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Full length Research

Inclusions of Mites (*Acari*) in Baltic Amber: Preliminary Studies

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Microscopic analyses of some hundreds of samples of raw amber collected in beaches of Polish coast of Baltic Sea, plus some pieces of polished amber as souvenirs and jewelery, which were made from Baltic amber, purchased in local markets and jeweler shops in Krynica Morska and other neighbouring seaside resorts (north region of Poland), show that some tens of them (10%) were containing inclusions of mites (*Acari*). Majority of them were identified mainly as free living mites belonging to oribatid or moss mites (*Oribatida* or *Cryptostigmata*) and astigmatids (*Astigmata*). Other groups (*Prostigmata, Mesostimata*) were represented by predators and parasites e.g. teneriffiids (*Teneriffiidae*), trombidiids or velvet mites (*Erythraeoidea*, *Trombiculoidea, Trombidioidea*). Analyses of amber samples are still conducted and examinations of some undetermined mite specimens (*Acari* indet.) will be continued; their final results will be published gradually soon after realization of the next stages of the studies.

Keywords: *Acari*, amber, fossils, inclusions, mites.

INTRODUCTION

Paleontological studies conducted on amber inclusions presented in publications by various authors show that majority of the fossils belong to arthropods (*Arthropoda*), mainly insects (*Insecta*) and arachnids (*Arachnida*). This last one group is represented first of all with spiders (*Araneae*) and mites (*Acari*). However, present knowledge concerning amber inclusions of arachnids, especially fossil mites, is comparatively scarce, e.g. by comparison with data on entomological fossils (Krzemińska et al. 1993, ROSS 1998, Weitschat and Wichard 1998, Engel 2001, Kosmowska-Ceranowicz 2000, among others). Situation is slightly better for oribatid mites owing to Sellnick (1918, 1927, 1931) and some recent contributions (Krivolutsky and Ryabinin 1976, Krivolutsky and Krasilov 1977, Norton 1998, 2006, Perkovsky et al. 2007, 2010, Heethoff et al. 2009, Weitschat and Wichard 2010).

The aim of these introductory studies is to present some pictures showing fossil mites prepared mainly on the base of small private author's collection of inclusions in Baltic amber and comparison of their results with some related pieces of information in literature.

MATERIAL AND METHODS

Studies presented here were based mainly on the author's private amber collection. Material was collected from nature, at the seaside in Krynica Morska, other beaches along the Polish coast of the Baltic Sea and some amber samples were collected from jeweler or souvenir shops. Souvenirs and jewelery were made from local Baltic amber collected in the region (information by amber collectors, jewelers/producers and sellers of jewelery). Some museum pieces of amber (deposits, exhibits) were also examined.

Some methodical data were published in earlier papers (Baker et al. 2003, Chmielewski 2011). Raw amber material (some hundreds pieces) was preliminarily selected before particular microscopic analyses. Selected, comparatively transparent samples containing inclusions of arthropods (ca. 13%), including mites, were analyzed under stereoscopic microscope. These specimens were compared with species described in keys for identification of contemporary living mite species. Some lists, descriptions and pictures of

acarological inclusions presented in literature (e.g. Sellnick 1931, Hirschmann 1971, Bolland and Magowski 1990. Krzemińska et al. 1993, Magowski 1995, Norton 1998, Ross 1998, Weitschat and Wichard 1998, Witaliński 2000, Kosmowska-Ceranowicz 2001, Judson and Mąkol 2009, Klimov and Sidorchuk 2011, Sidorchuk and Klimov 2011, Dunlop et al. 2012) were also very useful for analyses and introductory identification of selected materials.

RESULTS AND DISCUSSION

Microscopic analyses (stereoscopic microscope) of collected and selected part of amber material (460 samples) conducted show that among them were some tens of samples (10%) containing acarological inclusions. In great parts of them, single mite specimens were found but in a number of others, syninclusions (numerous specimens of mites, or mites and insects and/or other arthropods) were observed.

Following these observations it was found that multiplicity of fossil mites (*Acari*) found in part of examined amber collection was differentiated and ranged from single to some mite specimens belonging to various systematical groups in particular samples. Total numbers of fossil mites found so far in analysed material was calculated as over 40 units including *Oribatida* (14), various *Astigmata* (11), *Prostigmata* (9), *Mesostigmata* (5) and some *Acari* indet. (6). Majority of fossil mites were determined as free-living species, mainly moss mites or beetle mites (*Oribatida* or *Cryptostigmata*); some of them appeared to be related to some common oribatid families (*Galumnidae* and others). Inclusions containing oribatids were a bit more numerous than the fossils of other mites. Some fossil mite specimens found as inclusions in Baltic amber were also observed.

General appearances (shapes, dimensions) of some astigmatid mites (*Astigmata*) were reminiscent of these characteristics of modern representatives of this group, for example, belonging to super-families *Canestrinioidea* or *Acaroidea*. Some of their morphological features like sexual dimorphism of adults, opistosomal plates of males, legs, mouth parts – gnathosoma, or body setae of some undetermined fossil astigmatids seem to be similar to morphology of present-day acaroids (e.g. *Histiogaster*, *Michaelopus, Thyreophagus* spp., other *Acaridae* or *Glycyphagidae*), usually living under bark of trees, inhabiting galleries of insects, sap flux of trees, or in the soil, humus and forest litter, where they develop and feed fungal mycelia and other organic materials.

Presently, super-family *Acaroidea* is not yet known for Baltic amber and not enumerated in the lists of museum deposits of the world (Weitschat and Wichard 2010). However, there is one exception. In the list of deposits of inclusions in Baltic amber, there is information about fossils of some glycyphagid specimens (super-family *Acaroidea*, family *Glycyphagidae*), which are deposited at The Museum of the Earth (Polish Academy of Sciences, Warsaw) and were identified as "*Acarus rhombeus*" Koch et Berendt (Kosmowska-Ceranowicz 2001) But following recent publications (revision by Klimov and Sidorchuk 2011, Sidorchuk and Klimov 2011) the correct name of this species has been given as *Glaesacarus* (= *Acarus*) *rhombeus.* According to these authors, it is not acaroid that is now threatened within the super-family *Canestrionidea* and an extinct family Glaesacaridae. But with regards to astigmatids found in Baltic amber and presented herein, some of them are reminiscent of *G. rhombeus* - the "enigmatic" species re-described by Sidorchuk and Klimov (2011).

Particular analyses of the samples, consultations and discussion of their results were carried out. Some specimens seemed to be related also to the mite specimen from The Natural History Museum in London pictured by Ross (1998) in his publication. Following this exercise, it was observed that acaroids are fairly common in Baltic amber (for example, more common than in Dominican amber) but are usually overlooked because of their small size. Obtained results from the research presented here permits one to draw a conclusion which is compatible with the above opinion concerning frequent occurrence and multiplicity of these acarological fossils in Baltic amber. Explanations of some discussed questions need further precise investigations.

Predatory and parasitic mites were represented by specimens morphologically similar to anystids (*Anystidae*), bdellids (*Bdellidae*), teneriffiids (*Teneriffiidae*), trombidiids or velvet mites (*Erythraeoidea*, *Trombiculoidea*) and other *Prostigmata* and *Mesostigmata*. Imagos of some prostigmatids are usually active predators feeding on several different small arthropods. Larvae (chiggers) of *Erythraeidae*, *Trombiculidae*, *Trombidiidae* and other early stages of them are often ectoparasites and/or phoretic associates of other animals, mainly various arthropods. These mites are attached usually to bigger insect body surfaces (e.g. *Leptus* larvae parasitic on imagos of *Diptera*). Such cases of parasitism and phoresy are often observed between present-day living representatives of arthropods. These phenomena were also fixed in fossil resins and some authors publish documentation and photographs of syninclusions, which are an evidence of these interesting relations between these arthropods in the past (Weitschat and Wichard 1998).

Comparison of general body appearance and characteristics of examined fossil mites found in amber with key morphological features of present-day living mites is evidence that a lot of them are very similar to present-day species. However majority of them are probably evolutionary changed, others were unknown up to now; some of them were described as new to science, e.g. *Neophyllobius succineus* (Bolland and Magowski 1990), *Procaeculus eridanose* (Coineau and Magowski 1994), *Aclerogamasus stenocoris* (Witaliński 2000),

Atanaupodus bakeri (Judson and Mąkol 2009). However, following the present knowledge, it could be reasoned that they probably totally died out long ago or maybe live as undiscovered relics of the past in unknown, unexplored regions of our planet.

Results presented here are generally compatible with position of extant literature (Krzemińska et al. 1993, ROSS 1998, Weitschat, Wichard 1998, Kosmowska-Ceranowicz 2001, Baker et al. 2003), maybe with the exception of frequency of acarological inclusions and multiplicity of mites found in them, which comparatively seem (in the opinion of some authors) to be a little higher than respective data on the subject. This suggests that percentage of mites in amber is calculated significantly lower than other arthropods, i.e. as very low per cent of total number of amber inclusions of insects and spiders (Kulicka 1990, Sontag 2003). The reasons for such opinions are probably microscopic dimensions, body structure of mites and inconspicuous general view of these animals, e.g. by comparison to usually bigger, more coloured, rich form insects or spiders and other imposing arthropods. Besides, the bigger and unique exhibits are wanted as more attractive for natural history museums and decoration of private amber collections than majority of tiny mites, which are comparatively more difficult objects for identification and research than other amber inclusions.

Some works by various authors give some interesting pieces of information concerning amber inclusions of arthropods from the major world deposits. They present the list of recorded mite families based on origin of examined specimens, e.g. 53 families found in Baltic amber (out of 101 number of described species) (Weitschat and Wichard 2010) and 60 families in Rovno amber (Perkovsky et al. 2007, 2010). Perkovsky et al. (2007) publish also the set of percentage participation of the *Acari*, in comparison with the main taxonomic groups of other arthropods, in the representative samples of Baltic and Rovno amber, which ranged from 13.9% to 27.0% in Baltic amber (dependent on various collections) and 16.0% in representative Rovno amber collection.

Among acarological fossils in these publications, the most often were enumerated families of *Oribatida*; mite families of *Astigmata*, *Mesostigmata* and *Prostigmata* have also significant items. Mites belonging to families of some such interesting groups as water mites (*Hydrachnellae*) and ticks (*Ixodida*) were registered comparatively rare. However, there are some references concerning data on representatives of these last two groups (Weidner 1964, Lane and Poinar 1986, Szadziewski and Sontag 2001, Weitschat and Wichard 1998 among others). With regards to examined amber material presented herein, there have never been found inclusions of representatives of ticks and water mites; information concerning inclusions of other mite groups seems to be comparable and similar to that presented in the literature on the subject.

Some results obtained from recently conducted research can be supplements of present knowledge on amber inclusions of mites and a kind of framework for further studies on this topic, which obviously requires further studies in the future.

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