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Nematode infection as significant source of unjustified taxonomic descriptions in ants (Hymenoptera: Formicidae)

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Abstract

A significant proportion of taxa was described from a single specimen; however, miscellaneous influences are known to alter a phenotype, raising the question of the validity of taxa that have been reported only once in the history. The purpose of the present study was to highlight one of the possible sources of the high number of once-only taxa; the parasitogenic phenotype.

I report observations made using noninvasive X-ray microtomography, which provides direct evidence of the presence of mermithid nematodes in the gaster of certain type specimens, demonstrating that two of the three once-only *Myrmica* taxa were described on the basis of mermithogenic phenotypes. Microtomographic images show that *M. symbiotica* (MENOZZI, 1925) was described on a mermithogenic phenotype; so, I propose junior synonymy with *M. scabrinodis* NYLANDER, 1846. The formerly reported mermithid infestation of *M. myrmecophila* WASMANN, 1910 holotype, and synonymy with *M. sulcinodis* NYLANDER, 1846 is confirmed. Though the holotype of *Myrmica schenckioides* BOER & NOORDIJK, 2005 proved to be uninfected, the malformed features of the type specimen raise the possibility that it is a teratological case.

Key words: Alpha taxonomy, intermorph, *Myrmica*, nematode, parasites.

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Introduction

Alpha taxonomy is the science of describing and naming species predominantly by using phenotypic characterization. However, the mechanisms of the heritability (COYNE & BEECHAM 1987), phenotypic plasticity (NIJHOUT 2003) and developmental instability (VAN DONGEN & al. 2009) of traits are just beginning to be understood. Various environmental factors, e.g., temperature, pH, food quality, or parasites, can also cause physiological or developmental changes resulting in altered traits (EMLEN & ALLEN 2003). Mermithid nematodes are reported to infect a wide range of ant hosts (WHEELER 1928, GÖSSWALD 1929, KUTTER 1958, PASSERA 1974). These parasites are known to alter host morphology (VANDEL 1930, CZECHOWSKI & al. 2007a, b), and their role causing particularly stable, discrete parasitogenic phenotypes was explained (CSŐSZ & MAJOROS 2009).

Mermithogenic phenotypes of *Myrmica* ants may dramatically differ from their uninfected nest-mates, yet the phenotypic expression of the parasitism is fairly constant so that infested specimens are quite similar to each other.

The "mermithogenic syndrome" can be characterized by a combination of both worker-like and gyne-like structures and a few typically intermorphic morphological features, such as an oval head, more or less developed ocelli, reduced but visible thoracic sclerites, vestigial or completely missing wings, and swollen gaster in *Myrmica* ants (CSŐSZ & MAJOROS 2009).

Such malformations may well be construed as indicating a new taxon that is socially parasitic (BUSCHINGER 2009) on the "host" species; such false taxa can be called "parasitogenic taxa". To address the question as to how many parasitogenic taxa currently exist among *Myrmica* ants, I selected European *Myrmica* taxa that met two criteria for detailed investigation: (a) the taxon was described under the premise of a socially parasitic feature combination and (b) the taxon was reported to have been found only once. Among the sixteen European parasitic *Myrmica* taxa, three species, *M. myrmecophila* WASMANN, 1910, *M. schenckioides* BOER & NOORDIJK, 2005 and *M. symbiotica* (MENOZZI, 1925) met these criteria. Their type specimens are not available for autopsy or other invasive methods, and the lack of direct evidence of parasitism has made it difficult to claim convincingly that a putative species was parasitogenic. X-ray microtomography has been employed as a fairly noninvasive technique giving 3D visualizations that can provide direct evidence for the presence or absence of Nematodes in the gaster of the investigated type specimens.

Microtomography can reveal the presence of nematode infection in valuable ant specimens; and further, discoveries of other sorts of infestations or developmental malformations did not comprise part of the present study. Particular objectives of this study were (a) to test whether the selected types are indeed infested by a nematode; (b) to propose synonymy, if necessary, (c) to add proposals for the IUCN Red list status of the observed taxa if a mermithogenic feature of the type specimen has been demonstrated. More generally, I hope to draw the attention of entomologists particularly that of alpha taxonomists studying ants, to the problems of describing new taxa based on unique collection, and highlight mermithid parasitism as a possible source of rising alternative morphologies that might be described as a new taxon.

Material and methods

Label information of holotypes of the selected three taxa for microtomographic investigation is as follows:

Myrmica symbiotica (MENOZZI, 1925): Holotype: "Sestola, Emilia, viii-1921" [on the reverse side of the label], "C. Minozzi[sic!]" "TYPUS" "*Sommimyrma symbiotica* Menozzi Typus" (DiSTA, Universita' di Bologna, Italy).

Myrmica myrmecophila WASMANN, 1910: Holotype: "*Myrmica myrmecophila* Wasm. n.sp. [the rest of the label is unreadable]" "Areberg 27 / 8.91. s.e. sul" [?] (Natuurhistorisch Museum Maastricht, Netherlands).

Myrmica schenckioides BOER & NOORDIJK, 2005: Holotype: "Netherlands: GLD Hardewijk, Beekhuizerzand, 2004, RMNH'05 leg. Noordijk & Boer, *Myrmica schenckioides*" (Nationaal Natuurhistorisch Museum Leiden, Netherlands).

For purposes of **morphometric comparison** I measured infested individuals (n = 11), random samples of uninfected workers (n = 42) and gynes (n = 32) of *M. scabrinodis* NYLANDER, 1846. Material was collected from two populations; one from Kunpeszér (Hungary) collected in August of 2004 and 2005 leg. Csősz and Haute Alpes, near St. Bonnet (France) leg. G.W. Elmes, 8.VI.2003. Each individual of the comparative material was dissected to demonstrate convincingly the presence or absence of hairworms in the gaster. Comparative material is deposited in the Hungarian Natural History Museum, Budapest.

Morphometrics: All measurements were made with an ocular micrometer using an Olympus SZX9 stereomicroscope at a magnification of 150×. Data are given in µm, estimated precision was ± 2 µm. Repeatability of measurements for the concerning characters was described in CSŐSZ & MAJOROS (2009).

Frons width: measured the minimum distance between the frontal carinae;

Frontal lobe width: measured the maximum distance between external borders of the frontal lobes;

Head length: measured from the anteriormost point of clypeal margin to the mid-point of the occipital margin, in full-face view;

Head size: calculated from the arithmetic mean of head length and head width;

Head width: measured in full-face view, including compound eyes;

Lateral ocelli diameter: calculated from the arithmetic mean of maximum diameters of right and left lateral ocelli;

Median ocellus diameter: measured along the maximum diameter of the median ocellus. (Note: in workers and infested individuals ocelli are usually hardly discoverable, however using transmitting light these become well visible);

Mesosoma length: measured along a diagonal line in lateral view from the anteriormost point of the pronotal slope to the posterior (or posterio-ventral) margin of the metapleural lobes;

Mesosoma width: measured the maximum width of mesosoma in dorsal view;

Petiole width: measured the maximum width of the petiole in dorsal view;

Postpetiole width: measured the maximum width of the postpetiole in dorsal view;

Scape length: measured the maximum measurable straight line scape length excluding articulary condyle (see SEIFERT 1988, CSŐSZ & MAJOROS 2009);

Size of compound eyes: arithmetic mean of the minimum and the maximum diameter of the compound eyes;

Morphometric dataset was analyzed with PCA and the position of the subsets was visualized in a scatterplot using Statistica 6.0 statistical software.

Microtomography and 3D imaging technique: The microtomography was performed with a Skyscan 1072 X-ray microtomograph. All constructed cross-sections contained 1024 pixels, with an isotropic pixel size of 5 microns. 3D visualization was done using SkyScan Ctvox software.

Results

Myrmica symbiotica (MENOZZI, 1925)

Sommimyrma symbiotica MENOZZI, 1925 [original combination]

Myrmica symbiotica MENOZZI: BOLTON (1988)

Myrmica scabrinodis NYLANDER, 1846 [**New senior synonymy of *Myrmica symbiotica* proposed**]

BOLTON (1988) reported that the holotype might have been a developmentally abnormal specimen, avoiding any further speculations. According to the images (Figs. 1a, b) probably two or three nematode worms (confirmed by nematologists, Gábor Majoros and George Poinar) nearly completely fill in the gaster of the type individual. The worms are not completely developed; these parasites apparently did not attain the preadult stage. In general characteristics of external morphology the *Myrmica symbiotica* holotype specimen is reminiscent of the workers or mermithogenic phenotypes of *M. scabrinodis*, hence I conducted a PCA based morphometric comparison of the type with both infested and uninfected classes of *M. scabrinodis*. Results demonstrate that *M. symbiotica* holotype is nested in the cluster of infested *M. scabrinodis* individuals (Fig. 2). Based on these results I propose new junior synonymy with *M. scabrinodis*.

Myrmica myrmecophila WASMANN, 1910

Junior synonym of *Myrmica sulcinodis* NYLANDER, 1846: VAN BOVEN (1970) [confirmed]

A well-developed mermithid worm that nearly attained the preadult stage can be found in the gaster (Figs. 1c, d). Thus, the junior synonymy of *M. sulcinodis* (see VAN BOVEN 1970) is confirmed.

There was apparently an earlier attempt to track nematodes in the gaster of the *M. myrmecophila* type with an invasive method. Someone had scraped a 1 mm^2 area on the first gaster tergite of this specimen, and a part of the nematode had thereby become visible.

Myrmica schenckioides BOER & NOORDIJK, 2005

Junior synonym of *Myrmica schencki* VIERECK, 1903: RADCHENKO & ELMES 2010 [confirmed]

Holotype of *Myrmica schenckioides* does not contain any recognizable worm in the gaster; ventral (Fig. 1e) and

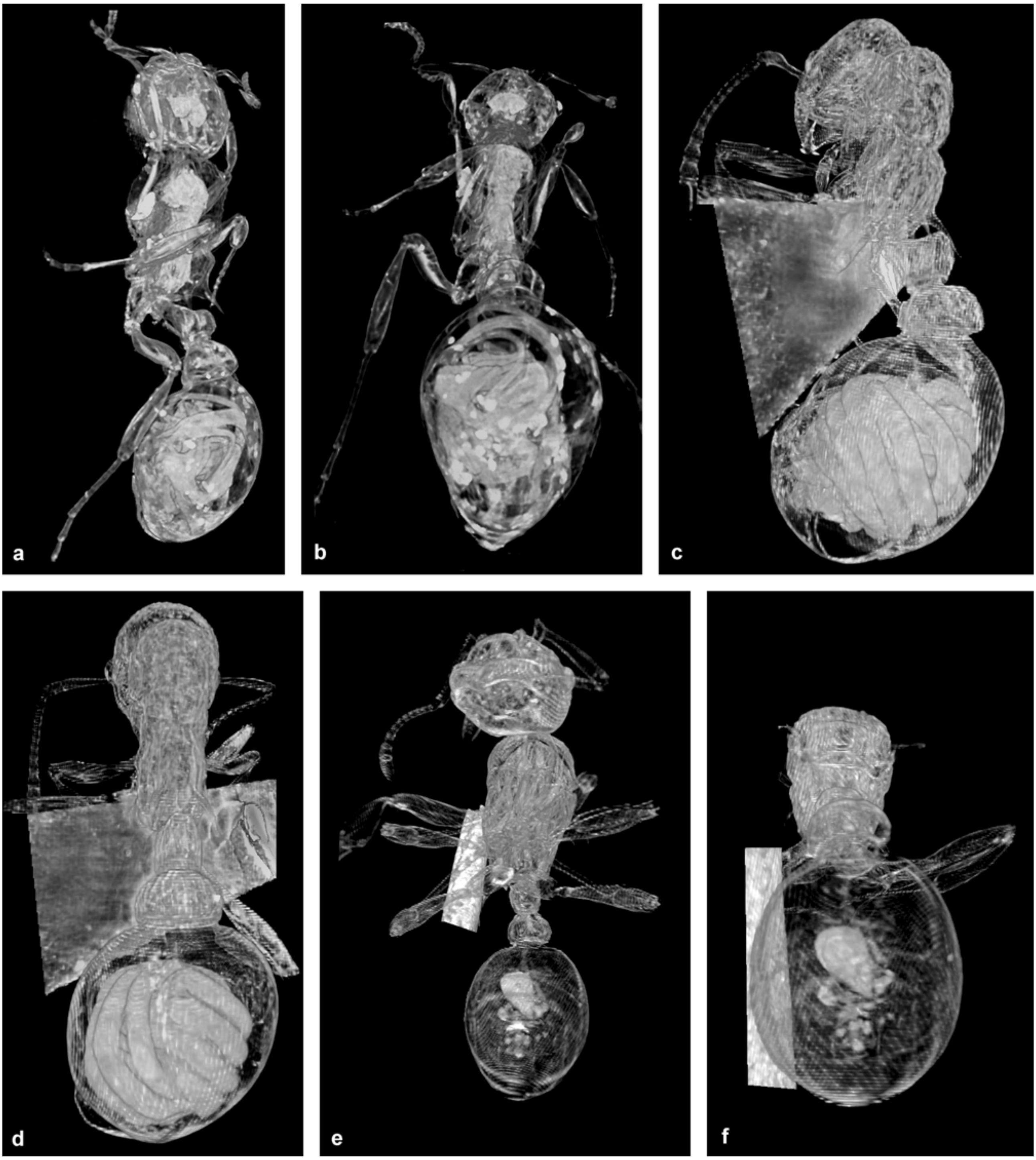

Fig. 1: Microtomographical reconstructions on the examined types. Dorsoventral (a) and dorsocaudal (b) view of *Myrmica symbiotica* holotype. Dorsal (c) and dorso-caudal (d) view of *Myrmica myrmecophila* holotype. Holotype of *Myrmica schenckioides* ventral (e) and dorso-caudal (f) view with the dried-up remnants of the gastro-intestinal tracts.

dorso-caudal (Fig. 1f) view of the type show the dried-up remnants of the gastro-intestinal tract.

The gaster of this type specimen is intact. Mermithid hairworms usually exit the gaster between tergal plates (S. Csősz, unpubl.), leaving the gaster severely damaged. Since the gaster appears to be intact, the mermithogenic explanation (i.e., the hypothesis that a hairworm left the gaster before the specimen was mounted) seems unlikely. Given that this type specimen does not bear the typical traits of mermithogenic syndrome, but rather lacks remarkable remnants of ovaria and has shape of petiole and postpetiole reminiscent of that of males, the holotype specimen may be a teratological case.

Here, I confirm its junior synonymy with *Myrmica schencki* as it was proposed by RADCHENKO & ELMES (2010).

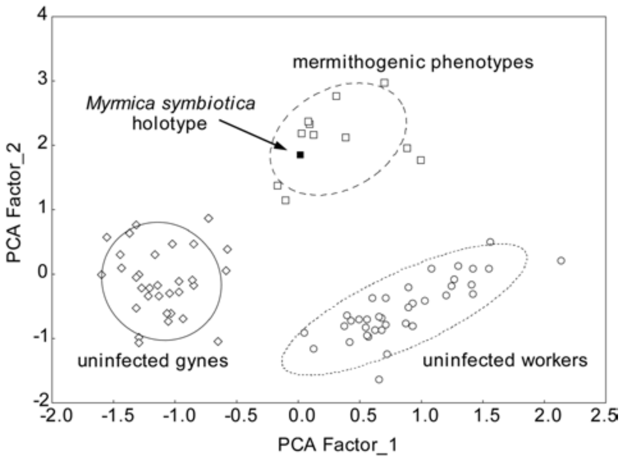

Fig. 2: Principal component analysis of raw data of 11 morphometric characters. *Myrmica scabrinodis* uninfested workers (white circles, n = 36); *M. scabrinodis* uninfested gynes (white diamonds, n = 34); infested mermithogenic phenotypes of *M. scabrinodis* (white squares, n = 11), *M. symbiotica* holotype (black square).

Discussion

Two of the three examined once-only-found taxa holotypes, *Myrmica myrmecophila* and *M. symbiotica*, proved to be mermithogenic phenotypes. X-ray microtomography was used to answer this question without dissecting the type specimens. Morphometric examination confirmed that dramatic morphological changes caused by parasites (HUGHES & al. 2008, CZECHOWSKI & al. 2007a, b), and the extreme stability (CSŐSZ & MAJOROS 2009) of these parasitogenic phenotypes, may suggest entomopathogenic parasitism as a possible explanation for the high number of taxa that have been reported only once.

Proportionately to the sixteen listed European permanently socially parasitic *Myrmica* species, the two infested taxa means a rate of 12.5%, which climbs to a dramatic 67% (2 / 3), calculated on the basis of the total once-only-found *Myrmica* taxa occurring in the same territory.

Apart from true rarity, the list of possible explanations for the high number of once-only-found taxa can be very long, however, the high rate of parasitogenic taxa raises the question whether or not the effect of parasitogenic malformations on alpha taxonomy of ants is underestimated. Though morphological alterations that are caused by nematodes are known to occur in virtually every ant subfamily (WHEELER 1928, GÖSSWALD 1929, KUTTER 1958, POINAR & YANOVIAK 2008), it is important to note that the author does not claim that this rate of parasitogenic taxa would be similarly common in each insect group, or even among other ant taxa. But this phenomenon might be widespread, hence, worth considering while assessing reliability of taxonomical surveys, checklists as well as the IUCN red list. One of the observed species, *M. symbiotica*, which was described on the basis of a mermithogenic phenotype, appears as a vulnerable D2 species in the IUCN red list (IUCN 2011). However, due to the new findings I propose to discard the taxon from the red list, due to the fact that it does not have any value in nature conservation or from the perspective of biodiversity.

I do not rule out the possibility that the investigated types might also carry other sorts of parasites that cannot be detected by microtomography. Parasites other than *Mermis* are also known to affect morphology of miscellaneous host organisms (TRABALON & al. 2000, HEINZE & al. 1998, MIURA & al. 2006). Therefore, the possibility of morphological abnormality caused by parasitism is worth taking into account in every taxon that has been reported only once or only a few times.

A wide-ranging impact study of the effect of the parasitogenic elements on our traditional morphologically based taxonomy might yield further surprising results.

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