The Imported Fire Ant in Mississippi

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ON THE COVER:

The photograph on the cover shows an unusually large imported fire ant mound in northeast Mississippi. This picture and the other two used in this bulletin were furnished by Dr. Ross E. Hutchins.
PREFACE

The imported fire ant presents many challenges to mankind. We can only hope that our social structures may ever be so orderly. The plastic responses of this species to its environment allows it to be highly successful and adaptable. This is of course, scant comfort to those people in infested areas.

The imported fire ant in its various phases may be: fragile or rugged, innocuous or fierce, secretive or obvious, subterranean or arboreal, terrestrial or aerial, solitary or gregarious, and so on ad infinitum. It seems neither to truly hibernate or estivate, yet it survives. It is omnivorous and voracious yet it may fast. It may survive drought or flood, fire or upheaval.

It is hoped that the information presented here may serve as both an introduction to those needing to learn about the imported fire ant, and as an informal review for those who may desire to see the relationship of the many facets of the subject presented in other published works.
THE IMPORTED FIRE ANT IN THE SOUTHEASTERN UNITED STATES

By

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The imported fire ant has been the subject of many popular articles, some of them sensational, in the past decade. The same ant has been discussed frequently in technical papers where it is known as Solenopsis saevissima (F. Smith) broad sense. Few insects can arouse the interest of the layman or the scientist as this one. Yet its presence would go largely unheeded, but for the vicious stings and the building of large mounds.

When a mound of the imported fire ant is disturbed, the ants rush out and climb up any foreign object. When they find a suitable place to sting, they bite with their mandibles to hold more securely and perhaps puncture the skin. Then they turn the sting on the tip of their abdomen to the wound and inject venom. A very few people have shown violent reactions to stings of the imported fire ant, but these individuals represent a very small fraction of our population. Most people feel a violent burning sensation from the stings, and in some cases a necrosis in the area of the sting occurs and a small sterile pustule forms on the skin. People in areas infested by the imported fire ant soon become wary of their mounds.

The mounds made by this ant are most noticeable in late winter and in the spring of the year. The mounds vary in size with: the age of the colony, habitat, season of the year, and some other factors that will be discussed later. They are most frequently seen in pastures or other areas where the grass is short, but the ants have been known to live in almost any situation from sandy beaches to the heaviest of clay soils. One major complaint by farmers concerning the fire ant, is the damage to mowers and other farm machinery when the mounds, which are often reinforced with grass, are struck by the machines. Populations of this insect may be a nuisance during harvest of many crops and there are records of some damage to crops, particularly vegetables.

Imported fire ants have seldom been reported to be detrimental in their feeding. The chief food is other insects, or insect products, such as honeydew of aphids or mealybugs, but the extent of their beneficial effect in this manner is not known.

Generally property owners are strongly opposed to the presence of the imported fire ants and because of spread of this pest to wide areas, federal work is being directed toward containment of the infestation with the intent of their eventual eradication from the United States.

IMPORTATION (S)

The imported fire ant, Solenopsis saevissima variety richteri Forel, was first reported in the United States at the port of Mobile, Alabama. The exact time, manner and source of this importation will probably never be known. The first official recognition of the imported fire ant was made by H. P. Loding in an observation dated July 15, 1929, in the United States. U.S.D.A. Insect Pest Survey Bulletin 9. The species was included by W. S. Creighton in 1930 in a paper entitled “The New World Species of the Genus Solenopsis.” Creighton reported that he first saw these ants in urban Mobile in 1926. He stated that he was told by Mr. Loding that they had appeared on the Mobile Bayfront in 1918.
The author observed the imported fire ant to be widely spread in urban Mobile in 1924. The imported fire ants in Mobile at that time were a dark brown color similar to those now found in the northeast Mississippi infestation. Highly effective insecticides were not available then, and there was no serious concern by most people that it would ever be accorded much national attention as a pest. Other native species of the same genus were well known then and they were usually not a serious pest, so even the larger mounds and more painful stings of the imported fire ant caused no great concern at that time.

There was apparently a slow spread of the imported fire ants for a number of years. Following World War II several highly effective insecticides such as chlordane became available and some control and eradication work was begun in several places. At first it appeared that individual mound treatment with the new insecticides would give almost complete kill of the ants; but in several years it became evident that natural re-infestation of the treated areas nullified the efforts.

At the time this early eradication work was going on in Mississippi, there were some widely isolated infestations of the imported fire ants, where this type of work might avoid their further spread. These isolated infestations appeared to have resulted from the ants being carried many miles into uninfested areas.

There are several known methods of spread of the imported fire ant. (1) Mechanical transportation of all or much of an intact colony from one place to another may occur. (2) Floodwater floating of colonies from inundated mounds will spread them for miles downstream. (3) Flights of mated queens will spread the ants under normal conditions several miles each generation—(the exact flight limitation of a mated queen in unknown). Again mechanical transportation can occur, by a mated queen being carried to a new location. (4) Colonies of ants frequently move by walking to new mound locations.

Under conditions of food scarcity, colony population pressure, or physical mound disturbance, colonies have been known to move as much as several hundred feet.

It was mentioned earlier that the first imported fire ants encountered in the United States were dark brown. The queens of these ants and their larger workers, which are imperfect females, have a honey colored band across the abdomen or gaster. Sometime after 1930 it was noted that some lighter colored fire ants were along the Gulf Coast and by 1950 most of the ants along this area of both Mississippi and Alabama were the lighter type.

At this time there was a small group of entomologists employed by the USDA, BEPQ, Division of Insects Affecting Man and Animals, stationed at Mobile, Alabama to make some studies of biology and control of the imported fire ant. Mr. Leyburn F. Lewis of this group, in a quarterly report, made some interesting observations concerning the variety of colors of these ants in the Mobile area. He found that in very wet, marshy situations, they were of the brown type or phase, while in the surrounding better drained areas, all the imported fire ants were the light colored phases. (The term “light colored” has been used here concerning the imported fire ant to cover a number of combinations of red, light brown, tan, or yellowish colors that may be found.) The author spent a day with Mr. Lewis at that time visiting a variety of ecological situations to study the relationship of soil moisture and fire ant colors. It appeared that the dark colored phase was being replaced by the lighter colored phases, and the reason for the presence of the dark ants in the very wet situations was that they had not been replaced due to the isolation of
In relatively recent years the imported fire ant has spread over this section of the Southeast. (Infestation as reported by USDA ARS Plant Pest Control Division, Southern Region.)

their colonies.

Wilson and Brown (1958) stated that the light phase of *S. saevissima* in the United States is morphologically identical to a geographic variant from a central sector of the South American mother population which has a large range there. Further they stated that the light phase interbreeding with the dark phase in the United States has resulted in a graded series of intermediate color forms, suggesting that the two extreme forms differ by polygenes. They inferred that until this interbreeding came about, that there was little spread of the ant in the United States, since the dark phase was not as successful or aggressive as the light phase. These writers seemed convinced that a second importation of the fire ant from South America occurred when the light phase ants appeared in the United States.

It would seem, however, that since both phases of *S. saevissima* were present in South America, that the light phase would have supplanted the dark phase there; or that interbreeding would have taken place to produce intermediate color forms like those found in the United States. Further it could be pointed out that the dark phase has spread rapidly in the United States since its removal from the Mobile area. Thus it can be said that the rapid spread of the imported fire ant in the United States did not necessarily depend on the introduction of the light phase as was inferred by Wilson and Brown (1958).

This then would pose the question of why the spread of *S. saevissima* was so slow for a number of years, and then spread so rapidly. Perhaps some sociological changes in the human population had much to do with it as will be explained later. The spread of the imported fire ant has been slowly progressing northward from a wide base along the Gulf Coast area of Texas, Louisiana, Mississippi, Alabama, and Florida. The spread to the north has been greatly accelerated in Mississippi, and perhaps in other places, by population skips du-
probably to human movement of the ants. This amounted to approximately 230 miles from the coast in the case of the dark phase infestation at Artesia, Mississippi. The spread to the north by natural means of queen flights has been aided by the prevailing winds from the south at the time of the greatest queen flights in the spring and early summer.

The spread to the east and west of Mobile for hundreds of miles along the Gulf Coast can best be explained by human movement of the light phase ants. This can best be illustrated with a map (Figure 1). Culpepper (1953) reported the movement of the imported fire ant by the shipment of nursery plants from infested areas. There are several plants such as azalea and camellia for which Mobile is famous, and there are a number of nurseries in that area from which plants have been moved along the Coast. Since most of the movement of these plants, and the widespread development of the Gulf Coast areas occurred subsequent to the transformation of most of the fire ant population of the Mobile area to the light phase; it seems likely that their movement east and west might have occurred largely by shipment of nursery plants. These plants are usually moved with a sizeable ball of soil around the roots, thus colonies of ants could easily be transported in the soil moved with the plants. Azalea and camellia are not cold hardy and do best along the Gulf Coast, thus the ant movements to the north in this manner likely would have been slow.

A human sociological aspect of the problem may have been involved in the slow spread of the dark phase ants northward from the Mobile area before the advent of the light phase ants in that area. Prior to the decade of the 1930's, the "cut-over pine lands" along the Gulf Coast area of Alabama and Mississippi were annually "burned over." Tenants and squatters in this area, and even some landowners, favored the practice of setting fires in the winter to burn the grass residue of the previous year. It was claimed that this practice favored early cattle and sheep grazing in the spring; but probably the tenants and squatters knew it also killed pine seedlings, that would force them from the land. The heat of the grass fires might easily have killed small new colonies which would have been near the soil surface at this time of the year, and survivors would have been faced with a dearth of food.

It was pointed out by Wilson and Brown (1958) that the light and dark phase imported fire ants differ in several ways other than color, such as: total size, size and form of the nest, and certain habitat selections. It is easily seen that the light phase ants build smaller mounds in most locations, and that the number of mounds per acre is much greater in the light phase ant population in Mississippi. From experience with a number of counts of mounds made in connection with control experiments with rather stable populations, it can be said that the dark phase ants in the Artesia, Mississippi area seldom exceed 20 mounds per acre, while the light phase ants north of Gulfport, Mississippi frequently exceed 30 mounds per acre, or about 50 percent more.

The light phase ants produce some brood during each month of the year in the southern part of Mississippi. This winter brood production is also reported from other states. By contrast, the dark phase ants stop brood production in the Artesia area usually in early December. Cold does not seem to be the controlling factor in this matter, since it usually gets colder in the southern part of the state during January than it does in Artesia in early December. The mean December temperature near Artesia from 1931 to 1960 was about 47°F., while the mean January temperature from 1931 to 1960 was 46°F., near Artesia, and 49°
F. in the southern part of Mississippi, where the light phase ants are found. Mean temperatures do not indicate the low extremes certainly, but soil temperatures where the ants are, do not fluctuate as much as free air temperatures.

Certain of the differences of dark and light phases might well be considered in the control or eradication work with the imported fire ant. The mounds of the dark phase ants are easier to see because they are larger than the mounds of the light phase ants. Individual mound treatment of the smaller, more numerous light phase ant mounds makes their control by this method less effective, since it depends upon finding the mounds. Also, the extended brood production of the light phase ants may pose a threat of reinfestation of treated areas by their queens earlier in the year. This point has not been proven, but there seems to be a possibility that this could happen.

The United States species of the genus *Solenopsis* were reported on by Snelling (1963). In this work the true fire ants are placed in the subgenus *Solenopsis*. The imported fire ant in the United States was referred to as *S. saevissima* (F. Smith), broad sense, rather than *S. saevissima* variety richteri Forel, which refers only to the dark phase. This conclusion was drawn as a result of the observations reported by Wilson (1952) and Wilson and Brown (1958).

If indeed the light phase ants eventually replace the dark ants on the hundreds of square miles they now infest, this position may result in less complicated reference to the species in general, to call them *Solenopsis saevissima* (F. Smith), broad sense.

**LIFE HISTORY**

A new colony of the imported fire ant starts with a mated queen, thus her source must be considered first. The queens have wings and may be produced by the hundreds in large mounds. At the same time an even greater number of winged males are usually produced. Some colonies may produce nearly all one sex or the other, and in the fall of the year, many colonies appear to produce only males. The winged queens and males are of nearly equal size, but the males can be easily distinguished by their very small heads (pinhead size), and their large humped thorax where the wings attach.

Some of the winged forms may be found in the mounds in any month of the year, and mating flights have been observed in all months; but in spring, mounds of all sizes makes great efforts to produce the winged forms in large numbers for flights in the late spring or early summer.

Mating or nuptial flights have frequently been seen during the middle of the day when it was bright and sunny, with a temperature of about 70° F. or higher. It is not known what causes or triggers these flights; but it seems to be related to a period of unsettled weather which usually results in rain just before or after the flight. Since these flights have been known to take place over an area of many hundreds of square miles on the same day, it is suspected that barometric pressure variations may be involved. This is the only weather variable that would be nearly the same over such a large area. This position is further strengthened by the fact that the winged or alate reproductive forms from indoor captive colonies fly at the same time as those under natural conditions. This is true even though the indoor conditions of temperature and humidity are very different from outdoors, and very little day-to-day variation is possible.

On the day that nuptial flight occurs, the worker ants become very agitated or excited in the area of the mound. Shortly before the flights, the workers
tear several holes about an inch in diameter in the top crust of each of the mounds from which flights are to occur. The alate reproductive forms issue from the mounds through these holes and climb up grass or other objects nearby, and from these they fly almost straight upward. It was reported by Wheeler (1960) that many kinds of ants mate high in the air in swarms. This has mostly been observed in Europe, but it is also known to occur in this country. There have been some studies of this aspect of the biology of the imported fire ant in Louisiana by Dr. Murray Blum of Louisiana State University, but this work is as yet unpublished.

On several occasions, large numbers of mated imported fire ant queens have been found descending from their nuptial flights on a small area about 100 feet in diameter. In these small areas thousands of the queens have been collected for starting study colonies; however, very few males were observed. At other times, the bodies of vast numbers of males have been found in small areas following nuptial flights and this may be further evidence that mating occurs in swarms. Males live only a short time after they leave the mound, though some may live in the mounds all winter with worker ants to tend them. Thus it seems they have very limited body reserves.

Although it would appear from the above discussion that the queens descending from the nuptial flights come down in small areas at high concentrations, there is also good evidence that they scatter over wide areas. This can be seen easily in the almost uniform distribution of mounds over vast areas of infested lands.

Queens, unlike the males, have great body reserves of nutrients when they leave the mound, for they are able to lay eggs and rear a small group of tiny worker ants from regurgitated, reabsorbed tissues of their bodies. This has been observed in the laboratory many times where the queens were confined individually in glass vials without food or free water. Their only requirement seems to be a high relative humidity (near the saturation point).

When the queens alight after their nuptial flights, they chew away their wings and walk about for a few minutes, usually until they find a nest site to their liking in which to dig a small hole or burrow. The burrow made by a queen is usually about two inches long. Most of them that have been dug out, went down about one-half inch and then turned to go parallel with the surface of the soil, terminating with a slight enlargement or chamber.

If for some reason (such as too hard soil) the queens do not get their chambers started in several hours, they may concentrate in large masses under objects on the soil surface such as boards. This fraternizing is contrary to the traits expressed by workers in the colonies, who defend their area of domination around their mounds against any intruders.

It was reported from laboratory studies by Khan (1965) that within 48 hours after their nuptial flights, nearly 100 percent of the queens started laying a few eggs. They were very maternal toward their first young. When they were disturbed they picked up in their mandibles and carried their mass of brood which they had stuck together with a protective mantle of saliva. Usually, the eggs hatched after several days and the queens fed the young larvae, as was mentioned earlier, with regurgitated, reabsorbed body tissues. Their useless wing muscles contain good source of this food material. The imported fire ants have a complete metamorphosis in their development and following the helpless globe-shaped larval stage, there is a pupal stage in which the characteristic ant structures
Inside the fire ant mounds are thousands of worker ants of various sizes. Here are shown workers caring for the young ants.

form, and can actually be seen before the ants become active adults.

The first workers reared by their queen are tiny. The workers of this caste are usually referred to as the minim workers. As more and more of these tiny forms mature, they begin to forage a short distance for food in about the fifth week following the nuptial flight of their mother. At this time there may be about 10 to 20 of them, and in addition to their food gatherings, they assume the responsibilities of caring for the eggs and brood of the colony. In nature the queens have been seen to leave their burrows and travel a short distance in the early stages of colony development. It is not known if they forage for food, but it seems unlikely, since workers always feed them in the colony.

In the laboratory, it was necessary to completely isolate the colonies when the minim workers became active, or they would abscond with the brood of their colony and move to join forces with the progeny of another queen, (Khan 1965). When several such colonies joined, they constituted a much more powerful force. It is not known if this happens in nature, but if it does occur, it would help the chances of survival of some of the colonies.

It has been found that frequent summer shower activity greatly enhances the chances of survival of the small new colonies by increasing the surface soil moisture, as was shown by Green (1962), who reported that as many as 1000 of the small colonies per acre had been counted. Earlier, (1952) Green reported that by midwinter only about 10 percent of the number of such small new colo-
nies could be located. It is not known if many of them joined forces during bad weather, or if large numbers died out.

As the minim workers of a new colony increase in number, and the food they can supply by foraging increase, the size of the workers produced in the colony gradually increases. Eventually the larger sized workers reach a size or caste arbitrarily called minor workers, and later on a larger media caste, and still later the largest or the major caste. It was mentioned earlier that the major caste workers have a band of color on the abdomen or gaster like queens. In the spring, almost a year following the nuptial flights of their queens, new colonies have been found to produce alate or winged reproductive forms; and thus this completes the reproductive cycle of the imported fire ant colonies. It has been reported informally by other workers with the imported fire ants, that they believe that they have seen some small new colonies that have been able to produce alate brood in the same summer or fall of the year that the colony started. This would possibly be of importance in timing retreatment activities in an eradication program.

Colonies reared in the laboratory from mated queens collected in the summer produced alate reproductive forms the following spring at the same season that the wild colonies in the field did so, at State College, Mississippi. This is in the same area with the dark phase ants from the Artesia infestation, where the alate brood production starts usually about the first of March.

WEATHER EFFECT ON NEW COLONY SURVIVAL

The spread of the imported fire ant has been restricted to some extent by dry weather in the summers. The most impressive example of how good weather conditions may influence the spread of the fire ant can be seen in the so-called "explosive" infestation of mounds that became noticeable about January 1957. These mounds resulted from high colony survival as influenced by the frequent summer showers of 1955 in the southeastern states. These showers started in most places in mid-June and lasted until about mid-August. More important than the amount of rainfall, was the number of showers and their frequency. The relation of summer shower activity to fire ant colony establishment from 1946 to 1960 was reported by Green (1962). In this period the shower activity was favorable for new colony survival only in 1946, 1949, 1950, 1955, and 1958 and each of these seasons resulted in a high rate of survival. The 1949 and 1950 groups, however, were probably killed by sub-zero weather in the early part of 1951 when the colonies were quite small.

The effect of extreme cold on imported fire ant colonies was reported by Green (1959). Under proper conditions, cold does not seem to seriously affect most of the ant colonies. Many large mounds may have little or no mortality in sub-zero weather. This seems to be due to the warming effect of the soil and the insulation of the air spaces in the larger mound.

When the ants get cold, they stop moving. This usually happens a few degree above freezing of the air temperature, when the ants stop and can be found motionless in various parts of the mound. They do not "ball" like honeybees, but may lie motionless for days until the weather is warm again. During this time of cold inactivity, the ants are helpless. When they are warmed slightly, even by holding them cupped in the hand, they will immediately resume activity.

It was found by Khan (1965) that ants were killed by a 24-hour exposure to
soil temperatures to 6 to 8°F. Also, it was found that when ants were held at a soil temperature of 32°F, for 7 days, about 70 percent of them died.

It was reported by Green (1959) that cold, under certain conditions in Mississippi, in 1958 had resulted in heavy ant mortality. The conditions that resulted in mortality were: that the ants in newly constructed mounds that had no grass for reinforcement in them, and had frost heaving of the soft soil, were settled in a cold rain, which was followed by several days of severe cold (between 10 and 20°F). This mortality resulted apparently in the portions of the mounds that settled, and thus lost their effect of insulation. The cold mortality in this case was an unusual combination of weather conditions. Usually rains occur at temperatures that are high enough for the ants to repair the mounds before the cold that follows. It appears, however, that in the United States, cold weather may be a limiting factor in the northward progress of new colonies, while the westward progress may be hindered by dry weather in the summer.

MOUNDS

The mounds of the imported fire ant are their most noticeable single characteristic. Although other ants build mounds, no other in the southeastern states build in such a spectacular manner as this ant. It was mentioned earlier that the mounds of the dark phase ants are larger than those of the light phases. The mound may be considered the focal point of the colony, as all activities radiate from or to this point.

The mounds are used in two ways: first to achieve a gradient of temperature and humidity best suited to the brood; and secondly, to evade excessive water or local flooding. Thus in dry, hot weather, they are not maintained to a high peak; and in very wet weather, particularly in the summer when there is much brood, they may be constructed very high. The latter is particularly true in a shade of tall grass away from direct sunlight.

The most noticeable mound construction occurs about mid-winter when the ants seem to anticipate the big spring brood production. This large mound building often occurs, in the case of the northeast Mississippi dark phase ants, about six weeks before the first eggs are laid. When the spring brood is started, the first few eggs can easily be detected by removing the mound crust on the sunny side. Since the weather is often cool at this season, the brood in the mounds is shifted during the day from the east to the south, and finally to the west side, in order to keep the brood on the sunny side of the mound. If the heat of the sun on the mound is too great, the brood is shifted to a cooler spot away from the sunny side. Vertical movement of the brood in the mound allows the ants to select the optimum humidity for brood development.

In very hot dry weather the ants move the brood below the soil line, under the mound proper. This is done to find the proper conditions for the brood development. The below-ground galleries are usually about equal in extent to those above ground. The underground galleries form a cone shape below the mound then there are several more or less twining vertical diggings that go much deeper. The extent of these deep diggings is unknown below the level of four feet; but perhaps they may go to a level of free soil water.
The mounds each have several foraging tunnels radiating from them about one-half inch below the soil level. Usually there are five or six such tunnels leaving the mounds at more or less fixed positions. The extremities of the tunnels are temporary, and can be changed easily as the needs arise. The tunnels branch and rebranch to fan out over the foraging area. They are constructed by moving soil particles from a new foraging run the ants start on the surface of the soil. These soil particles are placed along the sides of the run and eventually they bridge over the top and the tunnel is then underground. Thus they may simultaneously dig the whole length of the tunnel and quickly finish it. Tunnels may have holes that lead to the soil surface, or they sometimes terminate with a hole to the surface to allow the foraging ants access to the mound. Frequently tunnels lead to the base of plants where the ants are feeding. This will be discussed later concerning feeding habits.

During periods of frequent showers or rains, the ants use soft soil particles almost exclusively to build or repair the mounds or tunnels, but during dry, hot weather this is almost impossible, and under these conditions, various plant parts or ground litter may be employed. In a few cases the ants have been seen using green leaf or stem fragments apparently cut from plants solely for this purpose. During dry weather the ants have been seen to take advantage of natural soil cracks to construct tunnels. This was done by covering the cracks with bits of plants or particles of litter.

As was mentioned earlier, a growth of grass or weeds frequently comes up through the soil in the mounds. This seems to aid in reinforcing the mound structure and the ants do not usually try to remove it. This is particularly useful to them during the winter rains when some unreinforced mounds tend to settle due to heavy wet soil, at a time when the ants are too cold to make repairs. In general, the mounds do not deteriorate
badly from rain or weathering. This is apparently due to a bonding or waterproofing substance the ants use with the soil as the mounds are constructed. The surface of galleries have a waxy feeling to the touch, and the mounds will withstand complete inundation with little apparent ill effects.

The galleries of a mound and those in the soil below it are arranged as a random labyrinth of interconnected tunnels about one-fourth inch in diameter. The junctions of the soil structures are faired or shaped to offer a buttress effect in all directions.

The imported fire ants frequently build their mounds around, next to, or on some object such as a tree stump. They also move to fence rows, pond dams, terraces, ditch banks or other elevated areas. These actions all seem to be related to getting out of overly wet soil conditions. Slopes such as road fills are favorite sites for mounds. The ants tend to take advantage of any higher soil area to get a gradient of soil moisture conditions for their brood rearing.

Some observers have stated that the ants will move from areas, such as plowed fields, where mounds are frequently disturbed. This point has never been proven, and cases can be cited where the mounds have been disturbed daily without causing the ants to move. Possibly the moves that occurred following the plowing of fields may have been due to a dearth of food in the area after it was clean plowed.

**ECOLOGY**

It was mentioned earlier that the light phase ants were replacing those of the dark phase. In a similar manner either the dark phase or the light phase have been replacing the southern fire ant, *S. xylonii* McCook, where the two species have met in Mississippi. This was also reported by Wilson and Brown (1958), but they reported that this is not entirely the case with *S. giminata* (Fabricus), the tropical fire ant, in locations where it occurs. This seemed to be due to a dark phase of the latter ant species surviving in woodlawn sites where the imported fire ant is usually less numerous.

The low numbers of the imported fire ants in hardwood forest was reported by Green (1952). It was noted also by Green (1962) that tall grass or other heavy growths of vegetation restricted the establishment of new colonies. This seems to be due to the removal of surface soil moisture by plants in the summer when it is needed by the queens to rear their first brood in their shallow burrows. If a colony becomes established in such a wooded location, the ants seem to fare quite well, and they have been found to forage in the tops of timber by climbing the boles or trunks of the trees. The light phase ants frequently have large populations of colonies in young pine timber along the southern part of the range near the Gulf Coast. The rainfall in this area is usually frequent, and this may account in part for the success of new colony establishment in the pine forests.

Under the subject of life history, the development of the queen to a new colony about one year old was discussed. It was mentioned that in some situations, the small new colonies were sometimes found in large numbers. These small new colonies usually do not make noticeable mounds in the first spring, since they are usually only about the size of an inverted teacup. During the following summer they gain in vigor and large numbers of worker ants are produced. At this stage they are still very hard to notice; since their mounds, like most others in the summer and fall, are usually not constructed much above the soil level. During their second winter these new colonies build large mounds that can
be seen easily, since they are about 10 inches in diameter at the ground level and may be 6 to 10 inches tall. The dark phase ants have been studied more closely in this respect, and they frequently have mound populations of about 40 per acre at this stage of development.

During the spring equinoctial rains and storms, the dark phase ants from several neighboring colonies have been found to unite. In this manner it is usual for the mound count of these late second-year colonies to decrease to about 20 per acre during this period. The mounds are usually about 14 to 16 inches in diameter, and they may be about 10 to 14 inches high during the spring. On several occasions giant mounds have been observed. These formed as a result of most or all of the mounds combining from an area as great as 200 feet in diameter. These giant mounds and the associated uninfested areas have not been found later than about the first of May, and it is assumed that these united colonies may divide at some time before May.

When colonies are fully two years old, and at the time of the early summer nuptial flights, they seem to reach a stable size and number. There are usually about 20 mounds per acre and most of these measure from 16 to 24 inches in diameter at the ground level. The availability of food seems to limit the number and size of colonies in an area.

As the seasons progress, the stable number of mounds in a generally infested area usually decline. This may occur for any of several reasons, such as food supply, or perhaps moisture problems. Also colonies sometimes die out. It is not known how long a laying queen may live, or if more than one egg laying queen may exist in a colony. There seems to be some evidence that there is only one functional queen per colony, and there is some evidence that more than one may exist, at least for a time. The imported fire ant differs from the honeybee in this respect, since in the honeybee colony the queen does not tolerate the presence of another queen (even one of her daughters). On a number of occasions several wingless or delated fire ant queens have been observed in the same colony, but their lack of wings is not evidence that they were functional laying queens.

Fire ant queens, unlike queens of the honeybee, do not return to their parent colony following their nuptial flights. It has been noted on several occasions that mated fire ant queens were promptly killed when they landed in an area defended by workers of even small colonies. The presence of a few old colonies in an area seems to be a deterrent to new imported fire ant infestations by mated queens. Very few old colonies scattered about have been found to keep new colonies from developing; but this may be scant comfort to property owners if the old colonies are in objectionable locations.

**FEEDING HABITS**

The imported fire ant, like other species of fire ants, is considered to be "grease loving. Actually insects or insect products and other animals form the major part of the fire ant diet, as was mentioned earlier. No method has been devised to learn exactly what the food requirements are for their development; but Khan (1965) produced colonies that reared alate brood in nine months in the laboratory. This was done by furnishing insects as food, supplemented with hamburger meat, and High-Meat Dinner, strained baby food.

Mason (1957) calculated that there were about 60,000 ants that returned to an 18-inch mound in a 24-hour period. It was found in this study that the ants worked night and day at a nearly equal rate. Visual examination of the ants re-
revealed that about 25 percent of them returning from foraging trips were carrying burdens in their mandibles, and all of these burdens were parts of insects. Fire ant mounds can frequently be found in tall grasses due to the dark green color of the grass growing on or near the mounds as a result of the improved soil fertility in the mound area. This is due to the plant nutrients deposited there by the ants.

The various kinds of food used by the ants can often be studied by examining the refuse in their kitchen midden, which is often located in a soil depression on the south side of the mound. There are frequently large numbers of bits of arthropod (insects, millipedes, etc.) exoskeletons piled here and quite often enough morphological characters remain to determine what the ants feed on. The ants carefully remove all soft parts of these organisms and leave only the hard skeletal structures.

Although the imported fire ants will scavenge insects that they may find dead, they have been observed to attack and kill live, vigorous and apparently healthy insects such as grasshoppers. These large insects are usually impeded in their escape by the attacks of several ants, and during the struggle many ants may join the fray. They eventually ball up on the appendages of their prey, and all seem to be trying to sting it. In a short time the insect becomes paralyzed and then it is only a matter of time until the ants devour their victim.

Imported fire ants have been observed to attack and kill various kinds of caterpillars for food. Some of those killed were one to two inches long, thus they were many times larger than the ants; but their best efforts of writhing to shake the attacking ants were useless.

The use of termites as a major food source by the fire ant is doubtful, although they are known to feed on them. Apparently the termites being social insects are able to organize the defense of their galleries against serious attacks. The two insects share the same habitat in many places, such as in young pine timber. This is particularly noticeable where pine harvesting has left stumps and tops for the termites to infest.

The remains of pill bugs or other crustacea are often found in the kitchen mounds of the imported fire ant. At some times of the year, small terrestrial snails seem to form part of the ant diet also. The seasonal use of such forms for food is probably a result of their activity in the habitat due to favorable moisture conditions, or perhaps it is due to a dearth of insects for food for the ants.

Tests to determine the most acceptable of the families of insects as fire ant food have been inconclusive. The fire ants seem to have very poor receptors to aid is locating their food. Their eyes are not well developed, and apparently they are not readily able to detect the odors of food. Once a source of food is located by an ant it will return to a tunnel leading to its mound. Almost at once other ants appear at the food source. It has been determined that with the proper stimulation, glands at the tips of the abdomens of ants are used to lay down highly volatile, short-lived trails of chemical that can easily be detected by other members of that species. In this manner sister ants are able to find the food source. This is now called a trail finding pheromone.

Chemicals of this type have recently been termed pheromones, though for a time they were called external hormones. They have a wide range of adaptations by insects, and many other animals including man, are known to make use of them.

Another use of pheromones by the fire ant is to spread an alarm among ants when they are busy feeding. It has been
observed that when ants are feeding in large numbers, they do not easily notice an approaching object; however, if one of the ants is disturbed, it will emit an alarm pheromone, which triggers an alarm among all the ants in the group and they immediately hurry to the nearest tunnel. This is a most intriguing phenomenon to observe. The alarm is spread silently in a wave along a line of feeding ants, and their response appears to be to that of a command.

It was mentioned earlier that testing the fire ant preference to various kinds of insects as food was difficult. It can be seen from the feeding habits mentioned here that the first acceptable food they find, largely by chance, is consumed by a trail of ants, and then more food may be sought. Therefore, it is very difficult to get any clearer defined evidence of food preference.

Although the imported fire ant feeds extensively on the bodies of insects which would usually contain large amounts of protein food, this ant is still considered to be a “grease loving” type. Many insects have large fat reserves in their bodies in addition to proteins and other foods; thus the nutritional requirements of the fire ant may be met. The bait material presently used successfully for control of the imported fire ant uses a vegetable oil as a food material. Other baits have been tested that contained peanut butter which has a high oil content. A large number of other oily or greasy foods have been tested and found to be quite acceptable also.

During summer the ants have been found to tend a number of plant sucking type insects to collect a honeydew material secreted by them. They have been found on stems or leaves of a number of plants tending aphids of several sorts. Also they have been found tending scale insects on limbs of trees. The ants frequently construct “chimneys” or covers around these insects. This helps to protect these insects from their natural enemies. These structures are usually made of soil particles, but plant debris is frequently employed in dry weather. Mealybugs, particularly on the roots of a number of kinds of plants, are also tended by the fire ants, and these too are carefully covered by the ants.

When fire ants are tending a large number of insects on the plant, they sometimes construct a small auxiliary type of mound at the base of that plant. The function of this mound is not understood, however, since the ants are found constantly returning from it to the main mound, and no replete castes of workers have been found.

The need for the sweet honeydew food seems to be largely during the summer when the majority of the brood being produced is that of workers. It is not known if some other carbohydrate source is present in the spring when large numbers of a late reproductile brood forms are being produced; but no great feeding activity on honeydew has been noted. It is difficult to understand how the ants find enough food of any sort to produce the large spring brood. Usually this brood production starts in early March when insects that they would use for food would be at their lowest numbers.

Additional studies are needed on the foods and feeding habits of this ant. Studies are now underway to find some food additives that may improve the bait control presently being use.

**FISH KILL BY**

An interesting phenomena has occurred on several known occasions where bluegill fish and yearling largemouth bass were killed by feeding on fire ants.

**IMPORTED FIRE ANTS**

It has been reported that masses of ants floated into ponds or lakes following heavy rains in the spring, have been fed on by fish and that this has resulted in
fish mortality. The flights of reproductive forms of the imported fire ants landing in ponds were reported by Green and Hutchins (1960) as causing fish mortality. Both bluegills and yearling bass were found to be killed by feeding on these winged forms when flights of the ants landed on the ponds during the very early spring is unseasonably warm weather. As few as four winged females killed a yearling bass. In laboratory tests it was found that winged females or worker ants could cause fish kill, but males were not toxic. In these tests the ants were macerated and fed to fish in a water suspension with a glass pipette. Death of the fish occurred in a few minutes after the ants were fed to them. The fish would dart about wildly for a short time before they lost their equilibrim and died.

In unpublished reports, other investigators were unable to cause fish mortality by force feeding them on intact ants encased in gelatin capsules. Even repeated feedings in this manner failed to cause fish kill.

The above finding prompted further study in this matter by the author. It was found that several digestive enzymes reported to be present in fish would detoxify the fire ant venom. Thus it appeared that feeding the fish on ants in capsules would allow time for the detoxification of the venom. Ants that were removed from the stomachs of dead fish were partially intact, but it was impossible to say with certainty how badly they had been masticated by the pharyngeal teeth of the fish when they were ingested; since they had been partially digested either before or after the death of the fish.

Most ponds are overstocked with fish, and the loss of even a high percentage of them might be beneficial; but of the cases of fish mortality reported, at least two resulted in the harmful loss of fish. These cases involved extensive fish mortality early in the second year after the ponds were stocked, and this resulted in the loss of the major portions of the potential breeding stocks. The dead fish that were dissected had little food except winged fire ant reproductive forms in their stomachs. At this season of the year (late winter or early spring) very little other food was available to the fish.

FIRE ANT VENOM

It was reported by Adrouny et al. (1959), that there are two reactions to fire ant stings from a medical point of view: a local necrosis, or a systemic reaction presumably due to allergy. In this report the necrotic principle(s) of the venom were studied. It was found that all of the venom was held in the venom sac attached to the stinger. Venom was found to be a strongly hemolytic nonprotein, soluble in nonpolar solvents such as petroleum ether. The pure venom was Ninhydrin-negative, with an alcalin reaction and gave a positive nitrogen test, but lost its activity with exposure to cation exchangers. Thus it was felt that the homolytic principle was associated with the alkaline constituents and that it was probably an amine. A simple method of testing the effect of the venom in the laboratory was developed using the erythrocytes of rabbits.

While this study was being made at the Department of Biochemistry at Tulane University in New Orleans, a similar study was being made at the Department of Entomology at Louisiana State University at Baton Rouge. In this study by Blum et al. (1958) it was reported that one and possibly two human fatalities from the allergic reactions to fire ant stings had been reported. It was found that the venom was water insoluble, but dispersed in water as fine milky-colored
globules. The venom was composed of an alkaline not (due to metal ions) carrier, with droplets of higher density suspended in it. It was found to be non-proteolytic. Spectro-photometric and spectrograph analyses showed that it was probably non aromatic in nature with a carbonyl group which did not appear to be an open chain simple ketone. It contained both methyl and methylene groups and the globule portion of the venom probably contained most of the carbonyl containing compound.

In addition to the chemical studies mentioned above, Blum and his co-workers found that many common insects could be killed by a topical application of the venom. It did not appear that the fire ant was highly susceptible to its own venom however. The venom appeared to be about as toxic as DDT to some of the insects tested. Instantaneous paralysis resulted from the treatment, and this suggested a sedative type nerve poison. A 1 to 50 dilution of the venom displayed a strong antibiotic action on several bacteria and a variety of molds.

Wilson (1959) suggested that the venom was closely allied to the odor trail material used by foraging worker ants which was mentioned earlier. He demonstrated that the odor trail material was secreted by an accessory gland of the sting apparatus and that the stinger was extruded to lay the trail. He further suggested that venom material might be used by the ants to dilute the odor trail material which could be used in very minute amounts.

CONTROL OF THE IMPORTED FIRE ANT

Most people who have encountered the imported fire ants or have had mounds on their property are strongly in favor of controlling them.

Most people who live on infested properties have attempted in some manner to destroy the colonies. and it has been amusing to hear some of the sadistic schemes that have been tried. No manner of death was considered to be too horrible for the ant. A favorite method described has been the use of gasoline to saturate the mound, and in many cases this method was embellished by setting fire to the gasoline. This method incidentally is not very effective, and it can be very dangerous.

There are two general methods of control of the fire ant that can be stated for use under various conditions: (1) mound treatments by fumigation, or with residual insecticides or baits; (2) area treatments with residual insecticides or baits.

In recent years most of the scientific writings about the imported fire ants have been concerning various types of control studies. No attempt will be made here to review all of this work; but rather some typical work that have resulted in major change or improvement in the control of the imported fire ant will be cited in a chronological order.

Early control method used against the fire ant included bait, or mound fumigation or insecticidal treatment. Fumigation of fire ant mounds in the field is generally expensive or ineffective and sometimes dangerous. Under some conditions fumigation may be useful however. Most fumigant materials such as methyl bromide, hydrogen cyanide, carbon bisulfide or commercial grain fumigants are highly effective if the gas is confined to allow for complete penetration of the mound galleries. These materials may be used effectively in the field by releasing the fumigant under a tarpaulin to cover the ant mound.

Fumigants injected into mounds with-
out a covering frequently kill many ants, but survivors have been found to move out of the mound with their brood. Under some conditions it was found that surviving ants opened holes in the mound crust to allow ventilation and then reoccupied the mound.

Materials used to treat individual mounds before World War II were generally some type of petroleum product that saturated the mounds, usually with poor results. The advent of the residual synthetic chlorinated hydrocarbon insecticides gave great promise of control, and even hope of eradication of the fire ant. Most of the early formulations of these materials were dusts that were used to treat the mounds and the areas around them. The most effective of these chemicals were chlordane, aldrin or dieldrin.

During the early 1950’s methods were developed that made area treatments with the residual insecticides much easier. Formulations of insecticides were developed that could be sprayed at low volumes from newly developed power equipment; and granular insecticide formulation and equipment for their application were also developed.

In the summer of 1955, weather conditions were highly favorable for the survival of new fire ant colonies. This resulted is very large numbers of new colonies becoming evident in many new areas of the southeastern states in January of 1957. The resulting condition has been referred to as the “explosive spread of fire ants.” The widespread concern voiced by those in the newly infested areas was soon publicized in many of the news media. As in most cases of alarm or concern, some articles grossly exaggerated the situation. National interest in the problem soon resulted in initiation of an eradication program. It was necessary for this work to proceed with only meager research data on area controls.

Some work in Alabama by Eden and Garrett (1955) and Blake (1956) had shown that area treatments with residual insecticides would control the imported fire ant. The early eradication program was based largely on these reports where heptachlor gave best results. As more data on control in Mississippi became available (Green and Hutchin, 1958), it was soon possible to design treatments that used much less of the heptachlor insecticide. The USDA Agricultural Research Service, Southern Plant Pest Control Region based in Gulfport, Mississippi, directed the fire ant eradication program. A team of researchers attached to this group studied methods of fire ant treatment to aid in the eradication program. Studies of this team resulted in the adoption of a program of double applications of relatively low rates of heptachlor. This concept of the repeated use of residual insecticides for eradication required much modification of the reasoning concerning the methods of treatment.

Thus it was possible from these studies to recommend a reduction in the amount of heptachlor used, from the originally higher rate of 2 pounds per acre, to 1.25 pounds per acre, and finally to 2 applications, each at 0.25 pounds per acre. These lower rates made the impact of the treatment on other biological forms less drastic.

The problem of insecticide residue hazards has limited the use of heptachlor and other of the residual insecticides. At present, fire ant treatments with residual insecticides are largely restricted to such properties as plant nurseries used in compliance with regulatory requirements designed to avoid the shipment of live ants on nursery stock. Most control and eradication work with fire ants is now done with baits that are fed on by the ants.

For many years food high in greases, oils and protein have been used in poison baits prepared to combat fire ants. The
toxicant used in these baits was thallous sulfate. This material was frequently mixed at a one half percent concentration, and this posed a definite toxic hazard. Since these baits were dangerous and expensive, they had only limited usefulness, usually in homes. The imported fire ants seldom invade homes, however.

Baits are known to be an ideal method for poisoning ants since the egg producing queens of the colonies can be killed in this manner. For this reason, a “slow acting” toxicant for the bait is ideal. Following World War II a large number of synthetic organic insecticides became available; but most of these materials were found to be either repellent to the ants at toxic levels, or they killed the ants on contact.

The first major “breakthrough” came as a result of area spraying tests of a number of candidate insecticides at Mississippi State University. In one of these tests the insecticide Kepone was used to treat some of the plots. Data collected on the short term effects of this material were discouraging as compared to such materials as heptachlor. When the plots were re-examined after several months had passed, all the ants were dead. The manufacturer reported this to other research teams where work with baits was in progress and where there was a need for suitable bait toxicants.

It was soon found that Kepone-peanut butter baits were very effective in killing the fire ants, (Hays and Arant (1960). The good results with Kepone led to the discovery that Mirex, which is produced by the same company, was even more effective. Studies by the USDA group developed this presently used Mirex. Reports of some of their studies, Lofgren et al. (1961 and 1963) reveal the scope of their efforts in developing the bait.

Mirex baits of increased potency have been produced and this has decreased the costs, both of the bait and its application without reducing the bait effectiveness. Mirex bait is made by dissolving the toxicant in a partly refined grade of soybean oil, which is then used to treat “corn cob grits,” which absorb the soybean oil and act as a carrier. This bait has been effectively applied with aircraft as well as with ground equipment.

In view of the low order of toxicity of this bait, it has been used to treat even municipal and residential areas without harmful effects. Tests at Mississippi State University have shown that individual mounds can be effectively controlled by hand applications of small amount of the bait. This has been done by scattering the bait in the general area of each mound without disturbing the ants, so that feeding activities will continue in a normal manner.

Mirex bait applications have been made most effectively in fair, warm weather in the early spring before the winged reproductive adults are produced. Treated colonies often “die out” slowly, and it may be several months before the death of all the survivors.

At present, research efforts are directed largely toward studies of the biology of the imported fire ant. This is being done to improve the use of baits to try to avoid reinfestations of areas where the ants have been killed.

There has been a general policy of the Plaat Pest Control Division of the USDA toward a containment of the imported fire ant on the northern edge of the infested area by using large scale area-wide treatments with baits.
LITERATURE CITED


