

## EVIDENCE FOR RESISTANCE TO DDT IN THE COMMON GRASS-GRUB

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### Summary

The use of dose-effect experimentation to determine the susceptibility to DDT of different strains of the common grass-grub, *Costelytra zealandica* (White) is described. DDT-resistant populations are shown to occur and the future use of DDT for grass-grub control is discussed.

IN THE extensive use of DDT for the control of damage by the common grass-grub (*Costelytra zealandica* (White)), failures have sometimes occurred. In the past, many of these failures have been due to problems associated with the formulation of DDT-superphosphate and achieving its even distribution. Experiments with larvae from sites of failure have shown DDT-resistance to be the cause of some failures. Pasture response may be an indicator of successful treatment but lack of it does not distinguish between causes of failure. Insecticide resistance only becomes apparent when the effects of insecticide treatments to the insects themselves are considered.

### THE ORIGIN OF RESISTANCE

The standard explanation for the development of mass populations of insecticide-resistant insects has been the use of insecticides so as to kill a high proportion of the population of an area, together with the existence in the original population of a minority with the necessary physiological adaptation for survival already developed. The effects of sublethal dosage, inefficient application methods, or poor formulation have also been suggested as likely to encourage the production of resistant strains, but the logic of these suggestions is not entirely clear.

### FIELD EVIDENCE FOR THE EXISTENCE OF DDT-RESISTANT STRAINS

With many insect species, failure of previously effective treatment regimes may with some confidence be attributed to insecticide resistance since there is often little doubt about the conditions of exposure. With the grass-grub, failure of previously effective treatments, might, until the withdrawal of the finely divided DDT-superphosphate formulations, have been no more than an indication of wind speed on the day of application. Chemical analyses may indicate certain amounts of DDT present in certain soil layers, but minimum amounts of DDT necessary for effective control in different soils are not known; nor is a figure indicating chemical presence any guarantee of biological activity. In spite of doubts which may exist about the conditions of exposure to DDT, field evidence of DDT-resistance through failures in paddocks where control was formerly achieved should not be discounted. In some instances, laboratory evidence has confirmed insecticide resistance as the cause of failure.

TABLE 1  
Response of Third Instar Larvae of *Costelytra zealandica* of Different Populations to DDT Applied  
Topically in Acetone

Concentration of DDT (mg/ml)	Percentage affected at Stated Dose Level									
	Samples classed as Susceptible		Samples classed as Resistant		Samples classed as Susceptible		Samples classed as Resistant		Samples classed as Susceptible	
	Inglewood	Te Awamutu	Taurarunui	Masterton	Tapawera	Blenheim	Havelock	Eitham	Inglewood	
100.0	—	—	—	—	72.5	—	81.0	—	—	—
60.0	—	—	—	—	60.0	—	45.8	—	—	—
40.0	—	—	—	—	57.5	—	45.8	—	—	—
20.0	—	—	—	—	50.0	38.5	37.8	17.5	78.2	—
10.0*	100	97.5	100	100	50.0	17.0	15.2	12.5	51.2	—
6.0	97.5	82.5	100	100	62.5	30.8	18.9	12.5	35.0	—
4.0	90	70	—	—	22.5	20.5	8.2	2.5	23.2	—
2.0	83.5	35	—	—	25.0	0	18.9	5.0	—	—
1.0	36.6	17.5	—	—	20.0	0	—	—	—	—

\* Discriminating dose level

## LABORATORY EVIDENCE FOR THE EXISTENCE OF DDT-RESISTANT STRAINS

### THE DOSE-EFFECT EXPERIMENT

In order to know whether insecticide resistance occurs, it is necessary to test samples of insects taken in different places and at different times and compare their levels of susceptibility.

A common way of doing this is to divide the sample into equal batches and apply to the individuals of each batch a measured dose of insecticide, the doses applied to successive batches being progressively stronger. If the batches are all fair samples, the percentages killed by the increasing doses also increase in a regular way and can be plotted on logarithmic probability paper. The slope of the resulting line and the point at which it cuts the 50% mortality level — known as the L.D.50 (lethal dose to 50%) — gives a measure of the susceptibility of the sample. If the population sampled is normal, with the stronger and weaker individuals evenly grouped about the mean, the line is straight.

Bends in the line can be caused by the presence of more than one type in the original sample.

Evaluation of such dose-effect experiments depends on an ability to distinguish affected from unaffected insects. If death occurs quickly it is a usable criterion, but grass-grubs intoxicated with DDT may survive for weeks. Instead of death, the capacity of healthy grubs for burrowing has been used as the criterion of effect. After treatment, test batches are placed on the surface of soft moist earth. Unaffected grubs rapidly bury themselves, while those affected lie on the surface.

The L.D.50 now becomes an E.D.50 (effective dose on 50%) and comparison can be made between samples.

### NORMAL SUSCEPTIBILITY

Estimates of the susceptibility to DDT of samples of grass-grubs collected at intervals through the season and from different places have shown that there is a decline in susceptibility as grubs become older until about the eighth week in the third instar. Thereafter E.D.50 values for samples within a population tend to stabilize although fluctuations still occur (Elliott and Perrott, 1965).

Samples of several populations never exposed to DDT have allowed, after this "stabilization", a discriminating dose to be approximated. All or nearly all of the grubs in a batch of a susceptible strain exposed to this dose are affected by it. If significant numbers of insects survive treatment at this dose level, the sample may be classed as containing a proportion of resistant individuals. It is, however, always preferable to estimate susceptibility from the effects given by a range of doses rather than from that given at a single dose level.

### RESPONSES OF SAMPLES OF DIFFERENT POPULATIONS

From its first use, field treatments of DDT giving pasture response have not always resulted in the death of grass-grubs (Kelsey, 1952) and it is possible to find DDT-susceptible grubs in treated fields.

One result of this circumstance is that mixed populations of susceptible and resistant individuals occur and dose-effect experiments with samples of such populations do not give linear results. Simple treatment of such data cannot give meaningful E.D.50 values but the presence of resistant material in the sample can be deduced.

The data presented in Table 1 were obtained from samples taken from paddocks where DDT treatments had not been successful and indicate the range of response which is given by samples containing different proportions of resistant and susceptible material.

The nature of resistance to DDT in the grass-grub was investigated by estimating the susceptibility of samples of two DDT-resistant and two DDT-susceptible strains to DDD, to which specific DDT-resistance confers cross-resistance; and to dieldrin, to which it does not. The results in Table 2 show that specific resistance to DDT occurs.

TABLE 2  
Response of Four Populations of *C. zealandica* to DDT, DDD and Dieldrin

Insecticide	DDT-resistant Populations		DDT-susceptible Populations	
	Havelock	Riwaka	Pretty Bridge Valley	Baton
DDT	R	R	S	S
DDD	R	R	S	S
Dieldrin	S	S	S	S

R=Resistant.

S=Susceptible.

#### THE FUTURE OF DDT FOR GRASS-GRUB CONTROL

The emergence of DDT-resistant strains in some places is not a reason for abandoning DDT use in others. Where resistance to an insecticide occurs, further use of that insecticide is futile and in the absence of other control methods the logical course is to use an insecticide against which no selection has taken place. With the common grass-grub this course of action is not yet possible since presently available insecticides do not possess the necessary combination of properties to give control at the larval stage and not result in undesirable residues. Insecticides with the required persistence in soil all fall into the organochlorine group of dieldrin and related compounds which are unacceptable on account of their residue-forming properties.

The so-called residue-safe insecticides of the organophosphorous and carbamate groups tested to date do not appear to be sufficiently chemically stable to survive penetration into the soil except in very unusual circumstances.

The rate at which DDT will become generally ineffective in the control of grass-grub through the emergence of resistant strains is impossible to predict. There is no reason to suppose that the isolated populations of grass-grub which occur practically throughout the country are uniform in their potential for selection of DDT-resistant strains. There is, in fact, evidence that they are not uniform. Since 1962, when DDT resistance in grass-grub was first discerned, nearly fifty resistant populations have been recognized. Of these, only one occurred in Canterbury which has seen the longest use of DDT and where DDT resistance might have been expected first to arise. At present, the known DDT-resistant populations are probably not making a perceptible impression on national production, but the phenomenon is a threat to it which could easily become a reality.

#### REFERENCES

- Elliott, R.; Perrott, D. C. F., 1965: *N.Z. J. agric. Res.*, 8: 142-55.  
Kelsey, J. M., 1952: *N.Z. J. Agric.*, 83: 113-22.