Physiological ecology of California red scale *Aonidiella aurantii* (Mask.) and its natural enemies.

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Erratum

Page 218: The graph opposite the caption of Fig. 3 is the graph for

Page 223: Fig. 11, while the graph opposite the caption of Fig. 11 is the graph for Fig. 3.

DECLARATION

The work presented in this thesis is my own unless otherwise acknowledged, and has not previously been submitted to any university for the award of any degree.

GENERAL INTRODUCTION

This thesis comprises two series of papers (three papers each). The first series has been published in the Aust.J.agric.Res., 1973, 24: 111-42; and the second series in the Aust.J.Zool., 1974, 22 203-47.

California red scale, Aonidiella aurantii (Mask.) is probably the most injurious pest of citrus not only in Australia but also in most places in the world where citrus is grown.

The aim of this work was to establish certain basic parameters needed in the understanding of the population ecology of the scale which in turn is necessary if a proper control of the scale is to be achieved. This ecological study, however, was physiologically inclined.

In the first series of papers, the relative toxicity of malathion (the insecticide most commonly used for the control of the scale) to the stages of development of the scale and to its major natural enemies was studied, as an attempt to integrate chemical and biological control against the scale.

In the second series of papers, a study aimed at evaluating the biological control of the scale was carried out. The effect of extreme

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temperatures on stages of the scale and those of its natural enemies was studied, as an attempt to explain field data on numbers of animals in different times of the year. Also, the innate capacity for increase for the two most important parasites of the scale Aphytis chrysompheli Mercet and A. melinus De Bach was studied at different temperatures, in order to explain the observed fluctuation in relative abundance of these two parasites in the field, and assess their relative ability as biological control agents against the scale. Finally, the behaviour of the parasite A. melinus was studied, this included behaviour of oviposition and mutilation, as well as a study on control of sex and the factors that cause sex ratio to fluctuate. The behavioural study was necessary as it enables us to evaluate properly the biological control of the scale.

Abdelrahman, I. (1973). Toxicity of malathion to California red scale, Aonidiella aurantii (Mask.) (Hemiptera: Diaspididae). *Australian Journal of Agricultural Research, 24*(1), 111-118.

Abdelrahman, I. (1973). Toxicity of malathion to the natural enemies of California red scale, Aonidiella aurantii (Mask.) (Hemiptera: Diaspididae). *Australian Journal of Agricultural Research, 24(*1), 119-133.

Abdelrahman, I. (1973). A laboratory spraying apparatus. *Australian Journal of Agricultural Research, 24*(1), 135-142.

Abdelrahman, I. (1974). The effect of extreme temperatures on California red scale, Aonidiella aurantii (Mask.) (Hemiptera: Diaspididae), and its natural enemies. *Australian Journal of Zoology, 22*(2), 203-212.

Abdelrahman, I. (1974). Growth, development and innate capacity for increase in Aphytis chrysomphali Mercet and A. Melinus debach, parasites of California red scale, Aonidiella aurantii (Mask.), in relation to temperature. *Australian Journal of Zoology*, *22*(2), 213-230.

Abdelrahman, I. (1974). Studies in ovipositional behaviour and control of sex in Aphytis melinus debach, a parasite of California red scale, Aonidiella aurantii (Mask.). *Australian Journal of Zoology*, *22*(2), 231-247.

Conclusions

The natural enemies of red and yellow scale are much more susceptible to malathion than is the second moult female red scale. The regular use of malathion would be expected to result in only partial control of the pest and a substantial mortality in the parasites. This disturbance of the host-parasite relationship would make it necessary to rely more and more upon chemical control.

It is possible to develop a malathion-resistant form of A. melinus. However, the increase in resistance - 3.4 times in eight generations - was very low when compared with the natural resistance of the second moult female.

It is clear then that there is little to be gained by attempting to integrate biological control with chemical control by malathion.

Consequently the study was widened to include aspects of the physiological ecology of the red scale and its natural enemies. It was hoped that this would provide information that could be used to enhance biological control of the pest species.

The three stages of red scale that are parasitized by A. chrysomphali and A. melinus - namely second and third instars and prepupa - were least affected by extremes of heat and cold. They would then be more likely to be available throughout the year to provide hosts for the parasites.

A. chrysomphali appears to be adapted to a lower range of temperatures than A. melinus. This provides an explanation for the co-existence of the two species in the inland environment of Australia and for the fluctuations in relative abundance of the two species.

A. chrysomphali would be expected to be more numerous in winter and A. melinus would be the more abundant of the two species in summer.

The innate capacity for increase of the two species was 3.1 - 5.0 times that of the host scale. Thus both species were intrinsically capable of controlling red scale.

The two species obviously complement each other in the inland environments of Australia and their co-existence would appear to provide an ideal situation for biological control of red scale.

Studies on the behaviour of A. melinus showed that it is ideally suited for biological control of red scale. It was found that:

1) The parasites are capable of distinguishing between parasitized and unparasitized hosts.

2) The parasites avoid laying eggs in parasitized hosts under conditions in which there are enough hosts suitable for single oviposition.

3) When the density of hosts is high the parasites lay eggs in more hosts.

In summary the work has shown that better control will be achieved by discontinuing the use of malathion and related compounds which disrupt the balance between the host and its parasites. Instead efforts should be made to manipulate, augment and conserve the two parasite species and others (when imported and found capable of controlling red scale). Such measures should assist the parasites to maintain scale populations at low levels that will not cause economic loss.

However, there will be times when conditions favour the pest and are detrimental to the parasites. If chemical control then becomes necessary, it will be advisable to use chemicals that will cause least harm to the parasites. White oil is a suitable chemical since it is less toxic to the parasites and has no prolonged residual effects. If in addition spraying is confined to restricted

areas in which scale populations have got out of hand, the parasites will be protected to a large extent and will be able to exert their normal control of the pest population. Breeding and strategic release of parasites at such times should also prove advantageous.