reported data on microbial numbers in exudates exceeding those on the sausage surface by about two factors of 10. The lowest bacterial numbers for spoiled samples were observed in sausage cores, which again corresponded to results of the quantitative analysis. Short chains of coccoid cells, typically *Leuconostoc*, are visible in the core sample of Fig. 4a. To provide a basis for comparison, samples of freshly manufactured sausages were also prepared for SEM and examined for the presence of bacterial cells on surfaces and in cores. Results varied from very low numbers to total absence, as is evident from Fig. 4b, where only occasional cells are present on the surface and along the exposed core interface. No evidence of colonization of the substrate by the microbial cells was found in these samples.

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Ant recolonization of sand mines near Richards Bay, South Africa: an evaluation of progress with rehabilitation

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The ant fauna was sampled in eight rehabilitated, sand-mined areas and three coastal dune forest control plots near Richards Bay, South Africa. Rehabilitation was achieved by seeding with cover crops and mixed indigenous species; the sample plots represented the cover crop, grassland/scrub, thicket and Acacia karroo-*woodland stages of succession. A total of 76 ant species was recorded, of which 29 were found exclusively in the forest and 22 in the rehabilitation. Ant species richness increased over the first 2 years, declined thereafter and proceeded to increase further after 8 years of rehabilitation. Application of correspondence analysis to the ant community data indicated that the succession was following two trends, one represented by the 2–5-year-old plots and the other by the 8–13-year-old rehabilitation. These trends coincided with the massive increase in the density of* Pheidole megacephala *towards the fifth year of rehabilitation and by its subsequent decline. In terms of ant species richness and similarity, the 13-year-old rehabilitation had only partially attained a fauna which resembled that of the dune forest. The pattern of ant return is compared with results obtained elsewhere in the world and considered in relation to rehabilitation procedures and prevailing climatic patterns.*

Richards Bay Minerals is currently mining for heavy minerals (ilmenite, rutile, zircon and monazite) in the coastal dunes north of Richards Bay. This operation, which is one of the largest sand-mining operations in the world, takes place in four stages. Firstly, the vegetation in front of the mining face and, where applicable, the topsoil and humus layer are removed. Secondly, by means of a dredge, the minerals are separated from the sand by means of a gravity separation process and are then pumped to a stockpile adjacent to the plant. Thirdly, the mine tailings are returned to the area immediately behind the operation, the dune contours are recreated and then, finally, the mined dunes are rehabilitated according to the policies decided upon by the Kwa Zulu government.[1]

The area which is currently being mined centres on latitude 28° 40′S and longitude 32° 14′E. The area is in Köppen's humid subtropical (also known as warm temperate) (Cfa) climatic zone, with a mean annual rainfall of 1 292 mm (data from Cape St Lucia), of which 40% falls in winter and 60% in summer. The mean temperature of the warmest month is over 22°C[2] and the area experiences no arid period. Air photos of 1937 indicate that the area was highly degraded as a result of grazing and shifting cultivation.[3] At that time, it largely comprised a patchwork of mature coastal dune forest and anthropogenic secondary grassland, secondary *Acacia karroo*-

woodland and bare patches. Examination of 1974 air photos, following the resettlement elsewhere of the local inhabitants which took place in the early 1950s, indicated that many of the disturbed areas had reverted to secondary dune forest or had been reafforested with *Casuarina equisitifolia*, *Eucalyptus* spp. or *Pinus* spp.[3]

When mining commenced, the area comprised 60% *Eucalyptus* plantations, 20% grassland and 20% coastal dune forest. The current policy is to rehabilitate two thirds of the mined area to *Casuarina* plantations and one third to indigenous vegetation.[1] The latter is achieved by returning topsoil to the area and seeding a cover crop of the exotics, *Pennisetum glaucum* and *Crotalaria juncea*, as well as the indigenous grass *Eragrostis curvula*. A mix of seeds of mostly indigenous grass, herb, shrub and tree species is also applied and nursery-reared native trees and shrubs are planted at a later date. The resulting succession mimics that following the abandonment of farmed areas by rapidly proceeding through cover crop, grassland/scrub, thicket to *A. karroo*-woodland stages within an 8-year period.[1] Rehabilitation at Richards Bay is currently the subject of investigations on plant and mammal succession, bird usage and general insect occurrence.[1]

The consideration of animals in land reclamation programmes is extremely important for a number of reasons. Soil fertility and structure may be impeded if appropriate soil animals are not present, while the nature of plant succession is moulded by the activites of herbivores, pollinators and seed dispersal agents. Invertebrate animals provide food resources for insectivorous vertebrates, and certain invertebrate taxa may act as useful indicators of the degree of success of the rehabilitation programme.[4]

One example where animals have been used as bio-indicators of rehabilitation success or land disturbance is that of ants in Australia.[5,6] The various studies reported here suggest that ant community parameters provide a reflection of the nature of the plant community, of the physical environment and possibly even of the variety of other invertebrates present in the area. Further work on rehabilitated mine sites throughout Australia suggests that the speed of ant succession tends to be greater in areas of higher, or more favourable, rainfall distribution.[7] This in turn suggests that the resilience of other components of the ecosystem may be greater in such areas; a phenomenon which has practical implications for the way in which rehabilitation is planned and assessed. Although faunal studies in reclaimed areas are relatively numerous in Europe, North America and Australia, little work has been carried out in Africa. A world survey of faunal studies in reclaimed areas revealed 993 references, of which only three pertained to Africa.[8]

This paper reports a study of ant recolonization in rehabilitated sand mines near Richards Bay. The aims of the work were threefold: (1) to document the ant species which recolonize areas in this region; (2) to assess the extent of colonization of dune forest ants in areas rehabilitated to indigenous vegetation; and (3) to make comparisons with results from similar studies in Australia and Brazil in order to see whether rates were similar in areas of matched climatic conditions. In addition, it is hoped that this article will stimulate further studies on the use of invertebrates, such as ants, spiders, beetles, flies or springtails, as indicators of ecosystem disturbance or recovery in South Africa.

Methods

Selection and description of study sites

Three control and eight rehabilitated plots were surveyed. All three control plots (F1, F2 and F3) were situated in dune forest which consisted of a tree layer with canopy height varying between 12 and 15 m and a canopy cover of approximately 65–90%. Important tree species included *Celtis africana*, which dominated in all three plots, *Mimusops caffra*, *Allophylus natalensis*, *Teclea natalensis*, *Ochna natalita*, *Deinbollia oblongifolia* and *Maytenus undata*. A subcanopy layer consisting of understorey trees and shrubs was also present, which included *O. natalita*, *Clausena anisata*, *Diospyros natalensis*, *Tricalysia sonderana* and *Carissa bispinosa*. The herb/shrub layer at all three sites was relatively dense and tall (1.5–2 m), and was dominated by *Isoglossa woodii* and *Dracaena hookeriana*.

The rehabilitated plots, which had all received the same treatment, had been respectively revegetated 0.3, 0.4, 2, 4, 5, 8, 11 and 13 years previously. They are hereafter referred to by the notation R0.3, R0.4, R2, etc.

A 100-m ant-sampling transect (AST) was marked out in a representative area of each plot in such a way as to minimize edge effects. Markers were placed at 10-m intervals in order to facilitate ant sampling and also to serve as sites for characterizing the environment. Soil penetrability, percentage litter cover, litter depth and litter index (percentage cover × depth), percentage grass cover, percentage herb and shrub cover and also percentage tree cover were then assessed in metre-square quadrats at each marker. Mean tree height was recorded in each plot and the number of plant species in a 400-m² quadrat adjoining the AST were also recorded.

The mean plot values of physical and biological measurements are shown in Table 1. Soil penetrability exhibited no consistent trend with age of rehabilitation although, because of recent earthmoving activities, soil was generally more penetrable in the rehabilitation than in the forest. The litter layer built

Table 1 Mean values for physical and biological variables recorded along 100-m ant sampling transects in the eight rehabilitated and three control plots.

Variable	Rehabilitation age (years)								Controls		
	0.3	0.4	2	4	5	8	11	13	F1	F2	F3
Soil penetrability (cm)	128	101	95	125	105	121	122	132	98	112	90
% litter cover	3	3	62	88	75	100	91	95	87	74	90
Litter depth (cm)	0.5	0.1	1.6	0.9	1.8	1.5	0.9	2.1	3.8	1.4	2.3
Litter index	1	0	123	83	140	145	85	200	359	111	213
% grass cover	22	22	62	4	12	69	53	38	0	2	0
% herb/shrub cover	6	10	11	14	12	1	18	33	40	63	40
%tree cover	0	0	8	27	26	34	41	42	76	67	72
Tree height (m)	0	0	0.9	3.7	2.7	7.4	9.8	10.0	10.5	11.8	11.6
No. of plant species in 400 m²	12	21	18	18	23	22	30	36	52	49	45

Table 2 Species of ants sampled by standardized techniques in the eight rehabilitated and three control plots. Species indicated by (○) are additional collections obtained by baiting or litter extraction in plots R13 and F3.

	Rehabilitation age (years)								Controls		
Ant species	0.3	0.4	2	4	5	8	11	13	F1	F2	F3
Ponerinae											
Anochetus natalensis Arnold									•	•	•
Anochetus fuliginosus Arnold										•	
Hyponera sp. 37						•				•	
Hyponera sp 84							•		○		
Leptogenys maxillosa (F. Smith)									•		
Leptogenys attenuata (F. Smith)								•	•	•	
Leptogenys nitida (F. Smith)							•	•			
Leptogenys castanae (Mayr)									•		•
Odontomachus assiniensis Emery									•	•	•
Pachycondyla caffraria (F Smith)			•					•	•	•	•
Platythyrea cooperi Arnold									•	•	
Plectroctena conjugata Santschi				•			•		•	•	•
Prionopelta aethiopica Arnold									○		
Proceratium arnoldi Forel									•		
Cerapachyinae											
Simopone grandis Santschi											•
Dorylinae											
Dorylus helvolus (L.)				•	•	•	•	•	•	•	•
Aenictinae											
Aenictus rotundatus Mayr			•			•					
Pseudomyrmecinae											
Tetraponera sp. 1						•	•				
Tetraponera sp. 56						•	•	•			
Myrmicinae											
Calyptomyrmex piripilis Santschi									•		
Cardiocondyla shuckardi Forel	•	•	•						•		
Cardiocondyla new sp. 11		•									
Cardiocondyla emeryi Forel		•	•	•		•					
Cataulacus wissmanni Forel			•		•	•	•	•	•	•	•
Crematogaster sp. 3			•					•	•	•	•
Crematogaster sp. 21			•	•		•	•	•		•	•
Crematogaster sp 31						•				•	
Crematogaster sp. 47							•	•	•		
Crematogaster sp. 59						•					
Microdaceton exornatum Santschi									○		
Monomorium sp. nr *symmotu* Bolton				•	•	•	•	•	○		
Monomorium sp. nr *cryptobium* (Santschi)									○		
Monomorium sp. 82					•	•					
Myrmicaria sp 12		•									
Myrmicaria sp. 78			•								
Oligomyrmex sp 38/71							•	○	○		
Oligomyrex sp. 72			•					○	○	•	
Pheidole megacephala (Fabricius)			•	•	•	•	•	•	•	•	•
Pheidole sp. 25									•	•	•
Pheidole liengmei Forel.			•								
Pristomyrmex cribrarius Arnold										•	
Rhoptromyrmex opacus Emery				•							
Serrastruma ludovici (Forel)									•	•	
Smithistruma mandibularis (Szabo)								•			
Strumigenys irrorata Santschi									○		
Strumigenys faurei Arnold				•					○		
Tetramorium grassii Emery									•	•	
Tetramorium ?constanciae Arnold									•	•	•
Tetramorium phasias Forel						•				•	•
Tetramorium sp. 33										•	
Tetramorium muscorum Arnold									•	•	•
Tetramorium furtiva (Arnold)									•		•
Tetramorium weitzeckeri Emery				•		•	•	•	•	•	•
Tetramorium delagoense Forel				•	•		•	•	•	•	•
Tetramorium frenchi Forel			•	•	•	•	•	•			
Tetramorium sericeiventre Emery			•								
Dolichoderinae											
Tapinoma sp. 52			•	•	•	•					
Technomyrmex albipes (F. Smith)						•	•	•	•	•	•
Technomyrmex sp. 51			•	•	•	•					
Formicinae											
Acantholepis sp 9									•	•	•
Camponotus sp. (*maculatus*-group a)					•				•	•	•
Camponotus sp. (*maculatus*-group b)			•		•						
Camponotus postoculatus Forel			•				•	•	•	•	•
Camponotus arminius Forel									•	•	•
Camponotus brookei Forel							•		•		
Camponotus braunsi Mayr									•	•	•
Camponotus sp. (*rufoglaucus*-group)			•	•	•	•	•				•
Camponotus robecchii Emery											•
Oecophylla longinoda (Latrielle)									•		
Paratrechina sp. 54			•	•	•						
Plagiolepis sp. 20					•	•	•	•	•		•
Plagiolepis sp. 83							•				
Polyrhachis schlueteri Forel			•		•		•	•	•	•	•
Polyrhachis revoili Emery									•	•	
Polyrhachis gamu Santschi									•		•
Polyrhachis spinicola Forel						•	•				
Polyrhachis schistacea (Gerstaecker)										•	•
Total species	1	4	20	15	15	22	23	19	35	33	31
Total species (including baiting and litter samples)	–	–	–	–	–	–	–	21	44	–	–

d) occurring in older stage rehabilitation — *Tetraponera* sp. 56 and *Monomorium nr symmotu*.

e) occurring in older stage rehabilitation and also in forest — *Dorylus helvolus, Plectrotrena conjugata, Cataulacus wissmanni, Crematogaster* sp. 21, *Crematogaster* sp. 31, *Pheidole megacephala, Tetramorium delagoense, Tetramorium phasias, Tetramorium weitzeckeri, Technomyrmex albipes, Plagiolepis* sp. 20 and *Polyrhachis schlueteri*.

f) occurring only in the forest — *Anochetus natalensis, Odontomachus assiniensis, Pheidole* sp. 25, *Tetramorium ? constanciae, Tetramorium muscorum, Acantholepis* sp. 9, *Camponotus arminius* and *Camponotus braunsi*.

Also of interest is the fact that the nature of the succession appears to follow two directions, one illustrated by 0.3 through to 5-year-old rehabilitation, and the other from the 8th year through to 13-year-old rehabilitation (Fig. 2). This is also manifested in the plot groupings obtained on the plot dendrogram derived from the correspondence analysis (Fig. 2, inset). At the chi-square = 40 level there are four groupings: the less than 1-year-old rehabilitated plots; the 2–5-year-old plots; the up to values within the forest range by the second year of rehabilitation. However, unlike in the forest, litter in rehabilitated areas consisted largely of dead grass and *A karroo* leaflets. Although almost absent in the forest, grass density was high in the rehabilitation. Cover peaked in the second year of rehabilitation, dropped in year 4 due to competition from the dense *A. karroo* layer, and then climbed once more as these trees self-thinned and forest grasses invaded The herb and shrub layer exhibited a similar pattern, except that an initial peak was reached in year 4. Cover values in the rehabilitation never reached the levels found in the forest. Tree cover and height increased progressively as the rehabilitation matured, and consisted almost entirely of *A. karroo* foliage. While tree height in the rehabilitation had approached forest values by year 13, percentage tree cover had not yet done so. Plant species richness increased initially, dropped in years 2 and 4, and then rose to levels which were considerably lower than in the forest. We believe that the trough in plant species richness during the early stages of rehabilitation was associated with the dense cover of *A. karroo* and also the death of the original cover crop species.

Ant sampling and data analyses

A number of complementary sampling methods were used to survey the ant fauna. Ten pitfall traps, consisting of 25-mm internal diameter test tubes containing an ethanol/glycerol mix, were placed along each transect and left open for 7 days from 26 January – 2 February 1991. Between these dates, the soil/litter ants, shrub-associated ants and tree-associated ants were each sampled for 2 h per plot during mid-morning or mid-afternoon. General night-time ant collections were also made along each transect for 1.5 man-hours. Finally, the ant fauna of the oldest rehabilitated plot (R13) and one control plot (F1) was further sampled by means of 10 fish/honey baits set along the AST's for 2 h during the morning and also by extraction of ants from 6-litre samples of litter using Berlese funnels.

Ants were sorted to species level and either named to species or assigned species code numbers within each genus. A full collection of voucher specimens is deposited in the Entomology Collection of the South African Museum, Cape Town.

A checklist of ants for each AST was obtained by combining the collection data from all sampling techniques. The total number of species obtained for each transect is referred to as ant species richness. The quantitative data from the pitfall traps were then used to determine which species were most abundant on the ground. Notes taken whilst hand-collecting were also used to determine which species were most abundant on the vegetation. Correspondence analysis[9,10] was used to compare the plots in terms of the ant species which were present. This technique simultaneously displays the plot and species data along axes of a multidimensional space. This enables the user to elucidate the affinity between plots in terms of their species composition, and also provides a graphical means of elucidating which species are contributing to the separation of plots. It also provides hierarchical cluster analysis dendrograms of both plot and species groupings.

Results

A total of 72 species was recorded from the plots (Table 2), while an additional four species were sampled by the baiting and litter sampling in plots R13 and F1. Unless otherwise mentioned, the ants from the bait and litter sampling are excluded from the following analyses. Twenty-nine and 22 of the species, respectively, were recorded only in the forest and rehabilitated plots. This may in part reflect the rarity of, and hence difficulty in collecting, some species. However, some of

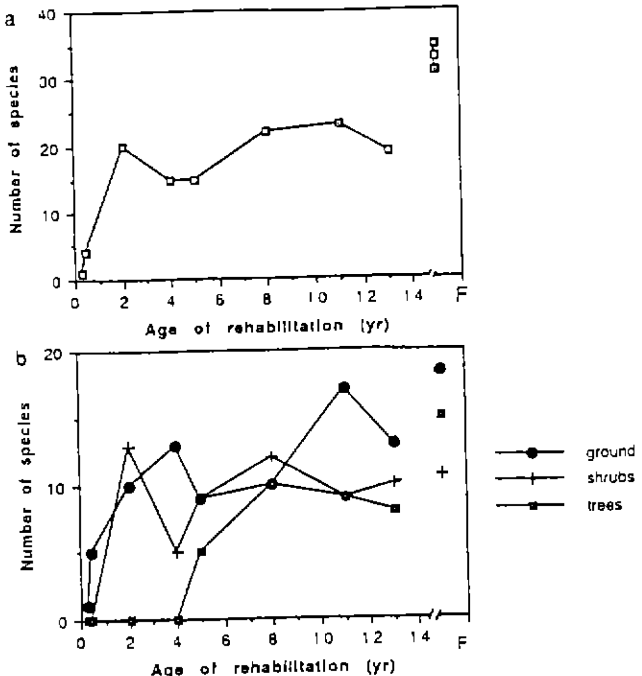

Fig. 1. Relationship between (*a*) the total number of ant species with rehabilitation age and also (*b*) the number of ant species sampled from the ground (●), the shrubs (+) and the trees (□). The mean of all three forest values is shown in (b).

these species would be ones which could not tolerate disturbance or, in the rehabilitation, pioneer species which benefit in some way from the rehabilitation process.

Trends in species richness per plot indicate an increase up to 2 years, a trough between 2 and 8 years and then a further increase (Fig. 1*a*). Values in the oldest two rehabilitated plots had not reached those in the forest plots. The trends in number of ground-, shrub- and tree-associated ant species with time indicate an immediate colonization by ground-associated species such as *Cardiocondyla shuckardi*, followed by subsequent increases in shrub- and tree-associated species by 2 and 5 years, respectively (Fig. 1*b*). Both ground- and shrub-associated ants exhibited troughs in species richness, between 4 and 11 years and 2 and 8 years, respectively.

The correspondence analysis was performed with species presence/absence data for the 52 ant species which occurred in two or more plots, and repeated with the 34 species which occurred in three or more plots. Figure 2 shows the positions of the plots on the first two axes of the correspondence analysis diagram, derived using the 52 ant species × 11 plot matrix. The analysis using 34 species produced similar results. It indicates a progressive change in ant community composition from the very youngest to the oldest rehabilitated plots and, on axes 1, 2 and 3 (the last not shown here), that the composition of the fauna in the rehabilitated plots had not yet totally converged, in terms of species composition, with that which characterized the forest controls.

The ant species which have contributed to the patterns of separation of plots on the correspondence diagram have, for reasons of clarity, not been plotted. However, inspection of the species dendrogram revealed six groupings of species which produced the observed separation of plots. The species which occurred in these groups and in three or more plots were:

a) occurring in very young rehabilitation — *Cardiocondyla shuckardi*.

b) occurring in very young to mid-stage rehabilitation — *Cardiocondyla emeryi*.

c) occurring in mid-stage rehabilitation — *Tapinoma* sp. 52, *Technomyrmex* sp. 51, and *Paratrechina* sp. 54.

between the rates of ant return without the confounding influence of differences in ant species richness within native vegetation.

Ant species richness climbs rapidly at all three sites during the first 2–3 years of rehabilitation. Of particular interest is that at both Richards Bay and North Stradbroke Island the ant fauna exhibits a decline in species richness which is concurrent with an increase in the abundance of *P. megacephala*, a cosmopolitan ant species of African origin.[13] The only difference is that this happened after 6 years in Australia compared with 2 years at Richards Bay. Majer[12] considered that the lower ant species richness in the older rehabilitation at the Australian site was partly caused by the low plant species richness in the older rehabilitation, since it was commonly found that animal species richness tracks that of the plants in rehabilitated areas.[7] However, competition by *P. megacephala*, which thrives in the older rehabilitation was considered to have an even greater impact on the colonizing ant fauna.[7] The current findings show a similar phenomenon, albeit with the decline in ant species richness occurring at an earlier stage. Once again, one or both factors could be responsible for the trend in ant species richness. Mid-stage rehabilitation exhibits a slight decline in plant species richness (Table 1), and our personal observations indicate that the 2–8-year-old rehabilitation exhibits remarkably low structural diversity. This could reduce the opportunities for a wide range of ant species. However, since the overall decline and subsequent increase in ant species richness (Fig. 1*a*) is inversely related to the upsurge of *P. megacephala* (Fig. 3), competition by this generalist ant is likely to be of greatest importance. Nest openings of *P. megacephala* were apparent on almost every square metre of soil in R5 and workers were foraging on almost every *A. karroo* plant, suggesting that this species was monopolizing a wide range of resources within the rehabilitation.

How similar is the ant fauna of the rehabilitated area to that of the coastal dune forest? In other words, how successful has rehabilitation been in providing opportunities for the original forest fauna? The forest ant fauna was characterized by a range of abundant *Crematogaster* spp. and also *T. albipes* on the trees, an abundance of *T. ? constanciae* and *Pheidole* sp. 25 on the ground, and a wide variety of cryptic ground- and vegetation-nesting ants. Most of the rehabilitation was quite different in that *P. megacephala* replaced *Crematogaster* spp. and *T. albipes* on trees, cryptic species were less commonly encountered and, as mentioned, the actual species present in the rehabilitation tended to be different from those in the forest. It was not until year 13 that trees dominated by *Crematogaster* spp. or *T. albipes* were commonly encountered and the area ceased to be dominated by *P. megacephala*. At this stage, the ant fauna of the area had started to resemble that of the coastal dune forest, although the similarity index for plots R13 versus F1 indicated that recovery of the ant community from disturbance was by no means complete. Inspection of the raw data and also the correspondence analysis diagram (Fig. 2) suggests that the fauna had only started to develop towards that of the original forest in the three oldest areas of rehabilitation which were studied. Unfortunately, the 13-year-old area is the oldest example of rehabilitation. A resurvey of these older areas in about 10 years' time would provide important information on how attainable the coastal dune forest option of rehabilitation really is.

In order to provide a comparable figure by which the rate of ant succession may be compared between sites, Majer[7-11] fitted lines to the ant species richness versus rehabilitation age data and read off the number of species which would be expected to occur in 3-year-old rehabilitation. It is not possible to fit such a line to the Richards Bay data because of the decline in ant species richness in the presence of *P. megacephala*. Inspection of the graph of overall ant species richness (Fig. 1*a*) suggests that the value would lie somewhere between 18 (if the trough is accounted for) and 22 (if the initial part of the curve is extrapolated upwards). This compares with 18 and 14.5 species, respectively, at the climatically matched Australian and Brazilian sites, suggesting that ant recolonization rates are relatively similar at humid subtropical sites within all three continents. It may well be that other climatic zones within South Africa exhibit ant recolonization rates which differ from the Richards Bay area, and which resemble those in other areas of Australia which possess similar climatic patterns. Although these observations on colonization rate are for ants, there is evidence that plants and other invertebrates may respond to climate in a similar way.[5] If this trend is confirmed, it may be possible to divide countries into zones, with each zone having a particular rehabilitation rate, or resilience. These zones would then provide valuable information on which to base guidelines and timescales for evaluating rehabilitation performance standards through time.

As well as providing information on progress with the Richards Bay rehabilitation programme, this study has indicated one application of the ant bio-indicator approach to environmental appraisal. It is hoped that readers will see other applications for this concept in South Africa and, by adapting it to the land-use involved or to the taxonomic group being used, commence using this valuable tool for assessing the quality and nature of the environment.

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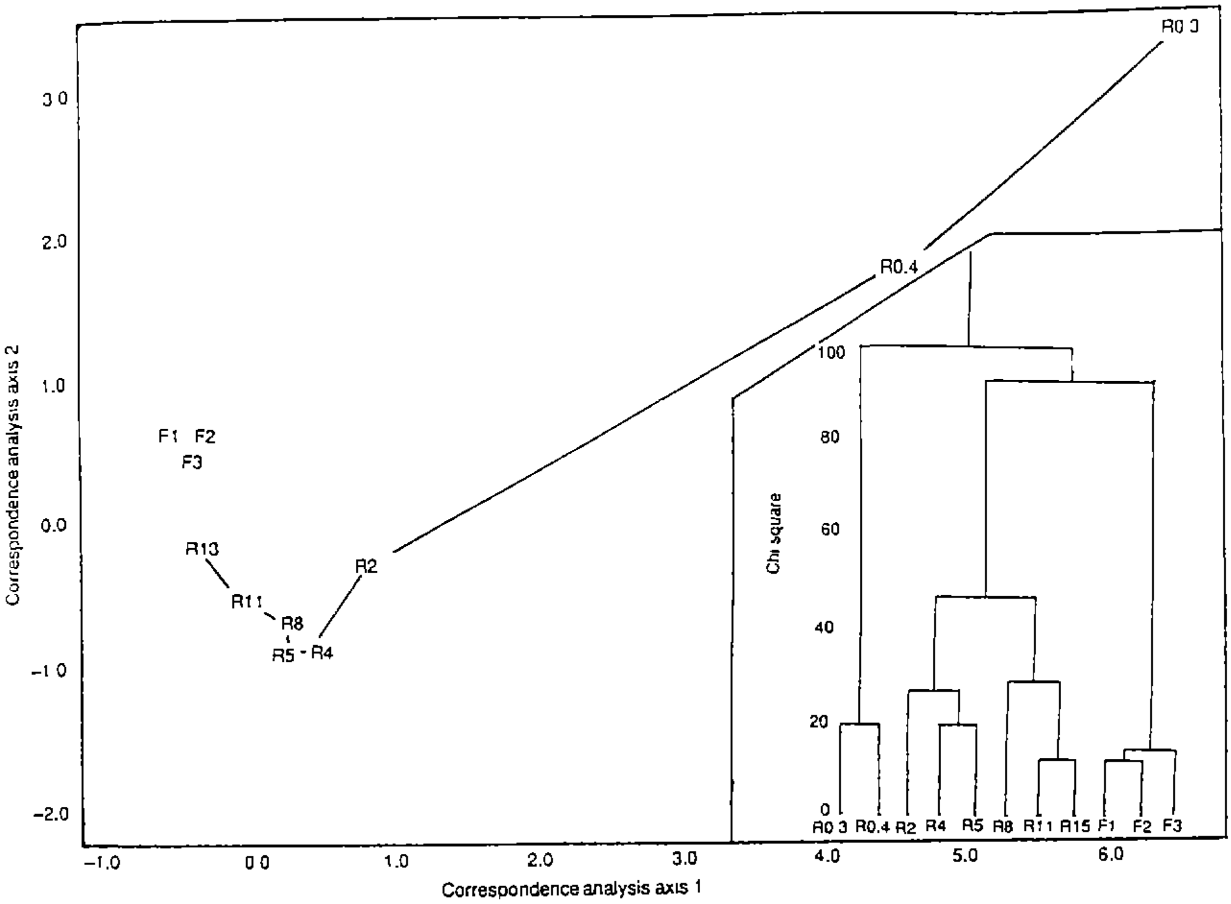

Fig 2. Position of rehabilitated and control plots on the first and second axes of the correspondence analysis diagram and also the groupings of plots obtained by the dendrogram derived during the same analysis (inset).

8–13-year-old plots; and the forest controls. Inspection of the quantitative pitfall trap data reveals one notable trend which concurs with this dichotomy in the plots — the proportion of *Pheidole megacephala* in the catch (Fig. 3). The proportion of this species increased steadily from the second year of rehabilitation up until year 5, when it comprised 97% of the catch. From then onwards the abundance of this species dropped to very low levels which, by year 13, were more characteristic of the forest. There was a tendency for ant species richness to decrease with increasing numbers of *P. megacephala* in the plots, although this relationship was not statistically significant.

Inclusion of the bait and litter sample data from plots R13 and F1 increased the species count from 19 → 21 in the former and 35 → 44 in the latter plot. This suggests that, although sampling by the other methods had been reasonably efficient in the rehabilitation, it had missed a range of cryptic or rare species in the structurally complex forest. Application of a similarity index [Similarity = $2a/(b + c)$, where a is the number of species common to both sites and b and c are the number of species in each of the two sites being compared] to the complete checklist of ants from these two plots produced a value of 0.48, indicating that the ant faunas of the oldest area of rehabilitation and plot F3 were still relatively dissimilar.

Discussion

The results of this survey indicate a reasonably high species richness of ants in the coastal dune forest and also the capacity of even the early stages of rehabilitation to support a variety of ant species. Application of the additional baiting and litter sampling techniques indicated that plots were undersampled, probably on account of the difficulty in locating rare species and also the general limitations of the other sampling techniques. This would be more of a problem in the structurally complex dune forest where the additional sampling indicated an 81% sampling efficiency (total species caught by pitfall plus hand collecting divided by this total plus species obtained by baiting and from litter) compared with 90% efficiency in the older but structurally simple rehabilitation.

Since identical pitfall trapping plus hand-collecting methods have been employed for ants in mines within Australia[7] and Brazil,[11] it is possible to compare recolonization patterns across the three continents. The most closely matched sites which have been studied are sandmines on North Stradbroke Island, Queensland, Australia (27° 20'S)[12] and bauxite mines at Poços de Caldas, Brazil (21° 51'S),[11] both of which experience humid subtropical climates (Cf). In both of these cases, ant species richness in control sites fell within the range found at Richards Bay (26–30 species in Queensland, 29–31 species in Brazil), so it is possible to make comparisons

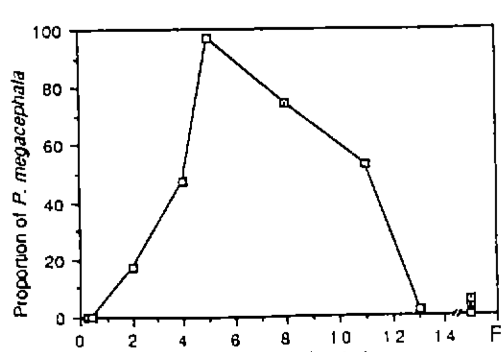

Fig. 3 Percentage contribution of *Pheidole megacephala* to the ants caught by pitfall trapping in the rehabilitated and control plots.