SUMMATION OF GRASS-GRUB RESEARCH

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Summary

The more important developments in grass-grub research are briefly reviewed. There is need for a great deal more research particularly on the biology and ecology of *Costelytra zealandica* (White). Such research may allow mass rearing of grass-grub providing a supply of larvae and adults for ecological, physiological and chemical research. The development of methods of chemical control using DDT, is outlined. The long-term solution to the residue problems associated with large-scale usage of insecticides in agriculture lies in further research on materials which do not produce residues in foodstuffs and, ultimately, on the possible development of sound biological methods of control.

INTRODUCTION

THE PASTORAL BASIS of New Zealand's agriculture clearly indicates that the control of insects affecting pastures is the major task facing economic entomologists in this country. There are many insects which are responsible, in some measure, for pasture deterioration but by far the most important insect is *Costelytra zealandica* (White), the common grass-grub. In certain parts of New Zealand, particularly in Canterbury, this insect has played a large part in determining the pattern of farming practised. Pastures in almost every district in New Zealand are liable to damage by grass-grub, and the present widespread use of chemicals to control this insect is indicative of its overall effect on pastoral economy.

Dumbleton (1942) gave a general review of the problem up to that time and outlined a programme for future research. The purpose of this paper is to bring the review of research on grass-grub up to date. In 1945 Entomology Division, D.S.I.R., began an investigation of grass-grub on a long-term basis. Late in 1946 a sub-station of the Division was established at Ashburton, under J. M. Kelsey, specifically to study grass-grub. Because of the pressing economic aspect, work tended to concentrate on control and within two years promise of control by means of chlorinated hydrocarbon insecticides had been obtained. The rapid development of large-scale insecticide usage in New Zealand agriculture has had many ramifications. Today the research organizations interested and actively engaged in aspects of the grass-grub problem give some indication of the complexity of the project. Within D.S.I.R., Entomology Division, Soil Bureau, Dominion Laboratory, Fats Research Laboratory and the New Zealand Fertiliser Manufacturers' Research Association are all actively engaged on grass-grub work. Within the Dept. of Agriculture, Wallaceville Animal Research Station and the Farm Advisory Division are concerned in grass-grub work. The agricultural chemical industry is also involved, both in the fertilizer and insecticide field, a number of companies being engaged in active research on new materials, and new formulations for grass-grub control. It is impossible in a short review paper to discuss adequately the contribution which all these organizations are making. Grass-grub research will be discussed under a number of headings.

TAXONOMY

The coleopterous sub-family Melolonthinae, to which the common grass-grub belongs, has approximately 120 endemic species in New Zealand and new species are still being discovered and described. Most of these species occur in circumscribed localities and few, other than *Costelytra zealandica*, have reached pest status. The common grass-grub occurs throughout both main islands and is also recorded from Chatham Islands. As part of an investigation into apparent differences in susceptibility of grass-grub to insecticide, B. B. Given of Entomology Division, Nelson, is at present investigating morphological differences in *C. zealandica* throughout its range. It is possible that physiological races of *C. zealandica* do exist and this work may provide a basis for distinguishing them.

The larvae of New Zealand Melolonthinae are not as well known as the adults, approximately 17% having been described. A similar morphological study to that being conducted on adults would be well worth while. In many fields of grass-grub research there is need for some method of determining the sex of living second and third instar larvae. Recent work by R. Elliott, Entomology Division, Auckland, indicates that such a method may be developed in the near future.

BIOLOGY AND ECOLOGY

As mentioned earlier the rapid expansion of chemical control of grass-grub led to a reduction in research into other aspects of the problem. This is clearly reflected in the present very limited precise knowledge which research workers have of the biology and ecology of grass-grub. It is unfortunate that efforts were not made to carry forward research in this field in the ten years following developments of DDT as an economic field control for grass-grub. With one exception all the published statements on the biology and ecology of grass-grub have been of a general observational nature. The exception is a paper by Kelsey (1957) on ovipositional preferences by *C. zealandica*. This work suggests that preference is given by ovipositing females to areas carrying pasture but no significant differences could be established in relation to different densities and heights of cover. Field observations do, however, suggest that there are marked differences in levels of larval populations where pasture conditions had differed at time of oviposition.

This lack of precise data on the biology and behaviour of grass-grub is now having an effect on currently planned work. As soon as trained staff is available this aspect will again be actively investigated on a broadly planned long-term basis. The future success of research in all phases of the grass-grub problem will depend largely on the answers to be provided to many questions frequently asked, but at present not satisfactorily answered, on biology and ecology.

One important difficulty in the present investigation of this phase of the work will arise from the widespread usage of insecticides. Great care will be needed to ensure that the grass-grubs under investigation have not been previously exposed to insecticide. All work will virtually have to be duplicated to establish normal reactions and behavioural patterns and the effect of insecticides in producing deviations from normal. Some considerable effort will have to be devoted to the study of methods for mass rearing of grass-grub. Such a programme if successful would allow the production of eggs, larvae and adults of known age and history

for further ecological, physiological and chemical studies. It must be emphasized that no satisfactory technique for mass rearing of a univoltine scarabaeid species has yet been developed anywhere in the world. The successful outcome of such a programme will be dependent on a very much better understanding of the grass-grub than that which we have at present.

BIOLOGICAL CONTROL

INSECT PARASITES AND PREDATORS

Although a number of tachnid parasites have been recorded from New Zealand melolonthines none of these parasites have been associated with *C. zealandica*. For six years from 1945, B. B. Given of Entomology Division, Nelson, was engaged in a study of parasites of related grass-grub species in south-western Victoria, Australia. A total of 14,000 pairs of thynnids were shipped to New Zealand. It was established that a number of these thynnid species would parasitize *C. zealandica* under laboratory conditions. Although some 10,000 pairs of thynnids were liberated in the field at various localities, there is no evidence that they succeeded in establishing. One species was recovered from an *Odontria* species near Ashburton in the seasons following liberation but not again recovered. This work has been detailed in a paper by Given (1953).

During 1945 to 1947 some investigations on the thynnid parasites of Scarabaeidae in western Patagonia were undertaken by Lloyd (1952). No material was shipped to New Zealand. The investigation of parasites in southern South America has now been resumed.

Even though *C. zealandica* is an endemic species the possibilities of achieving some measure of control by this means are such as would warrant continuation of this work.

A number of predacious insects are known to attack *C. zealandica*; these insects have not been studied and no indication can be given as to their effectiveness.

MICROBIOLOGICAL CONTROL

Some work has been done on the possibility of using introduced insect parasitic nematodes for the control of *C. zealandica*. While some control could be obtained under insectary conditions, no satisfactory control could be obtained under field conditions. Further investigation of nematodes would be warranted.

Dumbleton (1945) recorded the presence of a native milky disease of *C. zealandica*, the bacterium sometimes infecting as much as 50% of the population in restricted areas. The potentialities of this bacterium and the related American *Bacillus popilliae* Dutky have not been fully explored. G. Helson of Farm Advisory Division, Department of Agriculture, has begun a series of assessment trials using *B. popilliae* against grass-grub.

Very little work has been done on other bacteria, protozoa, and fungi associated with grass-grub in New Zealand. The importance of protozoa has been indicated by the recent implication of gregarines as a possible factor in increased tolerance of some larvae of *C. zealandica* to DDT. The whole field of microbiological control of grass-grub requires urgent investigation, one of the first tasks being a survey of the pathogens naturally present in New Zealand.

CHEMICAL CONTROL

The broad outlines of chemical control of grass-grub developed by J. M. Kelsey of Entomology Division, Lincoln, are well known. Preliminary investigations were made with a range of insecticides used as wettable powders, applied with a relatively low volume of water and followed by application of up to 1,400 gal of water per acre to wash insecticides on to and into the soil. These trials gave a clear

indication of the effectiveness of relatively low dosages of both DDT and BHC. Once the usefulness of these insecticides had been established work was concentrated on finding practical methods of application. Insecticide-fertilizer mixtures, particularly with superphosphate, proved quite practical when application was made through gravity fed topdressers. Dosage rate established at 2 lb ppi-DDT per acre and BHC was discarded as an insecticide for grass-grub control.

This dosage of DDT has no apparent harmful effects on earth-worm populations. No carefully controlled investigation has been made of the effect of DDT on micro-organisms present in soil nor has the effect of DDT on other soil inhabiting insects, including predators, been examined.

Commercial preparation of insecticide fertilizer mixtures have been blamed for many cases of partial or inadequate control of grass-grub during the early period of development of this method. This trouble apparently arose from faulty preparation of the mixtures. The physical difficulties of securing adequate mechanical mixes of dry fertilizer and insecticides led to B. W. Doak of the New Zealand Fertiliser Manufacturers' Research Association undertaking research on other methods of incorporating insecticides in the superphosphate. This work resulted in the development of "wet-mix" DDT-superphosphate. Apparently this material is not so quick acting as the dry mixtures but it has partly overcome the problem of faulty mixes.

During the period 1950 to 1956 many cases of apparent failure of DDT to control *C. zealandica* were due to faulty mixing or to faulty application techniques. More recently there have been a number of failures which cannot be attributed to these causes. These failures often occurred on pumice soils. Recent work by K. S. Birrell of Soil Bureau has shown that under laboratory conditions and at higher temperatures, allophane breaks down DDT. Allophane is a common constituent of pumice soils. P. J. Gallaher and L. Evans of New Zealand Fertiliser Manufacturers' Research Association have investigated the penetration and persistence of DDT under pasture. Recent work has shown that soils differ markedly in their ability to "fix" DDT. On some pumice soils penetration of DDT is confined to the top ¼ in.

An investigation of the susceptibility of larvae of *C. zealandica* to DDT was conducted by Prof. C. C. Roan, a Fulbright Scholar in 1961-62. This study revealed considerable variation in susceptibility and this aspect is under active investigation by R. Elliott and D. C. F. Perrott of Entomology Division.

As well as this failure of DDT to give adequate control in some circumstances there has been the increasing problem of toxic residues in agricultural products used for human food. Officers of Entomology Division have been aware of the dangers of residues ever since the inception of chemical control and have repeatedly stressed the necessity to observe carefully both the dosage recommendation and the methods of application. There is no evidence to suggest that where these recommendations have been observed appreciable contamination of foods beyond permitted limits has occurred. It is abundantly clear that these precautions have not been carried out by some farmers and residues have been detected in foodstuffs. The recent establishment of an Agricultural Chemicals Board and subsequent control of the usage of insecticides by regulation is a step in the right direction. There must, however, be adequate supervision and residue analysis of foodstuffs, together with an awareness on the part of individual farmers of the necessity for care in using toxic materials.

Residue problems have led to research on formulation of DDT in ways less likely to produce residues. Two developments in this field have been granular insecticides and granular fertilizer-insecticide mixes.

As a long-term solution to this problem of residues, there must be a great increase in the amount of research, not only towards the development of chemicals which will not leave residues in foodstuffs, but also towards development of sound biological methods of control. If research workers are fortunate, biological methods may allow farmers either to reduce drastically their usage of toxic chemicals or perhaps even eliminate their usage.

Arising from work initiated by Prof. C. C. Roan, Entomology Division now has a reliable laboratory screening technique using topical application of insecticide materials in acetone solution. Also being developed by P. Fenemore of Ivon Watkins Ltd., at present seconded to Entomology Division at Nelson, is a pot screening technique as an intermediary between laboratory and field experimentation. Field experimental techniques are also being improved to give a much higher degree of precision to results. Using these techniques a start has been made on the examination of a wide range of new insecticides for grass-grub control.

CULTURAL CONTROL

With the advent of a satisfactory means of chemical control very little research has been carried out on aspects of agronomic and cultural control of grass-grub. Before this work can be pursued with any real prospect of success research workers will require a very broad knowledge of the biology and habits of *C. zealandica*.

REFERENCES

- Dumbleton, L. J. 1942: The Grass Grub (*Odontria zealandica* (White): A Review of the Problem in New Zealand. *N.Z. J. Sci. Tech.*, 23A: 305-21.
——— 1945: Bacterial and Nematode Parasites of Soil Insects. *ibid.*, 27A: 76-81.
Given, B. B. 1953: General Report on a Search for Parasites of Melolonthinae in Australia. *ibid.*, 34B: 322-40.
Kelsey, J. M. 1957: Ovipositional Preference by *Costelytra zealandica* (White). *ibid.*, 38A: 633-37.
Lloyd, D. C. 1952: Biological Observations on Some Thynnids of Western Patagonia. *Bull. ent. Res.* 42: 707-19.