M 2417

PROCEEDINGS OF FAO/IAEA TRAINING COURSE ON USE OF RADIOISOTOPES AND RADIATION IN ENTOMOLOGY

Sponsored by

INTERNATIONAL ATOMIC ENERGY AGENCY

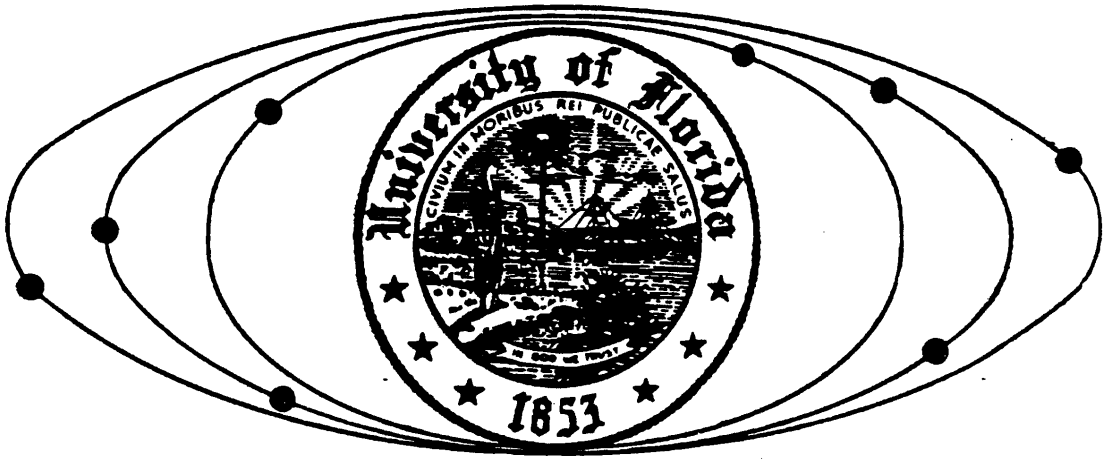
AND

FOOD AND AGRICULTURE ORGANIZATION

OF THE UNITED NATIONS

AND

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION



Host Institutions

Department of Entomology and Nematology

Institute of Food and Agricultural Sciences

University of Florida

Agricultural Research Service

United States Department of Agriculture

Gainesville, Florida

16 June - 8 August, 1986

USDA FIRE ANT PROGRAM
ECOLOGY, RADIOISOTOPE STUDIES, AND SURVEY OF BIOLOGICAL CONTROL AGENTS OF FIRE ANTS IN BRAZIL

Daniel P. Wojcik

Insects Affecting Man & Animals Research Laboratory
U.S. Department of Agriculture, P.O. Box 14565,
Gainesville, Florida 32604 USA

ECOLOGY STUDIES

Solenopsis invicta Buren, the red imported fire ant (RIFA), is a pugnacious, immensely successful invader of disturbed habitats throughout the Southeastern United States (Lofgren et al. 1975). The successful movement of RIFA into uninfested areas on its own by taking advantage of any manmade ecological disturbances, other than large-scale insecticide treatments, has not been documented. Gainesville, Fl, an area that has never received any large scale insecticide treatment, first became lightly infested with RIFA in late 1971.

Ants have been sampled periodically since March 1972 on 100 bait stations along 4 roadsides in Gainesville, Fl. Each bait station is marked and the baits are placed in the same relative positions for each sampling period. One honey-agar cube and one small hamburger meatball ere individually placed on one-inch aluminum squares one to 3 ft apart at each site (Wojcik et al. 1975). The baits are left in place for one hour before collection.

To date (March 1986), 22 genera and 53 species of ants have been collected on the transect. After 14 years, 11,000 bait

collections and 711,725 specimens have been examined. Approximately 1/3 of the baits were collected with more than one species of ant on them and 1,771 baits did not have any ants on them. RIFA has gradually increased to where they now represent almost 50% of the collections and over 50% of the specimens collected. Over 50 sites are now permanently occupied by RIFA. This increase in RIFA populations is shown in Table 1. This increase occurred in spite of high populations of S. geminata (F.) and Pheidole dentata (Mayr). These 2 species are the 2 most common species besides RIFA collected on the transect and are usually considered good competitors of RIFA.

RADIOISOTOPE STUDIES

Most information on the feeding habits of ectosymbionts is based on direct observation rather than experimentation. Obtaining noteworthy observations usually requires an inordinate amount of time.

The presence of cuticular secretions in ants was demonstrated by Berwig (1959) using ^{32}P. The use of radioisotope tracers to study food relationships and trophallaxis in social insects was reviewed by Wilson (1971). The only ecosymbionts whose food relationships have been studied using radioisotopes are 2 species of staphylinid beetles (Holldobler 1967, 1970, 1971). It was found that the beetle larvae eat host larvae, and obtain liquid food through trophallaxis. These studies confirmed observations that the adult beetles solicit food from the ants and showed that the ants obtain glandular secretions from the beetle larvae. The only Scarabaeidae reported to be predators on the larvae of their

ant hosts are Cremastocheilus spp. (Cazier and Mortenson 1965; Alpert and Richter 1975). Wojcik (unpublished) observed this behavior with Martinezia dutertrei Chalumeau (200 hrs observation), but not with Euparia castanea Serville (50+ hr of observation time). Many species of ectosymbionts have trichomes (tufts of long golden hairs associated with glands) on which their hosts feed (Wilson 1971). Travis (1941) observed Solenopsis geminata workers continually cleaning E. castanea at the junction of the prothorax and elytra (the usual location of trichomes). We observed this behavior often and saw similar behavior between S. invicta or S. richteri Forel and M. dutertrei. Examination of both species of beetles failed to reveal any trichomes or glandular areas at this junction (Wojcik unpublished).

These 2 beetles occur in fire ant nests in the Southeastern United States (Wojcik et al. 1977). M. duterteri was apparently introduced into the United States from South America with one or both of its introduced hosts, S. invicta and S. richteri (Woodruff 1973; Wojcik et al. 1977; Chalumeau 1983). E. castanea is native to North and Central America in nests of S. geminata and S. xyloni Mc Cook (Chalumeau and Howden 1984). As part of a continuing study of potential biological control agents of Imported Fire Ants, this study was designed to elucidate the feeding relationships between these beetles and their respective ant hosts.

E. castanea was tested with S. geminata. M. dutertrei was tested with S. invicta, S. richteri, and S. geminata and showed no preference for any one of these species. Whole colonies of ants were fed ^{32}P in beef baby food or ant diet. Unlabeled beetles

were exposed to various radioisotope labeled conditions for 24 hr (Table 2) and then checked for acquired radioactivity. Three groups of 10 unlabeled ants were separately exposed to labeled beetles for 24 hr and checked for transmitted radioactivity. M. dutertrei and E. castanea are symphiles which are predaceous on their ant hosts. In whole colony tests both species of beetles acquired radioactivity. M. dutertrei obtained food from live ants, but E. castanea did not. Both species of beetles ate ant larvae. E. castanea also obtained food from ant larvae by strigilation. Neither species of beetle fed on ant feces or other secretions on the substrate. Both species of beetle obtained food by strigilation from fresh dead and decomposed worker ants. M. dutertrei also ate both kinds of dead ants. Both species of beetles ate dead house flies, indicative of scavenging. This could indicate that they also feed on ant booty. Ants did not obtain food by trophallaxis or glandular secretion from either species of beetle (Wojcik 1975).

The use of radioisotopes to study relationships between ectosymbionts and their hosts has great potential. Carefully designed and controlled experiments could aid in defining ectosymbiotic relationships and quickly prove or disprove previously reported relationships.

SURVEY FOR BIOLOGICAL CONTROL AGENTS OF FIRE ANTS IN BRAZIL

In February 1984, the U.S. Department of Agriculture and the Empresa Brasileira de Pesquisa Agropecuaria jointly established a laboratory at the EMPA-MT Agricultural Research Station in Caceres, Mato Grosso (MT), Brasil, for the purpose of surveying

for and evaluating the natural biological control agents of fire ants, primarily S. invicta. Standard size samples of 2 1/2 liters of tumulus excavated from fire ant mounds are placed in buckets. The ants and myrmecophiles are separated from the soil by floatation with water (Jouvenaz et al. 1977). Individual ants and aqueous mass extracts of ants are examined microscopically for pathogens (Jouvenaz et al. 1977). Myrmecophiles are identified and preserved.

Since April 1986, 1000 fire ant colonies have been examined for natural enemies. All of the colonies were collected within 200 km of Caceres, except for about 100 colonies that were collected near Campo Grande, Mato Grosso do Sul. Single colonies may commonly contain several species of pathogens and/or myrmecophiles. No correlation has been found between the occurrence of any of the pathogens and/or myrmecophiles.

The total numbers and other parameters for each pathogen and myrmecophile collected during the 21-month survey (July 1984 through March 1986) are given in Table 3. Of the 1000 colonies examined, 757 contained at least one species of pathogen and/or myrmecophile. The known biology of these pathogens and myrmecophiles is discussed, respectively, by Jouvenaz (1986) and Wojcik (1986). The microsporidians, Thelohania solenopsae Knell, Allen, and Hazard and Vairimorpha sp., are known only from South America and infect brood and adult ants. The neogregarine, Mattesia geminata Jouvenaz and Anthony, has been found in Solenopsis spp. nests in North and South America and infects only immatures. The undescribed nematode (Mermithoidea: Tetradonematidae) was found for the first time in February 1985;

it infects brood and adults. Several other pathogens including virus-like particles, an undescribed neogregarine, a fungus and possibly a bacterium have been reported from fire ants in Brasil, but have not been collected during this survey.

The scarab beetles (genus Martinezia) and the unidentified Thysanura are predacious on fire ant brood. Nothing is known about the biology of the unidentified hister and chrysomelid (case-bearing larvae) beetles or the lygaeid bugs. The ectoparasitic larvae of the wasps of the genus Orasema (Eucharitidae) cause malformation and death of fire ant pupae. The adult wasps lay their eggs in plant tissue causing cosmetic damage. The workerless obligate parasitic ant, Labauchena sp., has been collected once during this survey, and our attempt to colonize this species in the United States was unsuccessful. One phorid fly puparium was dissected from an alate female fire ant. The unidentified millipedes are thought to be scavengers. Other myrmecophiles associated with fire ants in South America (Wojcik 1986) have not been collected during this survey.

In the coming year, we will continue the pathogen and myrmecophile survey. We will emphasize the collection and colonization of the nematode and the Labauchena sp. in order to evaluate these organisms for possible introduction into the United States. The ultimate goal of this project is to establish, in the United States, a complex of specific natural enemies as a biological control component of an intergrated pest management program for fire ants.

Literature Cited

Alpert, G.D., and P.O. Richter. 1975. Notes on the life cycle and myrmecophilous adaptations of Cremastocheilus armatus (Coleoptera: Scarabaeidae). Psyche 82: 283-291.

Berwig, W. 1959. Untersuchungen uber cuticulare stoffabbabe bei ameisenweibchen durchgefuhit mit radioisotopen. Naturwissenschaften 46: 610-611.

Cazier, M.A., and M.A. Mortenson. 1965. Bionomical observations on the myrmecophilous beetles of the genus Cremastocheilus (Coleoptera: Scarabaeidae). J. Kansas Entomol. Soc. 38: 19-44.

Chalumeau, F. 1983. Batesiana et Martinezia, nouveax genres d'Euparіini (Coleoptera: Scarabaeidae: Aphodiinae) du nouveau monde. Bull. Mensuel Soc. Linn. Lyon 52: 142-153.

Chalumeau, F., and H.F. Howden. 1984. Le genre Euparia (Coleoptera: Scarabaeoidea: Aphodiinae) Saint-Fargeau & Serville, 1828. Mitt. Schweiz. Entomol. Ges. 57: 85-94.

Holldobler, B. 1967. Zur physiologie der gast-wirt-beziehungen (myrmecophilie) bei ameisen. I. Das gastverhaltnis der Atemeles- und Lomechusa-larven (Col. Staphylinidae) zu Formica (Hym. Formicidae). Z. Vergl. Physiol. 56: 1-21.

Holldobler, B. 1970. Zur physiologie der gast-wirt-beziehungen (myrmecophilie) bei ameisen. II. Das gastverhaltnis des imaginalen Atemeles pubicollis Bris. (Col. Staphylinidae) zu Myrmica und Formica (Hym. Formicidae). Z. Vergl. Physiol. 66: 215-220.

Hollbobler, B. 1971. Communication between ants and their guests. Scient. Amer. 224: 86-93.

Jouvenaz, D.P. 1986. Diseases of fire ants: problems and opportunities. Fire Ants and Leaf Cutting Ants: Biology and Management (Lofgren C.S., Vander Meer R.K., ed.). Westview Press, Boulder, Co. pp. 327-338.

Jouvenaz, D.P., G.E. Allen, W.A. Banks, and D.P. Wojcik. 1977. A Survey for pathogens of fire ants, Solenopsis spp., in the Southeastern United States. Florida Entomol. 60: 275-279.

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

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

Wilson, E.O. 1971. The insect societies. Belknap Press, Cambridge, Ma. 548 p.

Wojcik, D.P. 1975. Biology of Myrmecaphodius excavaticollis (Blanchard) and Euparia castanea Serville (Coleoptera: Scarabaeidae) and their relationships to Solenopsis spp. (Hymenoptera: Formicidae). Ph.D. Dissert., Univ. Florida, Gainesville, Fl. 74 p. Dissert. Abstr. Intern. B 36: 5962.

Wojcik, D.P. 1986. Observations on the biology and ecology of fire ants in Brazil. Fire Ants and Leaf Cutting Ants: Biology and Management (Lofgren C.S., Vander Meer R.K., ed.). Westview Press, Boulder, Co. pp. 88-103.

Wojcik, D.P., W.A. Banks, and W.F. Buren. 1975. First report of Pheidole moerens in Florida (Hymenoptera: Formicidae). Coop. Econ. Insect Rep. 25: 906.

Wojcik, D.P., W.A. Banks, D.M. Hicks, and J.W. Summerlin. 1977. Fire ant myrmecophiles: new hosts and distribution of Myrmecaphodius excavaticollis (Blanchard) and Euparia castanea Serville (Coleoptera: Scarabaeidae). Coleopt. Bull. 31: 329-334.

Woodruff, R.E. 1973. The scarab beetles of Florida (Coleoptera: Scarabaeidae). Part I. The Laparosticti (subfamilies: Scarabaeinae, Aphodiinae, Hybosorinae, Ochodaeinae, Geotrupinae, Acanthocerinae). Arthropods of Florida and neighboring land areas. Vol. 8, 220 p.

Table 1. Summary of collections by year of red imported fire ants on the Gainesville transect.

YEAR	NUMBER OF MONTHS COLLECTED	NUMBER OF BAIT SITES OCCUPIED BY RIFA
1972	5	1
1973	6	1
1974	3	0
1975	2	7
1976	2	8
1977	5	17
1978	6	28
1979	6	34
1980	6	34
1981	5	48
1982	5	48
1984	2	57
1985	2	58
1986	1	52

Table 2. Experimental conditions of the 8 trials used in each of the 4 experiments to determine the feeding relationships between M. dutertrei and E. castanea and their respective ant hosts. Each trial lasted 24 hr.

Trial	Radioactive status of beetles	Experimental condition	
		Agent	Radioactive status
1	unlabeled	whole colony	labeled
2	unlabeled	worker ants	labeled
3	unlabeled	larvae	labeled
4	unlabeled	ant feces or secretions	labeled
5	unlabeled	fresh dead ants	labeled
6	unlabeled	3-day dead ants	labeled
7	unlabeled	fresh dead house flies	labeled
8	labeled	worker ants	unlabeled

Table 3. Summary of collection records for pathogens and myrmecophiles found in 1000 fire ant colonies in Brasil.

Organism	Number of colonies with organism	No. of specimens	Avg. No. per nest	Range	Median	Mode
Pathogen						
Thelohania	22					
Vairimorpha	46					
Mattesia	64					
Nematode	7					
Myrmecophile						
Scarabaeidae	213	637	3.0	1-31	2	1
Histeridae	189	392	2.1	1-12	1	1
Chrysomelidae	2	3	1.5	1-2	1.5	-
Eucharitidae	413	7225	17.5	1-598	4	1
Formicidae	1	101	-	-	-	-
Lygaeidae	16	28	1.8	1-5	1	1
Thysanura	17	30	1.8	1-12	1	1
Diplopoda	111	554	5.0	1-48	2	1
Totals	757	8970				

Abstract

Gainesville, Fl, an area that has never received any large scale insecticide treatment, first became lightly infested with Solenopsis invicta Buren, the red imported fire ant (RIFA) in late 1971. Ants have been sampled periodically since March 1972 on 100 bait stations along 4 roadsides in Gainesville, Fl. To date (March 1986), 22 genera and 53 species of ants have been collected on the transect. After 14 years, 11,000 bait collections and 711,725 specimens have been examined. Approximately 1/3 of the baits were collected with more than one species of ant on them. RIFA has gradually increased to where they now represent almost 50% of the collections and over 50% of the specimens collected. Over 50 sites are now permanently occupied by RIFA.

In the radioisotope studies, Euparia castanea Serville was tested with S. geminata (F.). Martinezia dutertrei Chalumeau was tested with S. invicta, S. richteri Forel, and S. geminata and showed no preference for any one of these species. Whole colonies of ants were fed ^{32}P in beef baby food or ant diet. Unlabeled beetles were exposed to various radioisotope labeled conditions for 24 hr and then checked for acquired radioactivity. Three groups of 10 unlabeled ants were separately exposed to labeled beetles for 24 hr and checked for transmitted radioactivity. M. dutertrei and E. castanea are symphiles which are predaceous on their ant hosts. In whole colony tests both species of beetles acquired radioactivity. M. dutertrei obtained food from live ants, but E. castanea did not. Both species of beetles ate ant larvae. E. castanea also obtained food from ant larvae by

strigilation. Neither species of beetle fed on ant feces or other secretions on the substrate. Both species of beetle obtained food by strigilation from fresh dead and decomposed worker ants. M. dutertrei also ate both kinds of dead ants. Both species of beetles ate dead house flies, indicative of scavenging. This could indicate that they also feed on ant booty. Ants did not obtain food by trophallaxis or glandular secretion from either species of beetle.

Brief accounts will be given of the known pathogens, parasites, and predators of the fire ants in Mato Grosso, Brasil. The Pathogens include two microsporidians, one neogregarine, and one nematode. Phorid flies, eucharitid wasps, parasitic ants, predaceous scarab beetles, hister beetles, chrysomelid beetle larvae, thysanura, and millipedes have been collected from fire ant nests in Brasil. Their potential for use in a biological control program for fire ants in the United States is discussed.