

Recent records of *Myrmicinosporidium durum* HÖLLDOBLER, 1933, a fungal parasite of ants, with first record north of the Alps after 70 years

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Abstract

Myrmicinosporidium durum HÖLLDOBLER, 1933, a fungus parasitizing various ant species, has been found only sporadically. During a collecting trip in April 2004, we have found a couple of infected colonies of *Temnothorax albipennis* (CURTIS, 1854) and one of *Chalepoxenus muellerianus* (FINZI, 1922) in the Italian region of Abruzzo. Two colonies of the slave-maker *Chalepoxenus muellerianus* with host workers [*T. unifasciatus* (LATREILLE, 1798)] bearing the infection had been found near the Garda Lake in the Italian Alps in 2003. On 4 September 2004 the infection appeared in workers and in swarming gynes of *Solenopsis fugax* (LATREILLE, 1798) at Darmstadt, Germany, which is the first record north of the Alps since more than 70 years after its description from Würzburg, Germany.

We report these recent findings because nothing is known yet on the way of infection, although there are data on the range of the fungus. It has been described from southern Germany, later was found in several Mediterranean countries (Italy, Spain, the former Yugoslavia). The same, or a closely related species of fungus had been recorded from Texas, USA, and from the Galapagos Islands. A couple of *Temnothorax* species and their social parasite *Chalepoxenus muellerianus*, two species of *Pheidole* (France and Galapagos), *Solenopsis fugax* (Europe), and one species of *Pogonomyrmex* (USA), all Myrmicinae, but also *Plagiolepis* spp. (Formicinae), are known as host species so far. In 2004 another two species of *Solenopsis*, two *Pheidole*, *Pogonomyrmex badius* (LATREILLE, 1802), *Paratrechina vividula* (NYLANDER, 1846), and *Pyramica membranifera* (EMERY, 1869) from USA had to be added.

Key words: *Myrmicinosporidium durum*, fungus, ant disease, Formicoxenini, Pheidolini, Solenopsidini, Plagiolepidini

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Introduction

The "Näpfchenkrankheit" of ants first had been described by HÖLLDOBLER (1927, 1933) from Würzburg, Germany. *Temnothorax* (= *Leptothorax*, *Myrafant*) *interruptus* (SCHENCK, 1852) (?) and *Solenopsis fugax* (LATREILLE, 1798) were first recorded as host species. Infected ants contain numerous dark, lentiform capsules (ca. 30 - 50 µm) that become bowl-shaped when dehydrated in alcohol and xylol or when processed for Canada balsam embedding. In yellow or lightly brown colored ants the high number of the capsules causes a black appearance of the ants' gasters.

Originally believed to represent a protozoan ("Haplosporidia") infection, SANCHEZ-PEÑA & al. (1993) found out that the organisms in fact are spores of a fungus species. It is probably related to *Coelomomyces* in the Chytridiomycetes (SANCHEZ-

PEÑA & al. 1993). Its life cycle remains unknown as well as the way of infection. Infested specimens are found quite sporadically, but apparently are frequent in certain years.

SANCHEZ-PEÑA & al. (1993) have published a list of the hitherto known records of *M. durum*. The host species were the Myrmicinae *Solenopsis fugax*, *Pheidole pallidula* (NYLANDER, 1849), nine species of *Temnothorax*, *Chalepoxenus muellerianus* (FINZI, 1922), and the Formicinae *Plagiolepis vindobonensis* LOMNICKI, 1925 and *P. pygmaea* (LATREILLE, 1798), from Germany, Switzerland and several Mediterranean countries. In addition, *Pogonomyrmex barbatus* (SMITH, 1858), a myrmicine from Texas, USA, had been found to represent a host species of *M. durum* (or a closely related species).

More recently, ESPADALER (1997) recorded *Pheidole williamsi* WHEELER, 1919 from the Galapagos Islands as an additional host species. The two latter records considerably extend the hitherto known European range of the parasitic fungus.

Finally, PEREIRA (2004) has published the occurrence of *M. durum* in the eastern United States, in seven new hosts, including the fire ant species *Solenopsis invicta* BUREN, 1972.

The infection is said to become evident in fall, the infected ants survive the winter, and die in (late) spring (HÖLLDOBLER 1933). The investigations of HÖLLDOBLER (1927, 1933) led to the only reported observations on the maintenance of live infected individuals and colonies in the laboratory so far.

Methods and Results

New records of *Myrmecinosporidium durum*

12 March 2003: Italy, Manerba, Lago di Garda, 130 m a.s.l. (45° 33.206' N; 10° 34.051' E): Two colonies of the slave-making ant *C. muellerianus*, one with five (out of 218) and one with two (out of 52) infected *T. unifasciatus* host workers. No slavemaker was found to be infected by the fungus in these colonies.

25-26 April 2004: Italy, Colle della Croce, Abruzzi National Park, 1170 m a.s.l. (41° 44.545' N; 13° 59.537' E): Three colonies of *Temnothorax albipennis* with numerous infested workers: One colony, lacking a queen, had three infected workers out of 63; in a second colony, with queen, 33 workers out of 83 were infected, and in the third colony, also queen-right, 84 workers out of 112 were bearing the infection) (Fig. 1). One colony of the slave-making ant *Chalepoxenus muellerianus* with *Temnothorax unifasciatus* as host: 29 out of 532 fungus-infected slaves and three out of 38 infected slave-makers.

4 September 2004: Germany, Darmstadt, 160 m a.s.l.: Alate females of *Solenopsis fugax* were found swarming from a garden terrace, at about 16:00. The weather was sunny, and the temperature just above the soil was ca. 30 °C. Four out of five females, and 10 out of 16 workers crawling around the nest entrances were found to be infested (Figs. 2 - 3).

Behavioral observations

In one of the two colonies collected in 2003, containing five infected *T. unifasciatus* host workers, the behavior of these fungus-infected workers was compared to the behavior of five uninfected *T. unifasciatus* workers during 90 sessions of scan-sampling (instantaneous sampling, ALTMANN 1974, MARTIN & BATESON 1993). The following behavioral categories were recorded: 1. location of the ant (outside /inside the nest); 2. antennation; 3. grooming; 4. exploring; 5. resting; 6. feeding.

Fungus-infected workers did not show any detectable aberrance in their behavior. They did not clus-



Fig. 1: Queen (center) and workers of *Temnothorax albipennis* (= *T. tuberointerruptus*) from one of the recently detected colonies in the Italian Abruzzo. The workers in the upper line have the characteristic black gasters, all other specimens are healthy.



Fig. 2: *Solenopsis fugax* gynes in translucent light. Left: a healthy specimen. The crop is shining, filled with an oily substance. Right: the somewhat enlarged gaster appears black, filled with numerous *Myrmecinosporidium* spores.

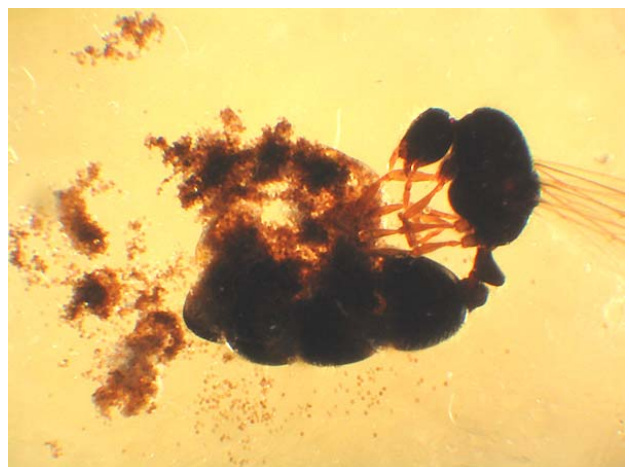


Fig. 3: Infested *Solenopsis fugax* gyne opened in order to expose the very numerous *Myrmecinosporidium* spores.

ter together but mixed with the uninfected workers and performed the usual worker tasks like foraging and feeding larvae. Infected and uninfected workers were similarly distributed inside and outside the nest during the scan-sampling (infected: 72 % of the times found inside the nest; uninfected: 75 %, χ^2 Test $p = \text{NS}$). There was no significant difference in the frequency of antennation with other workers between infected and uninfected individuals (infected workers: 17 % antennation over the total observation period, uninfected: 16%, χ^2 Test $p = \text{NS}$).

Comparable results were found in the second colony collected in 2003 and containing two infected host workers.

It is particularly remarkable that the gynes found at Darmstadt in spite of being severely infested nevertheless took off for the nuptial flight.

Discussion

This paper mainly aims at drawing attention of ant collectors to this remarkable fungal infection of ants, which still remains quite enigmatic. From previous observations (HÖLDOBLER 1927, 1933, BUSCHINGER & WINTER 1983) and present data, it appears that fungus-infected ants exhibit a largely normal behavioral repertoire. Infected ants, however, die after a hibernation during the following spring or summer. Highly infected colonies thus will be seriously damaged, losing a considerable fraction of their workers.

A novel trait, probably interesting with respect to the spreading of the infection, is the observation of infected gynes which nevertheless were flying off the nest. All additional information and records will be helpful to clarify the range of action and the life cycle of *M. durum*.

Particularly interesting are the dates of collections in Europe:

Discovered in 1926 and described in 1927 (HÖLDOBLER 1927, 1933) near Würzburg, southern Germany, the infection there could be detected several times until 1933. Since then, *M. durum* has never been recorded again from Germany, though A.B. has studied > 2,000 *Temnothorax* colonies, and numerous colonies of *Solenopsis fugax* in the vicinity of Würzburg and Darmstadt since 1963.

The next collecting took place in Austria in 1967 (W. Faber, see SANCHEZ-PEÑA & al. 1993).

Another series of records dates around 1981 (BUSCHINGER & WINTER 1983), the infested ants were found in France, Switzerland and the former Yugoslavia. Quite simultaneously, ESPADALER (1982) had found the infection in Spain.

Further findings in Europe were made in 1989/1990 (SANCHEZ-PEÑA & al. 1993), and again after a long period of "silence" this fungus species "reappeared" now in 2003/2004 (this paper, and PEREIRA 2004). The latter reports on the occurrence of *Myrmicinosporidium durum* in the eastern United States,

where *Solenopsis invicta*, *Solenopsis carolinensis* FOREL, 1901, *Paratrechina vividula*, *Pheidole tysoni* FOREL, 1901, *Pheidole bicarinata* MAYR, 1870, *Pyramica membranifera* (EMERY, 1869), and *Pogonomyrmex badius* (LATREILLE, 1802) were found to be infected, hence seven new host species, among them the notorious fire ant, *S. invicta*. "Prevalence in host populations varied between 2 and 67 % of the ants, and 3 - 100 % of the colonies" (PEREIRA 2004). As in Europe, the disease was mostly found in late summer and fall.

It may well be that the long gaps in the record are due to the episodic collecting activities of myrmecologists. However, the prevalence of this fungal infection may also be highly variable.

The host range appears wide, including the ant subfamilies Myrmicinae and Formicinae, with several common and widely distributed tribes. Most probably the true host range of *M. durum* is not known yet. It is very visible in yellow or light brown ant species where an abnormally black gaster of certain specimens in a nest is easily seen. This is different in largely black or dark brown species such as *Temnothorax exilis* (EMERY, 1869) or *Plagiolepis* spp., which nevertheless could be identified as host species. Infested dark or black ants usually have somewhat extended gasters as is the case with lighter colored species. Under strong illumination the spores can be seen with a dissecting microscope (25 to 50 x) also in such ants.

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Zusammenfassung

Myrmicinosporidium durum HÖLDOBLER, 1933, ein verschiedene Ameisenarten parasitierender Pilz, wurde bisher nur sporadisch gefunden. Während einer Sammelexkursion im April 2004 haben wir einige infizierte Kolonien von *Temnothorax albipennis* sowie eine des Sklavenhalters *Chalepoxenus muellerianus* in den Abruzzen (Italien) gefunden. Weitere zwei infizierte *Chalepoxenus*-Völker waren 2003 nahe dem Gardasee in den Italienischen Alpen gesammelt worden. Am 4. September 2004 wurde die Infektion in Arbeiterinnen und schwärmenden Jungköniginnen von *Solenopsis fugax* in Darmstadt, Deutschland, beobachtet. Dies ist der erste Nachweis nördlich der Alpen seit der Erstbeschreibung des Parasiten aus Würzburg, Deutschland, vor über 70 Jahren.

Wir berichten über diese neuen Funde, weil bisher über den Infektionsweg des Pilzes nichts, und über seine Verbreitung nur wenig bekannt ist. Er ist aus Süddeutschland beschrieben und später in mehre-

ren Mittelmeerländern angetroffen worden (Italien, Spanien, das frühere Jugoslawien). Dieselbe, oder eine nahe verwandte Pilzart ist in Texas (USA) und auf den Galapagos-Inseln nachgewiesen worden. Einige *Temnothorax*-Arten und deren Sozialparasit *Chalepoxenus muellerianus*, zwei *Pheidole*-Arten (Frankreich und Galapagos), *Solenopsis fugax* (Europa), und eine *Pogonomyrmex*-Art (USA), alles Myrmicinae, aber auch *Plagiolepis* spp. (Formicinae), sind bisher als Wirtsarten bekannt gewesen. 2004 sind je zwei weitere Arten der Gattungen *Solenopsis* und *Pheidole*, *Pogonomyrmex badius*, *Paratrechina vividula* und *Pyramica membranifera* aus USA hinzu gekommen.

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