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Occurrence of Ant (Hymenoptera, Formicidae) and Aphid (Homoptera, Aphidinea) Syninclusions in Saxonian and Rovno Ambers

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Abstract—Ant species found as syninclusions with aphids in Rovno and Saxonian ambers are listed for the first time. In a collection of 143 pieces of Rovno amber with worker ants, aphids were found in only one syninclusion with *Ctenobethylus goepperti* (Mayr). In a collection of Saxonian amber, 53 aphids of the genus *Germaraphis* were found in 152 amber pieces with ant workers; five syninclusions with aphids contained 19 specimens of *C. goepperti*; two syninclusions contained ten specimens of *Lasius schiefferdeckeri* Mayr; and three syninclusions contained one specimen each: one *Camponotus mengei* Mayr, one *Anonichomyrma constricta* (Mayr), and one *Formica flori* Mayr. Considering that the Rovno and Saxonian collections are nearly equal in the number of amber pieces, the fundamental difference in the number of syninclusions is striking. The number of *C. goepperti* in syninclusions is disproportionately high; the proportion of syninclusions with aphids and *C. goepperti* is 1.6 times that of all inclusions of workers of this species. They are found in 31% of examined inclusions of workers in the collection of the Saxonian amber, but in 50% of syninclusions of the entire collection. This strongly suggests that *C. goepperti* and *Germaraphis* formed an association during their lifetime.

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In the structure of myrmecofaunas, Rovno amber is essentially different from Baltic (Dlussky and Perkovsky, 2002) and Saxonian (Dlussky, pers. comm.) ambers, including in the occurrence of dominant species, which include *Ctenobethylus goepperti* (Mayr) and *Lasius schiefferdeckeri* Mayr in all Late Eocene ambers.

Another important distinctive feature of the entomofauna of the Rovno amber from other Late Eocene ambers is a relatively poor representation of aphids of the genus *Germaraphis*. In a representative collection of Rovno amber in the Schmalhausen Institute of Zoology, National Academy of Sciences of Ukraine (SIZC, Kiev), they constitute only 26.1% of homopterans (1.2% of all insects), and only two small larvae of *Germaraphis* have been found in one amber piece as the only syninclusion of ants and aphids (table).

In a representative collection of Baltic amber in the Booth Museum of Natural History in Brighton, England, *Germaraphis* aphids constitute 58.5% of homopterans (5.2% of all insects; recorded in 4.2% of pieces with inclusions), and syninclusions with more than one *Germaraphis* specimen contain 62.5% of all *Germaraphis* (a publication on the assemblage in this collection, as well as in a representative collection of Rovno amber, is currently in preparation; data provided by A.P. Rasnitsyn are used here).

Wheeler (1915) already supposed that "cases of simultaneous inclusion of different species" from the same piece of amber can serve as an important source of information about paleoecology and paleozoogeography. For such records, Koteja (1989) suggested the now widely accepted term syninclusions. That is why it is so interesting to compare occurrence of syninclusions of different ant species and aphids in Rovno and other Late Eocene ambers. Almost all known records of ant-and-aphid syninclusions in these ambers are provided by Kutscher (Kutscher and Koteja, 2000); it is worth noting that the remarkable syninclusion described by Wheeler from the historical Königsberg collection contained *C. goepperti.* Kutscher did not mention Larsson's (1978, p. 66) report of more than ten *Germaraphis* specimens of different lengths, including "larvae of different sizes were found, with at least 2 wingless adults (or last-stage larvae?)" and half of that number of dolichoderine ants in one piece of amber. According to Larsson, "this is an example which also shows that already in Palaeogenic period there was a symbiotic relationship between aphids and ants". Apparently, he was also referring to *C. goepperti.* Larsson listed *Iridomyrmex*, but this is the genus *C. goepperti* was formerly assigned to, and in the Baltic amber, *C. goepperti* is three to four times as common as other species that were attributed to *Iridomyrmex*. Regretta-

Composition of syninclusions of worker ants and aphids in the collections of the Saxonian and Rovno ambers. Designations: (F) samples of the Saxonian amber, (UA) samples of the Rovno amber, and (*n*) number of inclusions

No.	Ants	*n*	Aphids	*n*	Other arthropods
F-008	*C. goepperti*	13	*Germaraphis*	2	Acari
F-079	*F. flori*	1	*Germaraphis*	5	
F-145	*A. constricta*	1	*Germaraphis*	2	Diptera (Brachycera)
F-146	*L. schiefferdeckeri*	7	*Germaraphis*	5	4 Coleoptera specimens
F-147	*C. goepperti*	3	*Germaraphis*	10	Collembola, Arthropleona
F-148	*C. goepperti*	1	*Germaraphis*	1	
F-149	*L. schiefferdeckeri*	3	*Germaraphis*	23	
F-150	*C. goepperti*	1	*Germaraphis*	1	
F-167	*M. mayrianum*	2	*Germaraphis*	1	
F-205	*C. goepperti*	1	*Germaraphis*	4	
UA-1414–UA-1423	*C. goepperti*, head	1	*Germaraphis*	2	2 Isoptera wings, Coleoptera, 3 specimens of Sciaridae, Dolichopodidae, Platygastridae, Ceraphronidae

bly, a more detailed comparison with the Baltic amber has not yet been possible; museum collections are usually unsuitable for this purpose, whereas a representative collection contains only 18 amber pieces with ants (14 of them with workers), among which there is only one syninclusion of *C. goepperti*, with an unidentified aphid.

The only paper dealing with syninclusions of ants and Sternorrhyncha (Kutscher and Koteja, 2000) was published based on the material of the Bitterfeld collection of Kutscher (Sassnitz), with only one paragraph and two photographs dedicated to ant and aphid syninclusions in the Saxonian amber. Kutscher's (Kutscher and Koteja, 2000, p. 184) record of "at least six pieces containing formicine ants and aphids" was based on erroneous subfamily identification of ants from samples F-145, F-147, F-148, and F-150 (table).

Ants from Saxonian and Rovno ambers have been recently identified by Dlussky; this allows all ant species that have been found in syninclusions in these ambers to be listed for the first time. Of 204 amber pieces with ant inclusions examined by Dlussky in Kutscher's collection (152 pieces with workers among them), ten pieces contain syninclusions of ants and aphids, of which two have been shown in photographs published by Kutscher (Kutscher and Koteja, 2000, text-figs. 4, 5). One more syninclusion of an unidentified ant (*C. goepperti*, judging from the figures) and a scale insect (Matsucoccidae) is described in detail in the same paper. The reason why Kutscher's collection is discussed here is that it was the basis for the first work on ant and aphid syninclusions.

Of particular interest is the fact that syninclusions contain large numbers of ants and aphids; in Kutscher's opinion, this allows conclusions to be drawn not only about the association between the ants and the aphids, but also about the character of this association. Thus, ants found in an aphid colony (F-149) permitted him, although with some reservation, to assume a symbiotic relationship (Kutscher and Koteja, 2000).

This result may be tentatively generalized to the Saxonian amber because available data (Ritzkowski, 1997; Weitschat and Wichard, 2002) suggest that it was apparently redeposited from the same region as the Baltic amber. This allows a comparison of Rovno and Baltic ambers in terms of syninclusions. Aphids have been found in only one piece of Rovno amber among 151 samples with ant remains (143 pieces with workers) housed in the SIZC (table). Considering that the Rovno and Saxonian collections are nearly equal in the number of amber pieces, the difference in the number of syninclusions seems to be significant.

Representatives of *C. goepperti* were found in 50 pieces of amber studied in Kutscher's collection (workers were found in 47 pieces); five of them (10.6% of the total number of worker inclusions) also contain *Germaraphis*. Representatives of *L. schiefferdeckeri* were found in 32 pieces (workers were found in 29 samples), with two pieces (6.9% of the total number of worker inclusions) containing *Germaraphis*. Representatives of the two dominant ant species were found in one amber sample. Besides ants and aphids, sample F-146 contains two larvae and two imagoes of beetles, including a beetle mentioned by Kutscher (Kutscher and Koteja, 2000). Altogether, there are 53 *Germaraphis* specimens recorded as syninclusions with ants.

The share of *C. goepperti* in syninclusions is disproportionately high. The proportion of the ant-and-aphid syninclusions where ants are workers of *C. goepperti* is 1.6 times as high as the proportion of inclusions with workers of this species. This apparently supports an association between *C. goepperti* and *Germaraphis*. In Kutscher's collection, sample F-145 contains the only specimen of *Anonichomyrma constricta* (table); this

may support an association between these ants and *Germaraphis*.

In Kutscher's collection, there are 16 samples with *Formica flori* Mayr workers, with one piece containing an aphid (table). The proportion of samples with *F. flori* and *L. schiefferdeckeri* among syninclusions correlates with the share of these formicines among inclusions of workers. Kutscher's collection contains two specimens of formicine ants *Monomorium mayrianum* Wheeler, one of which also contains a small larva of *Germaraphis* (table); this collection contains a total of 13 pieces of amber; many representatives of this genus are known from other collections of Saxonian amber; however, F-167 is the only syninclusion of *Monomorium* and aphids.

In the collection of Rovno amber in Kiev, *C. goepperti* workers are found in 39 samples, *L. schiefferdeckeri* workers in 34 samples, *F. flori* is not uncommon (Dlussky and Perkovsky, 2002), and *Camponotus mengei* is represented by a single specimen (Dlussky and Perkovsky, 2002). *A. constricta* has been found in a single amber piece from the locality of Dubrovitsy; this species was not previously recorded in the Rovno amber.

A large piece of Rovno amber, in which an ant was found in association with aphids, was larger than all pieces of Saxonian amber with such syninclusions combined, and included abundant wood debris and other insects (table). It has been cut into laminae (inventory numbers UA-1414, UA-1415, UA-1416, UA-1417, UA-1418, UA-1419, UA-1420, UA-1421, UA-1422, and UA-1423). This record of a syninclusion in a mass burial in a large piece of amber highlights the uncommon nature of such syninclusions in Rovno amber, unlike Saxonian and probably Baltic ambers, where such syninclusions are common.

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