New *Dryocosmus* Giraud species associated with *Cyclobalanopsis* and non-*Quercus* host plants from the Eastern Palaearctic (Hymenoptera, Cynipidae, Cynipini)

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Abstract

Our knowledge about gall wasps associated with the diverse East Asian oaks, *Castanopsis* and *Cyclobalanopsis*, is limited due to the lack of extensive field studies. Here, we describe twelve new oak gall wasp species, *Dryocosmus cannoni* Schwęger & Tang, *D. caputgrusi* Tang & Schwęger, *D. crinitus* Schwęger & Tang, *D. harrisonae* Melika & Tang, *D. hearni* Melika & Tang, *D. hualieni* Schwęger & Tang, *D. konradi* Tang & Melika, *D. liyingi* Melika & Tang, *D. moriius* Tang & Melika, *D. quadripetiolus* Schwęger & Tang, *D. salicinai* Schwęger & Tang, and *D. taitungensis* Tang & Melika, from Taiwan and mainland China. Seven newly described species induce galls on *Quercus* subgenus *Cyclobalanopsis* and five on other Fagaceae genus, *Castanopsis*. All of the new species concepts are supported by morphological and molecular data. We provide descriptions, diagnoses, host associations for the new species and an illustrated identification key to Eastern Palaearctic *Dryocosmus* species. We represent natural language phenotypes in a semantic format supported by biomedical ontologies to increase the accessibility of morphological data.
Keywords
Cynipidae, Dryocosmus, Plagiotrochus, Cyclobalanopsis, Castanopsis, Lithocarpus, Castanea, biology, morphology

Introduction

Oak gallwasps (Hymenoptera: Cynipidae: Cynipini), with about 1000 species, are the most species-rich cynipid lineage (Csóka et al. 2005). Most cynipine species are associated with oaks of the Quercus L. subgenus Quercus L. in the Western Palaearctic and Nearctic (Stone et al. 2002, 2009, Abe et al. 2007). Although the other Quercus subgenus, the Asian Cyclobalanopsis (Oersted) C. K. Schneider, is represented by 76 species (Govaerts and Frodin 1998, Manos and Stanford 2001), our knowledge about Cyclobalanopsis associated cynipines is restricted to a few, recently described taxa (Abe et al. 2014a, b, Ide et al. 2010, 2012, 2013, Melika et al. 2011, 2013, Tang et al. 2011a, b, 2016a, b).

Similarly to Cyclobalanopsis, East Asia is also a diversity center for three other Fagaceae genera. The tropical and subtropical Castanopsis Miller is represented with 134 species in Asia and Malesia; the 325 species of Lithocarpus Blume (=Pasania (Miq.) occur almost entirely in Asia and Malesia (one species in the western North America), and the 8 species of Castanea Miller are distributed in the Northern Hemisphere (Govaerts and Frodin 1998). Associations between East Asian representatives of these Fagaceae genera and Cynipini have been revealed only very recently (Tang et al. 2011a and Tang et al. 2016a).

Of the ten Eastern Palaearctic Dryocosmus species, D. sakureiensis Ide, Wachi & Abe, D. sefuriensis Ide, Wachi & Abe, are associated with Cyclobalanopsis, four species, D. carlesiae Tang & Melika, D. pentagonalis Melika & Tang, D. testisimilis Tang & Melika, D. triangularis Melika & Tang, with Castanopsis, two species, D. kuriphilus (Yasumatsu), and D. zhuili Liu & Zhu, with Castanea. Hosts of Dryocosmus nanlingensis Abe, Ide, & Odagiri and D. okajimai Abe, Ide, Konishi & Ueno are unknown (Abe et al. 2014a, b, Ide et al. 2010, 2012, 2013, Melika et al. 2011, 2013, Tang et al. 2011a, b, Zhu et al. 2015). Ide and Abe (2015) described a new cynipine species, Dryocosmus kunugiphagus, from a section Cerris oak, Quercus acutissima Carruth, as the first Dryocosmus species developing on section Cerris oaks in the Eastern Palearctic. This species shares numerous diagnostic features with Plagiotrochus and lack key character states of Dryocosmus (e.g. in D. kunugiphagus the mesoscutum is rugose, with dense setae, the mesopleuron rugose and the apical setae of the ventral spine of hynopygium do not form a truncate apical tuft; Melika et al. 2010, Ide and Abe 2015), thus we did not treat Dryocosmus kunugiphagus in the present paper.

In this study we double the number of Dryocosmus species associated with non-subgenus Quercus oaks and describe twelve new Dryocosmus species from Taiwan and four from mainland China. Seven of these, Dryocosmus crinitus Schwéger & Tang, D. hualieni Schwéger & Tang, D. konradi Tang & Melika, D. liyingi Melika & Tang, D. moriius Tang & Melika, D. salicinai Schwéger & Tang, and D. taitungensis Tang
New Dryocosmus Giraud species associated with Cyclobalanopsis and non-Quercus host...


**Materials and methods**

Galls were collected from *Castanopsis* and *Quercus* subgenus *Cyclobalanopsis* species in Taiwan and China in March 2011 and 2012 from the following localities: Taiwan: *Castanopsis carlesii* (Hemsley) Hayata and *C. uraiana* (Hayata) Kaneh. & Hatus at Taoyuan and Taitung Counties; *Q. glauca* Thunb. in Murray at Hualien and Nantou Co., *Q. morii* Hayata and *Q. longinux* Hayata at Nantou Co., *Q. hypophaea* Hayata at Taitung Co., *Q. salicina* Blume at Taichung Co., *Q. sessilifolia* Blume at New Taipei City, China: *Castanopsis echinocarpa* Miq. at Yunnan Province, Xishuangbanna Lan Cang County and Xishuangbanna, Yunnan Province; *Castanopsis* sp.4 at Lan Cang County, Yunnan Province. Galls were kept at room temperature in plastic containers with openings on the lids that were covered with meshes to keep ventilation. Emerged adult wasps were preserved in 99% ethanol.

The type material is deposited in the following institutions: NMNS, National Museum of Natural Science, Taichung, Taiwan (curator M.L. Jeng); PHMB, Plant Health and Molecular Biology Laboratory, National Food Chain Safety Office, Budapest, Hungary (curator G. Melika); NCHU, Department of Entomology, National Chung Hsing University, Taichung, Taiwan (curator M.-M. Yang); USNM, U.S. National Museum of Natural History, Smithsonian Institution, Washington, DC, U.S.A. (curator M. Buffington).

Bright field images of adults and galls were produced with a digital Leica DC500 camera attached to a Leica DM2700M compound microscope using the LAS Store&Recall software, followed by processing in Adobe Photosh 6.0. High resolution plates are available from Figshare ([https://dx.doi.org/10.6084/m9.figshare.3837915.v1](https://dx.doi.org/10.6084/m9.figshare.3837915.v1)).

Anatomical terms were matched to concepts in the Hymenoptera Anatomy Ontology (Yoder et al. 2010) and a URI table (Suppl. material 1) containing morphological terms, definitions and Uniform Resource Identifiers resolved at [http://hymao.org](http://hymao.org) were generated using the text analyzer function (Seltmann et al. 2013, [http://portal.hymao.org/projects/32/public/ontology/](http://portal.hymao.org/projects/32/public/ontology/)).

Matrix-based descriptions were generated using mx ([http://purl.org/NET/mx-database](http://purl.org/NET/mx-database)). Terminology of morphological statements used in descriptions, identification key and diagnoses are mapped to relevant biomedical ontologies (Hymenoptera Anatomy Ontology (HAO), Phenotypic Quality Ontology (PATO), Biospatial Ontology (BSPO), Common Anatomy Reference Ontology (CARO); available at [http://obofoundry.org/](http://obofoundry.org/)).

We represent natural language phenotypes in an Entity: Quality (EQ) format: Entity attribute: value. Semantic statements of natural language phenotypes (Suppl. material 2) were composed in Protégé 5.0 ([http://protege.stanford.edu/](http://protege.stanford.edu/)) using the OWL Manchester syntax ([http://www.w3.org/TR/owl2-manchester-syntax/](http://www.w3.org/TR/owl2-manchester-syntax/)) following Balhoff et al. (2013) and Mikó et al. (2014).

The phenotypic descriptors “glossy and matte” (http://purl.obolibrary.org/obo/PATO_0001373), refer to the reflectance quality of the cuticle. These relation phenotypes can only be observed under direct light (without light diffusers) and might correlate to the cuticular hydrocarbon profile (Hora et al. 2007, 2010).

The phenotypic descriptor “smooth” refers to the sculpture quality of a cuticular region that lacks “leathery” microsculpture (Ball 1985). Hexagonal sculptural elements (scutes, http://purl.obolibrary.org/obo/HAO_0002430) of this microsculpture type most likely correspond to epidermal cells (Hinton 1970, Moretto 2015). Sculptures with convex scutes surfaces are referred here as “coriaceous” while that of flat scute surfaces are named “alutaceous”.

Species concepts of the present paper were also examined using genetic data. Part of the mitochondrial cytochrome b (cyt b) gene was amplified from extractions of whole genomic DNA from between one and four individuals per species using the primers CB1/ CB2 or CB1/CP2, following protocols in Nicholls et al. (2010). PCR products were cleaned up using a standard SAP/ExoI protocol, then sequenced in both directions using BigDye v3.1 terminator chemistry and run on an ABI3730 capillary sequencer. Base calls were confirmed by eye using Sequencher version 4.10.1 (Gene Codes Corporation 1995). Sequence data for the corresponding fragment were also obtained for two or three individuals of four previously described Dryocosmus species: D. carlesiae, D. pentagonalis, D. testisimilis, D. triangularis. Pairwise distances between all individuals were determined in PAUP* v4.0b10 (Swofford 1998) using a HKY model of sequence evolution, then average within- and between-species distances were calculated for each species-level comparison.

Results

Molecular markers

A 433 base-pair fragment of the cyt b gene was successfully amplified for between one and six individuals of each species; in total 49 sequences were obtained from 17 species (GenBank accession numbers KU760807–KU760855). Variation within species was minimal, ranging from 0 to 1.6% (Table 1, values on diagonal). Variation between all species, both new ones described herein and previously described taxa, was greater than 6.9% for all comparisons except the one between D. harrisonae and D. cannoni (2.0%), and in some instances was greater than 20% (Table 1). These values are consistent with those expected for within- and between-species variation both in gall wasps (Nicholls et al. 2012) and among insects in general (Hebert et al. 2003), supporting the distinctiveness of the newly described Dryocosmus species.
New Dryocosmus Giraud species associated with Cyclobalanopsis and non-Quercus host...  

Table 1. Pairwise genetic distances between 17 *Dryocosmus* species, based upon 433 base pairs of the cytochrome *b* gene using a HKY correction. Values on the diagonal indicate variation levels among individuals of the same species; off-diagonal values indicate between-species distances.

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<thead>
<tr>
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<th><em>D. cannoni</em></th>
<th><em>D. caputgrusi</em></th>
<th><em>D. crinitus</em></th>
<th><em>D. harrisonae</em></th>
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<th><em>D. kuriphilus</em></th>
<th><em>D. pentagonalis</em></th>
<th><em>D. testisimilis</em></th>
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Morphology

Dryocosmus Giraud, 1859

Description. Clypeus ventral margin shape: straight; Malar striae count: present; Malar striae dorsal limit: torulus-eye line on lower face and lower eye margin on malar area; Malar area: alutaceous; Malar sulcus: absent; Impression around central ocellus: present; Postgenal bridge / length of oral foramen: <1.

Transverse pronotal sulcus depth: deep; Notaulus limits: well-impressed, posterior end adjacent to posterior margin of mesoscutum, anterior end adjacent to anterior margin of mesoscutum; Mesoscutum sculpture: smooth or delicately alutaceous; Mesoscutum reflectivity: glossy; Metanotal trough sculpture: smooth; Metanotal trough reflectivity: glossy; Metascutellum sculpture: coriaceous; Scutellar foveae count: present; Foveal septum count: present or absent; Dorsomedian area of mesoscutellar-axillar complex (disc of mesoscutellum+axillar foveae) shape: trapezoid or quadrangular. Subaxilllar bar sculpture: smooth; Subaxilllar bar reflectivity: glossy; Mesoscutellar axillar complex posterior margin vs metanotum: overhanging; Mesopleuron sculpture: smooth, mostly glossy, only partially coriaceous; Speculum sculpture: smooth, mostly glossy, only partially coriaceous; Lateral propodeal carinae count: present; Central propodeal area reflectivity: glabrous; Lateral propodeal area pilosity: present; Nucha sculpture: with delicate longitudinal rugae dorsally and laterally; Wings fully developed; Marginal cilia: long; R1 distal end vs wing margin: adjacent to wing margin; Rs distal end vs wing margin: adjacent to wing margin.

Metasoma lateral height / metasoma lateral length: <1; Metasoma length / head+mesosoma length: <1; Second metasomal tergite sculpture: smooth; Metasomal tergites 3-6 reflectivity: glossy; Distal end of ventral spine of hypopygium shape: acute or rounded distallyapically; Prominent part of ventral part of hypopygium length / width: < 3.5; ventral part of hypopygium seta length: short.

Diagnosis. Most similar to Plagiotrochus Mayr by sharing the following character states: lower face with striae radiating from clypeus to inner margin of eye (sometimes indistinct because of short malar space), malar sulcus absent; lateral propodeal carinae curved outwards, median longitudinal carina sometimes present; central propodeal area with rugae; metasoma strongly compressed laterally; ventral spine of hypopygium short, acute or rounded apically, with or without a dense truncate tuft, prominent part < 3.5 times as long as broad (Melika et al. 2010).

Dryocosmus: mesoscutum smooth or alutaceous; ventral spine of hypopygium with setae forming a truncate apical tuft.

Plagiotrochus: mesoscutum entirely coriaceous or rugose; ventral spine of hypopygium with setae not forming a truncate apical tuft.
Key to *Dryocosmus* species

1. Mesosoma orange-yellow, metasoma light brown, female head orange-yellow to light brown, male head orange-yellow to dark brown .......................... 2

2. Body dark brown to black, with some minute, light brown areas ............... 3

3. Notaulus posterior region width / notaulus anterior region width = 5 (not: Fig. 73); posterior height of subaxillular bar / height of metanotal trough = 0.25 (sab, mtr: Fig. 72); central propodeal area with transverse carina (trc: Fig. 74) in dorsal 1/3rd and with longitudinal parallel rugae between transverse carina and nucha (Fig. 74) ..........................

4. Number of flagellomeres (female): 12; eye height / malar distance = 2.6; intertorular distance / eye torulus distance = 0.70; radial cell length / radial cell width = 3.40; 2nd metasomal tergite length dorsal view / length of metasoma dorsal view ≥ 0.50; prominent part of ventral spine of hypopygium length ventral view / prominent part of ventral spine of hypopygium width ventral view = 2.2 .......................... *Dryocosmus sakureiensis* Ide, Wachi & Abe, 2013

5. Dense setae present on lateral mesopleural surface ventral to transepisternal line (tel: Fig. 142) ... *Dryocosmus quadripetiolus* Schwéger & Tang, sp. n.

6. Striae marking transepisternal line extends ¾ of mesopleuron length (tel: Fig. 24) ........................................

7. Speculum striate (spe: Fig. 24) ................................................................

Female POL/OOL = 1.40 (Fig. 2); male eye height / malar distance = 8.1; male eye height / transfacial distance = 1.2 (Fig. 5); male pedicel length / scape length < 1 (Fig. 10). 

Female POL/OOL = 1.80 (Fig. 176); male eye height / malar distance = 8.70; male eye height / transfacial distance = 1.40 (Fig. 177), male pedicel / scape = 1.

**Dryocosmus triangularis** Tang & Melika, 2011

Disc of mesoscutellum glossy and smooth at least in anterior half (dms: Figs 25, 26).

**Dryocosmus caputgrusi** Tang & Schwéger, sp. n.

Disc of mesoscutellum entirely rugose, matt (dms: Figs 178).

**Dryocosmus pentagonalis** Tang & Melika 2011

Mesopleuron and speculum matt, uniformly coriaceous, without striae.

**Dryocosmus salicinai** Schwéger & Tang, sp. n.

Mesopleuron glossy, smooth without striae (Fig. 99) or with few delicate indistinct striae marking transepisternal line (tel: Figs 84).

Mesopleuron and speculum smooth, without striae (Fig. 113).

Mesopleuron with few delicate indistinct striae marking transepisternal line (tel: Figs 166, 182, 184).

Second metasomal tergite with multiple setae laterally (Fig. 87).

Second metasomal tergite without or few setae laterally (Fig. 119).

Scutellar foveae without longitudinal striae (scf: Fig. 100); female F1 / F2 = 1.00; female F1 / pedicel = 2.7; placoid sensilla present on F1–F12 (Fig. 97).

**Dryocosmus konradi** Tang & Melika, sp. n.

Scutellar foveae with longitudinal striae (scf: Fig. 83); female F1 / F2 < 1; Female F1 / pedicel = 1.6; placoid sensilla present on F2–F12 (Fig. 81).

**Dryocosmus hualieni** Schwéger & Tang, sp. n.

Scutellar fovea minimum diameter / foveal septum width = 3.00; anterior pits of foveal septum present. **Dryocosmus okayimai** Abe, Ide, Konishi & Ueno, 2014

Scutellar fovea minimum diameter / foveal septum width = 6.00–10.00; anterior pits on foveal septum absent (Fig. 183).

Disc of mesoscutellum with irregular rugae (dms: Fig. 183).

**Dryocosmus carlesiae** Tang & Melika, 2011

Transverse pronotal sulcus not foveolate (tps: Fig. 40); pronotum posterolaterally with few short rugae as long as or shorter than diameter of anterior thoracic spiracle (Fig. 40).

Transverse pronotal sulcus foveolate (tps: Fig. 113); pronotum posterolaterally with numerous long rugae 2–3 times as long as diameter of anterior thoracic spiracle (Fig. 113).

**Dryocosmus liyingi** Melika & Tang, sp. n.

Central propodeal area with 1–2 delicate longitudinal lateral rugae (cpa: Fig. 42).

**Dryocosmus crinitus** Schwéger & Tang, sp. n.

Central propodeal area with numerous irregular longitudinal and transverse lateral and medial rugae.... **Dryocosmus nanlingensis** Abe, Ide & Odagiri, 2014
New Dryocosmus Giraud species associated with Cyclobalanopsis and non-Quercus host...

Speculum striate dorsally (spe: Fig. 166)...............................................................Dryocosmus taitungiensis Tang & Melika, sp. n.

– Speculum without striae (spe: Figs 11, 55, 184).................................................19

Triangular mesopleural furrow present; frons, interocellar area, vertex glossy, smooth, if frons alutaceous than only in lateral part, along compound eye....

...............................................................Dryocosmus sefuriensis Ide, Wachi & Abe, 2013

– Triangular mesopleural furrow absent; frons, interocellar area, vertex alutaceous or coriaceous (Figs 184–185) ..........................................................20

Head width / head height >1; gena broadened behind eye, visible in frontal view along entire lateral eye margin (gen: Fig. 186).................................................................Dryocosmus kuriphilus Yasumatsu, 1951

– Head width / head height = 1; gena not or very slightly broadened behind eye, not visible in frontal view or only visible along ventral region of lateral eye margin (gen: Figs 1, 48).................................................................21

Parapsidal line and median mesoscutal line present (pl, mml: Fig. 12) ..............

...................................................Dryocosmus cannoni Schwéger & Tang, sp. n.

– Parapsidal line and median mesoscutal line absent (Fig. 56).................................Dryocosmus harrisonae Melika & Tang, sp. n.

Dryocosmus cannoni Schwéger & Tang, sp. n.

http://zoobank.org/1466DED3-5B57-474D-89FA-20A2B1A4356F

Figures 1–17


The female holotype and the male paratype are deposited in PHMB.

Etymology. Named after Prof. Chuck Cannon (Xishuangbanna Tropical Botanical Garden, Yunnan, China).

Diagnosis. Dryocosmus cannoni, D. harrisonae, D. sefuriensis and D. kuriphilus belong to the group of species in which the area dorsal to the transepisternal line is delicately striate anteriorly and the speculum lacks striae.

Dryocosmus cannoni is most similar to Dryocosmus harrisonae, sharing the presence of a slightly broadened gena visible only ventrally along the lateral eye margin.

Dryocosmus cannoni: parapsidal line and median mesoscutal line present (Fig. 12); placoid sensilla present on female F4–F12 (Fig. 9); scutellar foveae semilunar, with longitudinal parallel rugae; foveal septum absent (Fig. 13).
Figures 1–10. *Dryocosmus cannoni* sp. n. 1–4 head, female: 1 frontal view 2 dorsal view 3 posterior view 4 lateral view 5–8 head, male: 5 frontal view 6 dorsal view 7 posterior view 8 lateral view 9–10 antenna: 9 female 10 male (gen=gena).

*Dryocosmus harrisonae*: parapsidal line and median mesoscutal line absent (Fig. 56); placoid sensilla present on female F2–F12 (Fig. 53); scutellar foveae transversely ovate, without rugae; foveal septum present (Fig. 57).
Description. Sexual female: Head color: brown; mandibles, maxillary and labial palps yellowish; scape and pedicel yellow, flagellomeres progressively darker. Meso-soma and metasoma color: dark brown to reddish brown, except for lighter tegula, propodeum, and posterior half of metasoma, legs yellow.

Figures 11–15. *Dryocosmus cannoni*, female, sp. n. 11 mesosoma, lateral view 12 mesoscutum, dorsal view 13 mesoscutellum, dorsal view 14 metascutellum and propodeum, posterodorsal view 15 fore wing, part (mml=median mesoscutal line, pl=parapsidal line, spe=speculum).


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Body length: 2.30 mm (n=1).


Gall (Fig. 17): The main body of the gall is located on a long, thin stalk, 1.5–2.1 mm long, growing from the base of the petiole or midrib of the leaf. The gall body contains a spherical part 6.0–8.1 mm in diameter and a needle-like projection at the top of the gall body nearly the same length as the gall diameter. The gall is green, surface smooth; parenchyma is green and succulent. Unilocular, with a centrally
located larval chamber. The gall development coincides with sprouting of the host-plant in April.

**Biology.** Only the sexual generation is known. Galls were collected from *Casta-nopsis echinocarpa* in April; adults emerge from galls under laboratory conditions immediately after field collection.

**Distribution.** China: Yunnan Province (Xishuangbanna).

**Dryocosmus caputgrusi** Tang & Schwéger, sp. n.

http://zoobank.org/BE520902-9F48-41F3-97DC-0152ADEB90E9

Figures 18–32


The female holotype and 1 female paratype are deposited in NMNS, 1 female paratype in PHMB, 1 female paratype in NCHU.

**Etymology.** The Latin “caput” means “head”, and “Grus” is a common crane genus name. The name reflects the shape of the gall which looks like a crane head.

**Diagnosis.** *Dryocosmus caputgrusi*, *D. pentagonalis* and *D. triangularis* belong to the group of species in which striae marking the transepisternal line extend at least ¾ of the mesopleuron length and the speculum is delicately striate (Fig. 24).

In *Dryocosmus triangularis* the female POL/OOL = 1.8 (Fig. 176); the male eye height / malar distance = 8.70; the male eye height / transfacial distance = 1.40 (Fig. 177); male pedicel nearly as long as the scape.

In *Dryocosmus caputgrusi* and *D. pentagonalis* the female POL/OOL = 1.4 (Figs 20, 174); male eye height / malar distance = 8.1; male eye height / transfacial distance = 1.20 (Fig. 175); the male pedicel / scape < 1.

*Dryocosmus caputgrusi*: the disc of the mesoscutellum is glabrous, smooth, at least in anterior half (Fig. 25).

*Dryocosmus pentagonalis*: the disc of the mesoscutellum is entirely rugose, matt (Fig. 178).

**Description.** Sexual female: Head color: brown; mandibles, maxillary and labial palps yellowish; scape and pedicel yellow, flagellomeres progressively darker. Mesosoma and metasoma color: dark brown, except for lighter tegula, propodeum and posterior half of metasoma, legs yellowish.
Figures 18–23. *Dryocosmus caputgrusi*, female, sp. n. 18–21, head: 18 frontal view 19 posterior view 20 dorsal view 21 lateral view 22 antenna 23 pronotum and propleuron, frontal view.

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Notaulus posterior region width / anterior region width: NOT CODED. Mesoscutal suprahumeral sulcus anterior end vs notaulus anterior end: adjacent. Mesoscutal suprahumeral sulcus sculpture: NOT CODED. Median mesoscutal line: absent. Median mesoscutal line shape: NOT CODED. Parapsidal line: absent. Parapsidal line distinctness: NOT CODED. Anteroadmedian line: present. Antero-admedian line length / mesoscutum median length: 0.2. Dorsomedian area of mesoscutellar-axillar complex (disc of mesoscutellum+axillar foveae): smooth anteromedially, ru-

Metasoma length / head+mesosoma length: <1. Metasoma lateral height / metasoma lateral length: <1. 2nd metasomal tergite length dorsal view / length of metasoma

Body length: 2.60 mm (n=2).

Male: unknown

Gall (Figs 31–32): The gall is unilocular, spindle-shaped and is attached with a long stalk to the leaf. The gall is 8.0–12.7 mm long, 1.5–1.8 mm wide (n=4), with a stalk varying in length from 6.4 mm to 8.1 mm. The swollen part of the spindle-shaped gall indicates the position of the larval chamber. The gall is green at both young and mature stages, with a smooth surface when growing and delicately rugose when mature. Galls were found also on male catkins (Fig. 32). In this case, the gall is greenish and pubescent. The main body of the gall is spindle-shaped with a stalk; the spindle-shaped part is 5.3–6.0 mm long, and 1.1–1.4 mm wide (n=5). The length of the stalk varies from 4.9 mm to 6.8 mm (n=5).

**Biology.** Although only females were collected, the emergence of adults in May and the female morphology suggest that this is a sexual generation. Galls appear on
young leaves of *Castanopsis uraiana* in March; adults emerged in late May. The catkin galls (TWTc1, TWT601) were found on *Castanopsis carlesii* in late March; adults emerged in the first half of April.

**Distribution.** Taiwan: Taoyuan and Taitung Counties.

*Dryocosmus crinitus* Schwéger & Tang, sp. n.  
http://zoobank.org/EA49CB22-6819-4BA6-9134-E39C7BD63D3C  
Figures 33–47  

Figure 33–39. *Dryocosmus crinitus*, female, sp. n. 33–36 head: 33 frontal view 34 dorsal view 35 posterior view 36 lateral view 37 antenna 38 pronotum and propleuron, frontal view 39 mesosoma, dorsal view.

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The female holotype, 20 female paratypes are deposited in NMNS, 20 female paratypes in PHMB, 10 female paratypes in USNM, and 19 female paratypes in NCHU.

**Etymology.** Named after the dense pilosity covering the gall surface. The Latin “crinitus” means “fluffy”.

**Diagnosis.** *Dryocosmus crinitus*, *D. nanlingensis* and *D. liyingi* belong to the group of species in which the disc of the mesoscutellum lacks irregular rugae (Fig. 116), the scutellar fovea minimum diameter / foveal septum width = 6.0–10.0 and the anterior pits of foveal septum are absent (Fig. 116).

The central propodeal area has numerous distinct medial and lateral rugae in *Dryocosmus nanlingensis* and with 1–2 indistinct, delicate, longitudinal, lateral wrinkles in *D. crinitus* (Fig. 42). *Dryocosmus liyingi*: the transverse pronotal sulcus is foveolate; the pronotum posterolaterally has numerous long rugae which are 2–3 times as long as the diameter of the anterior thoracic spiracle (Fig. 113); the head is dark brown except yellowish brown malar region; the eye height / malar distance = 2.32; the transfacial distance / eye height = 1.44; the diameter of torulus / intertorular distance = 0.8 (Fig. 105); the POL/OOL = 1.06; the OOL / diameter of lateral ocellus = 2.1; the OOL / LOL = 2.05 (Fig. 106); the antenna is with 13 flagellomeres (Fig. 111).

*Dryocosmus crinitus*: the transverse pronotal sulcus is not foveolate; the pronotum posterolaterally has few short rugae as long as the diameter of the anterior thoracic spiracle (Fig. 40); the cranium is reddish brown anteriorly, dark brown dorsally and posteriorly, the eye height / malar distance = 4.54; the transfacial distance / eye height = 0.9; the diameter of torulus / intertorular distance = 1.8; the POL / OOL = 1.6; the OOL / diameter of lateral ocellus = 1.36; OOL / LOL = 1.36; the antenna is with 12 flagellomeres (Fig. 37).

**Description.** Asexual female: Head color: reddish brown, except for dark brown to black postgena, occiput, vertex; mandibles, maxillary and labial palps yellowish; scape, pedicel, F1 and F2 yellow, subsequent flagellomeres progressively darker. Mesosoma and metasoma color: black or dark brown, except for lighter tegula, propodeum, propuleuron and mesopleuron, legs yellowish.

Figures 40–47. Dryocosmus crinitus, female, sp. n. 40 mesosoma, lateral view 41 mesoscutellum, dorsal view 42 metascutellum and propodeum, posterior view 43 fore wing 44 metasoma, lateral view 45 ventral spine of hypopygium, ventral view 46–47 galls (photos by C.-T. Tang) (tps=transverse pronotal sulcus, cpa=central propodeal area).


Body length: 1.80–2.10 mm (n=10).  

Gall (Figs 46–47): The multilocular gall comprises 3–20 gall chambers in one cluster (n = 20). Each larval chamber is ovate at the base. The gall is attached to the leaf
midrib by a short stalk. A tuft of dense, dark brown hairs covers the larval cells. The gall is 10.7–15.5 mm long, and 8.1–13.3 mm wide (n=6).

**Biology.** The gall matures in late autumn, when the larval chambers drop off from the galls and the larvae overwinter in the leaf litter; adults emerge in the next spring suggesting that the asexual generation is described here. The sexual generation remains unknown. This species induces galls on *Quercus morii* and *Q. sessilifolia*.

**Distribution.** Taiwan: Renai Township, Nantou County; Jianshih Township, Hinschu County; Shishding Township, New Taipei City; Datung Township, Ilan County.

**Dryocosmus harrisonae** Melika & Tang, sp. n.
http://zoobank.org/796EC89B-9267-464E-B2B3-C888AEC76CFC
Figures 48–63


The female holotype and 1 male paratype are deposited in NMNS, 2 females and 1 male paratypes in PHMB, and 2 female paratypes in NCHU.

**Etymology.** Named in honour of Ms Warin Harrison (Xishuangbanna Tropical Botanical Garden, Yunnan, China), who was our guide during the collecting trip in China in 2011.

**Diagnosis.** See the diagnosis for *Dryocosmus cannoni*.

**Description.** Sexual female: Head color: dark brown, except for lighter clypeus; mandibles, maxillary and labial palps yellowish; scape and pedicel yellow, flagellomeres
progressively darker. Mesosoma and metasoma color: dark brown, except for lighter tegula and propodeum, legs yellowish.

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Figures 56–60. Dryocosmus harrisonae, female sp. n. 56 mesoscutum, dorsal view 57 mesoscutellum, dorsal view 58 pronotum and propleuron, frontal view 59 metascutellum and propodeum, posterodorsal view 60 fore wing, part.


Metasomal tergites 3–6 pilosity: absent. Prominent part of ventral spine of hypopygium length ventral view / Prominent part of ventral spine of hypopygium width ventral view: 1.16. Hypopygial setae apical end: not extending beyond posterior end of ventral spine of hypopygium.

Body length: 1.90–2.10 mm (n = 3).


Gall (Figs 62–63): Galls are located on axillary buds or young leaves on young shoots. The cross-section of the gall is triangular, with a short stalk connected to the host-plant. The gall is greenish, with a brownish tip and a greenish-brown central region, 3.9–4.6 mm long and 1.7–2.0 mm broad (n=2).

Biology. Only the sexual generation is known. Galls are on young shoots of *Castanopsis echinocarpa*. Galls were collected in April; adults emerged from galls under laboratory conditions immediately after field collection.

Distribution. China: Yunnan Province.
**Dryocosmus hearni** Melika & Tang, sp. n.
http://zoobank.org/3E8127B2-15D1-4180-A727-E63DCA523064

Figures 64–76


The female holotype, 4 female and 7 male paratypes are deposited in NMNS, 5 female and 7 male paratypes in PHMB, 2 female and 4 male paratypes in USNM, 4 female and 9 male paratypes in NCHU.

**Etymology.** Named in honour of Dr. Jack Hearn (Institute of Evolutionary Biology, University of Edinburgh, Scotland), whose help was crucial in the organization of the collecting trip to China in 2011.

**Diagnosis.** Most similar to *Dryocosmus testisimilis*.

*Dryocosmus hearni*: the head and mesosoma of females and males are orange-yellow (Figs 64–69, 72–73), the metasoma is dark brown. The notaulus posterior region width / anterior region width = 5 (Fig. 73); posterior height of subaxillular bar / height of metanotal trough = 0.25 (Fig. 72); the central propodeal area is with a transverse carina in dorsal 1/3rd (Fig. 74).

*Dryocosmus testisimilis*: in females the head and mesosoma are light brown, the mesoscutum, mesopleuron, metapleuron and propodeum are darker, the metasoma dark brown (Figs 180–181).

The body dark brown in males.

The notaual posterior region width / anterior region width = 1 (Fig. 181), posterior height of subaxilllar bar / height of metanotal trough>1; the central propodeal area without a transverse carina in dorsal 1/3rd (Fig. 179).
**Description.** Sexual female: Head color: orange-yellow, except for darker mandibles, scape, pedicel, F1–F5 yellowish brown, subsequent flagellomeres progressively darker. Mesosoma and metasoma color: mesosoma orange-yellow, except for legs yellowish, except tibia and first tarsomere dark brown, metasoma dark brown.

Figures 72–76. *Dryocosmus hearni* sp. n. 72–75 female: 72 mesosoma, lateral view 73 mesosoma, dorsal view 74 metascutellum and propodeum, posterodorsal view 75 fore wing, part. 76 gall (photo by C.-T. Tang) (not=notaulus, trc=transverse carina on central propodeal area, sab=subaxillular bar, mtr=metanotal trough).


Body length: 2.80–3.10 mm (n = 5).


Gall (Fig. 76): Galls are integrated leaf swellings, usually located at the base of leaves, and are concolorous with the leaves. The galls are 22.4–24.3 mm long, 18.2–19.0 mm wide (n=3).

Biology. Only the sexual generation is known. Galls were collected from young leaves of Castanopsis sp. in April and adults emerged from galls under laboratory conditions immediately after field collection.

Distribution. China: Yunnan Province

Comments. The pairwise genetic distances from other Dryocosmus species, based upon 433 base pairs of the cytochrome b gene (Table 1) and some morphological characters (the very broad notaulus in the posterior half, large scutellar foveae, the unique pattern of carinae on the central propodeal area, the uniformly orange-yellow body) make this species peculiar among all other Eastern Palaearctic Dryocosmus species which are associated with Cyclobalanopsis or Castanopsis.
Dryocosmus hualieni Schwéger & Tang, sp. n.
http://zoobank.org/658C175E-8C34-44CA-B9C4-F3E6B07D3290
Figures 77–90


The holotype female, 2 female paratypes are deposited in NMNS, 2 female paratypes in PHMB, 1 female paratype in USNM and 1 female paratype in NCHU.

Etymology. Named after Hualien County, Taiwan where the species was collected.

Diagnosis. Asexual females of Dryocosmus hualieni resemble the asexual females of D. taitungensis and the sexual females of D. konradi. All three species are known from Taiwan only and are associated with Cyclobalanopsis species. Dryocosmus hualieni and D. taitungensis induce stem swelling-like galls, while D. konradi induces bud galls.

In Dryocosmus hualieni and D. konradi the second metasomal tergite has multiple setae laterally (Fig. 87), while in D. taitungensis the second metasomal tergite has only few setae laterally (Fig. 171). In Dryocosmus konradi: the bottom of scutellar foveae without rugae (Fig. 100); the female F1 / F2 = 1; female F1 / pedicel = 2.7; placoid sensilla are present on F1–F12 (Fig. 97).

Dryocosmus hualieni: the bottom of scutellar foveae with numerous longitudinal rugae (Fig. 83); female F1 / F2<1; the female F1 / pedicel = 1.6; placoid sensilla are present on F2–F12 (Fig. 81); the frons is alutaceous; the acetabular sulcus absent, the speculum is without striae (Fig. 84), the mesoscutellum rounded, anterior part without rugae, glabrous (Fig. 83).

Dryocosmus taitungensis: the frons is coriaceous, with numerous transverse striae above toruli; the acetabular carina present; the speculum with striae (Fig. 166); the mesoscutellum trapezoid, uniformly rugose, matt (Fig. 167).

Description. Asexual female: Head color: black, except lighter clypeus, central part of lower face and area around toruli; mandibles, maxillary and labial palps yellowish; scape and pedicel yellow, flagellomeres progressively darker. Mesosoma and metasoma color: dark brown to black, except for lighter tegula, propleuron, propodeum; legs yellowish.

Figures 77–83. *Dryocosmus hualieni*, female, sp. n. 77–80 head: 77 frontal view 78 dorsal view 79 posterior view 80 lateral view. 81 antenna 82 mesosoma, dorsal view 83 mesoscutellum, dorsal view.

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Figures 84–87. Dryocosmus hualieni, female, sp. n. 84 mesosoma, lateral view 85 pronotum and propleuron, frontal view 86 metascutellum and propodeum, posterior view 87 metasoma, lateral view (tel=transepisternal line).

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Body length: 2.30–2.50 mm (n=6).

Gall (Figs 89–90): The gall is a multilocular stem swelling, similar to the asexual galls of Dryocosmus taitungensis. The gall is dehiscent when mature, larval cells drop off from the gall (stem swelling) during the winter and they overwinter in the leaf litter. The mature gall is 3.78–5.38 cm in length, and 1.05–1.28 cm in width (n=2). The larval cell is oblong, 4.78–5.68 mm long, and 1.74–2.13 mm wide (n=5).

**Biology.** The gall maturation in late autumn and the emergence of adults in spring, suggests that the asexual generation is described here. The sexual generation remains unknown. The host-plant is *Q. glauca*.

**Distribution.** Taiwan: Hualien County, Xiulin Township.

*Dryocosmus konradi* Tang & Melik, sp. n.  
http://zoobank.org/AFA7387F-1ABC-4885-BB4A-D8ED1637B279  
Figures 91–104

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120.981033°E, 1270m, ex small oval yellow gall towards base of young buds, (AG-WP-Morpho28), em. 27.III.2011, leg. C. T. Tang, F. Sinclair, J. Hearn, K. Lohse; 1 female paratype: TAIWAN: Nantou Co., road to Lingxiao Temple, Renai Township, ex *Quercus glauca*, 26.IV.2011 (TWT499), 24°59′48.08″N, 121°00′51.52″E, 774m, ex oval-shaped gall at bud base (AGWP-Morpho28), adult em. 28.IV.2011, leg. Chang-Ti Tang; 1 male and 1 female paratypes: TAIWAN: Nantou Co., road to Lingxiao Temple, Renai Township, ex *Quercus glauca*, 26.IV.2011 (TWT499), 24°59′48.08″N, 121°00′51.52″E, 774m, ex oval-shaped gall at bud base (AGWP-
Figures 99–102. *Dryocosmus konradi*, female, sp. n. **99–100** mesosoma: **99** lateral view **100** dorsal view **101** metascutellum and propodeum, posterodorsal view **102** fore wing, part (scf=scutellar fovea).


The female holotype, 2 female and 1 male paratypes are deposited in NMNS, 4 female and 2 male paratypes in PHMB, 4 female and 1 male paratypes in NCHU.

**Etymology.** In recognition of the continuous contribution of Dr. Konrad Lohse (Institute of Evolutionary Biology, University of Edinburgh, Scotland) in related studies on oak gallwasps.

**Diagnosis.** See diagnosis for *Dryocosmus hualieni*.

**Description.** Sexual female: Head color: black to dark brown, clypeus lighter; mandibles, maxillary and labial palps yellowish; scape, pedicel and F1 light brown, subsequent flagellomeres progressively darker. Mesosoma and metasoma color: dark brown, except lighter tegula; legs yellow.
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length / F11 length: NOT CODED. F12 length / F11 length: 1.76. F13 length / F12 length: NOT CODED. Placoid sensilla present on: F1–F12.


Body length: 2.10–2.30 mm (n=3).


Gall (Figs 103–104): The gall is single-chambered and ovate, greenish with a yellowish central area, 2.3–2.8 mm in length, 1.3–2.1 mm in width (n=5). Galls are located at the base of young shoots, covered by bud scales and are cryptic unless bud scales are removed.

Biology. Only the sexual generation is known. Galls were collected from late March through April on *Q. glauca* and *Q. longinux*; adults emerge from galls under laboratory conditions immediately after field collection.

Distribution. Taiwan: Renai Township, Nantou County. *Quercus glauca* is widespread from India through China to Japan; it is possible that this *Dryocosmus* species occurs in these regions as well.

Comments. Some specimens reared from galls on *Quercus longinux* slightly differ from those reared from galls on *Q. glauca* (the description given above): the head and mesosoma have weaker coriaceous sculpture, the head, mesosoma, and metasoma are more glossy; the mesoscutum narrower; F1 in females slightly shorter.
Dryocosmus liyingi Melika & Tang, sp. n.

http://zoobank.org/1CFE5699-CBF1-4901-B799-785B5872FE5B

Figures 105–121


The female holotype, 5 female and 3 male paratypes are deposited in NMNS, 5 female and 7 male paratypes in PHMB, 3 female and 3 male paratypes in USNM, 5 female and 3 male paratypes in NCHU.

Etymology. Named after Liying Mountain in Renai Township, Nantou Co., Taiwan, where it was first recorded.

Diagnosis. Dryocosmus liyingi resembles D. crinitus, see Diagnosis for D. crinitus. The species is also similar to Dryocosmus sakureiensis. In Dryocosmus liyingi the mesopleuron lacks striae and in D. sefuriensis the mesopleuron is striate anteromedially.

Description. Sexual female:
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Pronotum sculpture: alutaceous with some rugae laterally. Pronotal dorsal row of setae count: present. Transverse pronotal sulcus depth: deep. Transverse pronotal sulcus
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Figures 113–117. *Dryocosmus liyingi*, female, sp. n. 113 mesosoma, lateral view 114 pronotum and propodeum, frontal view 115 mesoscutum, dorsal view 116 mesoscutellum, dorsal view 117 metascutellum and propodeum, posterior view (tps=transverse pronotal sulcus, dms=disc of mesoscutellum).


Metasoma length / head+mesosoma length: <1. Metasoma lateral length / metasoma lateral length: <1. 2nd metasomal tergite length dorsal view / length of metasoma dorsal view: 0.40. Second metasomal tergite pilosity: present mediolaterally.
um length ventral view / Prominent part of ventral spine of hypopygium width ventral view: NOT CODED. Hypopygial setae apical end: extending beyond posterior end of ventral spine of hypopygium.

Body length: 2.10–2.20 mm (n=5).


Gall (Fig. 121): The gall resembles the sexual galls of *Dryocosmus sefuriensis*. The gall is a cluster of multiple larval chambers, and covered by bud scales and young leaves in a bud. The infected bud becomes thicker and the young shoot will not develop, providing a clue to search for galls on the host-plant. The mature gall is yellowish-white.

**Biology.** Only the sexual generation is known. Galls were collected from late March to late April. Adults emerged from galls in the laboratory immediately after collection. Galls are on *Q. morii* and *Q. sessilifolia*.

**Distribution.** Taiwan: Renai Township, Nantou County.

*Dryocosmus moriius* Tang & Melika, sp. n.

http://zoobank.org/9C8A4DD6-E635-4B7A-A8EB-02646151D521

Figures 122–135

**Type material.** HOLOTYPE female: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 26.IV.2011, leg. Chang-Ti Tang. PARATYPES: 31 females and 8 males: 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E, 2217m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 27.IV.2011, leg. Chang-Ti Tang; 3 female paratypes with the same labels as holotype; 2 male and 2 female paratypes: TAIWAN: Nantou Co., Mt. Liying, Meifeng, Renai Township, ex *Quercus morii*, 25.IV.2011 (TWT474), 24°04’49.68"N, 121°10’14.03"E,
New Dryocosmus Giraud species associated with Cyclobalanopsis and non-Quercus host...


2217m, ovipositing female on young leaves of host plant, leg. Chang-Ti Tang; 2 male and 1 female paratypes: TAIWAN: Nantou Co., near Cuifeng, Renai Township, ex Quercus morii, 25.IV.2011 (TWT498), 24°06'06.63"N, 121°11'24.47"E, 2285m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 1.V.2011, leg. Chang-Ti Tang; 1 male and 3 female paratypes: TAIWAN: Nantou Co., near Cuifeng, Renai Township, ex Quercus morii, 25.IV.2011 (TWT498), 24°06'06.63"N, 121°11'24.47"E, 2285m, ex small green oval bud gall cover by bud-scales (TWTb13), em. 2.V.2011,

The female holotype, 9 female and 2 male paratypes are deposited in NMNS, 9 female and 3 male paratypes in PHMB, 3 female and 1 male paratypes in USNM, 10 female and 2 male paratypes in NCHU.

**Etymology.** Named after the host plant, *Q. morii.*

**Diagnosis.** *Dryocosmus moriius* is most similar to *D. sakureiensis*, both sharing the presence of a basal lobe on the metatarsal claw.

*Dryocosmus sakureiensis*: Female antenna with 12 flagellomeres; eye height / malar distance = 2.62; intertorular distance / eye torulus distance = 0.67; radial cell length / radial cell width = 3.43; 2nd metasomal tergite length dorsal view / length of metasoma dorsal view> 0.50; prominent part of ventral spine of hypopygium length ventral view / prominent part of ventral spine of hypopygium width ventral view = 2.20.

*Dryocosmus moriius*: Female antenna with 13 flagellomeres, eye height / malar distance = 2.0; intertorular distance / eye torulus distance = 0.36; radial cell length / radial cell width = 4.5; 2nd metasomal tergite length dorsal view / length of metasoma dorsal view = 0.33; prominent part of ventral spine of hypopygium length ventral view / prominent part of ventral spine of hypopygium width ventral view = 1.3.

**Description.** Sexual female: Head color: Head black, except for light brown clypeus; mandibles, maxillary and labial palps yellowish; scape, pedicel, F1–F4 light...
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brown, subsequent flagellomeres progressively darker. Mesosoma and metasoma color: mesosoma black, except for lighter tegula; metasoma dark brown; legs yellowish.


Body length: 2.60–2.80 mm (n=5).


Gall (Figs 134–135): The gall closely resembles the sexual galls of Dryocosmus sakureiensis. The gall is unilocular, ovate, 2.8–3.4 mm long and 1.8–2.1 mm wide (n=5). Galls are at the base of young shoots, usually by bud scales. Galls are green and yellowish white in the central area.

Biology. Only the sexual generation is known. Galls are induced on young shoots on Quercus morii. Galls were collected in April and adults emerged from galls under laboratory conditions immediately after field collection.

Distribution. Taiwan: Renai Township, Nantou County. Quercus morii is endemic to Taiwan, suggesting that Dryocosmus morii is also endemic to Taiwan.

Dryocosmus quadripetiolus Schwéger & Tang, sp. n.
http://zoobank.org/C09DF087-BC26-466E-8A08-712688D50FF4
Figures 136–148

Type material. HOLOTYPE female: CHINA: Yunnan Prov., Lan Cang Co., Foufang quarry, ex Castanopsis echinocarpa, 11.IV.2011 (CHI38), 22.593300°N, 99.982633°E, 1625m, ex bird head shaped gall with ridges (AGWP-Morpho74), em. 11.IV.2011,
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leg. C. T. Tang, F. Sinclair, J. Hearn. One female PARATYPE with the same labels as the holotype.

The female holotype is deposited in NMNS, the female paratype in PHMB.

**Etymology.** Named after the shape of the gall, which has four petiole-like ridges.

**Diagnosis.** In *Dryocosmus quadripetiolus* the mesopleuron is densely setose ventral to the transepisternal line (Fig. 142), while in all other species the mesopleuron is glabrous or with few setae present along the margin of the lateral mesopleural face (Figs 24, 40, 72, 166).


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Figures 142–146. Dryocosmus quadripetiolus, female, sp. n. 142 mesosoma, lateral view 143 mesosoma, dorsal view 144 mesoscutellum, dorsal view 145 metascutellum and propodeum, posterodorsal view 146 metasoma, lateral view (tel=transepisternal line).

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Body length: 2.45 mm (n=2).

Male: Unknown.

Gall (Fig. 148): Galls develop from buds, detachable. The body of the gall contains a subglobose part and a needle-like projection; the subglobose part is 5.0–6.0 mm in diameter, 6.0–7.0 in height; the needle-like projection at the top of the gall body nearly as long as or slightly longer than the height of the subglobose part. The gall body is marked

with four longitudinal ribs, pubescent. The mature gall is brownish, similar to the color of the twig. The larval chamber is centrally located at the subglobose part, unilocular.

**Biology.** Based on the morphology, gall maturation and emergence period of adults, the described females represent the sexual generation. Galls are in buds on *Castanopsis echinocarpa*. Galls were collected in April and adults emerged from galls under laboratory conditions immediately after field collection.

**Distribution.** China: Yunnan Province (Lan Cang County).

*Dryocosmus salicinai* Schwéger & Tang, sp. n.  
http://zoobank.org/5D21585D-E7F1-4C5A-A23F-5A4350206028  
Figures 149–161

**Type material.** HOLOTYPE female: TAIWAN: Taichung City, 104.5 K, Central Cross Island Highway, Heping Dist., ex monolocular bud gall on *Quercus salicina* (TWTb16), 24°12'44.4"N, 121°18'20.2"E, 2437m, gall collected 19.III.2012 (TWT583), adult emerged 4.IV.2012, leg. Chang-Ti Tang. Three female and four male PARATYPES: 4 male paratypes with the same labels as the holotype: 3 female paratypes: TAIWAN: Taichung City, 104.5 K, Central Cross Island Highway, Heping Dist., ex unilocular bud gall on *Quercus salicina* (TWTb16), 24°12'44.4"N, 121°18'20.2"E, 2437m, gall collected 19.III.2012 (TWT583), adult emerged 5.IV.2012, leg. Chang-Ti Tang.

The holotype female, 1 female and 2 male paratypes are deposited in NMNS, 1 female and 1 male paratypes in PHMB, 1 female and 1 male paratypes in NCHU.

**Etymology.** The species is named after the host plant, *Quercus salicina*.

**Diagnosis.** *Dryocosmus salicinai* is the only *Dryocosmus* species in which the mesopleuron and speculum are matt, uniformly coriaceous, without striae. In all other *Dryocosmus* species the mesopleuron and/or speculum are glossy and smooth. Albeit the structure of the mesopleuron is somewhat similar to that of *Plagiotrochus*, based on the presence of the truncate apical tuft on the ventral spine of hypopygium and the smooth and glossy mesoscocutum we treat this species as *Dryocosmus*.

**Description.** Sexual female: Head color: black or dark brown, except for lighter clypeus; mandibles, maxillary and labial palps yellowish; scape and pedicel yellowish or light brown, flagellomeres progressively darker till last one. Mesosoma and metasoma color: mesosoma dark brown to black, except for lighter tegula; metasoma dark brown; legs uniformly brown.

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Body length: 2.30 mm (n=1).


Gall (Figs 160–161): The unilocular gall is pink and ovate. One or two galls are embedded in one bud, which is usually flat and short. The gall is 2.1–2.6 mm long and 1.3–1.6 mm wide (n=5). The presence of the gall interrupts the development of the shoot.

Biology. Only the sexual generation is known. Mature galls were collected in March and adults emerged from the galls under laboratory conditions in early April. This species induces galls on *Quercus salicina*.

Distribution. Taiwan: Heping District, Taichung City, and Renai Township, Nantou County. The distribution of *Quercus salicina* (Govaerts & Frodin, 1998) suggests the potential occurrence of this gallwasp species in Japan.
**Dryocosmus taitungensis** Tang & Melika, sp. n.
http://zoobank.org/B3BACB7F-F575-4E79-AA44-21ED50585781

Figures 162–173


The holotype female, 6 female paratypes are deposited in NMNS, 7 female paratypes in PHMB, 4 female paratypes in USNM, 7 female paratypes in NCHU.

**Etymology.** Named after Taitung County, Taiwan.

**Diagnosis.** *Dryocosmus taitungensis* resembles *D. liyingi*.

*Dryocosmus taitungensis*: female head black; POL / OOL = 1.6; OOL / diameter of lateral ocellus = 1.58; OOL / LOL = 1.37 (Fig. 162); central propodeal area with longitudinal rugae; lateral propodeal carina slightly curved outward in mid-height (Fig. 169).

*Dryocosmus liyingi*: female head dark brown, with a light brown lower face, POL / OOL = 1.06; OOL / diameter of lateral ocellus = 2.1; OOL / LOL = 2.05 (Fig. 105); central propodeal area with distinct longitudinal rugae; lateral propodeal carina
strongly curved outwards in the mid-height (Fig. 117). *Dryocosmus taitungensis* is also similar to *D. hualieni*, see diagnosis to *D. hualieni*.

**Description.** Asexual female: Head color: black, except for mandibles, maxillary and labial palps yellowish; scape, pedicel and F1 dark brown, F2–F12 darker. Mesosoma and metasoma color: black, except for lighter tegula; legs yellowish.
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New Dryocosmus Giraud species associated with Cyclobalanopsis and non-Quercus host...

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Body length: 2.20–2.40 mm (n=5).

Gall (Figs 172–173): The multilocular gall is a stem swelling on the current year shoot. The gall is 8.4–29.2 mm long and 3.6–7.7 mm wide (n=7). Galls are located proximally on the branches, never apically, and are concolorous with the bark. The gall is brownish-red if the external layer peels off from the gall surface. The tissue of the mature gall is hard and lignified. During the winter the larval chambers fall to the ground, and the larvae overwinter in the leaf litter. Sometimes the larvae remain in the galls. Larval chambers are 2.5–3.3 mm long and 1.4–1.8 mm wide (n=10).

Biology. The period of the gall maturation, the absence of males, and the adult morphology suggest that the asexual generation is described here. Mature galls were found in January and adults emerged under laboratory conditions in March and April in the next spring.

Distribution. Taiwan: Taitung County, Beinan Township. *Quercus hypophaea* is an endemic of Taiwan (Govaerts & Frodin 1989), thus the described species might be also endemic to Taiwan.

Discussion

East Asia harbours more than 70 species of the *Quercus* subgenus *Cyclobalanopsis* (Govaerts & Frodin, 1998). Despite this relatively high species richness, little was known about cynipine galls on *Cyclobalanopsis* until the recent description of the genera *Cycloneuroterus* Melika & Tang, 2011 and *Cyclocynips* Melika, Tang, & Sinclair, 2013 and new species of *Plagiotrechus* (Ide et al. 2010, 2012, 2013; Melika et al. 2013; Tang et al. 2011a, b, 2016a,b). Only one cynipine species, *Cycloneuroterus wangi* Abe, Ide, & Odagiri, 2014, has been reported to oviposit on *Cyclobalanopsis* outside Japan, Taiwan and Vietnam despite the wide Asian distribution (Abe et al. 2014) of this *Quercus* subgenus. Although *Dryocosmus* species have been collected in Yunnan province of southern China (Abe et al. 2014b) and in the Indochina region (Abe et al. 2014a), their host associations are unknown. Although all *Cyclobalanopsis* associated *Dryocosmus* species—including the five new species of the present paper—are known from Taiwan (Table 2), we can not confirm or deny if this restricted distribution is due to sampling bias.

While *Cyclocynips* and *Cycloneuroterus* are associated with *Castanea*, *Lithocarpus* and *Cyclobalanopsis*, the sole cynipine genus of *Castanopsis* is *Dryocosmus*. Our study doubled the number of *Dryocosmus* species associated with *Castanopsis*. With this new information, we can now clearly say that of all known Eastern Palaearctic *Dryocosmus*, almost half (n=9) are associated with *Castanopsis* (Table 2). Eastern Palaearctic species of *Dryocosmus* is known yet to associate with large and species rich *Quercus* subgenus *Quercus*.
Most oak gallwasps are cyclically parthenogenetic, with obligate alternation between a sexual and an asexual (unisexual) generation. Males and females of the sexual generation usually occur at the same time as the flush of new growth on host plants in the spring, while the parthenogenetic females of the asexual generation occur in the winter (Csőka et al. 2005, Abe et al. 2014b). Of the 22 described Eastern Palaearctic *Dryocosmus* species, no species are known to have alternate sexual and asexual generations; as sexual specimens are known for four and sexual for 18 species (Table 2). Likewise, a significant proportion of other Holarctic cynipine species are known from only one of the two generations (Melika 2006). Stone et al. (2008) confirmed that many of these species actually do have a sexual generation (Stone et al. 2008) and it is likely that alternate generation of many East Asian *Dryocosmus* species are yet to be described.

### Table 2. Eastern Palaearctic *Dryocosmus* species, their host plants, life cycles (sexual=known only from sexual generation; asexual=known only from asexual generation) and distributions.

<table>
<thead>
<tr>
<th><em>Dryocosmus</em> species</th>
<th>Host species</th>
<th>Life cycle</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>D. cannoni</em> Schwéger &amp; Tang, sp. n.</td>
<td><em>Castanopsis echinocarpa</em></td>
<td>sexual</td>
<td>China</td>
</tr>
<tr>
<td><em>D. caputgrusi</em> Tang &amp; Schwéger, sp. n.</td>
<td><em>Castanopsis uraiana</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. carlesiae</em> Tang &amp; Melika</td>
<td><em>Castanopsis carlesii</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. crinitus</em> Schwéger &amp; Tang, sp. n.</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>morii</em>, Q. (<em>C.</em>) <em>sessilifolia</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. harrionae</em> Melika &amp; Tang, sp. n.</td>
<td><em>Castanopsis echinocarpa</em></td>
<td>sexual</td>
<td>China</td>
</tr>
<tr>
<td><em>D. hearrii</em> Melika &amp; Tang, sp. n.</td>
<td><em>Castanopsis sp.</em></td>
<td>sexual</td>
<td>China</td>
</tr>
<tr>
<td><em>D. hualieni</em> Schwéger &amp; Tang, sp. n.</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>glauca</em></td>
<td>asexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. konradi</em> Tang &amp; Melika, sp. n.</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>longinuex</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. liyingi</em> Melika &amp; Tang, sp. n.</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>morii</em>, Q. (<em>C.</em>) <em>sessilifolia</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. moritus</em> Tang &amp; Melika, sp. n.</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>morii</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. nanlingensis</em> Abe, Ide, &amp; Odagiri</td>
<td>unknown</td>
<td>sexual</td>
<td>China</td>
</tr>
<tr>
<td><em>D. okajimai</em> Abe, Ide, Konishi &amp; Ueno</td>
<td>unknown</td>
<td>sexual</td>
<td>Vietnam</td>
</tr>
<tr>
<td><em>D. pentagonalis</em> Melika &amp; Tang</td>
<td><em>Castanopsis carlesii</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. quadripetiolus</em> Schwéger &amp; Tang, sp. n.</td>
<td><em>Castanopsis echinocarpa</em></td>
<td>sexual</td>
<td>China</td>
</tr>
<tr>
<td><em>D. sakureiensis</em> Ide, Wachi &amp; Abe</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>acuta</em></td>
<td>sexual</td>
<td>Japan</td>
</tr>
<tr>
<td><em>D. salicinai</em> Schwéger &amp; Tang, sp. n.</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>salicina</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. sefuriensis</em> Ide, Wachi &amp; Abe</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>acuta</em></td>
<td>sexual</td>
<td>Japan</td>
</tr>
<tr>
<td><em>D. taitungensis</em> Tang &amp; Melika, sp. n.</td>
<td><em>Quercus</em> (<em>Cyclobalanopsis</em>) <em>hypophaea</em></td>
<td>asexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. testisimilis</em> Tang &amp; Melika</td>
<td><em>Castanopsis uraiana</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. triangularis</em> Melika &amp; Tang</td>
<td><em>Castanopsis carlesii</em></td>
<td>sexual</td>
<td>Taiwan</td>
</tr>
<tr>
<td><em>D. kuriphilus</em> (Yasumatsu)</td>
<td><em>Castanea crenata</em>, C. <em>henryi</em>, C. <em>mollissima</em>, C. <em>sequinii</em>, C. <em>dentata</em>, C. <em>sativa</em></td>
<td>asexual</td>
<td>Holarctic</td>
</tr>
<tr>
<td><em>D. zhuili</em> Liu &amp; Zhu</td>
<td><em>Castanea henryi</em></td>
<td>sexual</td>
<td>China</td>
</tr>
</tbody>
</table>
The above mentioned uncertainties about the distribution, host association and biology of Eastern Palaearctic *Dryocosmus* species demonstrate that research on this taxon is still in its infancy. Further studies applying refined morphological and molecular methods on freshly collected Eastern Asian specimens is needed to galvanize life into the non-functional systematics of the likely polyphyletic *Dryocosmus* (Melika et al. 2010).

**Acknowledgement**

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**References**


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Supplementary material 1

URI table (Seltmann et al. 2013) containing anatomical terms, definitions and uniform resource identifiers of Hymenoptera specific classes in the Hymenoptera Anatomy Ontology (http://hymao.org).

Authors: Chang-Ti Tang, István Mikó, James A. Nicholls, Szabina Schwéger, Man-Miao Yang, Graham N. Stone, Frazer Sinclair, Miklós Bozsó, George Melika, Zsolt Pénzes

Data type: PDF file


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Supplementary material 2

Semantic statements of natural language phenotypes composed in Protégé 5.0 (http://protege.stanford.edu/) using the OWL Manchester syntax.

Authors: Chang-Ti Tang, István Mikó, James A. Nicholls, Szabina Schwéger, Man-Miao Yang, Graham N. Stone, Frazer Sinclair, Miklós Bozsó, George Melika, Zsolt Pénzes

Data type: PDF file

Explanation note: Semantic statements of natural language phenotypes composed in Protégé 5.0 (http://protege.stanford.edu/) using the OWL Manchester syntax.

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