Classical Biological Control of the Rose Aphid (*Macrosiphum rosae*) in Australia

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INTRODUCTION

Classical biological control (CBC) can be described as an attempt to regulate pest populations (mites, insects, mammals, weeds, pathogens) by using their natural enemies (parasites, predators, pathogens) that are imported and released into a new environment for this purpose (De Bach, 1974). The underlying hypothesis of CBC is that populations are regulated effectively by natural enemies and that exotic pest species have escaped this regulation by geographic isolation from their natural enemies (Van den Bosch and Messenger, 1973). Successful CBC combines permanency, selectivity, environmental safety, and economy in pest management (DeBach, 1974) and can be considered as a cornerstone in integrated pest management (IPM). Data from Huffaker et al. (1976) shows a return of $30 (U.S.A.) for each dollar spent in biological control of agricultural pests in California. Despite these positive benefits CBC is still a minor method of pest control compared to the use of pesticides. The main reason for the reluctance to CBC is that it is widely perceived as an unreliable method of pest control (Beirne, 1985). The overall rate of establishment of natural enemies of insects and arachnids worldwide was 34% (Hall and Ehler, 1979) and only 60% of those resulted in some kind of control. Particularly disturbing is that the rate of establishment of natural enemies in CBC is declining (Hall and Ehler, 1979). Another major concern regarding CBC is the possibility of an undesirable impact of the control agent on non-target species and the environment.

Unfortunately many CBC attempts are poorly described in the literature. Only a minority provide comprehensive data to enable detailed case studies of either success or failure that may provide useful hints for further experimentation (Hughes, 1989). The reasons for failure or success of CBC attempts are often not understood. This is very well described by Hughes (1989) who states that CBC is still considered as a kind of art rather than a science.

Since there was no urgent need to control the rose aphid, *Macrosiphum rosae* L., we had the rare opportunity to undertake some fundamental investigations on the principles of CBC with the release of the control agent*Aphidius rosae* Haliday. This paper is an introduction to the biology of the pest and its control agent. Aspects of the spread, establishment, and impact of *A. rosae* will be discussed.

CBC FOR ROSE APHIDS

Roses. Species of *Rosa* have been modified through selection and hybridisation in cultivation in many cultures giving rise to some 20,000 cultivars (Bailey and Bailey, 1976). However, the number of species is comparably small, probably comprising no more than 150 selections (Bean, 1980). As hybridisation has gone on, the system of cultivar classification has become complicated and inexact, so that it is now nearly impossible to classify accurately. Rose aphids feed on all cultivars, although susceptibility may vary between cultivars.

The Rose Aphid. *Macrosiphum rosae* is a large aphid and can vary in size between 1.7 and 3.6 mm for apterae and 2.2 to 3.4 mm in alatae. Colour ranges from dark green over deep pink to red brown or magenta. The green and brown stages are the most prominent forms and may change to the other over at least two generations in the field. Pink is often the intermediate colour during this changeover (Maelzer, 1977). In the field adults of *M. rosae* are easily recognised by their long deep shiny black siphunculi and black knees.

In regions with a mild winter *M. rosae* may be completely anholocyclic on roses, e.g., South Australia (SA) (Maelzer, 1977) and New South Wales (Wöhrmann et al., 1991). In these cases the aphids reproduce parthenogenetically and viviparously all the year around, despite small numbers in winter and midsummer, sexuals and eggs are not produced (Maelzer, 1977; Wöhrmann et al., 1991). *Macrosiphum rosae* is probably native to Eurasia and was introduced into Australia as a result of colonisation (Maelzer, 1977). In SA *M. rosae* is the most serious insect pest on roses. The growth of a colony of *M. rosae* on a rose bud and its potential for damage depend upon a complex interaction between seasonal rose growth, temperature, rainfall, predation and density-dependant mechanism of dispersal (Maelzer, 1977; Tomiuk and Wöhrmann, 1980). The population dynamics of *M. rosae* coincide mainly with the growth of the host-plant (Maelzer, 1977) and reaches two peaks in spring and one in autumn in SA. A number of native insect species including ladybirds, syrphids, and lacewings prey upon the aphid (Maelzer, 1977).

Macrosiphum rosae feeds mainly on the young shoots and buds of roses, up to the stage when the sepals start to fold back (Maelzer, 1977). By sucking and removing sap from the vascular system the aphid reduces the amount of nutrients available for the bud and the plant as a whole. Direct visible damage to the bud is rare and only heavily infested young shoots tend to wither or dry up. Maelzer (1977) describes the economic damage threshold as an infestation of 50 aphids per bud, at this level the plant responds by the reduction of growth and the inhibition of new buds shooting. However, roses which are grown for cutting or display have a much lower damage threshold, since minimisation of cosmetic damage is critical. In addition, indirect damage is caused by rose aphids as the accumulation of their honeydew excrement promotes the growth of sooty mould which causes cosmetic damage and reduces photosynthetic activity.

The role of *M. rosae* in transmitting viruses is unknown. However, compared to the other sources of infection, such as vegetative propagation with virus-infected buds, pruning with contaminated equipment, natural pollen transmission, and transmission by free-living soil-inhabiting nematodes (e.g., *Xiphinema* spp.) the role of *M. rosae* in virus transmission is probably minor (Horst, 1983). According to Blackman and Eastop (1985) the aphid is able to transmit at least 12 viruses, including the persistent virus strawberry mild yellow edge but not the important rose mosaic or rose streak.

The rose industry in Australia is valued at around $100 (A) million per annum. Seventy percent of this is attributed to the cut-flower industry. Pot and bare-root growers for garden supply account for the other 30%. CBC of *M. rosae* was considered to be of most benefit for commercial pot and bare-root growers since many of their plants are sold pruned and a light infestation with aphids is tolerable during their main growth period. Local councils and home gardens would also benefit from CBC on roses, as the control agent increased in numbers and spread naturally through urban areas. Replacing pesticidal sprays with biological control agents was considered highly beneficial, not only in terms of cost but also with regard to environmental pollution and public health.

The introduction of an effective predator for *M. rosae* was considered to be a potential cornerstone in a future IPM program on roses and an invaluable investment in the future. The use of an effective natural enemy reduces dependence on chemical control methods and alleviates the ever increasing problem of insecticide-resistant strains of rose aphids (DeBach, 1974). An effective biological control agent for rose aphids will also complement the use of predatory mites which are often used in the management of pest mite species. An IPM Program for the Western flower thrips (*Frankliniella occidentalis*) is being developed in Australia. This is unlikely to work on roses unless a concurrent programme for aphids is in place. A combination of control agents is necessary where there is more than one significant pest species. The long-term effects of an IPM program for roses will be of significant value. However, even in the short-term direct feeding damage or indirect damage through virus transmission by aphids occurs in proportion to their abundance (Dixon, 1985). Therefore, any decrease in aphid numbers resulting from the introduction of a CBC agent will be potentially beneficial (Hughes, 1989).

The Control Agent. In seeking a control agent of *M. rosae* a parasitoid seemed most promising. The existing parasitoid predators for rose aphids in Australia were negligible and other native predators did not provide sufficient control potential. It was hoped that a specific parasitoid could fill in the missing niche of parasitic control and, if not being effective by itself, at least augment the impact of existing predators. Specific parasitoids are the most promising group among CBC agents, especially when the pest occurs in permanent, stable environments on woody plants.

Aphidius rosae was selected. This aphid parasitoid is up to 3 mm in length and lays its eggs inside all instars of the rose aphid. Parasitised aphids are eaten and finally killed by the developing parasitoid. A paper-like skin is all that remains of an aphid after parasitism. The larvae of the parasitoid attaches the skin of the aphid to the plant and uses it as shelter in which to spin a cocoon. These round, shiny structures are called mummies and are easy to detect on roses. Inside the mummy the insect pupates. Depending upon temperature it takes 2 to 3 weeks from egg deposition to the emergence of the adult wasp from the mummy. Females have the potential to kill more than 800 aphids. *Aphidius rosae* is considered to be specific to its host (Pennàchio, 1989). To reduce the need for acclimatisation *A. rosae* was collected in Italy.

Specificity Assessment of *A. rosae* in Australia. In the past more than a dozen species of Aphidiinae were released into Australia (Hughes, 1989) including polyphagous species such as *Aphidius ervi* Haliday. To my knowledge there is no record of any of these introduced parasitoids parasitising species other than non-native aphids. In Australia, of 156 known aphid species, only 20 are indigenous, the rest are exotic and mostly pests (Carver, 1989). The few species of aphids which are native to Australia are found on species which are quite different to roses and live mainly in habitats which are very unlikely to attract *A. rosae*. It is expected that *A. rosae* will rarely encounter most aphid species occurring in Australia. Only on roses would the wasp have to distinguish between different aphid species.

Macrosiphum euphorbiae is the only aphid species other than *M. rosae* expected to be occasionally parasitised by *A. rosae*, but in this case offspring would not complete development. The long association of *M. euphorbiae, M. rosae*, and *A. rosae* on roses in other parts of the world indicates that no sudden change of host suitability is likely. Because of the specificity of *A. rosae*, the special composition of the Australian aphid fauna and the history of introduced aphidiine wasps into Australia, environmental risks resulting from the release of the control agent were extremely low.

Establishment. The release of *A. rosae* was used to test the hypothesis that a threshold of about 1000 insects released at a single site is needed for establishment (Hopper and Roush, 1993). Mummies (16, 64, 256, and 1024) of *A. rosae* were released in eight cities throughout Victoria. Six months after release, recoveries could be made in the three sites in which 64, 256, and 1024 mummies were released. After 1 year, mummies were also found in a place where only 16 were originally released. The establishment of *A. rosae* shows good prospects for its distribution over the country. Institutions and commercial rose growers should be able to establish this parasitoid without little effort and therefore achieve quick distribution in suitable parts of the continent with minimum outlay.

Spread. The ability of parasitoids to disperse is important in CBC since control agents cannot be released everywhere. Insect populations are usually clumped in time and/or space, and the distribution of these clumps can change from season to season. The patchy distribution of pest outbreaks may disrupt synchrony of parasitoids with their host population in space, even if they may be in synchrony with the host in time (Vinson, 1981). These uncertainties make dispersal a critical issue for the success of parasitic wasps in biological control, especially in CBC attempts where augmentative releases might not be considered. The dispersive movements of an established population of control agents in a patchy environment are of special interest at the beginning of a new season. Seven months after the first release of only 1600 individuals of *A. rosae*, the parasitoid inhabited an area of approximately 200 km^2 and could be found 18 km away from the nearest release site. Results suggest that parasitoids spread mainly in the direction of prevailing winds and that most individuals do not travel far.

Impact on Aphid Populations. Surveys during the first 2 years showed a significant reduction of aphids in spring with up to 80% parasitism. In autumn the abundance of rose aphids was less obviously influenced.

CONCLUSION

Since release, the wasp displays all the qualities of an effective CBC agent:

1) Despite small release numbers the wasp was easily established and is now abundant in wide areas around the initial release points.

2) The wasp has spread over more than 200 km^2 in the Adelaide region in less than 7 months.

3) The wasp is present as an adult in late winter, a short time before the build up of host aphid populations.

4) The wasps potential for population increase is at least comparable with that of its host.

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