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Biological control of *Ceroplastes rubens* Maskell, by the introduced parasitoid Anicetus beneficus Ishii and Yasumatsu

D. Smith

Summary

The parasitoid *Anicetus beneficus* Ishii and Yasumatsu (Hymenoptera: Encyrtidae) was introduced from Japan with first releases being made in January 1977. It gave effective control of *Ceroplastes rubens* Maskell (Hemiptera: Coccidae) in a detailed study in two blocks of citrus in south-east Queensland during 1977–84. At one site, scale numbers were reduced from 320 to less than 2 adult scales per 100 leaves 3.5 years after establishment. A year later the scale population dropped to near zero where it remained for the rest of the study. At the other site, the scale population dropped from 45 scales per 100 leaves to near zero within 12 months of establishment of the parasitoid. Approximately 70% of parasitoids emerging at the two sites were *A. beneficus* and the remainder mainly the endemic *Rhopalencyrtoidea dubia* Girault and *Aenasiodea varia* Girault (Hymenoptera:Encyrtidae). Where parasitoids were suppressed on trees treated with DDT, the scale population remained high and at one stage increased to 800 scales per 100 leaves.

A. beneficus was released at 60 coastal or subcoastal sites, from Weipa to Gatton. At 20 of these sites (where the parasitoid was monitored), it successfully controlled the scale in an average of 2.5 years.

INTRODUCTION

Pink wax scale *Ceroplastes rubens* Maskell (Hemiptera:Coccidae) is a serious pest of citrus and mangos throughout coastal and subcoastal Queensland. It also infests a wide range or ornamental shrubs and trees notably the umbrella tree (*Brassaia actinophylla* Endl.) and *Eugenia* spp. Both are commonly grown in gardens and parks and are usually disfigured by sooty mould associated with the scale (Brimblecombe 1956; Smith 1976). It is oriental in origin occurring throughout south-east Asia, Japan, several islands of the western Pacific and Hawaii. In Australia it has also been introduced to New South Wales, Western Australia and the Northern Territory.

Wilson (1960) lists the natural enemies of the scale recorded in Queensland and some unsuccessful attempts at the turn of the century to establish exotic parasitoids in Australia. The importance of *C. rubens* on citrus and other hosts (Froggatt 1915; Summerville 1935) suggests that natural enemies do not control the pest satisfactorily in Queensland and New South Wales. *Anicetus beneficus* Ishii and Yasumatsu (Hymenoptera:Encyrtidae) is an effective parasitoid of *C. rubens* where it occurs in Kyushu and Honshu in Japan (Yasumatsu 1968) with some innoculative releasing being practised at the beginning of summer on Honshu (K. Yasumatsu pers. comm. 1976). It was imported to Australia in 1955 but was not released (Wilson 1960). However, its continuing success in Japan prompted reimportation in September 1976 and the first releases were made in Queensland in January 1977.

This paper gives results of studies between February 1977 and October 1984 on the levels of control of *C. rubens* by *A. beneficus* and existing parasitoids in two field trials where the use of persistent pesticides was minimised. Results are also given on the establishment and colonisation of *A. beneficus* in coastal and subcoastal areas of Queensland.

MATERIALS AND METHODS

Scale and parasitism levels were monitored every 1 to 2 months from February 1977 to December 1983 on 1 ha of 25 years old late Valencia oranges (*Citrus sinensis* (L). Osbeck) at Palmwoods (27°S, 153°E) and from July 1983 to October 1984 on 0.5 ha of 8

years old Ellendale mandarins (*Citrus reticulata* Blanco) at Mundubbera (25° 5′S, 151° 5′E). At Palmwoods the scale infestation had been serious for 2 to 3 years while at Mundubbera it had developed during 1982–83. Live adult female scales 2.0 to 3.5 mm long (development is parthenogenetic) were counted on 20 leaves selected randomly from each of 25 trees on each occasion. Parasitism of adult scales was assessed by randomly collecting scale-infested leaves from each of the trees sampled for scales, transferring approximately 200 live adult scales to a petri dish and after 4 to 6 weeks, counting the emerged adult parasitoids. None of the scales had more than one emergence hole. This assessment of parasitism based on emergence of adults is probably an underestimate as it does not record parasitoids in the larval stage which die because they fail to complete their development before the scales dessicate.

Effects on parasitism of sprays of 0.1% DDT every 2 months was studied on two trees during 1978–79 and 1983 at Palmwoods. Scale populations on these trees were assessed monthly by counting live adult scales on 50 leaves selected at random.

A. beneficus was reared initially in the laboratory in aluminium framed 1 m high mesh cages on *C. rubens* infesting young potted *Eugenia* spp. A total of 3000 parasitoids was released on the Palmwoods block on 25 January 1977 and 11 March 1977. No releases were made at Mundubbera as the parasitoid had established in the study block from adjacent areas.

During 1977–81 releases of *A. beneficus* were made at 60 sites throughout coastal and subcoastal Queensland: two releases at Gatton (27° 5′S, 152° 5′E); 12 at Brisbane (27° 5′S, 153°E); 23 at Beerwah–Gympie (27°S, 153°E); five at Gayndah–Mundubbera (25° 5′S, 152°E); four at Howard–Bundaberg (25°S, 152° 5′E); six at Rockhampton–Yeppoon (23° 5′S, 150° 5′E); two at Bowen (20°S, 148°E); five at Cairns–Mareeba (17°S, 145° 5′E) and one at Weipa (12° 5′S, 142°E). Ninety per cent of releases were made in parks and home gardens where there was little or no disruption from pesticides. For releases made in 1977, a total of 5000 *A. beneficus* were laboratory reared on potted *Eugenia* spp. Subsequently the parasitoid was obtained by collecting scale infested leaves from sites where it had established, and holding them in cages until the adults emerged. Samples to confirm establishment and impact of *A. beneficus* were collected at 20 of these sites.

RESULTS

Figure 1 shows that scale and parasitism levels of the two sites and Figure 2 shows the average proportion of each parasitoid emerging each half year corresponding to the autumn and spring generations of scale.

A. beneficus, and the existing species *Rhopalencyrtoidea dubia* Girault and *Aenasiodea varia* Girault (Hymenoptera:Encyrtidae) were the most important parasitoids of the adult scale. Other species recorded were *Cheiloneurus* sp., *Aneristus ceroplastae* Howard and *Myiocnema* sp. (Hymenoptera:Encyrtidae). Some *Cheiloneurus* and *Myiocnema* species are known to be hyperparasitic (Quayle 1938) but the status of the two species occurring in pink wax scale in this study was not determined. At Palmwoods, after taking 12 months to parasitise 10% of scales, *A. beneficus* averaged 67% (56 to 81%) of parasitoids emerging during 1978–83. *R. dubia* was the most common species during the first year and during 1978–83 averaged 25% parasitism (range 15 to 41%). *A. varia* averaged 20% parasitism in 1977, fell to half of this level in 1978 and then to near zero. *A. varia* was more common than *R. dubia* before *A. beneficus* became fully established at Mundubbera (Figure 1), suggesting some competitive displacement of *A. varia* by *A. beneficus*.

The scale population at Palmwoods was high during 1977–79 (at times reaching over 300 scales per 100 leaves). The first signs of control occurred in the spring generation of 1979, and the autumn generation in early 1980 was reduced to 25 scales per 100 leaves. A similar pattern followed in spring 1980 and autumn 1981. In spring 1981 and autumn

1982, the population dropped to about two scales per 100 leaves then to near zero in subsequent assessments. At Mundubbera the initial population was 45 scales per 100 leaves, falling to two scales per 100 leaves by the autumn and subsequently to near zero.

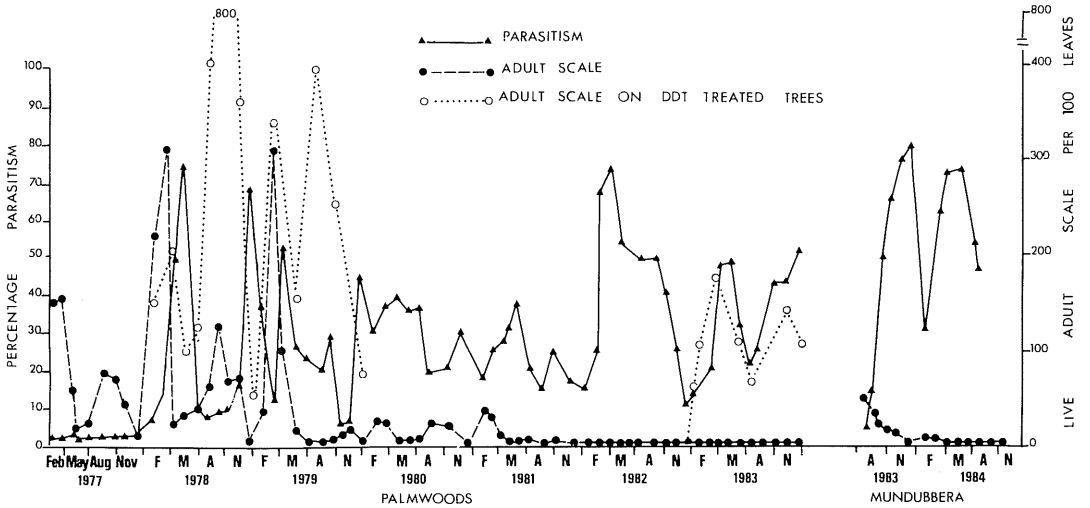

Figure 1. Numbers and parasitism levels of live adult female *C. rubens* on citrus leaves at Palmwoods 1977–83 and Mundubbera 1983–84 and numbers of live adult female scales on citrus leaves where sprayed with DDT.

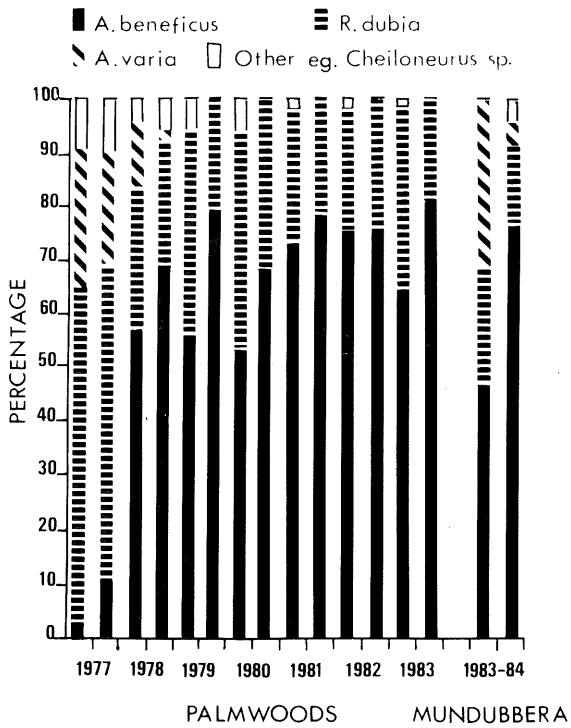

Figure 2. Proportion of *A. beneficus* and other parasitoids (averaged over 6 monthly periods) emerging from samples of live adult female *C. rubens* at Palmwoods 1977–83 and Mundubbera 1983-84.

Heavy infestations of up to 800 adult scales per 100 leaves developed on the two DDT sprayed trees during 1978 and 1979 (Figure 1). During spring 1979 the scale population in the parasitoid release area dropped to five scales per 100 leaves while the DDT-sprayed trees averaged 400 scales per 100 leaves. Spraying was discontinued during most of 1980–82 and resumed late in 1982 on a different pair of trees when scale numbers had been reduced by parasitism throughout the trial area. The population again increased rapidly on the sprayed trees to peak at 170 scales per 100 leaves.

A. beneficus was easy to colonise and time to first recovery for the parasitoid averaged 4 months (range 2 to 8 months) at the 20 monitored colonisation sites. Natural dispersal from such sites to others within 200 to 300 m was sometimes slow, taking up to 12 months. By 1984, the parasitoid was well established throughout most of coastal Queensland except in the Mackay area where the first releases were not made until November 1984. At the 20 monitored sites the parasitoid established well in 10 months (range, 6 to 12 months) and affected the scale population in about 15 months (range, 1 to 2 years). Successful control was achieved after an average of 2.5 years (range 1.5 to 4 years) with parasitism levels reaching 60 to 80% (60% by *A. beneficus*).

DISCUSSION

A. beneficus reduced the *C. rubens* infestation at Palmwoods from 320 to less than two adult scales per 100 leaves 3.5 years after release. An economic threshold for the pest in Queensland citrus was not defined while this study was in progress but later set at 2% of leaves infested with one or more adult scales (Smith and Papacek 1985). At Palmwoods the infestation for the last 3.5 years was well within this threshold and for the last 2.5 years near zero. At Mundubbera where *A. beneficus* was established throughout the block (albeit at a low level) at commencement, the scale population was reduced from 45 scales per 100 leaves to near zero within 12 months.

Parasitism was readily disrupted as shown by the two DDT-sprayed trees at Palmwoods. This indicates that improved parasitic control rather than factors such as weather was responsible for the improved scale control. Some unintentional pesticide disruption during 1980–81 at the Palmwoods trial site may have delayed the onset of satisfactory scale control. The block received one copper oxychloride and one or two mancozeb or zineb sprays annually for disease control, but these caused minimal disruption. It is suspected, however, that two or three applications of sulphur for citrus rust mite *Phyllocoptruta oleivera* (Ashmead) (Acarina:Eriophyidae) in 1979 and 1980 and one application of dimethoate for Queensland fruit fly *Dacus tryoni* (Froggatt) (Diptera:Tephritidae) in 1980 were made. Dimethoate in particular, while having little effect on *C. rubens*, is disruptive to scale parasitoids. At the only other site (one of the 20 colonisation sites where sampling occurred) where *A. beneficus* took 4 years to effect control, there was strong evidence to suggest that spray drift from roses growing under the release trees and sprayed weekly with pesticide, interfered with the establishment of the parasitoid.

Colonisation of *A. beneficus* throughout much of coastal and subcoastal Queensland was successful and *C. rubens* is now an insignficant pest in most areas. Pockets of scale infestation can still be found usually because the parasitoid has not yet located the infestation. Some areas such as Mackay still are in the initial stages of colonisation. *A. beneficus* is reported to be very successful throughout Cape York Peninsula (J. W. Turner, pers. comm. 1985), the Cairns–Mareeba area (I. C. Cunningham, pers. comm. 1984) and the Rockhampton area (R. J. Elder, pers. comm. 1984). The much improved biological control of *C. rubens* in citrus has significantly contributed to the successful implementation of IPM in Queensland citrus (Smith and Papacek 1985) with few sprays for the pest necessary since 1984.

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Mr D. Smith is an officer of Entomology Branch, Queensland Department of Primary Industries, and is stationed at Nambour, Q. 4560.