Cardiaspina fiscella (the brown lace lerp, Hemiptera: Psyllidae) in Western Australia

J D FARR*

Science Division, Department of Parks and Wildlife, Manjimup, Locked Bag #2, Manjimup, Western Australia, 6258

** Corresponding author ✉ janet.farr@dpaw.wa.gov.au*

ABSTRACT

In Australia the genus *Cardiaspina* contains 24 known species, most of which are found in eastern Australia. Of these, 10 species are known to cause serious defoliation of their host eucalypts. In Western Australia there are three endemic species, of which only one, *C. jerramungae* Taylor, has been known to reach outbreak levels. However, in 2001 *C. fiscella* Taylor was found in a *Eucalyptus robusta* Sm plantation near Albany WA. Previously unknown in WA, this species was initially recognised as a generic incursion; however, it is now well distributed on known eastern state eucalypt hosts throughout south-west Western Australia. Although no recognised hosts grow naturally in Western Australia, karri is closely related to known hosts and therefore a potential host for this species.

KEYWORDS: Introduced species, outbreak, karri, *Eucalyptus diversicolor*, forest pests, climate change

INTRODUCTION

Cardiaspina fiscella Taylor, commonly known as the brown lace lerp, is known to outbreak on eucalypts in NSW, Queensland and Victoria (Collet 2001). The genus *Cardiaspina* refers to a group of Hemipteran insects in the family Psyllidae. They are sapsuckers and build protective tests, called lerps under which the nymphs live on their host leaf. The nymphs and adults vaguely resemble aphids or small cicadas. Adults are winged and can disperse easily on the wind and in the jet stream. This genus contains many species known to outbreak on eucalypts throughout Australia. There are 24 Australian species (Morgan 1984, Hollis 2004). Ten species are known to outbreak and cause severe defoliation on eucalypts and, of these, four are known to cause severe, prolonged defoliation due to population outbreak (Table 1).

The genus predominates in eastern Australia and was introduced to New Zealand (*C. fiscella*) in 1996 where it spread rapidly on *E. botryoides* Sm and *E. saligna* Sm (Withers & Bain 2000, Withers 2001). In Western Australia there are three endemic species (Table 1). However, only *C. jerramungae* Taylor is known to cause severe defoliation. This species was first found in 1982 in a population outbreak on *E. occidentalis* Endl. (flat-topped yate) in the lower great southern (Farr 1992, Taylor 1992).

C. FISCELLA IN WESTERN AUSTRALIA

In Western Australia *C. fiscella* was first observed in a *Eucalyptus robusta* Sm plantation on Hanrahan Rd Albany WA in October 2001. Samples were sent to Australian National Insect Collection, CSIRO Canberra where they were positively confirmed as *C. fiscella* on 6 Nov 2001 by Mary Carver. Subsequently, the major insect collections at the Department of Parks and Wildlife WA (then Department of Conservation and Land Management), WA Department of Agriculture and Food, and the Western Australian Museum were contacted and all confirmed no records of *C. fiscella.* Consequently it was concluded that there was an incursion of *C. fiscella* in WA. However, subsequent to the initial discovery, further populations were found in Yarloop on *E. botryoides* (an amenity tree in a park at the south end of the old Yarloop workshops) on 7 Nov 2001, on amenity trees (*E. botryoides*) at the University of Western Australia research station at Floreat on 11 Nov 2001 where all populations were at high levels, and later in the koala enclosure at the Perth Zoo on April 19 2003 (J. Farr, personal observation). The psyllid was also later observed on *E. botryoides* in the memorial avenues of Kings Park and a plant nursery in Nannup in 2010 (Allan Wills Senior Technical Officer, Department of Parks and Wildlife WA); and in May 2015 by Mark Brundrett (Senior Ecologist, Department of Parks and Wildlife WA) in amenity plantings at the Department of Parks and Wildlife Perth Crawley on *E. robusta* Sm (Figure 1). In 2001 the then Forest Health Advisory Committee (FHAC) therefore concluded that although a generic incursion had occurred the species was now wide spread throughout southern WA and so the current Generic Incursion Management Plan (Gadgil 2000) for species eradication was not implemented.

BIOLOGY AND CONSERVATION ISSUES

There are usually three to five generations a year within the genus *Cardiaspina*, determined by ambient temperature. In south-west WA *C. jerramungae* has three generations per year, one in winter (May–Nov) and two in summer/autumn (Dec–Feb, Feb–May). However, exact timing can vary depending on the season (Farr 1992). It is likely that generation timing for *C. fiscella* will be similar. Nymphs of the species *C. fiscella* usually live on the

Table 1. *Cardiaspina* species in Australia.

Species	Authority	Distribution Status	Outbreak occurred	State outbreak
alba	(Frogg 1923)	NSW		
albicollaris	Taylor 1962	NSW, SA		
albitextura	Taylor 1962	NSW, SA, Vic	**	SA, Vic
artifex	(Schwarz 1898)	SA	*	Qld
bilobata	Taylor 1989	NSW, Vic	*	Vic (new in 1984)
brunnea	(Frogg 1923)	NSW		
caestata	Taylor 1992	Tas		
cerea	(Signoret 1879)	Qld		
corbula	Taylor 1962	NSW, Qld, Vic		
densitexta	Taylor 1962r	SA	**	SA, Vic
fiscella	Taylor 1962	NSW, Vic, WA	**	NSW, Qld, NZ, Vic
jerramungae	Taylor 1992	WA	**	WA (new in 1982)
maniformis	Taylor 1962	NSW	*	NSW, Qld
pinnaeformis	(Frogg 1900)	NSW, Vic		
retator	Taylor 1962	NSW, SA, Vic	*	Vic, SA
spinifera	(Frogg 1923)	NSW		
spinosula	(Signoret 1879)	Qld		
squamula	Taylor 1962	NSW	*	Tas
tenuitela	Taylor 1962	NSW	*	NSW
tetragonae	Taylor 1989	NT, WA		
tetrodontae	Taylor 1989	NT, Qld, WA		
textrix	(Frogg 1901)	NSW, Vic		
virgulipelta	Taylor 1962	NSW, Qld		
vittaformis	(Frogg 1923)	NSW		

(*= outbreak recorded, **= known for prolonged outbreaks)

Australian Capital Territory is included in NSW.

From Collet (2001), Hollis (2004) and Morgan (1984) supplemented by recent knowledge.

underside of leaves, where their stylets penetrate leaves through stomates. Another psyllid, *C. maniformis* Taylor is often found on the upper leaf surface in association with *C. fiscella* (Campbell 1992) since nymphs of this psyllid are capable of piercing the leaf cuticle. To date, *C. maniformis* has not been found in WA.

C. fiscella is known to outbreak on all its hosts in NSW and Victoria (Campbell 1992). Host range for individual psyllid species within *Cardiaspina* is usually restricted to two to three closely related eucalypts. But the hosts of *C. fiscella* in eastern Australia extend to six eucalypts: *E. grandis* W. Hill ex Maiden, *E. saligna, E. robusta, E. tereticornis* Sm, *E. blakleyi* Maiden and *E. botryoides* (Taylor 1962, Hollis 2004). *E. saligna* and *E. grandis* are in Transversaria section of *Eucalyptus* and all are closely related (Boland *et al* 2006). Karri (*E. diversicolor* F. Muell), endemic to WA and occurring in the high rainfall zone of the south-west, is also related to this group, although it exists alone in the series Inclusae. In general psyllids are known to have narrow host ranges, restricted within taxonomically closely related species (Hodkinson 1970, Hollis 2004, Burckhardt 2014). Within this restriction, however, at high populations another psyllid known for prolonged outbreaks (*C. densitexta*) has been reported on *Eucalyptus* species other than its two recognised hosts and is capable of developing from eggs to adults on some species (including species exotic to the natural distribution of this psyllid) (White 1970). Thus psyllids, particularly in the genus *Cardiaspina*, have the potential to expand their host range. A practical test of the potential of *C. fiscella* to be a problem for *E. diversicolor* is provided by the range of exotic eucalypt species in Waikumete Cemetery in Auckland, New Zealand. There, both *E. botryoides* and *E. robusta* were reported as suffering infestations of the introduced *C. fiscella*, but not *E. diversicolor* which is also planted within the cemetery grounds (Wilcox 1998). However, *E. saligna* and *E. tereticornis* are also within the same plantings and, although also hosts for *C. fiscella*, were not reported as being defoliated by this psyllid.

Over the past 30 years mean annual rainfall in the south-west of WA has decreased (Yu & Neil 1993). Although there is debate on whether global warming is the primary cause (Smith *et al.* 2000, Li *et al.* 2004), this region is becoming progressively drier. Karri occurs on deep loam soils in the 900–1300 mm rainfall region in south-west WA (Boland *et al* 2006). Although generally recognised as not drought susceptible, its historic distribution has been shown to be influenced by changes in rainfall (Churchill 1968).

Eucalypts, in common with other tree species respond to changes in water availability by adjusting leaf area (e.g. Matusick *et al*. 2013, Matusick *et al.* 2016). Stands of regenerating karri will naturally self-thin (Rayner 1992) and modern karri silviculture is aimed at utilizing timber resources in regenerating stands that would otherwise succumb to mortality or suffer insect attack in the self-thinning process (Conservation Commission of Western Australia 2013, Forest Products Commission 2016). The incidence of the cerambycid borer, commonly called bulls-eye borer (*Phoracantha acanthocera* (Macleay)), one of the few currently known insect pests in karri, increases in

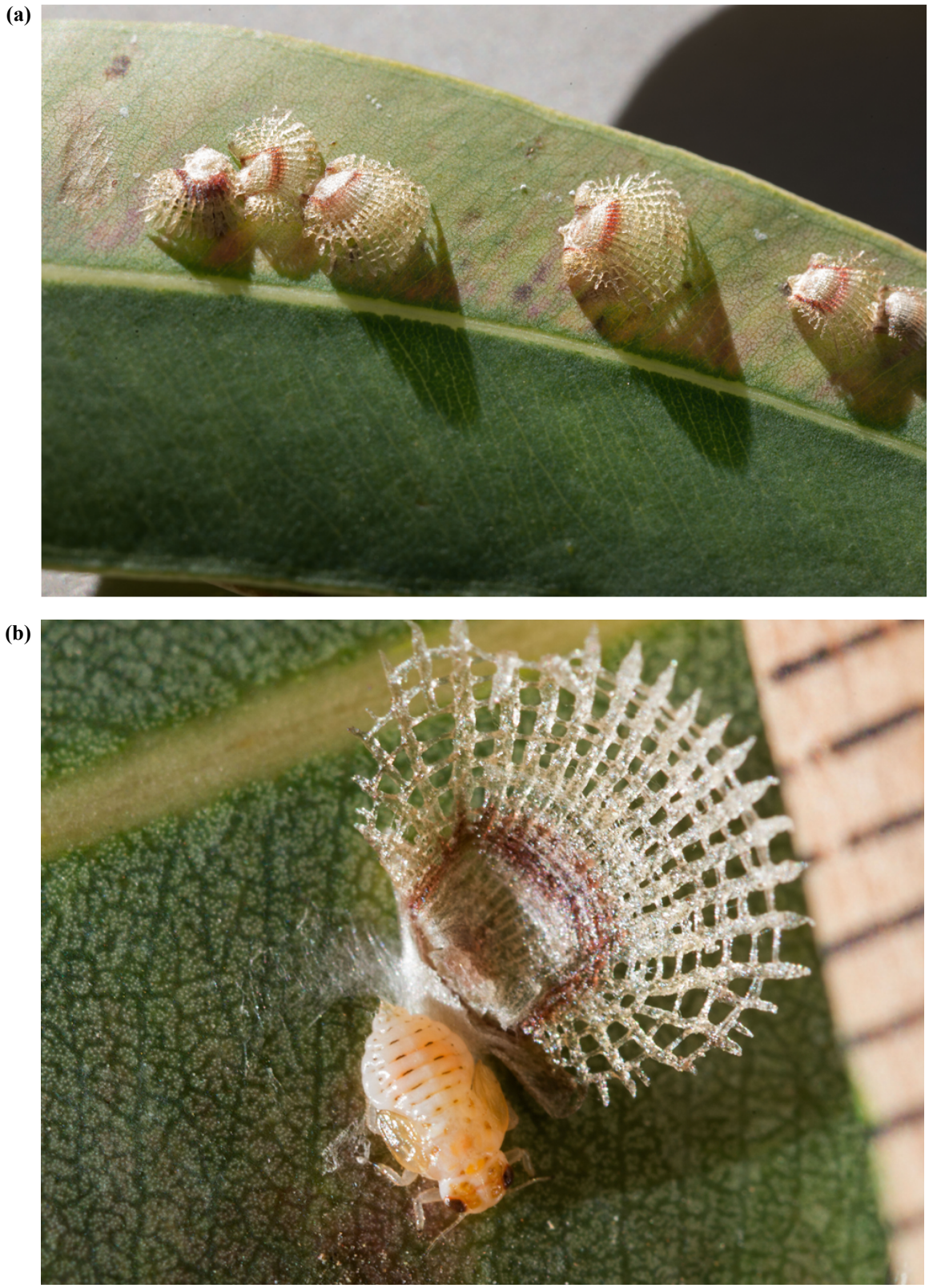

Figure 1. (a) *C. fiscella* lerps; (b) *C. fiscella* nymph and lerp (scale on right indicates millimetres). Photographs by Mark Brundrett.

dry sites (Farr *et al*. 2000), and is a threat to timber quality in un-thinned stands (Maher *et al*. 2010).

As a compensation for reduced leaf area, eucalypts increase leaf thickness and nitrogen per unit leaf area to increase photosynthetic activity (Farquhar *et al*. 2002). At a continental scale and using multiple Eucalypt species including the local Western Australian species Jarrah, Marri and Wandoo, Schulze *et al*. (2006) found that leaf nitrogen increased as rainfall declined. A widely held hypothesis on insect outbreaks implies water deficit through low rainfall can influence a plant's physiology, such that nitrogen availability to the insect herbivore increases and plant defence chemicals decrease, thus promoting insect survival and population growth (White 1984, Farr 1985, Mattson & Haak 1987). Although there is conflicting evidence for the plant stress hypothesis, an adaption of this concept, the pulsed stress hypthothesis (Huberty & Denno 2004, Mody *et al*. 2009), which involves intermittent stress on host plants, may more fully explain the response of phloem feeders such as psyllids which are reliant on plant turgor. Recent population outbreaks of the herbivore gum-leaf skeletonizer (*Uraba lugens* Walker on jarrah (*E. marginata*) are supportive evidence of plant stress promoting insect outbreaks in the region where Karri occurs (Wills & Farr 2016),

Climate models predict that between 0.1 – 6% of the karri estate could occur in rainfall areas below 900 mm in the next 30 years (Maher *et al*. 2010). Furthermore, potential consequences of increased levels of CO_2 could include the increased incidence of outbreaks of herbivorous insects (Coley 1998, Logan *et al*. 2003, Allen *et al*. 2010, Gherlenda *et al*. 2016). Therefore karri within these areas could be susceptible to *C. fiscella*, or other emergent endemic pest outbreaks, should species colonise karri as a result of drought and physiological changes in the tree's defence mechanisms.

CONTROL

Cardiaspina spp. generally outbreak in natural vegetation, thus control is often not applied. For plantations, control is usually implemented on a management basis, since in their natural distribution reinvasion will occur from outside the target area. Ideally, since this insect is a sapsucker and the nymphs live under a protective test, a systemic insecticide may be appropriate. However past experience has shown that impromptu application of insecticide for controlling outbreaks associated with this genus in natural environments can exacerbate rather than solve the problem unless extensive measures are taken to control populations on all nearby hosts and repeated applications are synchronised with the species' generation times and life cycle (Farr, personal observations 1992). Further information on insecticidal control can be found in Morgan (1984), Stone (1993), Neuman and Collett (1997) and Collett (2001). In NZ the parasitoid *Psyllaephagus gemitus* was investigated as a possible biological control for *C. fiscella* (Withers & Bain 2000) but was later found in field populations suggesting it was introduced with its host. In WA *Psyllaephagus* sp. has been isolated from *C. jerramungae* populations (Farr 1992), but the species has not been identified further and this parasitoid achieves little control in natural outbreak populations of *C. jerramungae*. Limited population control of psyllids by natural enemies has also been reported by Hall *et al*. (2015).

CONCLUSION

The brown lace lerp *C. fiscella*, a psyllid formerly only known in eastern Australia, is now established in Western Australia, currently on eucalypt species exotic to this state. This species has a history of causing serious defoliation of its host eucalypts during high population densities, both in its natural environment and environments where it has been introduced. The parasitoid *P. gemitus* is not known to control this psyllid but is known to have been introduced concomitant with the psyllid into NZ. Wasps of the genus *Psyllaephagus* are known to be associated WA endemic populations of *C. jerramungae*, therefore *P. gemitus* is likely to already be present in Western Australia but this has not been investigated. Furthermore, given the potential scenarios for climate change in the south-west of WA, karri is a potential host for this psyllid.

ACKNOWLEDGEMENTS

Thank you to Mary Carver for identifying specimens. Andrew Loch is thanked for finding the first Albany samples. The Western Australian Museum and Department of Agriculture and Food are thanked for inspection of their collections. Mark Brundrett, Department of Parks and Wildlife is thanked for his observations. Allan Wills is thanked for his road surveys to determine distribution in the south-west of Western Australia and for helpful comments on the manuscript. Thank you to Dr Jonathon Majer for editorial comments and suggestions.

REFERENCES

Allen C D, Macalady A K, Chenchouni H, Bachelet D, McDowell N, Vennetier M, Kitzberger T, Rigling A, Breshears D D, Hogg E H, Gonzalez P, Fensham R, Zhangm Z, Castro J, Demidova N, Lim J-H, Allard G, Running S W, Semerci A, Cobb N 2010. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. *Forest Ecology and Managemen*t 259, 660–684.

Boland D J, Brooker M I H, Chippendale G M, Hall N, Hyland B P M, Johnstone R D, Kleinig D A, McDonald M W & Turner J D 2006. *Forest trees of Australia.* Nelson, CSIRO Australia.

Burckhardt D, Ouvrard D, Queiroz D & Percy D 2014. Psyllid host-plants (Hemiptera: Psylloidea): Resolving a semantic problem. *Florida Entomologist* Mar 2014, pp. 242–246.

Campbell K G 1992. The biology and population ecology of two species of *Cardiaspina* (Hemiptera: Psyllidae) in plague numbers on *Eucalyptus grandis* in New South Wales. *Proceedings of the Linnean Society of New South Wales* 113, 135–150.

Churchill D M 1968. The distribution and prehistory of *Eucalyptus diversicolor* F. Muell., *E. marginate* Donn Ex Sm., and *E. calophylla* R.B.R. in relation to rainfall. *Australian Journal of Botany* 16, 125–151.

Coley P D 1998. Possible effects of climate change on plant/herbivore interactions in moist tropical forests. *Climate Change* 39, 455–472.

Collett N 2001. Biology and control of psyllids, the possible causes for defoliation of *Eucalyptus camaldulansis* Dehnh. (river red gum) in south-eastern Australia – a review. *Australian Forestry* 64, 88–95.

Conservation Commission Of Western Australia 2013. *Forest management plan 2014–2023*. Perth Western Australia.

Farquhar G D, Buckley T N, Miller J M 2002. Optimal stomatal control in relatin to leaf area and nitrogen content. *Silva Fennica* 36, 625–637.

Farr J D 1985. *The performance of Uraba lugens Walker in relation to nitrogen and phenolics in its food.* PhD thesis, University of Adelaide.

Farr J 1992. Lerps bugs and gum leaves. *Landscope* 8, 50–53.

Farr J D, Dick S G, Williams M R & Wheeler I B 2000. Incidence of bullseye borer (*Phoracantha acanthocera* (Macleay): Cerambycidae) in 20–35 year old regrowth karri in the south west of Western Australia. *Australian Forestry* 63, 107–123.

Forest Products Commission 2016. *Karri forest management plan, June 2016*. Forest Products Commission, Western Australia.

Gadgil P, Australian Department Of Agriculture Fisheries And Forestry & Standing Committee On Forestry (Australia) Forest Health Committee. 2000. *Responding to incursions: a generic incursion management plan for forest pests and diseases.* Forest Health Committee [Canberra]

Hall A A G, Gherlenda A N, Hasegawa S, Johnson S N, Cook J M & Riegler M 2016. Anatomy of an outbreak: the biology and population dynamics of a *Cardiaspina* psyllid species in an endangered woodland ecosystem. *Agricultural and Forest Entomology* 17, 292–301

Hodkinson L D 1974. The biology of the Psylloidea (Homoptera): A review. *Bulletin of entomological Research* 64, 325–329

Hollis D 2004. *Australian Psylloidea. Jumping plantlice and lerp insects.* ABRS Canberra, Australia.

Li Y, Cai W, Campbell E P 2004. Statistical modelling of extreme rainfall in southwest Western Australia. *Journal of Climate* 18, 852–863.

Logan J A, Regniere J, & Powell J A 2003. Assessing the impacts of global warming on forest pest dynamics. *Frontiers in Ecology and the Environment* 1, 130–137.

Maher D, McCaw L & Yates C 2010. *Vulnerability of Forests in South-West Western Australia to Timber Harvesting Under the Influence of Climate Change.* Department of Environment and Conservation SFM Technical Report No. 5

Mattson W J & Haack R A 1987. The role of drought in outbreaks of plant-eating insects *BioScience* 37, 110–118.

Matusick G, Ruthrof K X, Brouwers N C, Dell B & Hardy G E St J 2013. Sudden forest canopy collapse corresponding with extreme drought and heat in a mediterranean-type eucalypt forest in southwestern Australia. *European Journal of Forest Research* 132, 497–510.

Matusick G, Ruthrof K X, Fontaine J B & Hardy G E St J 2016. Eucalyptus forest shows low structural resistance and resilience to climate change-type drought. *Journal of Vegetation Science*. 27, 493–503.

Mody K, Eichenberger D & Dorn S 2009. Stress magnitude matters: different intensities of pulsed water stress produce non-monotonic resistance responses of host plants to insect herbivores. *Ecological Entomology*. 34, 133–143.

Morgan F D 1984. *Psylloidea of South Australia*. Government Printer, South Australia.

Neuman F G & Collett N G 1997. Insecticide trials of the steele blue saw fly (*Perga affinis*), a primary defoliator in young commercial eucalypt plantations of south-eastern Australia. *Australian Forestry* 60, 75–83.

Stone C 1993. Fertilizer and insecticide effects on tree growth and psyllid infestation of young *Eucalyptus grandis* and *E. dunnii* plantations in northern New South Wales. *Australian Forestry* 56, 257–263.

Wilcox M D 1998. Eucalypts at Waikumete Cemetery. *Auckland Botanical Society Journal* 53, 36 37.

Withers T M 2001. Colonization of Eucalypts in New Zealand by Australian insects. *Austral Ecology* 26, 467–476.

Withers T M & Bain J 2000. Mysterious arrival of *Cardiaspina* parasitoid. *NZ Tree Grower* May, 33.

White T C R 1970. Some aspects of the life history, host selection, dispersal, and oviposition of *Cardiaspina densitexta* (Homoptera: Psyllidae). *Australian Journal of Zoology* 18, 105–117.

White T C R 1984. The abundance of invertebrate herbivores in relation to the availability of nitrogen in stressed food plants. *Oecologia* 63, 90–105.

Rayner M E 1992. Evaluation of six site classifications for modelling timber yield of regrowth karri (*Ecalyptus diversicolor* F. Muell.). *Forest Ecology and Management* 54, 315–336.

Schulze E D, Turner N C, Nicolle D, Schumacher J 2006. Leaf and wood carbon isotope ratios, specific leaf areas and wood growth of *Eucalyptus* species across a rainfall gradient in Australia. *Tree Physiology* 26, 479–492.

Smith I N, McIntosh P, Ansell T J, Reason C J C & McInnes K 2000. Southwest Western Australian winter rainfall and its association with indian ocean climate variability. *International Journal of Climatology* 20, 1913–1930.

Taylor K L 1962. The Australian Genera Cardiaspina Crawford and Hyalinaspis Taylor, (Homoptera: Psyllidae). *Australian Journal of Zoology* 10, 307–348.

Taylor K L 1992. Two new species of *Cardiaspina* Crawford (Hemiptera: Psyllidae) from Western Australia and Tasmania. *Journal of Australian Entomological Society* 31, 171–175.

Wills A J & Farr J D 2016. Gumleaf skeletonizer *Uraba lugens* (Lepidoptera: Nolidae) larval outbreaks occur in high rainfall Western Australian jarrah (*Eucalyptus marginata*) forest after drought. *Austral Entomology* (in press) http://dx.doi.org/10.1111/aen.12255

Yu B & Neil D T 1993. Long-term variations in regional rainfall in the south-west of Western Australia and the difference between average and high intensity rainfalls. *International Journal of Climatology* 13, 77–88.