THE SEASONAL ABUNDANCE OF THE NEWLY ESTABLISHED PARASITOID COMPLEX OF THE EUCALYPTUS TORTOISE BEETLE (*PAROPSIS CHARYBDIS)*

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ABSTRACT

Enoggera nassaui has been the key biological control agent of the eucalyptus tortoise beetle *Paropsis charybdis* since 1987. In 2001 a second egg parasitoid *Neopolycystus insectifurax* as well as an obligate hyperparasitoid of *E. nassaui, Baeoanusia albifunicle* were detected in New Zealand. Monitoring of *Eucalyptus nitens* plantations in the central North Island revealed that 50% of *P. charybdis* eggs in half the sites were parasitised by *E. nassaui* in early summer. However, later in the season this was followed by a reduction to 10% parasitism by *E. nassaui*, the remaining 40% of parasitised eggs being hyperparasitised by *B. albifunicle. Neopolycystus insectifurax* parasitised an additional 35-100% of eggs in late summer. This indicates that, while *B. albifunicle* has the potential to severely reduce the effectiveness of *E. nassaui*, the new agent *N. insectifurax* is a promising alternative.
Keywords: biological control, egg parasitoid, *Baeoanusia albifunicle, Neopolycystus insectifurax, Paropsis charybdis.*

INTRODUCTION

The Eucalyptus tortoise beetle, *Paropsis charybdis* Stål (Coleoptera: Chrysomelidae), is a pest of *Eucalyptus* plantations. *Enoggera nassaui* (Girault) (Hymenoptera: Pteromalidae), an egg parasitioid, was introduced from Western Australia in 1987 as a biological control agent (Bain & Kay 1989) and initially had success in suppressing *P. charybdis* populations (Kay 1990). However, to improve biological control effectiveness in colder sites another population of *E. nassaui* from a colder climatic origin (Tasmania) was released in the central North Island in 2000.

In 2001 two new Australian parasitoids of *P. charybdis* were detected in New Zealand (Murphy 2002). These were the parasitoid *Neopolycystus insectifurax* Girault (Hymenoptera: Pteromalidae) and an obligate (Tribe 2000) hyperparasitoid of *Enoggera* sp., *Baeoanusia albifunicle* Girault (Hymenopetra: Encrytidae). At one site over half the egg batches parasitised by *E. nassaui* also contained the hyperparasitoid (B.D. Murphy, pers. comm.). It is feared this hyperparasitoid is disrupting the biological control of *P. charybdis* by *E. nassaui*. *Neopolycystus insectifurax* was originally released as a potential biological control in New Zealand in 1987 along with *E. nassaui,* but failed to establish (Bain & Kay 1989). Berry (2003) has determined that the recent occurrence of *N. insectifurax* is the result of a separate and probably accidental self-introduction rather than from those released in 1987. It is hoped that *N. insectifurax* could assist with the biological control of *P. charybdis* as species of *Neopolycystus* are not hyperparasitised by *B. albifunicle* (Tribe 2000). Because of this *N. insectifurax* was mass reared and released in the central North Island over the 2002/2003 summer, in an attempt to increase its distribution.

This paper reassesses the status of *P. charybdis* biological control following these new incursions by measuring the seasonal occurrence of the three species, *E. nassaui*, *B. albifunicle* and *N. insectifurax*, in parasitised *P. charybdis* eggs in the North Island.

METHODS

Four 2–3-year-old *E. nitens* plantations in the central North Island were monitored between October 2002 and April 2003 for the presence of *P. charybdis, E. nassaui, N. insectifurax* and *B. albifunicle*. The study areas spanned a range of altitudes and micro-climates, Haumingi (Lake Rotoiti, 38°03'S, 176°27'E), Rotomahana (Lake Tarawera, 38°05'S, 176°41'E) and Seven Oaks (north of Lake Taupo, 38°36'S, 175°56'E). A fourth site approximately 30 km south of Rotorua (Murphys, 38°20'S, 176°25'E) was added to the sampling regime in December when insecticide was sprayed at Seven Oaks. At each site, 10 trees were randomly selected and branches bearing flushing adult foliage were either cut from the tree or inspected from the ground each week for the presence of *P. charybdis* eggs.

Field-collected eggs were stored in separate vials in a laboratory at 20ºC (14:10 h light:dark photoperiod) until eclosion. The total number of eggs, and larvae, parasitoids and hyperparasitoids that emerged from each sample were recorded three times a week. Egg parasitism and egg hyperparasitism were determined as a percentage of the total monthly eggs collected at each site. Eggs were assumed to have had significant exposure to parasitism before collection and therefore all eggs collected were included in the analysis.

RESULTS

Paropsis charybdis egg numbers

The number of *P. charybdis* eggs collected each week was highly variable (Fig. 1). Egg abundance peaked in all sites between mid November and late December, except at Haumingi, where a peak did not occur until February. The Seven Oaks site was sprayed with the organophosphate insecticide 'Dominex' (active ingredient alpha-cypermethrin at 300 ml/ha) in late December and the Murphys site was sprayed with the organophosphate insecticide 'Fastrac' (active ingredient alpha-cypermethrin at 300 ml/ha) in early February to reduce the damage from *P. charybdis.* Egg numbers subsequently declined rapidly at Seven Oaks and no eggs were detected for the rest of the season. At Murphys no subsequent decline in egg numbers occurred, suggesting that the insecticide was ineffective. In the remaining two unsprayed sites, a peak of *P. charybdis* egg abundance occurred in February (Fig. 1).

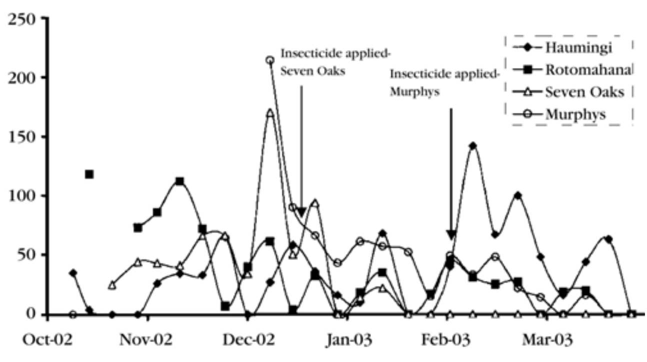

FIGURE 1: Total *Paropsis charybdis* egg abundance at four sites in the Central North Island.

Egg parasitism

Egg parasitism by *E. nassaui* differed between sites, being non-existent at Rotomahana prior to December, and low (<7%) at Haumingi and Seven Oaks. Parasitism by *E. nassaui* generally peaked in December (17-50%) at all sites. At the Rotomahana site the highest parasitism occurred in February (Fig. 2).

Enoggera nassaui suffered hyperparasitism from *B. albifunicle* at all sites except for Seven Oaks (Lake Taupo). *Baeoanusia albifunicle* was occasionally detected at Haumingi (Fig. 2a) and Rotomahana (Fig. 2b), where it parasitised a variable portion of eggs (10-20%) throughout the season. At Murphys (Fig. 2d), the hyperparasitoid was present in all months and as the season progressed it hyperparasitised an increasing portion of *E. nassaui*-parasitised eggs. By March, *B. albifunicle* had effectively destroyed all parasitism by *E. nassaui* at this site by attacking100% of parasitised eggs.

Neopolycystus insectifurax was detected in November and December at Haumingi and Murphys, where it parasitised 0.3-15% of eggs (Fig. 2a & 2d). In mid December, 650 laboratory reared *N. insectifurax* were released at both Haumingi and another site where it had previously not been recorded, Rotomahana. This species was subsequently recorded abundantly in samples at both release sites; for instance in March parasitism reached 86% of all eggs at Haumingi (Fig. 2a) and 100% of eggs at Rotomahana (Fig. 2b).

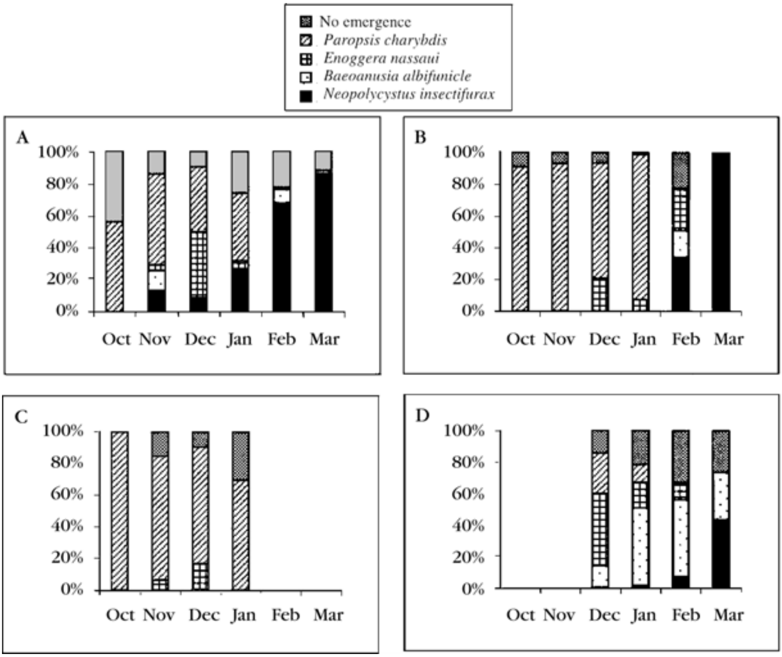

FIGURE 2: The mean rates of emergence (%) of *Paropsis charybdis, Enoggera nassaui, Neopolycystus insectifurax* and *Baeoanusia albifunicle* from collected *P. charybdis* eggs during 2002–2003. (a) Haumingi, (b) Rotomahana, (c) Seven Oaks and (d) Murphys.

DISCUSSION

In New Zealand, *P. charybdis* has two generations each summer. Overwintered adults emerge in spring and start ovipositing in October. The time from oviposition to adult eclosion is 7-9 weeks (Styles 1970). Hence the December peak in eggs follows the emergence of first generation adults. A second peak in eggs occurs in February following the emergence of second generation adults (Stevens 1973; Kay 1990; Murphy 1998). Murphy & Kay (2000) also found this same trend when they monitored *P. charybdis* populations from 1997–1998 using frass collection.

In previous studies, when *E. nassaui* was the only natural enemy effective against *P. charybdis* in New Zealand (Murphy 1998), *E. nassaui* induced low parasitism of *P. charybdis* eggs early in the season. This was thought to be due to high overwintering mortality of *E. nassaui*. By March however, good control of the *P. charybdis* population was generally achieved with at least 80% egg parasitism (Murphy & Kay 2000). Although there is only one season of data with which to compare the present complex of parasitoids to the earlier situation, some significant changes are evident. In the present study the early season trend of low parasitism by *E. nassaui* was identical. However, in 2003 by late season (March) all eggs that had been parasitised by *E. nassaui* were subsequently hyperparasitised by *B. albifunicle*. This large reduction in egg parasitism by *E. nassaui* in the second peak of *P. charybdis* egglaying is highly significant in terms of biological control of *P. charybdis*.

Hence in sites where *B. albifunicle* is present the abundance of *E. nassaui* has been severely reduced. However, hyperparasitism of parasitised eggs by *B. albifunicle* does still prevent *P. charybdis* eggs from hatching. So it is postulated that the only disruptive effect of *B. albifunicle* is the increased mortality, which will reduce the rate of population increase of *E. nassaui*. Overwintering survival of *E. nassaui* was already thought to be the factor limiting its effectiveness as a biocontrol agent, and this may now be further exacerbated by the hyperparasitism it is experiencing. The importance of both these factors requires further investigation.

The presence of *N. insectifurax* at three of our study sites as well as it not being hyperparasitised by *B. albifunicle* (Tribe 2000), suggest *N. insectifurax* has potential as an effective agent against *P. charybdis*. *Neopolycystus insectifurax* was first detected in November, though there was increasing parasitism as the season progressed towards autumn. No *N. insectifurax* were released at Murphys or within 35 km of this site, so the results may be indicative of a naturally occurring population of *N. insectifurax* in this region. The mean rate of parasitism increased from less than 1% in December through to 44% in March. Even more promising than this was the 100% parasitism *N. insectifurax* achieved late in the season in the eggs laid by the second generation of adults at Rotomahana. Because of the high parasitism rates achieved at this and the Haumingi site it is thought that the mass-rearing and release of *N. insectifurax* was worthwhile. It appears that *N. insectifurax* has the potential to control the eggs laid by the second generation of *P. charybdis* adults as it achieved >80% parasitism. In previous years *E. nassaui* attacked these eggs, but now that this species has been hyperparasitised, *N. insectifurax* will instead fulfil this function.

CONCLUSION

Effective biological control of *P. charybdis* in New Zealand was in doubt because of significant hyperparasitism of *E. nassaui* by *B. albifunicle*. It is likely that the abundance of this previously useful egg parasitoid will decrease and the self-introduced *N. insectifurax* will become more abundant, since the latter remains free from hyperparasitism. Further rearing and release of *N. insectifurax*, especially in the sites where *B. albifunicle* is found, is recommended in order to assure the establishment of *N. insectifurax* and continued control of *P. charybdis*.

ACKNOWLEDGEMENTS

We are grateful to Brendan Murphy for insect identification and to GSL Capital Ltd and Hardwood Management Ltd for access to sampling sites. This research was funded by FRST subcontract CO4X04 to Forest Research.

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