Discussion arising from the Symposium

Chaired by Dr G. W. Gibbs

Recorded by Dr T. K. Crosby

G. W. Gibbs The papers presented today have covered many different aspects of this subject. We have learned about possible evolutionary developments of these relationships, the nature of the interactions as regards the chemicals involved and their effects on insects, and how plants are affected by insect activities. The scope of the symposium was broadened by including the effects of nematode-plant interactions to see how these compared with the effects of insects, and this proved to be very interesting.

The diverse papers were tied together by the theme of "pests", and perhaps aspects which should be looked at when considering the selective breeding of resistant plants.

In opening the discussion, I consider that we should be concerned with 2 main areas of interest:

1 General research which needs to be done, and

2 How this relates to possible pest control.

J. S. Dugdale Dr Russell, you gave information about your work on the relationship between the compounds present in native conifers and the presence or absence of insect species, and specifically referred to the high levels of terpenes in *Podocarpus nivalis* and the lack of insect pests on this plant. Are these same compounds present in our exotic conifers, or, if not known, is it worthwhile trying to find out?

G. B. Russell Such work hasn't been done on the exotic conifers, and it could be worth investigating. However, other factors and compounds may be involved in these cases to affect the insects, e.g., attractants or deterrents which may mask the toxic effects of compounds such as the terpene lactones, and the behavioural response of the insect may be different to that which is expected.

G. W. Gibbs Mr Dugdale, do you think there is a relationship between the powers of dispersal in New Zealand polyphagous and monophagous species, with perhaps the polyphagous species more able to disperse?

J. S. Dugdale There is probably little relationship between the powers of dispersal and whether a species is polyphagous or monophagous. Some of the monophagous tortricids are very easily dispersed, e.g., *Ericodesma melanosperma* on *Dracophyllum longifolium* is from Campbell Island to Mt. Ruapehu.

P. S. Corbet Mr Dugdale, would you mind defining more exactly how you have considered the two different classes of polyphagous and monophagous genera? It would appear that the longer you look at a genus considered to be monophagous the more likely you are to find that in fact the genus is polyphagous.

J. S. Dugdale Yes, on a general basis your statement is probably true. In New Zealand, however, you must realise that the biotope is: 1) fragile, 2) disappearing fast, and 3) there are less than 100 entomologists to work on all problems. In all respects our situation differs from that of the Northern Hemisphere where such relationships have been worked out over a long time involving hundreds of observations.

G. W. Gibbs Are the endemic species of insects found on exotic plants in New Zealand polyphagous?

J. S. Dugdale Amongst the Lepidoptera they are nearly always polyphagous. Those monophagous on native conifers are not found on exotic conifers. Some genera are polyphagous on both the New Zealand and exotic conifers.

P. S. Corbet Some mention has been made of the use of insect juvenile growth hormones in pest control, and particularly their suitability for species which are pests mainly in the adult stage. In some cases, wouldn't the prolonging of the larval stage effectively cause more problems than already existed?

G. B. Russell Yes. For example, in one case juvenile hormones applied to Colorado potato beetle larvae resulted in very large larvae which greatly increased the amount of damage. In using juvenile hormones it must be emphasised that they must be applied to the larvae at a critical time in the life cycle so that the ability to undergo metamorphosis is inhibited.

P. S. Corbet Do all applications need to be precisely synchronised?

G. B. Russell Yes, but there is now a relatively stable juvenile hormone mimic for mosquito larvae which can be applied to an area, and persist long enough to cause insect control.

J. B. Waller How specific is it?

G. B. Russell It is specific for Diptera.

P. Singh This technique could be of some importance against the housefly and other insects of medical importance. In the tortricid *Epiphyas postvittana*, juvenile hormone was incorporated into the diet to increase larval size so more virus could be obtained. Although the larvae underwent 8 moults instead of 5 and increased its weight by 3 times, the yield of virus was not increased because the increased weight was due to increase in water content of the larvae.

G. B. Russell There are now a whole range of juvenile hormone mimics which are specific for certain insects.

G. W. Gibbs Is there potential for resistance to juvenile hormones?

P. G. Fenemore Yes, there are already examples recorded in the literature of induced resistance.

G. B. Russell This is really quite logical and expected. An insect in its normal course of development has to deactivate or metabolise such compounds when it no longer needs them. These rhythms could provide a mechanism for the development of resistance.

G. S. Grandison I was interested to learn that the active parts of compounds against insects were cyclopropenes, as in nematicides it is the propene which is the active part also.

P. G. Fenemore Is much known about the moulting of nematodes, and how this compares with insects?

G. S. Grandison For plant-feeding species little is known, but a lot is known about species found as parasites of animals. There is an ecdysis ring present in the nematode skin, and this must rupture to allow moulting. For this a hormone ecdysone is needed.

G. B. Russell The hormone ecdysone is the same as that found in insects.

A. D. Lowe To change the topic slightly back to points being discussed earlier, many host-specific sap-sucking aphids have good powers of dispersal. For example, *Eulachnus brevipilosis* in Canterbury is found on *Pinus sylvestris;*

there are only a few host trees in the region, yet the aphid is found on them. *Pinus radiata* is very common throughout Canterbury but this aphid is not found on it, which suggests that *P. radiata* has a real form of resistance to this aphid which could be measured.

[Data from Forestry Biology Survey Reports 1964/65, 1965/66 indicate *Eulachnus brevipilosis* is present in South Island plantations from Tawhai State Forest in the west and Omihi State Forest in the east, southwards. Principal hosts are *Pinus sylvestris, Pinus nigra* (? syn. *austriaca, laricio, calabrica*); additional, apparently occasional hosts reported are *P. banksiana, P. contorta, P. ponderosa,* and *P. radiata.*]

B. M. May Does the addition of chemical fertiliser add anything to a plant which might increase its attraction to insects?

J. A. K. Farrell In some cases chemical fertilisers can increase the resistance of plants to insect attack. In the case of larvae of *Spodoptera frugiperda,* the addition of nitrogen or potassium alone induced resistance in pearl millet, whereas millet fertilised with a complete NPK mixture was susceptible to the insect. There is another side in that increasing soil fertility can increase plant growth, which thereby induces tolerance to attack. What effectively happens is that the amount of damage caused is diluted. A plant which doubles in size because of fertilisers may seem to have less damage than a non-fertilised plant, whereas in reality the total amount of damage may be the same in each case.

R. P. MacFarlane Another example of indirect effects of fertilisers is that on lucerne. Fertilisers can increase the amount of nectar production, which can affect the number of bees.

J. C. Watt We have heard a lot about the effects of plant chemicals on insect behaviour and development. From the evolutionary point of view, if these chemicals upset insect behaviour or influence them adversely in some other way selection will favour their development as part of the plant's defense mechanism. I am curious to know what particular roles do these chemicals play in the normal physiology of plants, or, if they have no obvious roles, why have they evolved?

O. R. W. Sutherland The roles of primary chemicals such as sucrose and ascorbic acid which influence phytophages are well known. However, the roles of secondary chemicals such as the isothiocyanates are less well known; obviously many must have roles that have not yet been discovered. It should be also made clear that any chemical may have more than one role.

E. W. Hewett There are some chemicals which are essential for normal growth and development of the host plant but which can affect insect development. For example, the gibberellins are plant hormones which are relatively simple steroids, essential for controlling stem elongation and involved in the flowering and dormancy phenomena. Osborne and her colleagues have shown that the adult desert locust (*Schistocera gregaria*) is subject to developmental control by the gibberellins in desert plants. Swarming locusts feed on dry senescent vegetation, which contain low gibberellin levels, and do not become sexually mature. Only after rains with access to fresh green leaves which contain high gibberellin levels do the locusts become mature, mate, and lay eggs. This group has shown that the gibberellins fulfil some requirement necessary for locust maturation; female locusts feeding on senescent leaves matured sexually if synthetic gibberellin was added to their diet daily.

Many of the secondary chemicals present in plants are thought to play a role in conferring resistance not only to insect attack but also to pathogenic fungi and bacteria. There is considerable interest being shown in these chemicals by biochemists. It is difficult to visualise the evolutionary tie-up between chemicals which terminate metabolic pathways and their ability to confer host plant resistance to a range of pests and diseases.

G. B. Russell This is a very fruitful field for investigation. In the case of moulting hormones which are the same in plants and animals, it is interesting to speculate which evolved them first. Then, again what are the roles of the phytoecdysones in ecology? *Dacrydium intermedium* with an ecdysone level of 3% in the bark suggests they have a defensive role. We are now just starting to get to the point of considering the subject "chemical ecology".

O. R. W. Sutherland Another case is that of orchids which produce a chemical which is identical with a female wasp sex pheromone. Male wasps attempt to copulate with the flower, get covered with pollen, then carry the pollen to other flowers and fertilise them. Which came first? By chance did the orchid produce the correct female attractant, or did the relationship arise in some other way?

G. W. Gibbs It seems that this relationship has evolved three times independently in orchids, which makes it even harder to explain.

As a general statement about chemicals, it certainly seems as if there is really a limited array of chemicals involved, but they are used in a variety of ways and for a variety of functions.

O. R. W. Sutherland *Lotus pedunculus* roots and tops are resistant to insect attack, but why this should be so compared with other legumes cannot be satisfactorily answered. Amongst the several feeding deterrents we have located a potent toxin against grassgrub and black beetle. What is obvious is there are a whole series of compounds, for example, feeding deterrents, which prevent a plant being eaten. However, if in spite of these deterrents some of the plant is eaten, the toxin then affects the insect.

J. A. K. Farrell In the case of *Lotus pedunculatus* the foliage is readily consumed by adult *Costelytra,* whereas the roots are resistant to the larvae.

R. P. Pottinger What we are seeing here is the effect of a native insect on an introduced plant, which is effectively an artificial situation since they did not evolve together.

G. W. Gibbs What we saw from Mr Dugdale's paper is that some plants overcome all insects, many overcome most, and some have practically no resistance to attack.

A. D. Lowe A number of species feed on laurel, yet the crushed leaves are used in insect killing bottles because of the HCN they release. Why are the laurel leaf feeding insects not affected?

G. B. Russell The native passionfruit also has cyanogenic compounds, yet houseflies live quite happily when these materials are incorporated in the diet. It may be that the housefly does not have the enzymes which allow the breakdown of the nitriles to HCN. In the fresh leaf it could be that the plant enzymes and HCN compounds are not brought together to react when the leaf is eaten.

J. S. Dugdale The species that feed on laurel and *Tetrapathaea* are polyphagous, hence no special adaptation seems to be required to cope with the HCN compounds.

B. M. May The weevil which lives inside the native passionfruit tissue is also polyphagous.

D. Steven In *Paropsis,* HCN is in fact stored and used as a defense secretion, but is most probably not derived from eucalypt cyanoglycosides.

G. W. Gibbs Today's symposium has brought together an interdisciplinary group of speakers on a topic of obvious importance to the understanding of phytophagous insect pests. We cannot claim to have been entirely original but attention has been drawn to the local situation and to current research which, I hope, has provided all participants with a better understanding of host plant relationships. I think a particularly valuable aspect of the day's papers and discussion has been the inclusion of the work on nematodes and the impact of phytophages from the plant viewpoint.

It is certainly appropriate to be examining the state of our knowledge on insect-plant relationships at this time when conventional pesticide use is being criticised since this point of interaction holds great hope for pest control in the future. Man, who has passed through a phase of selectively breeding his crop plants to be more and more suitable for insect food than they were in the wild state, must now look for ways of reversing the process without losing the value of the crops from our point of view. We must now face the insect pests with a much more profound knowledge of their behaviour and physiology and an understanding of how they select their food. Today's papers and discussion have shown that this should indeed be a fruitful approach.

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