OBSERVATIONS ON THE SEXUAL CASTES OF THE FIRE ANT PARASITE *SOLENOPSIS DAGUERREI* (HYMENOPTERA: FORMICIDAE)

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Several natural enemies of fire ants, *Solenopsis* spp., have been under study as biological control agents (Briano et al. 1995a and 1995b; Porter et al. 1995a, 1995b and 1997; Orr et al. 1995; Pesquero et al. 1995; Williams et al. 2000). The workerless parasitic ant, *Solenopsis daguerrei* (Santschi 1930) (= *Labauchena daguerrei*), discovered in Argentina in 1930, has been considered a potential candidate for the biological control of the imported fire ants, *Solenopsis invicta* Buren and *Solenopsis richteri* Forel, in the United States since the 1970´s (Lofgren et al. 1975; Jouvenaz et al. 1981; Jouvenaz 1983 and 1990).

The abundance of this parasite and its detrimental effects in the host colony were documented on populations of fire ants in Argentina and other parts of South America (Bruch 1930, Silveira-Guido et al. 1973, Briano et al. 1997, Pesquero et al. 1998, Calcaterra et al. 1999). It was found only parasitizing the *Solenopsis* complex species (Calcaterra et al. 2000). Its presence was low in the areas surveyed (Briano et al. 1997), however, lower fire ant densities were observed in parasitized locations and fewer host queens were found in parasitized compared to nonparasitized colonies (Calcaterra et al. 1999).

Little is known about the mating behavior and dispersal mechanisms of this ectoparasitic ant. Observations made by Silveira-Guido et al. (1973), suggested that copulation is rapid, occurs inside the nest or on the tumulus, and that one male can copulate with several females or more than once with the same female. Thus, the purpose of this study was to determine if *S. daguerrei* females are effectively fertilized in the host nests and to observe them after they fly out of colonies.

Observations were made in two consecutive warm seasons (April to June 1999, and February to May 2000). Fifteen *S. richteri* colonies parasitized with *S. daguerrei* were collected in San Eladio, 60 km W of Buenos Aires, Argentina (59° 10'W, 34° 45'S). The colonies were put in buckets coated with talc, brought to the laboratory, and placed in a walk-in cage (2 by 2 by 2 m) in a plastic greenhouse. When weather conditions (24-33°C, and high RH) and time of day (from 2.30 to 5.30 p.m.) were acceptable, sexuals of *S. daguerrei* flew out of the host nests. Most of the sexuals (n = 756) were captured on the ground with an aspirator, immediately after landing, a couple of meters away from the buckets. Then, they were sexed. Females were kept overnight in small plastic (ventilated) tubes with moist tissue paper to discover if they lost their wings. Preliminary observations had indicated that many females lost their wings immediately after capture when still confined within the aspirator. Also, we assumed that the tendency to dealate would be similar to its fire ant host, whose newly-mated queens lose the wings immediately after landing for colony founding. A sample of the parasitic females (n = 183) was dissected to determine if the spermatheca contained sperm, a confirmation of insemination.

After several weeks, the parasitized colonies in buckets were separated from the soil by flotation (Banks et al. 1981). The remaining *S. daguerrei* sexuals were collected, sexed, and the females kept in tubes, then dissected to confirm insemination.

Almost all the sexuals captured on the ground, 97.6%, were females, and 62.3% of them lost their wings a few minutes after capture (Table 1). However, the tendency to dealate was not consistent; in some colonies, almost 92% of the females lost their wings, while in others, none of the females captured lost their wings (Table 1). The reason for this difference is unknown. Most females collected after flying out of host colonies were inseminated: 84% of wingless females and 76% of winged ones. Because of this, it seems that insemination by itself is not the only condition for dealation.

On the other hand, none of the 120 females collected after flotation lost their wings and only 40% were inseminated. It appears that these mated females remained in the nests waiting for appropriate conditions to fly. No males were found in the host colonies. However, because the ratio of females to males for *S. daguerrei* is usually 3:1 (Calcaterra et al. 1999), we assumed that most males did not leave their host colonies and died within them.

Based on these results, we conclude that most *S. daguerrei* females are fertilized in the host nest and immediately after they fly for dispersal. It seems that males do not abandon their host colony. This agrees with Wilson (1971) who reported that, in inquiline species, nuptial flights are often

TABLE 1. CAPTURE AND DISSECTION OF SEXUALS OF *S. DAGUERREI.*

Date	Temp. (°C)	No. of sexuals captured		% of females that lost their wings	No. (%) of wingless females		No. (%) of winged females	
		♂	♀		Dissected	Inseminated	Dissected	Inseminated
				Sexuals after flying out of the colonies				
20 APR 99	24	1	22	88.9	4	4 (100)	10	8 (80)
21 APR 99	27	1	37	91.3	6	5 (83)	4	4 (100)
22 APR 99	27.5	0	94	74.5	29	26 (90)	18	13 (72)
23 APR 99	32	5	156	75.4	—	—	62	55 (89)
16-23 FEB 00	27-33	7	245	73	36	28 (78)	—	—
24-31 MAR 00	28-32	4	106	—	—	—	—	—
5 APR 00	28	0	13	—	—	—	—	—
13 APR 00	28	0	27	35	—	—	—	—
24 APR 00	33	0	24	0	—	—	—	—
28 APR 00	32	0	14	0	—	—	14	2 (14)
Total or mean	29.2	18	738	62.3	75	63 (84)	108	82 (76)
				Sexuals remaining in the colonies				
16 JUN 99	—	0	28	0	—	—	28	9 (32)
20 MAR 00	—	0	34	0	—	—	34	17 (50)
15 MAY 00	—	0	58	0	—	—	58	22 (38)
Total or mean	—	0	120	0	—	—	120	48 (40)

replaced by the mating of nest mates within or near the host nest. He also stated that a probable consequence of this is geographic fragmentation of populations of inquiline species. This seems to be the case with *S. daguerrei,* which has small and localized populations in Argentina (Briano et al. 1997). According to Hölldobler and Wilson (1990) this applies to most permanent parasites.

To determine if mated *S. daguerrei* females could parasitize new host colonies, we took 326 females that flew out of their host colonies (most of them newly-mated queens) and transferred them to 8 *S. richteri* and 3 *S. invicta* nonparasitized colonies, collected in San Eladio and San Justo (Santa Fe Province), respectively. These test colonies were housed in trays according to Banks et al. (1981) and kept in darkness at 15°C to make it easier for establishment of the parasite. After a week, the colonies were put back under light conditions at 30°C to stimulate egg laying of both host and parasite queens.

Survival of the introduced parasites ranged from a few minutes to almost three weeks. Mortality of the parasite queens was 93% between days 1-3, 95.6% by day 7, 99.8% by day 14, and 100% by day 21. Despite the unsuccessful attempts at parasitism, we frequently observed that some queens of *S. daguerrei* found and yoked host queens very rapidly. These parasite queens survived longer in the host colonies, while those that did not yoke to any of the host queens were killed immediately. This lack of successful parasitization is consistent with some field attempts in which no parasitization was obtained.

We speculate that if eggs were laid by parasitic *S. daguerrei* queens before being killed, this F1 generation would be "accepted" by the host colony and thus initiate parasitism. However, further tests are necessary to confirm this hypothesis.

We thank Sanford Porter, Lloyd Morrison, and Everette Mitchell (USDA-ARS, Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, FL) for reviewing the manuscript. Support for these studies on *S. daguerrei* has been partially provided by Dr. Lynne Thompson, University of Arkansas-Monticello.

SUMMARY

When weather conditions were favorable, most females of *S. daguerrei* flew out of their host colonies. The large majority, 76 to 84%, were mated, and 62.3% lost their wings after the flights. Some females remained in their host colonies, 40% of which were inseminated. None of the females remaining in the colony lost their wings. Attempts to initiate parasitism were unsuccessful; however, those parasite queens yoked to host queens survived longer than those that did not.

REFERENCES CITED

BANKS, W. A., C. S. LOFGREN, D. P. JOUVENAZ, C. E. STRINGER, P. M. BISHOP, D. F. WILLIAMS, D. P. WOJCIK, AND B. M. GLANCEY. 1981. Techniques for collecting, rearing and handling imported fire ants. USDA. Sci. and Educ. Admin. Adv. in Agric. Tech. AAT-S-21. 9 pp.

BRIANO, J. A., R. S. PATTERSON, AND H. A. CORDO. 1995a. Relationship between colony size of *Solenopsis richteri* (Hymenoptera: Formicidae) and infection with *Thelohania solenopsae* (Microsporida: Thelohaniidae) in Argentina. J. Econ. Entomol. 88: 1233-1237.

BRIANO, J. A., R. S. PATTERSON, AND H. A. CORDO. 1995b. Long.term studies of the back imported fire ant (Hymenoptera: Formicidae), infected with a microsporidium. Environ. Entomol. 24: 1328-1332.

BRIANO, J. A., L. A. CALCATERRA, D. P. WOJCIK, D. F. WILLIAMS, W. A. BANKS, AND R. S. PATTERSON. 1997. Abundance of the parasitic ant *Solenopsis daguerrei* (Hymenoptera: Formicidae) in South America, a potential candidate for the biological control of the red imported fire ant in the United States. Environ. Entomol. 26: 1143-1148.

BRUCH, C. 1930. Notas preliminares acerca de *Labauchena daguerrei* Santschi. Rev. Soc. Entomol. Argent. 3: 73-80.

CALCATERRA, L. A., J. A. BRIANO, AND D. F. WILLIAMS. 1999. Field studies of the parasitic ant *Solenopsis daguerrei* (Hymenoptera: Formicidae) on fire ants in Argentina. Environ. Entomol. 28: 88å95.

CALCATERRA, L. A., J. A. BRIANO, AND D. F. WILLIAMS. 2000. New host for the parasitic ant *Solenopsis daguerrei* (Hymenoptera: Formicidae) in Argentina. Florida Entomol. (in press).

HÖLLDOBLER, B., AND E. O. WILSON. 1990. The Ants. Belknap, Cambridge, MA.

JOUVENAZ, D. P. 1983. Natural enemies of fire ants. Fla. Entomol. 66: 111-121.

JOUVENAZ, D. P., C. S. LOFGREN, AND W. A. BANKS. 1981. Biological control of imported fire ants: a review of current knowledge. Ann. Entomol. Soc. Am. 27: 204-208.

JOUVENAZ, D. P. 1990. Approaches to biological control of fire ants in the Unites States, pp. 620-627. *In* R. K. Vander Meer, K. Jaffe & A. Cedeño [eds.], Applied Myrmecology: A World Perspective. Westview Press, Boulder, CO.

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

ORR, M. R., S. H. SEIKE, W. W. BENSON, AND L. E. GILBERT. 1995. Flies suppress fire ants. Nature 373: 292-293.

PESQUERO M. A., S. D. PORTER, H. G. FOWLER, AND S. CAMPIOLO. 1995. Rearing of *Pseudapteon* spp. (Dipt. Phoridae), parasitoids of fire ants (*Solenopsis* spp.) (Hym. Formicidae). J. Appl. Entomol. 119: 677-678.

PESQUERO M. A., H. G. FOWLER, AND S. D. PORTER. 1998. The social parasitic ant, *Solenopsis* (*Labauchena*) *daguerrei* (Hymenoptera: Formicidae) in Sâo Paulo, Brazil. Rev. Biol. Trop. 46: 464-465.

PORTER, S. D., H. G. FOWLER, S. CAMPIOLO, AND M. A. PESQUERO. 1995a. Host specificity of several *Pseudacteon* (Diptera: Phoridae) parasites of fire ants (Hymenoptera: Formicidae) in South America. Florida Entomol. 78: 70-75.

PORTER, S. D., M. A. PESQUERO, S. CAMPIOLO, AND H. G. FOWLER. 1995b. Growth and development of *Pseudacteon* phorid fly maggots (Diptera: Phoridae) in the heads of *Solenopsis* fire ant workers (Hymenoptera: Formicidae). Environ. Entomol. 24: 475-479.

PORTER, S. D., D. F. WILLIAMS, AND R. S. PATTERSON. 1997. Rearing the decapiting fly *Pseudacteon tricuspis* (Diptera: Phoridae) in imported fire ants (Hymenoptera: Formicidae) from the United States. J. Econ. Entomol. 90: 135-138.

SANTSCHI, F. 1930. Un nouveau genre de fourmi parasite sans ouvrieres de l´Argentine. Rev. Soc. Entomol Argent. 3: 81-85.

SILVEIRA-GUIDO, A., J. CARBONELL, AND C. CRISCI. 1973. Animals associated with the *Solenopsis* (Fire ants) complex, with special reference to *Labauchena daguerrei*. Proc. Tall Timbers Conf. Ecol. Anim. Control Habitat. Manage. 4: 41-52.

WILLIAMS, D. F., D. H. OI, AND G. J. KNUE. 2000. Infection of red imported fire ant (Hymenoptera: Formicidae) colonies with entomopathogen *Thelohania solenopsae* (Microsporida: Thelohaniidae). J. Econ. Entoml. (in press).

WILSON, E. O. 1971. The insect societies. Belknap, Cambridge, MA.