

Ph.D. thesis

**Eastern Palearctic oak cynipid
inquilines (Hymenoptera: Cynipidae:
Synergini) and associated gallwasps
(Hymenoptera: Cynipidae: Cynipini)**

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Introduction

Cynipidae lies within the superfamily Cynipoidea of the Hymenoptera, which includes approximately 3,000 described species. Cynipids are divided into two main trophic groups: the gall inducers, and the gall-associated inquilines. Currently Cynipidae family divided into 12 tribes: Cynipini, Diplolepidini, Pediaspidini, Eschatocerini, Qwaqwaiini, Paraulacini, Aylacini, Aulacideini, Phanacidini, Diastrophini, Ceroptresini, and Synergini sensu stricto from which the latter 3 includes inquilines; our research was done within the last one, Synergini sensu stricto and oak gallwasps, Cynipini.

The first part of our research focused on the inquiline cynipids, which developing in the gall tissue of hosts in the gallwasp tribe Cynipini (oak gallwasps), which includes seven genera, *Agastoroxenia*, *Saphonecrus*, *Synergus*, *Synophrus*, *Ufo*, *Lithosaphonecrus* and *Rhoophilus*, and forming a distinct monophyletic lineage, Synergini sensu stricto. The recent molecular phylogenetic reconstructions within the Synergini sensu stricto supported the monophyly of the large genus *Synergus* while the monophyly of *Saphonecrus* was rejected. The phylogenetic position and morphological description of smaller Synergini genera, *Lithosaphonecrus*, *Synophrus*, *Ufo* and *Rhoophilus* has been re-appraised and re-established. All the newly described EP *Saphonecrus* and *Synergus* species are

supported by distinct DNA barcode haplotypes. On the other hand, there is some contradiction between morphology-based taxonomy and molecular phylogeny considering the classification on the species level what we discussed in this work.

The second part of our work is focused on the collecting, pulling together all the fragmented information on the biology, ecology, phenology, life-cycles and taxonomic history of all Eastern Palearctic (EP) Cynipini (oak gallwasp) species. There are only few Cynipidae reviews on the EP species. These are out of time and since then dozens of new species were described and a large number of nomenclatorial changes have been done. The most complete annotated list for EP Cynipini, with a list of species with uncertain status is given.

Main objectives of the work

- Taxonomic and phylogenetic re-appraisal of Synergini sensu stricto genera; synonymization of some genera and species.
- Combining keys for the identification of Synergini sensu stricto genera, with producing necessary colour plates with adequate morphological characters.
- Composing first keys to all EP *Synergus* species and to Palearctic *Saphonecrus* species, with

colour plates of adequate morphological characters.

- Detailed diagnoses, descriptions, biology and host associations of the New EP species of *Saphonecrus* (15 new species were described by us) and *Synergus* (8 new species were described by us).
- Re-appraisal of all EP *Synergus* species and that of Palearctic *Saphonecrus* species.
- Compilation of the up-to-date complete list of EP Cynipini.

Methods

Oak cynipid inquilines, *Synergini sensu stricto*

Wasps were reared in laboratory from fresh galls collected in different localities in Japan, Russia, China and Taiwan during 2008–2012 (reared by J. Nicholls and C.-T. Tang) and were identified by G. Melika. Samples were stored in 99% ethanol for further laboratory processing. For the host plants identification Lu *et al.* (2006) and Govaerts & Frodin (1998) were used.

Genomic DNA was extracted from legs from adult specimens, following the chelex extraction method. For phylogenetic reconstruction sequence of a fragment of the mitochondrial cytochrome c oxidase subunit I (*coxI*) gene and a fragment of the D2 expansion segment

of the nuclear 28S ribosomal array (28S D2) were determined following PCR amplification. Phylogenetic reconstructions were carried out in a Bayesian framework using MrBayes 3.2.4.

The terminology used to describe gallwasp morphology follows other recent cynipid studies. Images of wasp anatomy were produced with a digital Leica DC500 camera attached to a Leica DM2700M compound microscope with using the LAS Store&Recall software, followed by processing in Adobe Photoshop 6.0.

Oak gallwasps (Cynipidae: Cynipini)

The vast majority of the listed species have been collected different times in different parts of the EP and analyses support their existence as distinct biological units. Rare species listed have also been carefully checked and included.

Results and discussion

Oak cynipid inquilines, Synergini sensu stricto:

- We described fifteen new species of *Saphonecrus* from EP, *Saphonecrus chinensis* Tang & Schwéger, *S. gilvus* Melika & Schwéger, *S. globosus* Schwéger & Tang, *S. leleyi* Melika &

Schwéger, *S. lithocarpii* Schwéger & Melika, *S. longinuxi* Schwéger & Melika, *S. morii* Schwéger & Tang, *S. nantoui* Tang, Schwéger & Melika, *S. nichollsi* Schwéger & Melika, *S. pachylomai* Schwéger, Tang & Melika, *S. robustus* Schwéger & Melika, *S. saliciniae* Melika, Tang & Schwéger, *S. shanzhukui* Melika & Tang, *S. symbioticus* Melika & Schwéger, and *S. taitungi* Schwéger, Tang & Melika (Schwéger *et al.* 2015a).

- We combined a new, most species-rich key to worldwide known *Saphonecrus* species with the description of new species and the status of some earlier described *Saphonecrus* species was also discussed (Schwéger *et al.* 2015a).
- Palaerctic *Saphonecrus* is not monophyletic, several lineages identified earlier have been updated.
- We described eight new species of *Synergus* from EP, *Synergus symbioticus* Schwéger & Melika, *S. formosanus* Schwéger & Melika, *S. khazani* Melika & Schwéger, *S. abei* Melika & Schwéger, *S. belizinellus* Schwéger & Melika, *S. ishikarii* Melika & Schwéger, *S. changtitangi* Melika & Schwéger and *S. kawakamii* Tang & Melika (Schwéger *et al.* 2015b).

- We combined a new, most species-rich key to all *Synergus* species known from EP with all newly described species (Schwéger *et al.* 2015b).
- We discussed the status of all previously described EP *Synergus* species, and provided validation and synonymization of some species. Three *Saphonecrus* species were transferred to *Synergus*: *Synergus brevis* (Weld), *Synergus hupingshanensis* (Liu, Yang & Zhu), and *Synergus yukawai* (Wachi, Ide & Abe) (Schwéger *et al.* 2015a, b).
- The phylogenetic tree of Synergini has been updated with the new species. The current phylogenetic and morphological examination of EP *Synergus* supported that palaeartic *Synergus* comprise a monophyletic group (Pénzes *et al.* 2012, Schwéger *et al.* 2015b).
- Of 14 EP *Synergus* species for which the host gall and host plant associations are known, 11 species associate with hosts developing on *Quercus* subgenus *Quercus*. One species, *S. itoensis* is a gall-inducer on acorns of *Quercus* subgenus *Cyclobalanopsis* (Schwéger *et al.* 2015b).

Oak gallwasps (Cynipidae: Cynipini):

- We summarised what is known for Cynipini (oak gallwasps) in EP region.

- 85 Cynipini species for EP were found by us in different literature sources, about the half of them (49 species) are associated with *Quercus* subgenus *Quercus*, while 25 species with *Quercus* subgenus *Cyclobalanopsis* and only eight species known to associate with the rest three oak related Fagaceae genera, *Castanea*, *Castanopsis* and *Lithocarpus*.

List of publications:

The present thesis is based on the following publications:

Schwéger, S., Melika, G., Tang, C.-T., Yang, M.-M., Stone, G.N., Nicholls, J.A., Sinclair, F., Hearn, J., Bozsó, M., Péntzes Z. 2015a. New species of cynipid inquilines of the genus *Saphonecrus* (Hymenoptera: Cynipidae: Synergini) from the Eastern Palaearctic, with a re-appraisal of known species world-wide. *Zootaxa* 4054(1), 001–084. **IF: 0,994**

Schwéger, S., Melika, G., Tang, C.-T., Bihari, P., Bozsó, M., Stone, G.N., Nicholls, J.A. & Péntzes, Z. 2015b. New species of cynipid inquilines of the genus *Synergus* (Hymenoptera: Cynipidae: Synergini) from the Eastern Palaearctic. *Zootaxa* 3999(4), 451–497. **IF: 0,994**

Pénzes, Z., Tang, C.-T., Bihari, P., Bozsó, M., Schwéger, Sz. & Melika, G. 2012. Oak associated inquilines (Hymenoptera, Cynipidae, Synergini). *Tiscia Monograph Series* 11, 1–76.

Tang, C.-T., Mikó, I., Nicholls, J.A., Schwéger, Sz., Yang, M.-M., Stone, G.N., Sinclair, F., Bozsó, M., Melika, G. & Pénzes, Zs. 2016. (accepted) New *Dryocosmus* Giraud species associated with *Cyclobalanopsis* and non-*Quercus* host plants from the Eastern Palaearctic (Hymenoptera: Cynipidae: Cynipini). *Journal of Hymenoptera Research* **IF: 0,783**