Journal of the Royal Society of Western Australia, 75: 89-95, 1992

Ants as indicators of disturbance at Yanchep National Park, Western Australia

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Manuscript received January 1992; accepted July 1992

Abstract

Undisturbed sites at Yanchep National Park support ant communities which, in terms of species richness, evenness and functional group profiles, are typical of undisturbed sites elsewhere in south-western Australia. Slight modifications of the ecosystem result in slight alterations in ant communities. Replacement of native vegetation by gardens or plantations results in a considerable reduction in species and generic richness, reduction in the number of functional groups and altered species composition. Particular species of *Crematogaster*, *Tapinoma* and *Iridomyrmex* are indicative of relatively undisturbed sites, while particular species of *Melophorus* and *Tetramorium* are indicative of highly disturbed environments. Species richness of ants at undisturbed sites is not significantly correlated with numbers of vertebrate species at those sites.

Introduction

Ants are increasingly used as bio-indicators in studies of minesite rehabilitation, fire management, pesticide contamination, habitat disturbance and in theoretical considerations of reserve design (Andersen 1987, 1990, Majer 1983). They are of use in this respect because they are a diverse group of animals with a community structure which tends to reflect the nature of the environment in which they occur. In addition, the diversity and types of ants present are often correlated with the composition of other components of the invertebrate fauna (Majer 1983). Thus although many other invertebrate taxa would also respond to changes in the environment, a consideration of the ant fauna can tell us much about the trends in these other taxa. Ants are also sensitive and react quickly to ecological change (Andersen 1990), interact in many ways with other parts of the ecosystem, occupy a broad range of trophic levels, occupy varied niches and presumably influence a wide range of flora and fauna groups, although the nature of such relationships at a community level has not been elucidated. Ants are also better known taxonomically than many other groups of Australian invertebrates and are readily sampled. Information on distribution, relative abundance and community organization of ants can therefore be interpreted in the context of a whole array of ecological characteristics of the environment (Andersen 1987). Other groups of organisms, such as plants, could be surveyed in order to detect environmental change. Such studies, particularly integrated studies of vegetation structure and floristics, can provide much useful information about the ecological status of an area. However, data on ants can complement such information and, because the presence or absence of ants is influenced by a whole range of factors, can be used to integrate information on a wide range of environmental parameters.

The present study was initiated with the aim of investigating the structure of ant communities in disturbed and undisturbed sites in and near Yanchep National Park (31°32'S, 115°41'E), on the Swan Coastal Plain, near Perth, Western Australia. The only previous systematic sampling of ants in non-urban parts of the Swan Coastal Plain is by Rossbach & Majer (1983) who suggested that vegetation and soil type each played an important role in determining ant community composition in this area. They also suggested that the trends found in their study may also be discernible in other animal taxa.

Yanchep National Park is 50 km north of Perth. The area, first made a reserve in 1905 for 'Protection and Preservation of Caves and Flora and for a Health and Recreation Pleasure Resort' and vested in the Caves Board, became a National Park in 1969 (National Parks Authority, undated). However, as its main function in its early years was for recreation, some areas of native vegetation were replaced by parks and gardens, and other areas became invaded by weeds. To date, 71 weed species have been recorded in the study area (G J Keighery personal communication).

We set out to determine how the structure and composition of ant communities in disturbed environments in the Yanchep area differed from those in nearby relatively undisturbed native vegetation. It was expected that this would enable us to identify species which could be used as indicators of disturbance. Such indicators would then be of use in future studies when ecological disturbance is being investigated. We also wished to make comparisons between ant distribution patterns and vertebrate distribution patterns for ten sites for which there were pre-existing data on vertebrate animal occurrences (A H Burbidge & J K Rolfe unpublished data).

Methods

Study sites

Most of the study area is on the Spearwood Dunes with a small area on the western boundary being on Quindalup Dunes (Churchward & McArthur 1980). A soil map of the area, drawn from the data of W M McArthur, is shown in Smith *et al.* (1989). Vegetation is primarily woodlands and heaths (D Lamont in Smith *et al.* 1989). Rainfall in the area averages 750 mm per annum with most rain falling between April and October. The average maximum temperature is about 24°C and the average minimum 12°C (Bureau of Meteorology 1966). Ten disturbed sites and 10 undisturbed sites were sampled in and near the National Park

(Fig 1). The vegetation at each site is briefly described in Table 1.

Sampling

Ants were collected by pitfall traps, diurnal hand collections from the ground and vegetation (1.5 person hours per plot), and Winkler-sack extraction from the leaf litter (10 l of litter sampled per plot). At each site, 10 pitfall traps (1.8 cm internal diameter x 17 cm depth) were placed 10 m apart on a single 100 m transect. At sites where vertebrate sampling has been done (see Table 1) (A H Burbidge & J K Rolfe unpublished), the ant sampling transect was placed parallel with, and close to, the vertebrate pit line. Ant pitfall traps each contained about 3 ml of 8:2 (v:v) alcohol-glycerol mixture, which is not attractive to ants (Greenslade & Greenslade 1971). Pitfall traps were left open for seven days in late December 1989, with the other sampling methods being used in late December and early January. The weather was hot and dry during the sampling period.

Representative specimens of ants collected are held at the Wildlife Research Centre, Department of Conservation and Land Management, Woodvale. Collections which could not be assigned a specific name were assigned a species number unique to this study.

Analysis

Species richness for each site was derived by summing the total number of species obtained from pits and hand collections. Species evenness for each site was calculated following the method outlined by Majer (1983) and Rossbach & Majer (1983), using the formula

$$J' = \frac{H'}{\log S}$$

where H' is the Shannon-Weaver diversity index (Shannon & Weaver 1949) and S is the total species present.

Table 1

Vegetation at each sampling site in and near Yanchep National Park. The soil classification is that of McArthur, as shown in Smith *et al.* (1989). Vegetation classification is based on that of D Lamont, shown in Smith *et al.* (1989). Vertebrates have also been sampled at sites marked with an asterisk. Words in bold type are the basis of the site codes.

Site code: This study	Site code: CALM[1]	Vegetation
Q1*	9A	**Quindalup** dune vegetation with scattered *Acacia saligna* and *Xanthorrhoea* over shrubs to 1 m and herbs on Quindalup sands.
Q2*	9C	**Quindalup** dune vegetation with very sparse *A. saligna* over shrubs to 1 m and herbs on Quindalup sands.
D1*	4B	Mid-dense **Dryandra** heath to 2 m of mainly *Dryandra sessilis* over low shrubs of various species with herbs in more open areas, on Karrakatta limestone.
D2*	5B	Mid-dense **Dryandra** heath to 2 m of *D. sessilis* and *Hakea trifurcata* over low shrubs of various species with herbs in more open areas, on Karrakatta limestone.
B1*	2A	Low **Banksia** woodland to 8 m of *Banksia attenuata* and *B. menziesii* with scattered *Eucalyptus marginata* and *E. todtiana* over heath to 2 m with some herbs on Karrakatta sands.
B2*	6B	Open low **Banksia** woodland to 8 m of *B. attenuata* and *B. menziesii* over heath to 2 m with some herbs on Karrakatta sands.
J1*	3A	Low **Jarrah** woodland to 15 m of *Eucalyptus marginata* and *Banksia attenuata* over shrubs to 2 m with some herbs on Karrakatta sands.
J2*	7B	Low **Jarrah** woodland to 15 m of *E. marginata* and *B. attenuata* over shrubs to 2 m with some herbs on Karrakatta sands.
T1*	8B	Woodland of **Tuart**, *Eucalyptus gomphocephala*, over low woodland of *Jacksonia* and *Acacia* shrubs to 4 m and sparse herbs on Spearwood sands.
T2*	10B	Woodland of **Tuart**, *E. gomphocephala*, over low woodland of *Eucalyptus*, *Acacia*, *Melaleuca* and *Banksia* and shrubs to 4 m with patches of herbs on Spearwood sands.
HD	E	Scattered shrubs in **heath, disturbed** by past human activity, to 3 m of *Conospermum* and *Acacia rostellifera* over shrubs to 1 m of mainly *Hakea prostrata*, *Grevillea vestita*, *Dryandra nivea* and *Jacksonia stricta* adjacent to tuart woodland on Karrakatta sand with outcropping limestone.
TD	T	Woodland of **Tuart, disturbed** by previous grazing and simplification of understorey; *Eucalyptus gomphocephala*, over sparse understorey of *B. grandis* to 5 m and *G. vestita*, *Macrozamia riedlei*, *Solanum sodomaeum* and scattered herbs, particularly *Carpobrotus* and *Ehrharta*.
BG1	BG1	Low woodland, disturbed by trampling and weed invasion adjacent to **Boomerang Gorge;** *Eucalyptus gomphocephala* over shrubs of *Spyridium globulosum* and *Hibiscus huegelii* to 6 m with smaller shrubs, particularly *Acacia pulchella* and herbaceous weeds including *Myrsiphyllum asparagoides* and *Ehrharta breviflora*.
BG2	BG2	Low woodland, disturbed by trampling and weed invasion in **Boomerang Gorge;** *E. gomphocephala* over shrubs of *S. globulosum* and *H. huegelii* to 6 m with smaller shrubs, the sedges *Lepidosperma gladiatum* and *L. tenue* and weeds including *M. asparagoides* and *Conyza bonariensis*
G1	GL	**Garden** comprised of woodland of *Eucalyptus* spp. (mostly *E. gomphocephala*) and *Banksia littoralis* over mowed and watered lawn.
G2	R	**Garden** comprised of woodland of *E. gomphocephala* and *Agonis fl*[illegible] over mowed and watered lawn.
EP1	K	**Eucalypt plantation** (low woodland) of *Eucalyptus rudis*. *E. robusta* and *E. globulus* over low sedges and herbs, especially *Pelargonium capitatum*, on Beonaddy sand
EP2	MG	**Eucalypt plantation** (low woodland) of *E. viminalis*, *E. robusta*, *E. camaldulensis* and *E. globulus* over low sedges and herbs on Beonaddy sand
P1	P1	Low **pine** forest (plantation) of *Pinus pinaster* to ca. 10 m over rare *Macrozamia riedlei* on Karrakatta sands.
P2	P2	Ditto, about 200 m away.

[1] CALM = WA Department of Conservation and Land Management; site codes in this column have been used for CALM purposes and for the vertebrate and vascular plant survey, but have been simplified to those in the first column for the present survey.

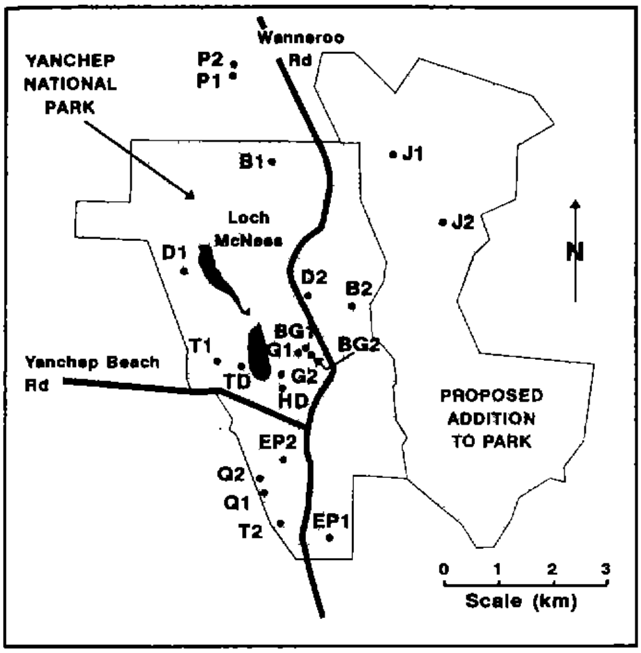

Figure 1. Location of sites used to sample ants in and near Yanchep National Park.

Ants collected from pitfall traps were classified into Greenslade's community structure categories (see Greenslade & Thompson 1981 and Andersen 1987, 1990).

Multivariate analyses were carried out using the computer package PATN (Belbin 1989, 1991a) in order to elucidate the relationships between sites in terms of the ant species which were present. Initially, a cluster analysis technique (classification) was used to detect similarities between sites and to determine the degree of similarity between disturbed and undisturbed sites. Sites were classified in terms of ant species presence using the Bray-Curtis (Czekanowski) association measure for presence-absence data, followed by hierarchical agglomerative fusion classification (flexible UPGMA, *beta* = - 0.1). This procedure is appropriate for ecological presence-absence data and is robust to variations in species abundance patterns and hence sampling efficiencies (Faith *et al.* 1987, Belbin 1991a).

The data were then subjected to an ordination procedure to provide an independent measure of similarity between sites. Sites which are close together in the ordination space will be those which are similar in species composition. Ordination was carried out using the procedure SSH (semi-strong hybrid multidimensional scaling) (Belbin 1991b), which is robust to species richness effects. This was followed by principal axis rotation in order to maximize the variance on each axis In order to facilitate interpretation of the observed patterns, ant species were also classified in terms of the sites at which they occurred. This was done using the two-step association measure of Belbin (1980) as this measure is robust for use in situations such as the present one where sites vary greatly in their levels of species richness (Austin & Belbin 1982). A two-way table was constructed from the classifications of sites and ants, in order to facilitate interpretation of both classifications.

Initial analyses showed that species which occurred at a single site were rare or undersampled species which occurred randomly in the data set. Such species contribute little to estimation of similarity between sites or interpretation of pattern in the data, and therefore were excluded from further analyses.

Data on vertebrate species occurrence are available for the undisturbed sites (A H Burbidge & J K Rolfe unpublished). Numbers of species of vertebrates (reptiles, birds, mammals and all vertebrates combined) were compared with ant species richness using the Spearman rank correlation procedure.

Results

Species abundances, richness and evenness

A total of 111 species from 31 genera were sampled from the sites. The number of ant species within each genus, and also various ant community variables are shown in Table 2.

The total ant species per site (species richness) varied from five to 28. Scanning across Table 2, the first 10 sites may be regarded as relatively undisturbed, the next four as modified native vegetation and the last six as replaced ecosystems. Ant species richness respectively varied from 15-28 and 16-23 in the first two groups of sites. These ranges of values are respectively indicative of undisturbed or slightly disturbed sites which have been sampled at this intensity (see examples in Majer 1983). Species richness values ranged from 5-15 in the replaced ecosystems which is beneath the range exhibited by all but one of the undisturbed sites. The range and number of total genera was similar in the undisturbed and the modified groups of sites, being 10-15 and 9-14 respectively. There was however, a discontinuity in the range of values for the replaced group of sites, where values ranged from 4-10. The ratio of species/genera reflected these trends, and ranges respectively varied from 1.50-2.08, 1.43-1.78 and 1.20-1.50 for the undisturbed, modified and replaced groups of sites.

Evenness values varied greatly between sites, often in cases where the vegetation was of the same type. This can result from the placing of traps near nests or ant trails, and highlights one of the problems of using this community index for ants. Most values for the undisturbed and modified sites fell within the range of 0.60-1.00, which is typical of native vegetation in Western Australia (Majer 1983). However, two of the undisturbed sites (Jarrah woodland J2 and Tuart woodland T1) exhibited exceptionally low values, as did the *Eucalyptus* plantations (EP1 and EP2) and one of the pine plantations (P1). It is interesting that gardens exhibited relatively high evenness values.

Functional groups

The distribution of ant species in functional groups is shown in Fig 2. This figure expresses the data as total ant species obtained by all sampling methods (Fig 2A) and as the proportion of individuals in the pitfall trap catch (Fig 2B). The latter analysis does not represent as many species as the former, because not all species were sampled by the pitfall traps.

Although all seven functional groups were present in at least some of the undisturbed and modified sites (Fig 2A), they were not present in all of them. This was because large, solitary foragers were not encountered at some sites and the disturbed tuart site TD lacked both large, solitary foragers and also dominant *Iridomyrmex* species. The numbers of functional groups in the modified sites vary within the range shown by the undisturbed sites. However, numbers of functional groups were lower in some of the replaced sites such as garden site G1, both *Eucalyptus* plantations and particularly in the pine plantations which lacked large, solitary foragers, cryptic species, subordinate species and, in the case of P1, dominant *Iridomyrmex* species.

The relative contribution of ant individuals to the various functional groups varied greatly between the various undisturbed and modified sites (Fig 2B) and no generalizations may be made, except that the ant communities at these sites were well represented by individuals from all functional groups except the large solitary foragers. This in part may be influenced by the inefficiency of the pitfall traps for catching large ants. By contrast, the catches in the *Eucalyptus* plantation and one garden (G2) were disproportionately comprised of dominant *Iridomyrmex* species and the pine plantations by opportunistic species.

Multivariate analyses

Examination of the dendrogram which classifies sites on the basis of ant species composition revealed that two major groups of sites could be discerned, each containing three sub-groups. These six sub-groups are superimposed on Fig 3. The first major group contained all modified and replaced sites, plus site T2 (tuart). The second major group contained only undisturbed sites. Within the first major group (containing modified and replaced sites), the first sub-group contained site T2 (a moist tuart site), the two Boomerang Gorge sites (BG1 and BG2), the disturbed tuart site (TD) and a disturbed tuart/heath site (HD), while the second contained the two garden sites (G1 and G2) and the eucalypt plantation sites (EP1 and EP2) and the third contained the two pine sites (P1 and P2). Within the second major group (undisturbed sites), the first sub-group contained a *Banksia* woodland site (B1), two jarrah woodland sites (J1 and J2) and a *Dryandra* heath (D1), the second contained a *Dryandra* heath (D2) and a dry tuart site (T1),

Table 2

Number of species of ants within each genus and various other summary data for the ant communities sampled within disturbed and undisturbed plots in and near Yanchep National Park.

	Quindalup heath		Dryandra heath		Banksia woodland		Jarrah woodland		Tuart woodland		Dist. heath	Disturbed tuart			Gardens		Eucalyptus plantation		Pine plantation	
	Q_1	Q_2	D_1	D_2	B_1	B_2	J_1	J_2	T_1	T_2	HD	TD	BG_1	BG_2	G_1	G_2	EP_1	EP_2	P_1	P_2
Myrmeciinae																				
Myrmecia			1				2	1	1	1	1			1		1				
Ponerinae																				
Brachyponera	1					1	1				1									
Cerapachys		1				1														
Heteroponera										1										
Hypoponera															1					
Platythyrea						1														
Rhytidoponera			1	1	2	1	3	2	2	2	1	2	1	2	2	2	1	1	1	1
Trachymesopus																1				
Myrmicinae																				
Adlerzia									1											
Anisopheidole								1				1					1			
Aphaenogaster	1	1	1			1	1										1	1		
Cardiocondyla															1	1	1	1		
Crematogaster	3		3	2	1	2	1	2	2	1	1	1	1	1	1	1				
Meranoplus	1	1	2		1		1	1	1	1										
Monomorium	2	6	4	2	3	2	1	2	3	4	2	4	3	1	2		2	1	2	1
Pheidole	1	1	1			1			1	1	1	1	1	1		1	1	1	1	1
Podomyrma		1	1										1							
Solenopsis								1					1	1	1					
Strumigenys														1						
Tetramorium			1		2		1	1		1	1		1		1	1	1	1		
Dolichoderinae																				
Dolichoderus					1		1	1	2	2	1	1	2	1						
Iridomyrmex	4	6	6	1	4	4	4	5	4	3	4		3	4	4	3	3	3		2
Tapinoma	2	1	1	1			1									1				
Formicinae																				
Camponotus	3	3		1	1	2	2	2	5		4	1	2	2		1	1	2		
Melophorus	2	2	4	3	4	1	6	3	4	1	2	2	4	2	1		2	2	1	
Notoncus	1	1		1		1			1	1	1		1	1						1
Paratrechina															1					
Plagiolepis							1			1	1		1							
Polyrhachis				1																
Prolasius				1						1	1			1						
Stigmacros	1	1	1	1	1		2	1				3	1	1						
Total species	22	25	27	15	20	18	28	23	27	21	22	16	23	20	15	13	14	13	5	6
Total genera	12	12	13	11	10	12	15	13	12	14	14	9	14	14	10	10	10	9	4	5
Species/genera	1.83	2.08	2.08	1.36	2.00	1.50	1.87	1.77	2.25	1.50	1.57	1.78	1.64	1.43	1.50	1.30	1.40	1.44	1.25	1.20
Evenness index (J')	1.03	0.87	0.82	0.67	0.49	0.70	0.68	0.32	0.24	0.58	0.84	0.63	0.58	0.91	0.67	0.67	0.37	0.49	0.44	0.67

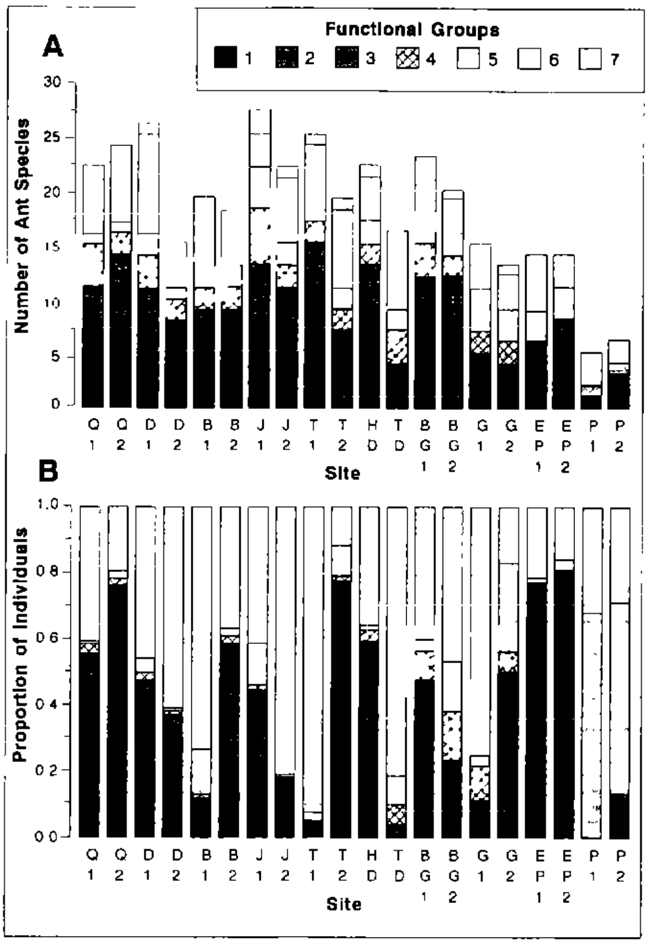

Figure 2. Breakdown of ant species by functional groups (after Greenslade & Thompson 1981 and Andersen 1987, 1990) in terms of (A) total ant species obtained by all sampling methods and (B) proportion of ant individuals in the pitfall trap catch. Key to functional groups: 1, dominant species; 2, subordinate species; 3, climate specialists; 4, cryptic species; 5, opportunists; 6, generalized myrmicines; 7, large solitary foragers.

and the third contained a site with open *Banksia* woodland over heath (B2) and two heath sites on Quindalup dunes (Q1 and Q2).

The groups identified from the output of the classification analysis could also be discerned in the scattergrams from the ordination of sites in terms of their ant species composition (summarized in Fig 3). Following rotation of the ordination output (see Belbin 1989), about 44% of the variance accounted for in the three dimensional ordination (stress = 0.16) was due to factors influencing axis 2, with 29% influencing axis 1 and 27% influencing axis 3. It is apparent that disturbed sites were mostly differentiated from undisturbed ones on the second axis. Groups appearing close together on Fig 3 are fairly well separated on the third axis: for example, sites T2, G1 and D2.

Four groups of species were chosen from the classification of ant species on the basis of the sites at which they occurred. The dendrogram was limited to four groups as this was the largest number that could be interpreted ecologically in terms of habitat usage by individual species. The first group contained species such as *Crematogaster* sp JDM 33 (that is, conspecific with *Crematogaster* sp JDM collection 33), *Tapinoma* sp JDM 134 and *Iridomyrmex* sp 18 (ANIC) (that is, conspecific with *Iridomyrmex* sp 18 Australian National Insect Collection [ANIC]) which are more frequent in, or confined to, undisturbed native vegetation. Patchily distributed species such as *Camponotus* sp 22 and *Camponotus* sp 36, which were less frequent in disturbed sites, were characteristic of groups two and three. The fourth group contained two subgroups. The first subgroup included widespread, frequently occurring species such as *Iridomyrmex agilis* gp 21 (ANIC), *Monomorium* sp JDM 225 and *Rhytidoponera violacea*. The second sub-group included species such as *Melophorus* sp 2 (ANIC) and *Tetramorium bicarinatum*, which are restricted to, or more frequent in, disturbed or moist sites.

Comparison with vertebrate species richness

In the undisturbed sites, the number of species of ants varied from 18 to 27, reptiles and amphibians from eight to 15, birds from 17 to 35 and mammals from two to six; total numbers of vertebrate species varied from 24 to 47 (Table 3). There was no significant correlation between ant species richness and vertebrate species richness. The Spearman rank correlation coefficients were: reptiles - 0.18, birds 0.30, mammals - 0.01 and for all vertebrates combined 0.25.

Discussion

Much of the native vegetation at Yanchep National Park supports ant communities which, in terms of species richness, evenness and functional group profiles, are typical of undisturbed environments elsewhere which have been sampled at this intensity (data in Andersen 1987, 1990, Majer 1983). Indeed, the composition of the ant fauna in the undisturbed sites is similar to that reported for equivalent locations on the Swan Coastal Plain by Rossbach & Majer (1983).

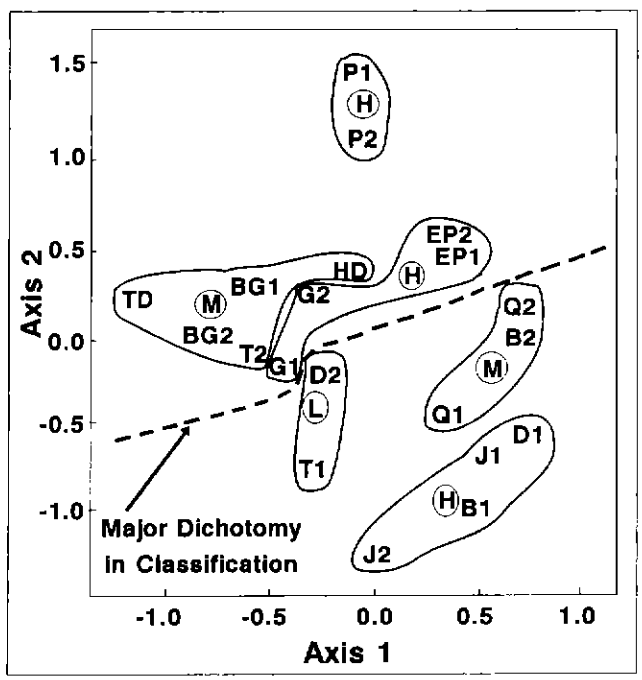

Figure 3. Results of the classification of sites in terms of ant species occurrences, superimposed on the first two axes of the ordination plot. The continuous lines encompass the members of each of the six subgroups recognized in the classification analysis. L, M and H denote low, medium and high values respectively on the third axis of the ordination.

Table 3

Species richness of ants and vertebrates at ten undisturbed sites in Yanchep National Park. (Vertebrate data from A H Burbidge & J K Rolfe unpublished).

Site	Species richness				
	Ants	Reptiles and amphibians	Birds	Mammals	Total vertebrates
Q1	22	11	26	6	43
Q2	25	11	26	6	43
D1	27	9	16	6	31
D2	15	8	12	4	24
B1	20	12	25	5	42
B2	18	15	17	6	38
J1	28	9	30	2	41
J2	23	11	25	5	41
T1	27	10	23	5	38
T2	21	8	35	4	47

The findings of the present survey also indicate that the ant fauna is altered by even slight modifications of the ecosystem, such as by trampling, exotic plant and weed invasion (for example plots BG1 and BG2) or by partial clearing followed by natural regrowth (for example plots HD and TD). The ant fauna in these modified ecosystems has a characteristic species composition and also slightly reduced species richness. The range of genera and the representation of ants in the major functional groups still lies within the range exhibited by the undisturbed sites, indicating that the main elements of the fauna are still present even though the species composition is changed.

The ecosystems in which the native vegetation has been replaced by a new one, such as a garden, or eucalypt or pine plantation, exhibited the most altered ant communities. Species and generic richness is considerably reduced, fewer functional groups are represented and, especially in the case of the pine plantations, the composition of species present is very different from that in the undisturbed areas. Evenness values (Table 2) were also atypical, but in some areas they are exceptionally low (EP1, EP2 and P1) while in the gardens they are relatively high. This is consistent with the fact that the plantations are dominated by one or a few species whereas the gardens support a wider range of species, none of which dominate the area. Presumably the ant fauna tends to reflect the distribution of plant species or their associated structural attributes within each plot

The more disturbed the site, the fewer ant functional groups were present (Figures 2A and B). Cryptic species may have been lost due to disturbance of the litter layer; litter of native plants may be replaced by dried grass or bare patches. Some of the large, solitary foragers and sub-ordinate species may be specialists which are unable to withstand the changed environment. Also, the dominant *Iridomyrmex* group may be absent from one of the pine plantations because of the heavy shade, a condition which does not favour this sun-loving genus, or alternatively due to the lack of invertebrate food resources in pine litter (Springett 1971).

The changes in the functional group profiles are also reflected in the presence or absence of particular ant species. The elucidation of indicator ant species, whose presence or absence indicates a particular environmental condition, is confounded by the fact that some species are rare and hence not commonly sampled. The absence of such species in a sample could therefore result from under-sampling or from a genuine absence of the species. With this limitation in mind, it appears that the presence of *Crematogaster* sp JDM 33, *Tapinoma* sp JDM 134 and *Iridomyrmex* sp 18 (ANIC) are indicative of sites in the relatively undisturbed state. Reasons for their presence could include respectively the presence of tree-nesting/foraging sites (*Crematogaster* sp JDM 33), a dense litter layer (*Tapinoma* sp JDM 134) and a mosaic of insolated ground, for nesting, together with a vigorous native herb and shrub layer which supports nectar and prey items (*Iridomyrmex* sp 18 (ANIC)). By contrast, *Melophorus* sp 2 (ANIC) and *Tetramorium bicarinatum* appear to be indicative of highly disturbed environments and may be benefiting from the highly insolated ground in cleared areas and from the abundance of grass seeds on which they feed.

The ant component of the fauna at Yanchep National Park is vulnerable to disturbance. The fact that changes in the ant fauna go hand in hand with changes in the composition of other invertebrates (Majer 1983) suggests that many other invertebrate groups would also be influenced by these disturbances. The ant data are less likely, however, to provide useful information concerning vertebrate species. At undisturbed sites, we found no significant correlation between the levels of species richness for ants and species richness of any major vertebrate groups or for all vertebrates combined. Ants (and presumably other invertebrates) show quite different patterns of occurrence than do vertebrates at Yanchep National Park.

From a conservation management point of view, it is important to have data concerning, and an understanding of, both vertebrate and invertebrate communities. Yanchep National Park has been subjected to various pressures including weed invasion, trampling, clearing of land around facilities, altered fire regimes and grazing (historically by domestic stock, currently by kangaroos and introduced rabbits). The observed sensitivity of the ant fauna to disturbance (including modification of vegetation structure) highlights the need to manage the area in such a way that such impacts are minimized; in view of the observed correlation between the species richness of ants and many other invertebrate taxa (Majer 1983) this would also be expected to minimize the effects on most other invertebrate groups. Information on vertebrates and vascular plants (A H Burbidge *et al.* unpublished) which is currently being analysed, will complement the ant study. When complete these studies should provide guidelines for managing the park to ensure that biodiversity is not adversely affected by the usage and management regimes to which it is subjected.

Acknowledgements: Mr R Shimmon (Senior Ranger, Yanchep National Park) and his staff assisted K L and S McD during sampling. A Postle and B Heterick assisted with preliminary identifications of ant specimens and G Keighery provided information on vegetation at each site. A N Andersen, W Cowling & G Keighery provided helpful comments on earlier drafts of this paper. Funding was provided by the Western Australian Department of Conservation and Land Management and Curtin University of Technology.

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