FAO Livestock Production and Health Division

PAATINFORMATION RESOURCESTRAINING MANUALS

Insecticides for tsetse and trypanosomiasis control using attractive bait techniques

Chapter 1: Insecticides for tsetse control

Introduction

The past trypanosomiasis control policies of national control organisations, significantly supported by donor agencies, have placed emphasis on the eradication of the tsetse vector (F.A.O. 1991). Although often successful in achieving their objective of controlling trypanosomiasis within the project area, these actions have usually not produced sustainable results because of the inability to consolidate and protect in the longer term against reinvasion. Financial continuity has also rarely been adequate.

The meeting of the F.A.O. Inter-Secretariat Group of the Programme for the Control of African Animal Trypanosomiasis and Related Development, held in Rome in December 1991, recommended that, in consideration of the problems experienced, the technical approach and the policy of the programme be revised to more accurately take into account the current dynamic situation. They argued for a change in emphasis from vector eradication towards vector suppression. However, whereas eradication implies a once and for all solution and cost to the problem, suppression is an ongoing process demanding a recurrent financial commitment. It can only be justified if it can be achieved and maintained at a favourable cost:benefit ratio and is environmentally acceptable.

Over the last 30 years, tsetse control and eradication attempts have largely involved the use of either selective ground spraying or the sequential aerosol application of insecticides. These techniques are considered more suitable for eradication and cannot be justified for continuous on-going vector suppression because of high recurrent costs and environmental considerations.

Since the success of long term control is largely dependent on the sustainability of the actions undertaken, the techniques used for long term vector suppression must be efficient, economically justified, simple to apply and environmentally acceptable. The recently developed bait techniques meet these prerequisites, in most circumstances, with many of the tsetse species concerned. They also offer the possibility of being adapted for implementation through the active participation of farmers and livestock owners.

Tsetse control can be carried out using artificial attractive devices, either with or without odours and/or insecticides, depending on the local situation and the tsetse species. Where the conditions are favourable, the use of livestock, regularly treated with an insecticide, may be used, either alone or in conjunction with artificial devices. Both methods may also be used to form barriers and so prevent, or retard, tsetse reinvasion.

Volume 4 in the series of FAO training manuals for tsetse control personnel deals with the practical and theoretical aspects of control using attractive devices.

These guidelines are intended to be of further assistance to the same target group through providing current information on the insecticides suitable for use with these techniques.

Properties required

High levels of toxicity to various tsetse species

Whilst this is a fairly obvious prerequisite, it has to be remembered that all insecticides will kill tsetse, provided they are exposed to an adequate amount. However, in practice, small doses of high toxicity are desirable because this reduces what may otherwise be the very high cost of transport and the number of times the spraying has to be halted to refill the spray equipment. The ideal insecticide would be one that needed only very small quantities to kill tsetse and had virtually no effect on any other animal at these doses. Unfortunately such an ideal does not exist. However, it is fortunate that tsetse are generally very sensitive to most of the known insecticides and it is possible, therefore, to apply relatively low dosages of any insecticide for tsetse control as compared to the use of, for example, the same insecticide in agriculture.

Ease with which they can be made into suitable formulations

Whilst the trap/target and/or livestock baits serve to attract the tsetse, they are only a part of the delivery system by which sufficient numbers are brought into contact with the insecticide. The efficiency of the chemical and the degree to which it can be adapted for practical use depends largely on the ease with which it can be processed into a usable form.

Most of the insecticides under consideration are concentrated solids in their primary manufactured state. They then have to be converted into an acceptable form (or formulation) for field use and so meet the following requirements:-

- easy to transport in sufficient quantities to remote and relatively isolated areas where, if necessary, they can be diluted to the required strength;

- easy to apply evenly and adhere to the relevant surface, be it cloth or animal;

- readily transferred to the tsetse, often by a very brief contact. The insecticide should be sufficiently toxic that a lethal dose is transferred to the fly even by such a brief contact;

- rapidly absorbed through the cuticle and into the insect so that death or "knockdown" occurs relatively quickly;

- once applied, be relatively stable in a variety of climatic conditions. They must not, for example, be rapidly degraded by sunlight or easily washed off the target surface by rain. Obviously the longer they persist and remain lethal to the tsetse, the more cost-effective they will be;

Formulation is therefore extremely important and it has to take into account many factors, some of which are not easy to reconcile. The subject of formulation is discussed in more detail later.

Low levels of mammalian toxicity

In the large scale use of insecticides, such as often required for tsetse control, it is not always practically possible for suitably trained technicians to closely supervise and monitor their use. Under such conditions, highly toxic chemicals would pose a severe risk not only to the handlers but also to local inhabitants and the environment in general. Also, insecticides with a high mammalian toxicity could not be considered for direct application to livestock as not only would this affect their well-being but may also be transferred to humans through milk and other animal products. The selection of a suitable insecticide must not, therefore, be based on its toxicity to tsetse alone but should take into account these other equally important considerations.

Stability and Persistence

The inherent physical stability of any insecticide and its persistence once applied in the field depend on the intrinsic stability of the actual chemical molecule and also of the resulting formulation, under a wide range of climatic situations. The formulation must be stable first in concentrated form in storage and transport, and then must remain relatively stable and toxic once diluted and applied in the field. Sunlight and extremes of temperature can affect the chemical structure and thereby the effective toxicity over time.

A third major factor concerns the surface to which the insecticide is applied. This can both react with the chemical and also bind the formulation to it, thus sometimes affecting the availability and pick-up of insecticide by the tsetse fly. Rainfall can also leach out the insecticide from the surface. Dust and mud can also cover insecticide-treated surfaces and so mask the insecticide from contact with the tsetse fly.

It is important that these factors are borne in mind when planning control operations and that bioassay and chemical weathering tests are carried out to confirm the effectiveness of the application over a period of time.

Environmental Considerations

Artificial tsetse attractive baits have been developed for maximum attractiveness, both visually and by smell, to this one particular insect. Also,as the insecticide is applied directly to the device, it is only those insects which come into contact with the surface that are killed. It has been shown that some individuals of other insect species, particularly blood sucking flies, are also attracted, but not to the same degree as tsetse. Similarly with insecticide-treated animal baits, it is only the non-target species that are also attracted to the animal that will be affected. In most cases the effects are again limited to nuisance and blood sucking species which to variable degrees restrict animal productivity or transmit other diseases : in this regard, their incidental control can be regarded as a bonus.

Nevertheless, the products should ideally have as little deleterious effect on non-target fauna as possible whatever the technique used. They should also be rapidly broken down into non-toxic derivatives once they are leached out or are released into the wider environment. There is no known insecticide at present which makes this completely possible but, with the choice of insecticide and formulation, type of application and low dosage rates required, it is possible, using the synthetic pyrethroids, to go a long way towards achieving these ideals.

Cost-effectiveness

This is a paramount consideration when selecting the vector technique to be used. If the costs involved are greater than the benefits derived, then control action is not justified. When the objective is control, then action has to be sustained over a long period, in which case even very modest annual expenditure could eventually prove more costly than using a more expensive eradication technique over a much shorter period.

The groups of insecticides

Insecticides are classified in groups based on common factors of their basic chemical composition. The following are the major groups of insecticides, with comments as to their suitability for use with the current tsetse control techniques :-

Organochlorines

Examples; DDT, dieldrin and endosulfan.

These are fairly active compounds with usually good stability. They are also relatively cheap. DDT and dieldrin were the insecticides of choice for selective application to tsetse habitats by ground spraying, because of their long persistence. A single application remaining effective for 2-3 months, and possibly longer, especially in the dry season.

Endosulfan, unlike other members of this group, is not so stable, and although it is, therefore, not suitable for residual ground spraying, it has proven very effective for sequential aerial application which uses very low dosages of insecticides dispensed as a non-persistent spray of minute droplets.

Dieldrin and a specialised formulation of endosulfan have also both been used as a residual deposit, applied by helicopter, in Nigeria and Cameroon.

Effective as these insecticides have been, there has been an increasing reluctance to use the more persistent members of this group, i.e. DDT and dieldrin, because of their possible adverse effects on the environment and their accumulation in food chains.

The use of endosulfan as a low dosage aerosol applied sequentially by aircraft has proven, through many ecological studies, to have minimal and in most cases only transient side-effects on non-target organisms. This is mainly because of the extremely low doses used and the relatively rapid breakdown of the compound when applied in this manner. It is, therefore, a recommended insecticide for use by this technique.

Organophosphates

Examples; malathion, parathion.

This group in general lacks sufficient toxicity and persistence to be used for tsetse control. Consequently, they have never been used for large scale field operations and it is, therefore, proposed not to discuss them further.

Carbamates

Example; carbaryl.

Like the previous group, the carbamates also lack sufficient toxicity and persistence to be used for tsetse control and again as for the organophosphates, it is not proposed to consider them further.

Pyrethroids

Examples; deltamethrin, alpha-cypermethrin, cyfluthrin, lambda-cyhalothrin.

This group has favourable chemical and physical properties which make several of its members ideal for tsetse control, especially for use with the more recently developed attractive bait techniques whether they be traps and targets or insecticide-treated livestock.

The naturally occurring pyrethrins, which are extracted from plants, are highly toxic to tsetse but are so unstable as to make them of little use for practical control.

Work begun at Rothamstead Research Station in the United Kingdom, over 30 years ago, led to the discovery of somewhat more stable synthetic pyrethroids such as allethrin and bioresmethrin. These chemicals, although they showed promise, were not ideal and it was only when a further generation of synthetic pyrethroids were discovered and developed that exciting prospects for tsetse control became apparent. This later group, or the "cyano group" as they are known chemically, contains the now well known insecticides such as deltamethrin, cypermethrin, cyfluthrin and cyhalothrin.

These compounds all have extremely high levels of toxicity for most insects, including tsetse, are very stable, and are only mildly toxic to mammals. They are, therefore, relatively safe to handle and are less likely to have undesirable effects on other non-target animals, particularly mammal and bird species.

It is, therefore, this group of insecticides which at present has the best potential for use with all attractive bait techniques including traps, targets and livestock. The properties of the group, and of individual members, which make them the most suitable of all known insecticides for tsetse control will be discussed in more detail.