reaching 50%.

The egg is typically small and not well protected; likewise the hatched larvae, and so hot dry conditions will not favour maintenance of the life cycle.

Platyhelminths

Liver Fluke

Liver fluke – *Fasciola hepatica* – is primarily a parasite of sheep but in unusual and favourable conditions can infest the pig. The life cycle is indirect requiring a snail (*Lymnaea* sp and the related *Galba truncatula*) as an intermediate host. These are typically moisture loving molluscs and disease will only tend to occur in pigs exposed to wet ground that has had contact with sheep previously or potentially where wild or feral pigs come into contact with outdoor pigs. This tends to restrict liver fluke to the backyard type pig – commercial outdoor pigs being kept on the drier eastern side of the country.

If severe infestation of the pig liver occurs blockage of the bile duct can result with weight loss, anorexia, jaundice and ultimately death is possible.

Tapeworms

The human tapeworm *Taenia saginata* and *Taenia solium* and the dog tapeworm *Echinococcus granulosa* and *Taenia hydatigena* all have intermediate hosts which whilst typically are sheep, cattle and small wild mammals, the pig can act in this capacity. (The pig is the most important intermediate host for *Taenia solium*). The rice grain segments of tapeworms are shed in the faeces of the primary host, maturing in the environment to be ingested by the pig. Hatching is followed by migration away from the intestine to various sites around the body including striated muscle, peritoneal cavity, liver, lungs and potentially brain. Here they form space occupying cysts which in the pig are usually asymptomatic. These cysts may be detected at meat inspection, although in practice, within the UK they are exceedingly rare. (Meat Hygiene Service personal communication)

The life cycle is completed by consumption of encysted raw or undercooked pork, predation by dogs or feeding of fallen stock to dogs.

The cysts are untreatable in the pig and control – discussed below in section 6 – rests on separation of pigs from human and dog faeces and treatment of the primary hosts.

5. Monitoring Worm Parasites

From the foregoing it is obvious that all of the significant worm parasites of pigs when present in mature forms shed eggs that are passed in the faeces. By this stage, damage to the host may already have occurred. Potentially it is thus possible to monitor and diagnose infestations with worms by examining the faeces. However, there are many limitations to this technique.

The technique involves floating eggs in a fluid medium and observing quantitatively by microscopy. For most pig helminth eggs, saturated salt solution is satisfactory, although the heavy eggs of *Metastrongylus* require a denser medium in which to float and magnesium sulphate or zinc sulphate should be used. These latter media may also improve detection of *Ascaris* and *Trichuris*.

The major limitations on using faecal worm egg counts for diagnostic or monitoring purposes are:

1. It requires mature egg shedding female worms to be present and in many clinical situations, especially involving growing pigs, disease is seen before the worms have matured.

2. The intermittent shedding of eggs by *Ascaris suum* means that where adult populations are low, random testing of faeces will often miss egg excretion.

However, for a herd monitoring programme for the breeding herd, routine screening of a reasonable number of samples on a six -12 month cycle can provide valuable information, particularly as the strongyle status of the sows, in herds which are believed to be free of these parasites, do not routinely de-worm. A typical sampling protocol would be collection of 10-12 separate faecal samples from each of the following groups:

1. Gilt replacements (maiden and in-pig gilts)
2. Mid pregnancy sows
3. Sows from farrowing to weaning
4. Boars

For each group the samples are pooled, thoroughly mixed and then examined.

From a diagnostic point of view it is reported that in seven years the Veterinary Laboratories Agency have identified helminthiases on 51 occasions, mostly by worm egg counts, (of which 14 have been *Trichuris*). Likewise, in the last eight years, the SAC recorded a prevalence of 3-5% worm eggs in pig faeces (equally split between *Strongyles* and *Trichuris*) although not all submissions are examined for parasites (personal communications from VLA Thirsk and SAC Edinburgh).

The most valuable monitoring tool for pig helminthasis relates to the most economically important parasite - *Ascaris suum* - and involves assessment of liver damage at slaughter.

The British Pig Health Scheme (BPHS) has been running since summer 2005 and involves routine veterinary surveillance of all batches of slaughter pigs on specific days at all the main pig slaughter plants. This includes recording of milk spot livers, and hepatic scarring (which may be the result of previous migrating larval damage). Between July 2008 and July 2009, a total of 6198 livers out of 177252 inspected were identified as having milk spot damage (i.e. 3.5%). However, within these figures 28.4% of batches (1205 out of 4245) were identified as containing at least one milk spot liver and over the year, 50% of all slapmarks showed evidence of at least one milk spot on one occasion. (BPHS 2009 personal communication). Furthermore, there is a distinct seasonal pattern to milk spot affected livers found at slaughter, with a rise to a peak in late summer/autumn each year.(see Table 2 courtesy BPEX BPHS Report 2005-8) reflecting the more rapid embryonation and development to infectivity in warm weather.

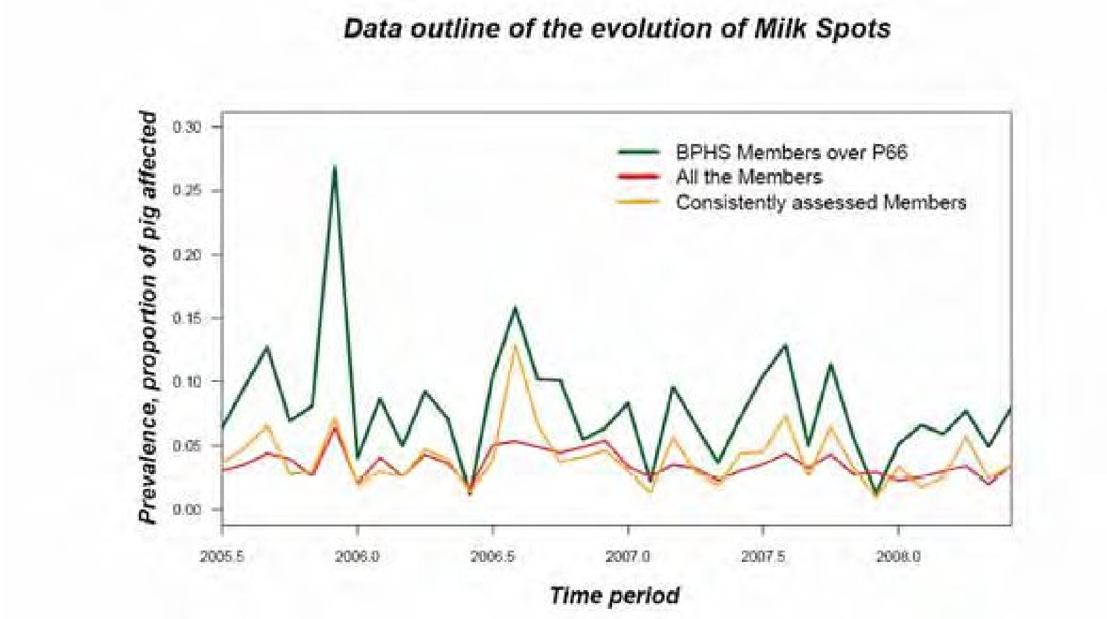


Table 2 Prevalence of Milk Spot Livers at Slaughter (BPHS)

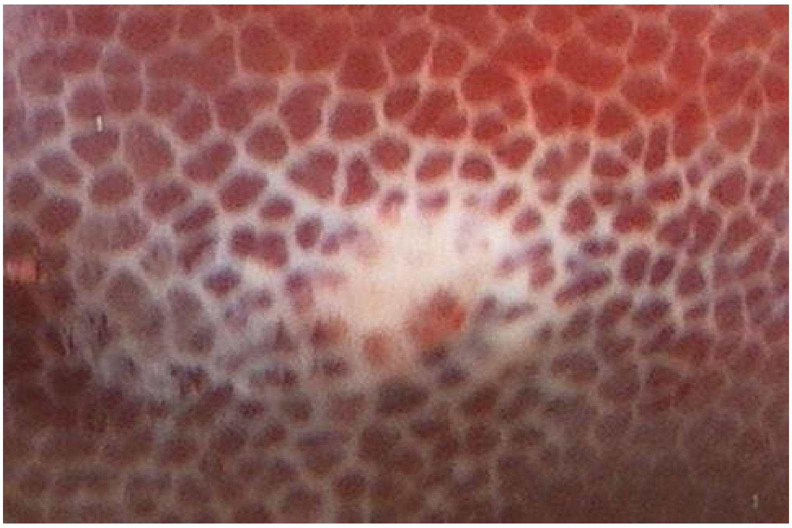
It must be born in mind that very low levels of lesions in some stock may not represent *Ascaris suum* – *Toxocara* species be implicated in low incidence damage.

Within batches of livers examined, (up to 50 livers per consignment) a number of distinct patterns are seen:

1. No evidence of any lesions.
2. High numbers of milk spots in many livers in which the liver may be severely affected.
3. Low numbers of milk spots in many livers - often no more than one or two lesions on each liver.
4. High numbers of milk spots in one or two livers within a batch.
5. Occasional milk spots in one or two livers.

The interpretation of these patterns is suggested to be:

1. No challenge with *Ascaris suum* within the previous two months
2. Uncontrolled *Ascaris suum* infestation.
3. Partially controlled *Ascaris suum* infestation.
4. Likely infestation in specific areas of the farm – probably hospital pens.
5. Very low challenge or possible *Toxacara* infection.



Figs 31-33 The variable appearance of milk spot

Where other parasites are suspected and worm egg counts on faeces is unsuccessful – especially *Strongyloides* in baby pigs and *Trichuris* in growers, euthanasia and post mortem examination may reveal evidence of the worms and the damage caused within the appropriate parts of the intestine.

6. Managemental control of worms

If there is one word which highlights the underlying principle of worm parasite control in pigs it would be hygiene. All worm cycles are maintained by faecal-oral spread to some degree and thus, any system which separates the pig from its own and others' faeces will go a very long way towards controlling endoparasites.

Thus, in intensive pig farms based entirely on slatted floors that came to the fore in the 1960's and 1970's – particularly in North East England – enteric parasitism all but disappeared and is still rarely a problem – especially in herds established free of the major strongyle worms. The increased use of AI and reduction in numbers of boars has also helped reduce spread of worms in breeding populations.

However, over the last 20 years or so there has been an increasing push to less intensification and replacement of slats with straw-based systems, in the interests of perceived welfare benefits. The increase in outdoor commercial pig production and a renaissance of backyard pig keeping also favour parasite proliferation.

In housed animals, in large dynamic groups (especially sows) and growing pigs in scrape-through systems, the presence of worms inevitably leads to increasing burdens unless controlled with anthelmintics.

The modern concept of 'all-in, all-out' management in which a population of pigs enters a clean site as one, grows on to target weight and then leaves as a group before the site is fully cleaned, disinfected and dried, is conceived on the premise that the cycle of any disease between consecutive batches is broken. Therefore, if pigs enter such systems free of worm parasites – either as a result of 'clean' original herds or by strategic worming – they remain free.

However, the cleaning process is critical and specific attention is needed for growing pigs where the two most common and harmful worms – *Ascaris suum* and *Trichuris suis* – both produce eggs that are highly resistant to destruction.

Conventional disinfectants and drying will not kill either of these eggs. There is even some evidence to suggest that routine disinfection improves *Ascaris* egg survival by destroying egg predation (Bonner-Stewart 2009a). Copious washing will, to some extent, wash the eggs away – especially *Trichuris* – but the sticky nature of *Ascaris* eggs means that such techniques are inadequate. Use of steam cleaners will help as will the preliminary application of detergents which can dissolve some of the sticky outer coating, allowing flushing away.

Destruction of either egg can, however, be achieved in one of two ways:

1. Fire and burning of the surface with a flame gun – where the structure of the building will permit – will destroy the eggs. Such burning must be thorough whilst observing the obvious health and safety precautions.
2. Lime washing. Hydrated lime mixed with water to form a thick emulsion undergoes a chemical reaction in which the pH rises to 13-14 i.e. it is highly caustic. Not only does this kill worms eggs but, if used thickly, seals them behind the film of lime. Due to its caustic nature, lime washing is a hazardous procedure for which operatives must be fully trained and provided with 100% coverage of protective clothing – including protecting eyes. Where either of these two worms is believed to be present, and

particularly if walls and floors are uneven or cracked, use of hydrated lime as a terminal disinfectant can be a valuable tool.

In outdoor situations and non-concrete floors, the management approach must be to avoid a build-up of worm eggs and larvae within the pig keeping area. This can be achieved by:

1. Regular strategic worming.
2. Movement of pigs to clean ground.

For outdoor weaners, it is usual to move weaner kennels every time new pigs are penned so that they sit on clean ground.

Fig 34 Moving weaner arcs to clean ground for each batch will assist parasite control

For the commercial outdoor herd the standard 2-3 year rotation around arable paddocks will help reduce worm build-up and if the move to clean ground can coincide with worming, this will further help reduce the risk of contamination.

It must, however, be remembered that with the *Ascaris suum* and *Trichuris suis* eggs capable of surviving many years, return to previously used ground will risk re-infestation.

For the small pig keeper, especially in backyard situations, pigs may occupy uncleanable ground for many years and as such there is always a risk of parasite build-up and the development of ‘pig sick’ land. If this becomes so contaminated, it may be necessary to completely abandon pig keeping on such ground – again the survival of some worm eggs making this more than a temporary measure. To avoid such build-ups in the first place, routine de-worming of backyard pigs is essential on a regular and routine basis.

For pet pigs, often kept within the owner’s living area, routine collection and disposal of faeces in exactly the same way as would be done for dogs, will prevent re-infestation and worm build-up and it is often un-necessary to treat adult pet pigs for worms. (They do however often require regular mange treatment and as such are de-wormed at the same time.)

7. Specific Worm Treatment Requirements

Avermectins

For all injectable 1% Ivermectin and Doramectin preparations the standard dosage is 300 μg/kg bodyweight or 1ml/33kg bodyweight, given by subcutaneous or intramuscular injection, respectively. Such a dose is effective at killing all 4th stage larvae and adults of pig nematodes with the exception of *Trichuris*. Both products tend to have prolonged activity in the body – approximately 2 weeks for Ivermectin and 4 weeks or more for Doramectin meaning that developing/migrating 3rd stage larvae will also be killed as they mature. However, the avermectins do not kill eggs, either those in the intestine prior to excretion from the host or after re-infection of the egg containing the early stage infective larvae.

Ivermectin is also available as an oral preparation fed over a seven-day period at a dose rate of 100 μg/kg bodyweight/day i.e. more than double the total injectable dose. This has a similar effect on worm larvae and adults although some control of migrating larvae can be achieved at this dose rate. Oral Ivermectin does not persist in the body to the same extent as the injectable form.

Special mention is required for two specific parasites. Avermectins at normal recommended dose rates have very limited activity against *Trichuris suis* although extended oral application (14 days) is more efficacious than injectable products. For a specific *Trichuris suis* problem, benzimidazole would be preferred. Strongyloides infection in young piglets can be effectively prevented by destroying adult egg producing worms in the sow prior to farrowing, for which all forms of Avermectin are highly effective.

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Benzimidazoles

These anthelmintics are available in a range of forms and it is necessary to detail specific application of the various products available.

Fenbendazole

Fenbendazole is available in:

- 1.5% pellets
- 4% powder

Irrespective of the form used, the standard dose rate is a total dose of 5mg/kg bodyweight per worming. This can be given in one of three ways:

1. Single dose either incorporated into one day’s feed or “top dressed” onto the feed for the individual pig or small groups, for which the ready to use 1.5% pellets are specifically authorised
2. The total dose divided over seven days – incorporated into the feed
3. The total dose divided over 14 days (sows only) incorporated into the feed

Due to its activity against eggs and larval forms as well as adult worms, this anthelmintic is effective at controlling all the major nematode parasites of the pig although to treat *Trichuris suis* and *Metastrongylus apri* (*elongatus*) it is recommended that the 7 day dosing programme is followed rather than the single dosing.

<u>Flubendazole</u>

Flubendazole is available in four formats:
1. 5% premix for incorporation in feed
2. 5% individual (top dressing) powder suitable for single pigs
3. 1.5% medicated premix for incorporation in feed
4. 10% oral emulsion for drinking water inclusion

The medicated feed farms require as standard feed inclusion of 30mg Flubendazole/ kg of feed, fed for 10 days to sows or 5 days to growing pigs.

(For *Trichuris suis* treatment, this level of treatment in growers should continue for 10 days.)

These dose rates, however, can be diluted down or extended so that it is possible to feed the total dose over 14, 21 or 28 days. It is the total dose rate of 5mg/kg bodyweight of flubendazole that must be achieved (effectively double this for *Trichuris* over a 10 day treatment period).

A similar dose rate using the water/emulsion form is required – 1mg/kg in water for 5 days, equivalent to 10gm of 10% Flubendazole for 1000kg live weight of pigs/day for 5 days.

Individual single dosing is useful for small numbers of pigs, again with a standard dose rate of 5mg/kg. (10gm 5% powder per 100kg body weight) although it should be noted that single day treatment is not indicated for lungworm (*Metastrongylus apri*) control.

All of these products may require repeated dosing, dependent upon the pig-keeping system and challenge of infection.

8. General Treatment Protocols

<u>Breeding Herd</u>

Before drawing up a treatment protocol for a herd it is necessary to know which parasites are present in the herd. Sarcoptic mange should be diagnosed clinically (and if necessary confirmed by way of microscopy on ear scrapings); *Ascaris suum* can be assessed on visible signs (occasionally sows will spontaneously pass occasional roundworms) and liver inspection at slaughter of growing pigs; suspicion of lungworm, *Strongyloides* and *Trichuris* in growing pigs on clinical grounds, can be supported by post mortem examination and laboratory confirmation; *Oesophagostomum* and

Hyostrongylus assessment is based on feed use, sow body condition and supported by worm egg counts on mixed screen samples.

Scenario 1:

No evidence of any significant parasite challenge. No routine or strategic worming is required but regular monitoring of dung samples (six-12 monthly) and slaughter pig livers, for milk spot damage.

Scenario 2:

Modest levels (up to 1000 egg of faeces) of strongyle eggs in sows and/or boars but no other parasites – worm all breeding animals twice yearly. Increase to four times per year in high challenge situations and improve hygiene.

Scenario 3:

Low levels of strongyles in boar faeces; sows otherwise free. Individual dosing of boars twice, eight weeks apart and continue to monitor dung samples annually/biannually. Wash and disinfect boar pens.

Scenario 4:

Mange positive herds. Treat all sows twice yearly by:

1) Incorporation of Ivermectin in feed for seven days, twice yearly.
2) Injection of whole herd twice yearly (simultaneously) with Ivermectin or Doramectin.
3) Injection of sows seven-14 days prior to farrowing each litter.

Scenario 5:

Significant milk spot damage in slaughter pigs or known *Trichuris suis* in growing pigs but no other parasites present. Worms sows annually and concentrate worming strategy on growing pigs.

Scenario 6:

Strongyloides infection known to exist in young piglets. Worm sows seven -14 days prior to farrowing every litter.

Scenario 7:

Lungworm infection identified in sows. Worm two to three times at four-weekly intervals and move to clean ground not returning for at least three years.

Outdoor herds

In addition to any of the above scenarios – in which Scenario 2 is the most common – treatment of the whole herd prior to moving to fresh ground is advisable. This is complicated by the fact that, unlike with ruminants that tend to be moved in one go, an outdoor commercial pig herd will move over a two to three month period. It is, therefore, wise to worm the whole herd immediately prior to the move and to repeat treatment if the move is not complete within two months – treating both the moved and unmoved pigs. Practically, treatment is usually done via the feed.

Replacement Stock

Replacement gilts and boars can be a source of nematodes for the recipient herd. Some seedstock suppliers will routinely de-worm prior to dispatch but on a precautionary basis if there is any doubt over the worm status of incoming animals, they should be de-wormed on arrival.

Growing Pigs

Multiple treatment programmes exist depending on the challenges presented. In practice the most significant challenges to growing pigs are from *Ascaris suum* (milk spot liver), *Trichuris suis* (colitis) and *Metastrongylus apri* (respiratory distress).

Scenario 1:

> No evidence of milk spot livers at slaughter or very low prevalence (Pattern 5, described in section 5,) and no clinical disease suggesting *Trichuris suis* or Metastrongylus apri. No routine worming needed.

Scenario 2:

> Significant levels of milk spot livers identified at slaughter. A worming programme must be introduced but will depend on the system of pig keeping.

1) In slatted accommodation i.e. 'all-in, all-out' situation where accommodation can be thoroughly cleaned before stocking, worm pigs on entry via food. Further treatments may not be needed but should be assessed on the basis of prevalence of milk spot at slaughter.
2) In contaminated environments repeated dosing is needed using benzimidazoles in feed; following a treatment on entry to finishing over a five to seven day course (depending on product) further courses of treatment should be given every four to five weeks up to slaughter weight – ensuring withdrawal periods are observed. Standard rate inclusions will suffice.

Scenario 3:

Evidence of clinical disease associated with *Trichuris suis* infestation. As above, if pigs enter a thoroughly clean environment – a single double dose treatment with benzimidazoles (5mg/kg total over a seven day period or 10mg/kg total over 10 days with Fenbendazole or Flubendazole respectively) will suffice.

In a heavily contaminated or continually occupied environment 5mg Fenbendazole over seven days or 10mg Flubendazole over 10 days should be administered every six weeks (subject to withdrawal periods).

Scenario 4:

Evidence of clinical disease associated with lungworm (Metastrongylus apri). De-worm with Fenbendazole (seven days) or Flubendazole (five days) at standard rates every four weeks, remove from infected pasture and do not re-occupy land for three years. (Where Sarcoptic mange is known to be present at significant levels in growing pigs, treatment on entry via the feed with Ivermectin will treat both the ectoparasites and any endoparasites the pigs are carrying. If any of the above scenarios apply, additional worming will be required as detailed.)

<u>Backyard Pigs</u>

Any pigs that are kept on permanently occupied ground that has a long history of pig occupation should be de-wormed regularly. Breeding animals should be wormed every three months (immunity does not develop to strongyles especially *Oesophagostomum*) and growing pigs between 10 weeks and slaughter, monthly. Where worm burden becomes extreme the ground should be abandoned for pig keeping. There is no environmentally acceptable way of sterilising soil if *Ascaris* or *Trichuris* eggs are present.

Fig 35 Given sufficient space and clean ground there is no reason why parasite control in pet or hobby farm situations cannot be straightforward

Treatment of Liver Fluke

Liver fluke is not commonly seen in pigs and no licensed medication is specifically available for the treatment of pigs in the UK. Where fluke is diagnosed it is therefore necessary to use a flukicide product 'off-license' under the cascade rule. Only a veterinary surgeon can make such recommendation and prescribe. For practical purposes it is preferable to use an injectable product (rather than a drench).

Options include:

- Ivomec Super Injection (Merial Animal Health) – a combination of 1% ivermectin and 10% clorsolon. This should be given at a dose rate of 1ml/33kg by subcutaneous injection and has the advantage of treating all worm parasites and mange mites. However the flukicide component is only effective against mature fluke. As use is off-license, the standard withdrawal period of 28days would apply; however the licensed withdrawal period for cattle is 35 days and as such this extended period should apply in pigs

- Trodax 34% (Merial Animal Health) containing nitroynil. Applying the ruminant dosage of 10mg/kg by subcutaneous injection, treatment of immature fluke as well as mature forms is possible. Caution should be exercised in treating pregnant sows. A 60 day meat withdrawal period should apply.

  A range of oral preparations based upon triclabendazole are available for ruminants and can be used under veterinary direction for treating mature and immature fluke infestation in pigs. As most products have licensed withdrawal periods in excess of 28days, these extended withdrawal periods should be applied.

In all cases it may be necessary to repeat treat four to eight weeks later, and to remove the pigs from the source of contamination.

9. Costs of Parasites and their Control

The cost penalty of worms in pigs can be difficult to evaluate due to the highly variable nature and severity of infection. However, some broad figures can be given by way of example:

a) Sow endoparasites – Measurable burdens of *Oesophagostomum* and/or *Hyostrongylus* in sows can increase required feed to maintain condition and productivity by 10% or 120kg feed/year. On current (2009) prices this represents £18/sow/year.[1] However, a failure to supply this extra feed can lead to a loss of sow output of more than two pigs weaned/sow/year based upon clinical experience. For every sow in the herd this gives a loss in net revenue for the breeder/feeder of £100/year with further losses incurred if lactation output is also compromised limiting weight at weaning.

b) Ascariasis – The effects of *Ascaris suum* infestation in growing pigs are additive. Not only will growth rates slow in affected individuals by up to 50gm/day between weaning and slaughter (costing 12 days additional growth at a financial penalty of £3 in extra feed)[2] but the presence of parasites will exacerbate other diseases (including colitis, PIA, respiratory disease etc), reduce lean meat percentage in the carcass and lead to condemnation of the liver at slaughter.

   It is claimed (Janssen 2009) that a link can be made between the incidence of milk spot livers at slaughter and the overall depressant effect on growth over the whole farm:-
   - 10% affected livers = 2% depression in daily gain.
   - 30% affected livers = 5% depression in daily gain.
   - 50% affected livers = 7% depression in daily gain.

   (See also McOrist *et al* 2008)

c) *Trichuris suis* – Severe infestation of *Trichuris suis* in growing pigs has been seen to slow growth by 15% between 30kg in sale weight (100 kg) equivalent to a loss of growth of 120gm/day adding 16 days to age at 100kg with an additional feed cost £4 /pig (2009 prices). This is in addition to treatment costs and loss of quality in the growing animal.

d) Lungworm – Trial studies have shown severe lungworm infestation in outdoor growing pigs had the effect of depressing growth by 26% (790gm/d v 1060gm/d for unaffected controls) with feed conversion

[1] Assumes average sow feed cost of £150/T
[2] Based upon 1.4kg/head/day for maintenance @c£180/T

ratios depressed by 18% (3.43 v 4.17) (Bonner-Stewart 2009b) representing a cost on current prices of up to £7 per pig.

e) *Strongyloides ransomi* – There is a paucity of recent evidence of the effects of *Strongyloides* on piglet weaning weights. However, in one study it is claimed that piglets suckled by sows treated with Ivermectin prior to farrowing (in situations where Strongyloides ransomi infection was known) were 0.78kg heavier at weaning (28 days old) compared to pigs treated with another anthelmintic (This may imply complications with Sarcoptic mange rather than a failure of the alternative treatment). If genuine, this implies pigs affected with Strongyloides ransomi would take 7 days longer to reach 90kg at an additional feed cost of £1.75/pig (Busse et al 1992). Oral ivermectin treatment of pregnant gilts has been shown to be equally effective at controlling Strongyloides infection as injectable forms (Barth *et al* 1996).

It can thus be seen that worm parasites alone can have dramatic damaging and costly effects on pigs, not to mention the health and welfare detriment they suffer. (If Sarcoptic mange is added to the picture the welfare and economic costs multiply markedly).

A routine monitoring and control programme is thus essential for all pig keeping enterprises along with prompt and accurate diagnostic investigation of potential problems.

Whilst the costs of anthelmintics maybe somewhat variable dependent upon special deals available for large volumes and penalties for treating small groups of pigs, Table 3 provides **approximate** costs of treatment at 2009 prices.

Table 3 Approximate costs of worming programmes at 2009 prices.

	Single Treatment Cost per 30kg weaner	**Single Treatment Cost per 50kg grower**	**Single Treatment Cost per 250kg sow**	**Cost to treat 1000kg liveweight of growing pigs once**
Doramectin injection	40p	60p	£3	£12
Ivermectin injection	15-20p	20-30p	£1-£1.50	£4-£6
Ivermectin Premix	14p	23p	£1.15	£4.50
Fenbendazole	6-10p	10-12p	40-60p	£2-£2.40
Flubendazole	6-10p	10-12p*	30-50p	£2-£2.40

*Double cost for treating *Trichuris*

The cost of treating worms alone (i.e. benzimidazole compounds) compared to the potential costs of infestation is trivial. The cost of monitoring worms in a commercial pig herd by way of biannual worm egg counts for the breeding herd coupled with membership of the BPHS to obtain a minimum of four reports per year of slaughter pig pathology – including milk spot liver assessment - would be no more than £150/year or half the cost of routine worming for a herd of 300 sows.

Comment is required regarding the differential costs of avermectins against benzimidazoles. With the former products, Sarcoptic mange and lice will also be treated and so any population that is affected with these parasites (also monitored under BPHS) would need to use these products in place of the pure anthelmintics (benzimidazoles). (Trial data has shown in the face of Sarcoptic mange, treatment with Ivermectin injection improves growth rates by 8-10% (Gutierres-Poster *et al* 1990)). Injectable avermectins may also be more convenient (even in the absence of mange) for small populations, small holdings or specific animals within a larger population (e.g. boars) although individual (top dressing) treatment packs of both fenbendazole and flubendazole are available.

10. Complications

(a) Resistance - As a general observation, resistance to anthelmintics in pig nematodes is not widespread, although it has been identified since 1987 in Denmark in *Oesophagostomum* sp. (Kagira *et al* 2003). However, most reports relate to old established products no longer used in UK pig production (e.g. Levamisole, Piperazine and Pyrantel). It is speculated that under-dosing may have played a part in such developments. There appears to be little evidence of avermectin or benzimidazole resistance in pig nematodes, which may reflect the lower parasite burdens, and more limited use of anthelmintics in pigs compared to ruminants, especially sheep.

At the current time there is no justification for a regular changing of the class of product used to de-worm pigs within a herd.

(b) Dosing Accuracy - Individual treatments given either by injection (Avermectin) or orally directly onto food (benzimidazoles) provide the most accurate way of dosing pigs but is dependent upon accurate estimates of body weight.

Where anthelmintics are incorporated into feed, adequate dosing depends upon an assumption regarding feed intake, sufficient duration of treatment and accurate incorporation. Care must be taken with animals with depressed feed intake such as sick pigs (often in hospital pens and harbouring high worm burdens) and farrowing sows. It is also important where the duration of treatment can vary (with a varying inclusion in finished feed) that farm staff is aware of the minimum time period required for treatment. Furthermore, accurate management of feed bins is needed. Standard bins empty from the centre of the feed mass such that new feed added to a bin still containing previous consignments will mix together diluting dose rates at the start and finish of a medication programme. Where a planned treatment programme is to take place, feed bins must be emptied before medicated feed is added and again before unmedicated feed is added at the end of the treatment period. (For the smaller farm, bagged food avoids these complications but adds considerably to cost.)

Feed bins must also be clean, avoiding accumulation of mouldy food, which can interfere both with appetite and potentially with efficacy of medication. Where it is safe to do so, feed bins can be power washed internally at least twice a year. It is preferable to install an inspection hatch in the side of the bin to allow cleaning to be achieved without entering it.

Fig 36 Feed bin management is an important component of herd worm control programmes.

Where treatment is provided in water systems it is important to ensure the water lines are clean at the start, accurate dose rates are calculated to match water intake, and correct mixing of the product. At the end of treatment, water lines should be flushed out to avoid residues remaining in the system, which can compromise withdrawal periods. Carefully follow the instructions provided with the marketing authorisations to ensure correct application.

(c) Adverse reactions - Adverse reactions to anthelmintics are extremely rare other than occasional pain reaction to injectable ivermectin. However, in very specific circumstances some significant reaction can occur.

Where a very heavy worm burden exists in an individual, killing the worm can have two possible harmful effects:-

i) Intestinal blockage as a bolus of dead worms passes down the small intestine (such blockages can occur with heavy *Ascaris* infection unrelated to de-worming). See Fig 18

ii) The sudden killing of large numbers of worms can release toxins into the intestine which cause gut disturbance, colic and diarrhoea. This problem has been seen in boars that are heavily burdened and if all working boars are wormed simultaneously, problems can occur with temporary unwillingness to work. If heavy worm burdens are suspected, boars should be wormed in two or three groups. In theory, the sudden killing of a large lungworm burden could lead to obstructive pulmonary disease, which could be fatal although this complication has not been reported.

In practice such described reactions are extremely rare with the use of modern licensed anthelmintics, and tended to be more common when levamisole was widely used.

(d) Environmental Risks – All avermectins are highly toxic to fish and aquatic organisms and it is critical that product does not contaminate waterways. This includes disposal of used containers, syringes and needles, waste product and any unused medicated pig food containing ivermectin, including any washing water from feed bin cleaning. Storage of unused product in secure areas in accordance with normal medicine requirements is critically important. All injectable anthelmintics are supplied in multiple dose bottles with the instructions that any used product should be discarded once the bottle has been opened for a specific time period. This is for a number of reasons:

   i) Risk of the bottle becoming contaminated with bacteria or other organisms
   ii) Increased air in the bottle increasing risk of oxidation damage
   iii) Temperature fluctuation between storage and use increasing product decay

   Partial or completely empty bottles constitute harmful waste and must be disposed of along with needles and syringes (which constitute hazardous healthcare waste) by incineration in approved equipment. Return of bottles to the supplier in a dedicated “sharps” container may be the best method of disposal. On no account should bottles, needles and syringes be disposed of with ordinary domestic or trade waste or on farm bonfires.

   Whilst benzimidazoles do not present the hazard to aquatic life forms seen with avermectins, safe disposal and storage of medicated products as per the marketing authorisation should apply.

(e) Withdrawal periods – All licensed anthelmintic products referred to in this document require a period of time to elapse between application and completion of treatment and the safe slaughter of the animal for human consumption. These meat withdrawal periods vary from product to product with the shortest withdrawal period being three days (for some Fenbendazole and oral Ivermectin preparation) to the longest being 60 days.

   Particular care is needed in the management of feed medication and water line treatments to ensure that the meat withdrawal time does not start until all medication is out of the feed or water system and it can be certain that pigs are not still receiving any residual medicine. Always consult the Marketing Authorisation to ensure observation of the correct withdrawal period, which must always be viewed as the minimum time required to elapse between completion of treatment and slaughter. In some circumstances, a Veterinary Surgeon may recommend an extension of the withdrawal period to ensure clearance from the body.

(f) Combination of medication – As with all pharmaceutical products, care should be exercised when administering other products simultaneously. There are no specific contra-indications for the combination of other products with anthelmintics but:-

   i) Never mix injectable products in the same syringe or administer at the same site
   ii) Do not simultaneously apply water containing flubendazole with other water soluble products
   iii) If anthelmintics are incorporated into feed containing other pharmaceutical products (e.g. antibiotics) then the longer of the two products withdrawal periods must apply

11. Recording

All the products referred to in this paper are licensed pharmaceutical preparations and as such when used in food producing animals there is a statutory requirement to record all products coming onto the farm in whatever format (in addition to the need where appropriate for a Medicated Feedingstuffs Prescription (MFS) issued by a veterinary surgeon, pharmacist or suitably qualified person). This record should include the batch number.

Recording of the actual application of the product is then needed either on an individual or group basis. In view of the long withdrawal periods of injectable products it is advisable to record each individual sow treated by date. (See Veterinary Medicines Regulations 2008; Animals and Animal Products); (Examination for Residues and Maximum Residue Limits Regulation 1997); (Welfare of Farmed Animals (England) Regulations 2007).

Records must be retained on farm for five years in the form shown in Table 4.

Table 4: Required Records for Animal Medicine Use

NAME AND FULL ADDRESS OF PERSON KEEPING RECORD:	TEL NO:	HOLDING NUMBER:
		HERD NUMBER:
POSTCODE:	E MAIL:	

TO BE COMPLETED AT TIME OF ACQUISITION					TO BE COMPLETED AT TIME OF ADMINISTRATION									
Name and Address of Supplier of Medicinal Product	Date Acquired	Identity and Quantity of Medicinal Product			Date of Administration	Withdrawal period	Identification of Animal or Batch of Animals Treated		Date treatment finished	Date withdrawal period ended	Name of person administering veterinary medicine	Amount of Product Administered & Total quantity of veterinary medicine used	Date, Quantity and route of disposal (if not Administered)	Reasons for treatment
		Name	Batch No	Quantity			ID	Number Treated						

12. Summary and Conclusion

Endoparasites in the form of nematode worms present a serious threat to the health of pigs as well as increasing costs of production. Two major classes of pharmaceutical products are available for worming pigs – the benzimidazoles group which operate only as wormers and the avermectin group which also treat ectoparasites (e.g. Mange and Lice).

The choice of product will depend upon parasitic challenge, convenience of use, personal preferences and cost but a protocol designed to work in conjunction with a managemental approach to parasitic control should be drawn up in conjunction with your veterinary advisor.

Acknowledgements

The author would like to thank many colleagues whose advice and constructive criticism have contributed greatly to this paper.
Figs marked * are courtesy of Merial Animal Health and those annotated ** are courtesy of Janssen Pharmaceutica NV both of whose permission to reproduce is gratefully acknowledged.

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