Exotic Ants

Biology, Impact, and Control of Introduced Species

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Impact of the Red Imported Fire Ant on Native Ant Species in Florida

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Introduction

Invasion by ants and their subsequent displacement of native fauna is a well known phenomenon (Lubin 1984, Ward 1987, Haskins and Haskins 1988). These invasions are most devastating on islands (Lubin 1984, Haskins and Haskins 1988). The published studies have not been conducted continuously over a long period of time, although the displacement of *Pheidole megacephala* by *Linepithema humile* in the Bermuda islands has been documented periodically through the years (Haskins and Haskins 1988).

The red imported fire ant, *Solenopsis invicta* Buren, is a pugnacious, immensely successful invader of disturbed habitats throughout the Southeastern United States (Lofgren 1986, Tschinkel 1987). Changes in native ant fauna resulting from insecticide treatment for *S. invicta* control have been documented (Apperson et al. 1984, Edmonson 1981, Markin et al. 1974), along with subsequent reinfestation by *S. invicta* (Summerlin et al. 1977). The effects of *S. invicta* invasion on native ant fauna (in the absence of insecticide treatments) have usually been studied by comparing habitats with and without *S. invicta* (Camilo and Phillips 1990, Fowler et al. 1990, Phillips et al. 1987, Porter and Savignano 1990, Porter et al. 1988, Whitcomb et al. 1972). However, after invasion by *S. invicta*, some native and other introduced species of ants are known to persist (Baroni-Urbani and Kannowski 1974, Glancey et al. 1976, Whitcomb et al. 1972).

The successful movement of *S. invicta* into uninfested areas by taking advantage of man-made ecological disturbances, other than large-scale insecticidal treatments, has not been properly documented. Glancey et al. (1976) examined the ant fauna of Mobile Co., Alabama, but their pre-*S. invicta* invasion comparisons were based on older publications. *S. invicta* had apparently displaced the introduced Argentine ant, *L. humile* (Mayr) (formerly *Iridomyrmex humilis*), and 2 native fire ants, *Solenopsis geminata* (F.) and *S. xyloni* McCook. An interesting observation on their data, although not realized at the time, was the continued presence of non-target native and introduced species.

Gainesville, Florida, an area that has never received any large-scale insecticide treatment, first became lightly infested with *S. invicta* in late 1971. In March 1972, a long-term study was initiated to assess the long-term effects of the ensuing population increases of *S. invicta* 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 *S. invicta* populations. The areas of Gainesville sampled by the transect are occupied only by monogyne *S. invicta* colonies.

Number of sites is defined as the number of bait stations out of 100 bait stations (each had 2 baits) for each sampling period for 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 and Iman 1976). Correlation was determined between the ranked values of monthly percent occurrence of the various species

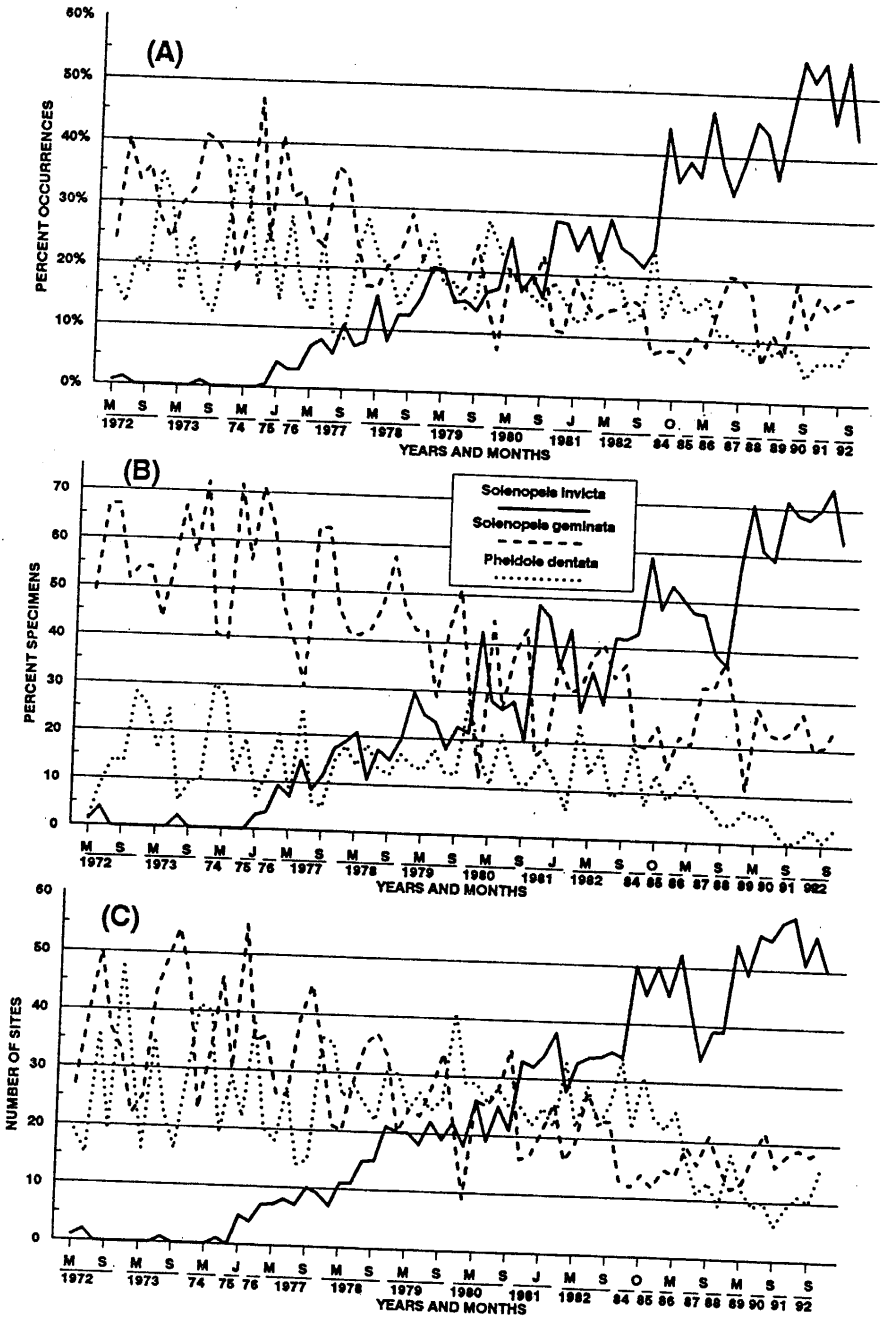
to ranked values of monthly percent *S. invicta* occurrence. Correlation coefficients were calculated using linear regression analysis with Lotus 123 ver. 3.3 and significance determined by t-test (Steel and Torrie 1960).

Results and Discussion

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. *S. invicta, 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 bourbonica* (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 *S. invicta* population has gradually increased until in September 1992 it now dominates the ant fauna: 43.3% of the sample occurrences (Figure 23.1A, maximum 55.8% in March 1990 and April 1992), 63.1% of the sample specimens (Figure 23.1B, maximum 74.3% in April 1992), and 50 sites (Figure 23.1C, 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

FIGURE 23.1 Percent occurrences (A), percent specimens (B), and number of sites (C) for major species of ants collects on the Gainesville transect from March 1972 to September 1992.



populations of *S. geminata* and *P. dentata*, two species which are predaceous on newly mated *S. invicta* queens (Whitcomb et al. 1972). *S. invicta* is an r-strategist or weed species with great reinfestation abilities, enabling it to invade, establish, and rebuild populations quickly (Buren and 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 and Carroll 1982, 1983), *S. invicta* dominates the ant fauna numerically and may affect other arthropod populations as well (Porter and Savignano 1990).

Both *S. geminata* and *P. dentata* showed significant negative correlations ($P<0.01$) when compared to *S. invicta* in percent occurrences (Figure 23.1A), in specimens (Figure 23.1B), and in number of sites occupied (Figure 23.1C). Tschinkel (1988) found that the outcome of the competition between *S. invicta* 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 *S. invicta* 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 *S. invicta* 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 *S. invicta* invasion (Glancey et al. 1976, Long et al. 1987, Cherry and Nuessly 1992). This decrease is at least partially attributable to the superior recruitment and displacement abilities of *S. invicta* over *P. dentata* (Fraelich 1991).

An additional 13 species occurred often enough to allow calculation of significant correlations against *S. invicta* occurrences (Table 23.1). 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 *S. invicta* (Table 23.1).

TABLE 23.1. Correlation of species ranked percent occurrences to ranked percent *S. 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

Native species which occur in habitats and niches similar to *S. invicta* have generally been negatively affected by the habitat disturbances in Gainesville and the corresponding increases in *S. invicta* populations. The population changes, as reflected in the percent changes in the ranked occurrences, of *Pheidole metallescens, Pheidole floridana, Pheidole morrisi* (Figure 23.2), *Paratrechina vividula, Forelius pruinosus,* and *Monomorium viridum* (Figure 23.3) 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 *S. invicta* queens, Whitcomb et al. (1972) report decreases in their populations as a result of *S. invicta* 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 *S. invicta.*

FIGURE 23.2. Percent occurrences of 6 species of ants collected on the Gainesville transect from March 1972 to September 1992.

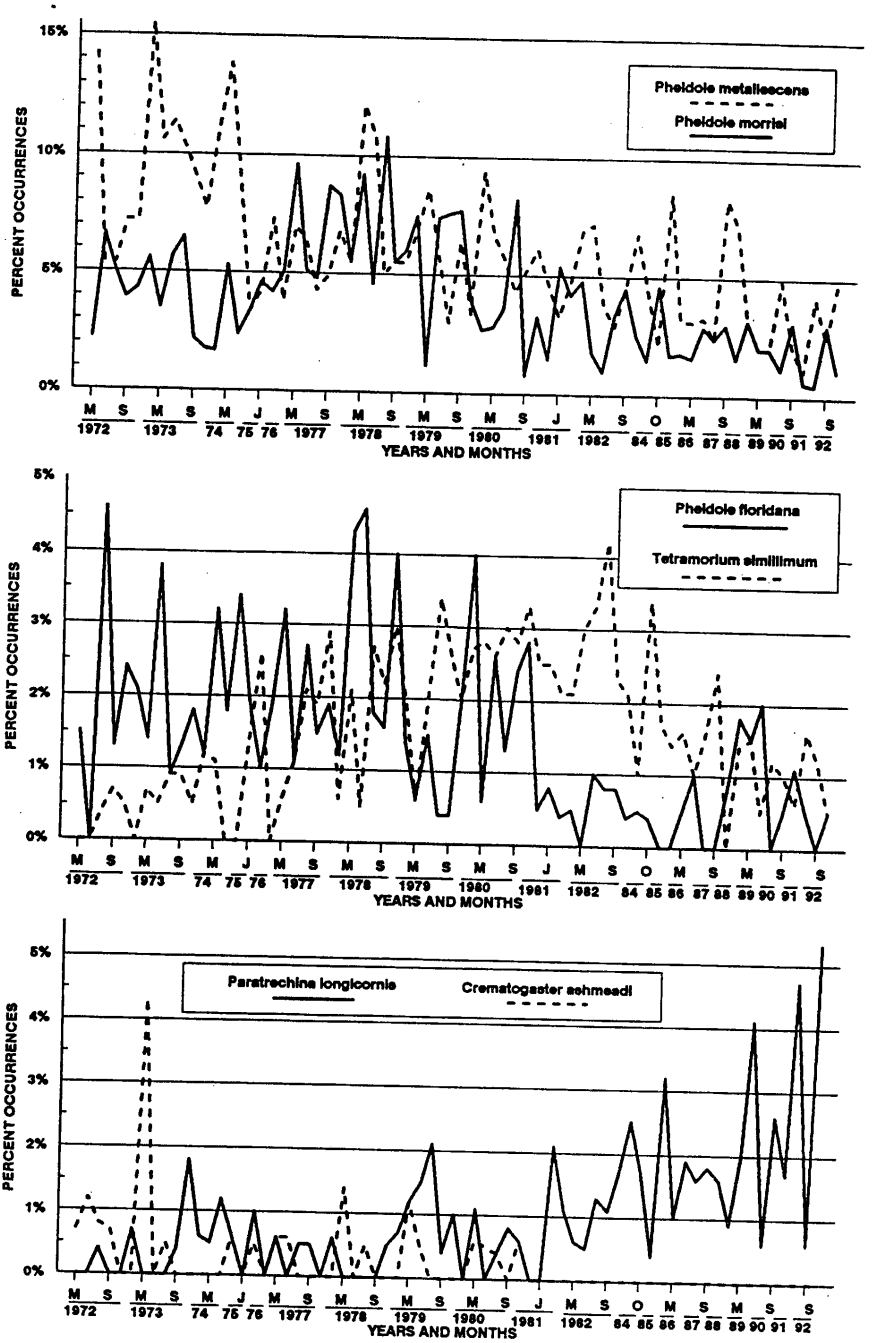
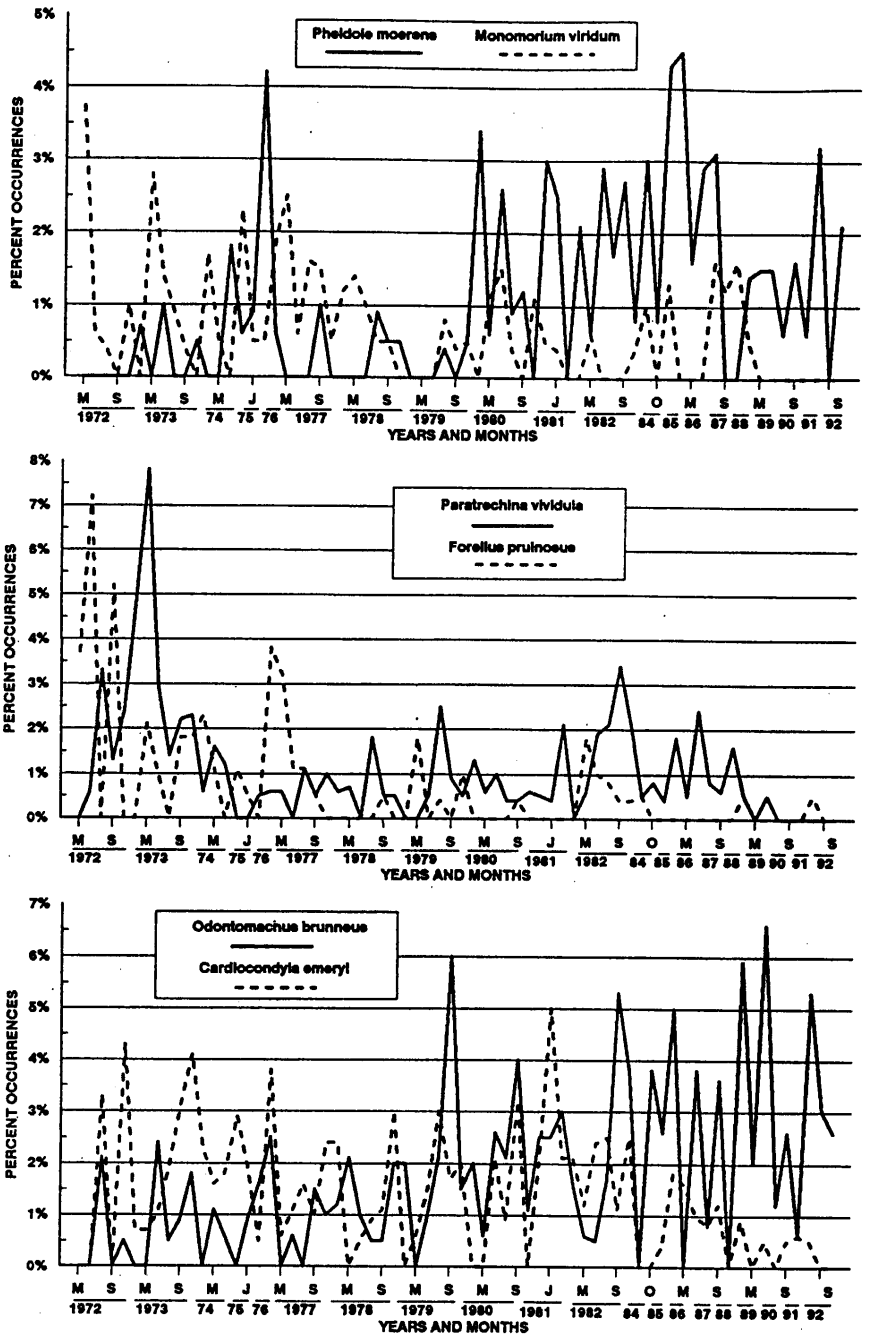


FIGURE 23.3. Percent occurrences of 6 species of ants collected on the Gainesville transect from March 1972 to September 1992.



The decrease in *Crematogaster ashmeadi* occurrences (Figure 23.2) is statistically significant ($P<0.05$). The change in *C. ashmeadi* 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. *Conomyrma bureni* occurrences (not figured) are weakly negatively correlated ($P<0.05$) with *S. invicta* 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 *S. invicta* (Hung 1974, Claborn et al. 1988, Trager 1988).

Odontomachus brunneus occurrences (Figure 23.3) showed an unexpected positive correlation ($P<0.05$) with increasing *S. invicta* occurrences. This native predator nests in small colonies (Creighton 1950, Brown 1976), which it successfully defends against *S. invicta* and other ants with a unique defensive mechanism (Carlin and Gladstein 1989). This species has an excellent ability to defend itself against *S. invicta* 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 *S. invicta* population. This species has been collected on both meat and honey-agar baits belying its strictly predatory reputation (Creighton 1950, 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 23.1). This indicates their populations increases with corresponding increases in *S. invicta* populations. The habitat disturbance and urbanization of Gainesville should favor population increases in these species. *Paratrechina longicornis* (Figure 23.2) has the largest positive correlation with *S. invicta*. This introduced species is a structural pest which can nest outdoors in northern Florida (Trager 1984). It coexists with *S. invicta*, even in its Brazilian homeland (Banks and Williams 1989). *Tetramorium simillimum* (Figure 23.2) and *Pheidole moerens* (Figure 23.3) are introduced pests which show weaker positive correlations ($P<0.01$) with *S. invicta* occurrences. These introduced species are structural pests which can nest outdoors in northern Florida (Smith 1965, Naves 1985).

Cardiocondyla emeryi was the only other introduced species collected in sufficient numbers for analysis (Table 23.2). This tiny ant is generally ignored by other ants and occupies slightly to heavily disturbed habitats (Creighton 1950). It showed a negative correlation ($P<0.05$) (Figure 23.3).

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 *S. invicta* 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 *S. invicta* populations reached stable levels. In the absence of large area-wide insecticide treatments, *S. invicta* populations may take years to reach their peak and stabilize. The Gainesville populations of *S. invicta* have not stabilized (reached the carrying capacity) and will continue to be monitored in the future.

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Resumen

Se discute en este capítulo los resultados de muestreos de hormigas realizados en sitios localizados a la orilla del camino en el area de Gainesville, Florida mediante el uso de cebos con carne y miel-agar, realizados desde Marzo, 1972 a Septiembre, 1992. Al usar 13,600 colecciones de cebos, se encontraron 990,079 especimenes. Esta colección representa 55 especies en 22 generos y 5 subfamilias. *Solenopsis invicta, S. geminata,* y *Pheidole dentata* fueron las 3 especies mayores colectadas en estos 21 años con una ocurrencia total (58.33%) y un número total de especimenes del 82.5%. *S. invicta* incrementó hasta Septiembre 1992 fué del 43.3% en ocurrencia y representó el 63.1% de los especimenes. Durante 1992, *S. invicta* fué colectada en el 65% de los sitios. Este incremento fué ayudado por la urbanización del habitat así como también su pertubabilidad. Tanto *S. geminata* como *P. dentata* mostraron

corelaciones negativas cuando se comparó con el porcentaje de ocurrencia, porcentaje de especimenes y número de sitios ocupados por *S. invicta*. Ocho especies de hormigas mostraron decremento significativo, tales como *Pheidole metallescens* Emery, *Pheidole floridana* Emery, *Pheidole morrisi* Forel, *Paratrechina vividula* (Nylander), *Forelius pruinosus* (Roger), *Monomorium viridum* (Brown), *Crematogaster ashmeadi* Mayr, *Conomyrma bureni* Trager. La hormiga nativa, *Odontomachus brunneus* (Patton), mostró una corelación positiva con el incremento de las ocurrencias de *S. invicta*. Tres especies introducidas, *Paratrechina longicornis* (Latreille), *Tetramorium simillimum* (F. Smith), *Pheidole moerens* Wheeler mostraron incrementos significativos en ocurrencia y *Cardiocondyla emeryi* Forel mostró una reducción significativa.

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