REPRINTED FROM

Fire Ants and Leaf-Cutting Ants

Biology and Management

edited by Clifford S. Lofgren
and Robert K. Vander Meer

Westview Press / Boulder and London

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Agricultural and Medical Impact of the Imported Fire Ants

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AGRICULTURE

The earliest suggestion of economic damage by imported fire ants (IFA), Solenopsis invicta and S. richteri (=S. saevissima var. richteri), was made in the spring of 1935 when a corn crop was damaged at Fairhope, Alabama; however, it was not reported until more than ten years later by Eden and Arant (1949). They also said damage to several other vegetable crops in 1937 was of sufficient concern that local, state, and Federal agencies attempted control of the ants with cyanogas dust on 2000 acres. Later, Lyle and Fortune (1948) concluded that IFAs were a major crop pest in Mississippi. Wilson and Eads (1949) conducted surveys in Baldwin and Mobile counties in Alabama and found that IFAs fed on corn, peanut and bean seeds, and the roots, stems and occasionally leaves of corn, beans, Irish potatoes, sweet potatoes and cabbage. Crop damage for these two counties for 1948 was estimated to be in excess of $500,000.

The absence of data on the economic impact of IFA for the ensuing 20 years may be correlated with the widespread use of chlorinated hydrocarbon insecticides to control a number of soil and crop insects. Though the use of these chemicals was cancelled by the Environmental Protection Agency during the 1960s, the residue remaining in the soil was probably not depleted until the mid-1970s. Thus, a resurgence of IFA populations in agricultural lands was not apparent until the late 1970s (Lofgren et al. 1975; Adams et al. 1976; Adams et al. 1977). It is commonplace at the present time to find soybean and corn fields supporting as many as 100 to 125 colonies/ha. Potato fields in central Florida have recently been found infested with IFA at damaging levels, and young citrus in the Indian River area of Florida currently support extremely heavy infestations (>200/ha), especially in groves with micro-mist irrigation systems.

The impact of IFA populations on the growth and yield of various crops has been studied in recent years so that cost-benefit ratios could be estimated. Adams et al. (1976, 1977) compared the yield of soybeans from paired fields in Georgia and North Carolina in which one field in each pair was infested with IFA (108 to 184 mounds/ha), and the other field was rendered essentially IFA-free through the use of mirex bait. Mechanical losses due to variations in combine or harvesting techniques ranged from \$6.00 to \$11.56/ha. However, Lofgren and Adams (1981) found that the lower yield of soybeans in infested fields could not be attributed solely to mound interference with the harvester. They found that yields from heavily infested fields invariably averaged 14.5% less than yields from lightly infested fields. Small plot studies conducted at Gainesville, Florida supported these findings with a statistically significant 15% reduction in yield from the IFA-infested plot.

Smittle et al. (1982) labeled corn, okra and soybean plants with radioisotopes (^{32}P) and found evidence of feeding by the IFA on all three crops. Ants were not observed feeding directly on soybean plants, but ants collected around the roots of these plants were radioactive, implying that they were feeding on plant roots.

Adams et al. (1983) reported that the plant density and yield of soybeans from field plots in Gulfport, Mississippi and Gainesville, Florida infested with IFA were significantly different from comparable non-infested plots. The plot in Gulfport was infested at a rate of ca 115 mounds/ha, while the plot at Gainesville was infested at ca 108 mounds/ha. The reductions in plant density in the infested plots at Gulfport and Gainesville were 20% (3.5 plants/m) and 35% (14.1 plants/m), respectively. Yields were reduced by 20% ($P < 0.05$) in Gulfport and 33% ($P < 0.001$) in Gainesville. Furthermore, the Gainesville study showed a significant decrease (P 0.02) in both plant height (4.9 cm) and in the number of bean pods per meter of row (215.3) in the IFA-infested plots.

Apperson and Powell (1983) studied the factors affecting soybean production in North Carolina in 1979 and 1980 and found a negative correlation between IFA and soybean seed yield. A reduction of 403 to 672 kg/ha of seed was attributed to IFA activity (C. Apperson, personal communication). However, IFA impact in soybeans, like other factors, can vary seasonally and geographically.

Adams (1983) reported the loss of ca 50% of an eggplant crop of 12 ha in Marion County, Florida. The loss was directly attributed to extremely heavy predation by IFA on the newly set seedlings. The growth tips of many surviving plants were damaged, and dirt was carried up and deposited in leaf axils and the crowns of the plants.

Our current research includes an investigation of the impact of IFA on production of Irish potatoes and citrus. The study on potatoes was initiated in 1983 at the Gainesville laboratory. Two plots, each consisting of 10 rows 30 m long, were planted with two varieties of potatoes (Sebago and Russett Centennial) in alternating rows. One plot was infested with IFA at a rate of 108 mature colonies/ha and the other was maintained IFA-free. In 1983, reductions of 27.1 and 27.9% of marketable potatoes were recorded from the Sebago and Russett Centennial varieties, respectively; in 1984 comparable reductions of 20.5 and 20.9% were noted.

Results from the 1984 small plot studies were compared with data collected from field studies of a commercial field in St. Johns County, Florida. Data collected from 25 randomly selected sites (1 meter of row ea.) in a 10 ha field heavily infested with IFA, and 25 similar sites in an ant-free field, showed a 35.0% reduction of marketable potatoes in the IFA-infested field (var. Sebago).

During the mid-1970s, reports were received regarding IFA shredding bark from newly planted, non-bearing citrus groves, four years or younger, in six counties in Florida. Recent surveys indicate that 22 of the citrus-producing counties in Florida are affected to some degree. A survey of young groves in Hendry County indicated that all groves were affected, and one grower claimed 25% tree loss in a newly set one-year-old grove of 240 ha. A second grower was preparing to re-set 3500 trees, representing 5.4% of the trees in a 400 ha grove. A random survey of the affected trees by the author and a Florida Extension Service Citrus Specialist indicated that half of the trees died of a fungus disease (Phythophora sp.) while the remaining trees showed classic symptoms of girdling by IFA. Replacement cost of the trees (1982 prices) was $1.75/tree plus $2.50/tree for planting, fertilization and labor. Grove maintenance was estimated at $10.00/tree/year.

Damage to young trees (one to five years old) apparently begins in late fall at the onset of cold weather. The IFA colony migrates to the base of the young tree and, using the trunk of the tree for support, constructs a mound that may be 30 to 50 cm in height. The ants forage actively in the tree, sometimes tending honeydew-producing scales or aphids. They also appear to be attracted to plant sap exuding from the tree. Other damage occurs when the ants shred the bark within the confines of the mound. In the early spring, citrus flowers are attacked by foraging worker ants, apparently feeding on the nectar. Feeding around the calyx results in a greater than 50% decrease in flower maturation. Newly set fruit from these flowers are readily attacked. With oranges, this occurs at the stylar end, while in grapefruit the stem end is attacked. More than 70% of the trees inspected in three groves were heavily infested with IFA in March coinciding with the appearance of the early flowers. Heavy damage (40.8%) to newly set fruit was apparent in early May, and only 15% of the original fruit set remained on the tree in late May. Following fruit set, IFA attacked new, succulent, flush growth, essentially pruning the young branches from the tree.

Surveys of infested counties showed that IFA populations in young citrus groves were extremely high, ranging from 160 mounds/ha in Hendry County to 556/ha in Indian River County. These high levels of infestation are attributed, in part, to the manner of land preparation prior to planting and to the fact that a majority of the newly planted groves are on reclaimed pasture land already heavily infested with IFA.

Laboratory studies confirmed that IFA readily feed on citrus flowers, sap and various tissues (unpublished data). This was evident from studies in which trees were labeled with ^{32}P and exposed to queen-right colonies, as well as the discovery of fresh plant tissue in infrabuccal pellets. In these tests with potted greenhouse trees, all other arthropods were excluded. About 30% of the ants collected the first day after exposure were radioactive. The percentage of radioactive IFA increased daily through five days reaching a maximum of ca 70%.

MEDICAL AND PUBLIC HEALTH

The word "fire" in the common name of S. invicta and S. richteri is descriptive of the reaction of people to their sting. It is not surprising then, that their medical and public health impact is of primary concern. Presently about 40 million people live in IFA-infested areas of the southeastern U.S. and Puerto Rico. Public health surveys by Clemmer and Serfling (1975) and Adams and Lofgren (1981) suggest that 29 to 35% of the population or 11 to 14 million individuals may be stung one or more times each year. Paull (1984) estimates from published data that 0.61% of people who are stung experience generalized systemic anaphylaxis. Assuming these estimates to be correct, 67 to 85 thousand individuals per year require the care of physicians and/or emergency treatment for anaphylaxis. Severe hyperallergic reactions are a constant concern for these persons. As Paull (1984) states, "Although deaths from fire ant stings are rare, many patients who have sustained allergic reactions to a fire ant sting live in daily fear of subsequent stings." Undoubtedly fears of this type are one of the driving forces behind demands for IFA control.

The serious potential to public health associated with IFA stings is also emphasized by the extreme potency of the proteinaceous allergenic compounds of the venom (Lockey 1974; James 1976). The average volume of venom of the IFA is 0.07 to 0.10 ul, of which less than 1% (0.001 ug) represents the proteinaceous components (Rhoades 1977). By comparison, the protein content of the average bee sting is ca 50 ug.

Additional concern about hypersensitivity to IFA stings is evident from the medical literature. Mueller (1959) suggests that unrecognized fatal cases of insect stings occur with greater frequency than is realized. Schwartz (1984) also emphasized the possibility that insect sting attacks may explain some deaths. His conclusion was based on a study of the blood samples of 95 individuals who died of unknown causes. Antibodies indicative of a reaction to insect stings were found in 23% of his study population while less than 1% of his control group of 216 healthy blood donors contained such antibodies. Further, he suggests that as much as 10% of the population may have allergic reactions to insect attacks and that the number of deaths from insect stings—officially listed as less than 100 per year—is grossly underestimated because of a lack of diagnostic tests by physicians and coroners.

Triplett (1973) reported generalized urticaria and angio-edema as the most common complaints of people to IFA stings. More severe complaints include respiratory, gastro-intestinal and shock symptoms. Rhoades (1977) further defined the symptomatology to include cardiovascular and neurologic symptoms. Adams and Lofgren (1982) reviewed the medical records of 329 patients from Fort Stewart, Georgia and found that edema (81%) and urticaria (51%) were the most common symptoms encountered while respiratory distress (7.1%) was the least common, though the most severe. These less serious reactions, edema and urticaria, though not life-threatening, may be no less debilitating to certain individuals. They further reported that 6.8% of the patients seeking aid for IFA encounters suffered secondary infections that required multiple visits to a doctor or hospital for medical assistance.

MISCELLANEOUS

Forestry

Direct loss of longleaf pine seedlings, *Pinus palustris*, resulted when 32.8% of germinating seeds were eaten by IFA (Campbell 1974). Wilkinson and Chellman (1979) reported a 40% reduction of mean tree height in a 50-ha pine plantation infested with native pine tortoise scale that was tended and propagated by IFA. The authors cited a high potential for damage should the scale-ant association develop and persist in the future.

Mechanical

Damage to secondary roads, resulting from IFA excavating soil from beneath the roadway, was reported from Carteret County, North Carolina, in 1975 (R. Grothaus, personal communication). This excavation, which reached a depth of 4 ft, weakened the road foundation and, subsequently, vehicular traffic caused a subsidence and eventual breaking of the surface of the road. In a survey of 40 miles of roadway in March 1977, fully mature IFA colonies averaged

20/mile with a corresponding subsidence at each colony location. Cost of repair to the highway, furnished by the North Carolina Department of Transportation, averaged $100/subsidence for material and labor. Similar damage to secondary roads reportedly occurs in all coastal counties in North Carolina.

Damage of a different type has been observed by the author on Interstate 75 in the vicinity of Tampa, Florida. In this case, a new silicone sealant used to seal expansion joints in the concrete highway was damaged when the ants chewed portions of the styrofoam backer rod and penetrated the sealant strip, thus permitting rain-water to seep into the joints. Random examination of 8,267 linear feet of seal revealed 226 sites of penetration by IFA. Each mile of highway contained about 36,500 linear feet of seal. Thus, 996 sites per mile of highway were damaged by IFA. Replacement costs, excluding inspection and labor, was reported to be $3.00/linear foot of sealant.

Wildlife

Fire ant predation on wildlife populations has been verified for 6 avian species. These include quail (Travis 1938, 1943), wood duck and the roseate spoonbill (Ridlehuber 1982), barn swallow (Kroll et al. 1973), Mississippi kite (Parker 1977), and black-bellied whistling duck (Delnicki and Bolen 1977). Mount et al. (1981) reported predation by IFAs on the eggs of the lizard Cnemidophorus sexlineatus using the radioisotope ^{32}P, and Mount (1981) reported that nine species of reptiles that were abundant in the Alabama coastal plain in 1968 were now either "locally common" (8 species) or "infrequent." He suggested that predation by IFA on the eggs and new-born young was primarily responsible for the observed lowered population trends. The author further states that a lapse of 10 to 20 years is to be expected between the time of initial IFA infestation and the time the impact becomes obvious to the field naturalist.

DISCUSSION AND SUMMARY

The preceding review graphically illustrates that IFA have a wide-ranging impact on man, animals, plants, and the general ecology of their habitats. Despite this, their economic impact has been a point of controversy for many years with their status reported as ranging from beneficial or minor nuisance to major economic pest. Published data suggest that their omnivorous diet includes a wide range of plant and animal life including pest and beneficial species (see Reagan, Chapter 6). Much of their economic impact can be attributed to their opportunistic feeding behavior in concert with their life cycle. For example, spring is a time of active planting of commercial crops which coincides with a surge in fire ant production of worker and sex brood. It is not surprising, then, that foraging fire ant workers take advantage of germinating seeds, seedlings, and new plant growth as food. Thus, soybeans, young citrus trees, and potato tubers become susceptible to attack. This plant-feeding aspect of IFA behavior has been neglected since the early report of Wilson and Eads (1949), possibly because soil residual insecticides were controlling the IFA.

Recent laboratory studies demonstrated the need of IFA colonies for carbohydrates (Williams et al. 1980). Plant sap is a logical source of this nutrient since feeding on honey-dew produced by insects is infrequently observed for fire ants. The importance of plant sap as an energy source was shown in detailed studies of the leaf-cutting ant, Atta cephalotes, by Quinlan and Cherrett (1979). They found that carbohydrates in plant sap, not the ants' fungus symbiont, provide the major energy requirements for the worker caste.

All of these data support the need for comprehensive studies of the nutritional and energy requirements of IFA and their potential sources in nature. Studies of this type would greatly enhance our ability to elucidate the potential harmful and beneficial aspects of IFA feeding behavior.

The public health problems of IFA stings have been the subject of many studies, but the actual monetary costs associated with them are, at best, poor estimates. Aside from costs, however, mental anguish coincident with hyperallergic reactions and dangers to very young children while they play outdoors are very real problems for many persons. Therefore, it is only proper that many allergists are alerting their fellow physicians to the fact that IFA stings are an increasing problem, one which they need to recognize and be prepared to treat (Lockey 1980; Paull 1984; deSchazo et al. 1984). For example, we have received three calls in the past six months regarding legal cases in which IFA have invaded nursing homes and attacked bed-ridden elderly patients. Hopefully, additional studies by medical authorities will continue to provide cost and injury data.

Miscellaneous activities of IFA associated with their mound-building and tunnel construction, aggressiveness, and their general obtrusive behavior in defending their territories can lead eventually to a variety of problems. Examples of this are the problems cited with ants tunneling under highways and their predation and harassment of wildlife.

For the future it is hoped that others will join in the documentation of both the harmful and beneficial aspects of IFA ecology. However, emphasis must be placed on the study of their total ecological impact. The fact that IFA are a "weedy" species (see Tschinkel, Chapter 7) insures that they will be man's constant companion as he lives, plays, and competes for space with them. It will behoove us to know our competitor so that simple, effective methods for maintaining the upper hand will always be available to control them in areas where they cause the most agricultural, medical, and environmental impact.

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