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

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ABSTRACT Abundance of the workerless parasitic ant *Solenopsis daguerrei* (Santschi) in fire ant populations was surveyed in southern and southwestern Brazil, eastern, central, and northern Argentina, western and northern Uruguay, central Paraguay, and Bolivia from 1974 to 1996. A total of 12,180 fire ant colonies was sampled from 726 collecting sites for the presence of adults or queens, or both, of the parasitic ant. The presence of the parasite in fire ant colonies within the area surveyed was very low. In Argentina, *S. daguerrei* occurred in the provinces of Buenos Aires, Santa Fe, and Entre Rios, in 1.4-7.0% of the colonies. In Brazil, the areas of Dourados, Campo Grande, and Rochedo, Mato Grosso do Sul contained 1-6.2% of parasitized colonies. In Uruguay, <1% of the colonies were parasitized. The parasite was not found in Paraguay and Bolivia. A new host (*S. macdonaghi* Santschi) is reported for *S. daguerrei*. The field site with the highest presence of *S. daguerrei* (7%) was selected in Buenos Aires province for ecological studies. The low presence in its native areas should not discourage the potential use of this parasite as a biological control agent of imported fire ants in the United States.

KEY WORDS *Solenopsis daguerrei*, imported fire ants, parasitic ant, social parasitism, biological control, South America

RESEARCH ON BIOLOGICAL control of the red imported fire ant, *Solenopsis invicta* Buren, in the United States was initiated in the 1960s as part of a program to find a permanent suppression of this serious economic pest (Lofgren et al. 1975). The biological control approach for fire ants has been further encouraged since mirex bait was canceled in 1978 because of the detrimental impact of toxic baits on the environment (Lofgren 1986) and because of efforts to reduce the use of chemicals for insect control.

The workerless parasitic ant *Solenopsis daguerrei* (Santschi) (formerly *Labauchena daguerrei*) was discovered by Juan B. Daguerre in colonies of *Solenopsis richteri* Forel (formerly *S. saevissima* variety *richteri*) in a pasture of "El Toro" Ranch, Las Flores, Buenos Aires province, Argentina (Bruch 1930). The ant is a permanent parasite and belongs to the most advanced group of social parasites of ants (Hölldobler and Wilson 1990). Observations on the biology, behavior, and distribution of this ant were reported by Bruch (1930), Silveira-Guido et al. (1962-1969), Silveira-Guido et al. (1973), and J.A.B. and L.A.C. (unpublished data). According to Bruch (1930), the parasite can kill the host colony by decapitating the queens, at least under laboratory conditions. However, Silveira-Guido et al. (1965) never saw any evidence of decapitation. According to Silveira-Guido et al. (1973), the parasite is specific to the *Solenopsis* complex and affects the biotic potential of the fire ant colonies by causing, eventually, the total inhibition of the production of host sexuals. All these findings have made this species a potential candidate for introduction into the United States for the biological control of the red imported fire ant. Jouvenaz (1990) and Wojcik (1990) considered this parasitic ant to be the most promising arthropod candidate for introduction into the United States.

We made surveys of natural enemies of fire ant populations in South America from 1974 to 1996. Most initial surveys and collections were made in southwestern Brazil, plus one collection trip made through southern Brazil, Paraguay, northern Argentina, and northwestern Uruguay. Research on fire ants in South America has been concentrated at the USDA-ARS South American Biological Control Laboratory, Hurlingham, Buenos Aires, Argentina, since 1987. The objective of this work was to detect the abundance of *S. daguerrei* and select a field site to measure its actual impact on South American populations of fire ants. In this article we report the

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results of all surveys for *S. daguerrei* conducted in South America.

According to Kusnezov (1956), there are only 2 described species of *Solenopsis* (formerly *Labauchena*) known to be parasitic: *S. daguerrei*, distributed in central Argentina, and *S. acuminata* (Borgmeier), in northern Argentina. However, both ants appear very similar morphologically and might be considered the same species (Kusnezov 1956). According to Silveira-Guido et al. (1973), *S. daguerrei* occurs also in Uruguay. A 3rd species, *S. hostilis* (Borgmeier), is reported from Rio de Janeiro and Paraná, Brazil. For the practical purposes of this study, all of the parasitic ants discussed in this article are considered to be *S. daguerrei*. Voucher specimens of collections made in Argentina and Uruguay were deposited at the Museo de La Plata, Paseo del Bosque, 1900 La Plata, Buenos Aires province, Argentina; also at the entomological collection of the USDA-ARS South American Biological Control Laboratory, Hurligham, Buenos Aires province, Argentina. Voucher specimens of collections made in other countries are deposited at the entomological collection of the Center for Medical, Agricultural, and Veterinary Entomology, USDA-ARS, Gainesville, FL.

Materials and Methods

Area Surveyed. We sampled a total of 12,180 fire ant colonies from 726 collecting sites in southern and southwestern Brazil, eastern, central, and northern Argentina, western and northern Uruguay, central Paraguay, and a small area in eastern Bolivia near the Brazilian border (Fig. 1). Collecting trips were conducted from July 1974 to June 1996, including general surveys for natural enemies of fire ants (1974, 1975, 1976, 1979, 1981, 1984, 1985, 1986, 1987) and special trips for *S. daguerrei* collections (1987–1996).

Because the Brazilian area of the Pantanal was believed to be the origin of *S. invicta*, the state of Mato Grosso was the 1st area surveyed for biological control agents in South America. A total of 3,888 colonies was sampled mainly in the state of Mato Grosso, but also, after its creation in 1979, in Mato Grosso do Sul.

In Argentina, several surveys of fire ant natural enemies have been conducted since 1987. In total, 7,727 colonies were sampled within the provinces of Buenos Aires, Santa Fe, Entre Rios, Corrientes, Misiones, Chaco, and Formosa. Some collecting sites within the province of Buenos Aires were sampled periodically, such as the area of Saladillo (180 km SW of Buenos Aires), where we conducted the most intensive sampling, including a total of 1,846 colonies of *S. richteri*. Sampling was done in April 1987, and then every 30–50 d from October 1988 to July 1990, and every 2–4 mo from September 1991 to January 1996. Another intensively sampled area was Las Flores, Buenos Aires province (190 km SSW of Buenos Aires), the type locality of *S. daguerrei*, where we sampled 1,108 colonies of *S. richteri* in April 1987 and then every 3–4 mo from October 1991 to November 1995.

In Uruguay, we examined 489 colonies in the departments (counties) of Artigas, Soriano, Rio Negro, Paysandú, Salto, and Tacuarembó. In Paraguay, we sampled 60 colonies in the central part of the country and only 16 colonies in eastern Bolivia, close to the Brazilian border.

The ants sampled in Mato Grosso and Mato Grosso do Sul, Brazil, were *S. invicta* (90%), *S. saevissima* Smith (9%), *Solenopsis* sp. (1%), and a few *S. macdonaghi* Santschi. The ants sampled in Bolivia were all *S. invicta*. The ants sampled in Paraguay, southern Brazil, and Argentina were *S. invicta*, *S. richteri*, *S. quinquecuspis* Forel, *S. macdonaghi*, *S. saevissima*, *S. megergates* Trager, and *Solenopsis* sp. The ants sampled in Uruguay were *S. richteri* and *S. macdonaghi*. All collecting sites were along roadsides and in pastures.

Collection Methods. In the collections made from 1974 to 1981, a small sample of ants and brood from the tumulus (1 liter or less) was put in buckets for separation by flotation in the laboratory (Jouvenaz et al. 1988). In the collections made from 1984 to 1986, the colonies were excavated and put in 10-liter buckets for flotation according to the methods described by Banks et al. (1981). In the collections made since 1987, the following 2 methods were used: (1) some colonies were sampled by scattering the mounds on the ground or pavement, and examining them intensively in the field; and (2) some colonies were excavated and put into 10-liter buckets for separation by flotation (Banks et al. 1981). The floated colonies were put in rearing trays and the presence of adults or queens, or both, of *S. daguerrei* was recorded. We kept alcohol samples of most colonies.

Some colonies collected during early trips were taken to the quarantine facilities of the Florida Department of Agriculture, Division of Plant Industry, Gainesville, FL. Most colonies collected during 1995 and 1996 were taken (or shipped) to the quarantine facilities of the Center for Medical, Agricultural, and Veterinary Entomology, USDA-ARS, Gainesville, FL, for further research. Exportation permits for material collected in Brazil were issued by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renovaveis, Departamento da Vida Silvestre, Brasilia, Brazil. The introduction into the United States was done under USDA- APHIS-PPQ permits.

Results and Discussion

The total presence of adults or queens, or both, of *S. daguerrei* was scarce in the area surveyed in South America. We found them only in 170 (1.4%) fire ant colonies (Table 1).

In Argentina, *S. daguerrei* was detected in 10 sampling areas within the provinces of Buenos Aires, Santa Fe, and Entre Rios in 1.4–7.0% of the colonies

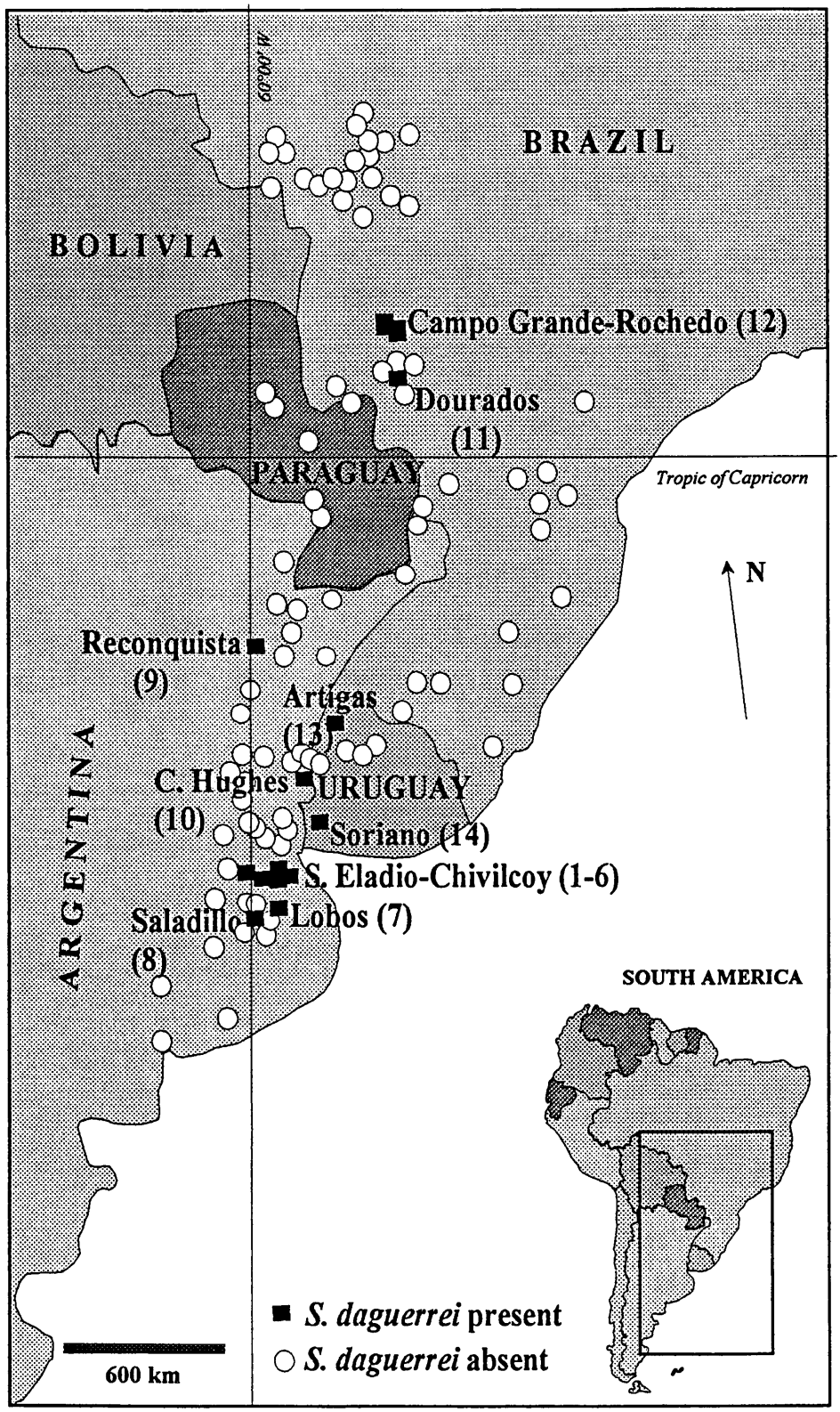

Fig. 1. Region of South America surveyed, indicating most collecting areas. Name of localities only where *S. daguerrei* was present (the numbers in parentheses refer to sampling areas in Table 1).

Table 1. Abundance of *S. daguerrei* in South America

Country and State	Sampling area[a]	No. collecting sites	No. colonies examined	No. (%) colonies parasitized	Sampling period
Argentina					
Buenos Aires	San Eladio (1)	9	828	58 (7.0)	I-VI-96
	Mercedes (2)	7	173	6 (3.5)	XII-95; I-96
	Suipacha (3)	6	250	7 (2.1)	I-III-96
	Chivilcoy (4)	5	149	3 (2.1)	I-III-96
	Luján (5)	1	96	2 (2.0)	V-96
	Duggan (6)	2	56	1 (1.8)	XII-95
	Lobos (7)	5	58	1 (1.7)	IV-87; IV-V-88
	Saladillo (8)	13	1,846	26 (1.4)	IV-87; VIII-88 to I-96
	Others	88	2,498	0	IV-87; VIII-88 to V-96
Santa Fe	Reconquista (9)	9	366	10 (2.7)	III-95; XI-95
	Others	28	423	0	X-XI-87; II-90; IX-94; III-95; XI-95
Entre Rios	C. Hughes (10)	3	94	2 (2.1)	XII-95; II-96
	Others	28	353	0	II-75; IV, VIII-87; II-90; XII-95; II-96
Corrientes-Misiones-Chaco-Formosa	Several	37	537	0	II-75; VIII-89; II-90; III-95; II-96
Brazil					
Mato Grosso do Sul	Dourados (11)	62	742	46 (6.2)	II, III, VI, X-86; VIII-87; IV, X-89; III-96
	C. Grande, Coxim, and Rochedo (12)	71	573	6 (1.0)	VII-74; II-75; II, III, VI, X-86
Mato Grosso	Cuiaba, Caceres, Rondonopolis, and others	251	2,495	0	VII, VIII-74; II-75; I-76; X, XI-79; V, VI-81; II, III, VI, XII-84; I, II, IV, IX-85; II, III, V, XII-86; XI-93
Rio Grande do Sul	Several	20	39	0	II-75
Santa Catarina	Lages, Sta. Cecilia	3	5	0	II-75
Paraná	Several	18	31	0	II-75
Sao Paulo	S. Grande, Maraci	2	3	0	II-75
Uruguay					
Artigas	Artigas (13)	6	128	1 (0.8)	XII-95
Soriano	Soriano (14)	9	194	1 (0.5)	XII-95
R. Negro-Paysandú-Salto-Tacuarembó	Several	15	167	0	II-75; XII-95
Paraguay					
Several	Several	26	60	0	II-75
Bolivia					
San Matías	San Matías	2	16	0	III-86
Total		726	12,180	170 (1.4)	

[a] Numbers in parentheses refer to sampling areas shown in Fig. 1.

(Table 1). We found the highest abundance of this parasite (7%) in the area of San Eladio, Buenos Aires province (80 km W of Buenos Aires). Surprisingly, we did not find *S. daguerrei* in its type locality (Las Flores). This contrasts with Silveira-Guido (1973), who reported that 31.6–38.4% of the colonies of *S. saevissima* variety *richteri* (now *S. richteri)* were parasitized in that area during 1964 and 1965. The reason for the decrease in the parasite population densities remains unknown and should be investigated.

In the area of Saladillo, the presence of adults of *S. daguerrei* was detected in March, May, June, and August 1989 (late summer, fall, and winter); in February, May, and June 1990 (summer and fall); in February, April, June, July, and August 1992 (summer, fall, and winter); in March 1995 (late summer), and in November and December 1995 (spring). This partially agrees with Silveira-Guido (1973) who reported 2 well-defined oviposition periods for this latitude: the 1st from July to October (winter-spring), which would determine the presence of sexuals in spring and summer; and the 2nd from January to March (summer) with sexuals in summer-fall. Surprisingly, we detected adult stages (sexuals) of *S. daguerrei* in winter also, when sexuals of the host are, in general, not present.

In Brazil, we found *S. daguerrei* only in Mato Grosso do Sul. In the area of Dourados, we found adults in 6.2% of the colonies, whereas in the area of Campo Grande and Rochedo in only 1% of the colonies of *S. invicta* (Table 1). We also collected adults from mounds in every season: July 1974 (winter), February 1975 (summer), March 1986 (late summer), June 1986 (late fall), October 1986 (spring), August 1987 (winter), April 1989 (fall), October 1989 (spring), and March 1996 (late summer). We did not detect the presence of this parasitic ant in this area during the trips made in 1976, 1979, 1981, and 1984. The reason for the apparent absence of the parasite during these years remains unknown, but it is consistent with the variations we observed in the collections in some areas of Argentina such as Las Flores and Santa Fe. Porter et al. (1992) in a survey in Mato Grosso do Sul, reported the presence of *S. daguerrei* in 4% of the *S. invicta*

colonies, similar to the parasitism reported above for the area of Dourados for a 22-yr period.

In Uruguay, this parasite was even rarer. We found adults of *S. daguerrei* only in Artigas and Soriano in 0.8 and 0.5% of the colonies, respectively (Table 1). We did not find *S. daguerrei* in Paraguay and Bolivia.

The 2 parasitized colonies found in C. Hughes, Entre Rios province, Argentina, and the 1 collected in Artigas, Uruguay, were *S. macdonaghi*. Silveira-Guido (1973) had mentioned only *S. richteri* and *S. saevissima* as natural hosts of the parasite in Argentina and Uruguay.

The finding of *S. daguerrei* in low densities agrees with Hölldobler and Wilson (1990) who reported that most workerless (permanent) parasitic ants are not abundant, and are distributed locally, found only at few sites, and very difficult to locate, thus giving the false impression that they are close to extinction. However, the abundance of *S. daguerrei* in the different areas surveyed in South America cannot be compared without considering the time and periodicity of the collections. As previously stated, density of this parasite in the area of Las Flores was extremely high in the 1960s (31.6–38.4%) but it was not detected in our surveys.

In the cold season (May to August), we observed that only the queens of *S. daguerrei* remained in some parasitized colonies. In these cases, the chances of finding them during a field examination are low and percentages of parasitism could be underestimated. For example, during our sampling at San Eladio in May, June, and July 1996 (fall–winter), we found that 10.3% of the sampled colonies, believed to be parasite-free after the 1st field examination, were actually parasitized. This was discovered once in the laboratory, where those colonies were floated and queens of *S. daguerrei* were found in them.

During the warm season (September to April), it is uncertain whether the immature stages and adults of *S. daguerrei* are always present within parasitized colonies. Some preliminary laboratory work (J.A.B., unpublished data) conducted in a rearing chamber at 26–28°C suggests that the presence of immature stages of *S. daguerrei* is cyclic. If this also occurs in the field, the absence of sexuals would not indicate the absence of parasitism and percentages of parasitism could be, again, underestimated. The recognition of egg and larval stages of the parasite within the host colony and the host–parasite relationship should be investigated. In summary, the abundance of *S. daguerrei* can be underestimated because of the collection method used and the apparent cyclic behavior of this parasite. This is especially true when colonies are opened, scattered, and examined in the field, because low infestation rates are difficult to detect with this method. Although extremely time consuming, the most efficient and reliable collection method (to avoid false negatives) was the excavation of most parts of the colonies and their examination in the laboratory after floation. We recommend this method be used in future collections.

Based on the surveys reported here, the areas of San Eladio, Argentina, and Dourados, Brazil currently show the highest abundance of *S. daguerrei*. It is important to consider, however, that the percentage of parasitism detected in San Eladio was obtained over a short period (from January to June 1996) and may not be stable in the future. Moreover, the search of other areas with higher densities of this parasite should be intensified to replicate field studies.

The low presence of *S. daguerrei* in South America could discourage research on its potential use as a biological control agent. However, we speculate that biotic or abiotic factors may limit its populations in South America. If so, once introduced in the United States and released from natural restrictions, *S. daguerrei* could propagate in the new habitat. However, both of these hypothetical limiting factors and a detrimental effect on the fire ants should be confirmed. The presence of this parasite in the San Eladio area will be monitored over time to better understand its dynamics and to evaluate its actual impact. This is essential before considering *S. daguerrei* for introduction into the United States for the control of the red imported fire ant.

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