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The potential of groundwater recharge plantations in the Lake Warden catchment, Esperance, to encourage diversity of invertebrates and birds

ALCOA FOUNDATION'S CONSERVATION AND SUSTAINABILITY FELLOWSHIP PROGRAM

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A NETWORK OF PLANTATIONS IS BEING TRIALED IN THE LAKE WARDEN CATCHMENT SURROUNDING ESPERANCE, IN ORDER TO LOWER GROUNDWATER TABLES AND REDUCE SALINITY AND LAKE INFLOW PROBLEMS. THESE PLANTATIONS ALSO HAVE THE POTENTIAL TO RESTORE BIODIVERSITY IN AN AREA WHERE 80% OF THE NATIVE VEGETATION HAS BEEN REMOVED. THIS STUDY INVESTIGATED THE BIODIVERSITY VALUE OF *PINUS PINASTER*, *EUCALYPTUS CLADOCALYX* AND *E. TRICARPA* PLANTATIONS BY SAMPLING THE INVERTEBRATES ON AND BENEATH TREES, AND ALSO THE BIRDS THAT INHABIT THESE AREAS. NATIVE MALLEE AND NON-REVEGETATED PASTURE PLOTS WERE ALSO SAMPLED TO PROVIDE BEFORE/AFTER BENCHMARKS. ALL THREE TYPES OF PLANTATION ENHANCED THE ABUNDANCE AND DIVERSITY OF CERTAIN GROUPS OF INVERTEBRATES, WITH EUCALYPTS SHOWING GREATER EFFECTS THAN PINES. *E. TRICARPA* APPEARED TO HAVE MORE VALUE THAN *E. CLADOCALYX* IN THIS REGARD. THE BIRD ASSEMBLAGES THAT UTILISE THESE AREAS, MANY OF WHICH FEED ON INVERTEBRATES, MIRRORED THESE RESPONSES, ALTHOUGH THEY HAD STILL NOT ATTAINED THE RICHNESS OF THE NATIVE VEGETATED AREAS. IT IS CONCLUDED THAT ALL TYPES OF PLANTATION ENHANCE INVERTEBRATE AND BIRD BIODIVERSITY, ALTHOUGH EUCALYPTS ARE MORE EFFECTIVE THAN PINES AT DOING THIS.

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Jonathan Majer is an insect ecologist, with more than 30 years of research experience in Western Australian ecosystems. Since insects are exceptionally diverse, and are found in almost every situation, Jonathan Majer's research has involved him in a wide range of issues, including the ecological impacts of urbanisation, impacts of prescribed burning of forests and nature reserves, impacts of habitat fragmentation, and restoration of ecosystems following mining or agriculture. He is also developing ways to use insects as bio-indicators of environmental health.

Maria (Mazé) de Sousa-Majer has a broad entomological background, having worked on bee diseases, microbial insect control, genetically-modified crops and post-harvest disinfestation of native crops. She holds undergraduate and MSc degrees from the Universidade Federal de Viçosa in Brazil and a doctorate from Curtin University of Technology, which was capped off by a postdoctoral fellowship at the same institution.

Francene O'Connor is the Farm Forestry Natural Resource Officer for the Esperance-based Private Forestry Development Committee (PFDC) South East Forest Foundation. Since completing a Bachelor of Forest Science at Melbourne University in 2000, Francene has had a variety of experience across both native and plantation forestry. She envisages a future where all agricultural farming systems integrate commercial tree planting, recognising it as a valuable tool towards achieving more sustainable land management practices and to support the development of local industry.

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Series Editors: Professor Jonathan Majer & Professor Daniela Stehlik

Introduction

The hinterland of the Esperance region was largely opened up for agriculture in the 1960s. It comprises two distinct areas of farmland, which are distinguished by their soil types; these are the Esperance Mallee (856,000 ha) and the coastal Esperance Sandplain (874,000 ha). Clearing has proceeded at a rapid pace, leading to approximately one million hectares, representing almost 80 percent of the original vegetation, being removed. As with elsewhere in the Western Australian wheatbelt, water tables started to rise, leading to salinity and waterlogging. In addition to causing a threat to the region's agricultural economy, this has important implications to the conservation of the local biota. Lake Warden (Figure 1a) is a wetland of international importance, as listed under the Ramsar Convention (Figure 1b). The lake, and other nearby water bodies surrounding Esperance, are suffering from an increased input of salt and a more regular inflow of water. The latter has resulted in a failure of much of the beach (or calcareous sand) shorelines of the lakes to become exposed during the summer, which in turn has denied feeding opportunities to wading birds, such as the near-threatened western subspecies of the Hooded Plover (*Thinornis rubricollis*).

(a)

(b)

Figure 1. Aerial photo of the Lake Warden Wetland system (a) and sign illustrating its importance (b). First photo courtesy of A. Massenbauer, DAFWA.

Since 1997, the Lake Warden Catchment (LWC) has been managed by the Department of Environment and Conservation as a 'Natural Biodiversity Recovery Catchment' under the State Salinity Action Plan. Commercial tree planting in the LWC is one option being used to help contain the impact of groundwater recharge on large-scale agriculture by targeting high recharge areas. Maritime pine (*Pinus pinaster*) has been identified as the most suitable commercial species for the Esperance climate and soil type. This is an introduced species, whose origin is Portugal. When planted on the deep, sandy soils, they act as biological pumps in the high recharge zones, which, in turn, reduces groundwater inflow to the creeks and wetlands of the Lake Warden Wetland System (LWWS). Other options that are currently being trialled include Sugar gum (*Eucalyptus cladocalyx*), Flat-topped yate (*Eucalyptus occidentalis*), and Red ironbark (*Eucalyptus tricarpa*). *E. occidentalis* is a West Australian species. However, the other two have been introduced from eastern Australia, with *E. cladocalyx* having its origins in South Australia and *E. tricarpa* originating from the southeastern Queensland/northern New South Wales area.

The Forests Products Commision (FPC) is monitoring the growth and timber potential of these tree species on the various soil types of the catchment (Anon, 2006). In addition, staff from the Department of Agriculture and Food WA (DAFWA) and from the South East Forest Foundation (SEFF) are monitoring plantations of these tree species to evaluate their hydrological benefits (O'Connor, 2007).

A third potential benefit of this revegetation is its potential ability to assist with the restoration of lost biodiversity in an area that has been subjected to so much clearing. In addition to providing benefits to the fauna of the lake system, these plantations could more directly contribute to the conservation of invertebrates on and beneath the trees, and to the many insectivorous species of birds that feed upon them. If plantations encourage the re-establishment of invertebrates, they could significantly assist the efforts to conserve the local biota. In addition, the trees might encourage beneficial predators or pollinators that might limit pests in adjacent agricultural areas and contribute to pollination of crops. A whole range of other ecological benefits might flow from the return of this lost biodiversity.

The aim of this study is fourfold. Firstly, it evaluates whether plantation establishment enhances the abundance and diversity of invertebrates in the canopy, the understorey and on the ground when compared to the cleared agricultural landscape. Secondly, it compares the value of Maritime pine versus eucalypt plantations to encourage the return of biodiversity. Thirdly, it assesses how successful these two types of plantations have been in achieving biodiversity levels that are characteristic of the surrounding mallee native vegetation. Finally, it looks at how the structure of the revegetated areas, and the invertebrates associated with them, have contributed to the re-establishment of native bird species within the area.

Site selection and methods

The site

The Lake Warden Catchment (LWC) is an area of flat to gently undulating plains covering an area of 212,000 ha. Elevation rises from near sea level to 180 m, with the average annual rainfall ranging from 400-700 mm. Eighty per cent of the LWC is agricultural land and 95% of this area has been cleared for farming. There are two dominant soil types and these are reflected in the native vegetation, which features a range of eucalypt, melaleuca, hakea, acacia and banksia species. At higher elevations, the soil type is an alkaline grey shallow sandy duplex soil and in the lower sand plain it is a grey shallow sand duplex soil with gravelly layers, which is prone to wind erosion and waterlogging.

The study was performed at the Frednavale property, at an elevation of 150-160m, about 50km north-north east of Esperance, in Neridup location 272 (lot 351 on Plan 30915) in the upper reaches of the Lake Warden catchment (Figure 2). This is old farmland that was cleared in the 1960s and which is bordered on its north-east side by a substantial 5000 ha tract of native mallee vegetation (Figure 3). The property contains a series of small lakes where groundwater manifests itself, along with associated salinity problems. Considerable areas of Maritime pine were planted by FPC Sharefarms in 2001, and most trees are now about 4 m high. A series of smaller experimental plots of *E. cladocalyx, E. occidentalis* and *E. tricarpa,* measuring from around 1-3 ha were established in the same year. These trees are about 3-4 m high at the present time. The understorey of the eucalypt plantations has been treated with herbicides, so the ground is largely bare. By contrast, the pines have not been treated, and have dense patches of African lovegrass (*Eragrostis curvula*) beneath them.

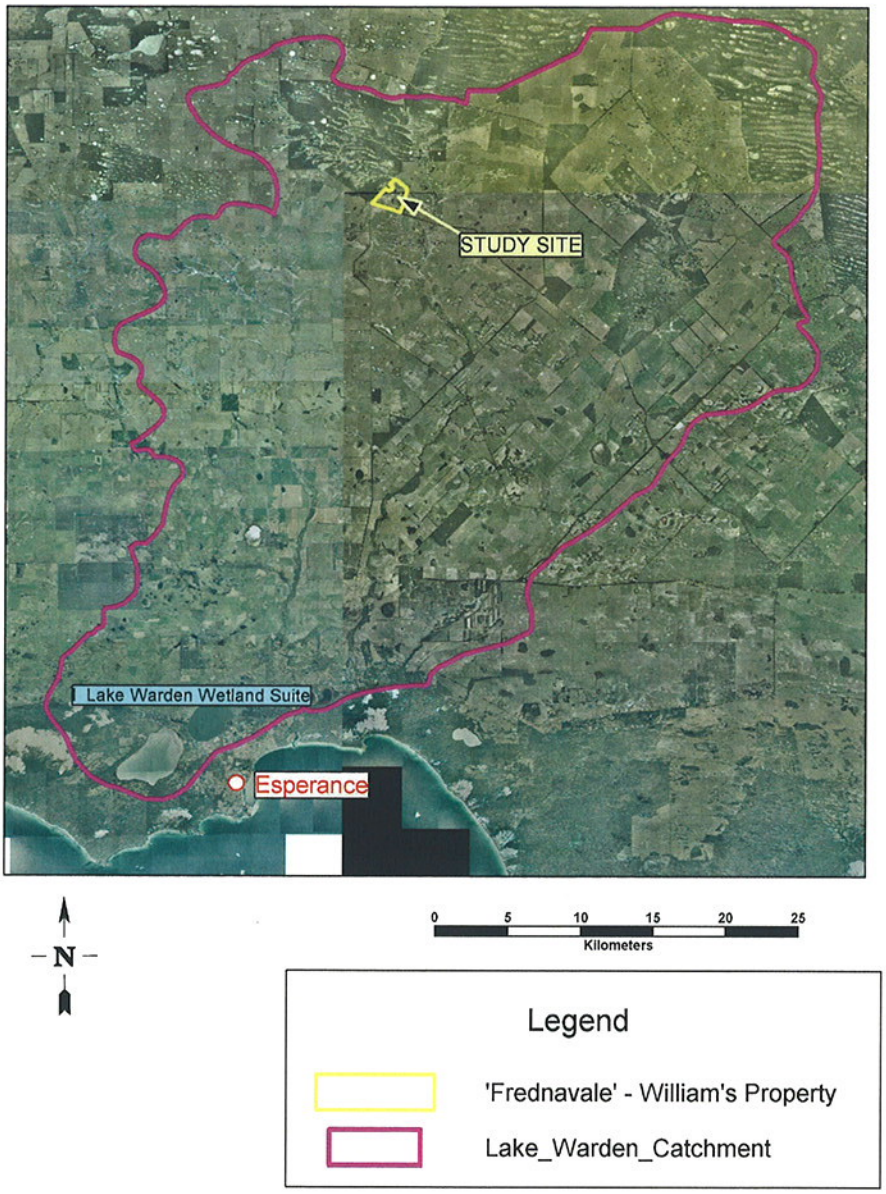


Figure 2. Map of the Esperance region, showing the Lake Warden catchment boundary and the position of the Frednavale property where sampling was performed.

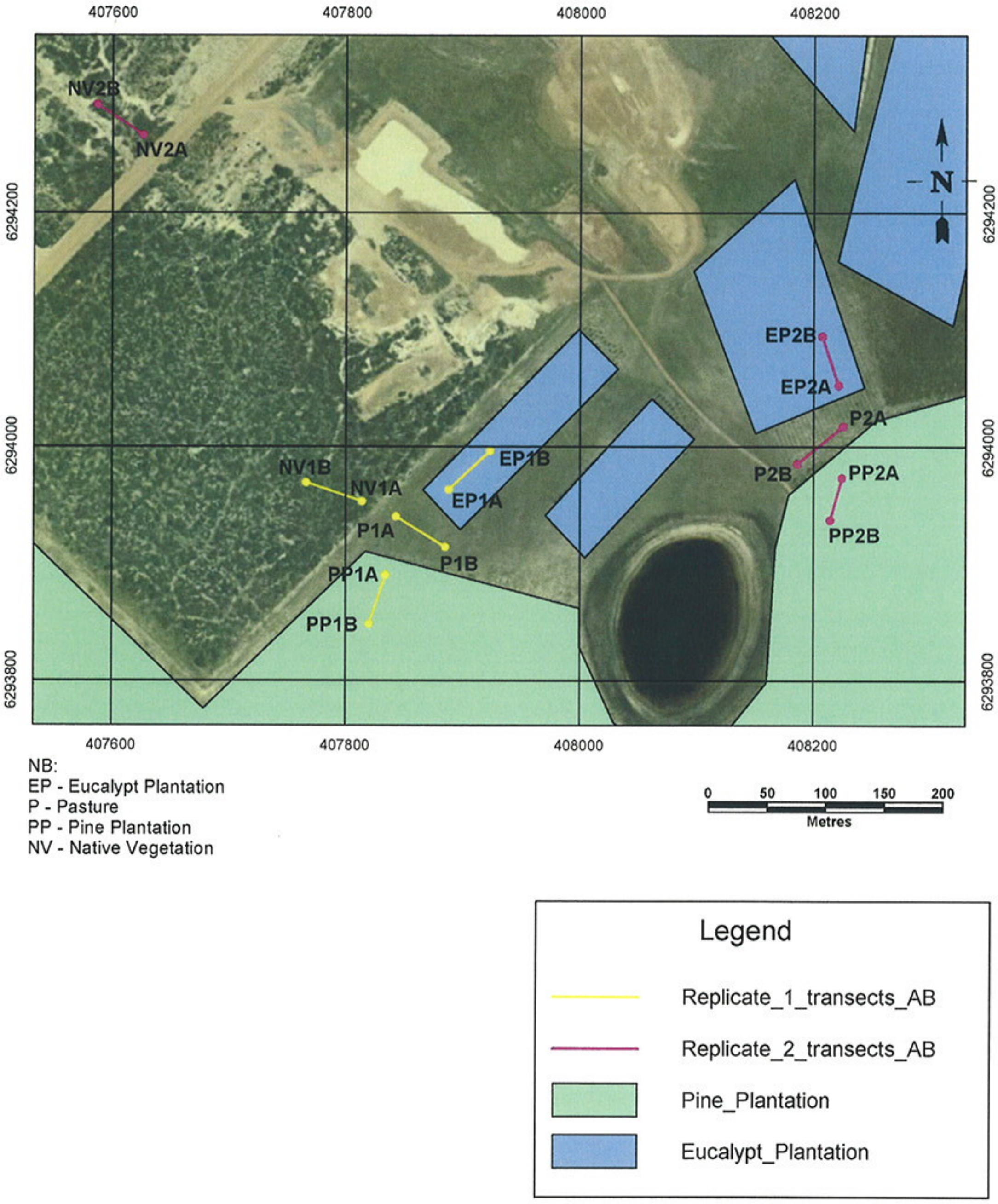


Figure 3. Map of the Frednavale property, showing the position of the invertebrate sampling transects. P1 & 2 = pasture; PP1 & 2 = pine plantation; EPI & 2 = eucalypt plantations and NV1 & 2 = native vegetation.

Two 40 m transects were marked out in replicated pine and eucalypt plantations and in two adjoining areas of non-revegetated pasture. All plantations had been established in 2001. Eucalypt plantation EP1 was of *E. cladocalyx* while EP2 was of *E. tricarpa*. Two areas of native vegetation, both largely dominated by Blue mallee (*Eucalyptus tetragona*) were also selected as controls; similar 40 m transects were established in these areas. The positions of the replicated pasture, Maritime pine, eucalypt and native vegetation transects are shown in Figure 3. General views of each of these vegetation types are shown in Figures 4a-d.

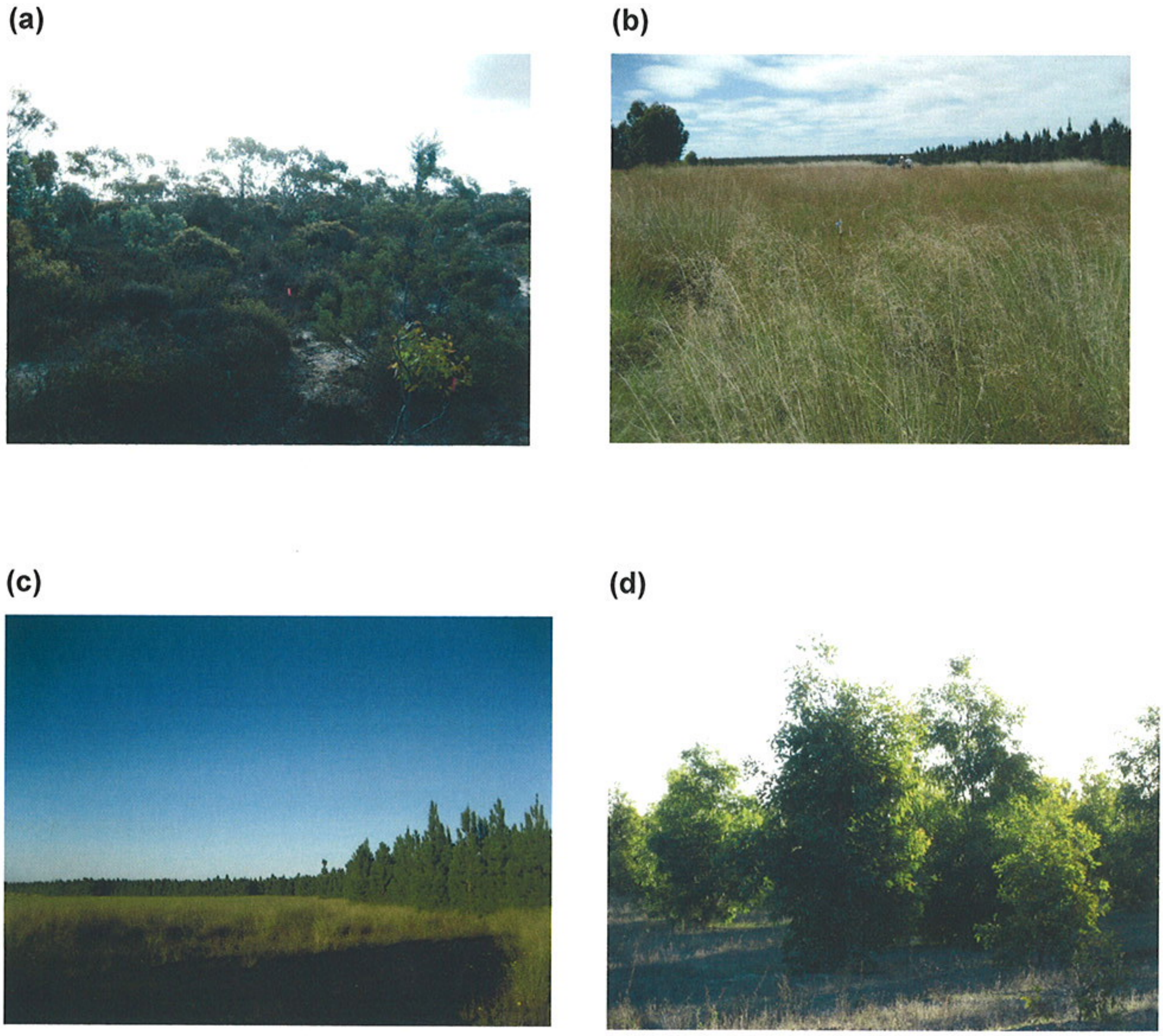


Figure 4. Views of the (a) native vegetation, (b) pasture, (c) pine plantation and (d) eucalypt plantation.

Invertebrate sampling

Invertebrate sampling was performed twice, during autumn (April 2007) and during spring (October 2007). This was a somewhat unusual year in that abnormally high rainfall was experienced in January, while the mid-winter months were drier than usual. Invertebrates were sampled by three complementary procedures which targeted ground-, shrub- and tree-associated fauna.

To sample the ground fauna, a series of five pitfall traps was established at 10 m intervals along each transect. These were 54 mm internal diameter plastic pots, which contained 50 ml of ethylene glycol (Figure 5a). These were inserted into the ground with an auger and left open on both occasions for 7 days.

The shrub-associated fauna was sampled with an entomological sweep net. At 10 m intervals along the transect, a series of five 20 m long swathes of vegetation, running at right angles to the transect, was swept on an outward and return walk to the starting point (Figure 5c). After stunning the contents of the net with a pesticide aerosol, the contents were tipped onto a white sheet and the invertebrates were picked up with forceps and placed into vials of 70% alcohol. The five sweep samples were retained in separate containers so that information on the variability of the shrub-associated fauna could be obtained.

The canopy-associated fauna was sampled by the chemical knockdown procedure (Figure 5b). Five trees were selected at equal distances along, and to one side, of each transect. In the case of the native vegetation, the nearest *E. tetragona* tree to the 10 m mark on the transect was sampled. The understorey and debris beneath each tree was first levelled using a machete and brushcutter. Then 4 × 4 m calico sheets were placed beneath each tree and secured with tent pegs. Following a settling down period, the trees were sprayed with Dominex® pyrethrin pesticide using a Stihl® petrol-driven mistblower. Trees were then left for 30 min to allow for the pesticide to take effect and for creatures that drop on silk threads to fall to the ground. The trees were then shaken to dislodge any remaining invertebrates and the sheets were folded up and returned to the laboratory for a thorough inspection. Invertebrates were removed using tweezers and placed in vials of 70% alcohol, with one vial allocated for each knockdown sample.

The invertebrates from the three sampling methods were sorted and counted at the order level. Trends for the more numerous taxa were then expressed graphically and differences between transect replicates and vegetation type were assessed using two-way analysis of variance. In order to obtain information on species richness, the ants (Hymenoptera: Formicidae), bees plus wasps (other Hymenoptera) and the beetles

(Coleoptera) were selected for further sorting and identification to species or morphospecies level. These particular taxa were selected on the basis of their excellent bioindicator potential (ants), their potential value as parasites or predators of nearby agricultural pests (other Hymenoptera) and their vital role in canopy dynamics (beetles). Ants were identified to species level for both seasons; due to availability of taxonomists the other groups were only separated for the April samples.

(a)

(b)

(c)

Figure 5. Photographs of (a) pitfall trap, (b) chemical knockdown and (c) sweep sampling procedures.

The birds present in each sampling area were assessed during the same week that invertebrate sampling was performed. This was done by two people slowly walking for approximately 30 min. through the general area where the transect had been established. Presence of the various bird species was assessed using visual observations and by listening to bird calls. Assessment was done twice along each transect in order to provide a reasonable census of the birds present. Assessment was performed in both autumn and spring.

Statistical analyses

Means and standard errors of each invertebrate order sampled by each sampling method were calculated and all consistently occurring taxa were graphed. Differences in invertebrate abundances between each vegetation type were examined by two-way analysis of variance, with vegetation type being the main factor and site replicate nested within this. Although the two *Eucalyptus* plantations were treated as a single vegetation type, differences in abundances between the two vegetation types was compared using unpaired t-tests.

Ants, other Hymenoptera (bees and wasps) and beetle species were tabulated for each transect and the resulting species richness values were graphed.

As with invertebrates, the bird species that were surveyed in each area were tabulated and graphed. However, in view of the relatively low number of species found, replicates of each vegetation type were combined for production of graphs.

Results

The mean numbers of arthropods within each order for the three sampling methods are shown in Tables 2a-c. The most consistently occurring groups are graphed for each sampling method and period in Figures 7-18. These graphs also indicate which vegetation types, if any, differ significantly from each other in terms of invertebrate abundances.

The total number of orders sampled in each vegetation type was relatively similar, and any trends between vegetation types that might exist were not consistent between sampling periods. For instance, although fewer orders were found in pine canopies than in eucalypt plantation and Blue mallee canopies during October, this was not the case during April (Figure 6a). Similarly, the trend of higher abundance beneath eucalypt plantations than beneath pines during October was reversed during April (Figures 6b, c).

Trends for canopy fauna amongst the individual orders were varied and, in many cases, unclear. In terms of the two types of plantations, there was a tendency for some taxa to be significantly more abundant in eucalypts than pines, in at least one of the sampling periods (e.g., Araneae (Figure 7a), Blattodea (Figure 9a), Orthoptera (Figure 11a), Thysanoptera

(Figure 13a), Heteroptera (Figure 14a), Homoptera (Figure 15a), Coleoptera (Figure 16a) and Diptera (Figure 17a)). In the majority of taxa, the abundance of certain orders was even more abundant in the canopy of eucalypt plantations than in the canopy of native Blue mallee during at least one of the sampling periods (e.g., Araneae (Figure 7a), Blattodea (Figure 9a), Orthoptera (Figure 11a), Psocoptera (Figure 12a), Thysanoptera (Figure 13a), Homoptera (Figure 15a), Coleoptera (Figure 16a) and Diptera (Figure 17a)).

The trends in the canopy may be summarised as a tendency for abundances to be greater in the *Eucalyptus* plantation canopy than in the pine canopy, and for abundances in the *Eucalyptus* plantation canopy to exceed that in the native Blue mallee canopy. There were obviously no invertebrates in the pasture canopy, as this stratum did not exist there. These trends were not reflected in the shrub or ground layers.

Trends in the shrub layer were inconsistent between groups, many of which showed no clear pattern. Araneae (Figure 7b) and Thysanoptera (Figure 13b) tended to be significantly more abundant in the pasture than in the plantations, suggesting that imposition of shade was detrimental to them. Heteroptera (Figure 14b), Homoptera (Figure 14b) and Coleoptera (Figures 16b) were all more abundant in the shrub layer of the plantation, and to an extent the pasture, than in the Blue mallee vegetation. By contrast, other-Hymenoptera (Figure 18b) were less abundant under the plantations than in the Blue mallee areas.

Few consistent trends were detected at the ground level, although levels of Collembola (Figure 8c), Orthoptera (Figure 11c) and Coleoptera (Figures 16c) tended to be lower than pasture when plantations were established.

Table 3 shows the ant species sampled by each method in each transect for the two sampling periods and for the sampling periods combined. Inspection of the latter indicates that pine plantations supported more (16) species than pasture (13), and eucalypt plantations supported even higher numbers (26). However, neither plantation type supported the richness of ants that was found in the nature vegetation (61). Inspection of the graphs for each sampling method (Figure 19) indicates that the progressive increase in richness from pasture, to pines, to eucalypt plantations up to native vegetation was manifested in all sampling methods. However, there were some inconsistencies between replicates of each vegetation type. A slight decline in pasture richness was also observed when pine plantations were established (Figure 19c).

As mentioned, data for other Hymenoptera (wasps and bees) are only available for the April sampling period (Table 4). However, they show similar trends as for ants, except that richness in the native vegetation transects (16) was almost half that of the eucalypt plantations. Inspection of the graphs for each sampling method (Figure 20) indicates that these trends are generally reflected in the canopy, shrub and ground layer samples.

As with other Hymenoptera, Coleoptera data are only available for the April sampling period (Table 5). Here, the trend was the same as for ants, with native vegetation clearly supporting the greatest number of species. These trends were clearly seen in the shrub layer (Figure 21b), although beetle richness was not as high as expected in the canopy and ground layer of the Blue mallee areas (Figure 21 a, c).

Comparison of abundances within orders between the *E. cladocalyx* EP1 and *E. tricarpa* (EP2) plantations revealed a number of significant differences ($P < 0.05$ using paired t-test). The direction of the difference was variable on the ground (April Collembola most abundant beneath *E. cladocalyx;* October Homoptera most abundant beneath *E. tricarpa).* However, sweeping on shrubs revealed consistently higher levels beneath *E. tricarpa* (April and October Araneae; April Orthoptera; October Psocoptera, Homoptera and Coleoptera). This trend was largely reflected in the canopies of these two eucalypt species (April Thysanoptera and Coleoptera; October Orthoptera), although the October Blattodea samples were significantly more abundant on *E. cladocalyx.*

Thus, although not conclusive, there is some suggestion that invertebrate abundances may be slightly higher on and beneath *E. tricarpa* than *E. cladocalyx.* This trend was reflected at the species richness level by beetles (Figure 21), although the opposite trend was exhibited by ants (Figure 19) and other Hymenoptera (Figure 20). There could be environmental reasons for these trends. Transect EP2 was in a moister area than EP1, which could have influenced the vigour of the understorey and trees, with flow-through effects on the invertebrates. Alternatively, differences in the structure, chemistry and/or palatability of the two eucalypt species could have been associated with these differences. At this stage we can only say that the reasons for such differences remain unresolved.

Table 6 shows the bird species that were observed in each area during April, October, and for the two periods combined. It should be stressed that many of these species may have been using the plantations on a temporary basis, and may have been feeding elsewhere. However, clear trends are evident, which closely mirror those for ant and beetle species, and to an extent those of wasps and bees. In total, two species were observed in the pasture, 12 in the pines, 14 in the eucalypt plantations and 30 in the Blue mallee areas. These trends were reflected in both seasons, although there was little difference between pine and eucalypt plantations during October (Figure 22).

Table 2a: Mean (SE) number of arthropods of each order sampled by pitfall traps in the paired pasture, pine plantation, eucalyptus plantation, and Blue mallee plots during April and October 2007.

		Apr - 07																Oct - 07															
		P1		P2		PP1		PP2		EP1		EP2		NV1		NV2		P1		P2		PP1		PP2		EP1		EP2		NV1		NV2	
Taxon		ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE
Araneae	Araneae	1.2	0.4	1.2	0.6	1.0	0.3	0.0	0.0	0.6	0.2	0.8	0.4	1.4	0.4	0.0	0.0	0.8	0.4	3.4	1.5	1.4	0.6	1.8	0.8	1.4	0.6	2.0	0.9	2.0	0.9	3.2	1.4
Araneae	Acarina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	1.0	39.6	17.7	2.0	0.9	5.8	2.6	3.4	1.5
Araneae	Pseudoscorpionida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Araneae	Scorpionida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chilopoda		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diplopoda		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Collembola		46.2	5.2	154.4	20.5	11.6	1.9	50.2	5.6	37.6	1.6	6.6	1.3	6.8	1.2	5.4	0.7	107.0	47.9	52.2	23.3	3.0	1.3	132.4	59.2	39.2	17.5	20.6	9.2	12.8	5.7	0.0	0.0
Insecta	Thysanura	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3
Insecta	Blattodea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Isoptera	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Mantodea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Dermaptera	0.6	0.2	0.2	0.2	0.2	0.2	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	0.0	0.0	0.6	0.3	1.0	0.4	1.4	0.6	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0
Insecta	Orthoptera	0.4	0.4	0.6	0.4	1.8	0.7	0.2	0.2	0.2	0.2	0.6	0.2	0.0	0.0	0.0	0.0	5.6	2.5	18.6	8.3	0.0	0.0	1.2	0.5	6.6	3.0	10.2	4.6	4.2	1.9	0.0	0.0
Insecta	Psocoptera	0.0	0.0	0.0	0.0	0.2	0.2	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	2.0	1.8	0.8	0.8	0.4	0.8	0.4
Insecta	Homoptera	0.2	0.2	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	1.0	0.2	0.1	0.4	0.2
Insecta	Heteroptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.4	0.0	0.0	0.0	0.0	0.4	0.2	0.4	0.2	0.8	0.4
Insecta	Thysanoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.8
Insecta	Neuroptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	1.5
Insecta	Coleoptera	20.0	3.4	7.2	1.8	3.8	1.3	5.0	1.7	7.2	2.3	10.2	2.3	0.4	0.4	0.6	0.2	2.4	1.1	4.8	2.1	2.4	1.1	6.2	2.8	10.8	4.8	2.4	1.1	4.2	1.9	3.0	1.3
Insecta	Diptera	0.8	0.6	0.0	0.0	0.8	0.6	2.0	1.0	1.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.5	2.6	1.2	2.0	0.9	7.8	3.5	1.4	0.6	4.6	2.1	0.0	0.0
Insecta	Lepidoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	1.0	0.4
Insecta	Hymenoptera	30.8	5.8	13.8	2.4	48.2	10.4	20.6	3.2	20.6	5.5	27.4	2.0	9.8	2.7	10.0	1.4	6.4	2.9	7.4	3.3	10.6	4.7	8.8	3.9	27.4	12.3	20.6	9.2	30.0	13.4	15.4	6.9
		9.0		6.0		8.0		8.0		6.0		5.0		6.0		6.0		5.0		8.0		7.0		8.0		9.0		10.0		11.0		11.0	
Total of orders sampled		9.0				9.0				6.0				8.0				8.0				9.0				11.0				14.0			

Table 2b: Mean (SE) number of arthropods of each order sampled by sweeping in the paired pasture, pine plantation, eucalyptus plantation, and Blue mallee plots during April and October 2007.

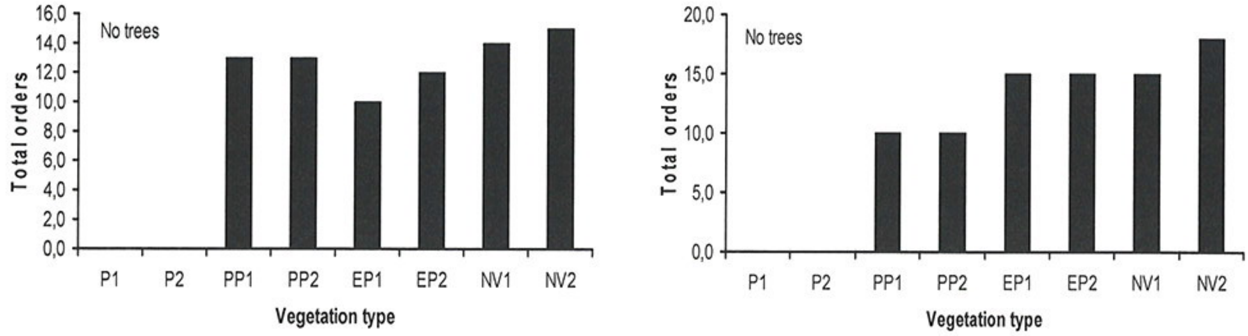
Taxon		Apr - 07															
		P1		P2		PP1		PP2		EP1		EP2		NV1		NV2	
		ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE
Araneae	Araneae	9.2	3.1	22.8	4.1	2.6	0.7	2.0	0.5	0.8	0.5	4.8	1.1	5.0	1.0	9.8	1.4
Araneae	Acarina	0.0	0.0	13.6	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	1.4	0.5
Araneae	Pseudoscorpionida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Araneae	Scorpionida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chilopoda		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diplopoda		0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0
Collembola		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	9.0	0.9
Insecta	Thysanura	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Blattodea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Isoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Mantodea	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2
Insecta	Dermaptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Orthoptera	1.6	0.7	2.6	1.0	1.2	0.5	1.4	0.5	0.8	0.2	1.8	0.4	0.4	0.2	0.4	0.2
Insecta	Psocoptera	0.6	0.2	0.2	0.2	6.6	2.0	1.0	0.6	0.0	0.0	0.0	0.0	4.2	1.5	0.0	0.0
Insecta	Homoptera	0.4	0.2	0.0	0.0	5.8	5.1	37.6	9.9	0.0	0.0	0.0	0.0	1.2	0.7	1.2	0.5
Insecta	Heteroptera	0.2	0.2	6.8	3.4	3.0	0.8	4.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Thysanoptera	2.6	2.1	2.2	0.5	1.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Neuroptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Coleoptera	0.4	0.2	0.0	0.0	1.8	1.1	5.0	1.5	0.2	0.2	0.6	0.2	1.0	0.5	1.4	0.7
Insecta	Diptera	8.0	1.6	5.4	1.9	8.6	1.3	5.6	1.3	2.4	0.7	3.8	1.0	4.4	1.2	3.8	1.4
Insecta	Lepidoptera	1.8	0.8	2.0	1.4	0.8	0.6	0.8	0.4	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.0
Insecta	Hymenoptera	0.8	0.4	0.2	0.2	1.0	0.4	1.2	0.4	1.6	0.5	1.0	0.4	4.0	1.4	3.4	0.9
		11.0		10.0		12.0		10.0		5.0		5.0		11.0		9.0	
Total of orders sampled		12.0				12.0				5.0				12.0			

Taxon		Oct - 07															
		P1		P2		PP1		PP2		EP1		EP2		NV1		NV2	
		ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE
Araneae	Araneae	3.8	1.7	5.2	2.3	2.8	1.3	4.0	0.7	3.8	1.7	10.6	4.7	5.6	2.5	3.2	1.4
Araneae	Acarina	5.2	2.3	5.2	2.3	0.0	0.0	0.0	0.0	19.6	8.8	22.6	10.1	4.8	2.1	3.4	1.5
Araneae	Pseudoscorpionida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Araneae	Scorpionida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chilopoda		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diplopoda		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Collembola		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	6.1	0.0	0.0
Insecta	Thysanura	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6	0.0	0.0	0.6	0.3	0.0	0.0	0.6	0.3
Insecta	Blattodea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Isoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insecta	Mantodea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.0	0.0
Insecta	Dermaptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0
Insecta	Orthoptera	2.6	1.2	3.4	1.5	0.0	0.0	2.2	1.3	1.8	0.8	8.4	3.8	3.6	1.6	0.0	0.0
Insecta	Psocoptera	2.2	1.0	0.0	0.0	0.8	0.4	5.2	3.3	0.0	0.0	9.4	4.2	2.4	1.1	0.8	0.4
Insecta	Homoptera	16.2	7.2	15.2	6.8	11.4	5.1	34.8	6.3	1.4	0.6	23.0	10.3	0.0	0.0	0.4	0.2
Insecta	Heteroptera	4.4	2.0	3.2	1.4	6.2	2.8	14.4	3.7	12.8	5.7	7.8	3.5	2.6	1.2	0.8	0.4
Insecta	Thysanoptera	25.0	11.2	2.0	0.9	0.0	0.0	2.4	1.1	1.8	0.8	5.6	2.5	1.8	0.8	1.8	0.8
Insecta	Neuroptera	0.2	0.1	2.4	1.1	1.2	0.5	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0	3.4	1.5
Insecta	Coleoptera	1.0	0.4	0.6	0.3	0.2	0.1	0.4	2.2	1.2	0.5	5.2	2.3	1.6	0.7	3.0	1.3
Insecta	Diptera	14.0	6.3	9.2	4.1	8.2	3.7	17.0	1.6	11.6	5.2	11.2	5.0	11.6	5.2	0.0	0.0
Insecta	Lepidoptera	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0	4.0	1.8	3.8	1.7	2.4	1.1	1.0	0.4
Insecta	Hymenoptera	3.2	1.4	2.4	1.1	2.2	1.0	2.6	1.0	8.0	3.6	8.4	3.8	4.4	2.0	15.4	6.9
		12.0		11.0		8.0		10.0		12.0		13.0		12.0		11.0	
Total of orders sampled		12.0				11.0				15.0				15.0			

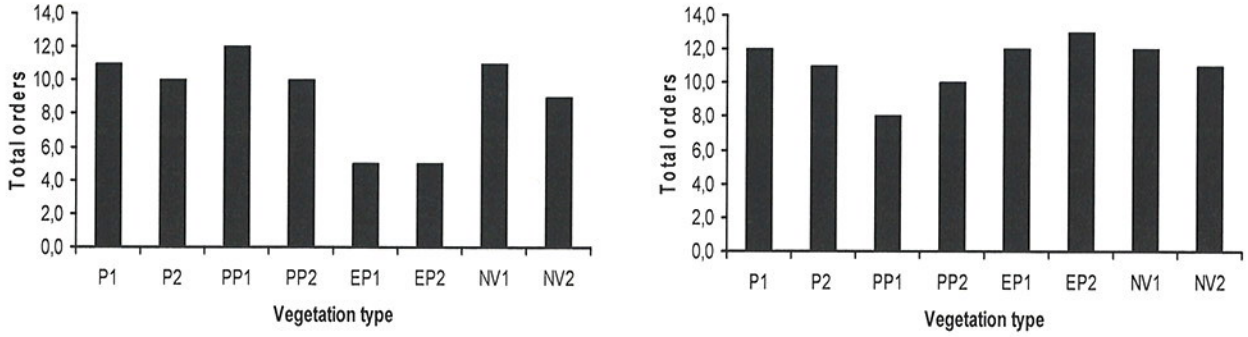
Table 2c: Mean (SE) number of arthropods of each order sampled by chemical knockdown in the paired pasture, pine plantation, eucalyptus plantation, and Blue mallee plots during April and October 2007.

		Apr - 07																Oct - 07															
		P1		P2		PP1		PP2		EP1		EP2		NV1		NV2		P1		P2		PP1		PP2		EP1		EP2		NV1		NV2	
Taxon		ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE
Araneae	Araneae	0.0	0.0	0.0	0.0	14.8	2.1	11.6	2.9	13.4	2.5	23.8	4.0	14.6	4.3	35.0	11.8	0.0	0.0	0.0	0,0	12.0	5.4	9.8	4.4	22.5	10.1	20.0	8.9	11.6	5.2	7.8	3.5
Araneae	Acarina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,0	0.0	0.0	0.0	0.0	3.0	1.3	14.8	6.6	3.4	1.5	1.6	0.7
Araneae	Pseudoscorpionida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0,0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2
Araneae	Scorpionida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chilopoda		0.0	0.0	0.0	0,0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diplopoda		0.0	0.0	0.0	0.0	24.0	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Collembola		0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.4	0.0	0.0	0.0	0,0	0.2	0.1	0.0	0.0	3.5	1.6	4.8	2.1	0.0	0.0	3.0	1.3
Insecta	Thysanura	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0,0	0.0	0.0	0.0	0.0	1.3	0.6	0.5	0.2	0.4	0.2	1.6	0.7
Insecta	Blattodea	0.0	0.0	0.0	0.0	2.4	0.5	4.4	1.5	5.6	2.1	0.8	0.4	1.8	1.3	1.2	0.8	0.0	0.0	0.0	0,0	1.6	0.7	1.0	0.4	4.8	2.1	0.3	0.1	0.8	0.4	1.0	0.4
Insecta	Isoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	3.7	0.0	0.0	0.0	0.0	0.0	0,0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.9	1.2	0.5
Insecta	Mantodea	0.0	0.0	0.0	0.0	0.6	0.6	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3
Insecta	Dermaptera	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	3.3	1.5	0.0	0.0	0.0	0.0
Insecta	Orthoptera	0.0	0.0	0.0	0.0	2.8	1.2	5.6	2.1	2.2	0.7	13.4	5.0	0.4	0.2	0.4	0.2	0.0	0.0	0.0	0.0	1.4	0.6	4.0	1.8	17.0	7.6	25.5	11.4	1.0	0.4	8.0	3.6
Insecta	Psocoptera	0.0	0.0	0.0	0.0	10.2	10.2	8.6	2.0	1.8	1.8	29.6	10.6	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	25.6	11.4	25.4	11.4	31.5	14.1	19.5	8.7	16.4	7.3	12.0	5.4
Insecta	Homoptera	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.4	25.4	20.1	49.2	8.6	4.0	3.0	10.2	2.0	0.0	0.0	0.0	0.0	11.4	5.1	0.6	0.3	14.3	6.4	11.8	5.3	3.2	1.4	2.0	0.9
Insecta	Heteroptera	0.0	0.0	0.0	0.0	1.6	0.7	1.4	0.5	0.0	0.0	0.0	0.0	0.2	0.2	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	124.5	55.7	15.3	6.8	42.0	18.8	24.0	10.7
Insecta	Thysanoptera	0.0	0.0	0.0	0.0	0.2	0.2	6.2	2.7	0.2	0.2	6.4	2.2	0.8	0.6	1.2	0.6	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	5.5	2.5	8.3	3.7	1.6	0.7	4.2	1.9
Insecta	Neuroptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	1.0	0.4	0.5	0.2	1.2	0.5	1.6	0.7
Insecta	Coleoptera	0.0	0.0	0.0	0.0	5.6	2.5	5.0	1.4	20.2	5.4	62.8	15.5	17.2	6.0	6.6	1.7	0.0	0.0	0.0	0.0	12.4	5.5	2.0	0.9	40.3	18.0	26.5	11.9	15.8	7.1	21.4	9.6
Insecta	Diptera	0.0	0.0	0.0	0.0	45.2	10.1	38.4	9	24.8	5.6	32.4	11.6	2.8	2.1	14.8	5.2	0.0	0.0	0.0	0.0	5.8	2.6	6.4	2.9	35.5	15.9	15.3	6.8	10.2	4.6	7.0	3.1
Insecta	Lepidoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.9	0.0	0.0	1.6	0.7	0.6	0.3
Insecta	Hymenoptera	0.0	0.0	0.0	0.0	10.4	3.1	13.8	3.9	149.2	71.6	51.0	11.2	92.8	39.6	64.0	48.5	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	124.5	55.7	15.3	6.8	42.0	18.8	24.0	10.7
		0.0		0.0		13.0		13.0		10.0		12.0		14.0		15.0		0.0		0.0		10.0		10.0		15.0		15.0		15.0		18.0	
Total of orders sampled		0.0				14.0				12.0				18.0				0.0				13.0				16.0				18.0			

(a)



(b)



(c)

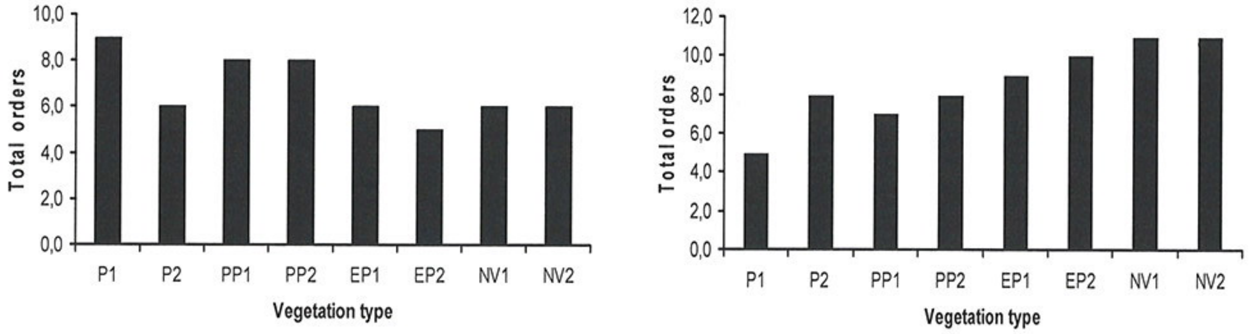
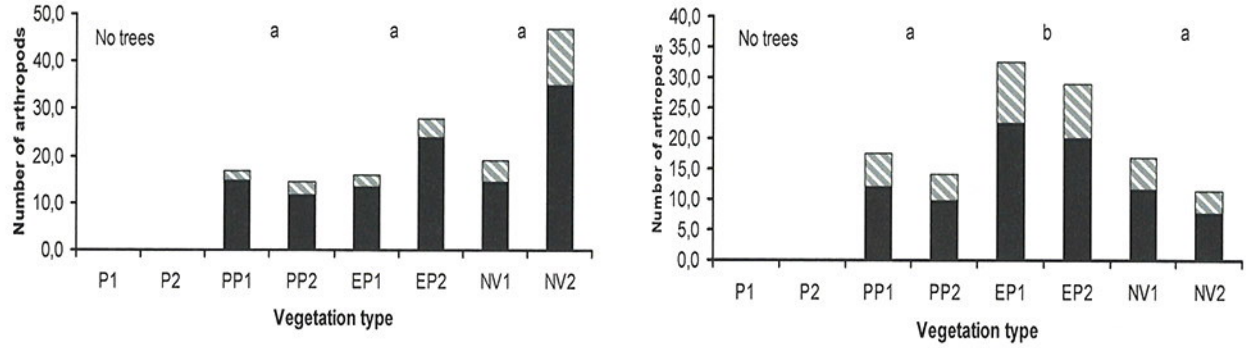
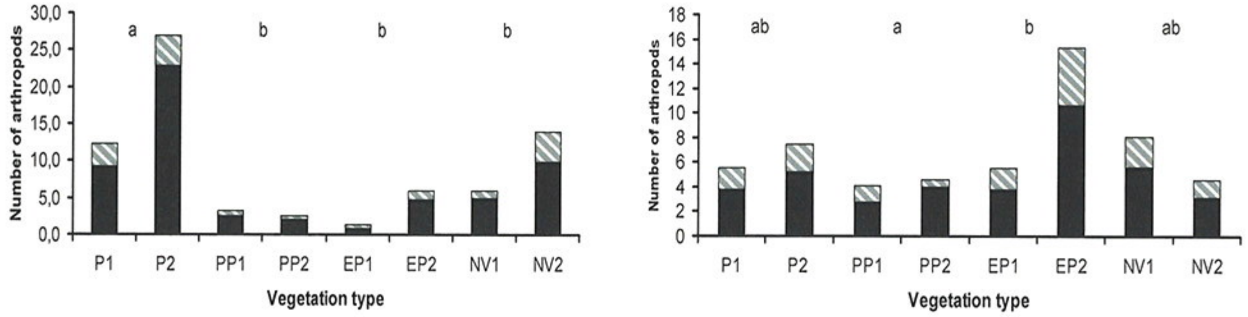


Figure 6. Total orders sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007.

(a)



(b)



(c)

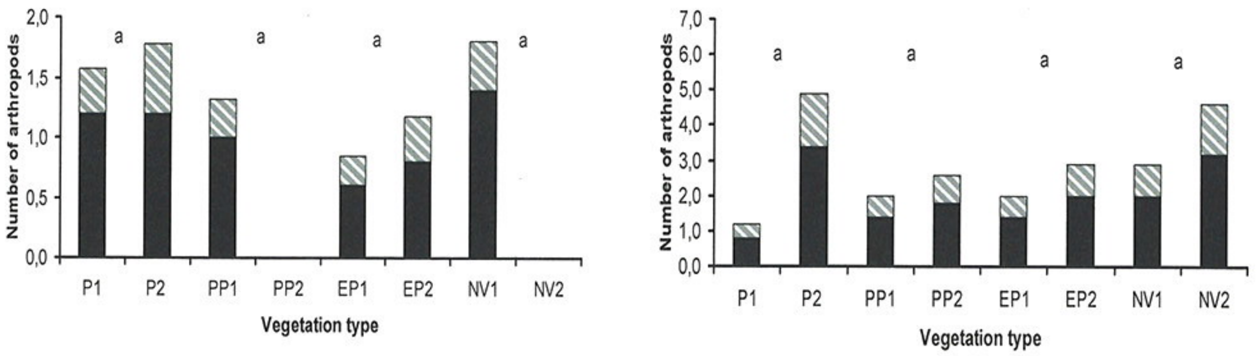
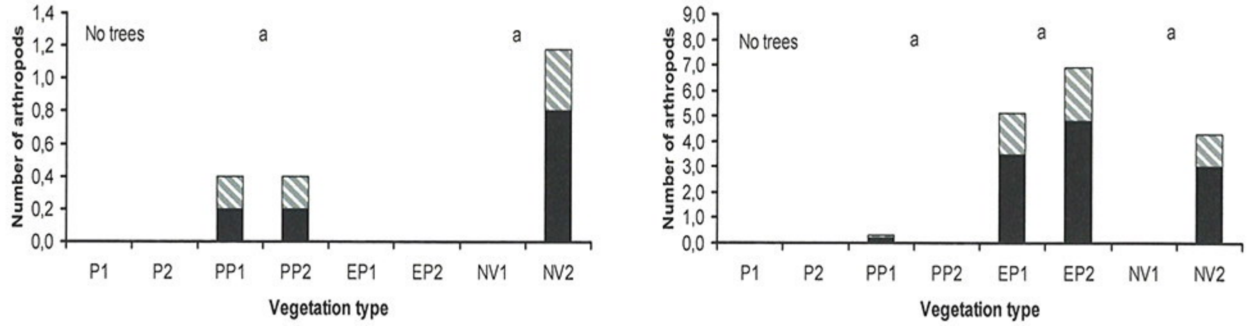
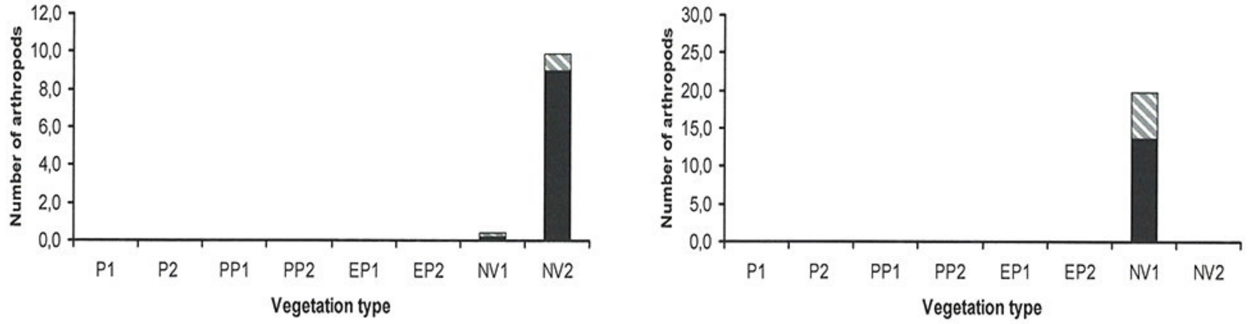


Figure 7. Mean (+ SE in stipple) number of Araneae (spiders) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

(a)



(b)



(c)

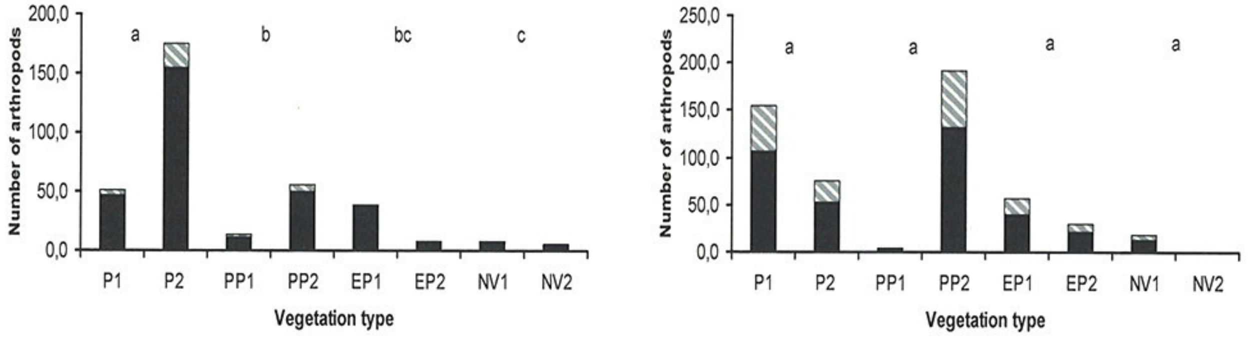
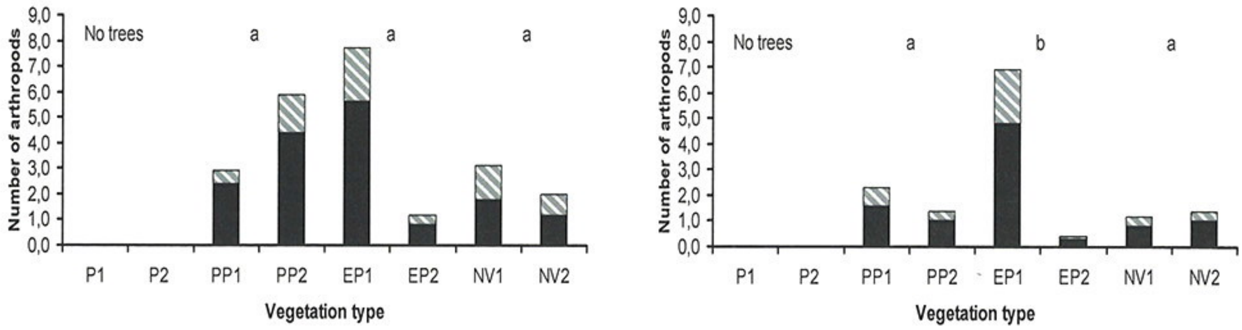


Figure 8. Mean (+ SE in stipple) number of Collembola (springtails) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

(a)



(b)

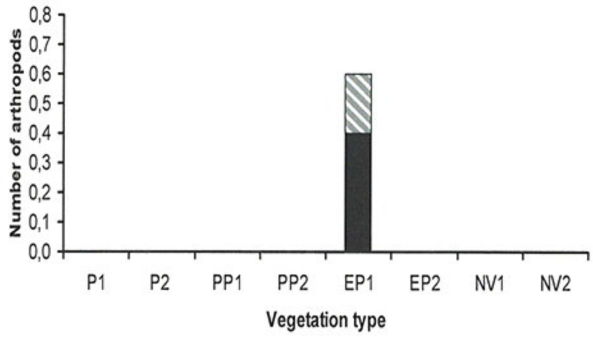


Figure 9. Mean (+ SE in stipple) number of Blattodea (cockroaches) sampled by (a) chemical knockdown, and (b) sweeping and in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. Blattodea were not found in sweep or pitfall trap samples in April and pitfall trap samples in October. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

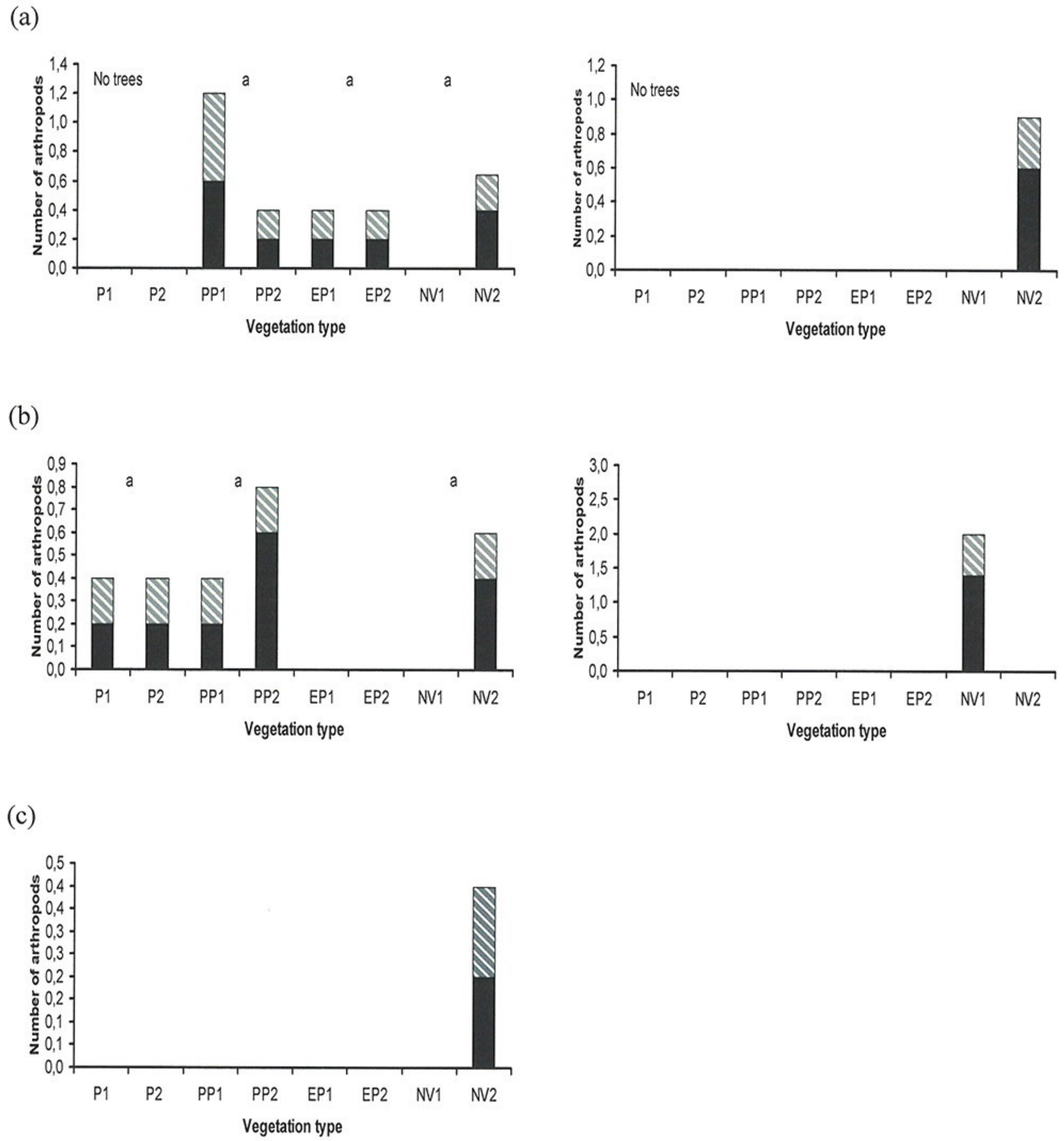
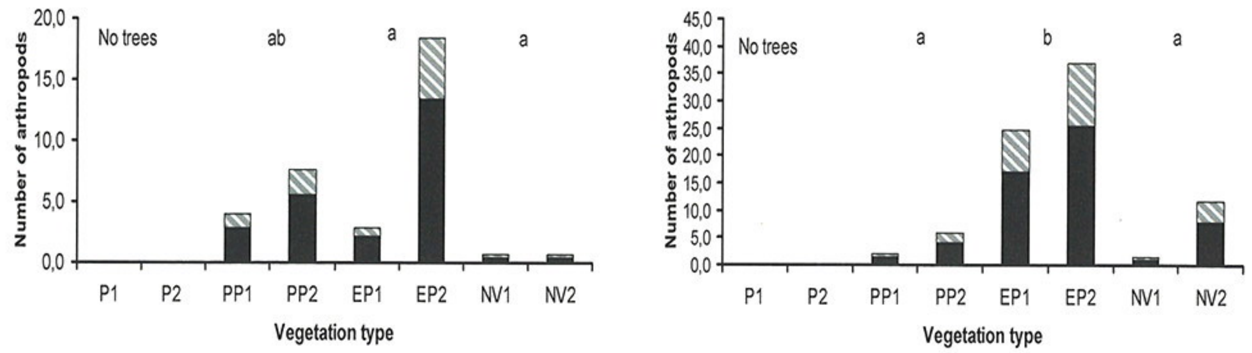
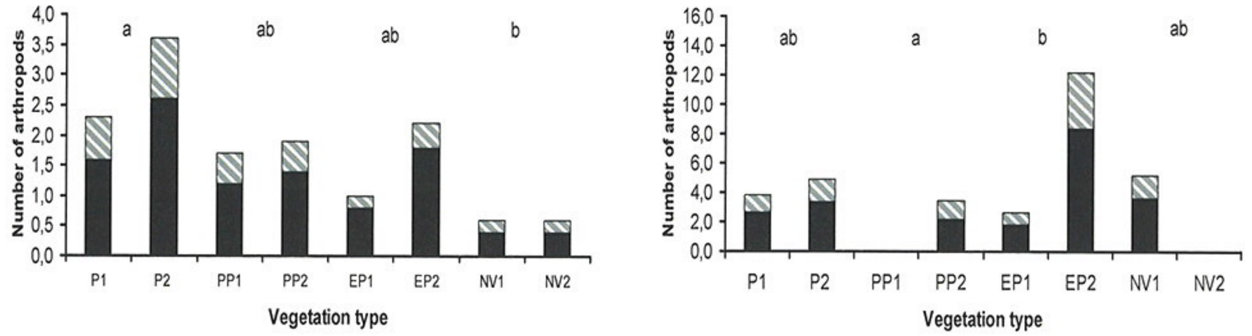


Figure 10. Mean (+ SE in stipple) number of Mantodea (mantids) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. Mantodea were not found in pitfall trap samples in October. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

(a)



(b)



(c)

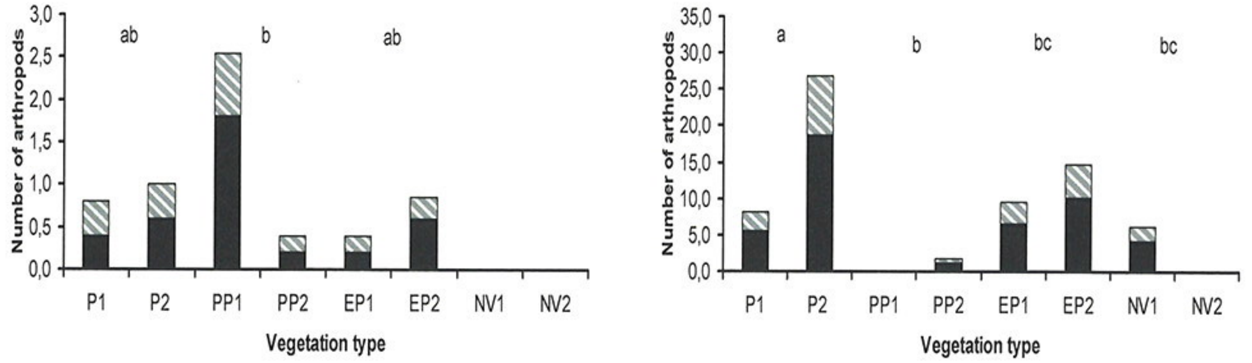
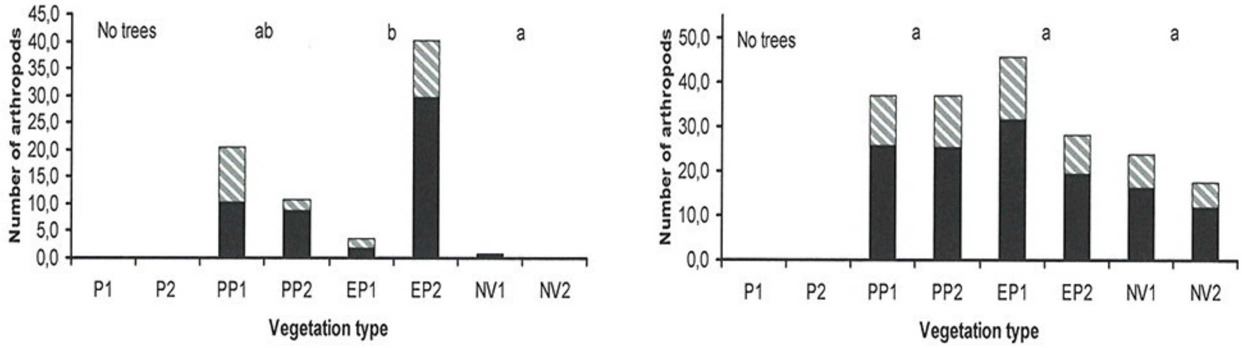
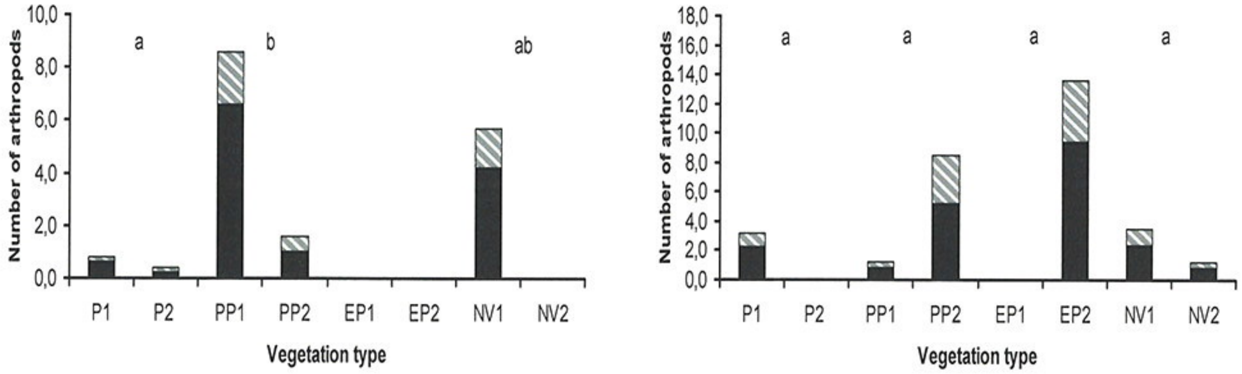


Figure 11. Mean (+ SE in stipple) number of Orthoptera (grasshoppers and crickets) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

(a)



(b)



(c)

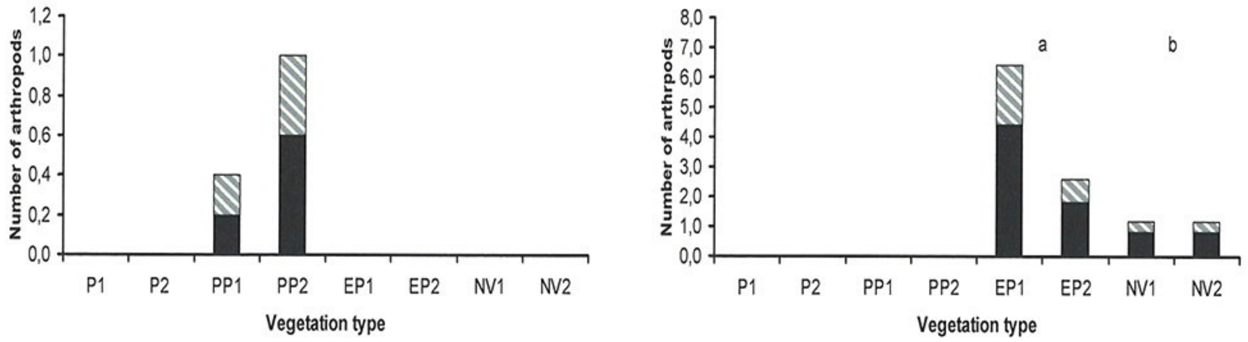


Figure 12. Mean (+ SE in stipple) number of Psocoptera (booklice) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

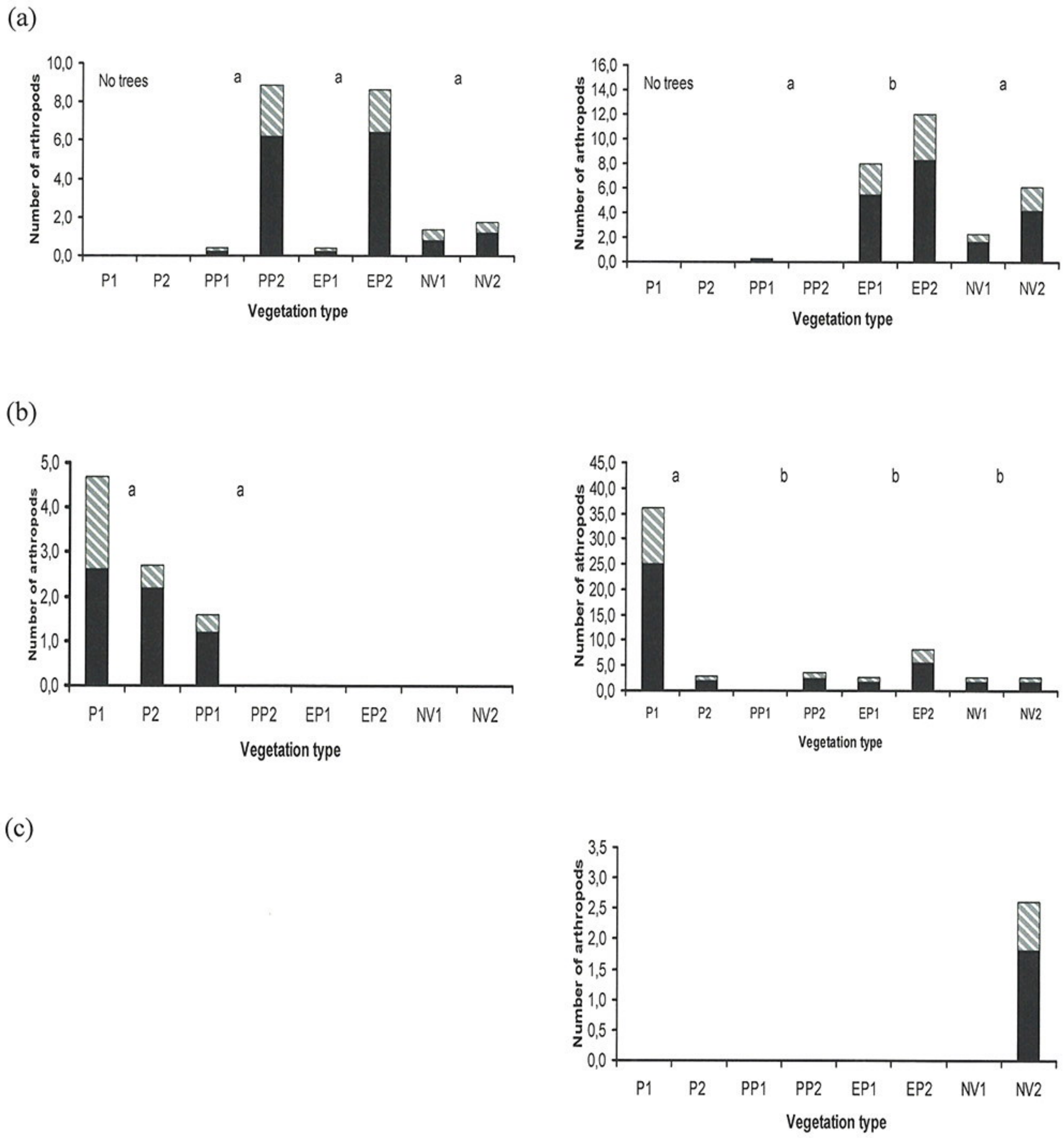


Figure 13. Mean (+ SE in stipple) number of Thysanoptera (thrips) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. Thysanoptera were not found in pitfall trap samples in April. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

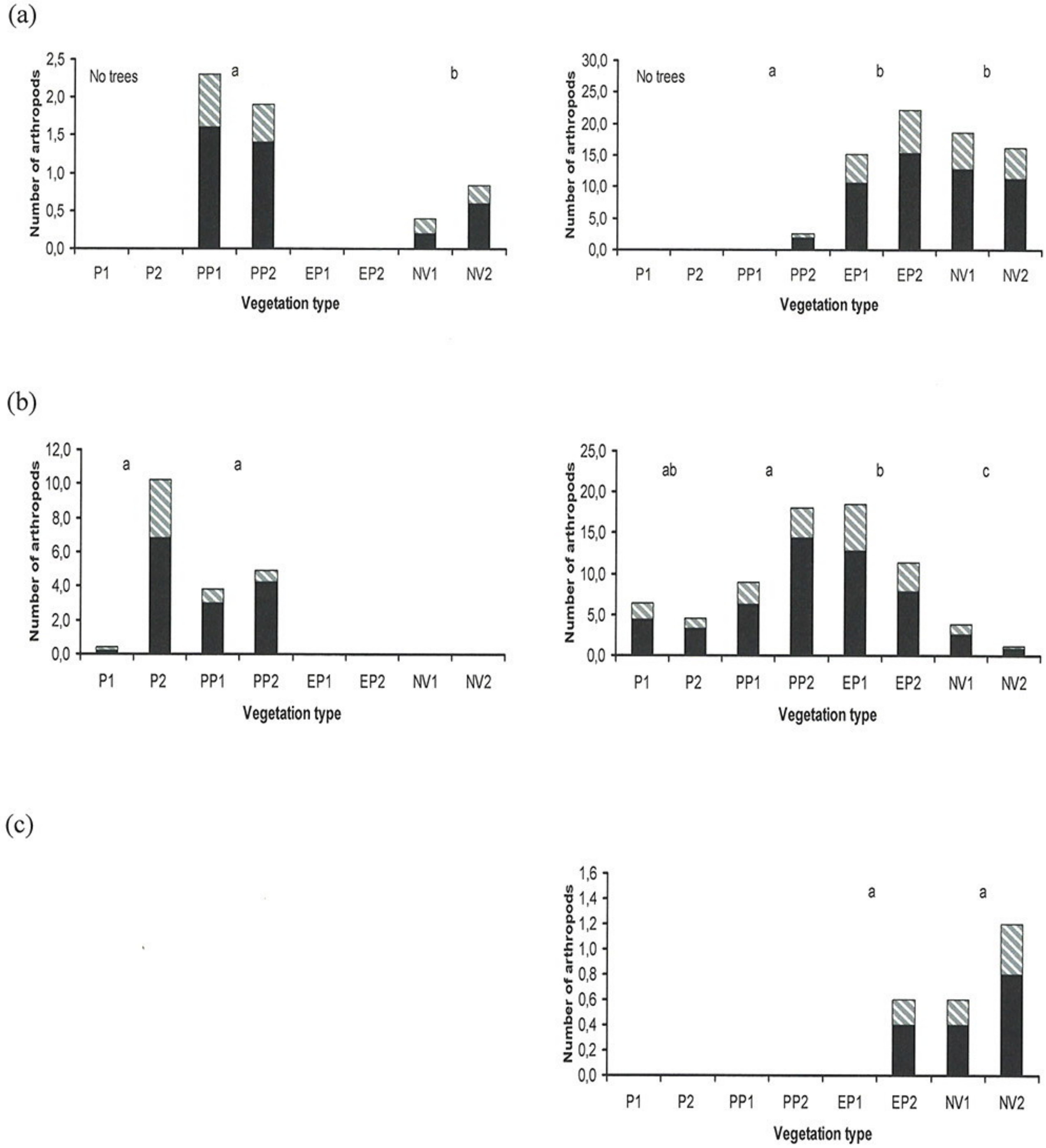


Figure 14. Mean (+ SE in stipple) number of Heteroptera (sucking bugs) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. Heteroptera were not found in pitfall trap samples in April. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

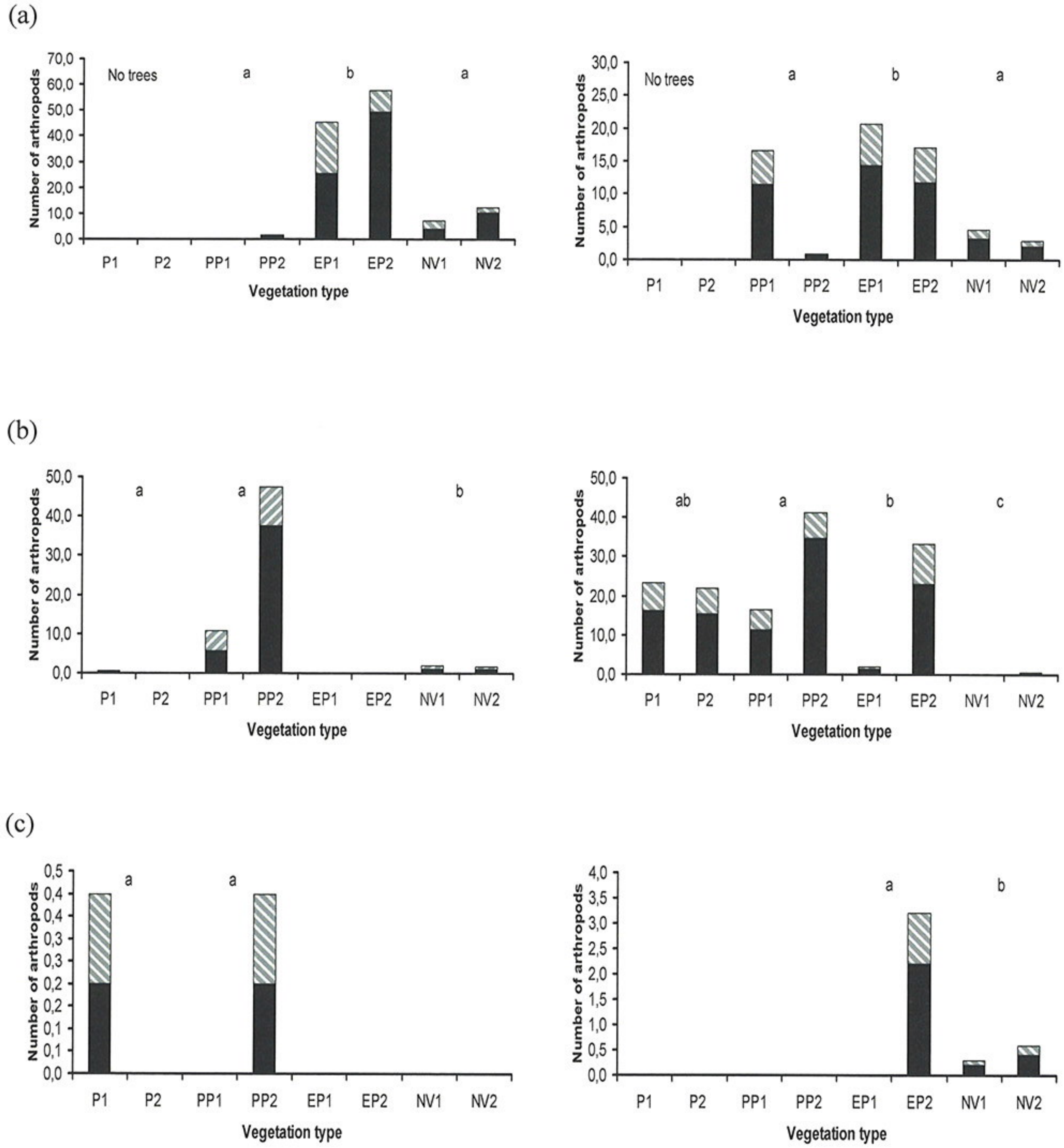
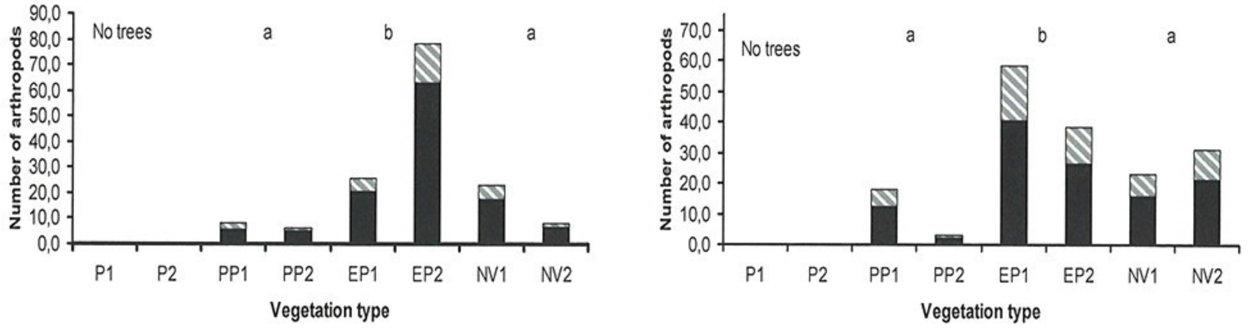
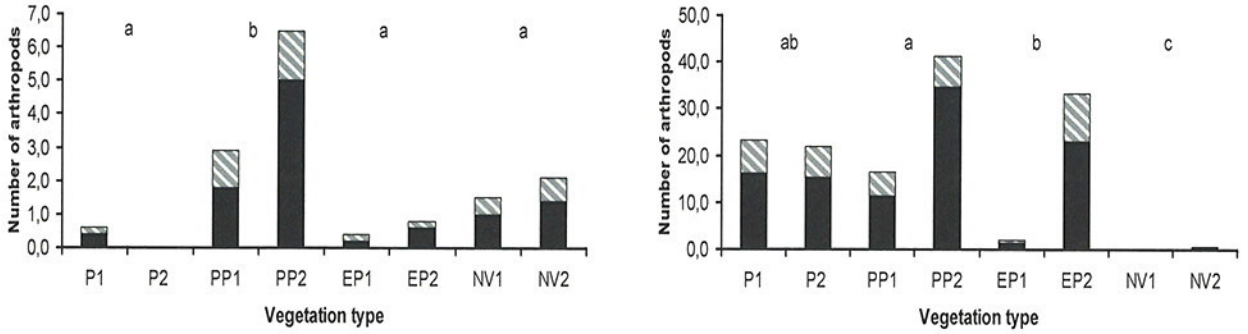


Figure 15. Mean (+ SE in stipple) number of Homoptera (sucking bugs) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

(a)



(b)



(c)

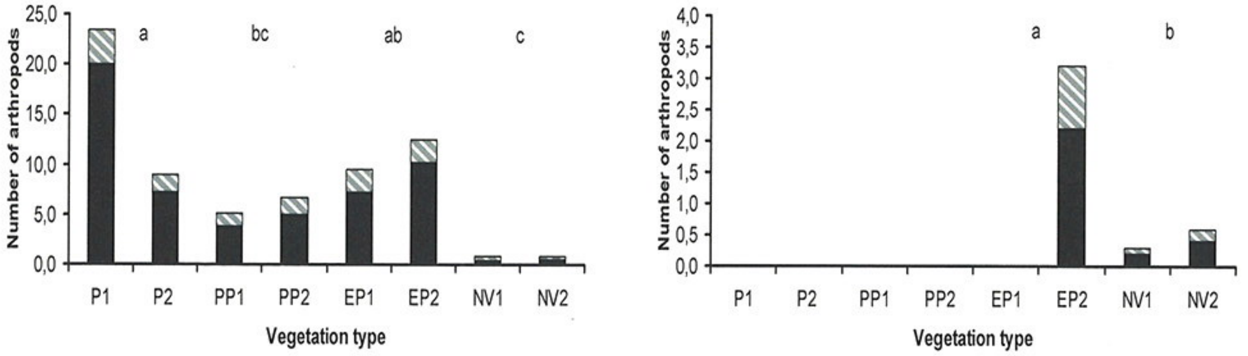


Figure 16. Mean (+ SE in stipple) number of Coleoptera (beetles) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

(a)

(b)

(c)

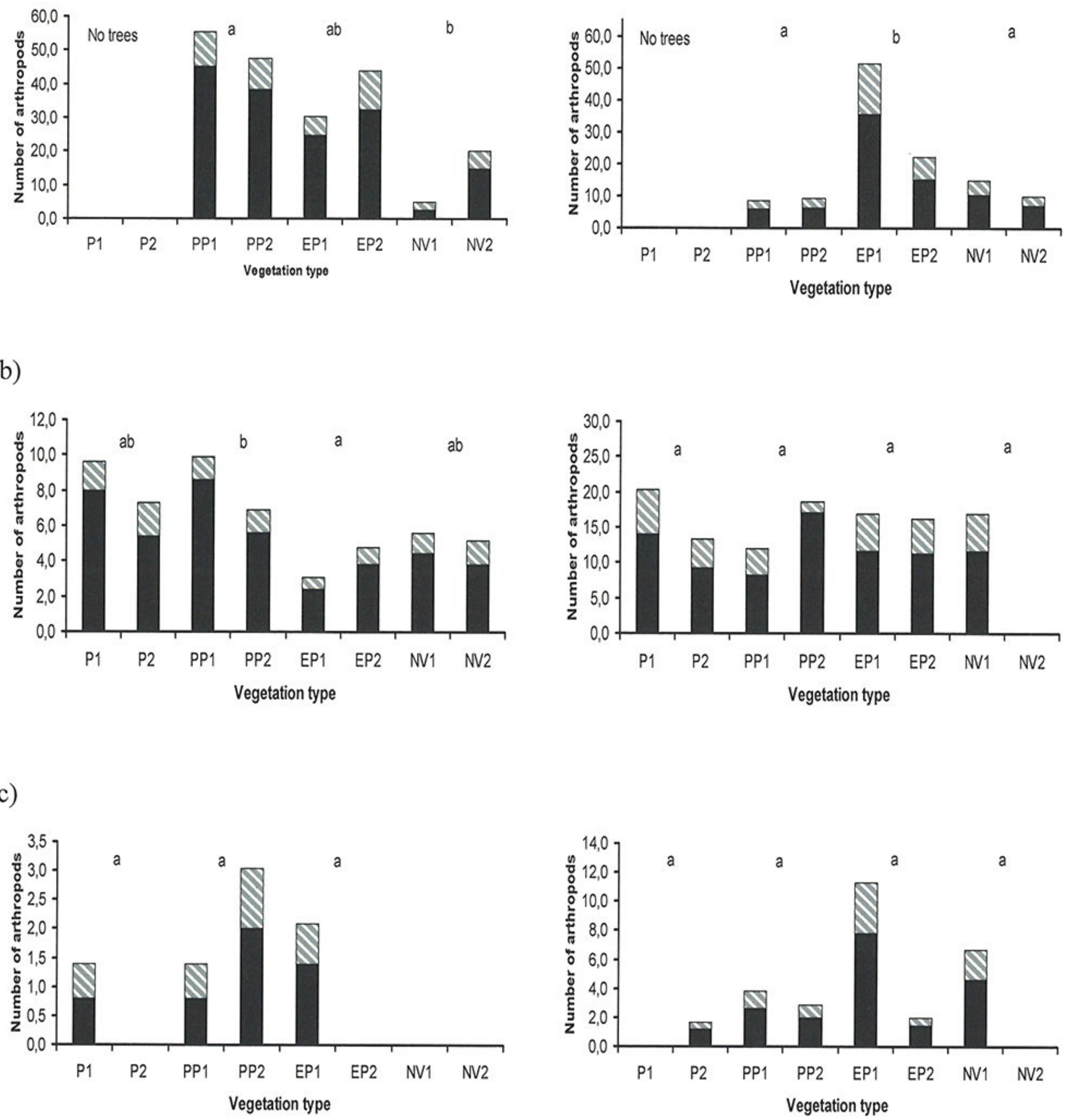


Figure 17. Mean (+ SE in stipple) number of Diptera (flies) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

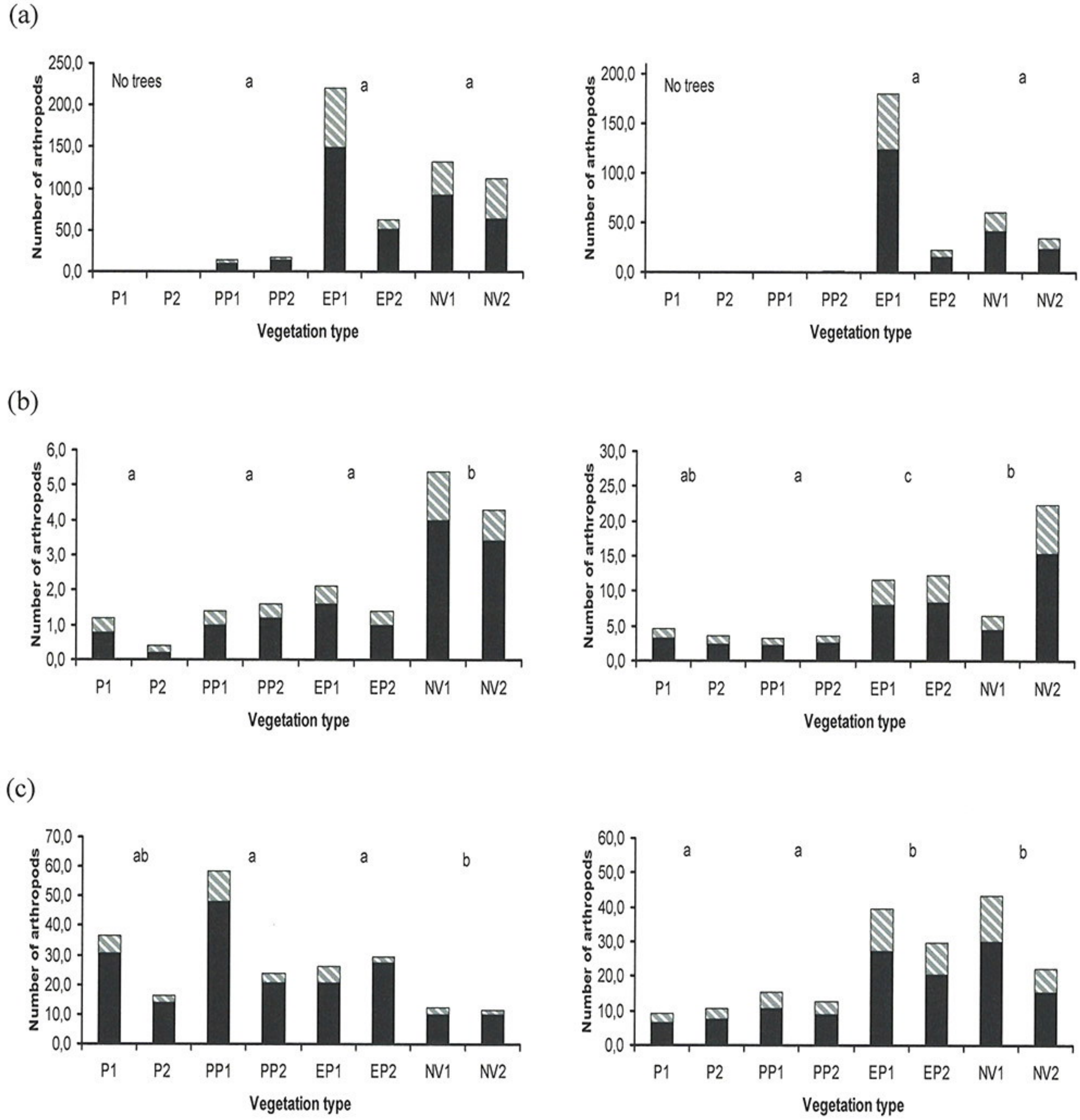
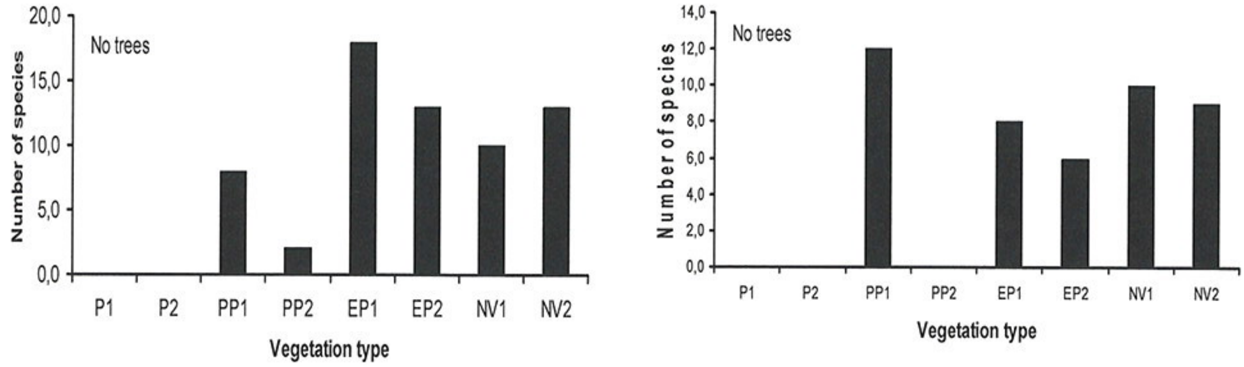


Figure 18. Mean (+ SE in stipple) number of other-Hymenoptera (wasps and bees) sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007. For each sampling method, plot types sharing the same letter do not significantly differ from each other at P< 0.05; two-way ANOVA with Tukey's HSD post hoc tests.

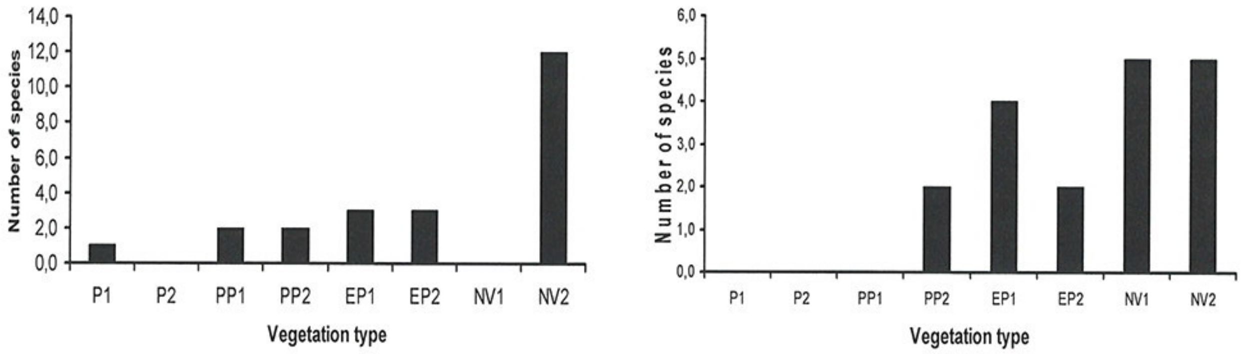
Table 3. Ant species sampled by pitfall traps (P), sweeping (S) and chemical knockdown (K) during April and October 2007 and for the two periods combined.

Species	Apr-07								Oct-07								Both periods							
	P1	P2	PP1	PP2	EP1	EP2	NV1	NV2	P1	P2	PP1	PP2	EP1	EP2	NV1	NV2	P1	P2	PP1	PP2	EP1	EP2	NV1	NV2
Anonychomyrma itinerans perthensis Forel							P																P	
Arnoldius sp. JDM 433						K									K	K						K	K	K
Camponotus chalceus Crawley							K, P	K							S, K								S,K,P	K
Camponotus claripes minimus Crawley					K								K, P								K,P			
Camponotus dryandrae McArthur & Adams								P																P
Camponotus gasseri (Forel)							K																K	
Camponotus lownei Forel					K, P																K,P			
Camponotus lownei complex sp. JDM 761															P								P	
Camponotus postcornutus Clark							P	S							P								P	S
Camponotus prosseri Shattuck								S							K	P							K	S,P
Camponotus prostans Forel															P	K, P							P	K,P
Camponotus terebrans (Lowne)							K																K	
Camponotus sp. JDM 26							P	S								S, P							P	S,P
Cardiocondyla nuda (Mayr)	P		K		K	K, P			P					P	P		P		K		K	K,P	P	
Crematogaster laeviceps chasei Forel							K	K							K	K							K	K
Doleromyrma rottnestensis (Wheeler)			P	P	P	P	P	S, P			P		P		P	P			P	P	P	P	P	S,P
Dolichoderus cf. *angusticornis* Clark							K	S							S, P	S, K							S,K,P	S,K
Froggattella latispina Wheeler							K																K	
Iridomyrmex bicknelli Emery	S, P	P	S, K, P	P	S, K, P	K, P	K	S, K	S	P	P	S	S, K, P	S, K, P	K, P	S, K	S,P	P	S,K,P	S,P	S,K,P	S,K,P	K,P	S,K
Iridomyrmex chasei Forel					K										K						K		K	
Iridomyrmex dromus Clark					S, K								P		P						S,K,P		P	
Iridomyrmex greensladei Shattuck	P	P	S, K		S, K, P	S, K		S, K, P	P	P	P		P	K	P	S, K, P	P	P	S,K,P		S,K,P	S,K	P	S,K,P
Iridomyrmex mattiroloi complex sp. JDM 845								S																S
Iridomyrmex mattiroloi splendens Clark						K	K, P	S, K, P							S, P							K	S,K,P	S,K,P
Iridomyrmex mattiroloi complex									S						P		S						P	
Iridomyrmex notialis Shattuck					K			K							K						K		K	K
Iridomyrmex prismatis Shattuck								K																K
Iridomyrmex rufoniger suchieri Forel (pop. 1)		S	K	K, P	K			S	P	P	S	S, P	S, K	K	K, P	P	P	S,P	S,K	S,K,P	S,K	K	K,P	S,P
Iridomyrmex rufoniger suchieri Forel (pop. 2)			P			K, P				P	P		K, P	K	P			P	P		K,P	K,P	P	
Iridomyrmex viridiaeneus Viehmeyer													K, P	P		K					K,P	P		K
Iridomyrmex sp. JDM 846								S, K							P								P	S,K
Melophorus insularis Wheeler							P																P	
Melophorus turneri Forel	P				K, P	K, P			P	P	P		K, P	P	P		P	P	P		K,P	K,P	P	
Melophorus ANIC sp. 3															P								P	
Melophorus sp. JDM 176															P	P							P	P
Meranoplus sp. JDM 74																P								P
Monomorium aithoderum Heterick								S, K								S								S,K
Monomorium decuria Heterick															P								P	
Monomorium fieldi Forel (ss)						P										P						P		P
Monomorium fieldi Forel (' *laeve nigrius* ')								K, P																K,P
Monomorium leae Forel							P								P								P	
Monomorium longinode Heterick							P								P								P	
Monomorium sordidum Forel	P	P	P	S, P	K, P	S, P			P	P	P	P	S, P	P	P	P	P	P	P	S,P	S,K,P	S,P	P	P
Monomorium sydneyense Forel																S, P								S,P
Monomorium sydneyense complex															P	P							P	P
Myrmecia dispar (Clark)					K																K			
Myrmecia picta F. Smith						K																K		
Myrmecia urens complex sp. JDM 1															K								K	
Ochetellus glaber gp. sp. JDM 19	P		K, P		K, P	S, K	K	S, K			S		S, K, P	S, K	S, K, P	K, P				S,K,P		S,K,P	S,K	S,K,P
Ochetellus glaber gp. sp. JDM 851															K	K							K	K
Pachycondyla (*Brachyponera*) *lutea* (Mayr)		P				P			P	P				P			P	P				P		
Pheidole ampla perthensis Crawley	P	P	K, P	P	K, P	K, P	P		P	P	S, P	P	P	K, P	P		P	P	S,K,P	P	K,P	K,P	P	
Pheidole nr. *variabilis* Mayr (JDM 177)								P							P	P							P	P
Plagiolepis squamulosa Wheeler															P								P	
Plagiolepis sp. JDM 189							P								P								P	
Podomyrma adelaidae (F. Smith)					K										S						K		S	
Polyrhachis gravis Clark								K																K
Polyrhachis (*Campomyrma*) sp. JDM 118					K, P	K		K							P	P				K,P	K	K	P	K,P
Polyrhachis sidnica complex sp. JDM 671															P								P	
Prolasius sp. JDM 551								P																P
Rhytidoponera metallica (F. Smith)	P	P	K, P	K, P	K, P	K, P	K, P	P	P	P	P	P	K, P	K, P		K, P	P	P	K,P	K,P	K,P	K,P	K,P	K,P
Rhytidoponera rufonigra (Clark)								P																P
Rhytidoponera violacea (Forel)				S																S				
Solenopsis clarki Crawley	P			P						P	P						P	P	P	P				
Stigmacros aemula (Forel)								P																P
Stigmacros brachytera McAreavey								P																P
Stigmacros sp. JDM 115															P								P	
Tetramorium impressum (Viehmeyer)	P	P	K, P	P	K, P	K, P				P			P		P		P	P	K,P	P	K,P	K,P	P	
Tetramorium striolatum Viehmeyer											P				P				P					
Total species per transect	10	8	11	9	19	17	19	27	10	11	12	5	14	12	41	23	12	11	14	9	21	19	48	37
Total species per land use type	12		13		15		36		13		12		16		48		13		16		26		61	
Total species pitfall trap	9	7	8	8	11	11	12	11	8	11	3	4	12	8	32	16	11	11	12	8	15	12	37	25
Total species sweeping	1	1	2	2	3	3	0	12	2	0	0	2	4	2	5	5	2	1	5	4	6	4	5	14
Total species chemical knockdown	0	0	7	2	17	13	10	12	0	0	12	0	8	6	10	9	0	0	8	1	8	20	15	19

(a)



(b)



(c)

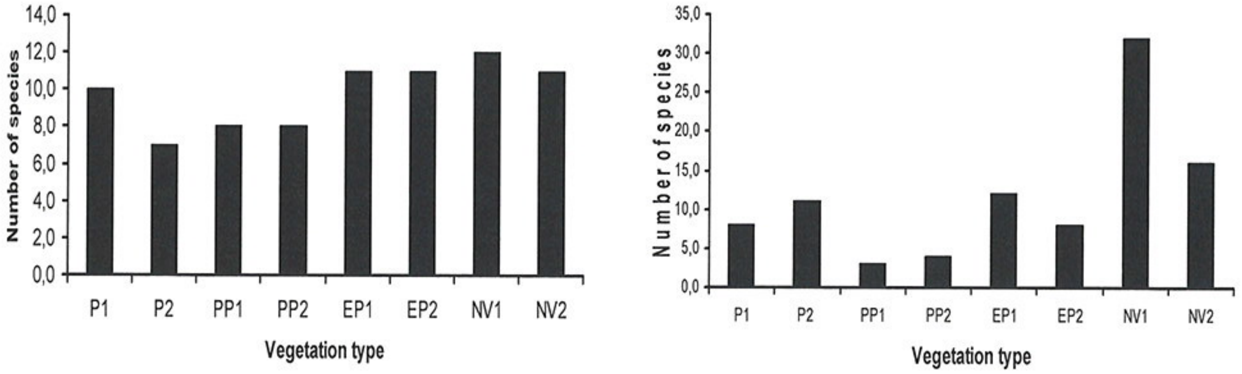
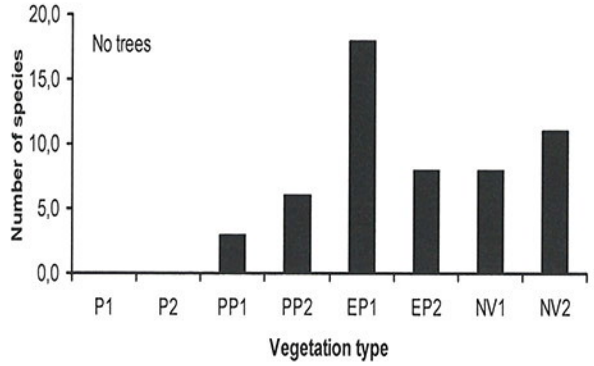


Figure 19. Total number of ant species sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007.

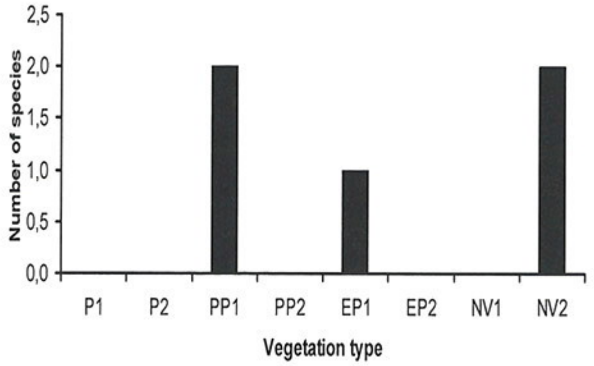
Table 4. Wasp and bee species sampled by pitfall traps(P), sweeping (S) and chemical knockdown (K) during April 2007.

Species	Apr-07							
	P1	P2	PP1	PP2	EP1	EP2	NV1	NV2
Megaspilinae: Megaspilidae					K			
?Phygadeuontinae: Ichneumonidae								K
Aphidius: Aphidiinae: Braconidae					K			
gen. nr. *Meteorus*: Euphorinae: Braconidae					K			
Apanteles: Microgasterinae: Braconidae						K		
Helconinae: Braconidae					K			
Miracinae: Braconidae								K
Rogadinae: Braconidae						K		K
Braconidae sp.							K	
Inostemma sp.: Platygasteridae								K
Platygasteridae sp. 1								K
Platygasteridae sp. 2				K				
Baryconus: Scelioninae: Scelionidae						K		
Telenomus sp.: Telenominae: Scelionidae						K		
Baryconini: Scelionidae sp. 1				K				
Spilomicrus: Diapriinae: Diapriidae			K					
Antrocephalus: Haltichellinae: Chalcididae					K			
Podagrion: Monodontomerinae: Torymidae			K		K			K
?*Eurytoma*: Eurytominae: Eurytomidae					K			
Megastigminae: Torymidae (?2 spp.)							K	K
Megastigminae: Torymidae (1 sp.)								K
Enoggera: Asaphinae: Pteromalidae						K		
Pteromalidae sp. 1						K		
Eucharitinae: Eucharitiae					K			
Eupelminae: Eupelmidae							K	K
Anicetus communis (Annecke): Encyrtidae								S, K
Encyrtinae: Encyrtidae							K	
Pediobius: Entedoninae: Eulophidae						K		
Eulophinae: Eulophidae			S					
Tetrastichinae: Eulophidae							K	
Eulophidae sp. 1							K	K
Eulophidae sp. 2					K			
Epyris: Epyrinae: Bethylidae				K				
Holepyris sp.: Epyrinae: Bethylidae								
Rhabdepyris sp. 1: Epyrinae: Bethylidae			K		K			
Rhabdepyris sp. 2: Epyrinae: Bethylidae					K			
Rhabdepyris sp. 3: Epyrinae: Bethylidae				K				
Sierola sp.: Bethylinae: Bethylidae				K		K	K	
Bethylinae: Bethylidae							K	
Epyrinae: Bethylidae					K			
Cryptocheilus: Pepsinae: Pompilidae						P		
Pepsinae: Pompilidae						P		
?Ceropalinae: Pompilidae	P					P		
Mutillidae sp. 1 (female)					K			
Mutillidae sp. 2 (female)					K, P	P		
Mutillidae sp. 3 (female)						K		
Mutillidae male sp. 1					K			
Mutillidae male sp. 2				K	P			
Thynninae: Tiphiidae sp. 1 (female)					S, K, P			
Thynninae: Tiphiidae sp. [1?] (male)					K			
Rhopalum: Craboninae: Sphecidae					K			
Leioproctus: Colletinae: Colletidae				P				
Apis mellifera L.: Apinae: Apidae			S					S
Total species per transect	1	0	5	7	22	12	8	13
Total species per land use type	1		12		31		16	
Total species pitfall trap	1	0	0	1	3	4	0	0
Total species sweeping	0	0	2	0	1	0	0	2
Total species chemical knockdown	0	0	3	6	18	8	8	11

(a)



(b)



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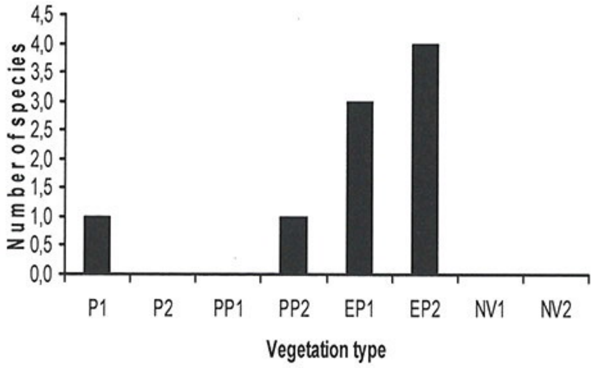

Figure 20. Total number of wasp and bee species sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April 2007.

Table 5. Beetle species sampled by pitfall traps(P), sweeping (S) and chemical knockdown (K) during April 2007.

Species	Apr-07							
	Pasture		Pine plantation		Eucalyptus plantation		Blue mallee	
	P1	P2	PP1	PP2	EP1	EP2	NV1	NV2
Dryophilodae sp. 1 Anobiidae							S	
Tomoderus sp. 1 Anthicidae		P				K		S
Apion sp. 1 Apionidae						K		
Microchaetes sp. 1 Byrrhidae			P			P		
Morychus sp. 1 Byrrhidae					S			
Epilectus sp. 1 Carabidae							P	
Gnathaphanus sp. 1 Carabidae	P	P				P		
Homothes sp. 1 Carabidae				K				
Notagonum sp. 1 Carabidae		P	P			P		
Simodontus sp. 1 Carabidae			K	P				P
Eboo sp. 1 Chrysomelidae					K, S	S, K		S
Paropsisterna sp. 1 Chrysomelidae						K		
Coccinella transversalis Coccinellidae						S		
Diomus sp. 1 Coccinellidae								S
Rhyzobius sp.1 Coccinellidae						K	K, S	S
Rhyzobius sp.2 Coccinellidae							K, S	
Rhyzobius sp.3 Coccinellidae							S	
Scymnodes sp. 1 Coccinellidae						K	S	S
Scymnus sp. 1 Coccinellidae			K, S	K, S		K, S		S
Ablabussp. sp. 1Colydidae							K, S	
Curculionidae sp. 1						K		
Catasarcus sp. 1 Curculionidae							K, S	S
Cydmaea sp. 1 Curculionidae							S	
Decilaus sp.1 Curculionidae							S	
Decilaus sp.2 Curculionidae			S					
Decilaus sp.3 Curculionidae			K		K		P	
Desiantha diversipes Curculionidae	P	P	P			P		
Dicomada sp. 1 Curculionidae							S	
Diethusa sp. 1 Curculionidae								S
Emplesis sp. 1 Curculionidae					K			
Hyplopsus sp. 1 Curculionidae	S	S	K	K	S, P	K		
Leptopius sp. 1 Curculionidae							S	S
Mandalotus sp. 1 Curculionidae					K			
Polyphrades sp. 1 Curculionidae					K			S
Sitona sp. 1 Curculionidae				K				
Storeus sp. 1 Curculionidae								
Agrypnus sp. 1 Elateridae							S	S
Aderus sp. 1 Euglenidae						K		
Cryptolestes sp. 1 Laemophloeidae								S
Corticaria sp. 1 Lathridiidae			K					S
Thalycrodes sp. 1 Nitidulidae				P, S	P	P		
Aphodius sp. 1 Scarabaeidae	P	PŹ	P	P	P	P		S
Heteronyx sp.1 Scarabaeidae			K					
Heteronyx sp.2 Scarabaeidae		P						
Heteronyx sp.3 Scarabaeidae	P							
Heteronyx sp.4 Scarabaeidae		P	P		P			
Liparetrus nr. dispar Scarabaeidae							S	
Liparetrus merredinensis Scarabaeidae					P			
Neodon sp. 1 Scarabaeidae							P	
Adelium brevicorne ? Tenebrionidae	P	P	K, P, S	K,	K, P	K, P		P
Celibe sp. 1 Tenebrionidae								S
Gonocephalum elderi Tenebrionidae						K		
Helea sp.1 Tenebrionidae	P	P	P		P	P		
Helea sp.2 Tenebrionidae					P			
Homotes sp. 1 Tenebrionidae							S	
Titaena sp. 1 Tenebrionidae								S
Total species per transect	7	10	14	8	14	20	17	18
Total species per land use type	11		17		28		30	
Total species pitfall trap	6	9	7	3	8	8	3	2
Total species sweeping	1	1	3	2	3	3	13	16
Total species chemical knockdown	0	0	7	5	6	12	4	0

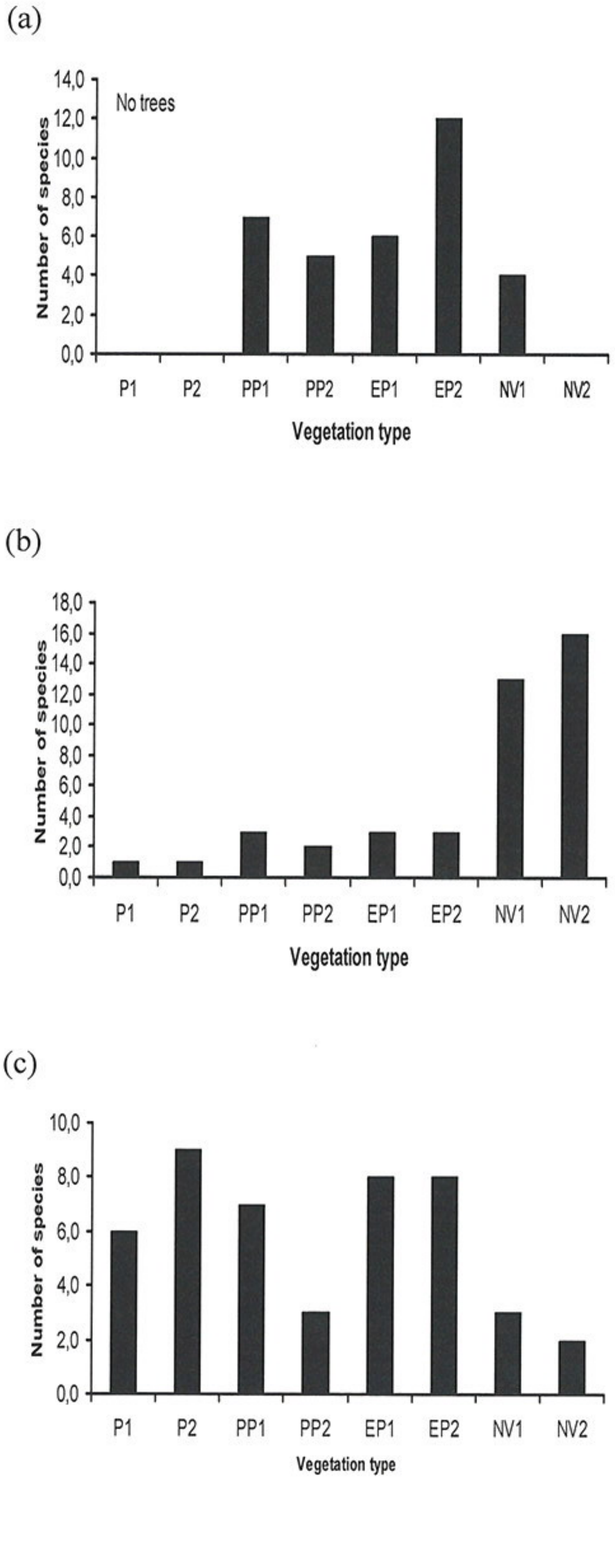

Figure 21. Total number of beetle species sampled by (a) chemical knockdown, (b) sweeping and (c) pitfall traps in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April 2007.

Table 6. List of bird species surveyed in the replicated pasture (P), pine plantation (PP), eucalypt plantation (EP) and native vegetation (NV) areas during autumn (April 2007) and spring (October 2007). The data for both seasons combined are also shown.

Species		Apr-07								Oct-07								Both periods							
		P1	P2	PP1	PP2	EP1	EP2	NV1	NV2	P1	P2	PP1	PP2	EP1	EP2	NV1	NV2	P1	P2	PP1	PP2	EP1	EP2	NV1	NV2
Australian Magpie	*Gymnorhina dorsalis*			*					*			*								*					*
Australian Raven	*Corvus perplexus*							*	*			*		*		*	*			*		*		*	*
Australian Ringneck	*Barnardius zonarius*																*								*
Brown Honeyeater	*Lichmera indistincta*							*	*								*							*	*
Brown-headed Honeyeater	*Melithreptus leucogenys*							*	*															*	*
Brush Bronzewing	*Phaps elegans*													*								*			
Common Bronzewing	*Phaps chalcoptera*																*								*
Crested Pigeon	*Ocyphaps whitlocki*							*								*								*	
Fantail Cuckoo	*Cacomantis flabelliformis*																*								*
Golden Whistler	*Pachycephala fuliginosa*											*					*			*					*
Grey Butcherbird	*Cracticus leucopterus*			*		*			*				*			*				*	*	*		*	*
Grey Currawong	*Strepera plumbea*				*												*				*				*
Grey Falcon	*Falco hypoleucos*														*								*		
Grey Fantail	*Rhipidura preissi*												*								*				
Grey Shrike-thrush	*Colluricincla rufiventris*							*	*															*	*
Inland Thornbill	*Acanthiza venus*						*						*		*						*		*		
Magpie-lark	*Grallina cyanoleuca*								*					*			*					*			*
New Holland Honeyeater	*Phylidonyris longirostris*							*	*							*	*							*	*
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*															*								*	
Red Wattlebird	*Anthochaera carunculata*								*							*	*							*	*
Silvereye	*Zosterops chloronotus*		*						*		*		*		*		*		*		*		*		*
Spotted Pardalote	*Pardalotus xanthopyge*					*		*	*					*			*					*		*	*
Striated Pardolote	*Pardalotus substriatus*					*	*	*	*													*	*	*	*
Tawny-crowned Honeyeater	*Phylidonyris melanops*																*								*
Tree Martin	*Hirundo neglecta*				*	*		*	*												*	*		*	*
Weebill	*Smicrornis occidentalis*																*								*
Western Gerygone	*Gerygone fusca*					*	*															*	*		
Western Spinebill	*Acanthorhynchus superciliosus*			*				*	*			*				*				*				*	*
Western Wattlebird	*Anthochaera lunulata*					*			*							*	*					*		*	*
White-backed Swallow	*Cheramoeca leucosternus*															*								*	
White-browed Scrubwren	*Sericornis mellori*											*				*	*			*				*	*
White-cheeked Honeyeater	*Phylidonyris gouldii*															*								*	
White-fronted Honeyeater	*Phylidonyris albifrons*												*								*				
Willie Wagtail	*Rhipidura leucophrys*							*																*	
Yellow-rumped Thornbill	*Acanthiza chrisorrhoa*						*		*		*				*	*			*				*	*	*
Yellow-throated Miner	*Manorina obscura*					*		*	*					*			*					*		*	*
Total species per transect		0	1	3	2	7	4	12	17	0	2	5	5	5	4	12	13	0	2	6	7	10	6	20	25
Total species per land use type		1		5		9		19		2		10		9		24		2		12		14		30	

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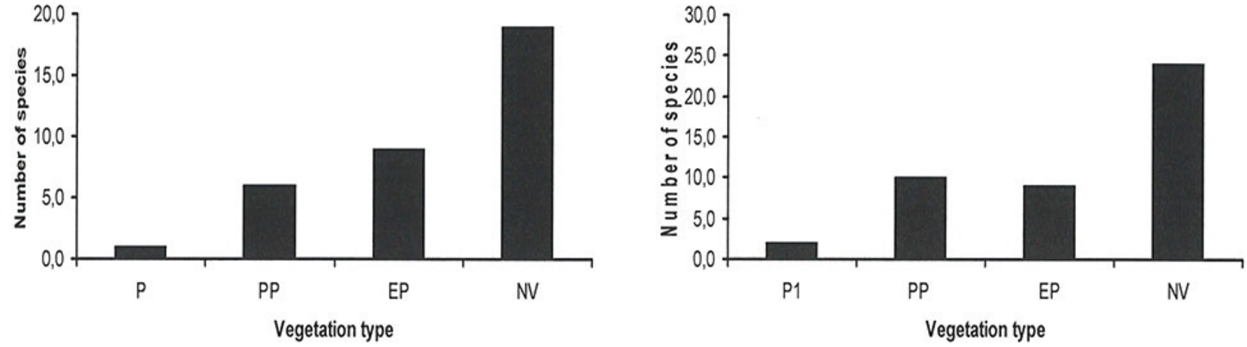

Figure 22. Total number of bird species surveyed in paired pasture (P), pine plantation (PP), eucalyptus plantation (EP) and blue mallee (NV) plots during April (left) and October (right) 2007.

Discussion and Conclusions

Samples from all three strata indicate that both pine and eucalypt plantations play some role in encouraging the return of invertebrate biodiversity in an area where much has been lost or has retreated in range due to intense clearing for agricultural purposes. Both of the eucalypt species investigated here enhanced invertebrate abundance and diversity to a higher degree than did the pines, and there is some evidence that *E. tricarpa* is superior to *E. cladocalyx* in this regard. It is well known that exotic pines grown in Australia support low levels of invertebrates (Bhulla & Majer, 2000), and this may result from the lack of adaptation of native invertebrates to the novel biochemistry and/or structure of the pine tissues. It is also common to find variation in attractiveness of different *Eucalyptus* spp. to invertebrates (Majer *et al.*, 2001), a feature that is sometimes associated with the levels of nitrogen or phosphorus in the foliage (Recher *et al.*, 1996).

These trends were reflected in the variety of birds that utilize these plantations and it is no coincidence that many of the species that were found in these areas were totally or partially dependent on invertebrates for their nutritional requirements (Appendix 1). The addition of tree structures would undoubtedly be partly responsible for the return of many species, but the fact that eucalypts were more effective than pines in this regard, even though they were similar in height, suggests that birds may have been benefiting from the food resources provided by the planted eucalypts. Whether they would return to an area in the absence of nearby native vegetation, which many of the species also utilise, is open to question. It should also be noted that when the pines mature and produce cones, they will undoubtedly provide a high energy food-source for the Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*), which is listed as 'Specially protected Fauna' under the Western Australian Conservation Act, 1950.

We conclude that both types of plantation are likely to provide conservation benefits, both to invertebrates and to the birds that feed upon them. However, eucalypts are clearly superior to pines in this regard. That said, there are hydrological issues that must be taken into account, so pines may still be an attractive option if they perform more effectively in lowering water tables. It should also be stressed that the trees were only 6 years old at the time of sampling. Their ability to support invertebrate biodiversity may change with age. This may be more pronounced with pines, as they shade out the area and produce a dense litter layer of pine needles (Springett, 1976). An additional factor is that, despite exhibiting high initial growth rates, pines can ultimately outstrip available nutrient and water availabilities, resulting in water or nutrient stress; this can in turn lead to pest attacks such as by the Pine adelgid, *Pineus pini* (Macquart) (M. Grimm, personal communication).

Acknowledgements

This work forms a component of the Curtin University *Sustaining Gondwana* initiative, which is addressing conservation and sustainability issues on the south coast of Western Australia. Major funding for this particular project was provided by a grant from Lotterywest. We thank Tim Frodsham for applying for this grant and making the initial arrangements for the project. Ken Read, Jean Read and Mike Gibbs from the Esperance Bird Observers Group carried out the bird surveys and for providing the bird dietary information; Dr Brian Heterick and Andras Szito determined the Hymenoptera and beetles, respectively.

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Appendix 1. Feeding habits of the birds encountered in this study.

Species		**Feeding Habitats**
Australian Magpie	*Gymnorhina dorsalis*	Insects, small lizards and other birds.
Australian Raven	*Corvus perplexus*	Insects, other young birds
Australian Ringneck	*Barnardius zonarius*	Nectar and blossum from *Eucalyptus* sp.
Brown Honeyeater	*Lichmera indistincta*	Nectar and insects and berries
Brown-headed Honeyeater	*Melithreptus leucogenys*	Nectar and insects and berries
Brush Bronzewing	*Phaps elegans*	Seeds
Common Bronzewing	*Phaps chalcoptera*	Seeds
Crested Pigeon	*Ocyphaps whitlocki*	Seeds
Fantail Cuckoo	*Cacomantis flabelliformis*	Insects
Golden Whistler	*Pachycephala fuliginosa*	Insects from smaller trees
Grey Butcherbird	*Cracticus leucopterus*	Insects, small lizards and other birds
Grey Currawong	*Strepera plumbea*	Insects, small lizards and other birds
Grey Falcon	*Falco hypoleucos*	Mice, lizards and other small birds
Grey Fantail	*Rhipidura preissi*	Insects
Grey Shrike-thrush	*Colluricincla rufiventris*	Insects from ground and smaller trees and scrub
Inland Thornbill	*Acanthiza venus*	Insects from taller trees
Magpie-lark	*Grallina cyanoleuca*	Insects
New Holland Honeyeater	*Phylidonyris longirostris*	Nectar and insects and berries
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*	Nectar and blossum from *Eucalyptus* sp.
Red Wattlebird	*Anthochaera carunculata*	Nectar and insects and berries
Silvereye	*Zosterops chloronotus*	Nectar and insects and berries
Spotted Pardalote	*Pardalotus xanthopyge*	Lerps and small insects from *Eucalyptus* sp.
Striated Pardolote	*Pardalotus substriatus*	Lerps and small insects from *Eucalyptus* sp.
Tawny-crowned Honeyeater	*Phylidonyris melanops*	Nectar and insects and berries
Tree Martin	*Hirundo neglecta*	Insects in flight
Weebill	*Smicrornis occidentalis*	Insects from taller trees
Western Gerygone	*Gerygone fusca*	Lerps and small insects from *Eucalyptus* sp.
Western Spinebill	*Acanthorhynchus superciliosus*	Nectar and insects and berries
Western Wattlebird	*Anthochaera lunulata*	Nectar and insects and berries
White-backed Swallow	*Cheramoeca leucosternus*	Insects on the wing
White-browed Scrubwren	*Sericornis mellori*	Insects and seed from mainly the ground
White-cheeked Honeyeater	*Phylidonyris gouldii*	Nectar and insects and berries
White-fronted Honeyeater	*Phylidonyris albifrons*	Nectar and insects and berries
Willie Wagtail	*Rhipidura leucophrys*	Insects
Yellow-rumped Thornbill	*Acanthiza chrisorrhoa*	Insects and seeds mostly on ground
Yellow-throated Miner	*Manorina obscura*	Nectar and insects and berries

sustaining gondwana
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Working Paper Series
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ALCOA FOUNDATION'S CONSERVATION AND SUSTAINABILTY PROGRAM

Sustaining Gondwana is a strategic initiative of Curtin University of Technology that has been funded by the Alcoa Foundation's Conservation and Sustainability Fellowship Program and by the University. Its aim is to research conservation and sustainability issues along the south coast of Western Australia, from Walpole to just east of Esperance. The vegetation and fauna of this area is so diverse that it is considered to be one of the world's bio-diversity hotspots. The five year program, which is connected internationally with other Universities and Sustainability Institutes, was launched in November 2005.

The initiative is co-ordinated by three cabinet members, professors Daniela Stehlik, Jonathan Majer and Fiona Haslam McKenzie. Six postdoctoral fellows are being appointed to work on issues related to this region, and their research will be augmented by activities of the cabinet members themselves as well as their graduate students. It is anticipated that the findings will be published in journals, conference proceedings and books. However, there is a need to communicate early findings, data sets and activities of group members in a timely manner so that stakeholders can benefit from outputs as soon as they become available. This is the aim of the *Sustaining Gondwana Working Papers* Series, which will be produced on an occasional basis over the life of the initiative.

The papers are not subject to peer review, but are edited by cabinet members in order to maintain standards and accuracy. Contributions from researchers and practitioners who are active in the region of focus can also be considered for publication in this series.

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