Microsporidan and Fungal Diseases of *Solenopsis invicta* Buren in Brazil[1]

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Abstract: The first record of a microsporidan infection in the family Formicidae is presented. The organism, a *Thelohania* sp., was isolated from *Solenopsis invicta* Buren colonies in Brazil in 1973. Microsporidan spores were also observed in three other species of the *S. saevissima* complex. *Metarrhizium anasopliae* is also reported from *S. invicta* and the leaf-cutting ant *Atta sexdens rubropilosa*.

DISCUSSION

Although the Formicidae has been one of the most extensively studied families of insects, our knowledge of pathogens associated with the ant group is one of the most deficient areas in insect pathology. Many of the pathogens described from ants were isolated from a small number of individuals since "epizootics," such as those that occur in the Lepidoptera, are rarely observed.

All levels of association, ranging from symbiotic to parasitic relationships, can be found between microorganisms and various ant groups. The association of members of the Tribe Attini and their respective fungal symbionts is a well-known phenomenon and is discussed in detail by Wheeler (1907) and Weber (1972). Another well-documented relationship is that of the Laboulbeniomycetes fungi and the various insect orders including Formicidae. This group includes predominately obligate parasites which seem to have little or no effect on the well-being of their hosts (Benjamin, 1973). According to Smith (1946), *Formica* is the most common ant genus associated with members of the Laboulbeniomycetes, especially the genus *Laboulbenia*. For further information the reader is referred to an excellent review by Benjamin (1971) which includes a summary of the studies of Thaxter and others on the Laboulbeniomycetes.

A brief review of known pathogen involvement with the ant group is summarized in Table 1. An interesting disease of *Formica rufa* Linne in Western Siberia has been attributed to the fungus *Alternaria tenuis* Nes. (Dlusskii, 1967). The course of epizootics of the disease is vividly described by Marikovsky (1962) and is the first report of *Alternaria* as an insect pathogen. There is,

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however, reason to question the identity of the fungus, since members of the genus *Alternaria* have been reported only as common plant pathogens.

Several species of the fungus *Cordyceps* have been reported as "pathogens" of ants (Mains, 1948; Petch, 1932; and Van Pelt, 1958). However, McEwen (1963) raises the question of pathogenicity of *Cordyceps*, noting the lack of detailed accounts of pathological conditions in infected hosts.

Mains (1948) discusses two species of fungi as possible conidial or imperfect stages of bicolored species of *Cordyceps* pathogenic to ants. Included in this group are the genera *Stilbum* and *Hymenostilbi.*

In addition, the cosmopolitan fungal pathogens *Metarrhizium anasopliae* (Metchnikoff) Sorokin and *Beauveria bassiana* (Bals.) Vuill. have been described from ants (Steinhaus and Marsh, 1967). These two fungi appear to be very important ant pathogens in South America.

To date, no virus diseases in ants have been reported. However, Steiger et al. (1969) have observed "virus-like" particles in cell lines derived from the cephalic ganglionic center of *Formica lugubris* Zetterstadt. As in the case of viruses, pathogenic protozoa have not been reported in the Formicidae. Several groups, especially the microsporida, are important pathogens of other families in the order Hymenoptera. *Nosema apis*, the cause of "Nosema disease" in the honey bee, *Apis mellifera*, is an excellent example.

DISEASES ASSOCIATED WITH THE *Solenopsis saevissima* COMPLEX

Our knowledge of ant pathogens is no doubt related to the "economic importance" given to this group of insects. Generally speaking, no ant species is ranked as a "major" pest of agricultural crops, man, or animals. An exception to this is the "red imported fire ant," *Solenopsis invicta* Buren, which in recent years has been the target of an extensive research program in the southeastern United States.

Buren (1972) proposed a taxonomic model for the *Solenopsis saevissima* complex and showed that there are two species of imported fire ants in the United States (*S. richteri* Forel and *S. invicta* Buren), each from different homelands within South America. In 1971, the authors organized and coordinated a 17-day trip through western Brazil and established as the homeland of *S. invicta* certain areas of Mato Grosso, Brazil (Allen et al., 1974). One of the objectives of the trip was to isolate pathogens of the ant. The following is a report of primary pathogens isolated from specimens collected during the 1971 trip and later collections made by the senior author in February 1973 in and around the city of Cuiabá, Mato Grosso.

Microsporida

During a taxonomic examination of the 1973 collections, the junior author observed subspherical "cyst-like" bodies in the gasters of alcohol-preserved workers

TABLE 1. Fungi reported as pathogens of ants.

Ant Species	Fungus	Comments	References
Formica rufa	*Alternaria tenuis*	No known record of *Alternaria* entomopathogenic; well-known plant pathogen	Dlusskii (1967) Marikovsky (1962)
UNKNOWN	*Cordyceps* sp.		McEwen (1963)
UNKNOWN	*Cordyceps Australis* *Cordyceps bicephala* *Cordyceps necator* *Cordyceps proliferans*		Mains (1948)
Megaponera foetens	*Cordyceps bicephala*		Petch (1931)
Camponotus pennsylvanicus	*Cordyceps unilateralis*		Van Pelt (1958)
Camponotus castaneus	*Cordyceps* sp.		Allen (unpublished)
Camponotus sp.	*Stilbum burmense*		Steinhaus (1951); Mains (1948)
UNKNOWN	*Hymenostilbi australienses*	Originally described *Stilbum formicarium* by Cooke and Masse (Cooke, 1889)	Mains (1948)
Atta texana	*Aspergillus flavus* *Beauvaria bassiana*		Steinhaus and Marsh (1967)
Solenopsis saevissima richteri (= *S. richteri*)	*Metarrhizium anasopliae*		Steinhaus and Marsh (1967)
Solenopsis invicta	*M. anasopliae*		Allen (unpublished)
Atta sexdens rubropilosa	*M. anasopliae*		Allen (unpublished)
UNKNOWN	*Beauveria densa*	Placed in synonymy with *B. bassiana* by de Hoog, 1972	Leatherdale (1958)

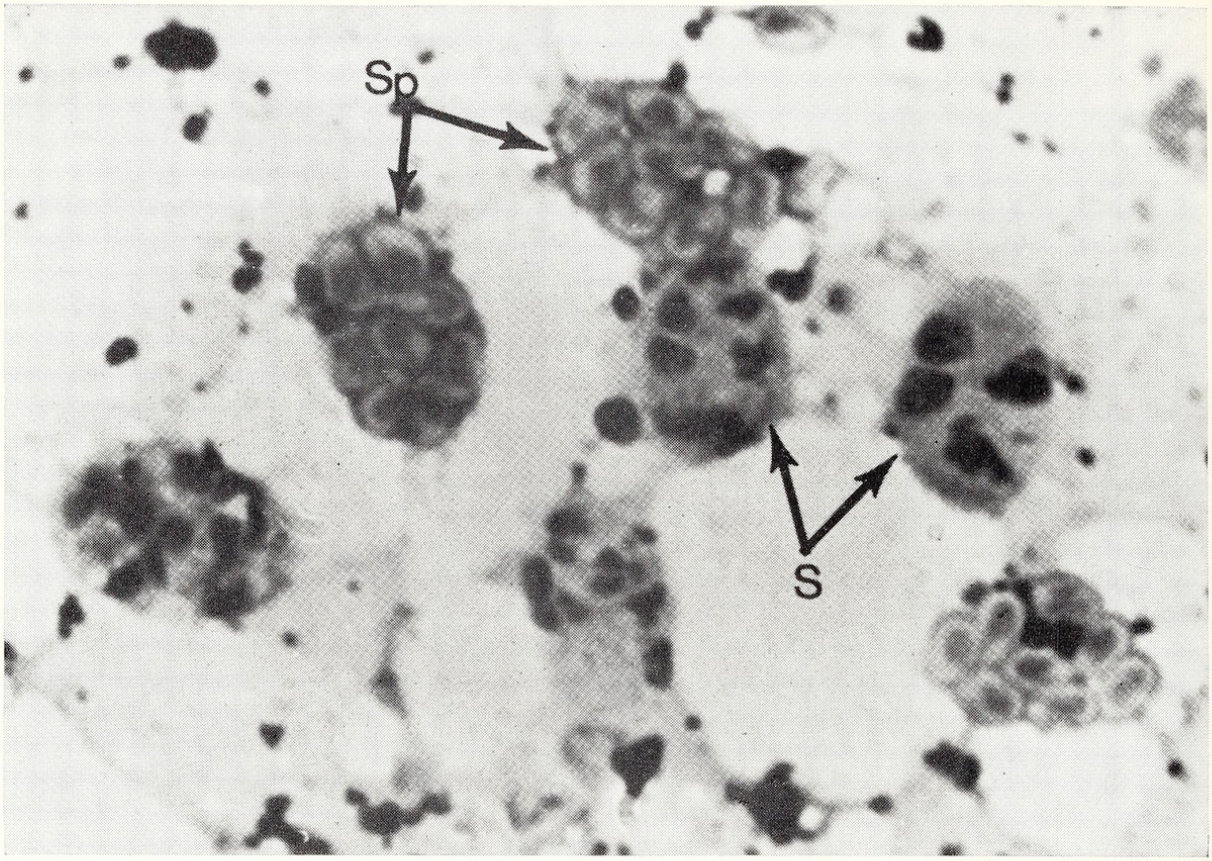

FIG. 1. Octanucleate sporonts (S) and spores within a sporont membrane (Sp) of *Thelohania* sp. in *S. invicta* workers, Giemsa smear, × 2,200.

of *S. invicta*. Histological examination showed the bodies were not cysts but rather masses of microsporida spores enclosed within fat body-cell membranes. These structures were not found in living ants examined later, even though both sporonts and spores were present.

The microsporidan isolated from living workers of *S. invicta* was *Thelohania* sp. Giemsa-stained smears showed that the octonucleate sporonts produce eight spores enclosed in a sporont membrane (Fig. 1). These characteristics place the microsporidan in the genus *Thelohania* Henneguy. Spores are pyriform with average fixed spore measurements of 3.4 $\mu \times 2.0$ μ. Schizonts of the microsporidan were also observed in Giemsa-staned smears of adult workers and queens of *S. invicta*. The primary site of infection was the fat body. To the best of the authors' knowledge, this is the first report of a microsporidan infection in the family Formicidae.

Every *S. invicta* colony sampled in 1973 showed a high infectivity rate. No mounds were evident and the colonies were found only after digging around large rocks, cement pillars, and other protective objects. Infected colonies appeared to have lower than normal populations and noticeable loss of vigor and pursuit when disturbed.

The potential of the *Thelohania* sp. as a biological control agent of *S. invicta*

in the United States can only be speculated at this point. The genus is well known and the associations of many of its species and their insect hosts have been described (Kudo, 1924; Weiser, 1961; Kellen et al., 1965; Chapman et al., 1966).

Microsporida spores were also observed in collections made in 1971 (Allen et al., 1974) from several localities, one of which appeared to be a *Nosema*. Collections of *S. invicta* from Cuiabá and Porto Velho were infected at the time of collection as well as three other species of the *S. saevissima* complex from Cuiabá, Mato Grosso, Campo Grande, Porto Manga, and Corumbá. Porto Velho is located in the Territory of Rondônia, which borders the state of Mato Grosso to the northwest. For a map depicting the location of these localities the reader is referred to Buren et al. (1974).

Fungi

The fungus *Metarrhizium anasopliae* was isolated from *S. invicta* workers and *Atta sexdens rubropilosa* Forel queens collected during the 1971 trip. This cosmopolitan pathogen is a well-known entomogenous fungus (Steinhaus and Marsh, 1962; Charles, 1941; and Leatherdale, 1958) which attacks a wide range of insect hosts. It was also reported from *S. saevissima richteri* Forel (= *S. richteri* Forel) in Uruguay (Steinhaus and Marsh, 1967).

Metarrhizium anasopliae reportedly attacks only the queens of *A. sexdens rubropilosa* in Brazil, where it is known as "queens disease" by the local citizens. The fungus may also attack worker ants, but these are not observed because the infected individuals probably leave the colony when infection is apparent, as is the case with *Formica rufa* (Marikovsky, 1962).

The foregoing report establishes the presence of both microsporidan and fungal diseases in *S. invicta*. Although we can report only the involvement of the *Thelohania* sp. and *M. anasopliae* at this time, there are strong indications that we can expect to find other genera of microsporida as well as "virus-like" pathogens of members of the *S. saevissima* complex in Brazil. Current studies are being conducted to determine the interrelationship of *S. invicta* and its *Thelohania* parasite and other pathogens of the *S. saevissima* complex.

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