THE EPIDEMIOLOGY AND CONTROL OF NEMATODE INFECTIONS IN CATTLE

I.K. HOTSON*

Summary

Gastro-intestinal parasites can potentially cause economic losses in dairy- and beef-cattle enterprises. Losses occur due to sub-optimal productivity of the host caused by continuing low-level parasite infection, as well as due to deaths during more dramatic "outbreaks" of disease.

The intensity of the parasite problem with grass-fed cattle is generally a function of the intensity of the enterprise. Worm burdens acquired under favourable climatic conditions may have an economically significant effect, depending on the numbers acquired, and the age and "resistance" of the host. In special circumstances, because of the phenomenon of hypobiosis (arrested larval development), certain parasites may not exert pathogenic effects until many months after they have been acquired. This fact has special implications in control in specific management situations.

Application of control measures to keep parasites within "economic" bounds can be soundly based when knowledge of seasonal incidence and importance of parasites is available for a specific area and enterprise. Research into application of the complementary techniques of grazing management and strategic anthelmintic medication in parasite control is now possible in the light of accumulating seasonal incidence information.

I. INTRODUCTION

Increasing interest in cattle production has emphasised the need for more basic knowledge of the epidemiology and importance of helminth parasites of cattle in various types of commercial enterprise, to serve as a basis for planning of control programs. This paper reviews information in these fields and discusses alternative strategies for parasite control. Consideration has been confined to the important gastro-intestinal nematode parasites of beef and dairy cattle.

II. IMPORTANCE OF NEMATODE INFECTIONS

Confirmation of the pathogenic effects of nematode parasites in cattle appeared in Australian literature in the early part of the century; for example, Gilruth and Sweet (1910) gave details of an outbreak of ostertagiosis in Victorian dairy cattle. Losses due to deaths or severe debilitation of cattle are readily appreciated and to a certain extent can be assessed quantitatively. However, considerable losses are also caused by the sub-optimal productivity of cattle suffering from continuing low-level infection which is inapparent and therefore generally not appreciated. Assessment of this type of loss is difficult. Winks (1970) considered that nematode parasites were not affecting productivity in the Queensland beef cattle.

* N.S.W Dept. Agriculture, Veterinary Research Station, Glenfield, NSW, 2167
Present address: Merck Sharp & Dohme (Australia) Pty. Limited, Veterinary Research & Development Laboratory, Ingleburn, N.S.W 2565
situations studied by him. However, with beef cattle at higher stocking rates in northern N.S.W, Dash, Sparke and Hotson (1973) showed that suppression of nematode burdens in beef calves by monthly anthelmintic treatment resulted in a significantly greater liveweight gain by treated cattle. Studies on beef cattle in New Zealand, reported by Cooper (1970) and McMullan (1973), also indicated improved performance following regular anthelmintic treatment. Brunsdon (1968) and Khouri, Manning and Moxham (1968) measured the effects of parasitism in dairy cattle using similar techniques.

As a generalisation, one can say that potential for economic loss due to parasitic diseases increases with the intensity of the rearing enterprise, being greatest in replacement dairy-heifer systems and least with beef cattle under low stocking-rate range conditions.

In the special case of "bare-ground" feedlot management, where re-infection seldom occurs, inadequate treatment of cattle on entry may leave residual parasite burdens which continue to exert pathogenic effects.

III. EPIDEMIOLOGY OF NEMATODE DISEASES

Epidemiology is the study of factors determining the occurrence and severity of disease. The major factors to be considered with nematode diseases of cattle are (a) the parasite, particularly the availability of infective stages on pasture, and the occurrence of arrested development of the parasite in the host (b) the host, with particular reference to "resistance", and (c) the environment, i.e. management factors.

(a) The Parasite

(i) Availability of larvae on pasture

The common nematode parasites of cattle have an essentially similar "direct" life-cycle. They do not multiply within the host. Eggs from adult worms in the gastro-intestinal tract pass out in the host's faeces and must undergo further free-living development before becoming infective to another grazing host. The survival of eggs and their development to larvae is governed by temperature and moisture. The cattle dung pat provides an admirable environment for egg development, and subsequently protects the infective larval stage from desiccation. The rate of development to the larval stage is governed by temperature. If temperatures at the time of deposition are unfavourable, the development of the egg may be slowed considerably and there may be a long time interval (several months) before the larva finally becomes available on pasture.

Larvae become available after softening of the dry outer layers of the dung-pat allows their release. Pats can act as a substantial reservoir of larvae over long periods, and there is usually a marked increase in larvae available on pasture after rain. Once larvae have emerged from the dung-pat, their survival is dependent on a favourable micro-environment. Pastures providing a moist humid "mat" with protection from desiccation are favourable for larval survival.

Techniques are available (e.g. Smeal and Hendy 1972) for the assessment of numbers of infective larvae on pasture. Some data are available regarding larval availability on cattle pastures in Queensland (Durie 1962) and on beef pastures in northern N.S.W (Smeal 1972) but there is a need for more detailed studies of the same type in other areas with different cattle management systems,
so that "normal" seasonable patterns might be determined. Of course, the epidemiologist soon learns that there is no such thing as a "normal" season, but repetition of studies over several seasons allows certain generalisations to be made. Studies relating contamination times to subsequent larval availability are important, as control programs aimed at preventing the acquisition of heavy parasite burdens must plan to prevent contamination at critical times beforehand. Smeal (1972) demonstrated the importance of contamination in the autumn and winter months as the source of infective larvae in the spring in several northern tablelands situations in N.S.W.

(ii) The phenomenon of hypobiosis (arrested larval development)

In the "normal" course of events, larvae ingested by the grazing host pass through certain developmental stages and reach maturity in their appointed portion of the gastro-intestinal tract in 3-6 weeks. If sufficient larvae are ingested over a short period of time, their effects on the host are almost immediately apparent.

On the other hand, at certain times of year, associated with changes in the host and/or the larva on pasture, the ingested larvae of certain nematode species may become arrested within the host at a specific stage of their development. These arrested larvae lie quiescent, usually deep in the gut lining, and may not resume development for many months. There is a progressive accumulation of the arrested larvae in the host, but even in numbers of hundreds of thousands, they appear to be relatively non-pathogenic. However, if at a later stage large numbers of previously-arrested parasites develop to maturity simultaneously they may cause severe pathogenic effects on the host.

The factors which act on the host and/or the parasite to induce this phenomenon are not clear. There is evidence that certain strains of parasite are more "inhibition-prone" than others (Armour, Jennings and Urquhart 1967) and that there is a well-defined seasonal occurrence of inhibition for several species of nematodes. In Britain, Anderson et al. (1965) showed that *O. ostertagi* acquired in autumn-winter were liable to be inhibited while those acquired at other times were not. In Australia, Anderson (1968) and Hotson et al. (reported in part by Smeal (1972)) have shown increasing inhibition of *Ostertagia* in spring and summer months, with subsequent maturation of parasites in late summer and autumn. Inhibited development of *Cooperia* has been reported (see Michel, Lancaster and Hong (1970), Brunsdon (1972a) and Smeal (1972)), and Hotson et al. (unpubl) have observed winter inhibition of *Haemonchus*.

The so-called "physiological" inhibition referred to above can be reproduced in some host-parasite systems under laboratory conditions by subjecting larvae to certain temperatures for specified periods (Hutchinson, Lee and Fernando 1972) suggesting that perhaps larvae on pasture may be "programmed" at certain times, by exposure to simple physical stimuli, to behave in a certain way on entering the host.

Resumption of development by arrested larvae in the host may normally occur in moderate numbers to replenish diminishing adult worm burdens or those removed by anthelmintic treatment (Michel 1969), or resumption may occur at the end of a "programmed" period, or in response to certain changes in the host environment at specific times. Massive maturation of larvae of *Ostertagia* has caused disease in cattle under winter housing conditions in Britain (Martin, Thomas and Urquhart 1957; Anderson et al. 1965) and in cattle on summer-autumn pasture in Australia (Hotson 1967). Association of sudden disease outbreaks with the parturient period in cattle has also been noted by Hotson (1967), Wedderburn (1970) and Salisbury (1973) under conditions in Australia and New Zealand. The factors responsible for larval maturation in cattle at
this time may be similar to those which stimulate a parturient egg-count rise in sheep during the parturient relaxation of resistance.

Whatever the reasons for the initiation and cessation of arrested larval development, the ability of a parasite to prolong its life cycle and remain quiescent in the host for a long period is of considerable epidemiological significance. A clear definition of the seasonal nature of the phenomenon under varying management conditions is essential to the planning of any control programs, as will be discussed in a later section.

(b) The *resistance* of the host

In grazing systems, successive crops of young susceptible hosts are periodically introduced to a contaminated environment, and acquire round-worm infections as they graze. In heavily contaminated environments such as calf-rearing systems for dairy or dairy-beef types, larvae will be available at most times of year and calves may acquire highly pathogenic burdens early in life. However, with increasing age, and in response to continuing parasite infection, resistance mechanisms of the host operate to regulate worm burdens and eventually provide strong protection against reinfection, even under conditions of heavy larval intake. The age at which a high level of protection is developed in grazing cattle varies with the species of parasite and with the host's previous infection history. The level of protection is not constant—it may alter in response to changing patterns of larval availability and in response to the general health status of the host. Malnutrition is a state in which *resistance* to disease, including parasitic disease, may be considerably diminished, and the parturient relaxation of resistance in the host has already been referred to.

The resistance mechanisms of the host affect parasites in a number of ways. The host may resist the establishment of worms, or cause expulsion of established worm's, as a means of regulating the magnitude of burdens. Michel (1969) has summarised evidence from studies with *O. ostertagi* which demonstrates that the worm burden of an animal exposed to constant infection is in a state of rapid turnover, and is regulated by a loss and replacement of worms. Individual parasites developing in resistant hosts are also affected by the host environment, being smaller in size and possibly showing morphological abnormalities compared with worms in susceptible hosts. Other manifestations of resistance are the inhibition of parasite development at a specific stage, and the suppression of egg output of female worms. Parasite populations in young susceptible hosts generally have a high worm-egg output, whereas those in resistant animals will produce few eggs. Young animals in which resistance is still developing are therefore a prime source of contamination of pastures, whereas older animals showing strong resistance contribute relatively little contamination.

(c) The grazing environment

The potential for outbreaks of parasitic disease in cattle increases with the intensity of the grazing enterprise. Beef cattle reared under range conditions at low stocking intensities seldom suffer from clinical parasitism. However, the situation in a calf-rearing unit is markedly different, and the chances of young susceptible calves acquiring pathogenic infections are much greater. Repeated use of particular paddocks for young animals will perpetuate problems, because of high-level contamination contributed by successive crops of susceptible hosts. Thus overall grazing intensity and grazing policy become important epidemiological factors in determining potential for disease.
IV. CONTROL OF NEMATODE INFECTIONS IN CATTLE

(a) General Principles

We have seen that the classes of cattle most at risk from parasite infection are young susceptible animals, and those managed at high intensity where levels of contamination, and consequently larval availability, are greatest. We have also seen that the availability of larvae on pasture is not constant, but that there are marked variations in numbers and species of larvae on pasture in response to climatic conditions, and that it is primarily at times of high larval availability that problems arise. An exception to this is the case of arrested larval development, where simultaneous maturation of large numbers of larval parasites in the host may cause pathogenic effects many months after the parasites have been acquired from pasture.

It follows that control of parasitic disease should be possible by programs of pasture and animal management designed to prevent the exposure of susceptible animals to heavy infections at critical times, whilst still permitting adequate experience of infection to allow development of the host's regulatory and protective "resistance" mechanisms. Anthelmintics can be employed most effectively in such programs in a complementary role, being applied at strategic times to enhance the effectiveness of the basic management program.

Control programs can best be planned using information of the seasonal incidence and importance of parasites in an area or type of enterprise. A knowledge of key contamination times, seasonal availability of larvae on pasture, seasonal hypobiosis, etc. is essential for logical planning.

(b) Grazing management and worm control

Programs of grazing management can be planned to minimise exposure of young cattle to high levels of infection at critical times of year. Studies in Britain summarised by Michel and Lancaster (1970) showed a regular seasonal rise in larval numbers on contaminated pastures in late summer-autumn. By removing calves from such contaminated pastures before the anticipated rise, and transferring them to paddocks used for crop ("aftermath") and therefore not contaminated for several months beforehand, the acquisition of disease-producing worm burdens was avoided. Following the same principle with beef cattle in the New England area of N.S.W, Smeal (1972) showed that moving yearling cattle to "spelled" pasture in late July avoided contact with the anticipated August increase in larval numbers on contaminated pastures. It had been shown in earlier studies (Hotson, et al., unpublished: see figure 1) that Ostertagia larvae taken up from August onwards were those which accumulated in grazing hosts to give the potentially-dangerous pre-type II ostertagiasis syndrome of Anderson et al. (1965), and the move to spelled pasture in July therefore avoided both acquisition of damaging burdens in the spring (type I disease) and the potential for autumn outbreaks arising later from arrested larval populations (type II disease).

Associated with both the British program and the Smeal (1972) program is a single broad-spectrum anthelmintic dose, given at the time of the move, to minimise contamination of the spelled paddock by incoming infected cattle. This is an example of strategic anthelmintic use, being complementary to the main program, by extending the period of potential usefulness of the spelled paddock. The timing of the move and of the treatment is important -- these must take place before there is any accumulation of arrested larvae, i.e. while the worm burdens of the calves are susceptible to anthelmintic treatment.
One of the biggest problems with arrested larvae (certainly with *Ostertagia*, and possibly with those of other species also) is that they are not removed by any of the presently-available anthelmintics (Armour 1970). This makes it essential for treatment to be given when worm populations consist of susceptible adults.

Although the management/treatment program shows promise for control of some important parasites of cattle, problems arise with provision of an adequately-spelled paddock, particularly in a "cattle-only" enterprise. Where mixed grazing is practised, grazing of paddocks by sheep in the autumn and winter months provides a paddock relatively free of cattle larvae in the spring (and vice-versa). An alternative procedure, is the grazing of paddocks with frequently-treated cattle to minimise autumn-winter contamination another instance of complementary strategic application of anthelmintic treatment. Further research is currently proceeding to determine economically feasible programs based on this principle for parasite control.

Similar programs should be applicable under dairy cattle management conditions in Australia and New Zealand once seasonal patterns of larval availability and hypobiosis are known. Brunsdon (1972b) has examined such a program under New Zealand conditions, and achieved a significant production response.

---

**Fig. 1. Ostertagia infections in beef cattle in tablelands areas of N.S.W showing interrelationships in the seasonal incidences of worm-egg contamination, pasture larval populations and parasite burdens in beef calves weaned in April-May of the first time sector. ---- Adult worms; ------ Arrested larval worms. The incidence of specific disease syndromes is also shown.**
(c) Anthelmintics and worm control

Anthelmintics give only short-term responses when used alone in control, rather than as a part of an overall integrated program. However, where management factors do not permit the use of pasture-spelling or alternate grazing programs, a series of anthelmintic treatments may be an effective alternative in certain situations. Cooper (1970) and McMullan (1973) demonstrated the value of winter anthelmintic treatments at 6 week intervals under New Zealand conditions.

Often under the high-stocking situations of dairy or dairy-beef enterprises, regular anthelmintic treatment gives adequate control during the period when calves are most susceptible, generally between 3-8 months of age (see Brunsdon 1968).

An alternative proposal under intensive conditions is the low daily dose of an anthelmintic such as phenothiazine, as a means of depressing worm-egg production, sterilising eggs and reducing overall pasture contamination. The efficacy and long-term economic advantages of such a system are worthy of further investigation.

In summary, the best long-term results will be derived from complementary programs of pasture spelling and anthelmintic treatments, designed to ensure that susceptible young cattle do not acquire pathogenic infections, and that accumulation of potentially pathogenic arrested larvae is prevented.

(d) Worm control for feedlot cattle

It was noted earlier that the phenomenon of arrested larval development was of considerable epidemiological significance, and it was subsequently noted that one of the problems was the ineffectiveness of available anthelmintics against the arrested larvae. It is therefore of prime importance in control to prevent young cattle acquiring potentially-dangerous larval burdens. However, it is also true that most young (yearling) tablelands cattle will carry appreciable burdens of arrested larvae by midsummer because of inadequate control. Many of these cattle at 15+ months of age could be destined for feedlots, and therefore pose a special problem. Anthelmintic treatment of these cattle will remove small adult worm burdens, but will not remove arrested larvae. However, the arrested larvae may subsequently mature progressively in modest numbers to replace the lost adults, and cause continuing (inapparent) sub-optimal productivity of the feedlot animals. In fully-integrated feedlot enterprises, the origin and history of introduced animals is known and some control may be exercised over parasite control programs before cattle enter the feedlot. However, where this is not the case, cattle enter lots with an unknown background and anthelmintic treatment may be given without knowledge of its possible deficiencies. Unfortunately presently-available diagnostic techniques (except post-mortem examination) do not permit accurate estimation of the magnitude of burdens of arrested larval parasites. However, even with such a test to indicate high positives, the course of action is not clear in the absence of effective anthelmintics.

A comprehensive review of the many managerial factors to be considered in application of parasite control in the feedlot is provided by Egerton (1972).

V. REFERENCES

