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FREQUENCY AND DISTRIBUTION OF POLYGYNE FIRE ANTS (HYMENOPTERA: FORMICIDAE) IN FLORIDA

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ABSTRACT

In order to determine the frequency and distribution of polygyne and monogyne fire ants (*Solenopsis invicta*) in Florida, preselected sites were surveyed from Key West to Tallahassee. Polygyne colonies were found at 15% of infested sites—a frequency similar to other states in the southeastern United States, but much less than in Texas. Polygyny was most common in the region around Marion county, but smaller populations were also scattered across the state. The density of mounds at polygyne sites was more than twice that at monogyne sites (262 versus 115 mounds/ha), although mound diameters were about 20% smaller. Polygyne and monogyne queens averaged the same size (1.42 mm, head width), but monogyne queens were much heavier (24.3 mg versus 14.4 mg) due to their physogastry. As expected, workers in polygyne colonies were considerably smaller than those in monogyne colonies (0.28 mg versus 0.19 mg, dry fat-free).

RESUMEN

Para determinar la frecuencia y distribución de "hormigas bravas" (*Solenopsis invicta*) políginas y monóginas en Florida, se muestrearon sitios preseleccionados desde Key West hasta Tallahassee. Se encontraron colonias políginas en 15% de los lugares infestados, una frecuencia similar a la de otros estados en el sureste de los EE.UU., pero mucho menor que la frecuencia de Texas. Las hormigas poliginas resultaron mas comunes en el condado Marion pero tambien se encontraron pequeñas poblaciones esparcidas a lo largo del Estado. La densidad de los túmulos en lugares con poliginia fue más del doble que en lugares con monoginia (262 versus 115, tumulos/ha), a pesar de que el diámetro medio de los túmulos fue 20% menor. Las reinas políginas y monóginas fueron del mismo tamaño (1.42 mm, ancho de cabeza) pero debido a su fisogastria, las reinas monóginas fueron mucho más pesadas (24.3 mg versus 14.4 mg). Como se esperaba, las obreras de colonias polígínas fueron considerablemente menores que las de colonias monóginas (0.28 mg versus 0.19 mg, peso seco, libre de grasa).

High densities of imported fire ants (*Solenopsis invicta* Buren) can cause substantial ecological and economic difficulties (Lofgren 1986, Porter & Savignano 1990). Polygyne or multiple-queen fire ants are of particular concern because they occur in densities that are often several times those of the more familiar monogyne form (Porter et al. 1991, 1992). High densities of polygyne fire ants are apparently a consequence of interconnected supercolonies that lack normal territorial boundaries (Bhatkar & Vinson 1987).

Polygyne *S. invicta* colonies were first discovered near Mobile, Alabama, where they appeared to be a curious anomaly (Glancey et al. 1973). Polygyne populations were subsequently found at scattered locations throughout the Southeastern United States (Mirenda & Vinson 1982, Fletcher 1983, Lofgren & Williams 1984). Recent studies indicate that polygyne colonies are much more common than previously suspected (Porter et al. 1991, 1992) and may even be spreading (Glancey et al. 1987).

Current genetic and morphological evidence indicates that both forms are the same species (Ross & Fletcher 1985, Trager 1991). Biochemical analyses of venom alkaloids and cuticular hydrocarbons indicate a close relationship, although slight differences have been detected in Texas (Greenberg et al. 1990). The origin of the polygyne form in the United States is unknown, but an independent introduction from South America does not seem likely (Ross et al. 1987). At least five other species and a hybrid in the genus *Solenopsis* also have polygyne populations (Summerlin 1976, Glancey et al. 1989, Jouvenaz et al. 1989, MacKay et al. 1991, unpublished data).

This study will document the frequency, distribution, and abundance of polygyne fire ants in Florida. It will also establish a baseline for monitoring future population changes of polygyne and monogyne fire ants.

Materials and Methods

In the primary survey, 85 sites were preselected along rural roadsides from Key West to Tallahassee, Florida (Fig. 1). Sampling began in south Florida on 20 March 1990 and concluded a month later near Jacksonville.

The following is a summary of environmental data obtained from primary sample sites. Adjacent habitat was 49% forests and shrubs, 19% residential or urban, 17% pasture or grassland, and 15% miscellaneous. Grass along roadsides averaged 12 ± 6 cm (SD) high with 88% of the ground vegetated. Soil moisture was dry at 38% of sites, damp at 41%, moist at 19%, and wet at 2%. The average soil temperature at 5 cm was 27 ± 5 °C. Right of ways were 8 ± 4 m wide.

Mound densities were determined from four belt transects, two on either side of the road (Porter et al. 1991). One transect on each side of the road was along the outer border of the right-of-way while the other was on the inner border adjacent to the road. Each transect was 70 paces long. All active mounds within reach of a 1.2 meter stick were tallied into one of six categories according to their diameter: ≤15, ≤30, ≤46, ≤61, ≤76, and >76 cm. The pace and reach of each investigator were determined and used to calculate the area sampled. On average, transects were 55 m long and 2.4 m wide.

A supplemental survey of 113 sites was conducted between February and April 1991 to more precisely delineate the extent and distribution of the polygyne populations in and around Marion County (Fig. 1 and 2). Mound densities were not measured at supplemental sites.

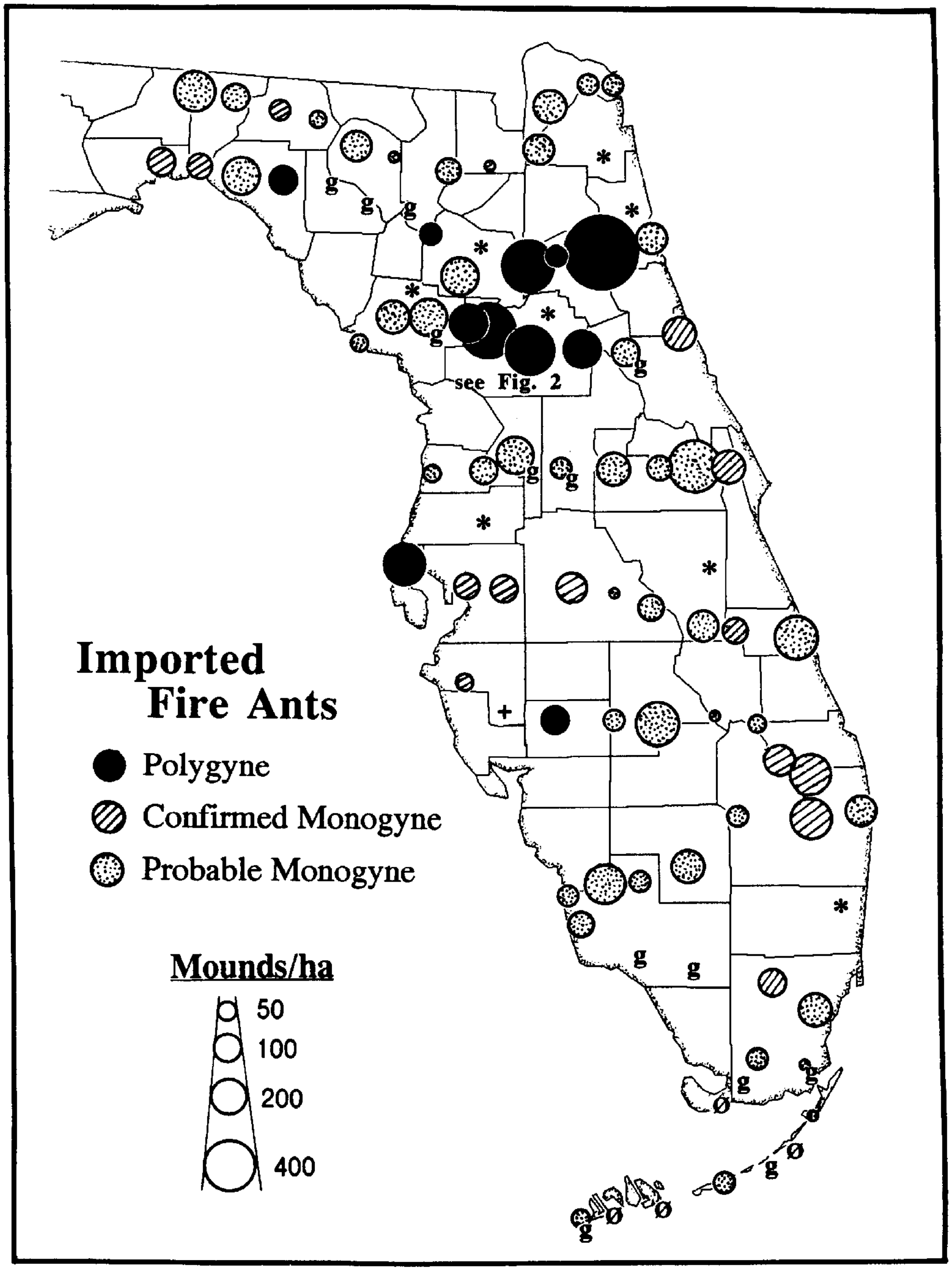

Fig. 1. Abundance and distribution of polygyne and monogyne imported fire ants (*Solenopsis invicta*) at 85 preselected roadside sites in Florida. The native fire ant, *Solenopsis geminata*, was found at sites marked with a "g". A plus symbol indicates one site where *S. invicta* was present but not sufficiently abundant to occur in transects. Sites without either species are indicated by a null set symbol "∅". Asterisks indicate counties where polygyny was confirmed by Glancey et al. (1987).

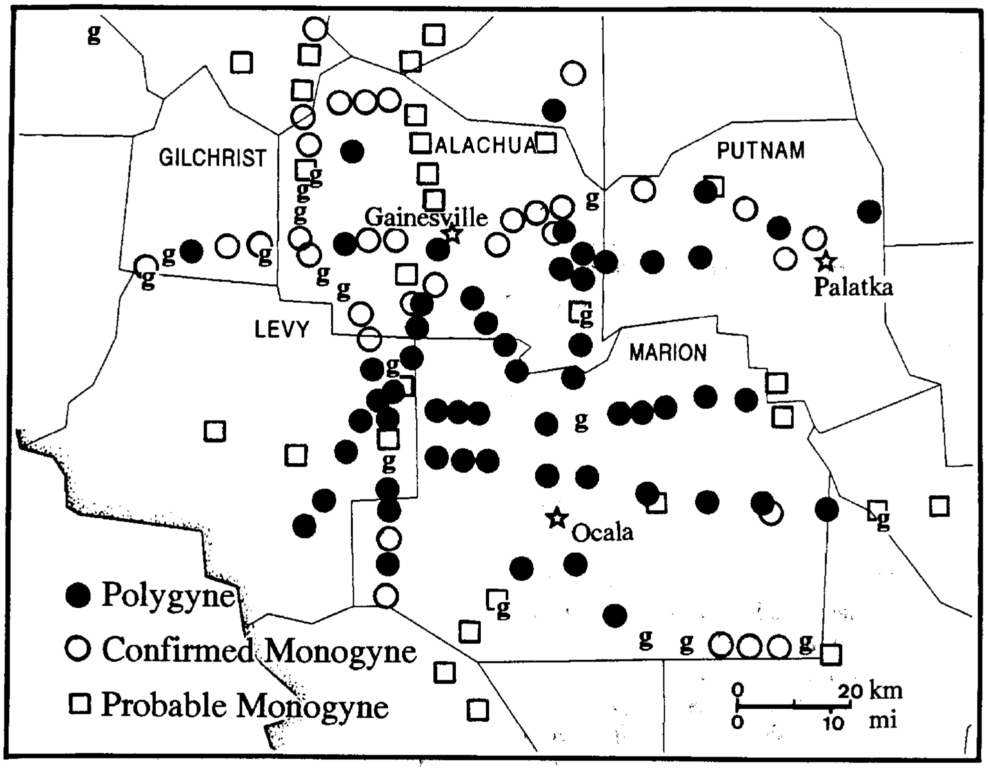

Fig. 2. Distribution of polygyne and monogyne fire ants (*Solenopsis invicta*) at 113 supplemental sites in north central Florida (14 additional sites are included from Fig. 1). Sites which appeared to have both forms are shown with overlapping symbols. Sites with *Solenopsis geminata* are marked with a "g". Major cities are indicated with an open star.

Polygyne and monogyne colonies were detected in both surveys by removing several shovelfuls of soil from a mound and scattering them across a plastic sorting sheet. Wingless queens in the supplemental survey were held on ice for several hours until they could be weighed (nearest 0.1 mg). A wedge micrometer (Porter 1983) was used to measure their head widths. In the primary survey, 4-5 mounds were inspected per site when possible. In the supplemental survey, we also sampled up to 5 mounds, but sampling was terminated after confirming one monogyne or two polygyne colonies.

Preserved queens were later dissected to determine if their spermathecae were filled with sperm. Sites were declared to be polygyne if at least one colony contained two or more inseminated queens. Confirmed monogyne sites contained at least one colony with a single highly physogastric queen. Probable monogyne sites were those where sexual production (Vargo & Fletcher 1987) and the worker size distribution (Greenberg et al. 1985) were characteristic of monogyne colonies, but no inseminated queens were recovered.

Several hundred workers were collected from mounds at each site by placing vials (20 ml) in mounds for several minutes. The inside rims of these vials were coated with talcum powder to prevent the escape of workers falling inside. Fifty workers were randomly chosen from selected colonies. This number allowed mean worker weight to be estimated within about 16% of the true colony mean 95% of the time. Workers were initially preserved in 70% isopropyl alcohol and then soaked in ether for 3-4 days to remove fats and reduce weight variability due to this factor. Preservation in alcohol reduced dry weights by 11% and soaking in ether by an additional 25% (n = 4 colonies).

Species identifications were made by the author and voucher samples have been placed in the Florida State Collection of Arthropods, Florida Department of Agriculture and Consumer Service, Division of Plant Industry, Gainesville, Florida, U.S.A. Means are presented ± one standard error unless otherwise indicated. Statistical analyses were done with Statview II software (Abacus Concepts 1987). Most statistical differences were determined using two-tailed unpaired *t*-tests. In order to normalize distributions, mound densities were log-transformed and mound areas were squareroot-transformed. A one-way ANOVA was used with Scheffé's S test to discriminate mean worker weights. A chi-square test was used to compare distributions of *S. invicta* and *S. geminata* (F.).

Results

Primary Survey

Solenopsis invicta occupied 87% of the sites (74/85) in the primary survey (Fig. 1). Polygyne colonies were found at 15% of the infested sites (11/74). Most of the polygyne sites (7/11) were in Marion and Putnam counties. Polygyny was relatively sparse in other counties, but localized populations are evidently scattered throughout the state. A previous sample of 10 sites in the Florida panhandle (Porter et al. 1992) failed to find polygyny in this part of the state.

Single highly physogastric queens confirmed monogyny at 14 sites in this survey. An additional 49 sites were designated as probable monogyne based on the large size of workers, the relative abundance of sexual brood, and the absence of multiple inseminated queens. Several monogyne colonies may have been present at two of the polygyne sites based on the size of workers in these colonies.

Mound densities of *S. invicta* at polygyne sites averaged 262 mounds/ha versus 115 mounds/ha for monogyne sites (Table 1; $t = 2.79$, $df = 70$, $P < 0.007$). The average diameter of mounds of polygyne sites was about 20% smaller than those of monogyne sites (Table 1; $t = 2.29$, $df = 69$, $P = 0.025$). The total surface areas of polygyne and monogyne mounds at sites in this survey were 1.2 and 0.9 m^2/site, respectively (Table 1; $t = 1.15$; $df = 69$; $P = 0.26$).

Supplemental Survey

The supplemental survey revealed that polygyne colonies predominate in an area of about 4600 km^2 (~1800 mi^2), including most of Marion county and large parts of Alachua, Levy, and Putnam counties (Fig. 2). Of the 113 supplemental sites, 40 were confirmed as polygyne, 33 were confirmed as monogyne, and 22 were probable monogyne. Six sites appeared to contain both monogyne and polygyne colonies and the remaining 12 sites contained only *S. geminata*. Seven of the previous sites also contained both *S. invicta* and *S. geminata*.

Solenopsis invicta was absent from a total of 23 sites in the primary and supplemental surveys (Figs. 1 and 2). *Solenopsis geminata* was found at 83% of the sites without *S. invicta*, but only 7% of the sites with *S. invicta* (19/23 versus 14/178; $\chi^2 = 82.9$; $df = 1$; $P < 0.0001$).

Queens from polygyne and monogyne colonies were the same size; mean head widths for both groups were 1.42 ± 0.03 mm (SD, n = 61 and 37, respectively; each queen was from a separate colony). Queens from monogyne colonies were much more physogastric than queens from polygyne colonies (Fig. 3A; $t = 21.0$, $df = 183$, $P < 0.0001$), and there was little overlap in their weight distributions. Ninety-five percent of queens greater

TABLE 1. A COMPARISON OF MOUND DENSITIES, MOUND SIZES, AND TOTAL MOUND AREAS AT SITES INFESTED WITH POLYGYNE AND MONOGYNE FIRE ANTS.[1]

	Survey Location[2]		
	Florida (11, 63)	Louisiana to Georgia[3] (9, 43)	Texas[4] (288, 232)
Mound Density (mounds/ha)			
Polygyne	262 ± 65	544 ± 115	680 ± 28
Monogyne	115 ± 10	170 ± 17	295 ± 16
Mound Diameter (cm)			
Polygyne	32 ± 3	32 ± 3	36 ± 1
Monogyne	40 ± 1	42 ± 1	39 ± 1
Total Mound Area (m^2/site)			
Polygyne	1.2 ± 0.2	3.0 ± 0.9	4.4 ± 0.2
Monogyne	0.9 ± 0.1	1.4 ± 0.1	2.2 ± 0.2

[1]Data are means ± SE.
[2]Numbers of polygyne and monogyne sites sampled are shown in parentheses.
[3]From Porter et al. 1992.
[4]From Porter et al. 1991.

than 20 mg belonged to monogyne colonies compared to less than 2% of queens from polygyne colonies.

Fat-free weights of workers from monogyne colonies were 50% heavier on average than workers from confirmed polygyne colonies (Fig. 3B; F = 31.9, df = 2, 90, P = 0.0001). The mean weight of workers from probable monogyne colonies did not differ significantly from their confirmed counterparts (P = 0.86, Scheffé's S Test) suggesting that very few polygyne colonies were included by accident.

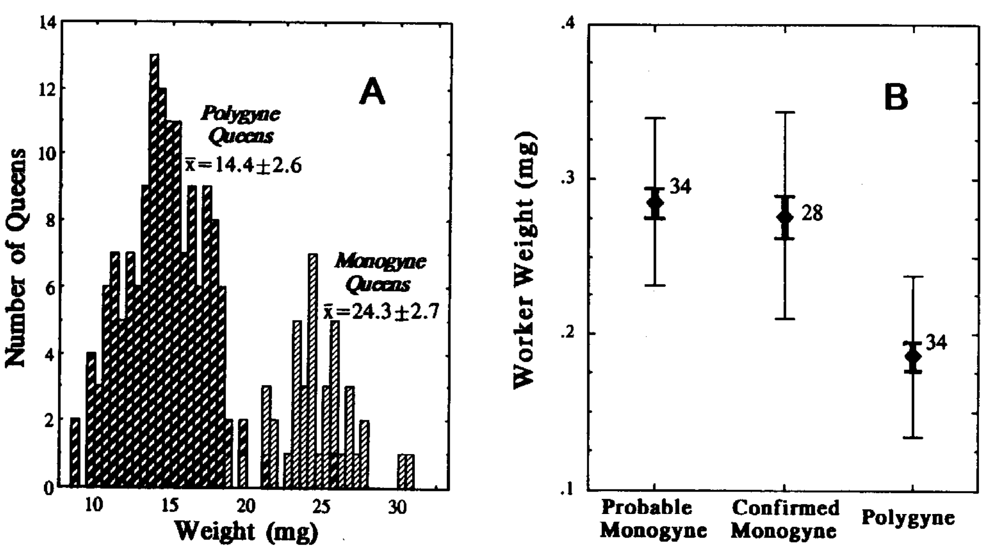

Fig. 3. A) Weight distributions of inseminated queens from 70 polygyne colonies (n = 145 queens) and 39 monogyne colonies (n = 39). B) Average dry weight (fat-free) of workers in polygyne and monogyne colonies. Standard deviations (narrow lines), standard errors (wider lines), and the number of colonies sampled are shown for each mean.

DISCUSSION

The frequency of polygyny in Florida (15%) was similar to that in other southeastern states (18%, Porter et al. 1992), but only a third of that reported in Texas (53%, Porter et al. 1991). Polygyny is apparently absent from most of the Mato Grosso region of Brazil (Porter et al. 1992), although several populations have been found in northern Argentina (Trager 1991, S.D.P. unpublished data).

The geographic pattern of polygyny in north central Florida (Fig. 2) was similar to the mosaic pattern observed in Texas (Porter et al. 1991). The reasons why polygyny is more abundant in one region than another (Fig. 1) are still not known. Habitat and climatic variables do not appear to be related to its presence or absence in the United States (Porter et al. 1991, 1992). Likewise, there does not appear to be a pattern associated with the invasion process, although very little is known about how polygyne populations change over time. Perhaps the mosaic distribution of polygyny in the United States is largely the haphazard result of expanding fire ant populations (Porter et al. 1991).

Polygyny was first reported in Florida by Lofgren & Williams (1984). Three years later, Glancey et al. (1987) confirmed polygyny in eight counties from Broward to Duval (Fig. 1). This survey confirmed polygyny in an additional six counties (Fig. 1, Fig. 2). The gradual expansion of polygyne populations in Florida and the United States seems likely (Glancey et al. 1987, Porter et al. 1991); however, current evidence of expansion is still mostly anecdotal. Surveys across time will be necessary to document the actual rate and extent of population changes.

The absence of *S.. invicta* from sites in the Florida Keys and the Everglades is attributable to the fact that *S. invicta* has only recently invaded this area, and that sawgrass and mangrove swamps make very poor habitat for both native and imported fire ants. The absence of *S. invicta* from three sites in northern Florida (Fig. 1) is more of a puzzle because *S. invicta* has been in this area for several decades. The native fire ant, *S. geminata*, is known to persist in drier undisturbed habitats of northern Florida (Tschinkel 1988a), but the habitat at these three sites was moist, disturbed and otherwise appeared ideal for *S. invicta*. Perhaps, an abundant population of *S. geminata* at these sites has diminished the success of founding *S. invicta* queens and delayed the invasion process (Porter et al. 1988).

The high frequency of the native fire ant, *S. geminata*, at sites without *S. invicta* indicates that the imported species has displaced native species from most of Florida's roadsides. *S. geminata* has met a similar fate almost everywhere the two species have met (Porter et al. 1988). In contrast with Texas (Porter et al. 1991), *S. geminata* continues to persist with the imported species at a few sites in Florida (Figs. 1-2). It will be interesting to determine if such coexistence will be maintained permanently.

Polygyne colonies are unambiguously identified by the presence of multiple inseminated queens with degenerate wing muscles. Almost all mounds at polygyne sites appeared to be polygyne based on the small size of their workers and their low sexual production. We were able to collect multiple inseminated queens from more than 60% of mounds inspected at polygyne sites; thus the probability of not confirming polygyny at a polygyne site was generally less than 5% when 4-5 mounds were inspected under appropriate weather conditions.

The presence of a single highly physogastric queen (>20 mg) identifies a monogyne colony with a high degree of probability (Fig. 3A). The weights of monogyne queens were similar to those reported by Tschinkel (1988b). The average weight of polygyne queens was about 2 mg more than that reported by Vargo & Fletcher (1989) probably because colonies in Florida had fewer queens than those studied in Texas. Worker weight alone was a relatively poor predictor of polygyny for a single colony (Fig. 3B), but the average size of workers from 6-7 mature colonies would identify pure monogyne or polygyne sites with about 95% accuracy. The overlapping standard deviations of worker weights probably resulted because young monogyne colonies have small workers (Tschinkel 1988c) and polygyne colonies with only a few queens may produce larger workers than those with many queens. Care should also be taken when using worker size or weight as an indicator of polygyny (Greenberg et al. 1985) because these characters can fluctuate seasonally (Tschinkel 1988b).

The average densities of mounds at roadside polygyne sites is usually 2-3 times those at monogyne sites (Table 1). Mound densities in Florida were less than those in other states. The cause of lower densities is uncertain, but they could reflect differences in climate, habitat, weather, or road management. Time since invasion is probably not a factor for most sites because *S. invicta* has occupied most of Florida for 15-20 years and mound densities usually stabilize within 4-5 years of the initial introduction.

Higher mound densities do not necessarily mean that polygyne sites have proportionately more fire ants. Polygyne mounds in this survey and in the survey from Louisiana to Georgia (Porter et al. 1992) were about 20% smaller in diameter than mounds of monogyne sites (Table 1). Polygyne mounds in Texas were also smaller, but the difference was less than 10% (Porter et al. 1991).

If total mound area at a site is used as an index of ant abundance, then ant densities at polygyne sites in Florida were only about 30% greater than those at monogyne sites. The total surface area of mounds at polygyne sites in the Louisiana to Georgia survey and the Texas survey were twice as large as totals for monogyne sites (Table 1). These data indicate that polygyne fire ant populations are consistently larger than monogyne populations; however, additional studies are needed which directly compare the number and biomass of workers in polygyne and monogyne populations.

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SUSPECTED AFRICAN HONEYBEE COLONIES IN FLORIDA TESTED FOR IDENTIFYING DNA MARKERS

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ABSTRACT

Fourteen honeybee colonies, present in the vicinity of Florida ports and suspected to be of African descent, were analyzed for distinguishing mitochondrial and nuclear DNA markers. Four of the colonies, previously identified as African on the basis of morphometrics, were found to have African mitochondrial DNA. Nuclear DNA markers characteristic of African bees were found predominantly in these four colonies.

RESUMEN

Catorce colonias de abejas localizadas cerca a puertos en Florida, y las cuales se sospechaba tenían ascendencia africana, fueron analizadas por marcadores de DNA de la mitocondria y el nucleo. Se encontró que cuatro colonias, previaménte identificadas como africanas en base a morfometría, tenían DNA mitocondrial africano. Se encontró predominando en estas cuatro colonias marcadores de DNA nuclear, caracteristíco de las abejas africanas.

The American honeybee population represents a number of introduced subspecies of *Apis mellifera* L. The bees imported by early settlers were mostly of the west European race *A.m. mellifera* L. Over the past hundred years, the more docile east European types, *A.m. ligustica* Spinola, *A.m. carnica* Pollmann, and *A.m. caucasia* Gorbachev, have become preferred for beekeeping and have largely replaced managed bees from the earlier importations (Pellet 1938, Oertel 1976, Sheppard 1989). European swarms that escaped from apiaries established self-sustaining feral populations in temperate regions but not in the tropics.

African honeybees are better adapted to tropical conditions. For this reason, a subspecies from South-Central Africa, *A.m. scutellata* Lepeletier (Ruttner 1988), was introduced into Brazil in 1956 with the hope of increasing commercial honey production (Kerr 1967). Unlike the European bees, the African bees established a large feral population that has expanded through much of the neotropics over the last 35 years (Michener 1975, Taylor 1977, 1985). Within the past year, the front of the African bee population has spread into Texas. Temperate climatic and ecological conditions are expected to limit African bees to the southern tier of the United States. A hybrid zone may be