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The Gainesville transect: Twenty-one years of RIFA population increases[1]

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Solenopsis invicta Buren, the red imported fire ant (RIFA), is a pugnacious, immensely successful invader of disturbed habitats throughout the Southeastern United States (Tschinkel 1987). Changes in native ant fauna resulting from insecticide treatment for control have been documented (Apperson et al. 1984, Markin et al. 1974), along with subsequent reinfestation by RIFA (Summerlin et al. 1977). The effects of RIFA invasion on native ant fauna (in the absence of insecticide treatments) have usually been studied by comparing habitats with and without RIFA (Camilo & Philips 1990, Phillips et al. 1987, Porter et al. 1988, Whitcomb et al. 1972). However, after invasion by RIFA, some native and other introduced species of ants are known to persist (Baroni-Urbani & Kannowski 1974, Glancey et al. 1976). The successful movement of RIFA into uninfested areas by taking advantage of man-made ecological disturbances, other than large-scale insecticidal treatments, has not been properly documented.

Gainesville, Florida, an area that has never received any large scale insecticide treatment, first became lightly infested with RIFA in late 1971. In March 1972, a long-term study was initiated to assess the long-term effects of population increases of RIFA on non-target ants in the absence of insecticide treatments.

Materials and Methods

One hundred permanent bait stations were designated and marked about every 0.8 km (0.5 mile) along 4 paved roads in Gainesville, Alachua Co., Florida (Wojcik 1983). The baits [a 1.9 cm, (0.7 inch) diameter ground-beef ball and a 1.3 cm (0.5 inch) honey-agar cube] were individually placed on 2.5 cm (1 inch) aluminum squares. In the field, the 2 baits were placed at bait stations in the same relative positions, 0.3 to 1 m (1-3 ft) apart, at 9 AM each sampling period (Wojcik et al. 1975). The baits were collected after one hour, the ants were preserved in alcohol, sorted to species and counted. Sampling of the ant populations has been conducted periodically for 21 years (March 1972 to September 1992). Initially, sampling was done every other month, but it varied with the demands of other projects and the rate of increase of RIFA populations (Table 1). The areas of Gainesville sampled by the transect are occupied only by monogyne RIFA colonies.

[1] This article represents the results of research only. Mention of a proprietary product does not constitute an endorsement or recommendation for its use by the USDA.

Number of sites is defined as the number of bait stations out of 100 bait stations (each had 2 baits) for each sampling period with a species. For each species, percent occurrences is defined as the number of baits with a given ant species out of 200 baits per sampling period. For each species, percent specimens is defined as the percent of all ant specimens collected per sampling period.

Data were transformed to rank values for each species with means for ties (Conover & Iman 1976). Correlation coefficients were calculated, for the ranked values of monthly percent occurrence of the various species to ranked monthly values percent RIFA occurrence, using linear regression analysis with Lotus 123 ver. 3.3 and significance determined by t-test (Steel & Torrie 1960).

Results and Discussion

To date (September 1989), 23 genera and 55 species of ants have been collected on the transect. After 17 years, 62 sampling periods, 12,400 bait collections and 825,648 specimens have been examined. Approximately 1/3 of the baits were collected with more than one species of ant on them and 2,126 baits did not have any ants on them. RIFA has gradually increased to where they now represent 45% of the collections and 60% of the specimens collected. Over 60 sites are now permanently occupied by RIFA. This increase in RIFA populations in shown in the figure. This increase occurred in spite of high populations of Solenopsis geminata (F.) and Pheidole dentata (Mayr). These two species are the two most common species besides RIFA collected on the transect and are usually considered good competitors of RIFA.

During 68 sampling periods over 21 years, 13,600 bait samples and 990,079 specimens were collected and identified. More than one ant species was collected on approximately 33% of the baits; 16% of the baits were blank. RIFA, S. geminata and Pheidole dentata were the 3 major species collected on the transect over the years in total occurrences (58.33%) and specimens (82.5%). Through September 1992, the following 55 species of ants from 5 subfamilies and 22 genera have been collected on the transect: Aphaenogaster ashmeadi Emery, A. flemingi Smith, A. floridana Smith, A. fulva Roger, A. near rudis, Brachymyrmex depilis Emery, Camponotus decipiens Emery, C. floridanus (Buckley), C. socius Roger, Cardiocondyla ectopia Snelling, C. emeryi Forel, C. nuda (Mayr), C. venustula Wheeler, C. wroughtoni (Forel), Conomyrma bureni Trager, C. medeis Trager, Crematogaster ashmeadi Mayr, C. atkinsoni Wheeler, C. lineolata (Say), C. pilosa Emery, Cyphomyrmex rimosus (Spinola), Forelius pruinosus (Roger), Formica archboldi Smith, F. pallidefulva Latreille, Hypoponera opaciceps (Mayr), Lasius alienus (Foerster), Leptothorax pergandei Emery, Monomorium viridum Brown, Odontomachus brunneus (Patton), Paratrechina boubonica (Forel), P. concinna Trager, P. faisonensis (Forel), P. longicornis (Latreille), P. parvula (Mayr), P. vividula (Nylander), Pheidole carrolli Naves, P. dentata Mayr, P. floridana Emery, P. metallescens Emery, P. moerens Wheeler, P.

morrisi Forel, _P. vinlandica_ Forel, _Prenolepis imparis_ (Say), _Pseudomyrmex ejectus_ F.Smith, _Solenopsis geminata_ (F.), _S. invicta_ Buren, _S. globularia littoralis_ Creighton, _S. picta_ Emery, _S. (Diplorhoptrum)_ spp., _S._ near _truncorum_, _Tetramorium bicarinatum_ (F.), _T. lanuginosum_ Mayr, _T. simillimum_ (F.Smith), _Trachymyrmex septentrionalis_ (McCook), _Trichoscapa membranifera_ (Emery).

The RIFA population has gradually increased until in September 1992 it dominates the ant fauna: 43.3% of the sample occurrences (Fig. 1A, maximum 55.8% in March 1990 & April 1992), 63.1% of the sample specimens (Fig. 1B, maximum 74.3% in April 1992), and 50 sites (Fig. 1C, maximum 59 sites in April 1991). This increase has undoubtedly been aided by habitat disturbances and habitat simplification (the process of urbanization) which have gradually occurred in Gainesville. The increase occurred in spite of high populations of _S. geminata_ and _Pheidole dentata_, two species which are predaceous on newly-mated RIFA queens (Whitcomb et al. 1972). RIFA is an r-strategist or weed species with great reinfestation abilities, enabling it to invade, establish, and rebuild populations quickly (Buren & Whitcomb 1977, Tschinkel 1987). Once established, it persists and dominates its habitat, becoming a keystone species and influencing community structure. Like its congener, _S. geminata_ (F.) (Risch & Carroll 1983), RIFA dominates the ant fauna numerically.

Both _S. geminata_ and _P. dentata_ showed significant negative correlations (P<0.01) when compared to RIFA in percent occurrences (Fig. 1A), in specimens (Fig. 1B), and in number of sites occupied (Fig. 1C). Tschinkel (1988) found that the outcome of the competition between RIFA and _S. geminata_ is usually mediated by the degree of disturbance in the environment. _S. geminata_ was able to overcome moderate disturbance, and persist and flourish in the presence of the RIFA invasion. _S. geminata_ populations can return to pre-disturbance levels if they are not displaced by competitors (Risch 1981). Whitcomb et al. (1972) reported that _S. geminata_ was one of the first species to decrease or disappear after RIFA invasion of soybean fields, but pesticide usage was not considered and no time parameters were given. Despite having an alarm-recruitment defense system specific to _Solenopsis_ species ants (Wilson 1976), _P. dentata_ has decreased wherever it has been studied following RIFA invasion (Glancey et al. 1976, Cherry & Nuessly 1992). This decrease is at least partially attributable to the superior recruitment and displacement abilities of RIFA over _P. dentata_ (Fraelich 1991).

An additional 13 species occurred often enough to allow calculation of significant correlations against occurrences. These species can be divided into native ants and introduced ants. Each group had species which were either negatively or positively correlated with the ranked percent occurrences of RIFA (Table 2).

Native species which occur in habitats and niches similar to RIFA have generally been negatively affected by the habitat disturbances in Gainesville and the corresponding increases in RIFA populations. The population changes, as reflected in the

percent changes in the ranked occurrences, of <u>Pheidole</u> <u>metallescens</u>, <u>Pheidole</u> <u>floridana</u>, <u>Pheidole</u> <u>morrisi</u> (Fig. 2), <u>Paratrechina</u> <u>vividula</u>, <u>Forelius</u> <u>pruinosus</u>, and <u>Monomorium</u> <u>viridum</u> (Fig. 3) are all significant (P<0.01) and represent real population decreases of these ants. Although many of these species are predators and will attack newly mated RIFA queens, Whitcomb et al. (1972) report decreases in their populations as a result of RIFA invasion. The smaller nest sizes, seasonally restricted mating flights, and limited ability to withstand habitat disturbance (Naves 1985, Smith 1965, Trager 1984, Harada 1990, DuBois 1986) puts these species at a disadvantage in relation to RIFA.

The decrease in <u>Crematogaster</u> <u>ashmeadi</u> occurrences (Fig. 2) is statistically significant (P<0.05). The change in <u>C</u>. <u>ashmeadi</u> occurrences probably represents habitat changes as this ant nests in trees, shrubs, and vines (Johnson 1988). This ant has not been collected on the transect since 1981, but it still can be found in wooded areas in and around Gainesville. <u>Conomyrma</u> <u>bureni</u> occurrences (not figured) are weakly negatively correlated (P<0.05) with RIFA occurrences. This native species is an ant of disturbed areas (Trager 1988), preferring small areas of bare soil for its nests. The decreasing number of occurrences probably do not represent a real population decrease as this species and its congeners can exist quite well in areas infested with RIFA (Hung 1974, Claborn et al. 1988, Trager 1988).

<u>Odontomachus</u> <u>brunneus</u> occurrences (Fig. 3) showed an unexpected positive correlation (P<0.05) with increasing RIFA occurrences. This native predator nests in small colonies (Brown 1976), which it successfully defends against RIFA and other ants with a unique defensive mechanism (Carlin & Gladstein 1989). This species has an excellent ability to defend itself against RIFA in direct confrontation as measured by Bhatkar (1988). The dynamics of habitat disturbance and urbanization have somehow improved the habitat for this ant in spite of the increases in RIFA population. This species has been collected on both meat and honey-agar baits belying its strictly predatory reputation (Whitcomb et al. 1972).

The second group of ants consists of introduced species most of which show a positive correlation (P<0.01) in the percent changes in the ranked occurrences (Table 2). This indicates their populations increases with corresponding increases in RIFA populations. The habitat disturbance and urbanization of Gainesville should favor population increases in these species. <u>Paratrechina</u> <u>longicornis</u> (Fig. 2) has the largest positive correlation with RIFA. This introduced species is a structural pest which can nest outdoors in northern Florida (Trager 1984). <u>Tetramorium</u> <u>simillimum</u> (Fig. 2) and <u>Pheidole</u> <u>moerens</u> (Fig. 3) are introduced pests which show weaker positive correlations (P<0.01) with RIFA occurrences. These introduced species are structural pests which can nest outdoors in northern Florida (Smith 1965, Naves 1985).

<u>Cardiocondyla</u> <u>emeryi</u> was the only other introduced species collected in sufficient numbers for analysis (Table 2). This tiny ant is generally ignored by other ants and occupies slightly

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to heavily disturbed habitats (Creighton 1950). It showed a negative correlation (P<0.05) (Fig. 3). As this species nests in plants as well as under items on the ground, the reasons for its decrease probably are similar to those responsible for the decrease shown by _Crematogaster ashmeadi_.

The habitat disturbance and urbanization of Gainesville has included the widening of streets and right-of-ways, which has resulted in the removal of native vegetation on the transect since the study began. These changes will undoubtedly continue in the future. The lack of a large area-wide insecticide treatment for RIFA has allowed us to study the gradual changes in other ant populations which have taken place over the last 21 years. The processes operating on the ant populations in Gainesville are also at work throughout the southeastern United States. In very few areas have the RIFA populations reached stable levels. In the absence of large area-wide insecticide treatments, RIFA populations may take years to reach their peak and stabilize. The Gainesville populations of RIFA have not stabilized (reached the carrying capacity) and will continue to be monitored in the future.

Acknowledgements

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Table 1. Summary of collections by year on the Gainesville transect from March 1972 to September 1992.

YEAR	NUMBER OF MONTHS SAMPLED[1]	NUMBER OF BAIT SITES OCCUPIED BY RIFA/YEAR
1972	5(3,5,7,9,11)	1
1973	6(1,3,5,7,9,11)	1
1974	3(1,3,7)	0
1975	2(1,7)	8
1976	2(1,7)	8
1977	5(3,5,7,9,11)	17
1978	6(1,3,5,7,9,11)	28
1979	6(1,3,5,7,9,11)	34
1980	5(1,3,5,7,9)	34
1981	5(3,5,7,9,12)	48
1982	5(3,5,7,9,11)	48
1984	2(3,10)	57
1985	2(3,10)	58
1986	2(3,10)	59
1987	2(3,9)	50
1988	2(3,9)	61
1989	2(3,9)	63
1990	2(3,9)	64
1991	2(4,9)	66
1992	2(4,9)	65

[1]Month: 1=January, 3=March, 4=April, 5=May, 7=July, 9=September, 10=October, 11=November, 12=December.

Table 2. Correlation of species ranked percent occurrences to ranked percent Solenopsis invicta occurrences (df = 66).

SPECIES	R	Number of Occurrences	Percent of Occurrences
Solenopsis invicta	-----	2659	20.27
Solenopsis geminata	-0.782**	2745	20.93
Pheidole dentata	-.543**	2247	17.13
Pheidole metallescens	-.589**	777	5.92
Pheidole floridana	-.551**	191	1.46
Paratrechina longicornis	+.745**	131	1.00
Tetramorium simillimum	+.554**	219	1.67
Pheidole morrisi	-.489**	537	4.09
Pheidole moerens	+.421**	144	1.10
Odontomachus brunneus	+.410**	251	1.91
Paratrechina vividula	-.400**	144	1.10
Forelius pruinosus	-.389**	83	.63
Cardiocondyla emeryi	-.376**	194	1.48
Crematogaster ashmeadi	-.353*	27	.21
Monomorium viridum	-.349*	80	.61
Conomyrma bureni	-.298*	1216	9.27

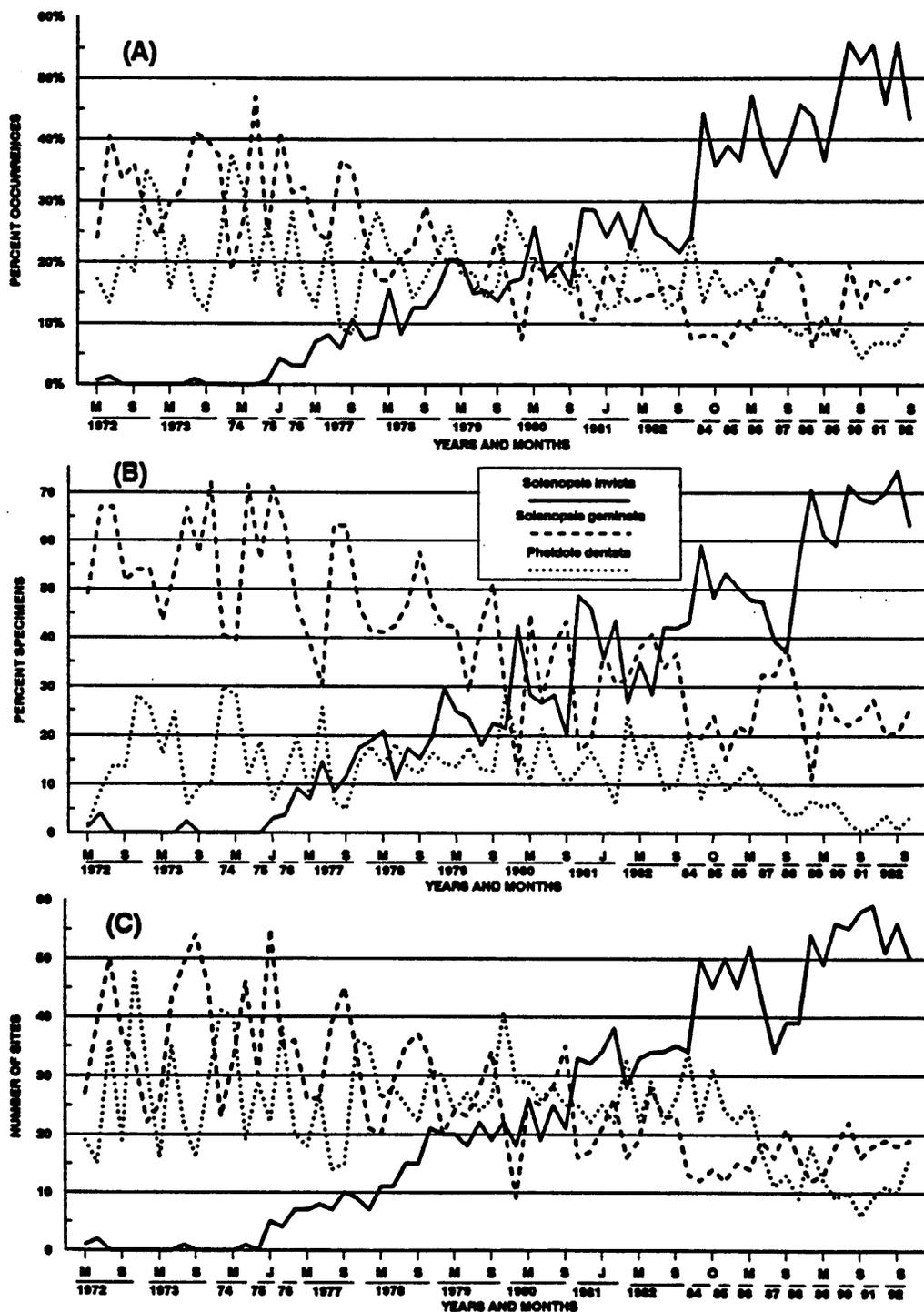(*significant at the 0.05% level; **significant at the 0.01% level)

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Figure 1. Percent occurrences (A), Percent specimens (B), and number of sites (C) for major species of ants collected on the Gainesville transect from March 1972 to September 1992.
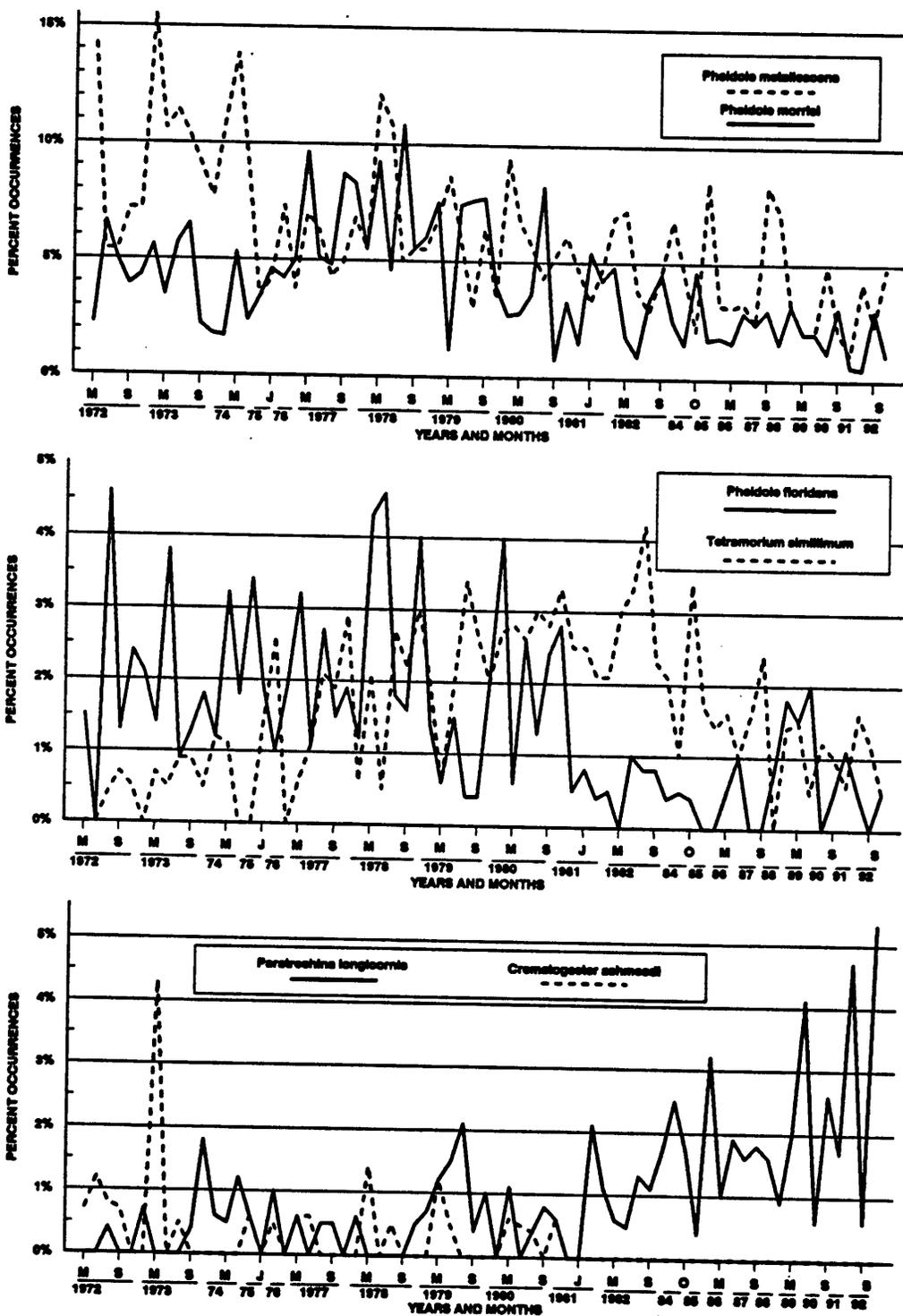
Figure 2. Percent occurrences of 6 species of ants collected on the Gainesville transect from March 1972 to September 1992.
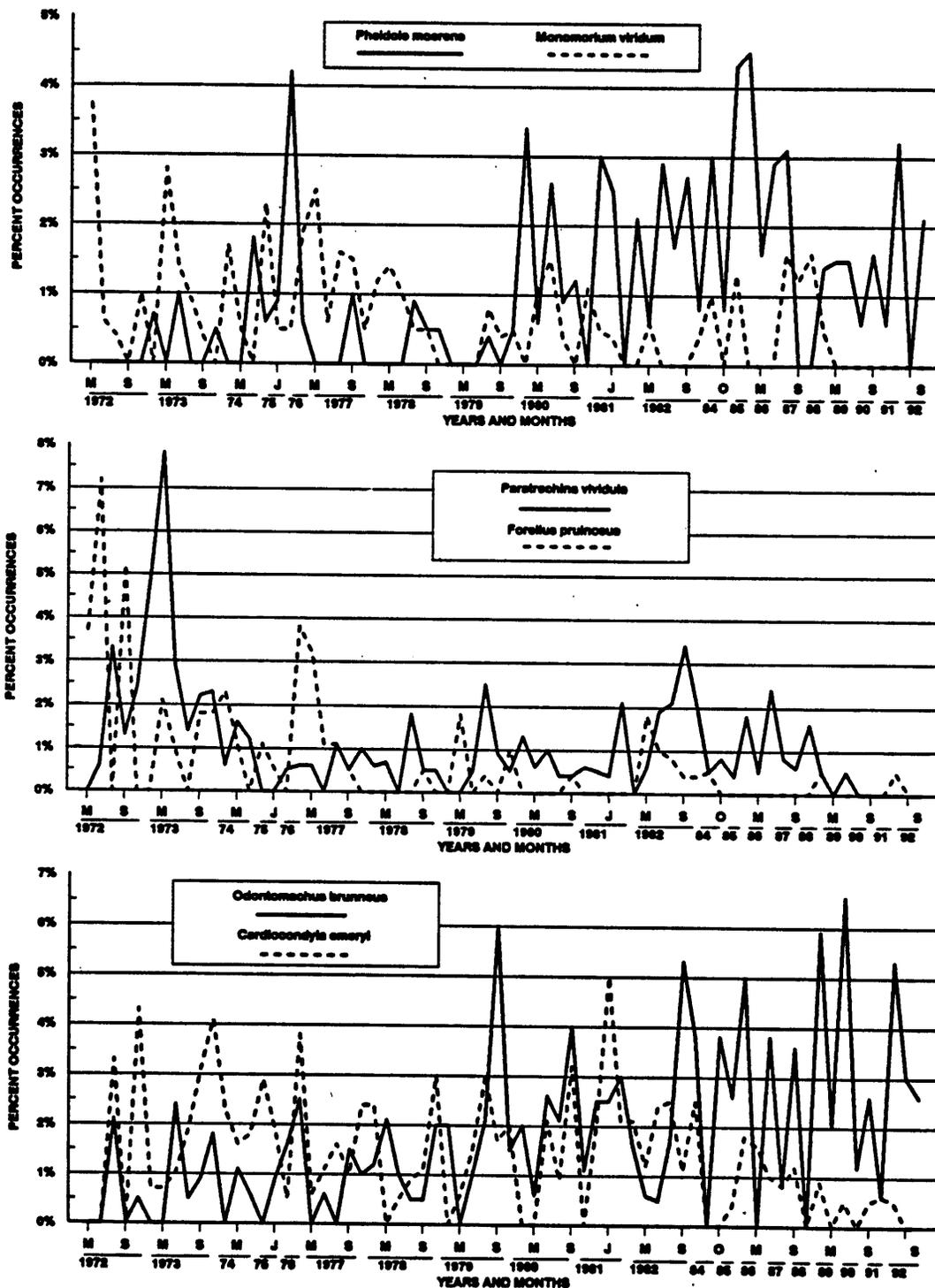
Figure 3. Percent occurrences of 6 species of ants collected on the Gainesville transect from March 1972 to september 1992.

Abstract

Gainesville, Florida, has never received any large scale insecticide treatment, and was first invaded in early 1971 by _Solenopsis invicta_ Buren, the red imported fire ant. Ants were sampled periodically from March 1972 to September 1992 using baits. After 21 years, 990,079 specimens have been examined, representing 55 species in 22 genera in 5 subfamilies. RIFA has gradually increased to where in September, 1992, it was 43.3% of the occurrences (maximum 55.8% in March 1990 and April 1992) and 63.1% of the specimens (maximum 74.3% in April 1992). Positive or negative correlation with RIFA populations were shown by 11 native ant species and by 4 introduced ant species.