Coccinellidae in biological control

The term 'biological control' (DeBach 1964; DeBach & Rosen 1991) is interpreted as the action of predators, parasites and pathogens in maintaining the population density of another organism at a lower level than would occur in their absence. In an applied sense, however, biological control is the study and utilisation of natural enemies (parasites, predators and pathogens) for the regulation of host population densities to reduce the damage caused by noxious organisms.

The modern history of biological control dates from the spectacular control of the cottony cushion scale (*Icerya purchasi*) by the introduced vedalia beetle (Caltagirone & Doutt 1989) in citrus plantations in California in 1888. Yet the value of ladybirds in destroying aphids in English gardens was well noted at the beginning of the 19th Century. *Rodolia cardinalis* (Mulsant) was first collected on *Icerya purchasi* in Australia (mostly in the Adelaide region) by Albert Koebele in late 1888. According to DeBach and Rosen (1991), five shipments, a total of 514 specimens, arrived in Los Angeles between November 1888 and March 1889. On 12 June 1889, 10,555 specimens were distributed to various growers and, a year later, by the end of 1899, the scale was no longer considered a threat to California citrus growers.

Thorpe (1930) analysed the success of *Rodolia*, pointing out some important qualities of *R. cardinalis*: (a) its broad climatic spectrum; (b) the beetle attacked many individual prey but was virtually monophagous; (c) it was free of natural enemies; (d) the beetle attacked all stages of the scale and was highly vagile while the prey was sedentary; and (e) the prey was large, easily located and less prolific than other scales.

Pope (1981) studied another important Australian species, *Rhyzobius ventralis* (Erichson), used as a biological control agent against various scales, mostly *Eriococcus* and *Lecanium* in California, Hawaii, New Zealand and other places, with mixtures of success and failure. His detailed taxonomic and ecological analyses of these introductions showed that two morphologically similar but biologically very different species (Richards 1981) were involved at various stages of introductions causing their common failure.

Smith, Papacek and Smith (1995) described integrated pest management (IPM) procedures applied in citrus orchards of south-eastern Queensland to control citrus snow scale, *Unaspis citri* (Comstock). Parasitoids and introduced species of ladybirds *Chilocorus circumdatus* Gyllenhal provided control of the scale within two years of establishment.