Environmental Assessments: A Veterinary Perspective

A.B. Forbes
Merck Ag Vet, P.O. Box 2000
(WBF 365), Rahway, NJ 07065, U.S.A.

Abstract

Environmental safety is an important consideration in the registration and use of veterinary products in farm livestock. A common approach to environmental risk assessment is through a tiered testing system in which compounds may be taken through a gradation of tests of increasing complexity and scale. Whilst activity at lower tiers is not necessarily predictive of impact in the field, absence of effect in small scale studies generally obviates the necessity to proceed to larger scale testing. If effects are observed in the initial experiments, then the likely environmental impact of a particular compound can be estimated from consideration of the predicted exposure of non-target organisms to the active ingredient and its physico-chemical and biological characteristics. Confirmation that environmental impact assessments based on this type of extrapolation are valid can be determined through further testing of products at higher tiers representative of conditions of particular use. Testing at these higher tiers is logistically more demanding and limits the degree of control and replication compared to that which can be achieved in the laboratory, however the results are more closely allied to normal farm conditions and evaluations can include population and community measurements.

Introduction

The science of agricultural ecotoxicology has its roots in the crop protection industry where the rate, frequency and extent of application of biologically active products require a measured approach to environmental risk assessment (Samsoe-Petersen, 1990). The information which may be needed to conduct such an assessment can be considered under four broad headings: Environmental Fate, Toxicology, Exposure and Ecology. Research carried out within the first two disciplines provides information on the basic biological properties of the active ingredients of a product, how it reaches the environment, how it behaves there and how it is degraded. An understanding of the basic biology of the ecosystem which the compound is entering may be required in order that the undisturbed patterns and processes are known, so that the effect of any perturbations can be evaluated in an appropriate context.

Veterinary products can enter the environment either directly or indirectly in host excretory products following administration. Direct entry of compounds into the environment is generally associated with runoff from topically applied products or disposal of residual or outdated materials or their containers. The focus of this paper is the indirect entry of veterinary medicines or their metabolites following excretion of parenterally and orally administered products in the urine and faeces of pastured cattle. Aspects related to the potential environmental impact of bulk disposal of manures and slurries from housed cattle will not be addressed.

Methodology

Environmental Fate

Introduction into the environment of veterinary compounds or their metabolites is via excretion in the faeces and the urine. The urine provides a vehicle for water soluble compounds or metabolites to reach the soil and overlaying herbage at sites of urination. They may cause effects at the site of deposition and they may also percolate through the soil or run off the ground surface and gain access to water courses. There is a paucity of published data on the fate of veterinary compounds which are excreted in the urine of pastured cattle.

Compounds which are not excreted in the urine reach the environment through the medium of faeces. Degradation of compounds in the faecal pats may result from a variety of processes, including photolysis and microbial breakdown; these processes are typically temperature and season dependent. The time taken for complete disappearance of the actives can vary from a few days to several months, but during the grazing season, weather conditions, characterized by high temperatures and prolonged sunlight, generally favour a fairly rapid breakdown. Other factors which affect the

Adapted from the Proceedings, XIX World Buiatrics Congress, Edinburgh, Scotland; July 8-12, 1996.

fate of compounds include their water solubility, ability to bind to soil, the extent to which they undergo hydrolysis and their potential to bioaccumulate.

Toxicology:

Information regarding toxicology in various non-target organisms is generally gleaned from a series of laboratory experiments. These can be described as first tier, or micro-level, experiments which help categorize and quantify the innate properties and behaviour of the test compound. First tier testing also provides direction as to the necessity and scope for additional testing at higher levels (Jepson, 1989).

Exposure:

In veterinary ecotoxicology, the exposure of non-target organisms to active residues is related closely to pharmacokinetics and product use patterns. In the latter particularly the veterinarian is well placed to provide understanding and perspective of likely use scenarios and hence exposure characteristic (Forbes, 1993). For example, it may be that only certain cohorts or sub-populations of cattle are likely recipients of treatment on a farm. Products may only be administered at particular times of year. Patterns of use may be different in beef enterprises compared to dairy farms. Economic factors can dictate choice of product and frequency of use. Exposure levels and rates are crucial factors in predicting and evaluating environmental impact; toxicological data is of limited value without the context of exposure (Inglesfield, 1989).

Ecology:

The cattle dung fauna and flora comprise a complex of organisms from several major taxa, including insects, earthworms, nematodes, fungi and bacteria. Their abundance, habits and microhabitats vary considerably according to the influence of edaphic and climatic factors and intra- and inter-specific interactions. The natural patterns of frequency and distribution of the constituent species and their successional and seasonal activity must be considered as essential background to any studies and evaluations on the effect of any disturbances. The invertebrates which colonize dung can assist in the physical and chemical decomposition of the pat and its constituents. This role varies considerably according to the geographical region, the season of the year, pasture management, the location of the pat and the population dynamics and spatial processes of the fauna.

Ecotoxicology:

For some products it may be possible to proceed to an environmental assessment through carefully considered extrapolations from the results of initial toxicology testing. The extrapolations need to include spatial and temporal aspects of exposure of non-target organisms to residues, and their relative sensitivity. Confirmation that such assessments are valid can be gained from testing on a larger scale with treated cattle grazing pastures over extended periods of time (Wratten & Forbes, 1995). These studies can help determine whether the effects observed in small scale experiments are expressed under more extensive, natural conditions. The logistics of these macro-scale studies are inevitably complex; it may be difficult to achieve adequate replication and there is limited capacity to control extraneous factors. On the other hand, the conditions of these studies more closely mimic those expected in the field and the results should be more predictive of likely environmental impact under normal farming conditions. Examples from the literature on both agricultural and veterinary products show that extrapolation from small-scale bioassays tends to overestimate environmental impact.

Discussion

Toxicological data obtained from lower tiers of testing generally represent a worse-case scenario in that the concentrations of active used and the degree of exposure of non-target organisms generally exceed those which are encountered under field conditions. Environmental assessments using these data and quantified extrapolations of maximum, practical exposure rates provide, therefore, a conservative evaluation of likely impact. The results from large scale field studies demonstrate that the actual observed impact is typically less than that predicted from such extrapolations. This discrepancy probably arises from the presence of natural behavioural responses, population regulatory processes and community interactions under field conditions; these cannot function in experiments conducted at lower levels of organization. It is important in environmental research to be able to differentiate between effects resulting solely from exposure to test material and similar (non-specific) effects which can arise naturally when organisms experience sub-optimal conditions arising from factors such as adverse climatic conditions, poor quality food and competitive interactions. Long term field evaluations of invertebrates on farmland can be further hampered by seasonal or annual alterations in agricultural practices (Heliovaara & Vaisanen, 1993).

The best approach to achieving objective environmental impact evaluations currently rests on the tiered testing system and associated quantified extrapolations where appropriate. Well-constructed and validated computer simulation models may also assist in data interpretation (e.g. Sherratt & Jepson, 1993).

References

Brown, KC and Stephenson, RR, 1990. The effects of pesticides on terrestrial non-target arthropods in broad-acre crops - a strategy for data collection. In: Proceedings of Brighton Crop Protection Conference, Pests and Diseases, November 19-22, Brighton, England. pp. 133-141. Forbes, AB, 1993. A review of regional and temporal use of avermectins in cattle and horses worldwide. *Veterinary Parasitology* 48: 19-28. Heliovaara, K. and Vaisanen, R, 1993. Insects and Pollution. CRC Press Boca Raton/Ann Arbor/London/Tokyo. Inglesfield, C, 1989., Pyrethroids and terrestrial non-target organisms. *Pesticide Science* 27: 387-428. Jepson, PC 1989. The temporal and spatial dynamics of pesticide side-effects on non-target invertebrates. In: Jepson, PC (Editor) Pesticides and Non-target Invertebrates, Intercept, Winborne, Dorset. pp 95-127. Samsoe-Petersen, L, 1990. Sequences of Standard Methods to Test Effects of Chemicals on Terrestrial Arthropods. Ecotoxicology and Environmental Safety 19:310-319. Sherratt, TN and Jepson, PC, 1993. A metapopulation approach to modeling the long term impacts of pesticides on invertebrates. Journal of Applied Ecology 30:696-705. Wratten, SD and Forbes, AB, 1995. Environmental assessment of veterinary products with particular reference to the avermectins. Pesticide Outlook, 6:20-24.