

Strangers in a strange land: do life history traits differ for alien and native colonisers of novel environments?

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Strangers in a strange land: do life history traits differ for alien and native colonisers of novel environments?

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Running title: Native/alien invaders of eucalypts

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Abstract

Do alien invasive species exhibit life history characteristics that are similar to those of native species that have become pests in their continent of origin? We compared eucalypt specialists that have become pests in Australian plantations (natives) to those that have established overseas (aliens) using 13 life history traits and found that although traits that support rapid population build-up were shared, overall, aliens and native colonisers differed significantly. Distance from source (New Zealand vs other) had no significant effect, but species that established more than 50 years ago exhibited different life history traits from those that established within the last 50 years, possibly because of more effective quarantine. Native and alien eucalypt insect invaders differed predominantly in traits that facilitate long-distance movement (pathway traits), compared to traits that facilitate establishment and spread. Aliens had longer adult flight seasons, were smaller and more closely host-associated (cryptic eggs and larvae), had lower incidence of diapause (i.e. were more seasonally plastic) and more generations per year than natives. Thus, studies of species invasive within their country of origin can shed light on alien invasions.

Keywords: eucalypt, establishment, invasion biology, pathway

Introduction

The science of invasion biology has beheld a recent explosion of research seeking to understand and predict invasion processes (Blackburn *et al.* 2011). Some light has been shed on potentially important life history traits of successful invaders (e.g. reproductive rate, dispersal ability, geographic distribution, association with humans, asexual reproduction) (e.g. van Kleunen *et al.* 2010a,b; Hayes & Barry 2008; Jeschke & Strayer 2007; Kolar & Lodge 2001) and although little of the research targeted invasive arthropods, the patterns may apply across taxa (Sakai *et al.* 2001). Thompson and Davis (2011) have argued, (albeit provocatively - see Hulme *et al.* (2011), van Kleunen *et al.* (2011)), that the suite of traits exhibited by invaders is the same as for native species that expand their range; that is, that life history strategies favouring colonisation apply across ‘successful’ species, regardless of their biogeographic origin. Pysek and Hulme (2009), however, contended that comparing alien and native species contributes to a better understanding of population dynamics, ecosystem function and species evolution, as well as biodiversity and conservation. As Valery *et al.* (2009) pointed out, native species can also be invasive. Whilst it is likely that successful native and successful alien species may share similar traits, there have been few empirical tests, and consequently, no justification to disregard the native/alien distinction (van Kleunen *et al.* 2011), an approach advocated by Valery *et al.* (2013), who contend that maintaining a native/alien dichotomy restricts our ability to adequately understand species’ redistributions. Here, we use the colonisation of eucalypts planted in novel environments within and outside Australia, by native and alien insect species, to test the validity of the native/alien division in considering invasion.

Eucalypts (*Eucalyptus*, *Angophora* and *Corymbia*) dominate native sclerophyll forest throughout Australia, with over 700 species, and only four uniquely endemic species outside Australia (Wardell-Johnson *et al.* 1997). Introduced worldwide, eucalypts now comprise millions of hectares of plantations, woodlots, fence rows, windbreaks and shade trees (Doughty 2000). Thousands of native insect species are estimated to use eucalypts as hosts throughout Australia (Majer *et al.* 1997, 2000; Strauss 2001). The movement of some of these Australian native insects to countries where eucalypts are planted exotically has occurred since the late 19th century (Withers 2001), and has received much recent attention as the rate of invasions increases (e.g. Withers 2001; Kliejunas *et al.* 2003; Paine *et al.* 2010; Paine *et al.* 2011). Within Australia, the establishment of commercial eucalypt forestry plantations, with trees often planted outside their endemic range as even-aged monocultures, likewise represent novel environments for colonisation by local eucalypt herbivores (Strauss 2001) whose natural habitat often comprises heterogeneous-aged mixed-species stands (deLittle & Madden 1975). The insect communities present in native forest do differ from those in monoculture eucalypt plantations (Cunningham *et al.* 2005). Thus, as Valery *et al.* (2013) have suggested, the insects colonizing eucalypt plantations within Australia may tend to exhibit the same traits as those in classical biological (i.e. alien) invasions.

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Herein, we test whether the insects that have become successful invaders into the novel habitat represented by plantations within Australia, and those that have become successful invaders overseas, share traits that are thought to increase invasiveness. We identified 38 endemic eucalypt specialists that have become significant pests in eucalypt plantations in Australia (the native invaders) and 37 Australian eucalypt

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specialists that have been introduced overseas (the alien invaders). We examined 13 life history traits, which were divided into “pathway” (i.e. likely to facilitate long-distance movement, especially overseas) and “establishment” traits (those likely to favour survival, reproduction and spread in novel habitats). Thus, we aimed to: 1) address whether research on invasiveness traits using a native-alien distinction can be useful to advance the current debate (Thompson & Davis 2011; van Kleunen *et al.* 2011); 2) examine trait differences between alien invaders as a function of geographical source proximity and time of first invasion; and 3) determine whether potential of a species to become invasive can be predicted by life history traits in this system.

Materials and Methods

Native invaders: we identified 38 major insect pests of eucalypt plantations within Australia using Strauss (2001) and numerous pest guides and literature from each Australian State where eucalypts are grown commercially, including Carnegie *et al.* (2002, 2008), Elliott *et al.* (1998), Elliott and de Little (1984), Kleijunas *et al.* (2003), Collett (2001), Philips (1996, 2011), Loch and Floyd (2001), and several affiliated websites (Appendix 1). Only insects that were eucalypt specialists (i.e. monophagous or oligophagous within eucalypts) identified to species were used; detection records only, and pests considered minor or rare were excluded as our primary aim was to study those which were the most ‘successful’ in the novel habitat of eucalypt plantations (*sensu* Thompson & Davis (2011)).

Alien invaders: we used Paine *et al.* (2010, 2011) and Withers (2001) as our major sources for determining Australian eucalypt specialists established overseas. Only the

first detection record of each species overseas was used, to ensure that its movement was most likely from Australia and not from another country where it was already present. Species were further divided geographically into those found only in New Zealand (“near”: i.e. close to the source), only in the rest-of-the-world (“far”: i.e. 5 much further from the source than NZ), and those found in both. The movement of Australian insects onto eucalypts worldwide appears to have occurred in two phases: first, associated with movements of people and commerce within the former British Empire, and a second phase beginning in the latter half of the twentieth century (Paine *et al.* 2011), so we also divided our dataset into those that were first detected as aliens 10 more than 50 years ago (“early” alien invaders) and those detected in the last 50 years (“later” alien invaders) to represent these two phases of movement.

Because data are extremely limited for non-invaders (i.e. those not establishing in novel eucalypt habitats), such non-pest species are, by their nature, unable to be 15 included in analyses as they have not been studied in sufficient detail to allow valid comparison with those that have become economically important; we sought to identify any differences between invaders within and outside of Australia.

Life history traits were characterised from available literature and classified according 20 to their likely influence on species movement overseas (pathway traits) and on growth, reproduction and spread (establishment traits) (Table 1). Pathway traits included those that affected temporal and spatial host (commodity) affiliation (i.e. contact with the host), and those that may influence either detection ability or survival during transit (based on Kleijunas *et al.* 2003). Establishment traits were those that 25 may affect a species’ ability to survive, reproduce and spread after arrival as colonisers, including natives (Table 1). All traits were hypothesised to be positively

associated with likelihood of colonisation (e.g. larger distribution increases chance of colonisation) except those that may influence detection ability (e.g. smaller size decreases chance of detection). Because the distributions of some continuous variables were quite skewed, all traits were categorised into two to four classes with each class well-represented, for consistency in methods across all traits.

Analyses

Differences in suites of traits between species within groups (“native” vs “alien”, and, within aliens, “near” vs “far”, and “early” vs “late”) compared to species in different groups were tested for statistical significance using permutation tests based on matrices of similarities between species. For each, the similarities were calculated using all categorical attributes, using the Euclidean metric for attributes with more than two categories and the simple-matching metric for binary attributes. The tests were conducted using the GenStat (2011) procedure ECANOSIM, which uses a permutation test with test statistic, R , the difference between the between-group and within-group mean rank similarities. For each test, 9999 permutations were conducted.

To summarise and illustrate the similarities between insect species, ordines were formed from the similarity matrix using principal coordinate analysis (PCO) and the points corresponding to the first two coordinates plotted.

To determine which traits differed most between the groups, they were screened by first examining all 13 traits separately using chi-square statistics. Probabilities were

calculated for the attribute \times group contingency tables, and the attributes ranked on probabilities.

Then, to more accurately indicate the degree of difference in attribute distributions
5 between the two groups for combinations of the categorical attributes selected on the
results of the previous screening tests, generalized linear models for predicting group
were ranked on adjusted residual deviance values within the set of all possible models
with the same number of predicting attributes, and the corresponding attribute chi-
square probabilities used to indicate the added effects given the effects of the other
10 attributes in the models. The models used the binomial distribution for group and
logit link.

Finally, classification trees were used to identify combinations of attributes that might
be used to predict overseas detection and to provide classification rules. Initially the
15 same categorical attributes as previously described were included in the analysis, as
an alternative screening method and to provide a lower boundary for
misclassification. Subsequent analyses included only attributes indicated as
potentially useful in previous screening. As body size was consistently selected, its
original measurement rather than category was also used in later analyses.
20 Colinearity between predictor variables was assessed using Pearson correlations on
the data as continuous variables.

Results

Most alien eucalypt invaders are not pests in Australian plantations. Just over one-
25 quarter (10/38) of the insects that have invaded plantations within Australia have also

moved overseas (Fig. 1). All overlapping native plantation pests and aliens are found in New Zealand, with only two 'species' in common globally: *Gonipterus* "scutellatus" (Coleoptera: Curculionidae) (now recognised as multi-species complex (Mapondera 2008)) and *Ctenarytaina eucalypti* (Hemiptera: Psyllidae). Distribution of alien and native invaders according to Order and guild are shown in Fig. 2.

Using all 13 life history traits and 9999 permutations, ANOSIM showed significant differences between the three main groups (Fig. 1: only native (white), alien + native, and only alien (grey)) ($R = 0.09$, $P = 0.01$): similar pairwise comparisons showed that the neither of the main groups differed from the 10 species of overlap (alien + native) (aliens: $R = 0.04$, $P = 0.27$; natives: $R = -0.01$, $P = 0.52$), but did differ significantly from each other ($R = 0.14$, $P = 0.002$). Natives and the 10 species of overlap compared with aliens only was close to significant ($R = 0.05$, $P = 0.05$), but the strongest differences occurred between natives and aliens + the 10 species of overlap ($R = 0.24$, $P < 0.001$).

The PCO ordinates summarised about 65% of the overall distances between insect species (Fig. 3), with a stress score of 0.11. The plot of the first two ordinates showed general separation between the native and alien groups, though with some species points amongst the points from the other groups.

Based on the conclusions from the permutation tests and the ordination plots, where the 10 species in common clustered more with aliens, remaining analyses considered only the two invasion groups, natives only (white in Fig. 1) and native+alien and alien only (all grey in Fig. 1), as the native and alien invaders, respectively.

Chi-square analysis of each trait separately (Table 2) showed that those contributing most strongly to differences between natives and aliens were diapause (plasticity), diet breadth (polyphagy), larval habit, and body size. Egg placement, active months, host-associated months, voltinism and proportion of lifecycle on host differed significantly between groups, while distribution, immature occupancy, clutch size and female fecundity did not differ between natives and aliens.

A further comparison of traits between natives and aliens with all possible models using binomial distribution and all possible subsets showed that body size and immature placement were the best predictors of a species' status as an alien (smaller, more internally located) or native (larger, more externally located), with the two terms explaining 25.7% of the variation, and both body size ($P = 0.008$), and immature placement ($P = 0.001$) significant.

The full classification tree with nine categorical attributes available (those significant in Table 2) used body size, active months, immature placement, egg placement, diet breadth and host-associated months, and had a misclassification rate for species of 6/63 (9.5%). The full tree with just body size (continuous) and larval placement had a misclassification rate of 7/65 (10.8%), while a simple tree with the same variables misclassified 9/65 (13.9%). The rules for the simple tree suggest insects are more likely to be aliens if they are small (body size < 7.326) or, if larger, have more internal larval placement and are not too large (body size < 24.44) (Fig. 4). These two predictor variables (body size and larval placement) were not correlated (Spearman rank correlation, $\rho = -0.09$, $P = 0.48$).

Using all 13 life history traits, the permutation test showed no significant difference between aliens grouped by proximity to Australia (NZ vs elsewhere: $R=-0.02$, $P=0.67$). The proximity to the source (“near” vs “far”), therefore, did not impact a species’ ability to become established overseas. However, across all traits, insects that established overseas early (more than 50 years ago) differed significantly from those that colonised in the last 50 years ($R=0.17$, $P = 0.01$).

Colinearity was identified between body size, clutch size and fecundity ($r > 0.89$, $P<0.001$), while egg and larval internal placement were correlated ($r = 0.6$, $P<0.001$), and so were voltinism and diapause ($r = 0.55$, $P< 0.001$): only the first three, however, exceed the recommended threshold (Dormann *et al.* 2013), yet only one of these (body size) was found to be a significant predictor variable, so the issue of co-linearity was unlikely to have influenced our results.

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Discussion

The global colonisation of eucalypts by endemic Australian insects supports maintaining a native/alien dichotomy in invasion biology (Valery *et al.* 2013). Largely separate suites of insect species have invaded novel eucalypt habitat in Australia and overseas, yet these native and alien invaders exhibited a number of *similarities* in life history traits: geographic range, clutch size, female fecundity and immature lifestyle. These traits in common between natives and aliens were all establishment traits (Table 1). Of these, clutch size and female fecundity are reproductive traits that are important in invasive species achieving high intrinsic growth rates and high population densities (see Sakai *et al.* 2001; Jeshke & Strayer

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2007), and were strongly correlated ($r = 0.98$) in our study. Insect species that invade novel eucalypt habitat share characteristics that promote rapid population build-up, regardless of their native or alien status.

5 Broad geographic range is often positively associated with invasiveness (e.g. Kolar & Lodge 2001; Hayes & Barry 2008), and also did not differ between alien and native invaders in our study. Within Australia, many insect species that are now pests in plantations have increased their geographic range as plantations have been established (e.g. *Paropsisterna (Chrysophtharta) agricola* – Nahrung & Allen 2003, *Gonipterus*
10 *scutellatus* – Loch & Floyd 2001, *Phylacteophaga froggatti* – Mayo *et al.* 1997). As a whole, the broad geographic range from which eucalypt aliens originated (see Paine *et al.* 2010) readily allows colonisation of similar climatic regions overseas.

Climate/habitat match was the only characteristic consistently associated with invasiveness across biological groups in the study by Hayes & Barry (2008).

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Propagule pressure (number of individuals introduced) is another important factor contributing to invasion success (Hayes & Barry 2008), and its surrogate traits here (clutch size and immature lifestyle (solitary/gregarious)) did not differ between natives and aliens. However, these traits exert paradoxical potential influences
20 between the groups – in aliens, for example, a solitary lifestyle decreases detection ability (pathway success), but also decreases propagule number and likelihood of starting a viable population on arrival (establishment success). Group size can also influence host exploitation in aliens and natives (e.g. Nahrung *et al.* 2001), while for natives, these two traits can also influence both apparency and defence to natural

enemies. Given these competing directional influences, it is not surprising that these traits did not differ between native and alien species.

5 The two most important traits in *separating* aliens from natives were body size and immature placement, with smaller, more internally located species more likely to occur as aliens. These traits relate solely to the pathway (detection ability/protection in transit), contrasting with the similarities found in establishment traits (Table 2).

10 Lawton and Brown (1986) also found smaller taxa to be better colonisers, with an inverse correlation between mean body length and probability of establishment for six insect orders, which they, and later Simberloff (1989), were unable to explain.

15 Interestingly, they found that sap suckers had the strongest colonisation probability, a notion borne out in our study, where sap suckers comprised the highest representation of species in common between aliens and natives, and represented 40% and 30% of the total of each, respectively. Paine *et al.* (2011) suggested that aerial dispersal may explain the dominance of sap-suckers as aliens in New Zealand, but we found no overall differences between traits of colonisers in New Zealand and elsewhere to support aerial dispersal as a predominant mode of movement (e.g. if smaller insects had established in New Zealand compared with elsewhere).

20 The incidence of diapause was also significantly different between natives and aliens using chi-square analysis alone: a trait considered relevant to both establishment and pathway, with aliens tending to diapause less than natives, thereby differing for establishment (i.e. exhibiting a more plastic lifecycle) rather than for pathway (i.e. they were not more protected or concealed for transit). Phenotypic plasticity is an important trait promoting invasiveness of weeds, conferring the ability to cope with a

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range of environmental conditions (Sakai *et al.* 2001) and may explain its significance as an establishment trait here. Voltinism was the only other establishment trait that differed significantly between aliens and natives, with aliens having faster generation times than natives and undergoing more generations per year. Indeed, diapause and
5 voltinism are tightly linked (Tauber *et al.* 1986) and were correlated here ($r = 0.55$), with lower voltine species exhibiting lower plasticity (higher diapause).

Unexpectedly, aliens exhibited a *narrower* diet breadth than natives, and this was the only pattern that did not fit the hypothesised direction (i.e. more polyphagous species
10 are more likely to become invasive – see Jeschke & Strayer (2007)). This pattern may have been influenced by the lack of endemic host records from several alien species that were unknown from Australia prior to being found overseas, by the inherent suitability and lower number of species of eucalypts planted overseas, or by the fact that only eucalypt specialists were considered in our study, such that the degree of
15 polyphagy was insufficient to detect differences. Further, many natives have increased their diet breadth to colonise eucalypts planted outside their endemic range within Australia (Paine *et al.* 2011) which may have unequally inflated diet breadth scores for this group.

20 There was a tendency for aliens to be more closely host-affiliated than natives, in terms of both the proportion of the lifecycle and number of months spent on the host, as well as for eggs and immature stages to be more endophagous (i.e. physically closely associated (e.g. gall-formers, borers)) than natives. These traits are also more related to increased probability of movement on infested material and reduced
25 likelihood of detection and protection from desiccation (pathway traits). Pathway

traits were more likely to explain differences between alien invaders and native invaders than establishment traits.

5 Alien species' life history traits did not differ according to their proximity to the source population, suggesting that aerial dispersal plays a minimal role in alien movement for this system. Indeed, that aliens to New Zealand are more likely to be detected in Auckland than elsewhere (Withers 2001) supports the likelihood of human-mediated introductions. That species which have achieved alien status in the last 50 years differ significantly from those which became aliens in the late 19th and 10 early 20th centuries illustrates that global trade, travel and/or quarantine changes in the last 50 years have significantly impacted invasion patterns, and supports the “two phases of movement” pattern outlined by Paine *et al.* (2011). Thus, in addition to understanding the life history characteristics identified here that may contribute to species becoming aliens, pathway and risk analyses for eucalypt insects may help to 15 identify, and potentially reduce, the mechanism by which their global invasion occurs (see Lawson *et al.* 2010). It is critical to understand the international routes of movement of eucalypt herbivores and to develop ways of detecting and preventing accidental invasions (Paine *et al.* 2011).

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Table 1: Life history traits used to characterise native and alien eucalypt species, and

5 whether these traits are likely to influence the pathway (P) or establishment (E) of species as natives or aliens.

Life history trait	P/E	Hypothesis/Mechanism – based on Kleijunas <i>et al.</i> (2003), Jeschke & Strayer (2007)
Active months (adult flight period duration)	P	Influences probability of association with commodity/dispersal to transport vector
Australian distribution (n states recorded)	E	Influences ability to survive under novel environmental conditions
	P	Affects likelihood of export
Body size (mm)	P	Affects detection and ability for airborne dispersal
Clutch size (n eggs/batch)	E	Affects chance of multiple individuals being introduced
	P	Affects detection ability
Egg placement (internal/external)	P	Affects detection ability and survival (via protection) during transit
Female fecundity	E	Affects likelihood of species establishing a viable population & having a faster rate of increase
Host-associated months (any stage)	P	Influences probability of movement on commodity or propagule
Immature lifestyle (solitary/multiple)	E	Affects likelihood of species establishing a viable population through multiple individuals; gregariousness may aid defence and host exploitation
	P	Affects detection ability
Immature placement (internal/external)	P	Affects detection ability and survival (via protection) during transit
Diet breadth (ratio of number of host subfamilies to number of hosts)	E	Affects ability to utilise hosts in new environment
	P	Influences probability of association with commodity
Proportion of lifecycle on host	P	Influences probability of movement on commodity
True diapause	E	Affects seasonal plasticity and ability to adapt to conditions in new environment
	P	Affects survival in transit and detection ability
Voltinism (n generations/year)	E	Affects ability for population increase

Table 2: Chi-square values and probabilities comparing between native and alien invaders for 13 life history traits, and the general conclusion from the results.

Life history trait		Chi-square value (df)	P-value	Aliens were:
True diapause	E/P	11.99 (2)	0.002	Less likely to diapause (i.e. more plastic) than natives
Body size	P	13.74 (3)	0.003	Smaller than natives
Immature feeding habit (internal/external)	P	13.78 (3)	0.003	More internal than natives
Egg placement (internal/external)	P	12.72 (3)	0.005	More internal than natives
Active months (adult flight)	P	10.21 (2)	0.006	Active for longer than natives
Diet breadth	E/P	10.38 (2)	0.006	Less polyphagous than natives
Host-associated months (any stage)	P	9.79 (2)	0.007	More closely-host associated than natives
Proportion of lifecycle on host	P	12.01 (3)	0.007	More dependent on host for lifecycle
Voltinism	E	6.241 (2)	0.044	More voltine than natives
Australian distribution	E/P	9.02 (4)	0.061	Not different from natives
Immature lifestyle (solitary/gregarious)	E/P	2.40 (1)	0.121	Not different from natives
Clutch size	E/P	3.02 (3)	0.388	Not different from natives
Female fecundity	E	1.12 (2)	0.572	Not different from natives

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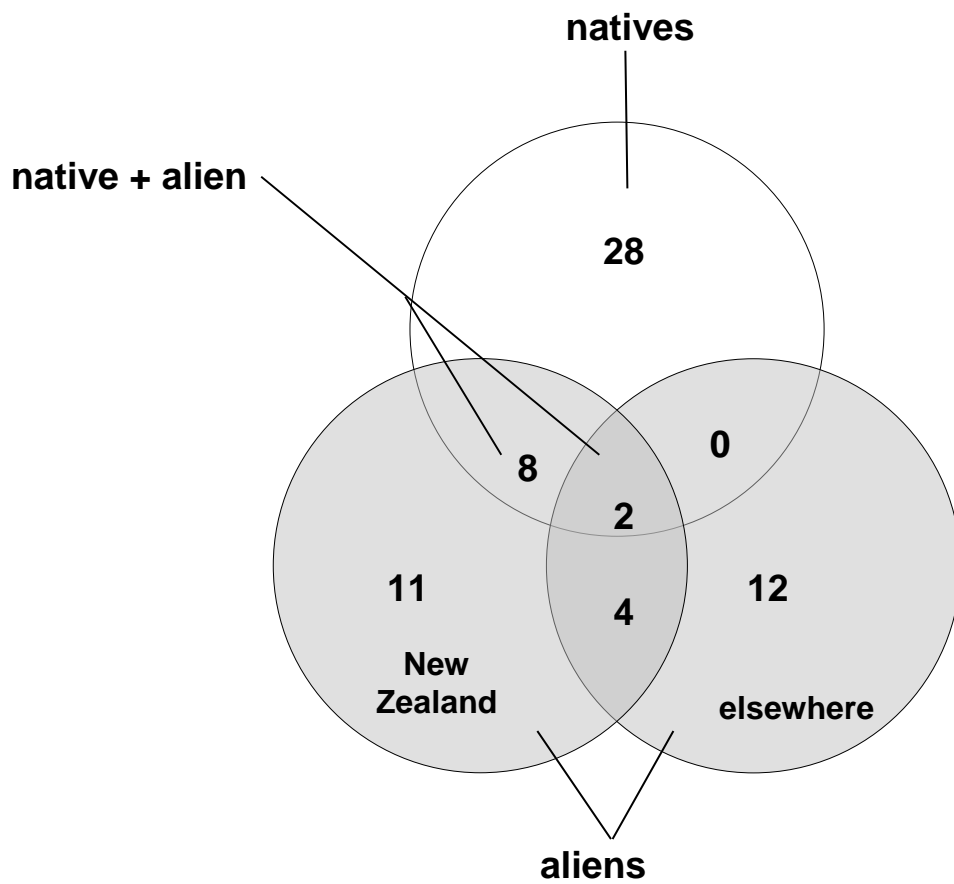
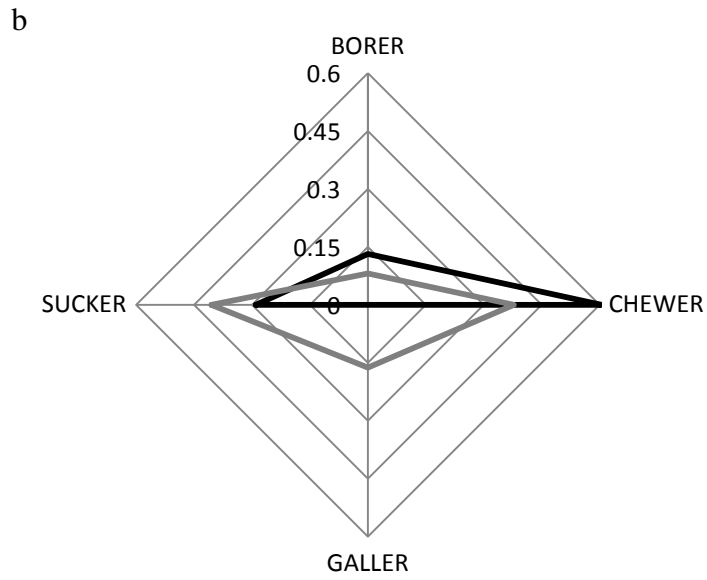
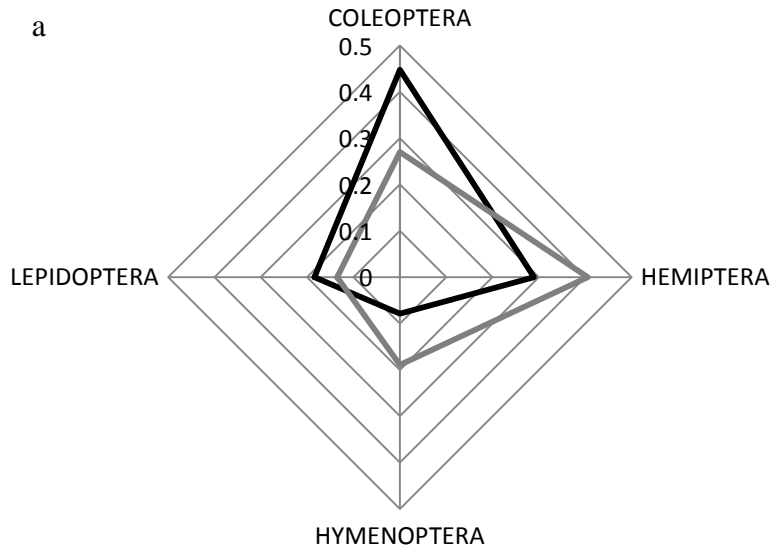


Figure 1: The distribution (numbers of species) of eucalypt specialists established as
 5 invasive species in Australian plantations as ‘natives’ (white) and overseas (grey) as
 ‘aliens’.



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Figure 2: Proportion of alien (grey) and native (black) eucalypt specialists according to Order (a) and feeding guild (b).

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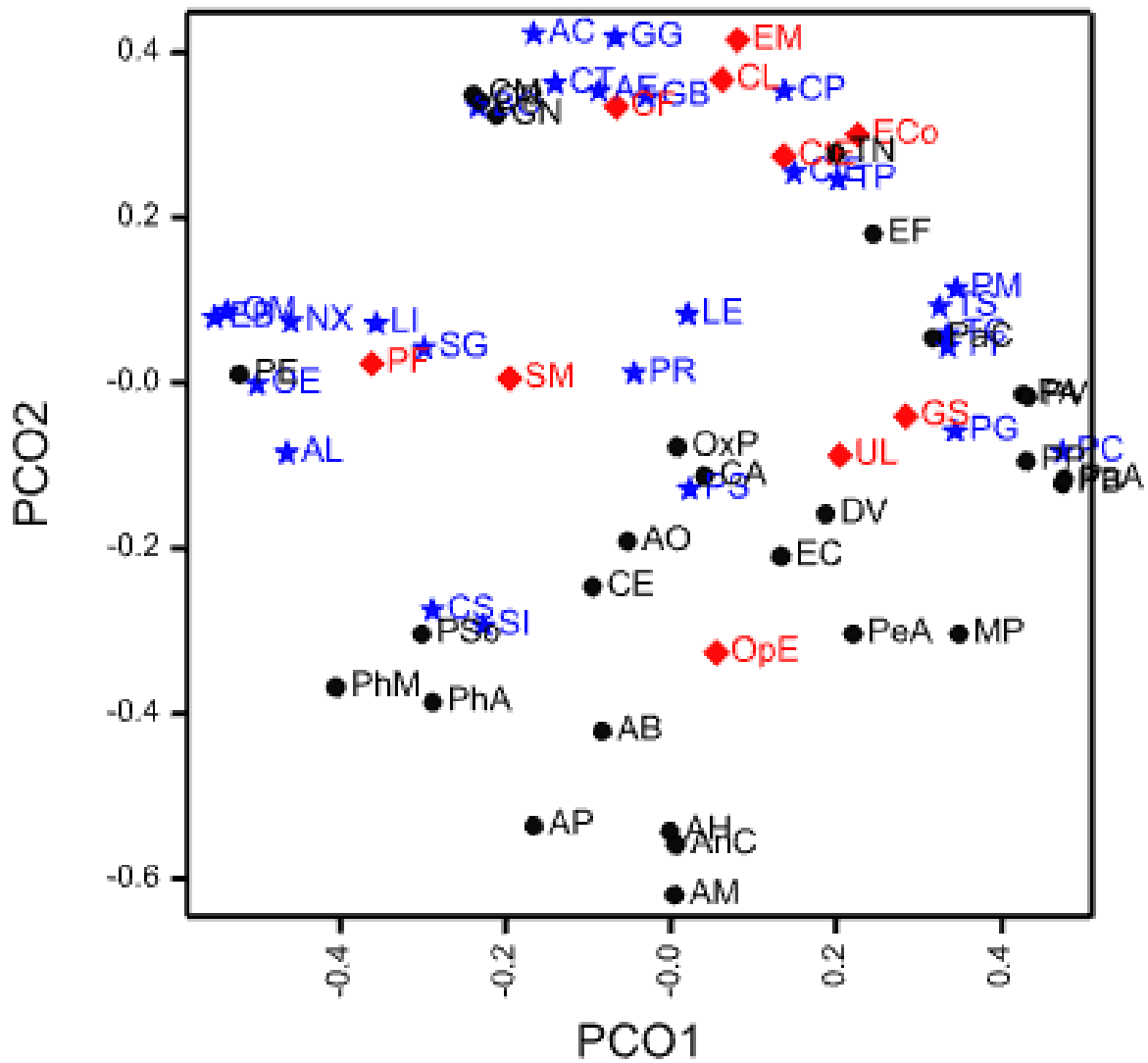


Figure 3: Principal components ordination of traits of native invaders (circles), alien invaders (stars) and in both environments (diamonds).

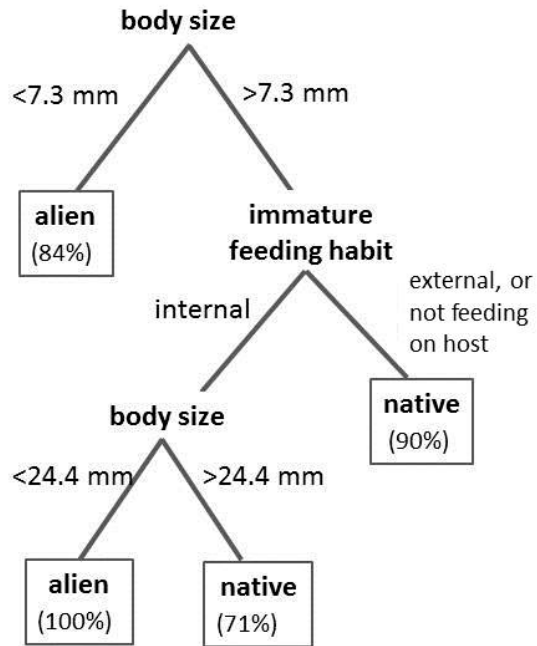


Figure 4: Simple classification tree for aliens and natives showing the importance of body size (mm) and immature feeding habit as traits in separating the two groups.

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Supporting information

List of insect eucalypt specialists invading eucalypt plantations in Australia (natives) and that have established overseas (aliens). Species in common to both are in bold.

Within aliens, E = early overseas establishment (1873-1955) L = late overseas

5 establishment (>1955), the two phases of movement described by Paine et al. (2011);

N = established first in New Zealand; F = established further from Australia. Initials

are as used in Figure 3.

Natives	Aliens
AO <i>Amorbus obscuricornis</i> (Hem: Coreidae)	AL <i>Acrocercops laciniella</i> (Lep: Gracillariidae) LN
AB <i>Anoplognathus boisduvali</i> (Col: Scarabaeidae)	AE <i>Aleuroclava eucalypti</i> (Hem: Aleyrodidae) EN
AnC <i>Anoplognathus chloropyrus</i> (Col: Scarabaeidae)	AC <i>Anoeconeossa communis</i> (Hem: Psyllidae) LN
AH <i>Anoplognathus hirsutus</i> (Col: Scarabaeidae)	BO <i>Blastopsylla occidentalis</i> (Hem: Psyllidae) LN
AM <i>Anoplognathus montanus</i> (Col: Scarabaeidae)	CS <i>Callidiopsis scutellaris</i> (Col: Cerambycidae) EN
AP <i>Anoplognathus porosus</i> (Col: Scarabaeidae)	CF <i>Cardiaspina fiscella</i> (Hem: Psyllidae) LN
CE <i>Cadmus excrementarius</i> (Col: Chrysomelidae)	CL <i>Creiis lituratus</i> (Hem: Psyllidae) LN
CF <i>Cardiaspina fiscella</i> (Hem: Psyllidae)	CT <i>Cryptoneossa triangular</i> (Hem: Psyllidae) LF
CM <i>Cardiaspina maniformis</i> (Hem: Psyllidae)	CtE <i>Ctenarytaina eucalypti</i> (Hem: Psyllidae) EN
CR <i>Cardiaspina rotator</i> (Hem: Psyllidae)	CP <i>Ctenarytaina peregrina</i> (Hem: Psyllidae) LF
CL <i>Creiis lituratus</i> (Hem: Psyllidae)	CtS <i>Ctenarytaina spatulata</i> (Hem: Psyllidae) LN
CtE <i>Ctenarytaina eucalypti</i> (Hem: Psyllidae)	EB <i>Epichrysocharis burwelli</i> (Hym: Eulophidae) LF
CA <i>Culama australis</i> (Lep: Cossidae)	EC <i>Eriococcus coriaceus</i> (Hem: Eriococcidae) EN
DV <i>Doratifera vulnerans</i> (Lep: Limacodidae)	EM <i>Eucalyptolyta maideni</i> (Hem: Psyllidae) LN
EC <i>Endoxyla cinerea</i> (Lep: Cossidae)	GB <i>Glycaspis brimblecombei</i> (Hem: Psyllidae) LF
ECo <i>Eriococcus coriaceus</i> (Hem: Eriococcidae)	GG <i>Glycaspis granulata</i> (Hem: Psyllidae) LN
EM <i>Eucalyptolyta maideni</i> (Hem: Psyllidae)	GS <i>Gonipterus scutellatus complex</i> (Col: Curculionidae) EN
EF <i>Eurymela fenestrata</i> (Hem: Eurymelidae)	LE <i>Lepidosaphes eucalypti (multiplora)</i> (Hem: Diaspididae) EN
GN <i>Glycaspis nigrocincta</i> (Hem: Psyllidae)	LI <i>Leptocybe invasa</i> (Hym: Eulophidae) LF
GS <i>Gonipterus scutellatus complex</i> (Col: Curculionidae)	NX <i>Nambouria xanthops</i> (Hym: Pteromalidae) LN
MP <i>Mnesampela privata</i> (Lep: Geometridae)	OE <i>Ophelimus eucalypti</i> (Hym: Eulophidae) EN
OpE <i>Opodiphthera eucalypti</i> (Lep: Saturniidae)	OM <i>Ophelimus maskelli</i> (Hym: Eulophidae) LF
OxP <i>Oxyops pictipennis</i> (Col: Curculionidae)	OpE <i>Opodiphthera eucalypti</i> (Lep: Saturniidae) EN
PA <i>Paropsis atomaria</i> (Col: Chrysomelidae)	PC <i>Paropsis charybdis</i> (Col: Chrysomelidae) EN
PP <i>Paropsis porosa</i> (Col: Chrysomelidae)	PG <i>Paropsisterna gloriosa</i> (Col: Chrysomelidae) LF
PaA <i>Paropsisterna agricola</i> (Col: Chrysomelidae)	PM <i>Paropsisterna m-fuscum</i> (Col: Chrysomelidae) LF
PB <i>Paropsisterna bimaculata</i> (Col: Chrysomelidae)	PR <i>Phoracantha recurva</i> (Col: Cerambycidae) EF
PaC <i>Paropsisterna cloelia</i> (Col: Chrysomelidae)	PS <i>Phoracantha semipunctata</i> (Col: Cerambycidae) EN
PV <i>Paropsisterna variicollis</i> (Col: Chrysomelidae)	PF <i>Phylacteophaga froggatti</i> (Hym: Pergidae) LN
PeA <i>Perga affinis</i> (Hym: Pergidae)	SG <i>Selitrichodes globulus</i> (Hym: Eulophidae) LF
PhA <i>Phoracantha acanthocera</i> (Col: Cerambycidae)	SI <i>Strepsicrates infensa</i> (Lep: Tortricidae) EN
PhM <i>Phoracantha mastersi</i> (Col: Cerambycidae)	<i>Strepsicrates macropetana</i> (Lep: Tortricidae) EN
PSo <i>Phoracantha solida</i> (Col: Cerambycidae)	TP <i>Thaumastocoris peregrinus</i> (Hem: Thaumasticoridae) LF
PE <i>Phylacteophaga eucalypti</i> (Hym: Pergidae)	TC <i>Trachymela catenata</i> (Col: Chrysomelidae) LN
PF <i>Phylacteophaga froggatti</i> (Hym: Pergidae)	TS <i>Trachymela sloanei</i> (Col: Chrysomelidae) LN
SM <i>Strepsicrates macropetana</i> (Lep: Tortricidae)	TT <i>Trachymela tincticollis</i> (Col: Chrysomelidae) LF
TS <i>Thaumastocoris safordi</i> (Hem: Thaumasticoridae)	UL <i>Uraba lugens</i> (Lep: Nolidae) LN
UL <i>Uraba lugens</i> (Lep: Nolidae)	