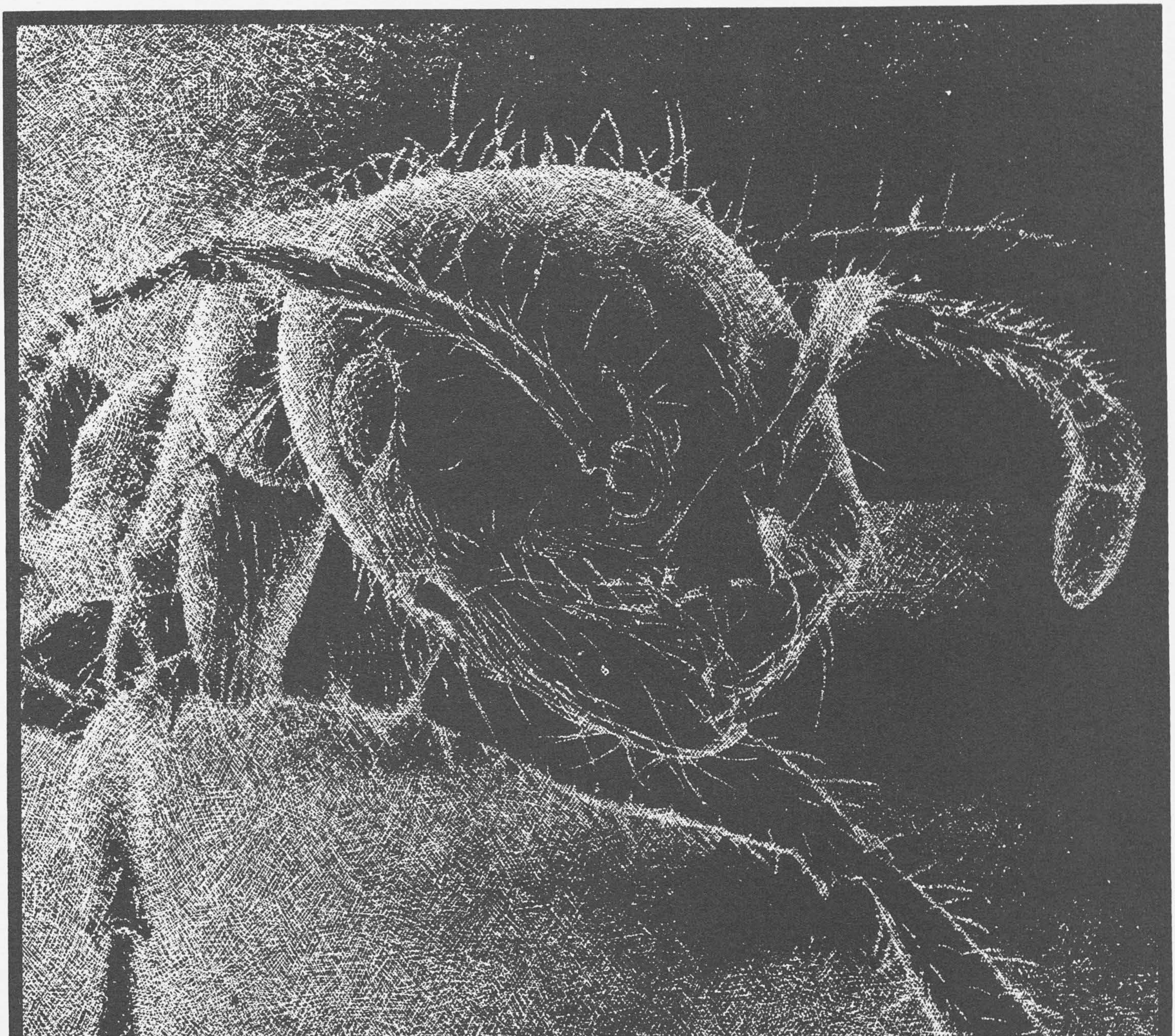
B-1185
October 1977

Identification, Distribution, and Biology of Fire Ants in Texas



The Texas Agricultural Experiment Station / Neville P. Clarke, Acting Director / College Station, Texas / The Texas A&M University System

Contents

Acknowledgments

This study is supported in part by the Texas Department of Agriculture Interagency Agreement IAC (74-75)-0448 and IAC (76-77)-0458. We thank H. R. Burke and J. A. Jackman for comments on the manuscript and colleagues in the Texas Agricultural Extension Service and USDA-APHIS for providing additional information on the distribution of *S. invicta*. Thanks are also extended to J. W. Summerlin, ARS-USDA, for assistance with field work.

Summary

Of the five species of fire ants recognized in the United States, only four presently are found in Texas, with the red imported fire ant (*Solenopsis invicta* Buren) now infesting most of eastern Texas. Although efforts to control imported fire ants have been a subject of controversy since the U. S. Congress authorized a cooperative federal-state eradication program in late 1957, these insects are acknowledged as serious nuisances to both people and domestic animals in the infested areas.

S. invicta, which made its appearance in the United States in the Mobile, Alabama, area around 1930, has since spread over nine states from the Carolinas to Texas. The ants usually nest in soil in open areas such as pastures but are found occasionally in wooded areas; mounds are generally dome-shaped. In man, the fire ant's sting is characterized by an intense burning sensation, accounting for the popular name of "fire ant." Within a day, a pustule is formed at the site of venom injection, which may become infected. In some sensitive individuals, stings can lead to swelling and occasionally death. In addition to its painful sting, the fire ant's large mounds can hamper the cultivation of land, and the fire ant itself can interfere with the running of livestock, since it has been known to attack small animals. *S. invicta* is considered to be the most economically important fire ant species.

Although not yet comprehensively studied, *S. xyloni*, the Southern fire ant, is also a ground-nesting species, with nests sometimes being found in wood work or masonry of houses. The nests in open areas are not dome-shaped; soil is thrown from the nest in irregular crater-shaped piles around the entrances. An immediate flare, followed by a wheal, occurs at the site of a Southern fire ant sting, but a pustule seldom forms.

The desert fire ant (*S. aurea*) is the least common specie of fire ant in Texas, reported from only two Texas counties. Nests are built in a fully exposed position in dry, coarse, gravelly soil, under stones and dried dung, and without a mound.

S. geminata, until the introduction of the imported fire ant the most economically important fire ant in Texas, like the other species usually nests in the soil. Mounds are not generally dome-shaped, but some of them may be as large as a bushel basket and as compact as those of *S. invicta.* The reaction of humans to the sting of the tropical fire ant is similar to that of the Southern fire ant.

Before the arrival of *S. invicta*, both *S. geminata* and *S. xyloni* were very common in Texas. However, with the westward expansion of *S. invicta* into Texas, both *S. geminata* and *S. xyloni* have been gradually eliminated. *S. invicta* appears to replace the two established fire ant species.

Mirex bait has been an effective area-wide control agent for the fire ant, but its use is now restricted. Heptachlor and chlordane are two other pesticides currently used to control the red imported fire ant; however, they can be used only in limited areas. All are persistent chlorinated hydrocarbon insecticides and can be used only where they will not constitute a hazard to wildlife, nonagricultural commodities, or livestock. Heptachlor and chlordane are not suggested for large block area treatment of the imported fire ant. Research is exploring alternatives to the use of these pesticides, including other insecticide compounds, microbial control agents, pathogens, and sterile male release.

Identification, Distribution, and Biology of Fire Ants in Texas

*Akey C. F. Hung, Margaret R. Barlin, and S. Bradleigh Vinson**

Five species of fire ants are presently recognized as occurring in the United States. Much publicity has been given to the two imported species, *Solenopsis invicta* and *S. richteri*, which are the subjects of all-out eradication efforts by the United States Department of Agriculture and the various state governments concerned. The native species, *S. aurea, S. geminata,* and *S. xyloni*, are of less general interest.

The taxonomic status of *S. invicta* and *S. richteri* has been subject to considerable controversy since Creighton (1930) first reported the imported fire ant in the United States. He suggested that the introduction of the species may have occurred at Mobile, Alabama, about 1918. This form was recognized by the name *S. saevissima richteri* Forel by Creighton (1930, 1950). The species remained confined to the Mobile area for about 10 years. It consisted of only the dark form, which is now known to correspond to the southernmost geographic variant of the South American population from which it obviously came. The dark form (now known as *S. richteri*) presently is found only in a relatively small area in northeastern Mississippi and northwestern Alabama. About 1930, a light form (now known as *S. invicta*) also made its appearance in the Mobile area (Wilson, 1958; Wilson and Brown, 1958) and has since spread over nine states from the Carolinas to Texas.

Wilson (1951) suggested that the light form originated either by mutation within the dark form population or by a second introduction. He later provided further information to support the second alternative, suggesting that the light form, which was introduced into the Mobile area shortly after 1930, is possibly a hybrid between two South American species, *S. saevissima saevissima* and *S. saevissima richteri* (Wilson, 1952 and 1953). According to Wilson and Brown (1958), the two color forms interbred completely in the United States and produced a graded series of intermediate forms. They referred to both of the forms as *S. saevissima*. In a revision of the North American fire ants, Snelling (1963) also used the name *S. saevissima* for the imported fire ant because the population in the United State then consisted almost entirely of the light form. Ettershank (1966) also synonymized *S. saevissima richteri* under *S. saevissima,* although he did not discuss the taxonomic reasons for such synonymy. Buren (1972) and Buren *et al.* (1974) accepted Wilson's double importation hypothesis but further demonstrated (a) that there are two morphologically distinct species of imported fire ants in the United States; (b) that these two species have remained phenotypically constant since the time of importation and are unchanged from their parent populations in South America; (c) that the two species apparently rarely hybridize; and (d) that their two homeland ranges in South America are geographically distinct. Accordingly, the dark form was recognized as *S. richteri* Forel, and the light form was described as *S. invicta* Buren (Buren, 1972).

Less than 50 years after the introduction of *S. invicta,* multiple-queen colonies were found in Mississippi (Glancey *et al.*, 1973) and Texas (Hung, Vinson, and Summerlin, 1974). These multiple-queen colonies produce a high percentage of aspermic males (Hung *et al.*, 1974), the significance of which is now under investigation in our laboratory.

S. xyloni occurs throughout the southern United States from California to Tennessee and North Carolina, with the exception of southern Florida. In Central Texas the range of *S. xyloni* is overlapped by that of *S. aurea,* an uncommon species occurring in dry areas of the Southwest.

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KEYWORDS: Fire ant/identification/distribution/biology/red imported fire ant (*Solenopsis invicta* Buren)/Southern fire ant (*Solenopsis xyloni* McCook)/desert fire ant (*Solenopsis aurea* Wheeler)/tropical fire ant (*Solenopsis geminata* [Fabricius])/control/research/Texas.

The two species occur together through western Texas, New Mexico, Arizona, and southern California. Although Gregg (1963) found a few colonies of *S. xyloni* near Higbee, Colorado, the complete distribution of *S. xyloni* in Colorado is not yet known.

The third native species, *S. geminata,* as Brown (1961) and Wilson and Brown (1958) indicated, is probably a post-Columbian introduction from its original range in Central America and northern South America. In the United States, *S. geminata* occurs from Texas to South Carolina and is primarily found near the coast; however, in Florida it appears to be distributed uniformly over the entire state (Creighton, 1950). One collection of *S. geminata* has been made in southwestern Arkansas (Warren and Rouse, 1969).

Recently, a new form of fire ant was found in the Bryan-College Station area (Hung and Vinson, unpublished); however, whether this is a new species or a hybrid has yet to be determined.

Thus, of the five species of fire ant presently recognized in the United States, four occur in Texas, with *S. invicta* (the red imported fire ant) now infesting most of eastern Texas. Although efforts to control imported fire ants have been a subject of controversy since the U.S. Congress authorized a cooperative federal-state eradication program in late 1957 (Brown, 1961; Coon and Fleet, 1970; Ferguson, 1970; Long *et al.*, 1958; and Reagan, Coburn, and Hensley, 1972), these insects are acknowledged as serious nuisances to both people and domestic animals in the affected areas. Fire ants are attracting attention from physicians in the areas of infestation as they become aware of the medical problems associated with stings (Brown, 1973; Clemmer and Serfling, 1975; Lawrence *et al.*, 1973; Lockey, 1974; Rhoades *et al.*, 1975).

IDENTIFICATION

Collection and Preparation of Specimens

The ideal way to collect fire ants for identification is to disturb the mound and then place a small object such as a match stick on the mound. The agitated ants soon crawl all over the stick, which is quickly picked up and put in a small bottle or vial containing rubbing alcohol. Cologne or bay rum are also used as preservatives but only if alcohol is not available. Use of formaldehyde is avoided, since this chemical is an irritant. As many different sizes of ants as possible are collected. A piece of white paper with the collector's name, the date, and the place (both county and nearest town) in which the ants were collected is included with the specimens. All information is written in pencil, since a ball point or felt tip pen may smear or become illegible.

It often requires several hours for ants in the alcohol to die. Before identification, the dead ants are placed in a shallow dish from which specimens of different sizes are selected with the aid of a stereomicroscope. The selected specimens are placed ventral side down on a piece of paper towel and the legs arranged symmetrically in a standing position. The ants are left this way until they are dry; the drying is hastened by heat from a microscope's illuminator.

When the ants are dry, they are mounted by gluing the ventral surface of each ant to the pointed end of an elongated cardboard triangle with white glue and inserting an insect pin through the other end of the triangle. Up to three specimens from the same colony are thus mounted on the same pin (Figure 1). A minimum amount of glue is used so that it will not conceal parts of the ant necessary for identification; ants are not mounted by placing a pin through their thoraxes.

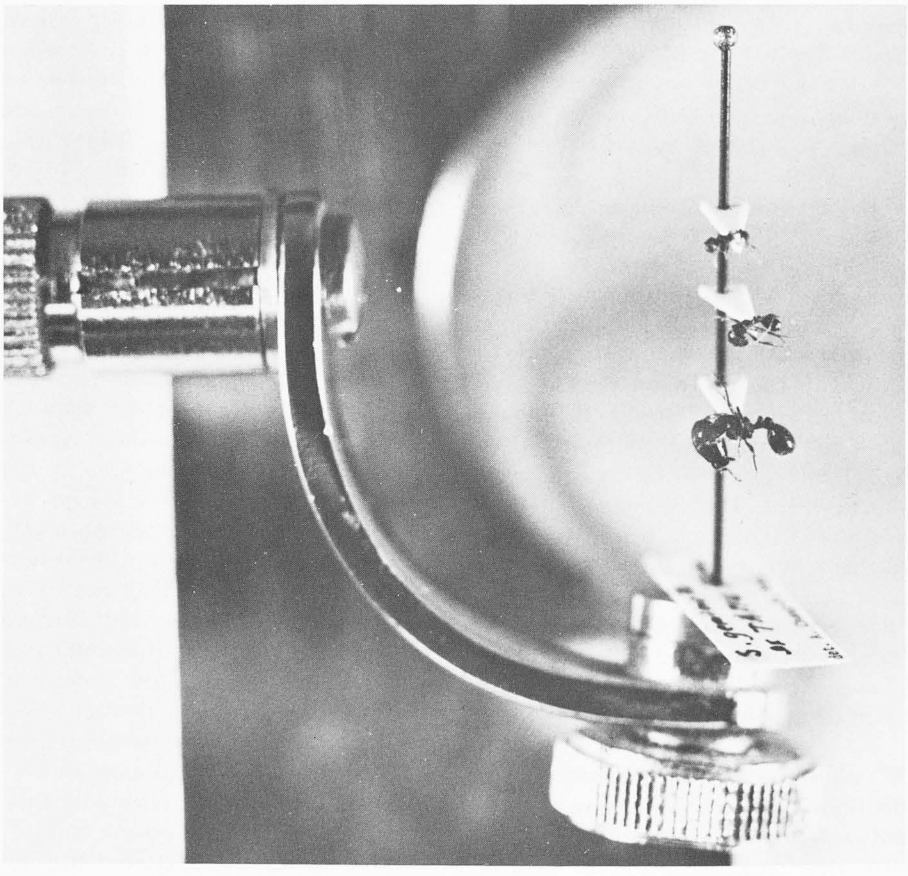

Figure 1. Ants mounted for identification.

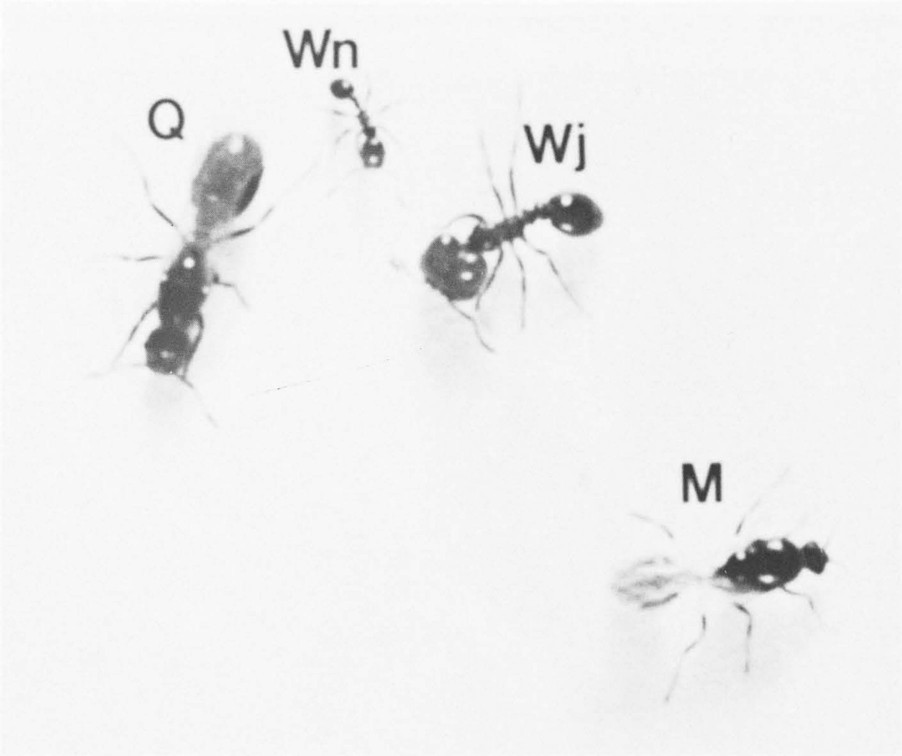

Figure 2. Male (M), virgin queen (Q), major worker (Wj), and minor worker (Wn) of *S. geminata*.

Description

A fire ant colony usually consists of workers, a nest queen (dealated), and the queen's brood. A mature colony may also contain winged males and virgin queens (winged) (Figure 2) during certain times of the year. Fire ant workers can be distinguished easily from other ants by their 10-segmented antennae with conspicuous 2-segmented club, unarmed propodeum, 2-segmented pedicel (the petiole and postpetiole), and the presence of a sting, which may be exposed (Figure 3).

Workers are polymorphic, varying in length from 1.6 mm to 6 mm. Large workers are called majors and small ones minors, although intermediate forms exist. Workers are wingless with a simplified thorax; in contrast, queens and males have two pairs of wings. The male is markedly different from the queen in several aspects: smaller and more slender body, darker color, smaller head, larger eyes, smaller mandibles, shorter antennal scape, longer and finer antennal funiculi, and more conspicuous genitalia. Queens usually break off their wings after the nuptial flight, but the thorax will still bear wing scars.

Methods

Identification of fire ant species is facilitated if one is familiar with the morphology of ants (Figure 3) and has a collection of specimens, including major and minor workers. The instruments needed for identifying ants are a stereomicroscope magnifying up to 80X and an illuminator which will provide an intense "spotlight" effect.

Separate keys are given below for the identification of major workers, minor workers, queens, and males, using a combination of characters. These keys are modified from Creighton (1950), Snelling (1963), and Smith (1965). Scanning electron micrographs (Figures 3-20) have been included to illustrate the key characters.

Measurements can be made with a grid mounted in the ocular of a stereomicroscope; only one eye should be used when measuring. If a character involves sculpture, illumination is important and the specimen should be turned so that the surface is observed at a 45° angle to the source of light. Occasionally a specimen may not fit all characters of either half of the couplet, because of intraspecific variation; if this occurs, the half of the couplet with the majority of characters matching the specimen should be chosen. Troublesome specimens should not be discarded. They may have scientific value and should be sent to the Department of Entomology, Texas A&M University, College Station, Texas 77843.

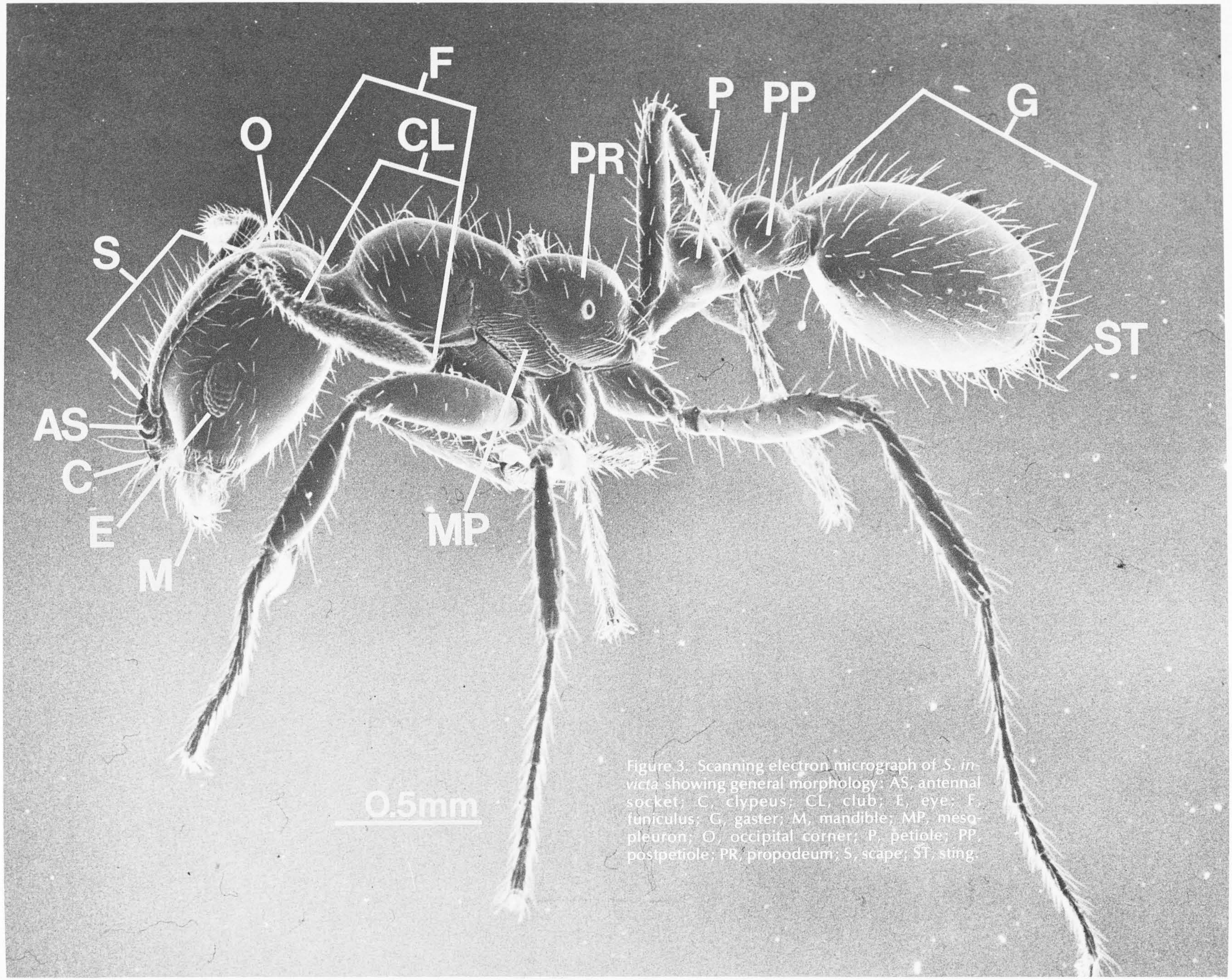

Figure 3. Scanning electron micrograph of *S. invicta* showing general morphology: AS, antennal socket; C, clypeus; CL, club; E, eye; F, funiculus; G, gaster; M, mandible; MP, mesopleuron; O, occipital corner; P, petiole; PP, postpetiole; PR, propodeum; S, scape; ST, sting.

KEY TO THE FIRE ANTS OF TEXAS

Major Workers

1a. Head bilobed (Figure 4, b) and extraordinarily large, out of proportion to remainder of body; mandible strongly incurved (Figure 4, M), the teeth often largely aborted or absent; anterior border of mesopleuron irregularly lamellated or toothed (Figure 5, MP.t); propodeum laterally carinate (Figure 5, PR.c) .... *geminata*

1b. Head of moderate size, only slightly bilobed (Figure 6, b); mandible evenly curved (Figure 6, M), with three or four teeth; anterior border of mesopleuron smooth (Figure 7, MP.a), neither lamellated nor toothed; propodeum smooth laterally (Figure 7, PR.s) 2

2a. Eye large and separated from the insertion of mandible by a distance one and one-half times as great as the maximum diameter of eye (Figure 8); antennal scape (Figure 3) length variable; petiole with (Figure 7, P.t) or without (Figure 10, P) ventral tooth 3

2b. Eye small and separated from the insertion of mandible by a distance twice as great as the maximum diameter of eye; antennal scape (Figure 8, S) failing to attain occipital corner (Figure 8, O) by about the length of the first two funicular segments (Figure 8, F.sg); petiole with distinct ventral lamella (like Figure 7, P.t, but extended two to three times further........................... *aurea*

3a. Mesopleuron shining, at most only weakly striated (Figure 7, MP.s); petiole with anteroventral tooth (Figure 7, P.t); antennal scape (Figure 8, S) failing to attain occipital corner (Figure 8, O) by about the length of the first two funicular segments (Figure 8, F.sg); mandible with three teeth (Figure 9, M), although a small protuberance may be observed on the superior border (Figure 9, M.a, as opposed to four teeth shown in Figure 12, M) .... *xyloni*

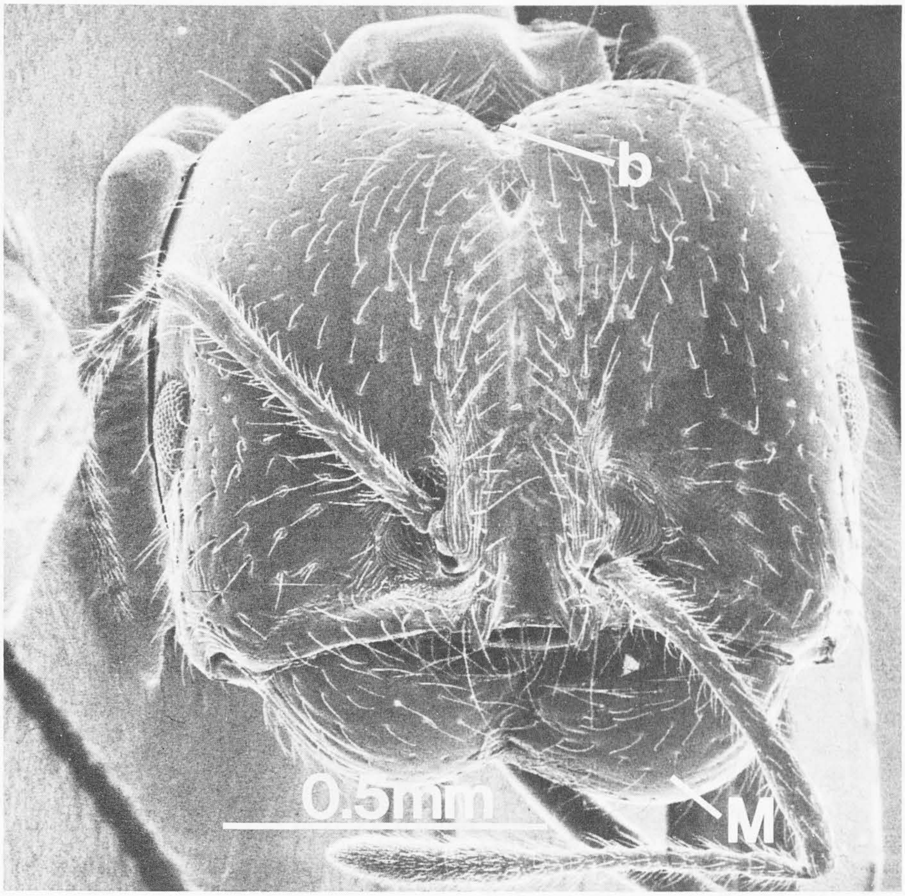

Figure 4. Major worker of *S. geminata* showing bilobed head (b) and strongly incurved mandibles (M).

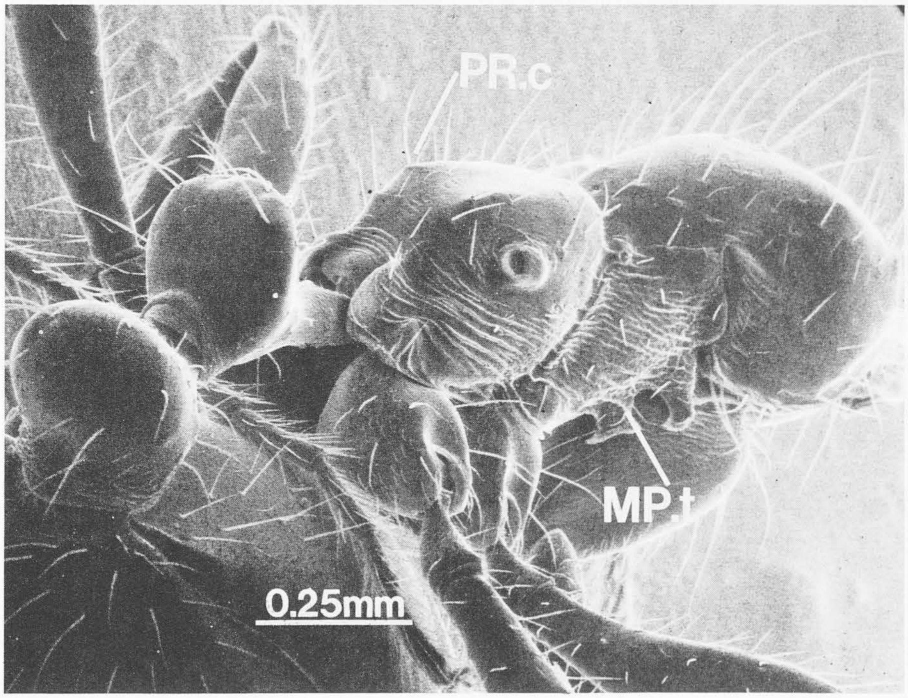

Figure 5. Major worker of S. geminata showing lamellated or toothed (MP.t) anterior border of mesopleuron and carinated propodeum (PR.c).

3b. Mesopleuron dull, roughened, or striated (Figure 3, MP, and Figure 10, MP.st); petiole without anteroventral tooth (Figure 10, P); antennal scape (Figure 11, S) failing to attain occipital corner (Figure 11, O) by less than length of first funicular segment (as opposed to Figure 8, O); mandible with four teeth (Figure 12, M) .... *invicta*

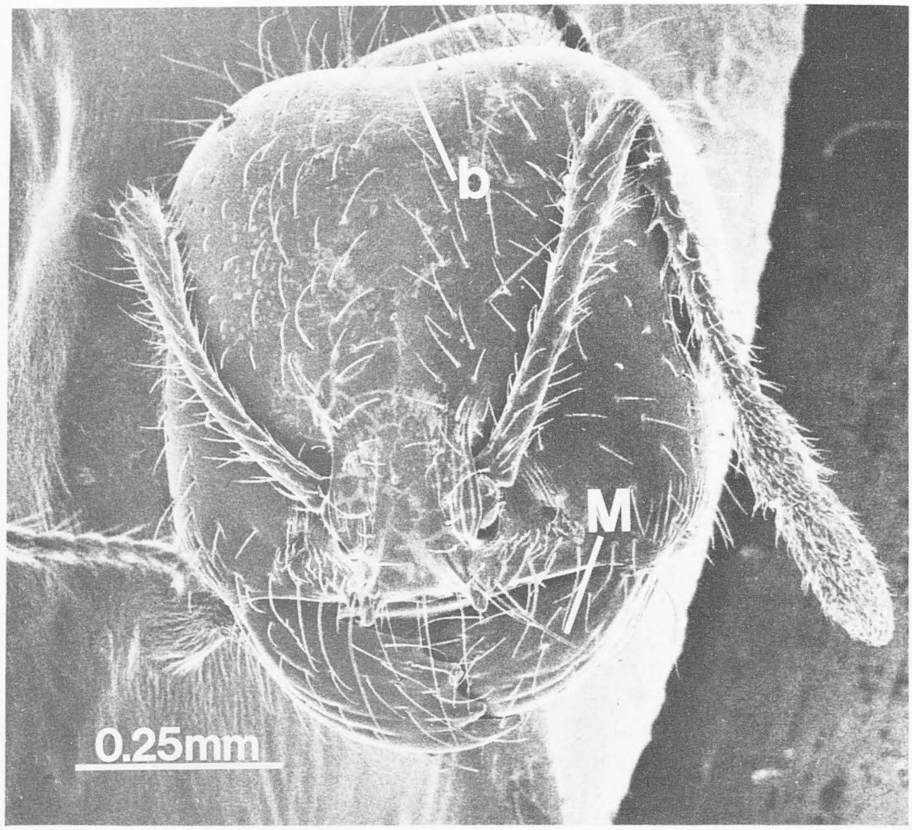

Figure 6. Major worker of *S. xyloni* showing slightly bilobed head (b) and evenly curved mandibles (M).

Minor Workers

1a. Mesopleuron dull, roughened, or striated (Figure 10, MP.st), with anterior border irregularly lamellated or toothed (Figure 5, MP.t); propodeum laterally carinate (Figure 5, PR.c); petiole without ventral tooth or lamella (Figure 10, P)......................... *geminata*

1b. Mesopleuron dull or shining, anterior border neither lamellated nor toothed; propodeum smooth laterally; petiole with or without ventral tooth or lamella........... 2

2a. Tip of antennal scape (Figure 13, S) surpassing occipital corner (Figure 13, O); petiole without ventral tooth; mesopleuron dull, roughened, or striated (Figure 10, MP.st, or Figure 3, MP) .... *invicta*

2b. Tip of antennal scape (Figure 14, S) not attaining occipital corner (Figure 14, O); petiole with distinct small ventral tooth (Figure 7, P.t) or lamella frequently present; mesopleuron shining or weakly striated 3

3a. Eye with about 20 facets; petiole with ventral tooth extended nearly the length of the segment caudally; body uniformly yellow .... *aurea*

3b. Eye with about 50 facets; petiole with ventral tooth not extended (Figure 7, P.t); gaster (Figure 3, G) darker than rest of body........... .... *xyloni*

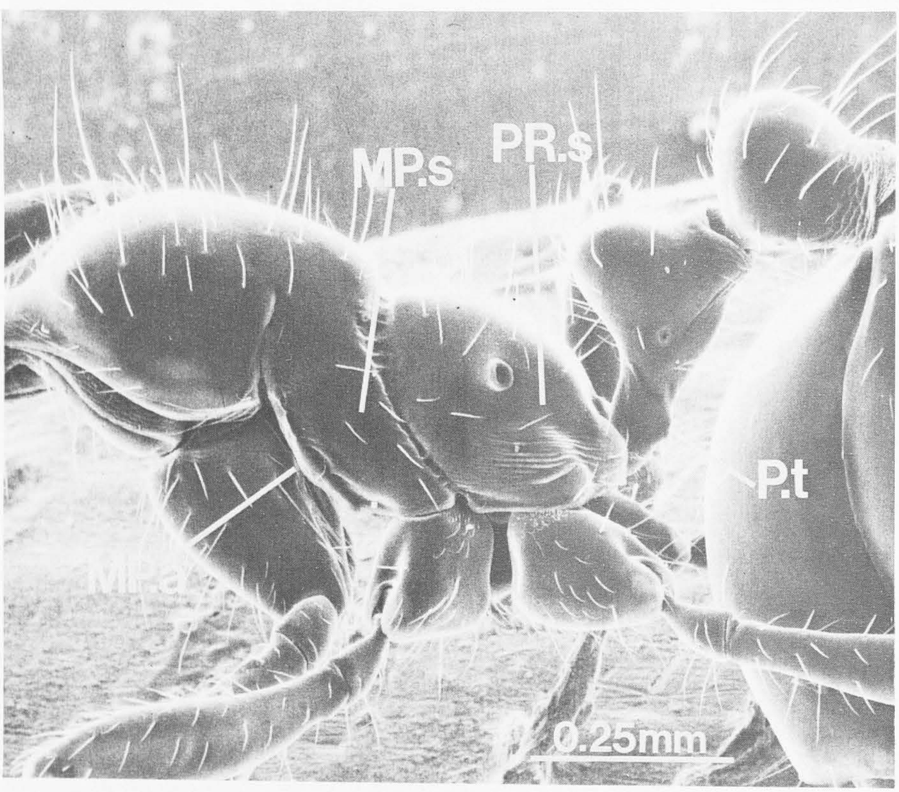

Figure 7. Major worker of *S. xyloni* showing smooth anterior border of mesopleuron (MP.a), mesopleuron smooth or weakly striated (MP.s); smooth propodeum (PR.s); and petiole and anteroventral tooth (P.t).

Queens

1a. Head, excluding mandibles, notably square (Figure 15); mandible abruptly incurved (Figure 15, M); antennal scape (Figure 15, S) failing to reach occipital corner (Figure 15, O) at least by one funicular segment .... *geminata*

1b. Head, excluding mandibles, weakly heart-shaped; mandible evenly incurved; antennal scape reaching or surpassing occipital corner 2

2a. Posterior two-thirds to three-fourths of propodeum distinctly transversely striated (Figure 16, PR.st); node of postpetiole striated on its posterior half (Figure 16, PP.st); mandible with four teeth as in Figure 12; antennal scape surpassing occipital corner; petiole without ventral tooth (Figure 10, P) .... *invicta*

2b. Posterior one-half or less propodeum with transverse striation; antennal scape at most reaching occipital corner; petiole with tooth; node of postpetiole with transverse striations indistinct or absent; mandible with three teeth 3

3a. Light yellow color, ventral tooth of petiole extending nearly the length of the segment ...... *aurea*

3b. Dark red color; petiole with ventral tooth not extended (as opposed to Figure 7, P.t) .... *xyloni*

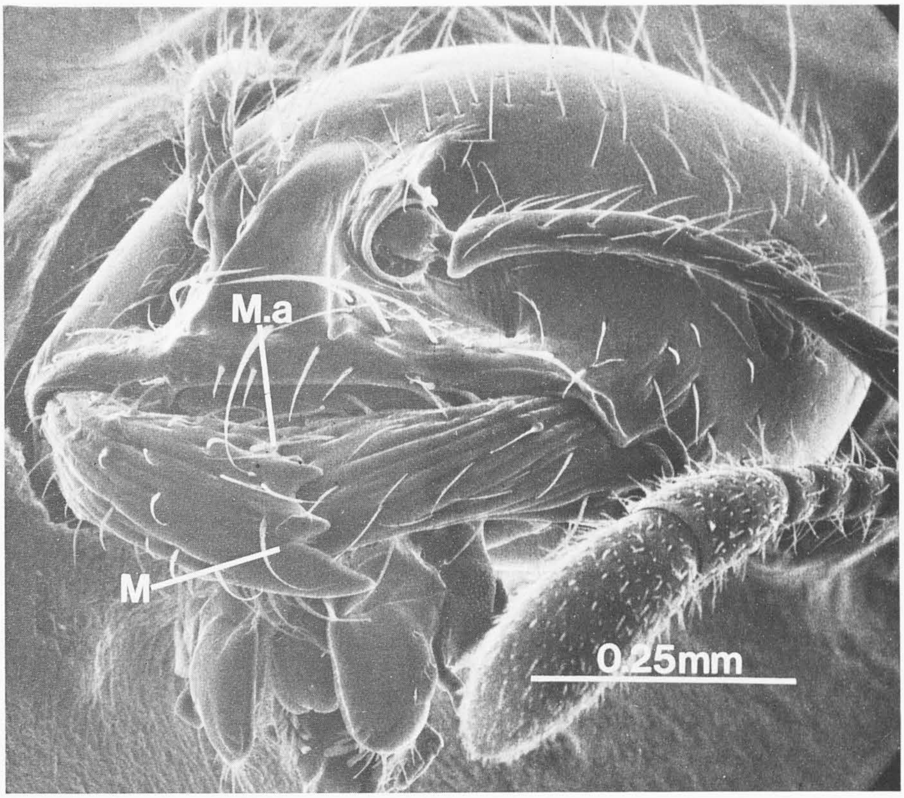

Figure 9. Major worker of *S. xyloni* showing 3-toothed mandible (M) and location of superior border (M.a) where a small protuberance may occur.

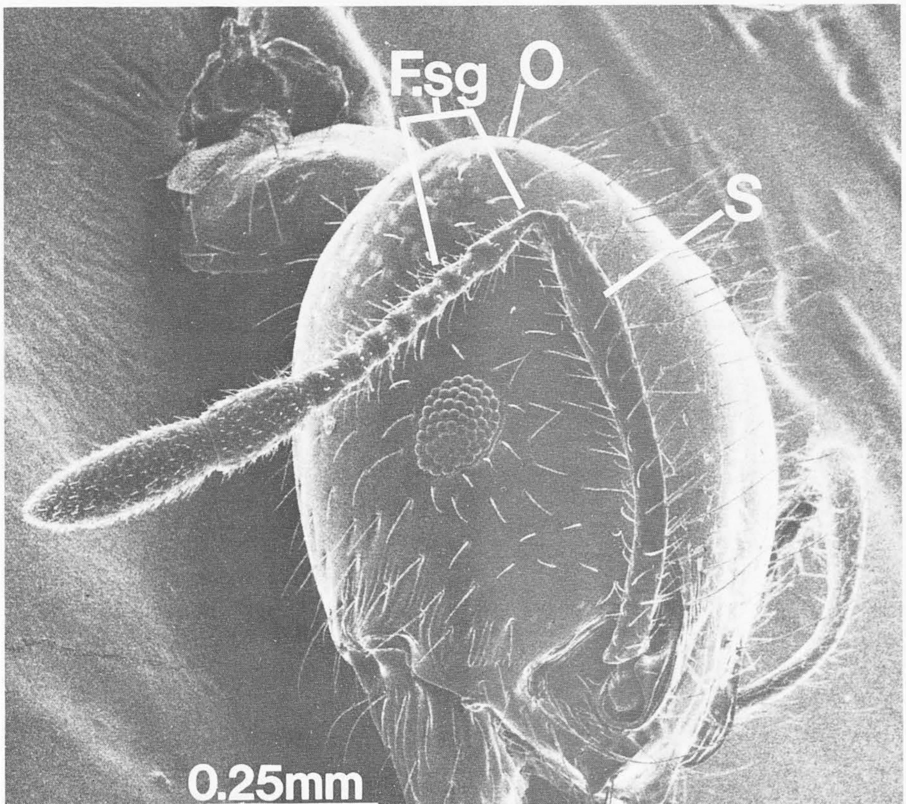

Figure 8. Major worker of *S. xyloni* showing antennal scape (S) failing to attain occipital corner (O) by length of first two funicular segments (F.sg).

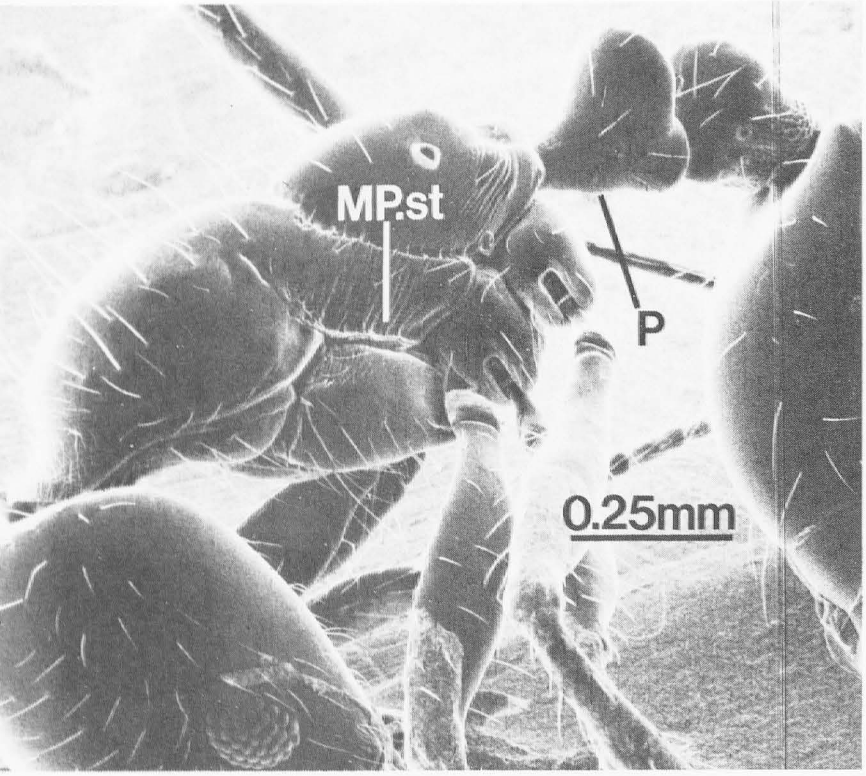

Figure 10. Major worker of *S. invicta* showing striated mesopleuron (MP.st) and petiole without anteroventral tooth (P).

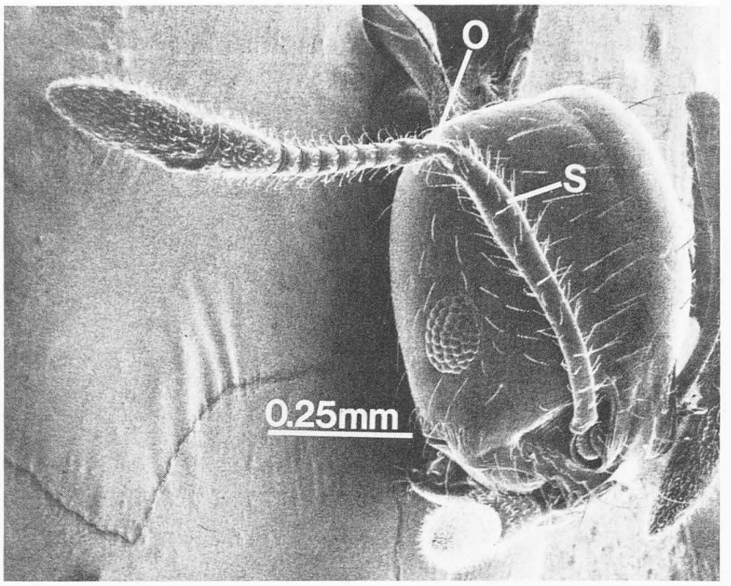

Figure 11. Major worker of *S. invicta* showing occipital corner (O) and length of antennal scape (S).

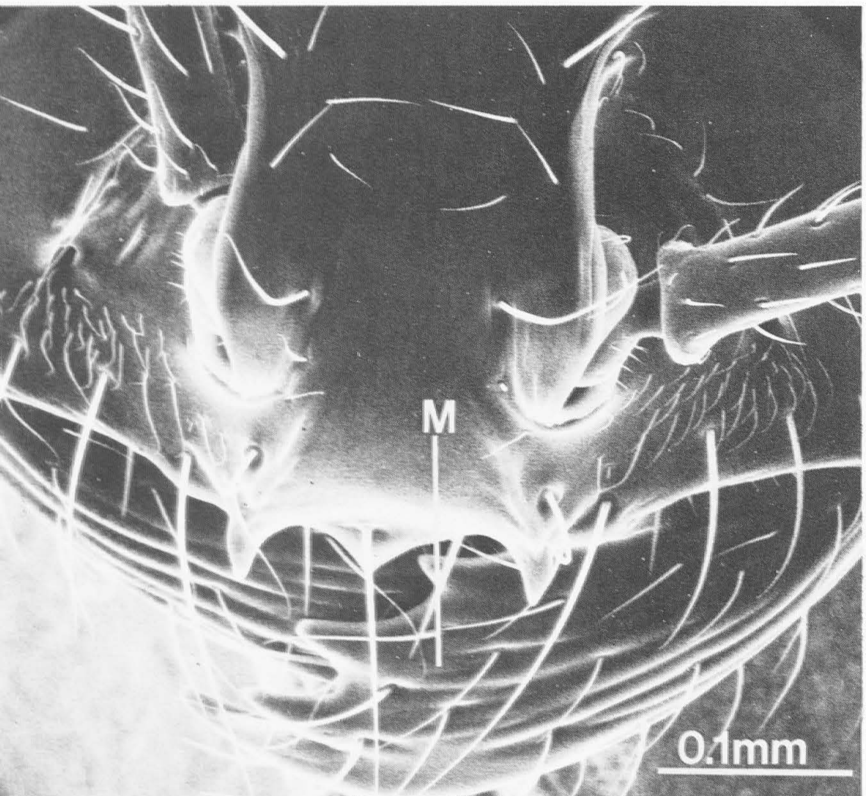

Figure 12. Major worker of *S. invicta* showing four-toothed mandible (M).

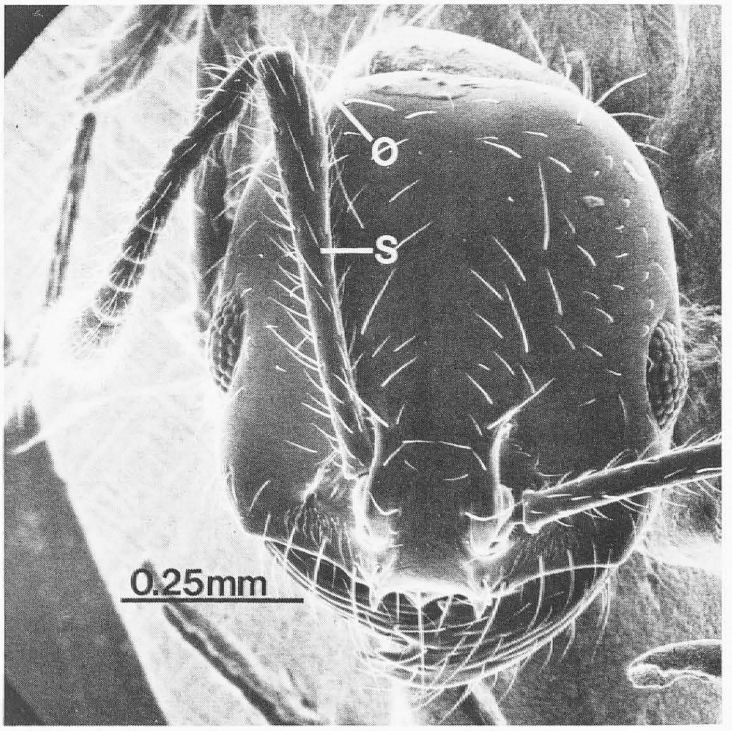

Figure 13. Minor worker of *S. invicta* showing tip of antennal scape (S) surpassing occipital corner (O).

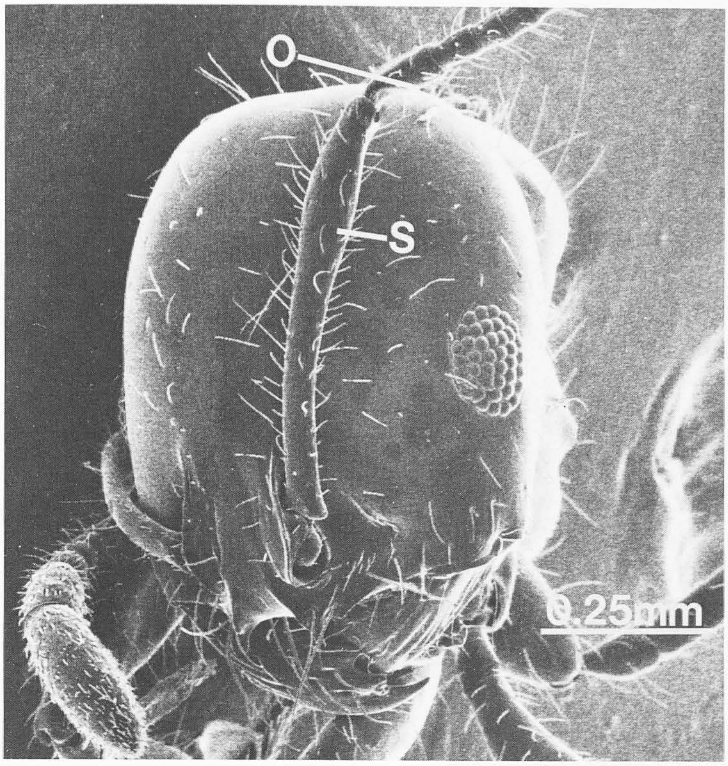

Figure 14. Minor worker of *S. xyloni* showing tip of antennal scape (S) not surpassing the occipital corner (O).

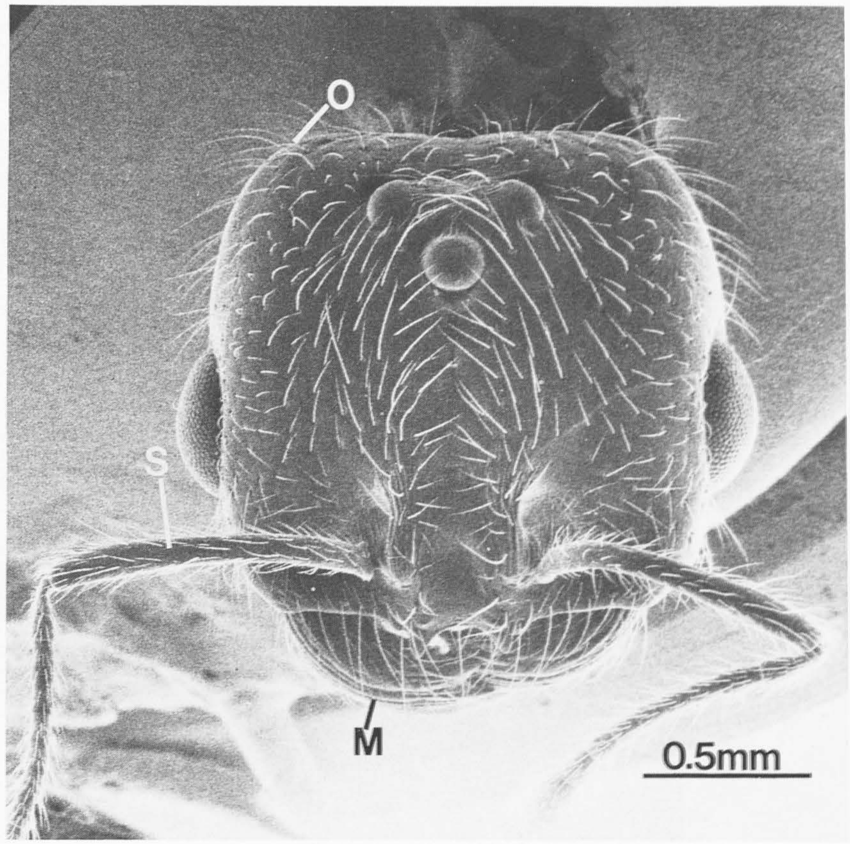

Figure 15. Queen of *S. geminata* showing square head; abruptly incurved mandibles (M); and antennal scape (S) failing to reach occipital corner (O).

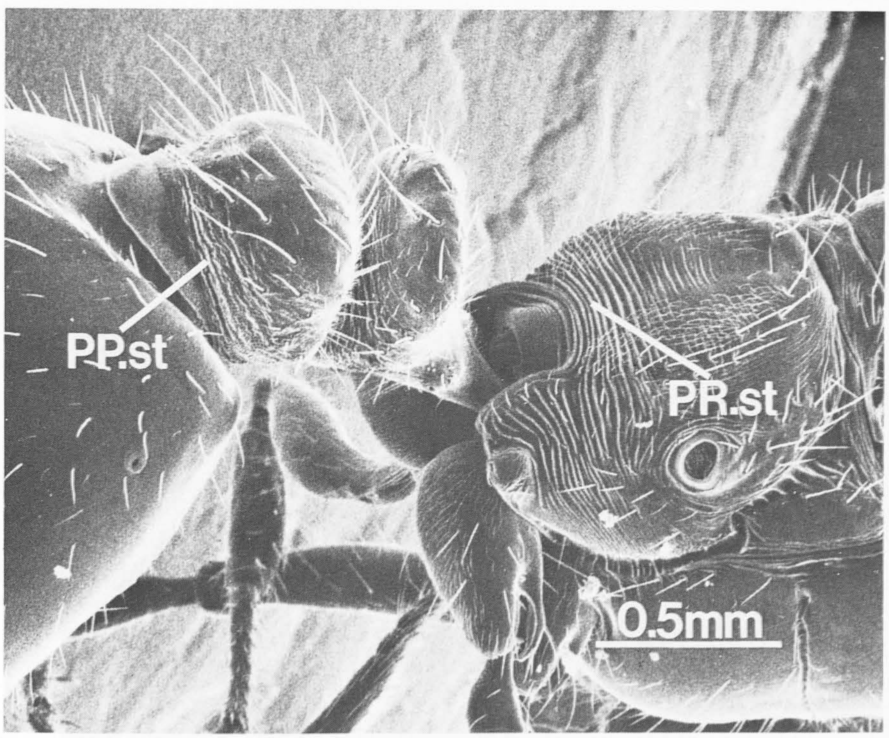

Figure 16. Queen of *S. invicta* showing striated propodeum (PR.st) and striated postpetiole (PP.st).

Males

1a. Distance between lateral and median ocelli about two-thirds or more times an ocellar diameter (Figure 17, x and y); as seen from above, clypeus convex, projecting forward between antennal sockets (Figure 17, C); petiole frequently with a small ventral tooth 2

1b. Distance between lateral and median ocelli about one-third an ocellar diameter (Figure 18, x and y); seen from above, clypeus flat, not projecting between antennal sockets (Figure 18, C) .... *geminata*

2a. Body uniformly black; mesosternal suture broad and deep (Figure 19, MS); petiole without ventral tooth .... *invicta*

2b. Body brownish or yellowish; mesosternal suture narrow (Figure 20, MS); petiole with ventral tooth.................................... 3

3a. Lateral area of propodeum with checkered markings, somewhat shining; petiole with a ventral tooth extending nearly the length of segment; gaster usually somewhat slightly darker brown than remainder of body; genital capsule yellow .... *aurea*

3b. Lateral area of propodeum dull, roughened, or striated; ventral tooth of petiole without lamella; gaster appearing black; genital capsule grayish-brown ..... *xyloni*

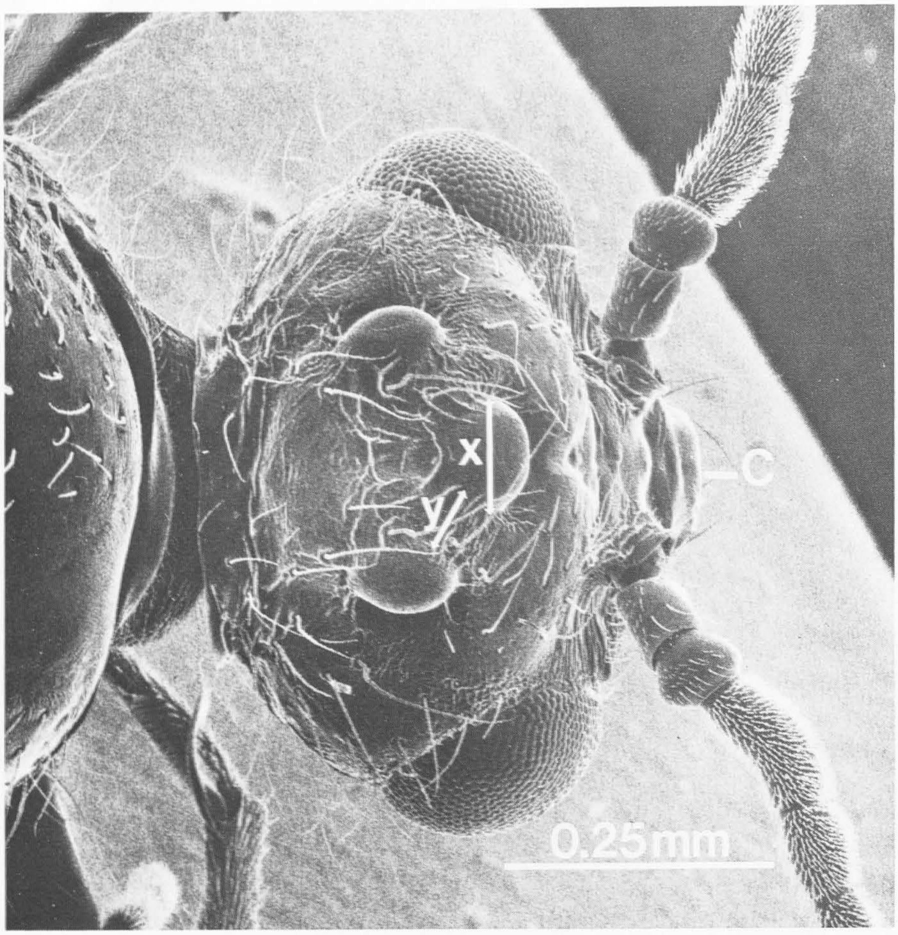

Figure 17. Male of *S. invicta* showing distance between lateral and medial ocelli (y = 2/3 x or > 2/3 x) and convex clypeus (C).

BIOLOGY AND ECONOMIC IMPORTANCE

Red Imported Fire Ant (Solenopsis invicta *Buren)*

This species ranges from the Carolinas and Florida west to Arkansas and Texas. It has been reported from the following counties (and towns) in Texas:

Anderson (Palestine)
Angelina
Atascosa
Austin (Bellville, Wallis)
Bandera
Bee (Papalote)
Bell (Belton)
Bexar (San Antonio, Wetmore)
Blanco
Bowie
Brazoria (Angleton, Manvel)
Brazos (Bryan, College Station, Millican)
Burleson
Caldwell (Lockhart)
Calhoun
Camp (Pittsburg)
Chambers
Cherokee
Collin (Plano)
Colorado
Comal
Cooke (Valley View)
Dallas (Richardson)
Denton (Lewisville)
DeWitt (Yoakum)
Ellis (Ferris)
Erath
Falls (Chilton, Lott)
Fayette (La Grange)
Fort Bend
Freestone (Teague)
Frio
Galveston
Gillespie (Harper)
Goliad (Fannin)

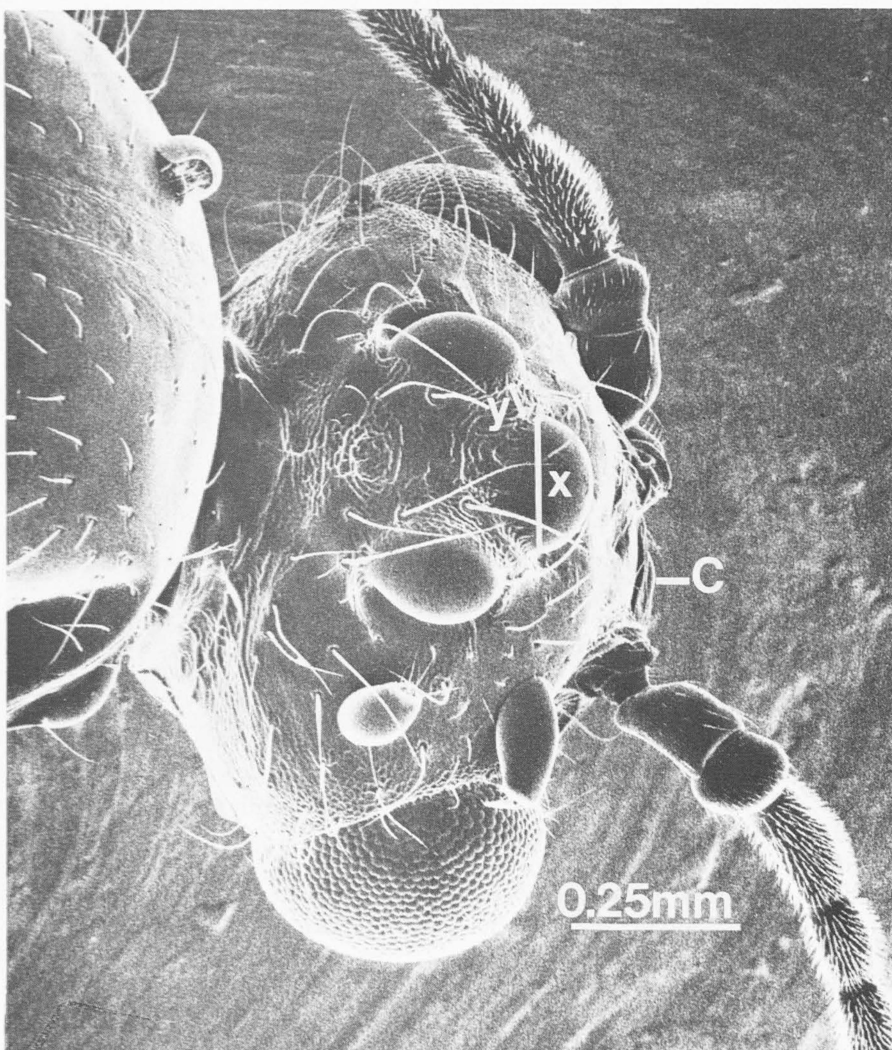

Figure 18. Male of *S. geminata* showing distance between lateral and median ocelli (y = 1/3 x) and flat clypeus (C).

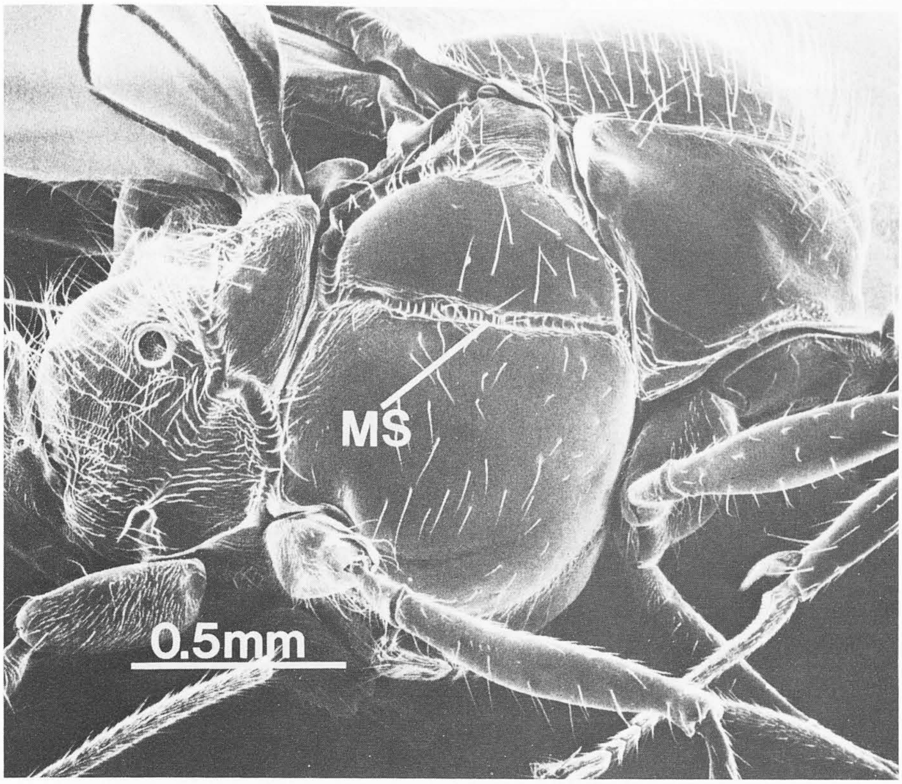

Figure 19. Male of *S. invicta* showing broad and deep mesosternal suture (MS).

Gonzales (Waelder)
Grayson
Gregg
Grimes (Anderson, Navasota, Plantersville)
Guadalupe (Seguin)
Hardin
Harris (Houston)
Harrison
Henderson
Houston
Jackson (Edna)
Jasper (Jasper)
Jefferson
Jim Wells (Alice)
Kendall
Kerr
Kleberg (Kingsville)
Lavaca (Hallettsville)
Lee (Giddings)
Leon
Liberty
Limestone
Madison
Marion
Matagorda (Bay City, Pledger)
McLennan
Medina
Milam
Montgomery (Conroe)
Nacogdoches
Navarro
Newton
Nueces
Orange (Vida)
Panola
Polk (Livingston)
Refugio (Tivoli)
Robertson
Rusk
Sabine
San Augustine
San Jacinto
San Patricio
Shelby
Smith
Tarrant
Travis (Austin)
Trinity (Trinity)
Tyler
Upshur (Big Sandy)
Uvalde (Uvalde)
Victoria
Walker
Waller
Washington
Wharton
Williamson
Wilson
Wood

The biology of *S. invicta* Buren has been studied extensively since this species is of considerable economic importance (Lofgren, Banks, and Glancey, 1975). The ants usually nest in various types of soil in open areas but are found occasionally in wooded areas. The larger mounds in open areas are generally dome-shaped (Figure 21) with numerous galleries and chambers; when these mounds become compact, they may damage or affect use of farm implements. A colony is usually started by a single queen; however, Markin, Collins, and Dillier (1972) found some incipient colonies in Gulfport, Mississippi, containing two to five queens. In addition, mature multiple-queen colonies have been reported from Mississippi (Glancey *et al.*, 1973) and Texas (Hung *et al.*, 1974). After the

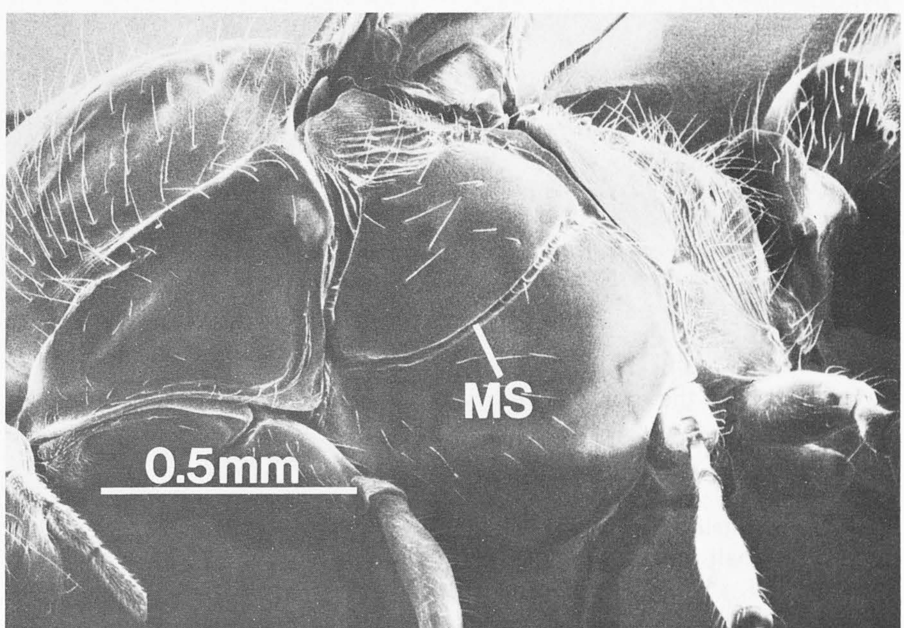

Figure 20. Male of *S. xyloni* showing narrow mesosternal suture (MS).

nuptial flight, the queen alights on the ground, breaks off her wings, and begins to excavate a burrow within 4 hours. She lays her first eggs within 24-48 hours after completing the burrow. The entire developmental time from egg deposition to emergence of the first worker (often referred to as minim workers) is about 24-30 days for naturally occurring colonies and 20-21 days for laboratory colonies held at 29.5°C to 30°C (Markin *et al.*, (1972). Reproductive forms are produced within 5 to 12 months, depending on the climate. A colony may contain as many as 240,000 workers after 3 years. Although brood production essentially ceases in the winter in areas north of 30° latitude, brood has been found in some mounds throughout the year in central and southern Florida and in coastal counties in Texas. Nuptial flights have been noted every month in these latter areas; however, peak activity occurs from late May through August, which is subsequent to the periods of highest production of sexual brood (Markin *et al.*, 1971). Flights generally occur from noon to 3 p.m. within 1 to 2 days after a rain, especially if the rain has been preceded by a period of dry weather. Although nuptial flights can take place in any month of the year in Texas, the best conditions for successful colony establishment occur between April and September.

The primary diet of fire ants is insects, spiders, myriapods, earthworms, and other small invertebrates (Green, 1967; Hays and Hays, 1959; Wilson and Eads, 1949; Wilson and Oliver, 1969); however, they are also known to feed on carrion and are attracted to sugar and honeydew. Food is collected by the foraging workers. These workers often leave the mound through tunnels which may extend as far as 15-25 m from the mound at a depth of 6 to 12 mm. Once food is found, the forager returns to the nest, laying a chemical (pheromone) trail which workers subsequently follow from the nest to the food source.

All stinging insects, with the exception of fire ants, utilize a venom rich in protein. The venom of fire ants is unique in containing alkaloids with a relatively small amount of protein (Brand *et al.*, 1972). The venom is used to immobilize or kill prey for food; in addition, it possesses insecticidal, bactericidal, and fungicidal activity (Blum *et al.*, 1958). When stinging, the worker attaches to its prey with its mandibles and then forces the sting into the tissue (Figure 22). In man, the immediate reaction to the injected venom is an intense burning sensation, which accounts for the popular name of "fire ant." A few minutes later a wheal appears at the site of the venom injection, and a pustule is formed within a few hours (Figure 23). A few individuals may have systemic reactions including nausea, vomiting, dizziness, perspiration, cyanosis, asthma, and other symptoms typical of severe allergic reactions. Death can result in a severe case if no medical assistance is received (Triplett, 1973).

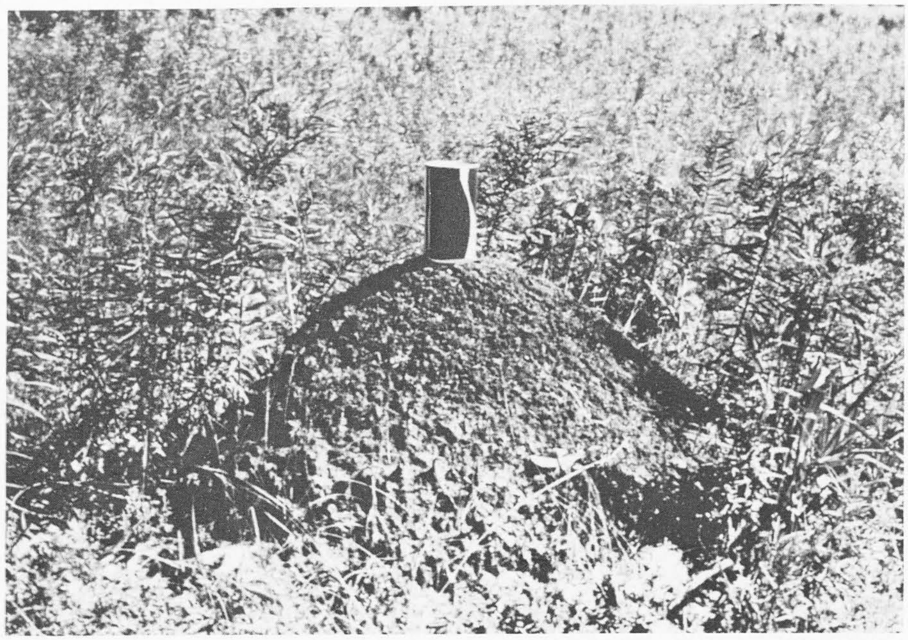

Figure 21. A dome-shaped mound of *S. invicta*.

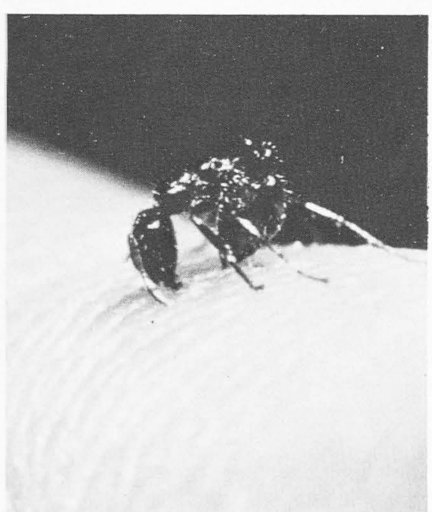

Figure 22. An imported fire ant worker stinging a human finger.

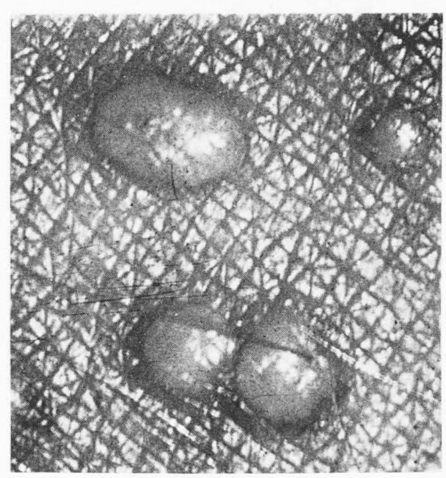

Figure 23. Pustules formed as the result of imported fire ant sting.

Southern Fire Ant (Solenopsis xyloni McCook)

This species ranges from California to North Carolina and the northwest corner of Florida. It has been reported from the following counties (and towns) in Texas:

Bee (Beeville)
Brazos (Bryan, College Station, Millican)
Crockett (TAMU Sonora Research Station)
Dallas (Kleberg, Dallas, Carrollton, Duncanville, Garland, Grand Prairie, Hutchins, Mesquite, Richardson, Rowlett, Sachse, Wilmer)
DeWitt
Eastland (Ranger)
El Paso (El Paso)
Falls
Fannin (Bonham)
Frio (Pearsall)
Galveston (Galveston)
Gillespie (Harper)
Goliad (Goliad)
Grayson (Denison)
Gregg (Longview)
Harris (Houston)
Henderson (Athens)
Jasper (Jasper)
Jefferson (Port Arthur)
Kimble
Madison
Matagorda
Morris (Daingerfield)
Navarro (Corsicana)
Nolan (Sweetwater)
Nueces (Corpus Christi)
Orange (Orange)
Parker (Weatherford)
Polk
Presidio (Presidio)
Red River (Clarksville, Detroit)
Refugio (Refugio)
Robertson (Hearne)
Smith (Tyler, Troup)
Sutton (TAMU Sonora Research Station)
Tarrant
Taylor (Abilene)
Upshur (Big Sandy)
Uvalde (Uvalde)
Van Zandt
Victoria (Victoria)
Washington
Wichita (Wichita Falls)
Wood (Quitman)

A comprehensive study has not yet been undertaken on the biology of *S. xyloni*. Like *S. invicta,* it is a ground-nesting species, although nests are sometimes found in woodwork or masonry of houses. The nests in open areas are not dome-shaped; soil is thrown from the nest in irregular crater-shaped piles around the entrances (Figure 24). A 40-cm wide mound containing at least 41 nest openings has been reported (Hess, 1958). Newly mated queens establish colonies independently in the soil (Smith, 1965), and although single-queen colonies are the rule, multiple-queen colonies have been found (Summerlin, 1976). Nuptial flights have been noted from June through September and occur primarily in the late afternoon. This species, like *S. invicta,* is a general feeder.

The venom of *S. xyloni* exhibits the same antimycotic and antibacterial properties as the venom of *S. invicta,* but the skin response of man to the stings of these two species is different (Blum, Roberts, and Novak, 1961). An immediate flare, followed by a wheal, occurs at the site of venom injection by *S. xyloni*, but its sting seldom results in pustule formation.

Desert Fire Ant (Solenopsis aurea Wheeler)

Arid regions of the Southwest from Texas to southern California, south into Mexico, are the general range of *S. aurea.* In Texas, it has been reported from Austin (Travis County) and Fort Davis (Jeff Davis County).

S. aurea is the least common species of fire ants. Little is known of its biology. The ants appear to be nocturnal or crepuscular, and the nests are usually built in a fully exposed position in dry, coarse, gravelly soil, under stones and dried dung, and without a mound. Workers are rarely found outside the nest during the day and will almost immediately disappear into the lower passages of the nest when exposed to the light (Creighton, 1930, 1950). This species apparently is not economically important.

Figure 24. Nest of *S. xyloni* with irregular craters.

Tropical Fire Ant (Solenopsis geminata [*Fabricius*])

This species occurs from Texas to South Carolina and Florida. It has been reported from the following counties (and towns) in Texas:

Aransas
Atascosa (Jourdanton, Pleasanton)
Austin (Bellville)
Bexar (San Antonio)
Blanco
Brazoria (Angleton, Freeport)
Brazos (Bryan, College Station)
Burleson (Caldwell, Dime Box)
Cameron (Brownsville, Harlingen)
Comal (New Braunfels)
Coryell (Gatesville)
Dallas (Kleberg, Carrollton, Coppell, Grand Prairie, Irving, Lancaster, Dallas, Seagoville, Richardson)
Falls (Lott)
Fayette (La Grange)
Fort Bend (Richmond)
Frio (Pearsall)
Galveston (Galveston)
Gillespie
Gonzales (Gonzales)
Guadalupe (Seguin)
Harris (Houston)
Hays (San Marcos)
Hildalgo (Edinburg)
Jackson (Edna)
Jeff Davis (Fort Davis)
Jefferson (Beaumont)
Jim Wells (Alice)
Kenedy
Kerr (Kerrville)
Kleberg (Kingsville, Riviera)
Lamar (Paris)
Lampasas (Lampasas)
Lavaca (Yoakum)
Lee (Lexington)
Llano (Llano)
Matagorda (Bay City, Pledger)
McLennan (Tehuacana Creek)
Median (D'Hanis)
Milam
Morris (Daingerfield)
Nueces
Real
Refugio
Robertson
San Patricio (Aransas Pass)
San Saba
Travis (Austin)
Uvalde (Uvalde)
Val Verde (Del Rio, Langtry)
Victoria (Victoria)
Walker (Huntsville)
Washington (Brenham)

Until the introduction of the imported fire ants, this species was not only the most common but the most economically important fire ant in Texas (Clark, 1931). *S. geminata* usually nests in the soil; the mounds are not generally dome-shaped, but some of them may be as large as a bushel basket and as compact as those of *S. invicta*. No detailed studies have been made on the biology of this species. Colonies usually contain a single queen; however Banks, Plumley, and Hicks (1973) reported two fertile queens in one colony of *S. geminata* in Florida, and multiple-queen colonies have been found near Victoria and Woodsboro and in the Bryan-College Station area (Hung, unpublished). According to Travis (1941), captive queens laid as many as 1,123 eggs in a 24-hour period, and workers were reared to the adult stage in 44 days at summer temperatures. He reported that in northern Florida and southern Georgia sexual larvae appeared in the mounds in early April and that alate forms were present in 25 percent of the colonies up to the end of December. In the Bryan-College Station area, alate forms were collected mainly in May through July, and nuptial flights occurring in the late afternoon have been noted in these months. This species, like the others, is a general feeder preying primarily on other insects and invertebrates.

The reaction of humans to the sting of this species is very similar to that of *S. xyloni*, as opposed to that of *S. invicta*. It has also been shown experimentally that, in Puerto Rico, workers of *S. geminata* can carry viable germs of dysentery on their bodies for at least 24 hours (Griffiths, 1942).

Black Imported Fire Ant (Solenopsis richteri *Forel*)

This imported species is found only in a relatively small area in northeastern Mississippi and northwestern Alabama. While not presently found in Texas, it is included to complete the species list in the United States. The biology is not as well known as that of *S. invicta* but appears similar in many respects. Workers of *S. richteri* will key out as *S. invicta* in the keys described herein. Buren (1972) gives the following characters for separating *S. invicta* and *S. richteri*:

"In *richteri* the sides of the head are usually broadly elliptical in shape and lack the weakly cordate shape seen in *invicta;* the peaks of the occipital lobes nearer the midline and the occipital excision more creaselike in *richteri* than in *invicta* in relation to their ability to reach toward the occipital peaks; pronotum with strong and rather angulate shoulders in *richteri,* this character nearly absent in *invicta*; a shallow but distinctly sunken area on posterior median dorsum of the pronotum of large workers in *richteri,* absent in large workers of *invicta*; the promesonotum strongly convex in profile in *invicta*, more weakly so in *richteri*; in profile the base of propodeum elongate and straight in *richteri*, convex and shorter in proportion to the declivity in *invicta*, the postpetiole wide and with straight or diverging sides posteriorly in *invicta,* narrower and usually with converging sides in *richteri;* transverse impression on posterodorsal face of postpetiole usually apparent and strong in *richteri,* usually weak or absent in *invicta.*"

SPREAD OF FIRE ANTS IN TEXAS

Before the arrival of *S. invicta,* both *S. geminata* and *S. xyloni* were very common in Texas. *S. xyloni* was the most common fire ant in the eastern half of Texas, while *S. geminata* was confined more to the southern or coastal section of the State. However, with the westward expansion of *S. invicta* into Texas, both *S. geminata* and *S. xyloni* have been gradually eliminated by *S. invicta*. For example, Smith (1936) reported *S. geminata* and *S. xyloni* at Houston, but the two species have now generally been replaced by *S. invicta.* In 1973, the authors found both *S. geminata* and *S. xyloni* side by side with *S. invicta* in an area along the bypass east of Highway 6 in College Station. These areas are now exclusively inhabited by *S. invicta*.

The past and present distribution of the four species of fire ants in Texas is illustrated in Figure 25. These county records are based on specimens identified by one of the authors (A. C. F. Hung) from the literature (Creighton, 1930; Hess, 1958; Smith, 1936) and from Extension and USDA-APHIS files (*S. invicta* only). Whereas the distribution record of *S. invicta* might be complete because it is compiled from current data, those of *S. geminata* and *S. xyloni* are by no means adequate. Although the records reported are current, new counties may become infested as *S. invicta* continues to spread through Texas. When *S. invicta* moves into new counties, it appears to replace *S. geminata* or *S. xyloni*. Because of the similarity in their ecology, it is likely that *S. invicta* will eventually move into those counties where the other two species of the fire ants are presently found.

CONTROL

Current Methods

Heptachlor and chlordane are used to control the red imported fire ant in limited areas: nurseries, industrial sites, lawns, golf courses, cemeteries, parks, and other restricted nonagricultural and nonaquatic areas. Both materials are persistent chlorinated hydrocarbon insecticides and can be used only where they will not constitute a hazard to wildlife, nonagricultural commodities, or livestock. They are not suggested for large block area treatment of the imported fire ant.

In the granular form, heptachlor (1.25 pounds per acre) and chlordane (1.0-1.5 pounds per acre) are used as broadcast soil treatments. Individual mounds in lightly infested areas are treated by applying either chemical to the individual mound. The mound is torn open and 1-2 cups of dust granules containing 10 percent chlordane or heptachlor are applied to the mound and the ground within a 10- to 12-foot area on all sides. Chlordane emulsifiable concentrate (4 pounds per gallon), at 4 tablespoons in 3 gallons of water, or heptachlor emulsifiable concentrate, at 8 tablespoons in 3 gallons of water (2 pounds per gallon), is used to thoroughly drench the mound and surrounding soil. Treated areas are examined within 3 weeks and surviving colonies retreated. These insecticides are most useful on the cooler days of spring or fall and winter months. County Extension agents or Extension entomologists should be consulted concerning the safety and advisability of treating a specific area.

All suggested chemicals must be registered and labeled for use by the U.S. Environmental Protection Agency and the Texas Department of Agriculture. The status of an insecticide label is subject to change. Such a change may have occurred since printing of this publication.

The insecticide user is always responsible for the effects of the pesticide used and the resulting residues on his own crops and livestock, as well as problems caused by drift to other properties, crops, or livestock. All label instructions should be read and followed carefully.

Research

In the late 1940's granular heptachlor was the most common insecticide used for the control of imported fire ants. Hays and Arant (1960) developed a bait concept for control, consisting of a toxicant in peanut butter. They reported that Kepone® was an effective toxicant applied as a bait. Lofgren, Stringer, and Bartlett (1962), Lofgren *et al.* (1964, 1967), and Stringer, Lofgren, and Bartlett (1964) further developed this method using mirex as the toxicant.

The first aerial application of mirex bait for area-wide control was made in the fall of 1961, with excellent results. For more than 10 years mirex bait was the standard control agent for fire ants and is still the only known area-wide control effective against the imported fire ant (Alley, 1973); however, the long environmental persistance of mirex, which results in bioconcentration in the environment, has received increasing criticism (Baetcke, Cain and Poe, 1972; Naqvi and de la Cruz, 1973; Wolfe and Norment, 1973; Summerlin, Hung, and Vinson, 1977). In addition, it accumulates in the fat of animals, including man (Gibson, Ivie, and Dorough, 1972; Ivie, Dorough, and Bryant, 1974; Anonymous, 1976, Kuty *et al.*,1974), and as one animal eats another, mirex is accumulated in its body. Mirex will also stimulate certain enzyme systems which affect an animal's susceptibility to other chemicals (Baker *et al.*, 1972). For these reasons, the use of mirex has been severely restricted.

An alternative toxicant for control of fire ants has been sought for the last 10 years. Lofgren *et al.* (1967) described a screening technique for toxicants effective against imported fire ants and reported laboratory test results of 334 compounds; however, no new compounds were found to replace mirex. Levy, Chiu, and Banks (1973) and Wojcik *et al.* (1973) suggested additional compounds as potential control agents, but none were found to be as effective as mirex. The reason for the success of mirex is that it does not rapidly kill food-foraging worker ants that eat it. Also, mirex is not destroyed by the stomach (crop) of the worker ant. The worker can carry the mirex back to the colony and spread it around by feeding other ants before it dies.

Most potentially effective compounds kill too rapidly (Wojcik *et al.*, 1973), although a group of chemicals called "insect juvenile hormone mimics" appear to have promise. These chemicals do not kill adults but kill the immature forms before they

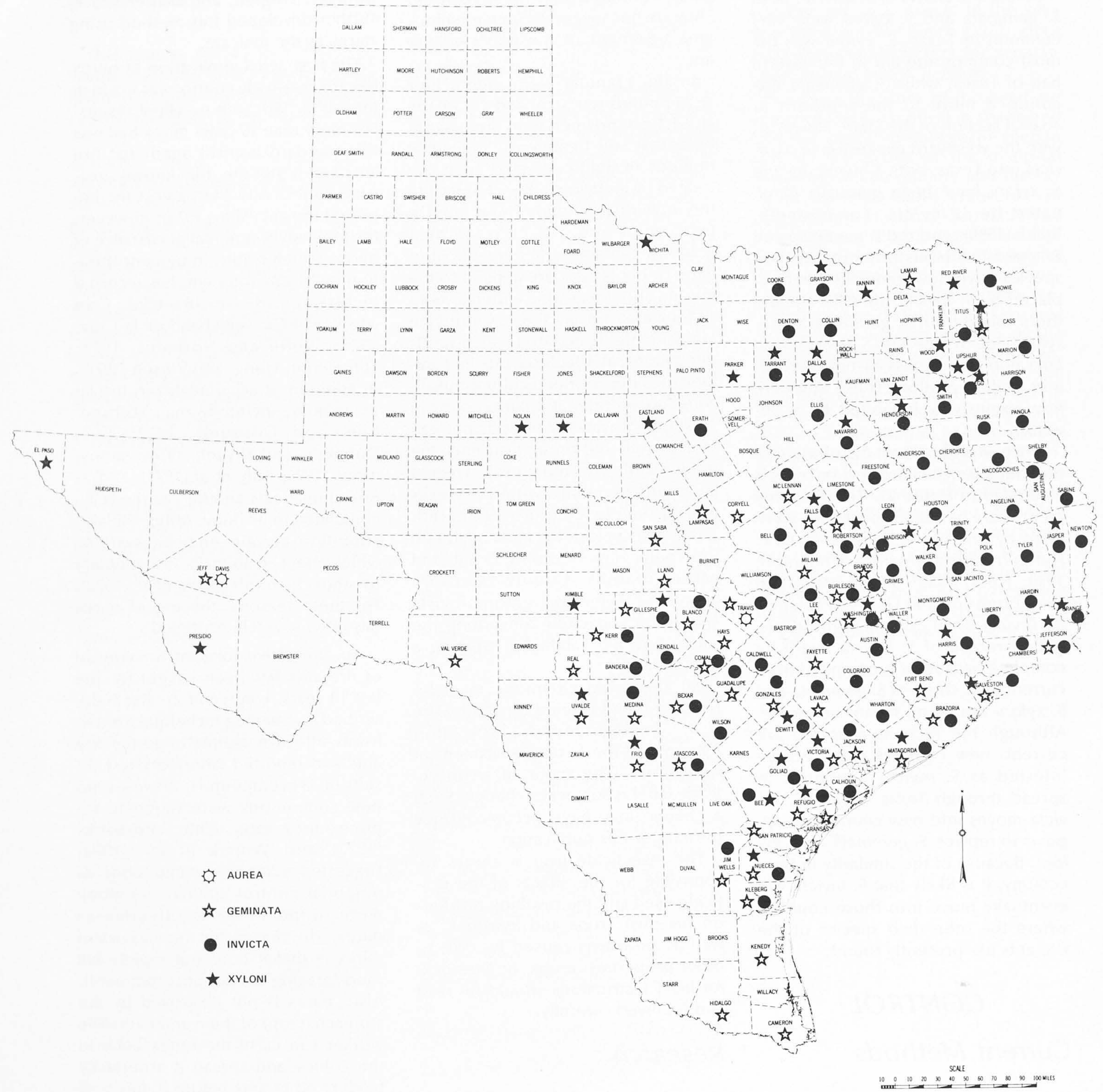

Figure 25. County distribution records of fire ants in Texas.

develop into adults. The compounds were formulated in an oil base bait and were found to be effective against small laboratory colonies of imported fire ants (Cupp and O'Neal, 1973; Triosi and Riddiford, 1974; Vinson and Robeau, 1974). A rapid screening program was developed and a number of compounds were screened for activity (Vinson, Robeau, and Dzuik, 1974), but the effectiveness of the compounds in the field was erratic (Vinson, unpublished). These erratic results were explained when it was discovered that the juvenile hormone was destroyed by the foraging worker ant so that very little was fed to the larvae (Wendel and Vinson, unpublished). Further work revealed that the juvenile hormones may be effective if they can be placed into a mound; for example, when a few larvae are treated with the hormone, the chemical is spread to others (Wendel and Vinson, unpublished). Recently, a brood pheromone was identified (Bigley and Vinson, 1975) that stimulates workers to carry materials into the nest. By mixing the pheromone and hormone, both materials were conveyed into a mound of the imported fire ant (Bigley and Vinson, unpublished). It is hoped that this approach will lead to an effective area-wide control without use of insecticides.

Other control methods have been and are being explored. Bacteria of the genus *Pseudomonas* and the three fungi, *Beauveria bassiana, Metarrhizum anisopliae,* and *Aspergillus flavus,* have been studied as microbial control agents (Broome, 1973; Sikorowski, Norment, and Broome, 1973); and recently, Allen and Buren (1974) isolated the microsporidian, *Thelophania* sp., from *S. invicta* colonies in Brazil. There is no evidence that any of these pathogens have effectively reduced infestations of fire ants. The role of predators and insect parasites in regulating populations of imported fire ants in the United States has also been studied (Hung, 1974; Lofgren *et al.*, 1975; O'Neal, 1974; Silveiro-Guido, Carbonell, and Crisci, 1973; Whitcomb, Bhatkar, and Nickerson, 1973; Williams *et al.*, 1973; W. F. Buren, personal communication).

Sterile males of *S. invicta* were found in field populations from College Station, Navasota, and Anderson (Hung *et al.*, 1974). The frequency of sterile males was as high as 100 percent in some colonies examined. Additional populations with sterile males have been found at Huntsville, Stephen F. Austin State Park, Pledger, and Varner-Hogg Plantation (Hung, unpublished). The possibility of using male sterility in genetic control of fire ants is now under investigation.

LITERATURE CITED

Anonymous. 1976. Mirex found in 40% of certain human tissue samples taken by EPA. Pestic. Chem. News July 14, 1976. p. 26.

Allen, G. E., and W. F. Buren. 1974. Microsporidian and fungal diseases of *Solenopsis invicta* Buren in Brazil. J. N.Y. Entomol. Soc. 82:125-130.

Alley, E. G. 1973. The use of mirex in control of the imported fire ant. J. Environ. Quality 2:52-61.

Baetcke, K. P., J. D. Cain, and W. E. Poe. 1972. Residues in fish, wildlife and estuaries. Pestic. Monit. J. 6:14-22.

Baker, R. C., L. B. Coons, R. B. Mailman, and E. Hodgson. 1972. Induction of hepatic mixed-function oxidases by mirex. Environ. Res. 5:418-424.

Banks, W. A., J. K. Plumley, and D. M. Hicks. 1973. Polygyny in a colony of the fire ant, *Solenopsis geminata* (F.). Ann. Entomol. Soc. Amer. 66:234-235.

Bigley, W. S., and S. B. Vinson. 1975. Characterization of a brood pheromone isolated from the sexual brood of the imported fire ant, *Solenopsis invicta*. Ann Entomol. Soc. Amer. 68:301-304.

Blum, M. S., J. E. Roberts, and A. F. Novak. 1961. Chemical and biological characterization of venom of the ant *Solenopsis xyloni* McCook. Psyche 68:73-74.

Blum, M. S., J. R. Walker, P. S. Callahan, and A. F. Novak. 1958. Chemical, insecticidal and antibiotic properties of fire ant venom. Science 128:306-307.

Brand, J. M., M. S. Blum, H. M. Fales, and J. G. MacConnell. 1972. Fire ant venoms: comparative analysis of alkaloidal components. Toxicon 10:259-271.

Broome, J. R. 1973. Microbial control of the imported fire ant, *Solenopsis richteri* Forel. PhD thesis. Miss. State Univ., State College, Miss.

Brown, L. L. 1973. The physician and fire ants. J. S.C. Med. Assoc. 69:322-324.

Brown, W. L., Jr. 1961. Mass insect control programs: Four case histories. Psyche 68:75-109.

Buren, W. F. 1972. Revisionary studies on the taxonomy of the imported fire ants. J. Ga. Entomol. Soc. 7:1-27.

Buren, W. F., G. E. Allen, W. H. Whitcomb, F. E. Lennartz, and R. N. Williams. 1974. Zoogeography of the imported fire ants. J. N.Y. Entomol. Soc. 82:113-124.

Clark, S. W. 1931. The control of fire ants in the lower Rio Grande Valley. Tex. Agr. Exp. Sta. B-435. 12 p.

Clemmer, D. I., and R. E. Serfling. 1975. The imported fire ant: dimensions of the urban problem. South. Med. J. 68:1133-1138.

Coon, D. W., and R. R. Fleet. 1970. The ant war. Environment 12:28-38.

Cupp, E. W., and J. O'Neal. 1973. The morphogenetic effect of two juvenile hormone analogues on larvae of imported fire ants. Environ. Entomol. 2:191-194.

Creighton, W. S. 1930. The new world species of the genus *Solenopsis*. Proc. Amer. Acad. Arts and Sci. 66:39-151.

Creighton, W. S. 1930. The ants of North America. Bull. Mus. Comp. Zool. 104:1-585.

Ettershank, G. 1966. A generic revision of the world Myrmicinae related to *Solenopsis* and *Pheidologeton*. Aust. J. Zool. 14:73-171.

Ferguson, D. E. 1970. Fire ant: whose pests? Science 169:630.

Gibson, J. R., G. W. Ivie, and H. W. Dorough. 1972. Fate of mirex and its major photodecomposition products in rats. J. Agr. Food Chem. 20:1246-1248.

Glancey, B. M., C. H. Craig, C. E. Stringer, and P. M. Bishop. 1973. Multiple fertile queens in colonies of the imported fire ant, *Solenopsis invicta*. J. Ga. Entomol. Soc. 8:237-238.

Gregg, R. E. 1963. The ants of Colorado. Univ. Colo. Press. Boulder, Colo. 792 p.

Green, H. B. 1967. The imported fire ant in Mississippi. Miss. State Univ. Exp. Sta. B-737. 23 p.

Griffiths, D. 1942. Ants as probable agents in the spread of *Shigella* infections. Science 96:271-272.

Hays, S. B., and F. S. Arant. 1960. Insecticidal baits for control of the imported fire ant, *Solenopsis saevissima richteri* Forel. J. Econ. Entomol. 53:188-191.

Hays, S. B., and K. L. Hays. 1959. Food habits of *Solenopsis saevissima richteri* Forel. J. Econ. Entomol. 52:455-457.

Hess, C. G. 1958. The ants of Dallas County, Texas, and their nesting sites; with particular reference to soil texture as an ecological factor. Field and Lab. 26:1-72.

Hung, A. C. F. 1974. Ants recovered from refuse pile of the pyramid ant, *Conomyrma insana* (Buckley). Ann. Entomol. Soc. Amer. 67:522-523.

Hung, A. C. F., S. B. Vinson, and J. W. Summerlin. 1974. Male sterility in the red imported fire ant, *Solenopsis invicta*. Ann. Entomol. Soc. Amer. 67:909-912.

Ivie, F. W., H. W. Dorough, and H. E. Bryant. 1974. Fate of mirex C^{14} in Japanese quail. Bull. Environ. Cont. Toxicol. 11:129-135.

Kuty, F. W., A. R. Yobs, W. G. Johnson, and G. B. Wiersma. 1974. Mirex residues in human adipose tissue. Environ. Entomol. 3:882-884.

Lawrence, R. S., J. E. Keil, L. L. Brown, and H. B. Jackson. 1973. The imported fire ant: a newly recognized public health problem in South Carolina. J. S.C. Med. Assoc. 69:319-321.

Levy, R., Y. J. Chiu, and W. A. Banks. 1973. Laboratory evaluation of candidate bait toxicants against the imported fire ant, *Solenopsis invicta*. Fla. Entomol. 56:141-146.

Lockey, R. F. 1974. Systematic reactions to stinging ants. J. Allergy Clin. Immunol. 54:132-146.

Lofgren, C. S., W. A. Banks, and B. M. Glancey. 1975. Biology and control of imported fire ants. Ann. Rev. Entomol. 20:1-30.

Lofgren, C. S., F. J. Bartlett, C. E. Stringer, Jr., and W. A. Banks. 1964. Imported fire ant toxic bait studies: further tests with granulated mirex-soybean bait. J. Econ. Entomol. 57:695-698.

Lofgren, C. S., C. E. Stringer, W. A. Banks, and P. M. Bishop. 1967. Laboratory tests with candidate bait toxicants against the imported fire ant. USDA-ARS 81-14. 25 p.

Lofgren, C. S., C. E. Stringer, and F. J. Bartlett. 1962. Imported fire ant toxic bait studies: GC-1283, a promising toxicant. J. Econ. Entomol. 55:405-407.

Long, W. H., E. A. Cancienne, E. J. Cancienne, R. N. Dopson, and L. D. Newsom. 1958. Fire-ant eradication program increases damage by the sugarcane borer. Sugar Bull. 37:62-63.

Markin, G. P., H. L. Collins, and J. H. Dillier. 1972. Colony founding by queens of the red imported fire ant, *Solenopsis invicta.* Ann. Entomol. Soc. Amer. 65:1053-1058.

Markin, G. P., J. H. Dillier, S. O. Hill, M. S. Blum, and H. R. Hermann. 1971. Nuptial flight and flight ranges for the imported fire ant, *Solenopsis saevissima richteri*. J. Ga. Entomol. Soc. 6:145-156.

Naqvi, S. M., and A. A. de la Cruz. 1973. Mirex incorporation in the environment: residues in nontarget organisms — 1972. Pestic. Monit. J. 7:104-111.

O'Neal, J. 1974. Predatory behavior exhibited by three species of ants on the imported fire ants, *Solenopsis invicta* Buren and *S. richteri* Forel. Ann. Entomol. Soc. Amer. 67:140.

Reagan, T. E., G. Coburn, and S. D. Hensley. 1972. Effects of mirex on the arthropod fauna of a Louisiana sugarcane field. Environ. Entomol. 1:588:591.

Rhoades, R. B., W. L. Schafer, W. H. Schmid, P. F. Wubbena, R. M. Dozier, A. W. Townes, and H. J. Wittig. 1975. Hypersensitivity to the imported fire ant. J. Allergy Clin. Immunol. 56:84-93.

Sikorowski, P. P., B. R. Norment, and J. R. Broome. 1973. Fungi pathogenic to imported fire ants. Miss. Agr. Forest. Exp. Sta. Inf. Sheet 1212.

Silveiro-Guido, A., J. Carbonell, and C. Crisci. 1973. Animals associated with the *Solenopsis* (fire ants) complex, with special reference to *Labauchena daguerri.* Proc. Tall Timbers Conf. Ecol. Animal Control Habitat Manage. 4:41-52.

Smith, M. R. 1936. A list of the ants of Texas. J. N.Y. Entomol. Soc. 44:155-170.

Smith, M. R. 1965. House-infesting ants of the eastern United States. USDA-ARS Tech. Bull. 1326. 105 p.

Snelling, R. R. 1963. The United States species of fire ants of the genus *Solenopsis,* subgenus *Solenopsis* Westwood, with synonymy of *Solenopsis aurea* Wheeler. Occasional Papers - No. 3, Bur. Entomol., Calif. Dept. Agr. 1-11.

Stringer, C. E., C. S. Lofgren, and F. J. Bartlett. 1964. Imported fire ant toxic bait studies: evaluation of toxicants. J. Econ. Entomol. 57:941-945.

Summerlin, J. W. 1976. Polygyny in a colony of the southern fire ant. Ann. Entomol. Soc. Amer. 69:54.

Summerlin, J. W., A. C. F. Hung, and S. B. Vinson. 1977. Residues in nontarget ants, species simplification and recovery of populations following aerial applications of mirex. Environ. Entomol. 6:193-197.

Travis, B. V. 1941. Notes on the biology of the fire ant, *Solenopsis geminata* (F.) in Florida and Georgia. Fla. Entomol. 24:15-22.

Triosi, S. J., and L. M. Riddiford. 1974. Juvenile hormone effects on metamorphosis and reproduction of the fire ant, *Solenopsis invicta.* Environ. Entomol. 3:112-116.

Triplett, R. F. 1973. Sensitivity to the imported fire ant: successful treatment with immunotherapy. South. Med. J. 66:477-480.

Vinson, S. B., and R. Robeau. 1974. Insect growth regulator effects on colonies of imported fire ant. J. Econ. Entomol. 67:584-587.

Vinson, S. B., R. Robeau, and L. Dzuik. 1974. Bioassay and activity of several insect growth regulators on the imported fire ant. J. Econ. Entomol. 67:325-328.

Warren. L. O., and E. P. Rouse. 1969. The ants of Arkansas. Univ. Ark. Agr. Exp. Sta. Bull. 742. 68 p.

Whitcomb, W. H., A. Bhatkar, and J. C. Nickerson. 1973. Predators of *Solenopsis invicta* queens prior to colony establishment. Environ. Entomol. 2:1101-1103.

Williams, R. N., J. R. Panaia, D. Gallo, and W. H. Whitcomb. 1973. Fire ants attacked by phorid flies. Fla. Entomol. 56:159-262.

Wilson, E. O. 1951. Variation and adaptation in the imported fire ant. Evolution 5:68-79.

Wilson, E. O. 1952. The *Solenopsis saevissima* complex in South America. Mem. Inst. Oswaldo Cruz. 50:60-68.

Wilson, E. O. 1953. Origin of the variation in the imported fire ant. Evolution 7:272-263.

Wilson, E. O. 1958. The fire ant. Sci. Amer. March: 36-41.

Wilson, E. O., and W. L. Brown. 1958. Recent changes in the introduced population of the fire ant *Solenopsis saevissima* (Fr. Smith). Evolution 12:211-218.

Wilson, E. O., and J. H. Eads. 1949. A report on the imported fire ant, *Solenopsis saevissima* var. *richteri,* in Alabama. Spec. Rep. Ala. Dept. Conserv. Mimeo. 54 p.

Wilson, N. L., and A. D. Oliver. 1969. Food habits of the imported ant in pasture and pine forest areas in southeastern Louisiana. J. Econ. Entomol. 62:1268-1271.

Wojcik, D. P., W. A. Banks, J. K. Plumley, and C. S. Lofgren. 1973. Red imported fire ant: laboratory tests with additional candidate bait toxicants. J. Econ. Entomol. 66:550-551.

Wolfe, J. L., and B. R. Norment. 1973. Accumulation of mirex residues in selected organisms after an aerial treatment, Mississippi, 1971-72. Pestic. Monit. J. 7:112-116.

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