A new way to slay old pests

Tests are under way at the Microbial Research Establishment, Porton Down, to determine the safety of two viruses which may be used in the control of insect pests. News of the work, which is being carried out under contract for the Ministry of Overseas Development, was given by Dr T. W. Tinsley to members of the British Association, gathered for their annual meeting at Guildford last week. Dr Tinsley, who is Director of the Natural Environment Research Council's Unit of Invertebrate Virology at Oxford, described the potential of viral control to Peter Collins.

AWARENESS of the potential of the virus control of an insect pest dates from the 1930s. At that time, the European spruce sawfly, *Gilpinia hercyniae*, which was causing catastrophic damage to spruce forests in Canada, began to decline in numbers and within a few years was no longer an economically important pest. The reason was found to be infection by a virus, which in Europe was one of the factors controlling the natural sawfly population. But development of the possibilities opened up by this fortunate incident was delayed by the Second World War and then inhibited by the discovery of the vast range of new chemical pesticides which set the pattern for pest control in the immediate post-war era. This pattern was to last at least as long as the commercial profitability of the chemical pesticides, especially when it was found that the research required to develop viruses for this purpose was possibly as costly, and certainly as time-consuming, as the development of new chemical agents.

There are several reasons why the situation has changed in recent years. Initially, increasing resistance on the part of pests of agricultural as well as medical importance drew attention to the advantage of all types of biological control. Further pressure in the same direction resulted from increased concern at the environmental effects of many "classical" pesticides. More recently, two even more potent factors have given impetus to all research in this field: first, the growing seriousness of the world food situation, and hence the urgent need for more efficient control of all manner of pests and diseases, and, second, the enormous and sudden rise in the cost of all chemical products.

The part that may be played by viral agents in this new era of pest control, and the reasons why the advance into this field must be gradual and cautious were clearly stated by Dr Tinsley in his contribution to the symposium on the work of the research councils at Guildford last week. As Director of NERC's Unit of Invertebrate Virology (UIV) at Oxford, Dr Tinsley indicated what has been achieved so far and gave some idea of what may be expected in the next few years, at least within the unit's terms of reference.

For reasons of safety, and in particular because of the risk of cross-infection with higher animals, the WHO and the FAO have recommended that among the seven groups of viruses known to occur in insects, only the baculoviruses should be considered as pesticidal agents. So far as is known, these have neither chemical, physical nor biological properties in common with any virus found in vertebrates or plants, thus limiting the risk of cross infection to other insects or, at worst, invertebrates. Within this group, the unit's work is at present concentrated on the nuclear polyhedrosis viruses (NPVs) which attack four members of the Lepidopteran genus *Spodoptera*. The larvae of these Noctuid moths are now among the world's most serious pests, attacking a wide range of important crop plants from grass to fruit trees in Asia, Africa and across the Atlantic. In particular, interest has been concentrated on *S. exempta*, the East African army worm, possibly the world's most serious grassland pest. Able to produce up to 11 generations in a single year, it is found from southern Tanzania to Ethiopia, and its outbreaks have been known to denude up to 300 square miles of pasture in a few weeks. Not surprisingly, this work is being actively supported by the Ministry of Overseas Development (MOD), and the unit works in close collaboration with MOD's Centre for Overseas Pest Research.

One of the major problems in the use of viral pesticides hitherto has been the lack of precise information about the nature and characteristics of the viruses being used, and it is towards filling this gap that the unit's programme is directed. Its prime objectives were defined by Dr Tinsley as "the investigation of the chemical, physical and biological properties of insect viruses, and then determination of the effects on the insect hosts and the manner in which the viruses spread under natural conditions". The first of these objectives involves fundamental research in a field where little such work has been done, and in fact the unit is here leading the world.

To be of value in developing any virus as a biological control agent, four distinct steps have to be taken, and these too have been precisely defined. They involve:

- The isolation, purification and detailed characterisation of each virus in such a way as to enable its unequivocal identification. (It is surprising that this has not even been done previously for the viruses which are already in use as pest control agents in various parts of the world.)
- Testing the purified virus under laboratory conditions to assess its efficacy and establish its host range.
- Testing the toxicological properties of the virus "together with any associated formulative materials". This must be accompanied by investigation of the possibility of infection of, and replication in, non-target invertebrates and vertebrates.
- Field trials, on an increasing scale, on the crop and in the areas in which it is intended to use the virus as a pesticide. To do this final step satisfactorily, some system of monitoring needs to be evolved, and such monitoring will have to be continued for several years. It is thus apparent that the whole process is a lengthy one, and any idea that viral pesticides can provide an immediate panacea, even within the range of pests against which their use is intended, has to be forgotten.

Only the first two steps are the responsibility of the UIV at Oxford, and already some of the results are apparent. Thus, examination of the viruses of the four species of *Spodoptera* has indicated that these viruses, although each distinct and recognisable, fall into two groups or serotypes, each with several closely related strains. This has gone some way towards answering the question whether or not, as has hitherto been taken for granted, insect viruses are specific—a matter of the utmost importance if any such virus is to be widely distributed in a natural environment. Moreover, again to quote Dr Tinsley, "this is the first time that such a detailed investigation has been undertaken and also the first time it has been possible to make unequivocal identifications of any of the baculoviruses". Moreover, until this had been done, "it was not possible to be certain that the host insects had died from the test virus, from a second unrelated virus which occurred as a latent infection, or from a cross contamination"—points that have needed to be ascertained before the second step could be undertaken with any confidence.

When sufficient purified and identified material of any of the viruses is available, it passes to the Microbiological Research Establishment (MRE) at Porton, working under contract from the MOD. One of the problems that is arising at this third stage is that although the MRE has the necessary facilities for undertaking any tests that may be required to check the toxicity of the viruses for vertebrates, their staff have no experience in handling, or working with, insects—and any results from Porton will need to be checked against the insect host. Arrangements are therefore being made, with the cooperation also of the Medical Research Council, for the closest possible collaboration between MRE and UIV at this stage. Only when a virus has been cleared of any potential ecological hazard at the laboratory level can the fourth stage of field testing, in the areas where its use is envisaged, be started. The first candidate to reach this stage is likely to be the virus affecting *Spodoptera exempta,* if only because of the MOD's very special interest in protecting the grasslands of the Commonwealth countries (and others) of East Africa. Meanwhile, however, research into the ecology of an active, natural outbreak of an insect virus is also being carried out by staff from the UIV. The insect concerned is, again, the spruce sawfly, *Gilpinia hercyniae* an outbreak of which was identified some years ago in the Forestry Commission's Hafren Forest in Mongomeryshire, UK. Dr Tinsley was already applying for permission to experiment with the relevant virus at Hafren, when, in 1970, a natural infection was discovered in the forest, which thus became an ideal field laboratory for research into the ecology and epidemiology of a natural insect virus outbreak.

Although in the UK this fundamental approach to the development of viral pesticides has been adopted and is being rigorously pursued, the same is not true elsewhere. Viral pesticides have for some time now been on the market in the USA and they are known to have been used extensively for some years in the USSR, particularly against pests of forest trees and certain industrial crops. What is happening in Russia is not at all clear, nor is it known what precautions are taken or what problems, if any, have arisen. But certain of the difficulties that the pesticide industry may face, when it comes to commercial production of a virus that has successfully passed through all four preliminary stages, have recently become evident from American experience. The viruses concerned are again those affecting certain lepidopterous larvae, namely the genus *Heliothis,* including *H. zea* (on cotton, and probably the UIV's next target insect), *H. virescens* and *H. armigera,* pests of tobacco and maize respectively; the area on which Heliothis NPV has been used is said to be as much as five million acres. Successes in field trials on a vast scale led, in 1971, to a "temporary exemption from tolerance requirements" on the part of the ES Environment Protection Agency, and when this was later confirmed, the way was clear to go ahead with commercial production. Two companies, International Mineral Corporation and Nutrilite, put viral pesticides on the market—Viron and VHZ respectively—confident that they had at last achieved a breakthrough. Prolonged testing and field use had indicated that the degree of control was at least as good as that with chemical insecticides, whereas after 12 years of experimentation there was said to be no change in the specificity of the virus and no sign of any resistance on the part of the host. And yet, within recent months, the product actually put on sale has seemed to be less effective than those years of testing had led the manufacturers to believe. The extent to which this is so, why it should be, and how it can have happened, is not clear.

While these and other developments are going ahead in the UK and the USA, no one, in the UK at least, believes that rapid and sensationally successful control of the target pests is just around the corner. Problems will certainly arise at higher altitudes for example, unless some way can be found of getting over the undeniable fact that NPVs are inactivated by ultraviolet light (although one recent report indicated the reverse effect for the virus of one Lepidopteran, *Autographa californica* at least when grown *in vitro*). Then there seem to be problems relating to the effect on the virus of various leaf surfaces. A great deal of work will have to be done on the evolution of suitable formulations for large scale manufacture and application of the commercial product—especially in view of recent American experience. Finally, there is some uneasiness about the adequacy of the protocols for safety testing, so far developed by the WHO on the basis of those used at present in the United States—and themselves developed for non-replicating, easily identifiable chemical pesticides.

But once these new pesticidal agents become available, unequivocally identified and rigorously tested, in standardised formulations that can be used in complete safety, a new and most powerful weapon will be available against many of the pests that threaten the world's essential food supplies and industrial crops. □

KENNETH MELLANBY

Mathematics out of molehills

THERE is generally an optimum period for any worker to continue in a particular field of research. It takes a little time to become familiar with a new topic, productivity may then build up, but eventually he becomes stale and the "law of diminishing returns" seems to ensure that progress becomes slower and slower. This is the time to change direction, though after a fallow period the field may once again become productive.

These musings were prompted by a reader who writes: "Last week I was staying on a farm and looked at mole tracks as the moles went about ruining a newly seeded lawn. Why do the tracks so often run at right angles; they seem to turn through 90° at various points along their track. Perhaps they are particularly geometric beasts". Now I have been interested in moles for years and have even produced a monograph on the subject, but familiarity has evidently prevented me from recognising the interest of the tunnel pattern. My immediate reaction on receiving the letter was to go out and see what wild moles were actually up to. I looked with new interest at the working in my own garden, four acres of near-wilderness where wildlife is encouraged. I also returned to my main study area, Monks Wood National Nature Reserve. I may perhaps remind readers that moles, like most of our native fauna, are primarily woodland creatures, though they have been able to adapt to man-made habitats like farmland and lawns. I found everywhere, and clearly recorded in my own data made in previous years in farmland, that they do indeed have a prediliction for right angled bends in their tunnels, particularly in new excavations in cultivated soil. In the wood, where they live in permanent tunnels which house generation after generation of solitary moles, this pattern is not so noticeable, possibly because of modificattions over the years where repairs have been executed

Another observation revealed something which may also be a function of