Paropsine beetles (Coleoptera: Chrysomelidae) in south-eastern Queensland hardwood plantations: identifying potential pest species

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Summary

Paropsine chrysomelid beetles are significant defoliators of Australian eucalypts. In Queensland, the relatively recent expansion of hardwood plantations has resulted in the emergence of new pest species. Here I identify paropsine beetles collected from *Eucalyptus cloeziana* Muell. and *E. dunnii* Maiden, two of the major *Eucalyptus* species grown in plantations in south-eastern Queensland, and estimate the relative abundance of each paropsine species. Although I was unable to identify all taxa to species level, at least 17 paropsine species were collected, about one-third of which have not been previously associated with hardwood plantations. *Paropsis atomaria* Olivier and *P. charybdis* Stål were the most abundant species collected in *E. cloeziana* plantations, while *Chrysophtharta cloelia* (Stål) and *P. atomaria* were most commonly collected from *E. dunnii*. Occasional collections from *Corymbia citriodora* (Hook.) Hill and Johns. ssp. *variegata* revealed an additional four species implicated in plantation damage. Abundance and voltinism varied between species and sites. I predict which paropsine species are likely to threaten plantation productivity.

Keywords: defoliation; insect pests; plantations; *Chrysophtharta*; *Paropsis*; *Eucalyptus cloeziana*; *Eucalyptus dunnii*

Introduction

Paropsine chrysomelid beetles are major pests in all Australian states where eucalypts are grown commercially (de Little 1989; Simmul and deLittle 1999). Indeed, the single most important economic pest of commercial hardwood production forests in Tasmania is the paropsine beetle *Chrysophtharta bimaculata* (Olivier) (Elliott *et al.* 1998). Adult beetles and larvae feed on the flush foliage of eucalypts, removing apical leaves and resulting in a characteristic 'broom-topped' appearance. Severe defoliation by paropsines can affect the growth rate, height, volume and possibly pulpwood quality of trees (Candy *et al.* 1992; Elek 1997; Elliott *et al*. 1998). Paropsines cause not only significant losses to eucalypt plantations in Australia, where the beetles and trees are native, but also where the beetles have been accidentally introduced to eucalypt-growing regions of South Africa (Tribe 2000) and New Zealand (Withers 2001).

The expansion of hardwood plantations throughout peri-coastal Australia, often with eucalypt species planted outside their native ranges (e.g. *E. globulus* Labill. in Western Australia; *E. nitens* (Deane and Maiden) Maiden in Tasmania), resulted in unpredicted paropsine species emerging as pests. For example, *C. agricola* (Chapuis) was not considered a risk to commercial forestry but became a significant pest of *E. nitens* in Tasmania (de Little 1989), and the two most abundant paropsine species (*C. variicollis* (Chapuis) and *C. nobilitata* (Erichson)) in *E. globulus* plantations in WA were not pests of native forest there (compare Selman 1994; Loch 2005), nor were they initially considered pests of *E. globulus* (see Simmul and deLittle 1999). Indeed, reference to paropsine chrysomelids is almost entirely absent from the seminal Australian forest entomology texts of Froggatt (1923, 1927), published when only native forest logging occurred. Damage and high numbers of paropsine beetles in native forest regrowth was reported by Greaves (1966). Further, there is some evidence of paropsine species expanding their geographic distribution in response to plantation estate expansion (Nahrung and Allen 2003; Nahrung 2004).

The relatively recent introduction of large-scale eucalypt planting in Queensland is likewise leading to the emergence of new pest species. Wylie and Peters (1993) did not list any paropsines as emergent plantation pests, but only a decade later several paropsine pests were recognised (Lawson and Ivory 2000). Furthermore, anecdotal evidence suggests that the duration of beetle activity in the field in the sub-tropics is longer than that experienced in temperate regions; hence paropsine beetles may become more significant pests in the former area.

For this study I sampled three plantations representing two *Eucalyptus* species, *E. cloeziana* and *E. dunnii*, grown within their native ranges (see Boland *et al.* 1992) in south-eastern Queensland (SEQ), to identify the most abundant paropsine beetle species, and hence, those most likely to establish as significant pests of commercial hardwood forestry in the Australian sub-tropics. I compare voltinism and relative seasonal abundance of the most common species.

Materials and methods

Three eucalypt plantations in SEQ were sampled every two weeks between September 2004 and April 2005, the seasonal period when beetles were active on foliage. Beetles were collected using a beating tray and by visually searching foliage within reach of ground height (about 2 m). All beetles were collected and taken to the laboratory where their length was measured (tip of clypeus to posterior elytra) using a digital vernier calliper (±0.1 mm); their sex was determined using differences in the third tarsal segment of the foreleg (Baly 1862) and they were identified to species, where possible, or otherwise designated morphospecific monikers within determined genera. Representative specimens of all species collected are deposited in the Queensland Department of Primary Industries and Fisheries Forest Insect Collection, Meiers Road, Indooroopilly.

The plantations were all on ex-pasture land and were 2–3 y of age at the time of sampling. Site details are as follows:

- *Eucalyptus cloeziana*: Site I (via Gympie) 26°04'30.72"S 152°44'8.88"E about 38 ha planted in May 2002; Site II (via Glastonbury) 26°11'20.4"S 152°29'40.2"E about 10 ha planted in March 2002. *Ad-hoc* sampling was also conducted on 2-y-old spotted gum, *Corymbia citriodora* subsp. *variegata*, another major forestry species in Queensland, which had been planted concurrently with the *E. cloeziana* at Site I.
- *Eucalyptus dunnii*: Site III via Beaudesert 28°00'3.24"S 152°55'26.4"E about 7 ha planted June 2001.

The two *E. cloeziana* plantations were quantitatively sampled every two weeks by collecting beetles for about 15 minutes from each of eight representative plots throughout each plantation, allowing comparison of abundance between the two sites. The *E. dunnii* plantation was sampled by collecting for at least 45 min from trees throughout the entire site on each monitoring date. Temporal abundance measures are therefore not comparable between eucalypt species. The temporal and relative prevalence of each beetle species collected was determined. Only species for which >10 individuals were collected over the whole season were considered in statistical analyses (*t*-tests).

To distinguish beetles that completed development in the plantation I measured elytral rigidity as an indicator of beetle maturity (i.e. teneral (soft) beetles represented those recently emerged from pupation and probably developed from larvae within the site). Elytral softness was qualified by compressing the beetle antero-posteriorly: any elytral deformation indicated that the beetle was newly emerged and assumed to be sexually immature (see Nahrung and Allen 2004). The proportion of hard and soft beetles of each species was used to estimate the number of generations of each of the common species for the 2004–2005 season. Peaks in the proportion of teneral beetles signified emergence of new-generation adults, from which voltinism was inferred. Size of males and females was compared for each species using *t*-tests to which Bonferroni corrections were not applied since the procedure appears to lack biological justification (Moran 2003).

Results

A total of 4364 specimens, representing at least 17 species from four genera, was collected from the three plantations throughout the season (Table 1). Of these, three species were found at all three sites, while three were collected only from *E. cloeziana* plantations, and ten were collected only from the *E. dunnii* plantation (Table 1). At all sites, the most abundant species represented about 80% of all beetles collected (Site I and Site II: *Paropsis atomaria* 83% and 79%, respectively; Site III: *Chrysophtharta cloelia* 82%). Relative abundance of remaining species varied between the *E. cloeziana* sites: *Paropsis charybdis* was the second-most abundant species at Site II, while at Site I the second-most abundant was *Chrysophtharta* 'gold-shoulders'.

At both *E. cloeziana* sites, populations of the three most abundant species (*P. atomaria*, *P. charybdis* and *C.* 'gold-shoulders') varied seasonally, peaking in March at Site I (Fig. 1a) and in January at Site II (Fig. 1b). Female beetles of all species were generally

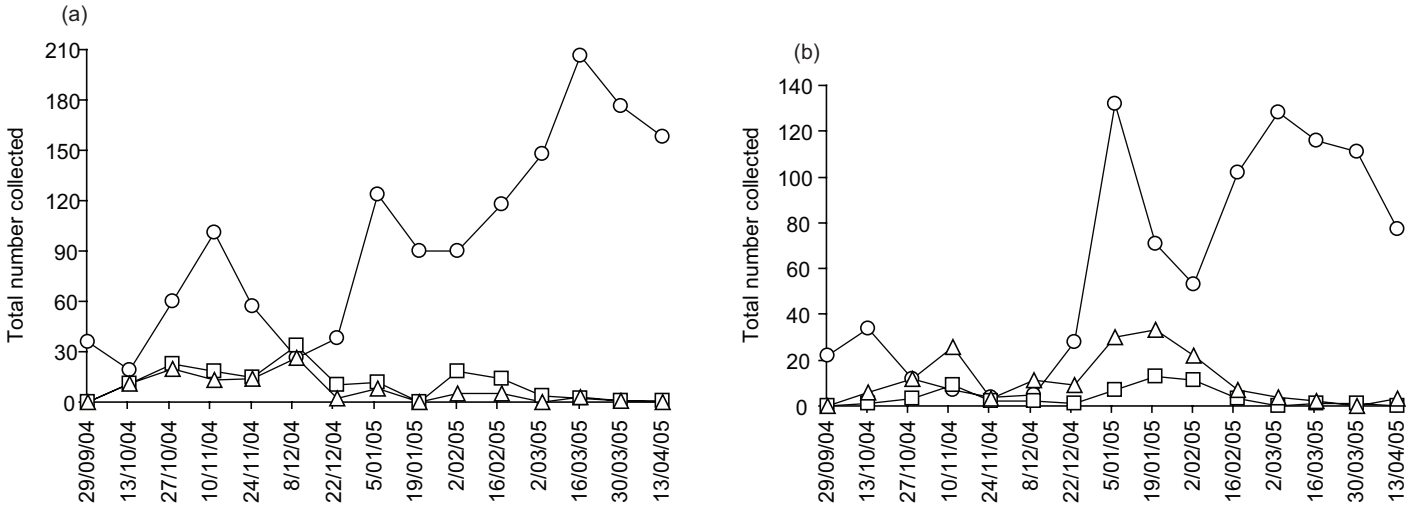

Figure 1. Total numbers of the three most abundant paropsine species collected from *Eucalyptus cloeziana* throughout the 2004/05 field season at (a) Site I plantation; (b) Site II plantation. Species are *Paropsis atomaria* (circles), *P. charybdis* (triangles) and *Chrysophtharta* 'gold-shoulders' (squares).

Table 1. Numbers, sizes, and estimated voltinism of paropsine species collected from three sites and two eucalypt species. NG = number of generations; M = male; F = female.

Paropsine species	Site (eucalypt species)								
	I (*Eucalyptus cloeziana*)			II (*Eucalyptus cloeziana*)			III (*Eucalyptus dunnii*)		
	No. (%)	Mean length ± s.e. (range) (mm)	NG	No. (%)	Mean length ± s.e. (range) (mm)	NG	No. (%)	Mean length ± s.e. (range) (mm)	NG
Chrysophtharta 'gold shoulders' (sp. 12)	165 (8.5)	M: 7.52 ± 0.04 (6.93–7.97) F: 8.17 ± 0.03 (7.26–9.12)*	2	54 (4.7)	M: 7.54 ± 0.07 (6.95–7.94) F: 8.17 ± 0.06 (7.14–8.96)*	1	0	–	–
C. nr *amoena*	0	–	–	1 (<1)	F: 7.27	#	18 (1.4)	M: 6.62 ± 0.07 (6.35–6.95) F: 7.02 ± 0.1 (6.6–7.56)*	1
C. nr *minerva*	0	–	–	0	–	–	6 (<1)	M: 7.33 ± 0.17 (7.05–7.74) F: 7.42 ± 0.87 (6.8–8.03)	#
C. m-fuscum	0	–	–	0	–	–	4 (<1)	M: 6.57 F: 7.23 ± 0.16 (7.09–7.11)	#
C. cloelia	7 (<1)	M: 7.72 ± 0.15 (7.33–8.05) F: 8.10 ± 0.12 (7.67–8.49)	#	2 (<1)	F: 8.02 M: 7.50	#	1041 (82)	M: 7.28 ± 0.02 (5.86–8.39) F: 7.98 ± 0.02 (6.25–9.12)*	2
C. sp. 21	0	–	–	0	–	–	2 (<1)	F: 6.9 ± 0.28 (6.7–7.1)	#
Paropsis aegrota	0	–	–	0	–	–	13 (1.1)	M: 9.63 ± 0.12 (8.93–10.13) F: 10.98 ± 0.59 (10.17–12.37)*	1
P. atomaria	1614 (83.3)	M: 9.82 ± 0.02 (7.4–11.85) F: 11.34 ± 0.02 (8.84–13.61)*	3–4	916 (79.3)	M: 10.07 ± 0.03 (8.25–11.98) F: 11.48 ± 0.03 (9.0–13.12)*	2	56 (4.4)	M: 10.17 ± 0.09 (8.53–11.87) F: 11.4 ± 0.16 (9.82–12.15)*	1
P. charybdis	108 (5.6)	M: 9.83 ± 0.07 (8.70–10.72) F: 10.41 ± 0.06 (8.5–11.41)*	1	168 (14.5)	M: 10.01 ± 0.05 (8.43–11.14) F: 10.46 ± 0.05 (9.28–11.18)*	2	0	–	–
P. geographica	0	–	–	0	–	–	1 (<1)	M: 9.19	#
P. lutea	0	–	–	0	–	–	1	F:	#
P. obsoleta	0	–	–	0	–	–	27 (2.1)	M: 7.19 ± 0.06 (6.77–7.66) F: 7.54 ± 0.23 (6.56–8.05)*	1
P. variolosa	18 (1)	M: 12.9 ± 0.25 (10.82–14.08) F: 13.81 ± 0.13 (13.06–14.64)*	1	13 (1.1)	M: 13.04 ± 0.19 (12.16–13.74) F: 13.42 ± 0.35 (12.18–14.17)	2	5 (<1)	M: 12.16 ± 0.88 (11.98–13.23) F: 13.24 ± 0.26 (12.94–13.66)	1
Paropsisterna sp. A	0	–	–	0	–	–	63 (4.9)	M: 11.15 ± 0.12 (10–12.36) F: 11.82 ± 0.14 (9.42–13.0)*	2–3
Paropsisterna octomaculata	0	–	–	0	–	–	2 (<1)		#

Table 1 (continued). Numbers, sizes, and estimated voltinism of paropsine species collected from three sites and two eucalypt species. NG = number of generations; M = male; F = female.

Paropsine species	Site (eucalypt species)								
	I (*Eucalyptus cloeziana*)			II (*Eucalyptus cloeziana*)			III (*Eucalyptus dunnii*)		
	No. (%)	Mean length ± s.e. (range) (mm)	NG	No. (%)	Mean length ± s.e. (range) (mm)	NG	No. (%)	Mean length ± s.e. (range) (mm)	NG
Trachymela sp. A	24 (1.2)	M: 8.52 ± 0.12 (8.05–8.83) F: 9.31 ± 0.11 (8.28–10.11)*	1	1 (<1)	F: 9.46	–	0	–	–
Trachymela catenata and sp. B	0	–	–	0	–	–	34 (2.7)	M: 6.62 ± 0.07 (6.35–6.95) F: 7.02 ± 0.1 (6.6–7.56)*	1
Total	1936			1155			1273		

* = females were significantly larger than males (*t*-test, $P<0.05$)
# = no teneral beetles were collected so the number of generations was not determined

larger than males (Table 1). The occasional samples collected from *C. citriodora* subsp. *variegata* yielded *P. atomaria*, *P. maculata* Marsham, *P. ornata* Marshall, *Dicranosterna picea*, *Trachymela* spp. and *Paropsisterna sexpustulata* (Marsham).

Discussion

Based on these survey results, *Paropsis atomaria*, *P. charybdis*, *Chrysophtharta cloelia* and *C.* 'gold-shoulders' appear the most likely pest species of the currently-favoured hardwood plantation species in SEQ. Although initially not considered a major pest in commercial eucalypt plantations (Elliott *et al.* 1998), *P. atomaria* is now a recognised pest of *E. grandis* (Hill ex Maiden), *E. cloeziana* and *E. pilularis* Smith in Queensland and NSW, and of *E. camaldulensis* Dehnh., *E. dunnii* and *E. pilularis* in NSW (Simmul and de Little 1999; Lawson and Ivory 2000) and is associated with several eucalypt species in Victoria (Collett 2001) and South Australia (Phillips 1996). This survey extends potentially at-risk plantation species in Queensland to *E. dunnii* and *C. citriodora* subsp. *variegata*, the latter its first host record for *Corymbia* (see CAB International 2005). Moreover, *P. atomaria* was the only paropsine species found at all sites and on all three eucalypt species in this study. *Paropsis atomaria* was recently detected in a *Corymbia* trial at Walkamin, via Atherton in northern Queensland (*pers. obs.*), its northernmost collection record (M. Schutze, QUT, *pers. comm.* 2005). Its broad host range of around 20 species (CAB International 2005) further implies it is likely to achieve significant pest status in Queensland hardwood plantations. However, it appeared to perform better on *E. cloeziana* than on *E. dunnii* in this study, reaching much higher levels of abundance and undergoing more generations on the former species. Mason (2003) also reported a preference for *E. cloeziana* over *E. dunnii* by *P. atomaria* in larval performance trials. *Eucalyptus dunnii* hosted about twice the number of paropsine species than did either *E. cloeziana* or *C. citriodora* subsp. *variegata*, although climatic conditions may also influence the distribution of beetles between sites.

Paropsis charybdis is a major defoliator of eucalypts in New Zealand, where it was accidentally introduced (Styles 1970; Withers 2001), and is a pest of *E. nitens* plantations in Tasmania (de Little 1989), although was considered rare in Australia prior to the large-scale planting of suitable host species (see Styles 1970; Withers 2001). Its native geographic range extends from Tasmania to Queensland and populations are thought to be highly migratory (Selman 1994). In New Zealand, it undergoes two generations each year and causes considerable damage to several eucalypt species (Styles 1970; Withers 2001). In this study, two generations were detected at one site, but it appeared to undergo just one generation at Site I. Its relatively high abundance at Site II site suggests that it might also become an important pest in Queensland hardwood plantations.

Chrysophtharta cloelia is a recognised pest of *E. grandis*, *E. pellita* F.Muell. and *E. urophylla* Blake in Queensland, and of *E. grandis* and *E. dunnii* in NSW (Selman 1994; Elliott *et al.* 1998; Simmul and deLittle 1999): its preferred host, however, is thought to be *Angophora floribunda* (Smith) (Selman 1994). In the *E. dunnii* plantation surveyed here, it appeared to have only two generations during the season, although in NSW it can have up to five (Elliott *et al.* 1998). There was no evidence of it reproducing on the *E. cloeziana* surveyed, although a small number of mature adults was collected from both *E. cloeziana* plantations sampled. *Chrysophtharta cloelia* is considered a member of a complex of species that also includes *C. obovata* (Chapuis) and *C. variicollis* (Chapuis) (Selman 1985) which, collectively, are pests of *E. grandis*, *E. camaldulensis*, *E. globulus*, *E. nitens*, *E. dunnii* and *E. viminalis* (Simmul and deLittle 1999; Loch 2005).

Despite its abundance and likely pest status, *C.* 'gold-shoulders' is an undescribed species, and is the only common species collected in this survey that has not been implicated in plantation damage in other Australian states. Of the other species collected, *C. amoena* (Clark), *P. aegrota* Boisduval, *P. obsoleta* Olivier, *P. variolosa* Marshall, *Paropsisterna* spp. and *Trachymela* spp. are pests of commercial hardwoods in other areas (Phillips 1996; Simmul and deLittle 1999; Carnegie 2002). About one-third of the species collected in this study have not been previously associated with eucalypt plantations.

The 2004–2005 season was exceptionally dry, with only two-thirds the long-term average rainfall at Site III, and 25% less

rainfall than average at Sites I and II during the sampling period (Bureau of Meteorology). The resultant lack of flush new growth probably affected the population dynamics of the species examined here, since paropsine adults prefer flush growth for oviposition (Steinbauer *et al.* 1998) and larvae require young growth for feeding establishment and development (Larsson and Ohmart 1988; Nahrung *et al.* 2001). Hence, we may expect paropsine populations to reach higher levels in more favourable seasons than those experienced here.

Conclusions

The last decade has seen an increase in the establishment of eucalypt plantations in SEQ with a coincident increase in the appearance of paropsine beetles associated with them (compare Wylie and Peters 1993; Lawson and Ivory 2000). Paropsine beetles are important pests in eucalypt plantations in other Australian states, New Zealand and South Africa. The most abundant species in *E. cloeziana* and *E. dunnii* plantations in SEQ in this survey were *Paropsis atomaria*, *P. charybdis*, *Chrysophtharta cloelia*, and *C.* 'gold shoulders' (an undescribed species), with several other species collected.

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