A New Inquiline Species of *Saphonecrus* (Hymenoptera: Cynipidae: Synergini) Associated With Cecidomyiid Galls on Oak Trees in Japan

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Ann. Entomol. Soc. Am. 104(3): 369–373 (2011); DOI: 10.1603/AN10187

ABSTRACT A new inquiline oak gall wasp species, *Saphonecrus yukawai* Wachi, Ide & Abe, sp. nov. (Hymenoptera: Cynipidae: Synergini), is described from Japan. Although most inquiline oak gall wasps are associated with cynipid galls on *Quercus* trees, the adult wasps of *S. yukawai* emerged from galls induced by the gall midge *Ametrodiplosis acutissima* (Monzen) (Diptera: Cecidomyiidae) on *Quercus* (sect. *Cerris*) *acutissima* Carruthers. Host shift from cynipid galls to cecidomyiid galls in inquiline oak gall wasps is discussed.

KEY WORDS inquiline oak gall wasp, new species, Cecidomyiidae, *Quercus*

Although inquiline gall wasps belonging to the tribe Synergini (Hymenoptera: Cynipidae) are usually associated with cynipid galls, isolated instances of galls induced by some species of gall midges (Diptera: Cecidomyiidae) on oak (*Quercus* spp.) trees have been reported to occasionally host inquiline gall wasps (Mayr 1872, Pujade-Villar and Ros-Farré 1998, Askew 1999, Melika 2006; Table 1). Yukawa and Masuda (1996) reported that inquiline gall wasps are occasionally reared from galls induced by the cecidomyiid *Ametrodiplosis acutissima* (Monzen) (fig. C-077 in Yukawa and Masuda 1996) on *Quercus* (sect. *Cerris*) *acutissima* Carruthers in Japan. Yukawa (1971) stated that further study is required to clarify the taxonomic position of this gall midge, and inquiline gall wasps developing in cecidomyiid galls have not yet been described.

Because the members of Synergini have lost the ability to induce their own galls, they feed on gall tissues induced by other insects, mainly cynipid gall wasps on *Quercus* (sect. *Cerris*) *acutissima* (Hartig, 1843; and *Andricus* bur-undus) Giraud (Pujade-Villar et al. 2003). Pénzes et al. (2009) revised *Synophrus* by using morphological and molecular data and suggested that *Saphonecrus* should be synonymized with *Synophrus*. Moreover, other phylogenetic studies of some *Saphonecrus*, *Synophrus*, and *Synophrus* species by using molecular methods do not support monophyly of the *Saphonecrus* (Ács et al. 2010). Further research considering other genera from around the world is therefore required to provide a better and more robust classification of inquiline oak gall wasps (Nieves-Aldrey and Medianero 2010).

Here, we describe the new species of Synergini that was reared from the gall induced by the cecidomyiid *A. acutissima* on *Q. acutissima*, and we discuss its taxonomic position and host shift from cynipid galls to cecidomyiid galls in inquiline oak gall wasps.

Materials and Methods

The following morphological abbreviations are used: POL, the postocular line (the distance between the inner edges of the two lateral ocelli); OOL, the ocular-ocular line (the distance from the outer edge of a lateral ocellus to the compound eye); and LOL, the lateral-ocular line (the distance between frontal and lateral ocelli). Morphological terminology mainly follows Richards (1977), Ronquist and Nordlander (1989), Ronquist (1994), and Liljeblad et al. (2008); cuticular surface terminology follows Harris (1979).
Gall numbers (as C-xxx) and the Japanese names of galls follow Yukawa and Masuda (1996).

The external structure of the dry-mounted wasp specimens and gall specimens was studied with binocular stereomicroscopes (model SZ60, Olympus, Tokyo, Japan; model MZ12, Leica, Solms, Germany, fitted with model DS-L1, Nikon, Tokyo, Japan), and the lengths of the forewing and hind tibia in 23 females and 21 males were measured using an ocular micrometer. Five specimens were gold-coated with a sputter coater and examined with a scanning electron microscope (model JSM-5600LV, JEOL, Tokyo, Japan). The right forewing of a female wasp was slide-mounted in Euparal.

Specimens Examined. In total, 58 specimens (26 females and 32 males) that emerged from galls of A. acutissima were examined and deposited at the Biosystematics Laboratory, Graduate School of Social and Cultural Studies, Kyushu University [BLKU], Fukuoka, Japan.

Results

Saphonecrus yukawai Wachi, Ide et Abe, sp. nov. (Figs. 1–9)

Holotype Male. Head dark brown, except for yellow compound eye and antenna; mesosoma dark brown, except for brown coxae and yellow other segments of legs; metasoma brown, except for dark brown metastomal tergum I and posterior margin of fused metastomal terga II and III.

Head 1.2× as broad as high in anterior view, as broad as mesosoma in dorsal view. Vertex with sparse setae. POL:OOL:LOL = 9:5:4, area among ocelli roughly rugose, frontal carina distinct, antennal rim distinctly widened lateroventrally. Distance between antennal rims as long as distance between antennal rim and inner margin of compound eye, lower face with dense long setae, facial strigae radiating from clypeus almost reaching compound eye, gena broadened behind eye in anterior view. Antenna 15-segmented; relative lengths of flagellomeres: 4, 2, 2, 2, 1.5, 2, 1.5, 2, 1.5, 1.5, 1.5, 2; first flagellomere incised on outer margin, weakly swollen distally (Fig. 9).

Mesosoma pubescent but mesopleuron shiny except for lower part and subalar triangle. Pronotum rugose, lateral pronotal carina present. Mesoscutum transversely rugose, notaulus complete and distinct with a distinct anterior pit, anteroadmedian and parapsidal signa present, posterior margin of mesoscutum with median mesoscutal impression reaching one third of mesoscutum; scutellum rugose with two foveae at base; mesopleuron striate; propodeal carinae nearly parallel and distinct.

Marginal cell of forewing open on anterior margin, 3.3× as long as broad, wing surface closely ciliated.

### Table 1. Inquiline gall wasps that develop in cecidomyiid galls

| Inquiline gall wasp | Host | Galls on | Reference |
|---------------------|------|---------|-----------|
| Synerus variabilis  | J. acutissima | Q. cerris | —a |
| S. variabilis       | Dryomyia circinnans | Q. cerris | —a |
| Saphonecrus haimi J. cerris | Q. cerris | —a |
| Cerapteres inermis (Walsh) | C. pilulae | (Osten Sacken)b | Burks (1979) |

a Mayr (1872), Pujade-Villar and Ros-Farré (1998), Askew (1999), Melika (2006).

b Rosquist (1994) mentioned that this record needs confirmation.
Tarsal claw with a long subapical seta, apex of claw strongly bent, base expanded to a lobe pronounced but blunt incision rounded. Metasomal terga II and III fused, shiny and smooth, with a few setae basolaterally. Length of forewing 1.9 mm, of hind tibia 0.84 mm.

**Female.** Differs from the male as follows. Antenna 13-segmented, relative lengths of flagellomeres 1–11: 3.5, 1.5, 2, 2, 1.5, 1.5, 1.5, 1.8, 1.8, 3. Ventral spine of hypopygium short with a few setae.

**Variation.** Other materials are darker than the holotype and paratypes: head black, except brown terminal antennal segment and yellowish brown mandible and other antenna segments; mesosoma black, except for brown tegula, coxae, tarsal claws, hind femur and yellowish brown other leg segments; metasoma brown. In some specimens, the basal half of hind femur is dark brown. Two females have a transverse line on the terminal antenna segment possibly originating from fusion of two flagellomeres. Length of forewing (mean ± SD): 1.3–2.6 (2.1 ± 0.35) mm in females (n = 23), 1.4–2.5 (2.0 ± 0.3) mm in males (n = 20); length of hind tibia: 0.48–0.96 (0.67 ± 0.12) mm in females, 0.48–0.96 (0.67 ± 0.12) mm in males.

**Type Material.** HOLOTYPE. Male, with three labels of ‘Oita Forestry Experimental Station, Hita City, Oita Pref., Japan, Mid. IV-1977, J. Yukawa leg.’, ‘kunugi-eda-hime-kou-fushi’ and ‘Holotype’. PARATYPES. Nine males, same locality, date, collector and host gall as the holotype. Ten females and six males, Kuju, Oita Pref. Japan, IV-1988, Y. Abe leg., em. V-1988, same host gall as the holotype.

**Other Material Examined.** They also were reared from ‘kunugi-eda-hime-kobu-fushi’ on *Q. acutissima* in

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**Figs. 6–8.** Female of *S. yukawai*. (6) Forewing (scale bar = 500 μm). (7) Ventral spine of hypopygium (scale bar = 50 μm). (8) Tarsal claw of hindleg, the arrow indicates the subapical seta (scale bar = 20 μm).

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**Fig. 9.** Male of *S. yukawai*: Basal segments of antenna, in posterodorsal view.

**Fig. 10.** Host galls for *S. yukawai* (scale bar = 1 mm).
Japan. Three females, Kanmuri-Kogen, Yoshiwa, Hat- 
suka-ichi-City, Hiroshima Pref., 26-XI-2007, Y. Abe, N. 
Wachi, and K. Matsuo leg., em. 5-IV-2008. One female 
and one male, Mt. Sakurei, Saga Pref., 3-V-2008, Y. Abe 
and N. Wachi leg. Four females and six males, 11-V- 
2008. Yoshibu, Kuju, Oita Pref., Y. Abe and N. Wachi 
leg. One female, Azami-dai, Kokonoe-cho, Oita Pref., 
11-IV-2009. Y. Abe. T. Ide and N. Wachi leg., em.11- 
IV-5-V-2009. Eight females and eight males, 18-IV-
2010., same locality, N. Wachi and O. Tanaka leg., em. 
V-2010.

Etymology. Named in honor of J. Yukawa, a signif-
icant contributor to cecidology, particularly the tax-
onomy and ecology of gall midges (Diptera: Ceci-
domyiidae).

Host Gall. The twig gall on Q. acutissima (Fig. 10) 
was described as “kunugi-edo-hime-kobu-fushi” mean-
ing “Q. acutissima-twig-smaller-swelling-gall” in 
Japanese (fig. C-077 in Yukawa and Masuda [1996]). 
Yukawa and Masuda (1996) regarded Ametroteliosis 
acutissima (Monzen) as the gall inducer, although 
the adult gall midges reared from this gall lack any diag-
nostic characteristics of the genus Ametroteliosis (S.
Sato and J. Yukawa, personal communication).

Geographic Distribution. Japan (Honshu, Kyushu).

Remarks. In a key to the world genera of Synergini 
(Melika et al. 2005), this new species is classified as 
Saphonecrus except that the gena is broadened behind 
the compound eye. S. yukawai can be distinguished from 
the recently established genus, Agastoroxenia 
Nieves-Aldrey and Medianero by the following: 1) 
the marginal cell of the forewing is closed in Agastoroxenia 
but open in S. yukawai and 2) the antenna is 13-
segmented in both sexes of Agastoroxenia but 13-seg-
mented in female and 15-segmented in male S. yu-
kawai.

Seventeen species of Saphonecrus have been known 
from the Holarctic region, eight of which are distrib-
uted in the Eastern Palearctic region (Melika 2006, 
Abe et al. 2007). Of these, Saphonecrus connatus (Har-
tig), which is the type species of this genus and which 
also is distributed in the Western Palearctic region, has 
been known from Japan (Sakagami 1949, Abe et al. 
2007). Sakagami (1949) reported that the wasps of S. 
connatus were reared from a leaf gall on Quercus den-
tata Thunberg, which is figured in Monzen (1929) and 
is the sexual gall of the cynipid oak gall wasp Andricus 
hakonensis (Ashmead) (Yukawa and Masuda 1996, 
Wachi and Abe 2010).

S. yukawai can be distinguished from S. connatus as 
follows: 1) the notaulus is incomplete and reaching 
half of the mesoscutum length in S. connatus but com-
plete and distinct in S. yukawai and 2) the frontal 
carina is absent in S. connatus but present in S. yukawai. 
Among other members of Saphonecrus, S. yukawai is 
most similar to S. chaodongzhui Melika et al. 2004, 
because they have both the frontal carina and distinct 
and complete notaulus. However, S. yukawai can be 
distinguished from S. chaodongzhui by the following three 
characteristics: 1) the frontal carina is very weak in 
S. chaodongzhui but distinct in S. yukawai, 2) the 
gena is not broadened behind compound eye in S. 
chaodongzhui but broadened in S. yukawai, and 3) an 
anteor pit on the notaulus is absent in S. chaodong-
zhui but present in S. yukawai.

Discussion

Inquiline oak gall wasps usually depend on galls 
induced by other cynipid gall wasps (Ronquist 1994, 
Stone et al. 2002, Abe et al. 2007). As reported by 
Mayr (1872), Pujade-Villar and Ros-Farré (1998), Askew 
(1999), and Melika (2006), Saphonecrus haimi (Mayr) 
and Synergus variabilis Mayr are exceptions (Table 1).
Both species usually depend on cynipid galls but may 
occasionally occur in cecidomyiid galls on Quercus 
cerris L. leaves. Because S. yukawai wasps have only 
been reared from A. acutissima galls on Q. acutissima, 
this new inquiline gall wasp is probably the first known 
species specialized to depend on cecidomyiid galls.

Numerous cecidomyiid species are known to in- 
gue galls on Fagus spp. (Fagaceae); however, only a 
few species of this family are known to induce on 
Quercus spp. (Yukawa and Masuda 1996, Yukawa et al. 
2005). Conversely, most cynipid species induce galls 
on Quercus spp. (Ronquist 1999, Stone et al. 2002, 
Csöka et al. 2005, Abe et al. 2007, Liljeblad et al. 2008). 
Inquiline oak gall wasps are considered to have di-
verged extensively from the ancestral species on Quer-
cus spp. through a shift in host galls. The most plausible 
explanation for the evolution of the host association in 
S. yukawai is that the female ancestor of this species, 
which was probably dependent on cynipid galls that 
was probably induced on Q. acutissima, accidentally ovi-
posited into galls induced by the cecidomyiid, A. acut-
tissima, and some of the resulting offspring developed 
successfully. Over successive generations, these wasps 
became increasingly specialized to using A. acutissima 
galls.

In a review of the genus Syrophorus, Pérezes et al. 
(2009) suggested that Saphonecrus should be synon-
ymized with Syrophorus. However, the systematic po-
sition of Saphonecrus is uncertain because the place-
ment of the type species, S. connatus, is equivocal 
based on the molecular data (Pérezes et al. 2009). 
Further phylogenetic analyses considering the 12 
other known Saphonecrus species are required to more 
accurately infer the taxonomic affiliations within the 
genus (Pérezes et al. 2009). Furthermore, Ács et al. 
(2010) confirmed that Saphonecrus is probably not 
monophyletic. In the absence of a global phylogeny 
for all inquiline genera that includes taxa from the 
Eastern Palearctic, Nearctic, and Neotropical regions 
(Nieves-Aldrey and Medianero 2010), we prefer to 
retain Saphonecrus as an inquiline genus as defined by 
Melika (2006).

Acknowledgments

We are indebted to J. Yukawa (Kyushu University) for gift 
of specimens for the types of the new inquiline gall wasp 
species and helpful suggestions. We thank S. Sato (Miyazaki 
University) for comments on the taxonomic position of A. 
acutissima. Thanks also are due to K. Matsuo (Kyushu Uni-
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Received 24 November 2010; accepted 14 December 2010.