July 2012

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Ann. Entomol. Soc. Am. 105(4): 555–561 (2012); DOI: http://dx.doi.org/10.1603/AN12021

ABSTRACT A new cynipid species, *Saphonecrus hupingshanensis* Liu, Yang, et Zhu, sp. nov. (Hymenoptera: Cynipidae: Synergini), is described from China. This is the first species of the inquilinous tribe Synergini ever known to have an association with chinquapins (Fagaceae: *Castanopsis*). The biology and implication to species diversity of Cynipidae in eastern and southeast Asia are discussed.

KEY WORDS *Saphonecrus*, new species, Cynipidae, Synergini, *Castanopsis*

Species of the gall wasp family Cynipidae (Hymenoptera: Cynipoidea) are exclusively plant feeders, but of two different feeding guilds, the gall makers, which actually induce plant galls, and the inquilines, which do not make galls of their own and live as nest parasite in the galls made by their gall inducing hosts (Weld 1952, Askew 1984, Ritchie 1984, Ronquist 1999, Nieves–Aldrey 2001, Melika 2006). Recent phylogenetic analyses indicated that cynipid inquilines have evolved from gall-making ancestors and are gall wasps that have lost the ability to induce galls (Ronquist 1994, Liljeblad and Ronquist 1998, Ronquist and Liljeblad 2001, Nylander et al. 2004). Phylogenetic reconstruction based on molecular data suggested that inquilinism has obviously evolved several times in Cynipidae (Nylander et al. 2004) whereas morphology-based phylogeny showed a single origin of the cynipid inquilines (Ronquist 1994, Liljeblad and Ronquist 1998). Despite the uncertainty of the early evolution of the cynipid inquilines, their morphological similarities allow them to be conveniently classified in a single tribe Synergini (Weld 1952, Ritchie 1984, Nieves–Aldrey 2001, Melika 2006).

The Synergini, comprising a total of 160–170 known species (Ronquist and Liljeblad 2001, Melika 2006), are classified into nine genera, including the recently described *Ufo* Melika et Pujade-Villar, 2005. and *Agastoroxenia* Nieves–Aldrey & Medianero, 2010 (Ronquist 1999, Ronquist and Liljeblad 2001, Melika et al. 2005, Nieves–Aldrey and Medianero 2010). All synergine genera are known to be relatively conservative in host use, both with regard to the host gall maker and the associated host plant (Ronquist and Liljeblad 2001). *Periclistus* Hartig use galls induced by the genus *Diplolepis* on rose plants (Ritchie 1984), *Synophromorpha* Ashmead species use *Diastrophus* galls on plants of *Rubus* in the rose family (Ritchie and Shorthouse 1987, Abe 1998), and *Rhoophilus* Mayr use galls induced by a cecidosid moth genus *Scyrotis* on *Rhus* species (Anacardiaceae) (Van Noort et al. 2007), whereas the rest all exploit galls on oaks, mostly induced by wasps of the tribe Cynipini (Ronquist and Liljeblad 2001, Melika et al. 2005, Nieves–Aldrey and Medianero 2010, but also see Abe et al. 2011, Wachi et al. 2011). Most of the oak associated inquiline genera fall into the so-called *Synergus* complex (Ronquist and Liljeblad 2001), which was subsequently shown to be monophyletic (Nylander et al. 2004). The *Synergus* complex originally included *Synergus* Hartig, *Saphonecrus* Dalla Torre and Kieffer, and *Synophrus* Hartig (Ronquist and Liljeblad 2001), but obviously also include the two subsequently described genera *Ufo* (Melika et al. 2005) and *Agastoroxenia* (Nieves–Aldrey and Medianero 2010). They differ from the other oak associated genus *Ceroptres* in having not clearly differentiated clypeus, a sulcate, collar-shaped metasomal tergite 1, and metasomal tergite 2 completely fused with tergite 3 to form a huge syntergite (Melika et al. 2005).

The genus *Saphonecrus* Dalla Torre et Kieffer, 1910 (Dalla Torre and Kieffer, 1910) comprises 20 known species distributed throughout the northern hemisphere (Table 1). The systematic status of the genus has long been considered to be in need of revision (Pujade–Villar and Nieves–Aldrey 1990, Pujade–Villar et al. 2003, Melika 2006, Penzes et al. 2009) and a recent phylogenetic study based on sequence data indicated the genus to be paraphyletic (Acs et al. 2010). Nonetheless, a proper assessment of the taxonomic status of the genus appears to be premature without a phylogenetic analysis of all known species of genus and selected species of both *Synergus* and *Synophrus* (Penzes et al. 2009), especially because of the

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0013-8746/12/0555–0561$04.00/0

Table 1. Known species of *Saphonecrus* Dalla Torre et Kieffer, 1910: distribution and host associations

Species	Distribution	Host plant	Host insect
S. hupingshanensis Liu et al, sp.n.	EP/O: Hunan, China	*Castanopsis carlesii*	Gall inducer (?)
S. yukawai Wachi, Ide, and Abe (2011)	EP: Japan	*Q. acutissima*	*Ametrodiplosis acutissima* (Cecidomyiidae)
S. excisus (Kieffer 1904)	EP: Bengal (Kurseong)	*Quercus*	*Neuroterus haasi*
S. serratus Weld, 1926	O: Luzon, Philippines	?	?
S. areolatus Weld, 1926	O: Luzon, Philippines	?	?
S. sinicus Belizin (1968)	EP: Sichuan, China	?	?
S. diversus Belizin (1968)	EP: Primorskij Kraj, Russia	?	?
S. chaodongzhui Melika, Ács, and Bechtold (2004)	EP: China: Yunnan,	?	?
S. naiquanlini Melika, Ács, and Bechtold (2004)	EP: China: Zhejiang	?	?
S. flavitibilis Wang et Chen, 2010	EP: China: Zhejiang,	?	?
S. tianmushanus Wang et Chen, 2010	EP: China: Zhejiang,	?	?
S. brevis Weld, 1926	NA: USA: Arizona, New Mexico	*Quercus* (white oaks)	*Andricus ruginosus*
S. brevicornis (Ashmead, 1896)	NA:	*Q. wislizeni*	*Andricus*
S. favanus Weld, 1944	NA: USA: Missouri, Washington, DC	*Quercus* (red oaks)[a]	*Dryocosmus favus*
S. gemmariae Ashmead, 1885	NA: USA: Florida	*Quercus* (red oaks)[a]	*Callirhytis quercusgemmaria*
S. barbotini Pujade–Villar & Nieves–Aldrey, 1985	WP: Iberica	*Quercus*	*Plagiotrochus* spp.
S. connatus (Hartig)	WP: Europe	*Quercus*	*Andricus, Callirhytis, Cynips, Neuroterus*
S. haimi (Mayr)	WP:	*Quercus*	*Andricus, Dryocosmus, Neuroterus, Janetiacerris* (Cecidomyiidae)
S. lusitanicus (Tavares, 1902)	WP: southern Europe	*Quercus*	*Plagiotrochus* spp.
S. undulatus (Mayr)	WP: C. Europe, N. Africa, Asia Minor	*Quercus*	*Aphelonyx, Dryocosmus, Synophrus politus*
S. irani Melika & Pujade-Villar, 2006	WP: Iran	*Quercus*	

Insect hosts of all species are members of the oak gall wasp tribe, Cynipini except where indicated otherwise. Where only the host plant genus name is given, the *Saphonecrus* species is known to be associated with several host plant species of the same genus.

[a] Associated host plant was not indicated in the original description, but is deducted through host insect associations. The table is mainly based on the original species descriptions and works on regional fauna (Weld 1952, Burks 1979, Askew 1999, Nieves–Aldrey 2001, Melika 2006, Sadeghi et al. 2006).

fact that the phylogenetic signals of the used gene sequences for resolving the phylogenetic relationship among inquiline oak gallwasps are mixed (Acs et al. 2010). In this article we report a new species of *Saphonecrus* from Hunan, China, according to the current definition of the genus (Melika 2006, Wang et al. 2010). The new species is of particular interest because it is the first reported inquilinous cynipid wasp species associated with the chinquapin genus *Castanopsis* (Fagaceae).

Materials and Methods

Fresh galls were collected in the field in the months of July through September (9 June 2009, 6 August 2010, and 16 September-19, 2010). To rear adult gall wasps, galls were brought back to the lab and placed in beakers containing moistened tissue. The beakers were covered with nylon mesh and placed in a climate chamber set at room temperature. The rearing beakers were checked every 2 d to ensure that the galls would not get too dry and to monitor wasp emergence.

All specimens were preserved in 95% ethanol and air dried before being mounted on pin. Specimens were examined using an Olympus SXZ12 stereo microscope. Specimens were photographed at multiple focal planes using a Minolta Maxxum7D digital camera mounted on the SXZ12, and pictures of the same frame at multiple focal planes were subsequently "stacked up" using the computer program CombineZP (Hadley 2010).

We follow Ronquist and Nordlander (1989) and Melika (2006) for terminology of morphological structures and Harris (1979) for terminology on surface sculptures. Abbreviations for forewing venation follow Ronquist and Nordlander (1989), Melika (2006), and Liu and Engel (2010).

All types are deposited in the Insect Collection at the College of Life Sciences, Central South University of Forestry and Technology, Changsha, China.

Results

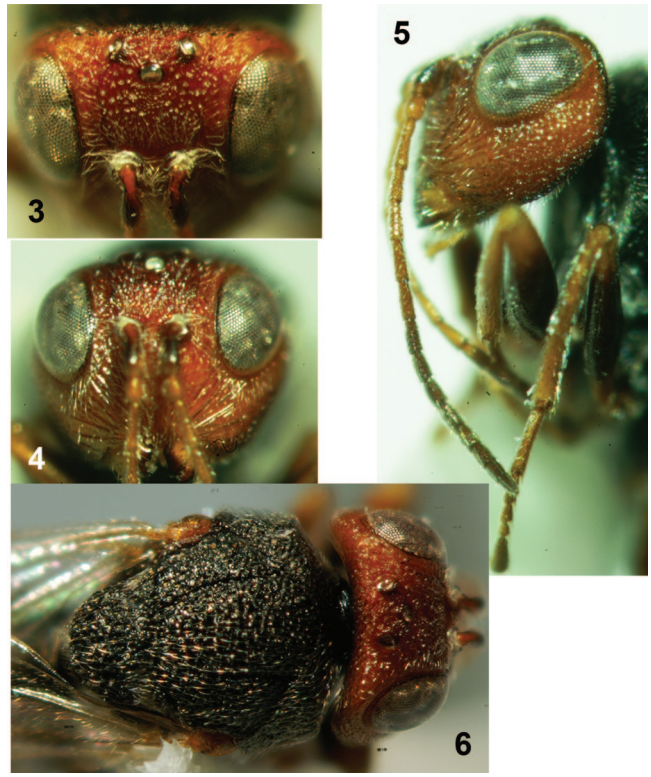
Saphonecrus hupingshanensis Liu, Yang, et Zhu, New species
(Figs. 1–8)

Holotype Female. Length of body 2.5 mm, antenna 2.9 mm, fore wing 1.83 mm, and ovipositor sheath 0.4 mm.

Head (Figs. 2–5). Head as broad as mesosoma, 2.6 times as broad as long medially in dorsal view and 1.4 times as broad as high in frontal view, POL (postocellar distance measured as the distance between inner margins of posterior ocelli) 1.25 times as broad as OOL (ocellar-ocular distance measured as the mini-

Figs. 1–2. *S. hupingshanensis* Liu, Zhu et Yang, sp. n. (♀): 1) whole insect in lateral view (Holotype); 2) fore wing. (Online figures in color.)

mum distance from outer margin of lateral ocellus to inner margin of compound eye), OOL 2.0 times as wide as diameter of lateral ocellus. Vertex, interocellar area, frons and occiput scabrous punctate, gena expanded behind compound eye in dorsal view, and scabrous punctate with sparse pubescence; impressed



Figs. 3–6. *S. hupingshanensis* Liu, Zhu et Yang, sp. n. (♀): 3) head, antero-dorsal view; 4) head, front view; 5) head in lateral view and antenna; 6) head and mesosoma in dorsal view. (Online figures in color.)

Figs. 7–8. *S. hupingshanensis* Liu, Zhu et Yang, sp. n.: 7). Gall on leaf; 8) gall dissected. (Online figures in color.)

area between antennal toruli and ocellus with interrupted carinae laterally in lower two-thirds; toruli border with dense long white setae; lower face and malar space densely pubescent, with distinct striae irradiating from clypeus to antennal toruli and compound eye, median keel of lower face as strong as the irradiate striae; malar space 0.60 times as long as height of eye.

Antenna (Fig. 4). Antenna 14–segmented; flagellomeres slightly broadened from F6 to F12; F1 distinctly enlarged apically, 2.0 times as long as pedicel and 1.3 times as long as F2; F12 1.8 times as long as F11, with an apparent segmentation in the middle.

Mesosoma (Figs. 1 and 5). Mesosoma ≈1.2 times as long as high in lateral view. Pronotum entirely densely punctate with setae in median area and punctate-foveate reticulate on lateral area, densely pubescent lateroventrally, lateral pronotal carina present. Mesoscutum nearly three-fourths as long as broad, scabrous with interrupted transverse rugae; notauli complete, deeply impressed, and distinctly convergent in posterior half; anteroadmedian signum of mesoscutum present, extending to one-third of the entire length of mesoscutum; median mesoscutal impression mostly obscured by the heavy surface sculpture of the scutum and only vaguely detectable in posterior one-third; parapsidal signum of mesoscutum distinct, extending from transscutal fissure to middle of mesoscutum. Mesopleuron, including speculum, entirely longitudinally striate; mesopleural triangle and mesopleuron along ventral margin with tuft of long white setae. Scutellum slightly longer than medium width and scabrous; scutellar foveae as roughly sculptured as scutellum, and separated by median keel. Metapleural sulcus reaching mesopleuron in at four-fifths of its height. Propodeum with uniformly relatively dense white pubescence, median propodeal area coriaceous, median propodeal carina absent, lateral propodeal carinae straight and parallel, median propodeal area with a distinct median transverse carina. Tarsal claws of legs with a triangular basal lobe.

Fore Wing (Fig. 6). Margin ciliated; radial cell open, 3.2 times as long as broad; areolet distinct, relatively large, closed; second abscissa of vein Rs almost straight, slightly curved apically, almost reaching wing margin; vein R_1 + Sc interrupted before reaching vein R. Rs + M basally reaching basalis at two-thirds from front.

Metasoma (Fig. 1). Petiole/metasomal tergite 1, sulcate dorsally and laterally, subrectangular in shape; syntergite (fused T2 + T3) showing a visible fissure between tergite 2 and tergite 3 in lower half, with an anterolateral patch of white setae, very finely punctate postero-apically; hypopygium with very minute dense punctures, ventral ridge with short white setae, prominent part of ventral spine of hypopygium 2.2 times as long as broad.

Color. Head entirely orange except compound eyes and occiput, which is dark brown medially; antenna: scape dark brown to orange, pedicel and F1-F6 yellowish orange, F7-F12 yellowish brown; mesosoma and coxae of legs entirely black, except base of wing

attachment orange; legs except coxae largely yellow except medially dark brown femur; wing membrane hyaline, veins brown to yellow; metasoma dark mostly black to dark brown, dark orange along ventral and posterior margins.

Male. Unknown.

Type Material. Holotype ♀, CHINA: Guanshan, Jiangping, Hupingshan National Forest Park, Hunan Province, 2009–10-23~11–03, reared from galls, Xiaohui Yang. Paratypes 5♀♀: 2♀♀ same as Holotype, 3♀♀, location as Holotype, 2010–10-28~11–03, Xiaohui Yang.

Etymology. The new species is named after the type locality, Hupinghan National Forest Park, located in Shimen County, Hunan Province, China.

Diagnosis. The new species can be easily separated from all other species of the genus by a combination of the following features: F1 distinctly expanded, radial cell >3 times as long as wide (Fig. 2), antennal scrobes are laterally separated from the rest of frons by a weak lateral frontal carina (Fig. 3), lateral pronotal carina present, having an anterolateral patch of dense setae on metasomal syntergite, and syntergite with a distinctly visible fissure laterally ventrally (Fig. 1). It is similar to *S. undulatus* (Mayr 1872), *S. haimi* (Mayr 1872), *S. naiquanlini* Melika, Acs et Bechtold, 2004, *S. yukawai* Wachi, Ide et Abe, 2010 in having distinct lateral pronotal carinae. However, the species can be easily separated from *S. undulatus* (Mayr 1872), *S. haimi* (Mayr 1872) by having distinct notauli and from *S. naiquanlini* Melika, Acs et Bechtold, 2004, *S. yukawai* Wachi, Ide et Abe, 2010 by having contrastingly bright orange head. The color pattern of the new species can also be used to separate it from all other known species of the genus from China except *S. chaodongzhui*, which can be easily separated using afore-mentioned diagnostic features.

Biology. All specimens were reared from galls collected from *Castanopsis carlesii.* The galls are nondetachable and multi-chambered (Fig. 8), formed on the mid rib on the underside of leaves (Fig. 7). We collected the galls as early as 10 June (2010), and we were able to rear adults from galls collected on 10 June (2010) and 9 July (2009) alike. Adults emerged in the end of October and early November.

Distribution. Hupingshan National Forest Park, in northwestern Hunan Province of China.

Discussion

Although members of Synergini are mostly known to be inquilines, Abe et al. (2011) has reported gall-inducing *S. itoensis.* For *S. hupingshanensis* described herein, we conducted field collection several times in 2 yr and were able to rear >50 wasps, including 10 adults of the species and rest of two species of the parasitic family Torymiidae. Nonetheless, we were unable to rear any specimen of the "expected gall inducing hosts." Given Abe et al.'s (2011) discovery of *S. itoensis*, we do not exclude the possibility that *S. hupingshanensis* is in fact a gall inducer, which needs to be tested by experiments in the future.

The vast majority of known gall wasp diversity, with roughly ≈1,350 species worldwide, is from western Palearctic and Nearctic (Ronquist and Liljeblad 2001, Abe et al. 2007, Liljeblad et al. 2008). It is a widely held belief among working entomologists on cynipid gall wasps that the species diversity of Cynipidae in eastern Asia, especially in China, should be much higher than is known if properly studied (Liljeblad 2002, Abe et al. 2007, Liljeblad et al. 2008). This is mainly because of two factors. Firstly, there exists great species diversity of potential host plants of cynipid gall wasps in the area, including *Quercus* and the quite speciose, related genera *Lithocarpus*, *Castanopsis*, and *Cyclobananopsis.* The genus *Lithocarpus* is endemic to east and Southeast Asia, with 300 or so species, among which 123 species (69 endemic) are from China alone (Huang et al. 2000); the only species previously classified to the genus from western North America (Nixon 1997) is now the monotypic species of the newly created genus *Notholithocarpus* Manos, Cannon, and Oh (Manos et al. 2008), which is considered more closely related to *Quercus*, *Castanea*, and *Castanopsis* than to *Lithocarpus* (Manos et al. 2008, Oh and Manos 2008). All the 120 known species of *Castanopsis* are from tropical and subtropical Asia with 58 species (30 endemic) in China (Huang et al. 2000). In addition, *Cyclobalanopsis*, which is often treated as a subgenus of *Quercus* (Nixon 1997), is also endemic to Asia and has ≈150 species with mainly tropical and subtropical distribution, with 69 species (43 endemic) in China (Huang et al. 2000). Secondly, the vast majority of the gall wasp diversity is found in the tribe Cynipini, with ≈1, 000 known species (compared with 1,350 known species of all cynipids), and most of them induce galls on oaks (hence the name oak gall wasp tribe) (Ronquist and Liljeblad 2001, Abe et al. 2007). Furthermore, ≈125 species of the rest of the family are obligate inquilines of oak gall wasps (Ronquist and Liljeblad 2001).

Known gall wasps of the tribe Cynipini are almost exclusively associated with oaks, with only a few exceptions (Ronquist and Liljeblad 2001, Buffington and Morita 2009). Three of the four oak gall wasp species that induce galls on hosts other than oaks are from western United States, that is, *Andricus mendocinensis* on *Lithocarpus densiflorus* in (Weld 1957), *Dryocosmus castanopsidis* on *Chrysolepis chrysophylla* and *Ch. semperviris* (Weld 1957, Buffington and Morita 2009), *D. rileypokei* on *Ch. semperviris* (Buffington and Morita 2009). The other nonoak galling species is the notorious oriental chestnut gallwasp *D. kuriphillus* on *Castanea* spp. (Yasumatsu 1951, Ding et al., 2004, Long and Wang, 2011). The chestnut pest species native to eastern Asia has been introduced to North America (Rieske 2007, Anagnostakis et al. 2009) and Europe (EFSA Panel on Plant Health, 2010). It is interesting to notice that oak gall wasps are able to exploit both species of *Chrysolepis* and the only species of *Notholithocarpus* in the United States, where there is a long history of studies of Cynipidae, with figures such as Beuttermueller, Gilleate, Kinsey, and Weld. It certainly is not unfounded to suggest that the low species diversity of cynipid known from Asia is largely because

of lack of studies. In fact, quite a number of new species of cynipids have been reported from eastern Asia including China (Melika et al. 2004, 2007, 2011; Tang et al. 2009, 2011; Ide et al. 2010; Wang et al. 2010, 2012; Abe et al. 2011). Of particular interest are the studies of Ide et al. (2010), which described *Plagiotrochus masudai* associated with *Cyclobananopsis*, and Melika et al. (2011), which described four species of the genus *Dryocosmus*, including two species associated with *Castanopsis* and *Lithocarpus*, respectively. Our discovery of *S. hupingshanensis*, if confirmed to be inquilinous, would suggest that some synergine species were able to "track" gall making hosts at some point in their evolutionary past and become associated with plants of *Castanopsis*. All these discoveries put together show that the long predicted high species diversity of Cynipidae in eastern and southeastern Asia is a true reality.

Acknowledgments

We thank Zhu-Jie Kang, Fan-Zhang Du, and Qing-Yi Liao from Hupingshan National Forest Park for field assistance and Peng-Fei Lu from CSFTU for help in the field as well as in the lab. This work was supported by National Nature Science Foundation of China (no. 30872036). George Melika, Jose-Luise Nieves–Aldrey, and an anonymous reviewer have provided very helpful comments.

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Received 17 February 2012; accepted 29 May 2012.