Reprinted from *The Florida Entomologist*, Volume 66, Number 1, March 1983

COMPARISON OF THE ECOLOGY OF RED IMPORTED FIRE ANTS IN NORTH AND SOUTH AMERICA

DANIEL P. WOJCIK
Insects Affecting Man and Animals Research Laboratory
USDA, ARS
Gainesville, FL 32604 USA

Various investigators have had the opportunity to study *Solenopsis invicta* Buren, the red imported fire ant (RIFA) in South America which has led to discussions on whether RIFA populations are higher in North America or South America. The point to discuss is not whether populations are higher in North or South America, but rather do similar habitats have similar populations? This discussion will be limited to RIFA.

Abiotic factors such as temperature, rainfall, and soil are difficult to separate and will be discussed together. In North America it is commonly accepted (CAST 1976) that RIFA will not survive above the 10°F January isotherm (Fig. 4). The 10°F isotherm, in South America, extends from extreme southern Argentina north along the eastern slopes of the Andes Mountains. The areas to the east and west of known RIFA populations in Argentina, Paraguay and Brazil are occupied by other competing fire ant and non-fire ant species (Buren et al. 1974). The Pantanal area of Mato Grosso, Brazil, the homeland of RIFA (Buren 1972), is subject to antarctic could fronts which can occur from May to October (Lennartz 1973). RIFA apparently does not hibernate (Buren et al. 1974) and the northern expansion of RIFA in North America may be limited by winter kill (Morrill 1977). I have, however, seen RIFA colonies which were encased in ice in the mound, recover completely upon being thawed. The 0°F isotherm on the USDA Plant Hardiness map has been proposed as the northern limits of the ecological range of RIFA (Anon. 1972). The 0°F isotherm is farther north than the 10°F isotherm and is probably not a good estimate of eventual RIFA range. Probably a better indicator of eventual range would be average depth of frost penetration (USDA 1941, p. 747) since colonies in natural locations would be frozen to death. However, RIFA can move into buildings to survive cold temperatures (Hung & Vinson 1978).

The possibility of RIFA spreading across the southwestern United States to Salifornia has been discussed by several authors (most recently by Canter 1981). In a climatic analysis, mainly in Texas, Pimm & Bartell (1980) used a combination of temperature and moisture to predict Texas counties that might become infested. Whether RIFA will invade these counties and move further west remains to be seen. It must be remembered that RIFA is an opportunistic invader and may only require small irrigated areas to expand its range. Whether RIFA would become a dominant ant under the drier western conditions also remains to be seen.

In South America, RIFA does not usually construct mounds as large as it does in the United States (Allen et al. 1974, Buren et al. 1974, Wojcik et al., unpub.). However, after rain or in wet areas, larger mounds up to 20 cm (8 in) in height and 60 cm (24 in) in width have been found (Banks,

Jouvenaz and Wojcik, unpub.). Ant mounds of other species are known to function in thermoregulation (Petal 1977) and RIFA mounds have been assumed to serve the same function. RIFA brood develops faster in warmer temperatures (Markin & Dillier 1971a, Markin et al. 1973) and the workers move the brood in the mound in response to temperature and moisture (Rhoades & Davis 1967). In cooler weather the ants and brood are concentrated on the sunny side of the mound (Banks et al. 1981) and can be easily collected. In well drained soils with moderate soil temperature, the ants may build very low mounds. In Puerto Rico, where RIFA has recently been reported (Buren 1982), the RIFA built low mounds (less than 6-in high) in all areas where they were observed (from Ponce to a point 40 km west of Ponce, Wojcik, unpub.). This southern coastal area of Puerto Rico is considerably drier than the rest of the island (Calvesbert, 1974). In North and South America in areas of heavier clay soils, the mounds build up over time, resist weathering, and retain their shape and size (Wojcik, Banks and Jouvenaz, unpublished). Conversely in areas of lighter sand soils, the mounds do not resist weathering and are rapidly leveled by rain.

In most of the United States, rain is not usually a limiting factor for RIFA, except in the west. Drought may be a temporary limiting factor in terms of colony founding by newly mated queens (J. Milio, Univ. of Fla., unpub.) but should not affect established colonies adversely. In South America, most of the areas where RIFA are known to occur have a winter dry season during which there is very limited rainfall (USDA 1941, p. 674).

Larger RIFA mounds are commonly found in South America in areas of higher soil moisture such as stream banks and in the Pantanal (Wojcik, Banks and Jouvenaz, unpub.). These large mounds are built to escape excessive soil moisture similarly to mounds built in certain areas in the United States (USDA 1958). Soil type as such is not a predominant factor in RIFA distribution, as the ants nest in all soil types in southeastern North America (USDA 1958) and appear to do so in South America. The major way that soil type seems to be a factor, is that clay soils hold moisture longer than sands, thereby favoring colony foundation (J. Milio, Univ. of Fla., unpub.).

RIFA occupy disturbed habitats including highways, urban and cultivated areas in North America (Lofgren et al. 1975) and South America (Lennartz 1973, Allen et al. 1974, Wojcik,, Banks and Jouvenaz, unpub.). Highway construction creates a temporary ecological vacuum, which RIFA can fill because of their high reproductive potential (Morrill 1974b) whenever meterological conditions are suitable for mating flights (USDA 1958). Once road construction ceases, the right of way becomes stable, i.e. it is maintained in a grass cover which favors RIFA. Urban areas are similar to highways in that an ecological vacuum is created by construction and human habitation. The act of human habitation creates the conditions which are suitable for RIFA invasion and occupation. Constant disturbance, reduction in competition, and irrigation favor RIFA occupation of cultivated land.

The 2 areas of natural habitat of major concern in South America are the cerrado and the pantanal. The cerrado is an area characterized by mixed grasses and scrub trees on dry poor soils. It extends from the pantanal to the north, east and southeast (Santos et al. 1977). This is not

a major RIFA habitat unless disturbed. In North America, there are no habitats which are strictly comparable to the cerrado. Superficially, the southwest coast of Puerto Rico and the longleaf pine-xerophytic oak (e.g. turkey oak) forests in southeastern North America resemble the cerrado.

The pantanal is a large swampy grassland with large areas of trees that flood naturally each year (Santos et al. 1977). RIFA is well adapted to flooding with its floating behavior which it uses for survival and dispersal (Lennartz 1973, Morrill 1974a). All areas are not flooded each year; Fig. 1 shows a pasture which was surrounded by flooded forests and fields. No fire ants were found in this pasture, but high populations of *Paratrechina fulva* (Mayr) and several species of army ants were observed. However, 8 *Solenopsis* sp. nests were found 200 m from this pasture, in a field bulldozed from a forest and planted with rice. In North America, some large swampy areas (e.g. the Atchafalya Basin in Louisiana) and many smaller wetter areas are similar to the pantanal.

In North America and South America, RIFA occupies forests as well as open areas. However, population levels are inversely proportional to the amount of crown cover (Brown 1980). As crown cover seldom reaches 100%, a few nests are found in openings and along roads in forests. Although, RIFA may not establish or maintain nests in shaded areas of forests, the ants will forage extensively on the ground and up in the trees (Wilson & Oliver 1970). I have seen workers extensively foraging on the ground and on trees 200 ft within a dense forest in southern Alabama.

Table 1 summarizes the available data on RIFA nest count in Mato Grosso, Brazil, and Florida, Alabama, and Texas, United States. The high-

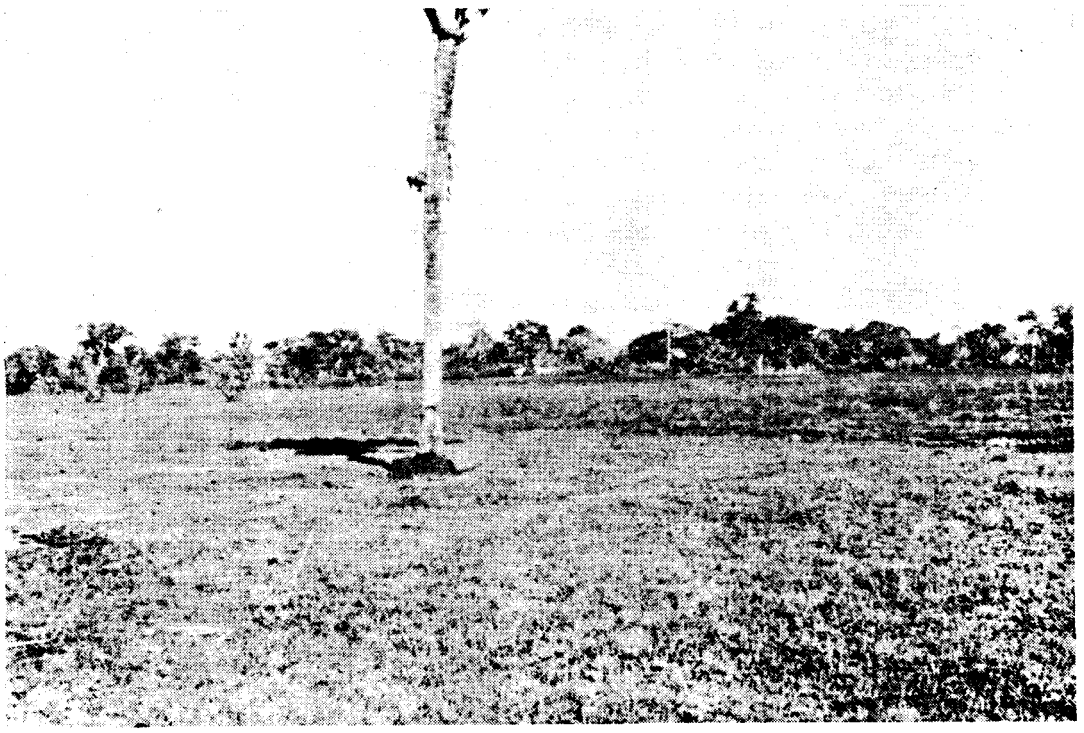

Fig. 1. Pasture at Fazenda Bahia das Pombas in Pantanal, Mato Grosso, Brazil, April, 1981. This pasture had not been flooded this season while the surrounding pastures and forests were still flooded. No fire ants were found in this pasture or along its margins. (Photo by author).

TABLE 1. COMPARISON OF POPULATIONS OF RIFA NESTS IN MATO GROSSO, BRAZIL, AND THE SOUTHERN UNITED STATES IN VARIOUS HABITATS.

Habitat	Average ant nests per acre			
	Brazil Cuiaba	Florida E of Tampa	Alabama S of Birmingham	Texas E of Beaumont
Highway (age)				
1-2 Yr	66[1]	2[3]	16[3]	10[3]
3-4 Yr	25[2]			
4-5 Yr	13[1]			
6-7 Yr	23[1]			
10+ Yr		11[4]		
Unknown		4[3]	15[3]	13[3]
Forest	13[1] (cerrado)	9[4] (native & planted pine)		
		1[3]	1[3] (dense woods)	2[3]
Urban	14[1]	22[4]		
	9[2]			

[1]W. A. Banks, D. P. Jouvenaz, J. D. Atwood and D. P. Wojcik, unpub. manuscript.
[2]D. P. Wojcik and D. P. Jouvenaz, unpub. data.
[3]USDA, 1967, unpub. data, 2% random sample of 64,000 acre blocks.
[4]R. E. Brown, 1979, unpub. data, systematic random sampling over entire state of Florida.

way aged 1-2 years is the same highway aged 3-4 years. In similar habitats the number of mature RIFA nests are similar if time of infestation is considered.

Another method of estimating ant populations is by collecting the ants attracted to baits along a transect through a test area. This method was used to compare ant populations in Brazil and the United States. Ants were collected from baited transects using the method described by Wojcik et al. (1975). Briefly, a small piece of hamburger and a small piece of agar containing 40% honey were placed individually on small pieces of aluminum foil. The 2 baits were placed on the ground, one to 3 ft apart, at each bait station. The bait transects in Brazil were conducted in the same manner except that the meat ball and liquid honey were placed directly in 1 oz plastic cups (minus lids) on the ground. The first Brazilian site sampled was the Federal University of Mato Grosso (FUMT), Cuiaba, Brazil. The site was located around the agriculture building on campus, 2 sides of which are well-kept gardens; the other 2 sides are cleared cerrado. The second Brazilian site sampled was the median strip of the Coxipo-Varzea Grande Highway. In both transects, the 30 bait stations were spaced about 10 m apart. The baited transects in Gainesville, FL, are part of a continuing survey along urban and rural roads through Gainesville and adjacent areas. The area was lightly infested when the collections were started in 1972. The 100 bait stations are located 0.2 miles apart. In addition to the Gainesville survey area, we are also surveying a roadside near Baldwin, FL, a highly infested area. The 30 bait stations are spaced 0.2 miles apart. The surrounding area consists of pine forests, pasture and homesites.

The data for the bait collections made in Brazil and the United States in 1981 are summarized in Fig. 2 and 3. The FUMT and Coxipo samples were collected on 3-V-81, Gainesville on 11-V-81, and Baldwin on 29-VII-81. All baits were placed out at approximately 9 AM and retrieved about 1-h later. The other ants listed in the figure belong to genera commonly

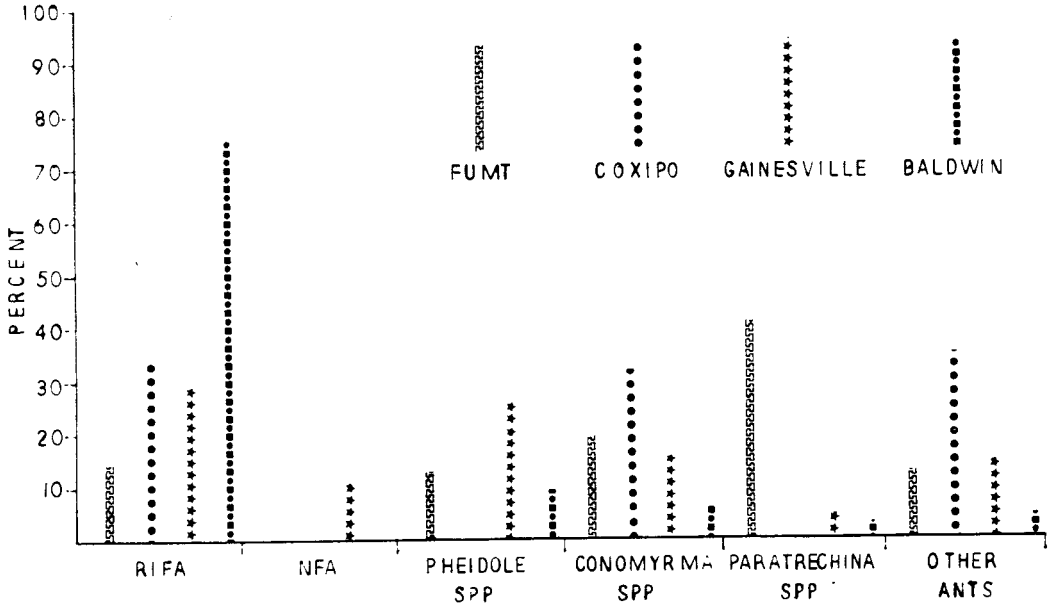

Fig. 2. Results of meat and honey-agar bait collections from 4 bait transects (described in text). The percent of baits where each species was collected is shown for each transect. RIFA=red imported fire ant, NFA= native fire ant, *Solenopsis geminata* (F.). Wojcik, unpub. data.

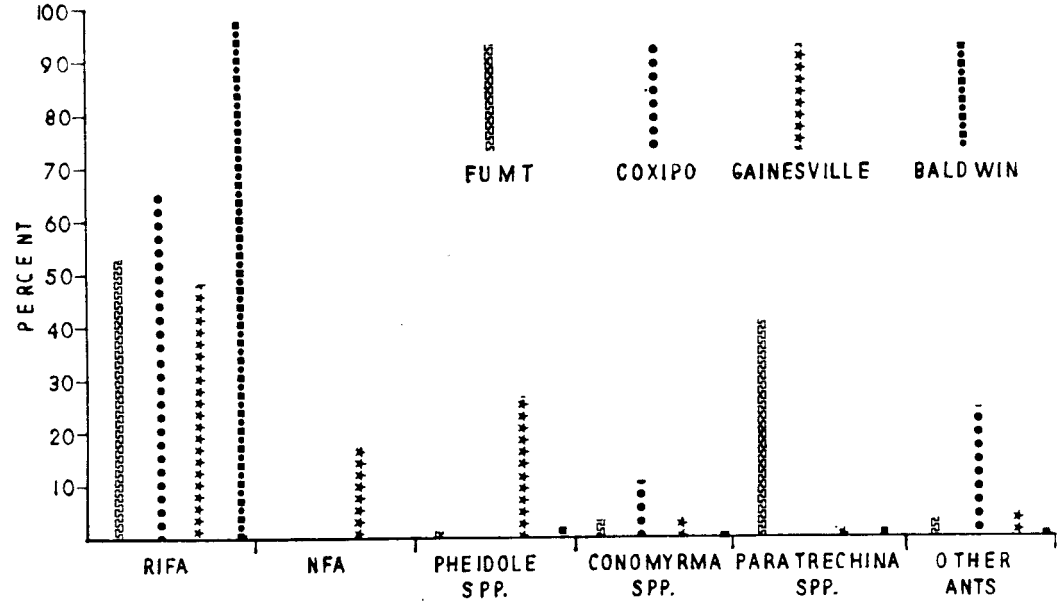

Fig. 3. Results of meat and honey-agar bait collections from 4 bait transects (described in test). The percent of the total number of specimens for each species collected is shown for each transect. RIFA=red imported fire ant, NFA=native fire ant, *Solenopsis geminata* (F.). Wojcik, unpub. data.

considered good competitors of RIFA (Buren and Whitcomb 1977). The dominance of RIFA over the other ant species is evident in Brazil and Baldwin. In Gainesville, RIFA populations are slowly increasing as will be discussed later in this paper. The percent of collections (Fig. 2) contrasted with the percent of specimens captured (Fig. 3) illustrates some interesting points. At FUMT, RIFA account for only 14.8% of the collections but 52.9% of the specimens collected. Conversely for the other genera shown, except for *Paratrechina* sp., the percent of collections was more than the percent of specimens, i.e. *Pheidole* spp. 12.5% of collections versus 0.6% of the specimens. Generally this trend holds for the other collection areas. These data show that RIFA, being strong trail laying ants (Wilson 1962), recruit large numbers of workers to the bait once it is found. RIFA also have the advantage of having larger colonies than the other species present.

RIFA are considered to be very successful pests in the United States because of their dispersal ability. Dr. William F. Buren, (Univ. of Fla., personal communication) considers RIFA the *Solenopsis* species which has the best developed ability to disperse of all the 20+ *Solenopsis* species he has observed and studied in South America. RIFA can invade new areas by 2 means, man-assisted and natural. The man-assisted mode is through transportation of queens or colonies by commerce, which is most likely the way the ant arrived in the United States. The U.S. Quarantine Regulations established in 1958 (USDA 1958) have effectively stopped this mode of spread. The 2 natural modes of dispersal are mating flights and floating on water. The mating flights of RIFA are its primary means of dispersal. The unmated males and females leave the mound when conditions are suitable (Markin et al. 1971b), fly into the sky (up to 1000 ft) and mate. The female returns to the ground, removes her wings, and searches for a nest site. Aside from this little is known about the mating behavior of RIFA. However, it is known that RIFA queens can disperse up to 12 miles during nuptial flights (Banks et al. 1973). It is well known that the wind plays a large part in dispersal (Johnson 1969). We have several unpublished reports of RIFA "flying" in excess of 20 miles across water in North Carolina and to oil rigs in the Gulf of Mexico. RIFA can also disperse by floating as discussed earlier.

In the United States, early spread of RIFA resulted mainly from movement of queens or colonies in nursery stock, sod and other articles with which soil is transported (USDA 1958). The distribution of RIFA in 1950 after the first surveys were completed is shown in Fig. 4. After quarantines were instituted in 1958, RIFA spread mainly by mating flights and probably floating down streams. The smaller incipient infestations gradually grew and coalesced into the generally infested area by 1962 (Fig. 5). The latest available data are for 1976 (Fig. 6) showing the total area infested to date. Much discussion has taken place on whether large scale insecticide treatments have aided RIFA spread. Brown (1980) discusses the treatment program in Florida, which specifically refutes this hypothesis. Markin et al. (1972) reported that as of 1972 over 103 million aggregate acres had been treated but much of this represented areas that had received more than one treatment (Banks et al. 1973). Currently (1980) 230 million acres are infested (Canter 1981). It is apparent, when

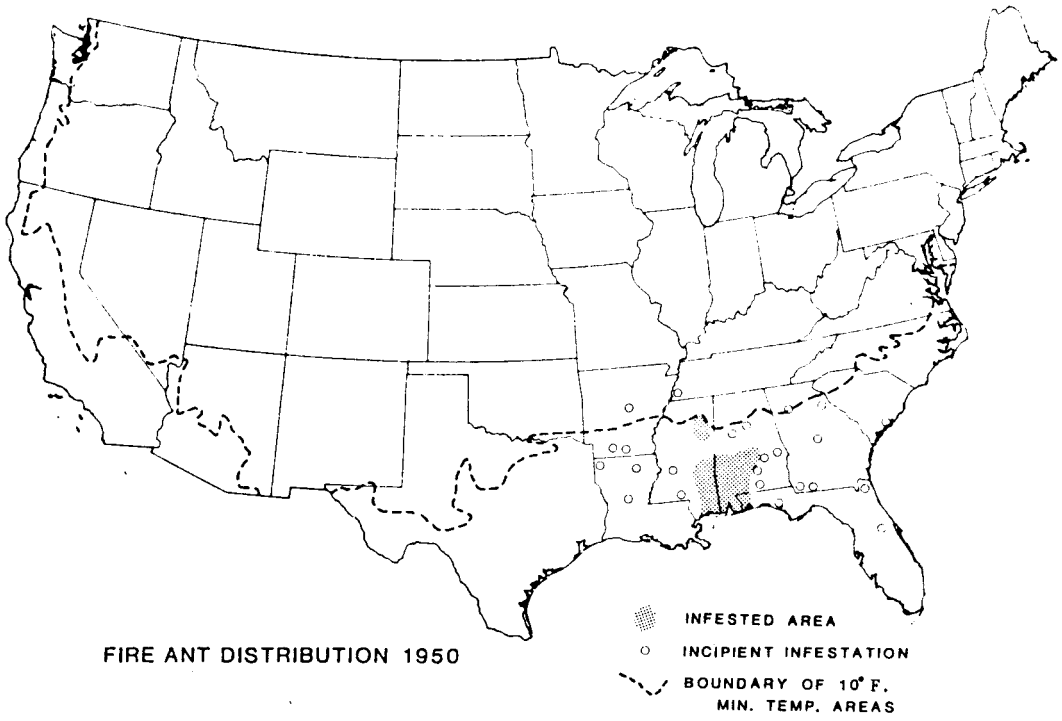

Fig. 4. Fire ant distribution in 1950 showing generally infested area and incipient (isolated) infestations. From CAST 1976.

all aspects of the question are studied, that insecticides played a minor role in the spread of RIFA over most of the infested area.

That RIFA can successfully move into uninfested areas on their own by taking advantage of any manmade ecological disturbances is illustrated

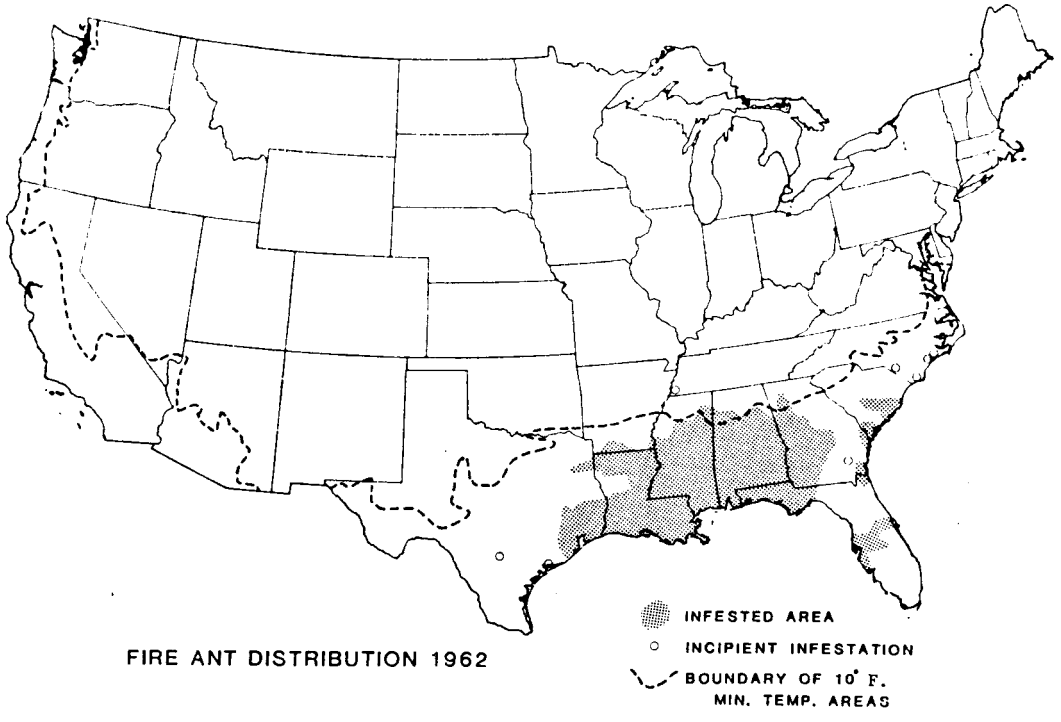

Fig. 5. Fire ant distribution in 1962 showing generally infested area and incipient infestations. From CAST 1976.

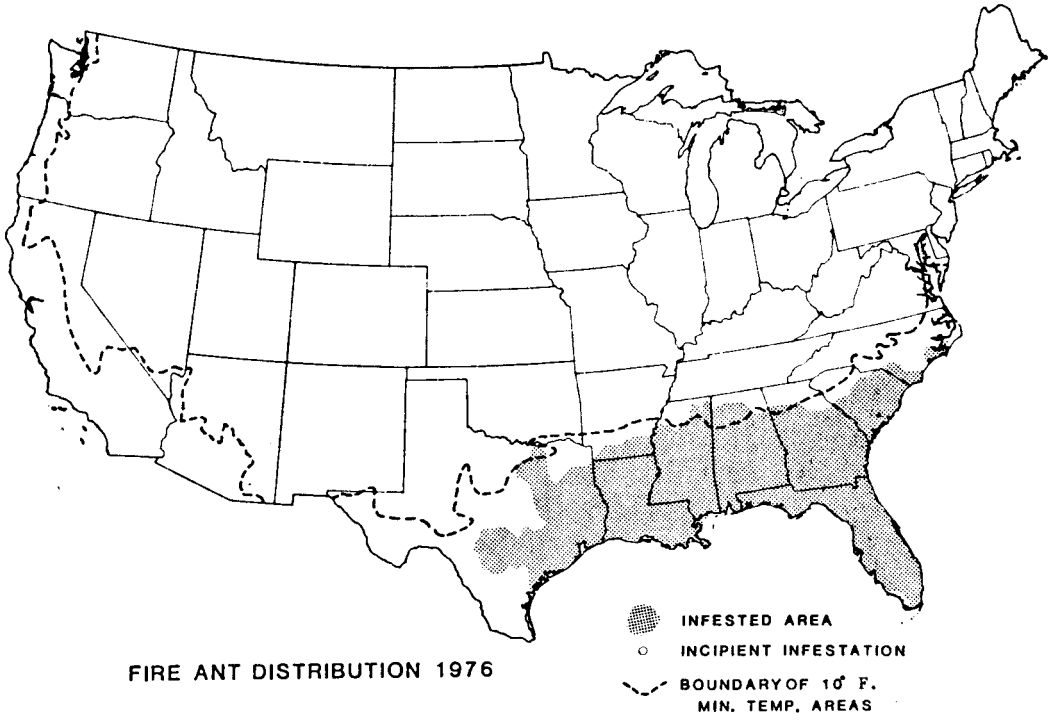

Fig. 6. Fire ant distribution in 1976 showing generally infested area. Present (1982) infested area is slightly increased in TX, AR, MS, AL, GA, SC, and NC. From CAST 1976.

in Fig. 7. The increase in RIFA populations in Gainesville, FL an area which has never received any large scale insecticide applications has been consistent from March 1972 to March 1982. This increase demonstrates the ability of this insect to utilize its biology (high reproductive potential and large colony size) and exploit man-created ecological disturbances to increase its population levels. This increase occurred despite high population levels of *S. geminata* (F.) and *Pheidole dentata* (Mayr). These 2 species are the 2 most common species besides RIFA collected on the

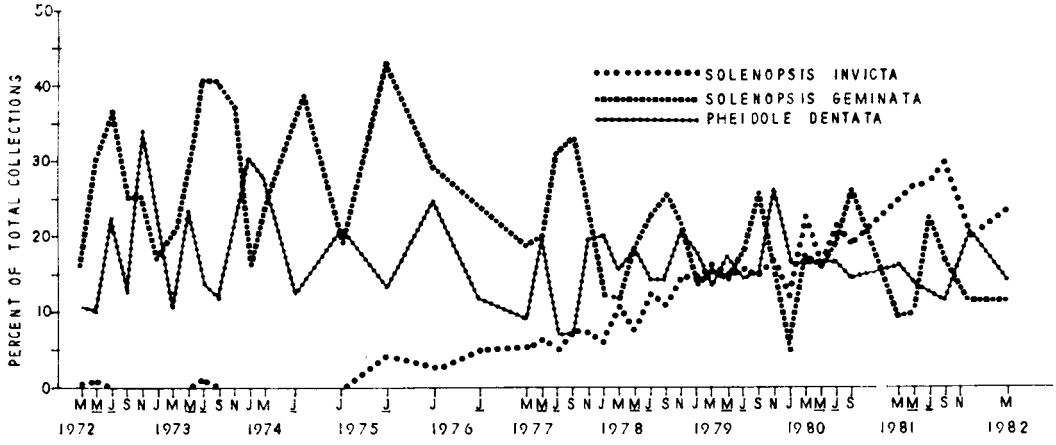

Fig. 7. Changes in percent of collections for 3 ant species from the Gainesville bait transect over a 10 year period. Samples collected every other month (J=Jan., M=Mar., *M*=May, *J*=July, S=Sept., N=Nov.) from March 1972 to July 1974 and March 1977 to date; and Jan. and July 1975 to 1976. Wojcik, unpub. data.

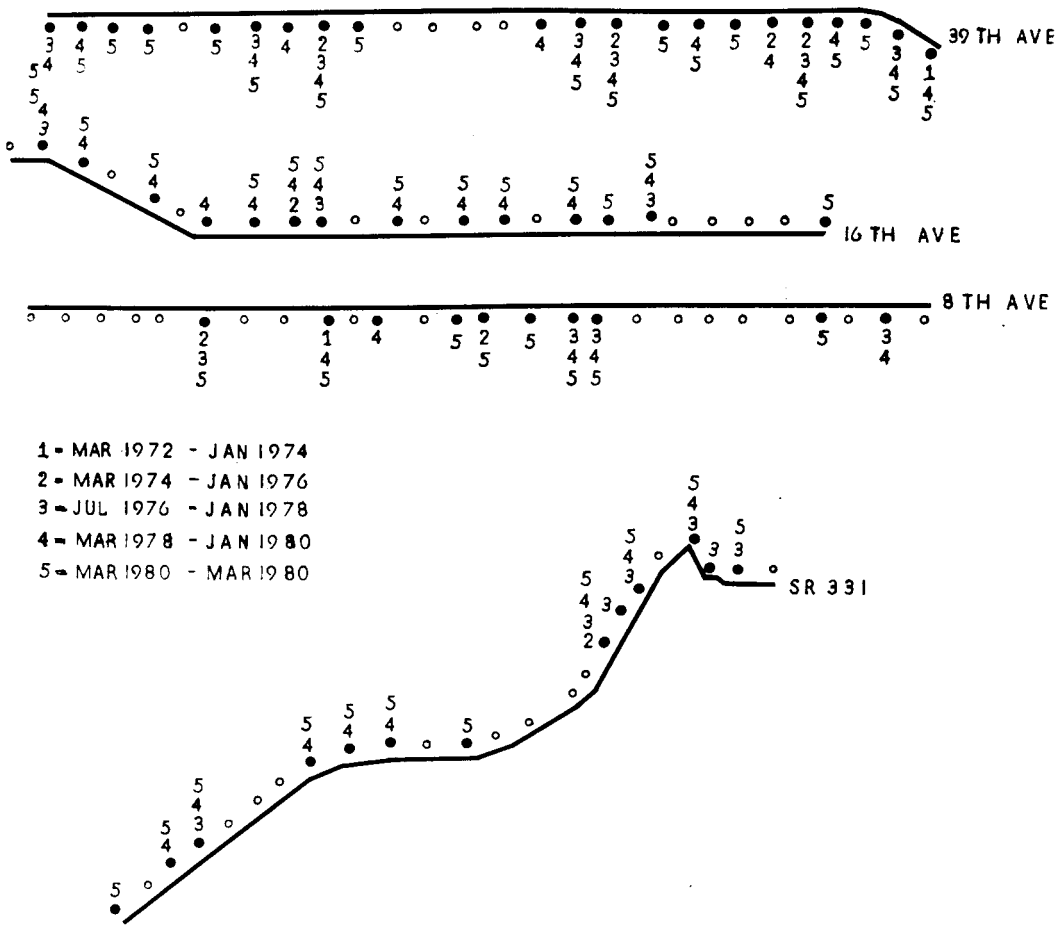

Fig. 8. Increase in RIFA Collection sites in 2 year increments on the Gainesville transect. RIFA collected at 2 sites out of 100 bait sites in first 2 year period, 8 sites in second 2 year period, 20 sites in third 2 year period, 39 sites in fourth 2 year period and 50 sites in fifth 2 year period. Open circles = bait sites where RIFA has not been collected; closed circles = bait sites where RIFA has been collected.

transect and are usually considered good competitors of RIFA (Buren 1983). Another way to illustrate this increase is given in Fig. 8 which shows the number of sites where RIFA were collected in Gainesville in 2 year increments. The number of collections increased from 2 sites in 2 years, to 8 in 4 years, to 20 in 6 years, to 39 in 8 years, to 50 in 10 years.

Another point to be made with the data in Fig. 8, is the dominance of RIFA. After initial occupation, RIFA becomes firmly established and dominates the immediate area, i.e., the bait site. From that point, RIFA can, by mating flight or whole colony migration, spread to uninfested areas. As a RIFA colony increases in size, it reduces native ant populations either by direct predation or indirectly by competition for food and nest sites. Over time without any additional ecological disturbance, the number of RIFA colonies will increase to the carrying capacity of the habitat.

References Cited

Allen, G. E., W. F. Buren, R. N. Williams, M. deMenezes, and W. H. Whitcomb. 1974. The red imported fire ant, *Solenopsis invicta:*

distribution and habitat in Mato Grosso, Brazil. Ann. Ent. Soc. America 67: 43-6.

ANON. 1972. Ecological range for the imported fire ant—based on plant hardiness. Coop. Econ. Insect Rep. 22(7): centerfold map.

BANKS, W. A., B. M. GLANCEY, C. E. STRINGER, D. P. JOUVENAZ, C. S. LOFGREN, AND D. E. WEIDHAAS. 1973. Imported fire ants: Eradication trials with mirex bait. J. Econ. Ent. 66: 785-9.

———, C. S. LOFGREN, D. P. JOUVENAZ, C. E. STRINGER, P. M. BISHOP, D. F. WILLIAMS, D. P. WOJCIK, AND B. M. GLANCEY. 1981. Techniques for collecting, rearing and handling imported fire ants. U.S. Dept. Agric., SEA ATT-S-21: 1-9.

BROWN, R. E. 1980. The imported fire ant in Florida. Proc. Tall Timbers Conf. Ecol. Anim. Control Habitat Manage 7: 15-21.

BUREN, W. F. 1972. Revisionary studies on the taxonomy of the imported fire ants. J. Georgia Ent. Soc. 7: 1-26.

———. 1982. Red imported fire ant now in Puerto Rico. Fla. 65: 188-9.

———. 1983. Artificial faunal replacement for imported fire ant control. Florida Ent. 66: 93-100.

———, G. E. ALLEN, W. H. WHITCOMB, F. E. LENNARTZ, AND R. N. WILLIAMS. 1974. Zoogeography of the imported fire ants. J. New York Ent. Soc. 82: 113-24.

———. AND W. H. WHITCOMB. 1977. Ants of citrus: some considerations. Proc. Int. Soc. Citriculture. 1977 2: 496-8.

CALVESBERT, R. J. 1974. The climate of Puerto Rico and the U.S. Virgin Islands, Pages 453-80 In Climates of the States, Vol. I, Eastern States, Water Information Center, Inc. Port Washington, N.Y. 486 p.

CANTER, L. W. 1981. Cooperative Imported Fire Ant Program. Final programmatic environmental impact statement. USDA, APHIS-ADM-81-01-F. 240 p.

CAST. 1976. Fire ant control. Council for Agricultural Science and Technology. CAST Rep. No. 62, 2nd Ed. Rep. No. 65, 24 p. Iowa State Univ., Ames.

HUNG, A. C. F., AND S. B. VINSON. 1978. Factors affecting the distribution of fire ants in Texas, USA. (Myrmicinae, Formicidae). Southwest. Nat. 23: 205-14.

LENNARTZ, F. E. 1973. Modes of dispersal of *Solenopsis invicta* from Brazil into the continental United States—a study of spatial diffusion. 242p. M. S. Thesis, Univ. Florida, Gainesville.

LOFGREN, C. S., W. A. BANKS AND B. M. GLANCEY. 1975. Biology and control of imported fire ants. Annu. Rev. Ent. 20: 1-30.

MARKIN, G. P., AND J. H. DILLIER. 1971a. The seasonal life history of the imported fire ant, *Solenopsis saevissima richteri*, on the gulf coast of Mississippi. Ann. Ent. Soc. America 64: 562-5.

———,J. H. DILLIER, S. O. HILL, M. S. BLUM, AND H. R. HERMANN. 1971b. Nuptial flight and flight ranges of the red imported fire ant, *Solenopsis saevissima richteri* (Hymenoptera: Formicidae). J. Georgia Ent. Soc. 6: 145-56.

———, J. H. FORD, J. C. HAWTHORNE, J. H. SPENCE, J. DAVIS, H. L. COLLINS AND D. C. LOFTIS. 1972. The insecticide mirex and techniques for its monitoring. USDA, APHIS, Rep. 81-3, 19 p.

———, J. H. DILLIER AND H. L. COLLINS. 1973. Growth and development of colonies of the red imported fire ant, *Solenopsis invicta*. Ann. Ent. Soc. America 66: 803-8.

MORRILL, W. A. 1974a. Dispersal of red imported fire ants by water. Florida Ent. 57: 39-42.

———. 1974b. Production and flight of alate red imported fire ants. En-

viron. Ent. 3: 265-71.
———. 1977. Overwinter survival of the red imported fire ant in central Georgia. Environ. Ent. 6: 50-2.
PETAL, J. 1978. The role of ants in ecosystems, Pages 293-325, In M. V. Brian (ed.), Production ecology of ants and termites. Cambridge Univ. Press, London. 410 p.
PIMM, S. C. AND D. P. BARTELL. 1980. Statistical model for predicting range expansion of the red imported fire ant, *Solenopsis invicta*, in Texas. Environ. Ent. 9: 653-8.
RHOADES, W. C., AND D. R. DAVIS. 1967. Effects of meterological factors on the biology and control of the imported fire ant. J. Econ. Ent. 60: 554-8.
SANTOS, L. B. D., N. R. INNOCENCIO, AND M. R. DE SILVA GUIMARAO. 1977. Vegetacao, p. 59-84. Geografia do Brasil, Regiao Centro-oeste, Vol. 4. Fundacao Inst. Brazil. Geogr. Estat., Rio De Janeiro, Brasil 364 p.
U.S. DEPARTMENT OF AGRICULTURE. 1941. Climate and Man. Yearbook of Agriculture. 1248 p.
———. 1958. Observations on the biology of the imported fire ant. Rep. ARS-33-49, 21 p.
WILSON, E. O. 1962. Chemical communication among workers of the fire ant *Solenopsis saevissima* (Fr. Smith). I. The organization of mass-foraging. Anim. Behav. 10: 134-47.
WILSON, N. L., AND A. D. OLIVER. 1970. Relationship of the imported fire ant to Nantucket pine tip moth infestations. J. Econ. Ent. 63: 1250-2.
WOJCIK, D. P., W. A. BANKS AND W. F. BUREN. 1975. First report of *Pheidole moerens* in Florida (Hymenoptera: Formicidae). Coop. Econ. Insect. Rep. 25: 906.