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PROSPECTS FOR EXTENDING THE USE OF AUSTRALIAN LACEWINGS IN BIOLOGICAL CONTROL

T. R. NEW

Department of Zoology, La Trobe University, Victoria 3086, Australia
E-mail: zootn@zoo.latrobe.edu.au

Very few Australian lacewings have been utilised in biological control programmes, despite the need to manage an enormous variety of arthropod pests on a wide range of crops. Only two species (*Micromus tasmaniae* WALKER, *Mallada signatus* (SCHNEIDER)) have attracted wide attention. The reasons for this focus are discussed, and the biology and abundance of Australian Hemerobiidae and Chrysopidae reviewed as a basis for discovering further opportunities to manipulate native lacewing species for pest management. These opportunities are explored in the context of (1) the undesirability of introducing further exotic natural enemies to Australia and the consequent need to enhance use of native taxa, and (2) the characteristics of a 'good predator' for pest management.

Key words: pest management, natural enemies, predators, Neuroptera, Hemerobiidae, Chrysopidae

INTRODUCTION

The diversifying nature of integrated pest management continues to emphasise the need to employ all available natural enemies of agricultural pests. Continued introduction of exotic species into Australia for this purpose is questioned increasingly, on the grounds of environmental protection, and there has been renewed interest in improving the values of native natural enemies for pest management, with implications that the pool of suitable species may be considerably larger than those already being utilised. Within the Neuroptera, only single species of Hemerobiidae (*Micromus tasmaniae* WALKER) and Chrysopidae (*Mallada signatus* (SCHNEIDER)) have attracted wide attention as manipulable predators in Australia (HORNE *et al*. 2001*a, b*). Both families are diverse in Australia and have attracted considerable focus for biological control elsewhere in the world (NEW 1999). Opportunities to extend this predator spectrum in Australia initially seem to be available. The likelihood of utilising more Australian species of Neuroptera for pest management, as part of a transition from importing classical biological control agents to augmenting the use of available native species, is discussed in this paper.

CANDIDATE TAXA

The Australian Hemerobiidae includes 34 described species (NEW 1988), and Chrysopidae includes 60 species (NEW 1996). Most of these species, in both families, are poorly known. Some are scarce, or apparently scarce, and are known only from their types and from single localities. For many, no data are available on habitat tolerances and basic biology. Many appear to be geographically and/or ecologically restricted, for example to native forests in either the temperate or tropical parts of Australia.

The regions of greatest interest for agricultural pest management are the Bassian region and the central and central north parts of the east coast, where most field, orchard and forestry crops are produced. The spectrum of Hemerobiidae and Chrysopidae in these areas is considerably less than for Australia as a whole, and most of the species recorded are not common. Trap catches of lacewings in crops and natural environments in the region yield few common species, and few taxa are consistently present. Most catches are dominated by the two species noted above, *M. tasmaniae* and *M. signatus*.

However, at least three other species occur in reasonable abundance in the region, and at times in association with crops:

Hemerobiidae

Drepanacra binocula Newman is widespread in the region, although always markedly less abundant than *M. tasmaniae*. It is found predominantly on native vegetation such as *Acacia* trees (NEW 1984). It is a specialist feeder on Psylloidea. *D. binocula* occurs only rarely on field crops, but can be more common in orchards. All other Hemerobiidae are scarce, or occur only very sporadically on and around crops.

Chrysopidae

Plesiochrysa ramburi (SCHNEIDER) is very widespread in Australia and much of the western Pacific. It has been introduced to New Zealand from Australia on several occasions, but has not become established there (WISE 1995).

Apertochrysa edwardsi (BANKS) is sometimes the most abundant chrysopid on native vegetation in southern Australia (NEW 1983). As with *D. binocula*, it is common on *Acacia.* It can by far outnumber other Chrysopidae in such natural habitats, but appears not to be strongly pre-adapted to native prey (NEW 1982).

Sporadic reports of other Australian Neuroptera on field crops or in association with pest arthropods occur – mainly in the north east, for *Mallada traviatus* (BANKS) (BOROS 1984), *M. basalis* (WALKER) and *Micromus timidus* HAGEN – but none has been noted as of potential economic value for crop protection in Australia. There are also very few 'early' records of lacewings as important predators. WILSON (1960) made no mention of hemerobiids in his review of biological control activities in Australia, and only casual note of *P. ramburi* and *M. signatus* in lists of purported natural enemies of scale insects. Neuroptera have been overshadowed substantially by Coccinellidae, whose predatory values have attracted much wider attention in Australia (FROGGATT 1902).

In New Zealand, *M. tasmaniae* and *D. binocula* are both indigenous, and regarded as long established from Australia (WISE 1995). Both have been implicated as important predators, the latter as 'the most important' predator of Homoptera on *Pittosporum* (CARTER 1949), although its incidence was too sporadic to effect control. Other New Zealand studies were summarised by WISE (1995). *D. binocula* was also exported from Australia to Hawaii for control of *Psylla* (=*Accizzia)* *uncatoides* on native *Acacia* species (LEEPER & BEARDSLEY 1976). Much earlier, *M. timidus* had also been introduced into Hawaii from Australia, to control sugarcane pests (WILLIAMS 1927). An initial stock of 14 living specimens from north Queensland was used to rear more than 5000 adults for release, together with numerous eggs. The lacewing established rapidly on several islands, and adults and larvae (as with *M. tasmaniae*) are both voracious predators.

By contrast with other parts of the world where Neuroptera are important biological control agents, Australia lacks members of the '*Chrysoperla carnea* group' of species so predominant in such activities. In Australia, *Chrysoperla* is represented by *Ch. congrua* (WALKER), a widespread species known from parts of northern and central Australia but absent from much of the east and south of the continent where needs for pest management are paramount. Many of the chrysopid genera in Australia have no historical involvement elsewhere in biological control operations. Likewise, most Hemerobiidae are not members of genera used widely in pest management (NEW 2001). The single Australian species of *Hemerobius*, for example, is poorly known, elusive, and its biology is unknown.

The 'pool' of candidate Neuroptera in Australia related to taxa manipulated elsewhere is thus genuinely small. Much original research would be needed to investigate their suitability for pest management and, even, to elucidate their basic biology. The more immediate priority is the enhancement of the effects of the two most abundant taxa, whose biology is reasonably well understood.

Established values of M. tasmaniae *and* M. signatus

These two species are among the most widely distributed lacewings in Australia (NEW 1997), and have been reported from all mainland states and Tasmania. *M. tasmaniae* and *M. signatus* are both generalist feeders and disperse readily on to low vegetation as a normal component of their habitats. Both features are important in biological control, in which a broad spectrum of management activities to enhance the impacts of natural enemies may be available. These include:

1. Multiple introductions, including augmentative releases of native species.
2. Reducing direct mortality by eliminating pesticide use, or seeking pesticide-resistant natural enemies.
3. Providing supplementary resources to attract or sustain natural enemies.
4. Increasing within-field and nearby vegetational diversity.
5. Manipulating features of the host plants.
6. Using semiochemicals (such as kairomones) to stimulate effective searching behaviour and selection of natural enemies in the field (after ALTIERI & NICHOLLS 1999).

The great majority of pest arthropods on Australian crops are exotic species, which have been present only during the recent period of European settlement, with new ones continuing to arrive and establish. Many are not closely related to native species, so that there is no predictable suite of pre-adapted specialist consumers. For example, Australia's few native aphid species are predominantly associated with forest environments, and virtually all the aphids on low vegetation are exotic species. Pest Lepidoptera include native noctuid moths, but others (such as *Pieris rapae* and *Plutella xylostella* on brassicas) are exotic. For these, and many other pests, biological control in Australia has relied heavily on the use of parasitoids. Use of native natural enemies, including predators, in IPM is relatively recent, together with associated mass rearing and dissemination of these.

The Coccinellidae commercially available in Australia are all predators of Homoptera. *Cryptolaemus montrouzieri*, *Rhyzobius lophanthae* and *Chilocorus* spp. are all recommended for use against mealybugs (*Cryptolaemus*) and various scale insects. The recommended pest target range for *M. signatus* is much broader, and indicates that it is one of the most effective generalist predators available on a commercial scale: aphids, two-spotted mite (*Tetranychus urticae*), greenhouse whitefly, scales, mealybugs, moth eggs and small caterpillars (PAPACEK *et al.* 1995). It is recommended also for use in a variety of contexts, including field crops, nurseries and greenhouses, and a considerable variety of crops in these environments.

M. signatus is available from two commercial facilities in Queensland, and is also reared elsewhere. *M. tasmaniae* has only recently become the focus of mass rearing studies, and has proved amenable to this (HORNE *et al*. 2001*a*); it is likely to receive considerably more attention in the next few years.

Both species are suitable for short term releases to increase impact of natural enemies over the life of a crop, with the underlying assumption of repeating the exercises in the future rather than relying on 'permanent' suppression of the pest. However, possibilities for conservation in crop environments and natural augmentation of both species by using food sprays and other attractants would seem to exist.

M . tasmaniae is recognised as a significant predator on aphids in New Zealand (ROHITHA & PENMAN 1986) and Australia (MILNE & BISHOP 1987). Both sexes disperse readily and, unusually for Hemerobiidae, the larvae are also mobile and descend from plants and traverse open ground to reach others. They are thus amenable to capture using pitfall traps, which have proved valuable in population assessment (RIDLAND 1988). The lacewing has been regarded as a 'key predator' of aphids (HORNE *et al*. 2001*b*), and its high tolerance to some pesticides led RUMPF *et al.* (1998) to believe it had 'high potential' in IPM in the region.

M. signatus is typically much less abundant than *M. tasmaniae* on field crops. Initial studies on its abundance in association with *Helicoverpa* caterpillars on cotton in Queensland (SAMSON & BLOOD 1979) suggested that it might be relatively more effective as a control agent than some analogous Chrysopidae employed widely in North America. More recently, it has been implicated in suppression of pest Lepidoptera on macadamia (Queensland) and grapevines (Victoria). However, more detailed studies of this very promising species are needed (HORNE *et al.* 2001*a*).

FUTURE DEVELOPMENTS

There has been a history of neglecting 'generalists' as biological control agents, with long-standing belief that feeding specificity is a key requirement for such natural enemies. However, this requirement is not as vital if native taxa are used within their natural ranges, rather than for exotic taxa being introduced into new ecological associations.

Very few studies (summarised by CHANG & KAREIVA 1999) have measured the contributions to biological control of generalist and specialist species on the same prey, and the results of these provide no general basis for recommendation. Non-target effects of native generalist predators may include decreasing numbers and impacts of specialist species, if these are also available. Conversely, as with both the lacewing species discussed here, persistence in the local environment is likely (even, usual) during periods of low pest abundance when alternative foods are either present or provided as a component of management. They may then be regarded as 'lying in wait' (CHANG & KAREIVA 1999) and as 'insurance' against pest outbreaks. Refining management may lead to greatly increased reliance on such native generalist species in many pest management contexts.

The two species discussed here may have complementary roles, based on their size difference and the consequent differential vulnerability of different sizes of prey. *M. signatus* is able to take relatively larger caterpillars than *M. tasmaniae*, for example. Both species manifest many of the features of 'good' generalist predators. They occupy a large range of climatic regimes, and are easily manipulated in a variety of IPM contexts over much of the Australian continent, with local stocks likely to be available for enhancement. At present the limits to their use are not clear. The abundance of *M. tasmaniae* in the cooler regions of Australia and New Zealand implies that it could parallel some North American Hemerobiidae in being a useful control agent over the cooler parts of the year. *M. signatus* also breeds throughout the year, but is more abundant in the warmer seasons. Trials with artificial food sprays (MENSAH 1997) demonstrate the likelihood of effective population enhancement from local populations.

Both species are already regarded as valuable contributors to pest management on numerous crops, at a time when agricultural and horticultural diversification is an increasingly important strategy in Australia; and both are useful in both broad acre applications and more restricted environments. It is unlikely that their widespread use will be approached by any other lacewings in Australia, although *D. binocula* and *P. ramburi*, in particular, may have potential for development in some more specialised IPM contexts. At present there is little practical incentive to enhance the number of species of Neuroptera used as biological control agents in Australia and, apparently, few suitable candidate taxa with which to do so.

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