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Stability of Polygyne and Monogyne Fire Ant Populations (Hymenoptera: Formicidae: *Solenopsis invicta*) in the United States

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ABSTRACT Over the past decade, polygyne red imported fire ants (*Solenopsis invicta* Buren) have been found at more and more sites across the southeastern United States. The objective of my study was to determine if polygyne (multiple-queen) populations are expanding and at what rate this might be occurring. More than 200 sites were inspected for polygyny in Florida and several other southeastern states. These sites were reinspected 1–3 yr later. Results showed that polygyne populations were not expanding rapidly in the areas studied (i.e., >4–6% per yr); however, more data will be needed to determine if polygyne populations are expanding slowly (i.e.,1–2% per yr). Overall, polygyne and monogyne sites were about 95% stable from year to year; in other words, they did not commonly switch back and forth from one form to the other. As expected, average mound densities in the Florida survey (62 sites) remained relatively constant from 1990 to 1992.

KEY WORDS polygyny, multiple queens, exotic pest

THE RED IMPORTED FIRE ANT, *Solenopsis invicta* Buren, was probably introduced into the United States from South America sometime in the 1930s (Lofgren 1986). Over the last 50 yr, this species has gradually expanded its range and occurs in most of the southeastern United States. At first, all colonies appeared to be monogyne (i.e., they contained a single functional queen). In the early 1970s, however, several populations were reported with colonies that contained multiple functional queens (Glancey et al. 1973, Hung et al. 1974). Initially, this appeared to be a curious anomaly. As time progressed, more and more polygyne populations were found (Fletcher et al. 1980, Mirenda & Vinson 1982, Lofgren & Williams 1984). By the late 1980s, it was clear that polygyne fire ants were scattered throughout the North American range and in many areas they were the predominant form (Porter et al. 1991, 1992, Porter 1992).

Glancey et al. (1987) reported that polygyne populations appeared to be increasing in frequency throughout the southeastern United States. This possibility is particularly distressing because polygyne fire ants have the potential for much greater economic and environmental damage resulting from mound densities that are usually two to three times larger than those of the monogyne form (Porter 1992). The objective of my study was to determine if polygyne populations are expanding and how rapidly this might be occurring.

Materials and Methods

To study the long-term dynamics of polygyne populations, I re-examined 225 sites from three previous surveys (see Porter [1992], Porter et al. [1992] for maps). The first survey was initiated in mid-March 1989 (n = 52 sites). Sites in this survey of five southeastern states were spaced at intervals of about 40 km on a loop from Lake Charles, LA, to Gainesville, FL, and then back through Tifton, GA, to Shreveport, LA. These sites were reinspected between late April and early May 1992. A second large-scale survey was conducted in March and April 1990 (n = 70 sites). Sites in this survey of Florida were about 25 km apart on a route that crisscrossed the state seven times from Naples to Jacksonville. These sites were reinspected between late February and early April 1992. Roadside mound densities were measured for both 1990 and 1992 (see Porter [1992] for details). The third survey was designed to monitor the expansion of a large polygyne population in and around Marion County in north-central Florida. The initial sampling for this survey was conducted between late February and mid-April 1991 (n = 103). Sites in this mesoscale survey were 5–10 km apart. These sites were reinspected between March and April 1992. Sites for all three surveys were selected at predetermined intervals; they were generally along two-lane paved roads in rural areas. The weather conditions were recorded at each site.

Directions to each site were also recorded to ensure revisitation within 50–100 m.

Mounds were classified as polygyne or monogyne by scattering several shovels of dirt across a sorting sheet and carefully examining the contents for wingless queens. Wingless queens were collected, preserved, and later dissected to determine if they were inseminated and if they had degenerate wing muscles. Polygyne colonies were defined by the presence of multiple inseminated queens with degenerate wing muscles. Degenerate wing muscles demonstrated that the queen was not a recent dealate. The presence of a spermatheca showed that a queen had mated and was capable of laying fertilized eggs. Monogyne colonies were confirmed by the presence of a single inseminated highly physogastric queen (>20 mg) (i.e., a queen so full of eggs that the intersegmental membranes were visible between at least two of her gaster segments in dorsal view).

During the original inspections, we examined up to five mounds at each site (when available), but sampling was usually terminated after confirming one monogyne or two polygyne colonies. The same procedure was used for the sampling in 1992 except that two confirmed monogyne colonies were required before sampling was terminated. If a site changed category on reinspection, three to five additional colonies were also examined. When queens could not be found, sites were classified visually as "probable monogyne" or "probable polygyne" based on the relative size of workers (Porter 1992) and the abundance of sexual brood (Vargo & Fletcher 1987).

Exact binomial probabilities (Ott 1977) were calculated to test the hypothesis that the number of sites switching to polygyny deviated significantly from equilibrium. Mound densities in the Florida survey were analyzed with a combination of linear regression, paired *t* tests, and analysis of variance (ANOVA)(Abacus Concepts 1992).

Results and Discussion

Classifications for both polygyne and monogyne sites were very stable over the 1–3 yr study periods (Table 1). Upon reinspection, 94% of the monogyne sites were still monogyne and 97% of polygyne sites remained polygyne. In other words, sites did not commonly switch back and forth from one form to the other.

This study also indicated that polygyne populations were not expanding rapidly in the three areas sampled (Table 1). After 3 yr, the percentage of polygyne sites in the southeastern United States survey increased from 17 to 24%. This increase was a result of the discovery of small patches of polygyne colonies at four sites previously categorized as monogyne. All four sites still appeared to contain some monogyne colonies. Another site along a dike in southern Louisiana switched from strongly polygynous to strictly monogynous. The cause of this switch is unknown; however, a long period of flooding is one possible explanation. Adjusting 1992 data to 1989 sampling efforts resulted in one of the mixed sites being categorized as probable monogyne. The net adjusted increase for polygyne sites was 4% (2/49) after 3 yr or 1.3% per yr. Neither the adjusted nor the unadjusted figures were significantly different from a null hypothesis of equilibrium in which 50% of all changes would be to polygyny and 50% would be from polygyny (Table 1; binomial probabilities: unadjusted, $P = 0.16$; adjusted, $P = 0.23$). Three of the original 52 sites were eliminated because of construction (1) or inadequate directions (2).

Table 1. Temporal stability of polygyne and monogyne fire ant populations (*Solenopsis invicta*)

Results on reinspection of sites	Survey[a]			Totals
	SE United States (3 yr)	Florida (2 yr)	Marion County (1 yr)	
Remained monogyne	36 (36)	51 (51)	44 (45)	131 (132)
Remained polygyne	8 (7)	9 (9)	41 (40)	58 (56)
Switched to polygyny	4 (4)	1 (1)	3 (2)	8 (7)
Switched from polygyny	1 (2)	1 (1)	0 (1)	2 (4)
Totals	49 (49)	62 (62)	88 (88)	199 (199)

[a] Numbers indicate the number of sites in each survey that switched between monogyny and polygyny or remained unchanged after the period indicated. Numbers in parentheses are numbers of sites after adjusting to equal sampling effort.

In the Florida survey, one site switched to polygyny and one switched from polygyny for a result of no change after 2 yr (Table 1). Both sites that switched appeared to be mostly monogyne in 1990 and 1992; consequently, the changes were technically not changes to or from monogyny. Eight of the original 70 sites were eliminated from consideration because of poor directions (1), road construction (3), or the absence of fire ants (4). Mound densities in 1992 were not significantly different from those in 1990 (Porter 1992; paired *t* test: $t = 1.09$, df = 62, $p = 0.28$). Mound densities at sites in 1990 and 1992 were significantly correlated (linear regression: $F = 24.6$, df = 58, $P < 0.0001$), but the coefficient of determination was rather low ($R^2 = 0.32$). Densities at polygyne sites in 1992 averaged 289 ± 50 (SE) mounds per ha compared with 128 ± 11 mounds per ha for polygyne sites (ANOVA: $F = 15.3$, df = 1, 58; $P = 0.0002$; [square root transformed]). This 226% difference was almost equal to the 228% difference reported 2 yr earlier. Mounds at polygyne sites were smaller than those at monogyne sites (1,530 ± 180 cm^2 versus 2,130 ± 190 cm^2; ANOVA: $F = 2.32$; df = 1, 56; $P = 0.13$), but the summed area of mounds at polygyne sites was still about 75% larger than the average at monogyne sites (2.33 ± 0.14 m^2 per site versus 1.32 ± 0.51 m^2 per site; ANOVA: F = 5.1; df = 1, 58; P = 0.027).

In the Marion County survey, three sites switched to polygyny and none switched from polygyny (Table 1). After equalizing sampling effort, however, only two sites would have changed to polygyny and one would have changed from polygyny, for a net adjusted increase of 1.1% per yr for polygyne sites. Neither this difference nor the unadjusted difference departed significantly from the null hypothesis of equilibrium (binomial probabilities: adjusted, P = 0.38; unadjusted, P = 0.13). Fifteen of the 103 original sites were eliminated because fire ants were absent (13) or directions were poor (2).

When the data from all three surveys were summed, the unadjusted shift toward polygyny was significant (Table 1: binomial probability: P = 0.043); however, the significance disappeared after the sampling and resampling efforts were equalized (binomial probability: P = 0.16). Most of this difference can be attributed to the exclusion of extra colonies that were sampled when a site appeared to switch categories. Sites in the three surveys that were originally designated "probable monogyne" were no more likely to switch to polygyny than sites that were originally designated "confirmed monogyne" (4/69 compared with 4/69, respectively). These data indicate that designation errors for monogyne sites were uncommon, although several may have occurred. Almost all of the polygyne sites (59/61) were confirmed as polygyne. Two sites, however, were designated "probable polygyne" because of small worker size, few sexuals in the colonies, and poor weather conditions that made finding queens difficult.

The adjusted yearly change to polygyny ranged from 0% per yr in the Florida survey to 1.3% per yr in the Southeast survey. The sampling efforts in the individual surveys could have detected yearly increases of 3–5% in the frequency of polygyny if none of the polygyne sites had switched to monogyny. Because one or two sites switched from polygyny in each of the surveys, the net yearly shift to polygyny would have needed to be about 4–6% per yr for the results to have been significant.

Almost 8% of polygyne sites (5/61) also contained some confirmed monogyne colonies. Another 26% of the polygyne sites (16/61) contained colonies that looked like they could have been monogyne based on worker size; however, a portion of these were probably polygyne colonies with larger than expected workers (Porter 1992). Seven of the 10 sites that switched either to or from polygyny also appeared to have a mixture of both polygyne and monogyne colonies. Mixed populations might have occurred because the change from monogyny to polygyny is a very gradual process requiring many years to complete on a local level (Porter et al. 1988). However, it is also possible that some of the apparent switches may have been artifacts of sampling small numbers of mounds from stable mixed populations rather than actual switches in the types of ants that were present at the site. At least one case is known where a mixed population of polygyne and monogyne fire ants coexisted for more than 6 yr without replacing each other (Greenberg et al. 1992).

In summary, my study demonstrated that populations of monogyne and polygyne fire ants are very stable from one year to the next. Sites in this study did not show either a rapid shift to polygyny or a tendency to switch back and forth from one form to the other. T. C. Lockley (unpublished data) also found that polygyne populations around Gulfport, MS were generally stable and showed no indication of range expansion. Results from both studies suggest that previous reports of expanding polygyne populations may have been premature. Neither study, however, can refute the possibility that polygyne fire ant populations are expanding very slowly. Slow rates of regional expansion would not be surprising because polygyne colonies expand primarily by colony budding (Vargo & Porter 1989) and are known to require years or even decades to move a few hundred meters (Porter et al. 1988, Greenberg et al. 1992). Even slow changes, however, could result in substantial cumulative differences over a period of 10–20 yr if the growth occurred from numerous foci in a mosaic like distribution such as that found in Texas and Florida (Porter et al. 1991, Porter 1992). To determine if polygyne fire ant populations are expanding slowly, the study sites will need to be resampled again in 4–5 yr.

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