

Taxonomy and biogeography of gall wasps (Hymenoptera: Cynipidae) in Asia

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Cynipid gall wasps consist of six tribes (Table 1): Aylacini, Diplolepidini, Eschatocerini, Pediaspidini and Cynipini are gall inducers and Synergini are gall-associated inquilines. They comprise around 1,300 species worldwide, predominantly in temperate regions of the Holarctic. The Eschatocerini are restricted to the Nearctic, but the other five tribes are found in Asia (Abe *et al.*, 2007).

The Aylacini are herb gall inducers. All the Palaearctic Aylacini species were revised (Melika, 2006), and the aylacine fauna of eastern Asia is poorly known.

The Diplolepidini, gall inducers on *Rosa* (Rosaceae), are divided into two genera, *Diplolepis* and *Liebelia*. Some undescribed species of this tribe are distributed in Asia, including Japan (Yukawa and Masuda, 1996).

The Pediaspidini consist of three species. One of them is a well-known European species, *Pediaspis aceris* (Gmelin), that shows cyclical parthenogenesis with alternating bisexual and unisexual generations on maple *Acer* trees. *Himalocynips vigintilis* was collected in the Himalaya of Nepal and described as a parasitoid wasp in the family Figitidae (Cynipoidea) (Yoshimoto, 1970). Later, this species was placed in Pediaspidini on the basis of its morphological features (Ronquist, 1995), although the host associations of *H. vigintilis* are still unknown. *Paraulax perplexus* Kieffer induces galls on *Nothofagus* (Fagaceae) in Chile. *Paraulax quereicola* Shinji was described in Japan but later transferred to the genus *Ceroptres* (Liljeblad *et al.*, 2008).

The Synergini are inquilines that develop within the galls induced by other insects, primarily cynipid gall wasps. Some species of this tribe were described as gall inducers, and thus the taxonomy of cynipids has been confused. The genus *Ufo* that was established in 2005 is restricted to Asia (Melika *et al.*, 2007).

The Cynipini includes c. 1,000 species, and most of them induce galls on oak *Quercus* trees. Heterogony, cyclical parthenogenesis, occurs in many species of this tribe. Female adults of the bisexual and unisexual generations of the same species differ considerably, not only in their morphology but also in the shape of galls that their offspring induce. Therefore, the two generations of the same species have often been described as different species, which confuses the taxonomy of oak gall wasps. The taxonomy of hitherto known Asian species of Cynipini must be revised. In addition, a rich fauna of oak gall wasps awaits discovery in Asia. The plant genus *Quercus* consists of the Holarctic subgenus *Quercus* and the subgenus *Cyclobalanopsis*, which is distributed only in Asia. Many species of Cynipini are expected to induce galls on *Cyclobalanopsis*, but no cynipid gall inducers on this subgenus have been described. Oaks and their close relatives probably

diversified in Southeast Asia. It is plausible that this same region was the cradle for the origin and initial diversification of Cynipini. Identification of center(s) of origin of Cynipini, and the frequency and direction of exchange between the Nearctic and the Palaearctic, can only be examined using a phylogenetic analysis of gall wasp relationships across the Holarctic (Abe *et al.*, 2007).

In conclusion, the Asian fauna of cynipid gall wasps has been little studied but is potentially extremely rich. Further taxonomic studies on this group are needed.

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Table 1 Classification, diversity and host associations of Cynipinae (after Abe *et al.*, 2007)

Tribes	No. of genera	No. of species	Hosts
Aylacini	18	122	Asteraceae, Rosaceae, Lamiaceae, Papaveraceae, Apiaceae, Valerianaceae, Brassicaceae, <i>Smilax</i> (Smilacaceae)
Diplolepidini	2	50	<i>Rosa</i> (Rosaceae)
Eschatocerini	1	3	<i>Acacia</i> , <i>Prosopis</i> (Fabaceae)
Pediaspidini	3	3	<i>Acer</i> (Aceraceae)
Cynipini	27	c. 1,000	Fagaceae (mostly <i>Quercus</i> , also <i>Castanea</i> , <i>Chrysolepis</i> and <i>Lithocarpus</i>)
Synergini	8	159	Inquilines in galls induced by other insects



Fig. 1. Unisexual galls of *Andricus* sp. on *Quercus dentata*. The gall wasp larvae within the galls manipulate the host plant to secrete a sweet and sticky food attractive to ants on the surface of the galls. In return for the food, the attending ants protect the galls against parasitoid attack.



Fig. 2. Bisexual galls of *Neuroterus* sp. on *Quercus acutissima*. The male catkins are transformed to the wool-like galls by the gall wasp larvae. One gall usually contains a couple of dozen larval chambers.



Fig. 3. A unisexual gall of *Andricus kashiwaphilus* on *Quercus dentata*. To my knowledge, this gall is the largest among cynipid galls found in Japan. Nonetheless, it contains only one larval chamber.