PAROPSIS CHARYBDIS DEFOLIATION OF EUCALYPTUS STANDS IN NEW ZEALAND'S CENTRAL NORTH ISLAND

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ABSTRACT

Paropsis charybdis, the most serious pest of *Eucalyptus* in New Zealand, was controlled with the introduced Australian egg parasitoid *Enoggera nassau* in the late 1980s. Using frass traps to monitor *P. charybdis* populations, we report that pest outbreaks still occur, resulting in heavy defoliation of susceptible *Eucalyptus* species. The results suggest that the presence of large larval populations and commensurate defoliation result from poor spring parasitism by the parasitoid. A second wave of *P. charybdis* oviposition is effectively attacked, preventing late season defoliation by larvae. A climatic mismatch of *E. nassau* is suspected to be the cause of this poor performance.

Keywords: *Paropsis charybdis*, *Enoggera nassau*, *Eucalyptus*, biological control.

INTRODUCTION

The Australian *Eucalyptus* tortoise beetle, *Paropsis charybdis* Stål (Coleoptera: Chrysomelidae), is a highly fecund, bivoltine species that accidentally established in New Zealand in the early 1900s (Styles 1970). The lack of natural enemies to regulate this pest resulted in large populations, with both adult and larval stages defoliating susceptible host species. This seriously impeded establishment of a commercially viable New Zealand *Eucalyptus* resource (Wilcox 1980). Initial success with a classical biological control agent, the egg parasitoid *Enoggera nassau* Girault (Hymenoptera: Pteromalidae) from western Australia (Kay 1990), suppressed *P. charybdis* populations, allowing establishment of susceptible host species, particularly Shining gum, *Eucalyptus nitens* (Deane & Maiden) Maiden, a tree suitable for short rotation short-fibre pulp production. The subsequent detection of *P. charybdis* outbreaks by forest health surveys prompted concern about the efficacy of the parasitoid and levels of defoliation occurring.

Sampling for *P. charybdis* in tall, fast-growing *Eucalyptus* plantations is restricted by foliage accessibility, and non-intrusive sampling methods benefit from not disturbing the target system. Frass monitoring provides one such method of indirectly estimating defoliation caused by target species and the magnitude of its population. This technique is also useful in that data can be collected from low target populations where control may be effective.

The aim of the work presented in this paper was to determine whether New Zealand's *Eucalyptus* resource was still at risk from *P. charybdis* defoliation, and if this was a result of poor parasitism by *E. nassau*.

METHODS

Frass trapping and analysis

Seven *E. nitens* sites (Table 1), consisting of both shelter-belts and commercial plantations were selected in the Central North Island region to provide a contrast of *P. charybdis* defoliation levels. Sites ranged in size from ~100 to 10 000 stems and were aged between six and thirteen years. After visual inspection of defoliation, the sites were arbitrarily categorised as either 'problem' or 'low-damage', where

P. charybdis populations were assumed to be high or low respectively. Five plastic conical traps, each with a collecting area of 0.25 m², and with a fine gauze bottom to allow water to escape, were placed randomly (with adjustments where necessary to ensure placement under canopy) along a 50 m transect in each stand and supported by wooden stakes. Traps were cleared of debris approximately weekly over the 1997-98 summer. The Tumunui site was felled before completion of the study, after only 14 weeks, reducing the frass capture by approximately 8 weeks.

Frass was separated from the debris collected in the traps using a vibrating sieve sorter (2 mm diameter) and by hand under dissection microscope, then dried at 50 °C for 24 hours. The dried frass from each trap was weighed and a daily average for each trapping period calculated. Total frassfall for each site was converted to kg/ha/yr. Analysis of variance (ANOVA) was performed on the total frass capture for each site. Assuming an approximate digestibility (A.D.) of 26.8 % for *P. charybdis* larvae (Edwards and Wightman 1984), total frassfall weights were converted to fresh weight of foliage consumed after reworking the A.D. formula of Morrow and Fox (1980) to yield *weight of leaves eaten* = (*frass weight* / 1 – 0.268).

Egg parasitism

An estimation of egg parasitism was undertaken by removing *P. charybdis* egg batches from 10 tagged shoots in each site concurrently with clearing of frass traps. Eggs were maintained in vials until either *P. charybdis* larvae emerged or until the characteristic symptoms of parasitism by *E. nassaui* were detected, and a percentage parasitism rate calculated. Only data for the three problem sites is available due to the low numbers of eggs found in the low-damage sites. The data was chronologically divided to provide parasitism rates for the early season (October through December) and late season (January through March) periods.

RESULTS

Total annual frass production

The four low-damage sites showed similar low levels of frass collected, whereas at the problem sites frass levels were much higher (Table 1). Frass measurements between these two groups of sites were significantly different ($P < 0.01$).

TABLE 1: Estimates of annual *P. charybdis* frass production ($\pm$ SE) and calculated foliage consumption.

Site ¹	Stand status	Annual frassfall (kg/ha/yr)	Annual leaf consumption (kg/ha/yr)
Cpt. 1060	Low-damage	2.93 $\pm$ 0.06	4.07
Kapenga	Low-damage	6.31 $\pm$ 0.08	8.76
Mamaku	Low-damage	6.30 $\pm$ 0.08	8.75
Poronui 1	Problem	45.22 $\pm$ 0.68	62.81
Poronui 2	Problem	102.29 $\pm$ 1.87	142.07
Tautara	Low-damage	6.38 $\pm$ 0.05	8.86
Tumunui	Problem	17.47 $\pm$ 0.37	24.26

¹Tumunui site felled before completion of study.

Frass trapping

Paropsis charybdis frass was detected over a six month period from mid-October till late March (Fig. 1). Frass levels in the problem sites were higher than in the low-damage sites. Three main periods of frass production are apparent, occurring in early November, early December and early January. The November period is characterised by two rises in frassfall. The major period with longer duration and higher volume occurred from December through to January. Moderate levels of frass were apparent

FIGURE 1: *Paropsis charybdis* frass measurements ($\pm$ SE) in central North Island *Eucalyptus nitens* study sites. Dashed lines are from problem sites and solid lines are from low-damage sites.

from early February until mid-March. Little pattern is evident at the low-damage sites although small rises were seen in February.

Egg parasitism

Parasitism rates of *P. charybdis* eggs by *E. nassau*i (Table 2) show that early season parasitism rates for all three sites are below 20%, but that late season parasitism was above 80%.

TABLE 2: Early season and late season numbers of *P. charybdis* eggs collected and their parasitism rate by *E. nassau*i for the three problem study sites.

Site	Early season		Late season	
	<i>P. charybdis</i> eggs	% Parasitised	<i>P. charybdis</i> eggs	% Parasitised
Poronui 1	1118	14.7	861	87.7
Poronui 2	1061	12.6	2166	80.8
Tumunui	1968	17.0	123	92.7

DISCUSSION

Two generations of *P. charybdis* occur each summer. Phases of the life cycle correlate with the main periods of frass production seen in Fig. 1. The initial frass period results from consumption of the host flush (expansion of new shoots) by beetles recently emerged from overwintering. This feeding stimulates the commencement of reproduction and oviposition. The eggs hatch one to two weeks later, and early instar larvae feed exclusively on expanding foliage as they are too small to attack mature foliage. The major period of defoliation and corresponding frass production during December and January results from the presence of large numbers of *P. charybdis* larvae. Fully developed larvae drop to the ground to pupate. Emergence of adults from this pupation coincides with the subsequent period of frass production seen during

February and March. At this time, teneral beetles consume a second host flush in preparation for breeding, or if emerging later in the season, storage of fat bodies for overwintering.

The production of large amounts of frass presumably due to the presence of large larval populations would suggest that *E. nassaui* has not effectively attacked *P. charybdis* eggs during spring. A simple monitoring of egg-parasitism rates in these sites confirmed this, with parasitism in the early season period at less than 20%. Due to high parasitism rates in the late season period, *P. charybdis* larvae were uncommon, and a second period of larval defoliation that would otherwise have occurred (Kay 1990) was effectively removed. *Paropsis charybdis* outbreaks seen in problem sites in this study appear to result from poor spring parasitism by *E. nassaui*.

Although a monospecific study, frass levels presented here are comparable to those of natural systems in Australia. Ohmart (1985) suggested that typical frassfall in woodland *Eucalyptus* ranges from 100–150 kg/ha/yr (dry weight). Our data suggest that outbreak *P. charybdis* populations, even when the second larval generation is almost entirely removed, can still cause substantial defoliation. Although errors may have resulted from using larval assimilation efficiency instead of the higher adult value (Edwards and Wightman 1984) we assumed that larvae contributed the majority of frass/defoliation to simplify the results. The frass data from low-damage sites seems remarkably consistent, suggesting that where *E. nassaui* operates effectively, *P. charybdis* is maintained at barely detectable levels. *Trachymela sloanei* (Blackburn) is another introduced paropsine with frass similar to that of *P. charybdis*, but as this was uncommon in the study region, it is assumed to have had a negligible contribution to frassfall.

Even moderate paropsine defoliation reduces *Eucalyptus* growth rates for several seasons (Elliott *et al* 1993), impacting on the economic viability of *Eucalyptus* plantations. The potential of bio-insecticides (Jackson and Poinar 1989) and conventional insecticides (Baker and de Lautour 1962) to control paropsines have been well documented. However, bio-insecticides suffer from problems of application timing and field-durability, and conventional insecticides have undesirable non-target impacts.

That *E. nassaui* could fail to effectively control *P. charybdis* in New Zealand conditions was not unexpected. Bain and Kay (1989) doubted the ability of the parasitoid to self-perpetuate in cool inland areas of New Zealand. *Eucalyptus nitens* is often planted in colder sites to take advantage of its frost tolerance (Wilcox 1980), and *P. charybdis* outbreaks similar to those shown here are consistently recorded from colder inland sites (Forest Research, unpubl. records). We hypothesise that *E. nassaui* is inadequately adapted to conditions in some parts of New Zealand due to introductions originating from frost-free areas in western Australia. *Enoggera nassau* has a widespread range in Australia (Naumann 1991). Therefore, there may be biotypes from areas climatically matched to cooler areas in New Zealand that are better suited for control of *P. charybdis* in these areas. Current research is focusing on the potential of Tasmanian *E. nassau* for this purpose.

CONCLUSION

Despite the presence of a biological control agent, severe problems with *P. charybdis* defoliation can still occur in the Central North Island region of New Zealand. These may result from the parasitoid *E. nassau* failing to achieve high parasitism levels of *P. charybdis* eggs in spring.

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