SCIENTIFIC PAPERS

The scientific papers were presented over six half-days, the sessions being presided over by the following: A. P. Arnason, R. M. Belyea, W. G. Friend, W. E. Heming, D. K. McE. Kevan, J. B. Maltais, M. L. Prebble, H. E. Welch, A. S. West, and G. Wishart.

Symposium

Strategy and Tactics of Insect Control

Perspectives on Insect Control

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During the past 100 years, insect control has been a predominant objective and influence on the development of entomology in Canada. Preoccupation with the insecticide method of insect control threatened for a while to divert entomologists from the biological bases of their science. But the scientific questions and practical problems raised by insecticides have recently generated a renaissance of biological thinking about insects and ways to control them. Older biological methods and certain promising new ones are receiving increased attention. Insecticides have won a permanent place in our arsenal but we can no longer continue to rely so heavily on this one weapon. A new perspective is emerging in which strategies of insect control will be formulated on the basis of population dynamics studies and will involve assembling from a variety of control methods the appropriate combinations to meet particular problems. The requirements of these combined strategies will impinge increasingly on economic and social affairs which, in turn, will modify the technology of insect control.

One hundred years ago we could not have held a symposium on strategy and tactics in insect control. For strategy and tactics are concerned with decisions between alternatives, and no such choices were available to meet insect problems. The essence of what has happened in the one hundred years is that we have acquired this power of choice. And in the exercise of it, insect control has been projected into the first rank of human affairs.

In Canada, a first and fundamental step towards directed choice in insect control was taken about the time of the beginning of the century these meetings celebrate. In 1856 it became a matter of public concern when insects caused losses estimated in excess of two million dollars to the wheat farmers of Canada West, now Ontario. Then, as now, public concern stimulated expenditure from the public purse. The Province of Canada West offered prizes for the three best essays on pests of wheat. The first prize was won, significantly, by a Professor of Chemistry at Trinity College, Toronto. His prize of £40 marked the first government support of applied entomology in Canada. And the government believed in the usefulness of this knowledge, or at least wanted to demonstrate its enlightened attempt to meet the problem, for it printed and distributed the essay to the farmers of the province – a first effort in entomological extension. The significance of this event lies, of course, in the faith that the scientific study of insects will yield solutions to practical insect problems.

But during the latter part of our century, it appeared that we were losing this basic faith. As it was found that people with special knowledge of insects

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could do something about the pressing practical problems of the farmer, the forester, and the doctor, entomology developed primarily as an applied science. Because of the urgency, number, and variety of these problems, the population of entomologists increased rapidly. And with the increase came differentiation. A separate class arose, distinguished as *economic* entomologists. Canadian entomologists played leading roles in the initiation and development of two separate societies in North America which recognized and fixed this distinction. The Entomological Society of America and the Association of Economic Entomologists each published its own journal and partitioned the entomological literature between them according to content: basic studies in systematics, morphology and physiology on the one hand, and applied studies leading to methods of control, on the other. These developments marked the growing schism within entomology. But it was the success of chemical insecticides, I think, that drove this schism deeper than that which normally divides a science into its pure and applied aspects. Normally, the applied science uses the basic tenets and working methods of the pure science, and differs mainly in its object – to seek the solution of practical problems. And this was true for certain aspects of applied entomology. The beautiful biological sleuthing that revealed the insect vectors of malaria and yellow fever for instance, still affords classical examples of entomological observation, experimentation, and deduction. Scientifically elegant work in the interest of practical problems also characterized attempts to control insects by parasites and predators, and by the use of cultural methods to make the environment unfavourable. Both these approaches involved intimate study of the life-histories, behaviour, host relations, feeding habits, and so on, of the insects involved. But the early approach to chemical insecticides involved little intimate study of the insects themselves and their interrelations with their environment. The insecticides available were generally inorganic substances known to be general poisons – paris green, fluoride, arsenate, and petroleum oils. The question asked was simply: "Will it kill this or that insect?" The answer was found by empirical testing and the ingenuity required was more chemical than biological, more technological than scientific, for the trick was to formulate the poison into bait or spray that would ensure a high mortality in the pest population.

Although this kind of work did little to enhance the scientific reputation of entomologists, it did enhance their reputation for usefulness. By and large, the chemical insecticides provided useful protection against many important insect pests. This success stimulated the chemical industry to search for more effective insecticides, and this search culminated, of course, in the spate of synthetic organic insecticides during the past 15 years. Armed with this great arsenal, applied entomologists at first met with unprecedented success. And under the pressures of higher standards of public health and fastidiousness, and the demands for greater production per acre, an increasing proportion of the entomological community was devoted to developmental work with insecticides.

In my perspective, it was during this period of preoccupation with the application of chemical control methods that applied entomology came close to losing its scientific base. In general, applied entomologists forgot they were first biologists, forgot they were dealing with a class of animals subject to the general laws of variability and complex interrelations, and forgot their scientific obligation to seek explanations in terms of general concepts – to ask how and why, as well as what and where. The most striking support for this contention lies in the failure of entomologists generally to anticipate the development of resistance to insecticides as a consequence of one of the basic tenets of biology – the principle of natural selection.

Yet, I believe that the chemical insecticides have themselves generated an emerging Rennaissance of biological thinking about insects and ways to control them. The need to understand how insecticides exert their toxic action, and the principles governing selective toxicity, promoted studies on insect physiology and biochemistry in relation to other animals, as scientific curiosity had not done before. The need to understand how insecticides affect the interrelations between insect pests and the other biological components of their environment stimulated studies in population dynamics and established links with wildlife and fisheries biology. Above all, the development of resistance to insecticides provided entomologists with a beautiful example of evolution at work and administered a salutary reminder about genetic variability and selection. Moreover, the practical impact of resistance stimulated enquiry into the genetic mechanisms involved, and prompted new and thoroughly biological thinking about alternatives to chemical control. So the genie that clouded our view of insects as part of the biological complex now seems to be forcing us back to deeper enquiries about the biology of insects and their environmental relations.

These are the positive repercussions, stimulated directly, during what may become known as the insecticide era. But there are negative repercussions also, forcing us in the same direction. These, of course, are the now well-known disillusionments and fears about the long-term effects and the ultimate effectiveness of insecticides. For the very success of insecticides has led to their widespread use, and this in turn has faced us with the hazards of introducing toxic residues into our food, of damaging our wildlife resources and the productivity of our soils, of creating new pests, and inducing resistance in old ones. And throughout, there is uneasiness, and some evidence that while insecticides may be winning the individual battles, they are not winning the war – that each season's crop must be defended against an unabated or even increased attack – in short, that insecticides are a palliative rather than a cure for our pest problems. These misgivings too, are pushing us back to the conviction of 1856 that the way to solve insect problems is to learn more about insects.

The current reappraisal of insect control derives not only from these misgivings about insecticides but also from the potentials of a number of non-insecticidal methods. Some of these are new, such as the sterile-male method, and others are old but now being viewed with a new awareness of their potential, as for instance biological control. But as we attempt to develop these potentials we are immediately confronted with our lack of knowledge about the intimate biologies of individual pest insects. To apply the sterile male method we need to know far more than we do about mating habits and frequency, and flight habits and ranges. The same is true for the so-called chemosterilants. And for the associated sex attractants we need to know more about the chemistry of these substances and about sensory perception. In biological control we need the most elemental kind of information about the species, habits, and distribution of endogenous parasites and predators of many of our pest insects. This paucity of basic biological knowledge about insects has become particularly apparent in attempts to construct mathematical models to predict and account for the effects of the total environment on pest populations. As Dr. Watt will illustrate, even very incomplete data can be used to derive tentative conclusions and point up crucial gaps in our knowledge which must be filled before the conclusions can be adequately tested. And here I want to say that I think the theoretical development and application of the population dynamics of pest insects is more important for the future of insect control than any of the individual strategies of control we have or will develop. For it is basic to all of them because insect control is ideally a matter of understanding, and knowingly manipulating, the multitude of factors, both natural and imposed, that govern the abundance of pest populations. The concepts and methods of population dynamics, developed so pre-eminently in Canada, will provide a powerful device for guiding the appropriate use of our strategic weapons and our overall strategy in insect control.

So we have, potentially at least, a range of strategic weapons and a basic guidance device. The weapon we have developed most fully – the insecticides – has shown certain deficiencies in actual operations, and there are those who question its further development. They see the alternatives as "cleaner" weapons avoiding the deficiencies of insecticides. Yet I think there are grounds for supposing that as we push the development of these alternatives to make them as fully effective and widely used as the insecticides, we will encounter many of the same difficulties. For one thing, any method that threatens the existence of a population seems certain to meet resistance of some sort. And, as Turnbull and Chant have pointed out, certain "direct" pests that cause damage at low population levels must be reduced to the verge of extinction. But we may be thwarted in other ways. For instance, in the method of biological control, there is always the possibility, and some unfortunate examples, of finding a highly effective imported predator of an important insect pest which also has some potential for damaging a cultivated crop. A decision must then be made, weighing the gain for one resource against the risk for another, as for instance we must now do with chemical insecticides in relation to wildlife. Culture controls also often involve decisions between resources as, for instance, when stubble is ploughed under to effect insect control, and the soil is exposed to drifting. Or again, a major effort to develop insect control based on resistant crop varieties might well turn up some highly effective resistance to an important pest that depended on the presence of, say, a plant alkaloid with a low mammalian toxicity. We would then be faced with the same kind of decision we must make now when an effective pesticide treatment leaves a toxic residue.

Our reappraisal of insect control must also consider, I suggest, that non-insecticidal methods – manipulation of the environment for cultural control, the breeding of resistant crops, and biological control – all existed as concepts and practices before the modern insecticides. Yet, they failed to achieve the dominance in insect control which the insecticides have won. I think this dominance of insecticides has not been fortuitous. For insecticides have certain compelling advantages over biological methods – they can achieve a more immediate and a higher reduction of an almost universal range of pest insects. These advantages contain the seeds of the disadvantages we have recognized, but as *protective* agents the insecticides were, and remain, superior to all other methods. By contrast, the biological methods are generally less widely applicable, less immediately effective, and slower in reducing the levels of pest populations. They are therefore poor protective methods but capable of long-term pest suppression – in other words, of *cure*, if the level of suppression is adequate. Of the newer non-insecticidal methods, the sterile-male technique shows great promise as a curative method, but it, too, appears to lack universality and to require development for individual pest species with characteristics that lend themselves to the method. It, and the even more promising chemosterilants, seem ideally suited to attacking key pests whose control by conventional insecticides now prevents the operation of biological agents effective against other pests in the same environment.

I think it is true that our preoccupation with insecticides has hampered the vigorous development of the older alternatives and inhibited our vision of new ones. I think our experience with insecticides, both the difficulties encountered and the new knowledge gained, have made it clear that we cannot continue to depend so heavily on this one strategy. My only fear is that in the present climate, both lay and scientific, the pendulum may swing too far. I do not mean that I am afraid we will abandon insecticides. They are still clearly our most valuable strategic weapon, and in many areas of pest control we are utterly dependent on them. And we will continue to be dependent on them during the years it will take to bring alternative methods to adequate levels of development. But I am afraid that we may reverse the previous situation, and neglect the further development and refinement of the insecticide method.

And I think we are going to need it in any overall strategy of insect control. We will have to modify it. Already it is clear that certain tactics within the strategy, such as area treatments and the use of certain highly persistent compounds, will have to be curtailed and controlled, as Dr. Hurtig will point out. And we will have to restrict and refine its use in ways such as those Dr. Chant will outline. Above all, we will have to learn how to mesh it with non-insecticide methods to take advantage of its strengths and offset its weaknesses. For the millenium will come when we have learned to match the variability of nature with varied controls; when instead of thinking first, and often exclusively, of insecticides, we will be able to assemble knowingly from a variety of methods the appropriate strategy for a particular insect problem.

But the choices we then make will not be governed solely by scientific and technological considerations. Just as the most brilliant military strategies have often been modified or thwarted by political policies, so will our strategies for insect control be modified by economic and social considerations. This is already so when, for instance, a highly effective insecticide must be withdrawn or applied only at certain times to avoid toxic residues on food or hazard to wildlife. But these kinds of restrictions will become more stringent as we develop combined strategies involving interplay between biological, cultural, and chemical control methods. These combined operations will have to be based and controlled over large regions, rather than individual holdings in order, for instance, to preserve and foster natural control agents. And so one more of the old social freedoms – the right of an individual to take up his own weapons to protect his own land – will have to be sacrificed. And because of increasing intervention of authority in the development, application, and control of these operations, public concern about costs, hazards, and competition between resources will increase, with the result that entomologists will be required to furnish much more stringent proofs of the necessity and economic returns from insect control operations.

Thus, from the tiny beginning in 1856, insect control in Canada has become a complex enterprise affecting many aspects of our national affairs. Clearly, the future holds grave responsibilities and great opportunities for Canadian entomology. I believe this symposium will show our awareness of these responsibilities and our potential for exploiting the opportunities.