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GUEST EDITORIAL

The use and abuse of feed-through compounds in cattle treatments

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The dung-feeding habit

When vertebrates evolved onto land, insects were already a well established terrestrial group. The vertebrates offered many new food resources in the form of blood, dung, fur, feathers, secretions, skin, and waste food. Although many insects were committed to life styles from which they could not capitalise on such resources, other species developed close associations with vertebrates, often utilising their dung. This valuable source of nutriment has been exploited by many insects, particularly in the Coleoptera and Diptera, where entire larval lives are spent feeding on dung.

Among the varied relationships between insects and vertebrates, there are some extremely damaging examples which are well known in the livestock industry. Although parasitic dipterous larvae are horrific, they are thought to inflict less economic damage to the livestock industry (in overall terms) than those adult Diptera that pester cattle by feeding on bodily secretions and blood (Drummond *et al.*, (1988). The latter habit is common to members of the Ceratopogonidae, Culicidae, Glossinidae, Muscidae, Simulidae and Tabanidae. Of particular importance in cattle are muscids with painful bites like the horn fly, *Haematobia irritans*, and stable fly, *Stomoxys calcitrans*. Although not a biter, the face fly, *Musca autumnalis*, pesters cattle by feeding around the head, and also causes indirect damage by pathogen transfer. Even the house fly, *Musca domestica*, is a nuisance, probably of greater importance in poultry houses. These four species also use livestock dung and bedding as a breeding site.

Chemical control of dipteran pests of livestock

The need to feed on warm-blooded animals provides a partial solution for the control of some pests: insecticides can be applied as sprays; animals can be dipped; tags releasing pesticide can be attached to the ears; and dust bags can be provided in livestock runs. The efficacy of such treatments is somewhat controversial; it depends on many factors, in particular the thoroughness of administration. Another approach is to eradicate the larvae of the pests. Treating larval Simulidae, Culicidae and Ceratopgonidae poses special problems because the stages are aquatic and the widespread treatment of watery environments is both difficult and undesirable; although whole rivers have been dosed in programmes against Simulidae. By contrast, larvae of *H. irritans*, *S. calcitrans*, *M. autumnalis* and *M. domestica* are restricted to terrestrial livestock dung (usually cattle) or soiled bedding, and a new technique for their control has been developed. Pesticides can be added to livestock feed with the purpose of rendering the livestock faeces unsuitable for fly development. This poses fewer problems that treating entire rivers!

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Feed-through compounds

In-feed additives have been available for some 25 years. Originally, phenothiazine and the organophosphate, ronnel, were available as food additives for beef cattle to suppress dung-breeding stages of the pest flies. A small daily dose of phenothiazene eradicates 95% of horn and face fly larvae, a similar level of control over horn flies being obtained with ronnel. The advent of stirifos and its subsequent development in capsular form made in-feed organophosphates available for dairy cattle because little of the pesticide found its way into the milk.

In the mid 1960s, research in insect endocrinology heralded the concept of 'third-generation insecticides'. The first-generation comprised natural products (nicotine, derris) and heavy metals (arsenic, antimony) which gave way to the second generation which were synthetic pesticides: organochlorines, organophosphates, carbamates, and pyrethroids. Both categories of pesticides are essentially neurotoxins or metabolic inhibitors. The third generation utilised chemicals that mimicked the insect juvenile hormone, which is secreted at precise times and in controlled amounts during normal life to regulate development at each moult. If administered at the appropriate time, the hormone disrupts post-embryonic development and leads to malformed intermediate stages and/or sterile adults. Unlike the second-generation compounds, juvenile hormone mimics (e.g. hydroprene and methoprene) are not generally toxic to other animal groups.

The development of methoprene was followed by that of diflubenzuron. This chemical (and similar derivatives) interferes with chitin synthesis and disrupts the moulting process. Like methoprene, such compounds are non toxic and show marked specificity towards insects. Finally, the discovery that extracts of the neem tree inhibit feeding in many insects and cause endocrine disfunction, led to the isolation of azadirachtin which is effective against several insect species. Substances like methoprene, diflubenzuron and azadirachtin are classified incorrectly as insect growth regulators. They do not regulate growth in any way: by contrast, they disrupt normal growth processes.

These recent products have great potential as feed-through preparations. In addition to being less toxic to many non-target organisms, their mode of action is different so that they should be active where resistance to neurotoxins has occurred.

Methods of administration

The technology of administration has changed over the years. The early chemicals were given as feed additives, as supplements in mineral blocks, or even in the drinking water. Such dosing is not always effective because over and underdosing can result when animals in effect choose their intake. Much longer protection can be provided by sustained-release boluses that lodge in the rumen to release their product constantly over predetermined periods of time. Thus coumaphos, delivered to in this way, will prevent 95% face flies from developing in cattle dung for 8-10 weeks. Methoprene released daily from a slow-release bolus can suppress 95% horn fly development for 28-32 weeks, and similar devices delivering diflubenzuron can control horn flies and face flies respectively for 14-17 weeks.

Not all the chemicals that find their way into cattle faeces do so by experimental design. For example, dichlorvos, phenothiazine and piperazine are found in the faeces following routine treatments for nematode control. The avermectins are excellent examples of this behaviour. Over ninety per cent of the dose given by subcutaneous injection is secreted into the alimentary canal and voided with the faeces; and elimination continues for several weeks after treatment. Clearly, the use of avermectins in routine treatments against nematodes has the additional effect of simultaneously rendering the faeces hostile towards pestiferous fly larvae. Sustained-release devices for the administration of avermectins to cattle have been under test for several years.

Costs and benefits

The benefits of eradicating the above flies from livestock-production areas are obvious: there are improvements in efficiency of food conversion, all of which benefit both the producer and consumer economically. But is it acceptable to consider only financial returns? For example, is there some cost to other members of the dung habitat and if so, what long-term effects can be expected in terms of pastureland biology?

Earlier, the point was made that many species of insects have evolved to utilize the short-lived and valuable commodity of dung. To the present time, research and development have focussed only on the pestiferous flies - although these species are in a minority. Many more types of insect breed in dung and do not pester cattle; some of these are valuable members of the pastureland community, active in recycling dung pats, and contributing directly to food chains. The terms pest and benefactor have no biological validity and the chemicals used to treat dung cannot differentiate between them. Here we have another example of the classical problem with pesticides: damage to many non-target species in the eradication of nuisance insects.

Research into non-specific effects of dung treatments

It is accurate to conclude that scant attention has been given to non-target organisms while developing in-feed pesticides. The majority of bioassays on cattle dung involve horn flies and face flies, yielding EC_{50} and EC_{90} values, from which calculations are based on the effective dose to be given to cattle to eradicate such pests from the dung. Concurrent bioassays on non-target organisms in cow pats are few and far between. Over 15 years ago, attention was drawn to the adverse effects of phenothiazine and dichlorvos on beetles that recycle cow pats (Blume *et al.*, 1976), but the work has been ignored. In reviews on in-feed technology, it is asserted that the treatments should affect only the pest species (Miller & Miller, 1984). Yet who has checked this? In comparison to all of the work on organophosphates, methoprene, diflubenzuron, azadirachtin or avermectins in dung treatments, how many papers consider the non-target species? The answer is very few; and because there are very few, we are ignorant of the scale of damage. We cannot anticipate the overall consequences of eradicating pest flies in cow pats, a problem that has been reviewed in relation to avermectin usage (Strong, 1992).

The outlook

However, it is easy to be critical of pesticide usage without offering anything in its place, and this article would be incomplete if other solutions were not considered. The use of beetles to disperse or bury dung and limit the growth of fly larvae has received attention in various parts of the world. From the limited data available, biological agents such as predators and parasites are not effective in regulating populations of pest flies, although some success has been achieved in the confines of factory farms. Dung can be removed from rearing buildings and dispersed as manure, flies being unable to develop in the thin layer of drying dung. However, the treatment of free-range dung is another matter. In favour of the chemicals used against the adult flies, their effect is more localised than that of treating manure indiscriminately. A further option is trapping the adults, many types of traps having been tested with varying degrees of success against muscoid flies. The designs are such that adults are usually brushed off the cattle as they pass through the traps, although some farm buildings have been fitted with water sprays, as well as electrocutor devices. The encouraging results obtained with attractants against screw worm and tsetse flies suggest that odours with or without visual targets may be developed. The use of traps combined with chemosterilants that catch, sterilise and release adults can achieve the sort of effect seen with the sterile insect approach, but without the need to release vast numbers of irradiated blood-feeding flies into the field! However, the utilization of traps involves radical changes in the practices of livestock producers. Effort has to be diverted from other work into building and maintaining traps: providing in-feed preparations certainly requires less work. Furthermore, the producer needs to know why insects of the cow-pat community should not be killed indiscriminately before being willing to change habits, and reasons cannot be given until more research is done on the effects of eradicating non-target insects.

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