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Andricus mukaigawae and *A. kashiwaphilus* from China with remarks of morphological differences and inquilines (Hymenoptera: Cynipidae)

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Abstract

Andricus mukaigawae (Mukaigawa, 1913) and *A. kashiwaphilus* Abe, 1998 are reported for the second time from China on plant hosts *Quercus mongolica* Fisch. ex Ledeb. and *Q. dentata* Thunb., respectively. The morphological characters useful to differentiate these agamic forms are firstly provided. Three inquilines species were obtained and identified from their plant host galls: *Saphonecrus laleyi* Melika & Schwéger, 2015, *Synergus khazani* Melika & Schwéger, 2015 and *Ceroptres masudai* Abe, 1997, and all of them are new records for China. *Andricus mukaigawae* is the first host known for *S. laleyi,* and *A. kashiwaphilus* is a new host for *C. masudai.*

Key words: Cynipidae, gallwasp, *Andricus*, taxonomy, biology, inquilines, China.

Resum

***Andricus mukaigawae* i *A. kashiwaphilus* a Xina amb observacions de les diferències morfològiques i dels inquilins (Hymenoptera: Cynipidae)**

Es citen per segon cop a Xina les espècies *Andricus mukaigawae* (Mukaigawa, 1913) i *A. kashiwaphilus* Abe, 1998, sobre *Quercus mongolica* Fisch. ex Ledeb. i *Q. dentata* Thunb., respectivament. Es donen per primer cop caràcters morfològics per diferenciar les formes agàmiques d'aquestes espècies. Tres espècies inquilines han estat obtingudes de les gales d'aquestes espècies: *Saphonecrus laleyi* Melika & Schwéger, 2015, *Synergus khazani* Melika & Schwéger, 2015 and *Ceroptres masudai* Abe, 1997, totes elles noves per a la fauna de Xina. *Andricus mukaigawae* es el proimer hoste conegut per *S. laleyi,* i *A. kashiwaphilus* es un nou hoste per *C. masudai.*

Paraules clau: Cynipidae, gales, *Andricus*, taxonomia, biologia, inquilins, Xina.

Introduction

Gall wasps (Hymenoptera: Cynipidae) are endophytophagous herbivores whose larvae develop in galls induced on host plants, either as gall-inducers, or as inquiline inhabitants of galls induced by others (Liljeblad & Ronquist,1998; Csóka *et al*., 2005; Liljeblad *et al*. 2009; Pénzes *et al*., 2009; Ronquist *et al*., 2015); few unusual species appear to be seed feeders as well (Buffington & Morita, 2009). Of the approximately 1400 known gall wasp species, the Cynipini is a monophyletic tribe with around 1000 species included in 34 genera, which induce galls on oaks (*Quercus* L.) and related Fagaceae (Ronquist *et al*., 2015).

The Chinese gall wasps and inquilines fauna are poorly known. Only 10 gall forming species are known whereas 51 species were mentioned in Eastern of Palaearctic and Oriental areas. Regarding inquiline species, only 14 are known when 57 species were reported in Eastern of Palaearctic and Oriental areas. Several species are being studied to be described in other manuscripts, after the revisions of Schwéger *et al*. (2015a, b) revisions.

The aims of this study are: first, correct the previous and recent studies which mention that the species *Andricus mukaigawae* (Mukaigawa, 1913) and *A. kashiwaphilus* Abe, 1998 have not been previously cited from China, being cited for the second time in this study; second, indicate for the first time the morphological differences of the agamic forms of these species until now unknown; and third, to mention the inquilines obtained from the examined galls: *Saphonecrus laleyi* Melika & Schwéger, 2015 (only known from Far East of Russia), *Synergus khazani* Melika & Schwéger, 2015 (previously known from Far East of Russia and Japan), and *Ceroptres masudai* Abe, 1997 (only know from Japan).

Material and methods

The current terminology of the cynipid gall-wasp morphology follows Liljeblad & Ronquist (1998) and Melika (2006). Abbreviations for the forewing venation are taken from Ronquist & Nordlander (1989) and the cuticular surface terminology from Harris (1979). Measurements and abbreviations used here include: F1–F12, first and subsequent flagellomeres; post-ocellar distance (POL) is the distance between the inner margins of the posterior ocelli; ocellar–ocular distance (OOL) is the distance from the outer edge of the posterior ocellus to the inner margin of the compound eye; LOL, the distance between lateral and frontal ocelli. The width of the forewing radial cell was measured from the margin of the wing to the Rs vein.

Scanning electron microscope (SEM) images of some described species were taken in the «Serveis de Microscopia Electrònica» at University of Barcelona (UB),with the Leica Stereoscan-360 at high voltage (10 kV) without gold coating to preserve the specimens,

The Chinese specimens collected in Luanping (north-eastern Hebei province, China) are deposited in the Hymenoptera Collection of the Zhejiang Agricultural and Forestry University (ZAFU, China) and the University of Barcelona (UB, Catalonia), first author col. Few other specimens of Professor Yoshihisa Abe from Japan were also examined.

Results

Andricus mukaigawae (Mukaigawa, 1913)

Studied material (asexual form)

Luanping (China), 41º N 117º E, (Hebei province, China) on *Q. mongolica* Fisch. ex Ledeb. 1850 (Tang Guanzhong leg.), (19.x.2015) 26.x.2015: 5 ♂. Katsunuma (Yamanashi Prefecture, Japan), *Q. serrata*, (x.1983) xii.1983: 2 ♂ (UB).

Short description (asexual form)

Color

Body ferruginous with black areas. Head testaceous; clypeus and its adjacent areas, margin of mandibles and occiput black; maxilary and labial palpus yellowish-brown, apical segments brown. Mesosoma testaceous, pubescent; propleura, margins of pronotum, anterior parallel lines of metanotum, mesopleura ventrally, scutellar foveae and area between carinae of propodeum black. Metasoma reddish brown, dorsal surface dark.

Head (Figs 1a-c)

With coriaceous sculpture, pubescent, transverse (1.2-1.3 times as broad as high), slightly narrower than mesosoma in dorsal view (2.2 times as broad as long). Transfacial line 1.3 times as long as eye length. Clypeus projecting over mandibles, ventral margin slightly incised; striate radiating from clypeus short. Genae broadened behind eye. Vertex coriaceous with piliferous points. POL 1.3 times as long as OOL and OCO slightly longer than the diameter of lateral ocellus.

Antenna (Fig. 1e)

15-segmented, dark, scape, pedicel, F1 and apical portions of F2 and F3 brown. Pedicel globular, F1 around 1.3 times as long as F2, the following gradually shortened, sometimes F12 and F13 partially fused; placodeal sensilla on F3-F13.

Mesosoma (Figs 2a, 2c)

Pronotum punctured. Mesoscutum coriaceous, punctured; anterior parallel lines and lateral lines present; notauli complete; posterior medial line absent or very short indicated basally. Scutellum as long as broad, with reticulate-rugose sculpture; scutellar foveae well defined, oval, deep, separated by a carina, bottom smooth. Propodeal carinae weakly bowed outwards in the middle delimiting an smooth and bare quadrangular area.

Wings

Hyaline, ciliated in margin, veins brown; radial cell around 3.8 times as long as broad.

Legs

Bases of coxae and tarsae dark; tarsal claws toothed (Fig. 3b).

Metasoma

Tergites smooth, shiny and bare except metasomal terguite II with dense white setae anterolaterally (Fig. 3a). Ventral spine of hypopygium 2.5 times as long as broad with lateral long setae, which extending behind apex of spine not forming a really tuf (Fig. 3d).

Asexual gall

Unilocular gall (sometimes a few galls clustered). Bud gall (25 mm of diameter maximum), urn-shaped in outline, surrounding by numerous lanceolate spines, developed from axillary bud (Fig. 4a). Larval chamber oval (4×6 mm), embedded in acorn-like cup.

Hosts

Quercus of the section *Quercus*: *Q. aliena* Blume, *Q. dentata* Thunb., *Q. mongolica* Fisch. ex Ledeb, *Q. mongolica* subspecies *crispula* (Blume) Menitsky (=*Q. mongolica* var. *grosseserrata* Rehid. et Wils.) and *Q. serrata* Thunb.

Distribution (Fig. 4c)

China: species previously mentioned by Weih (1965) from Shenyang (Liaoning province in China) on *Q. mongolica* Fisch. ex Ledeb. 1850 (= *Q. liaotungensis* Koidzumi 1912), here in Hebei province (new record); Japan (Abe 1986, 1988, 1991, 1998, 2007; Schwéger *et al*., 2015b); Far East of Russia (several localities of Primorskij Kraj: Kovalev, 1965 and Schwéger *et al*., 2015b). According Kovalev, (1965) and Abe *et al*. (2007), this species may be present at North Korea and South Korea respectively.

Biology

Alternating asexual and sexual generations are known (Abe, 1986). This species was studied in detail by Abe (1986, 1988, 1991, 1998, 2007).

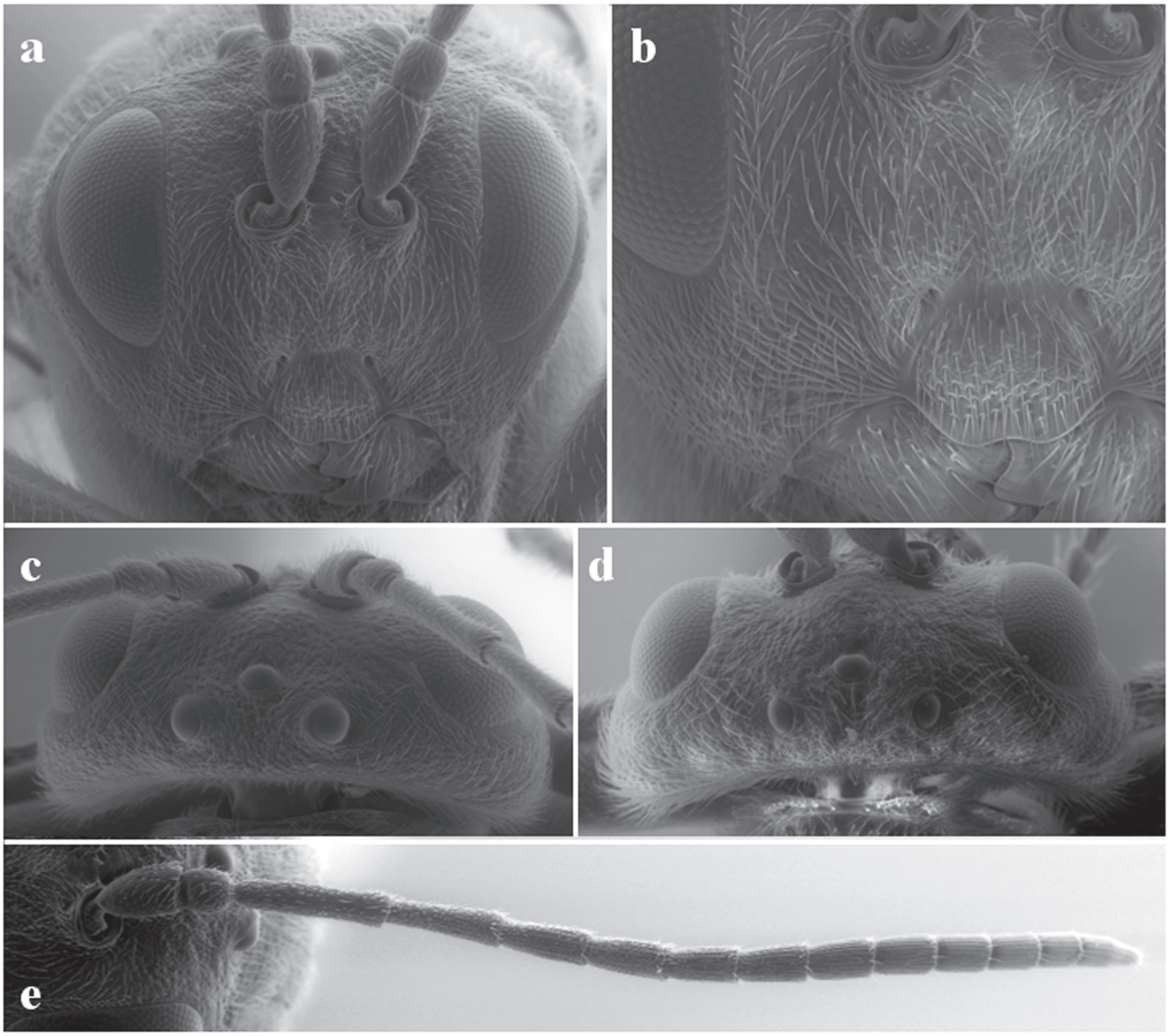

Figura 1. SEM pictures of *A. mukaigawae* (a-c, e) and *A. kashiwaphilus* (d). Head in frontal view (a), detail of lower face (b), head in dorsal view (c-d), antenna (e).

Comments

Two inquiline species have been obtained from these asexual galls: *Saphonecrus laleyi* Melika & Schwéger, 2015 in 3.xi.2015 (2♀) and *Synergus khazani* Melika & Schwéger, 2015 in 8.xi.2015 (1♀); both are recorded for the first time from China. *Andricus mukaigawae* represent the first host know for *S. laleyi*.

Andricus kashiwaphilus Abe, 1998

Studied material (asexual form)

Luanping, 41º N 117º E, (Hebei province, China) on *Q. dentata* Thunb. (Tang Guanzhong leg.), (19.x.2015) 13.x. 2015: 18 ♂ (2 ♂ UB). Kuju, (Kyushu, Oira Prefecture, Japan) on *Q. dentata*, (9.xii. 1982)17.xii.1982: 1 ♂; idem (4.xii.1983) i.1984: 1 ♂.

Diagnosis (asexual form)

Similar to the aforementioned species except in: POL 1.5 times as long as OOL and OCO 1.4 times the diameter of lateral ocellus (Fig. 1d); mesoscutum more densely pubescent (Fig. 2b), the presence or absence of short posterior medial line is not possible to check due the presence of basal pubescence; scutellar foveae slightly more transversal (Fig. 2b); radial cell slightly shorter (3.3 times as long as broad); lateral carina of propodeum delimiting a rectangular transversal area (Fig. 2d); ventral spine of hypopygium with shorter setae not or very shortly extending behind apex (Fig. 3e), around 3.0 times as long as broad; tarsal claws more obtuse (Fig. 3c).

Asexual gall

Presents an unilocular gall (sometimes a few galls clustered). Bud gall, flower-shaped (Fig. 4b), surrounded by a

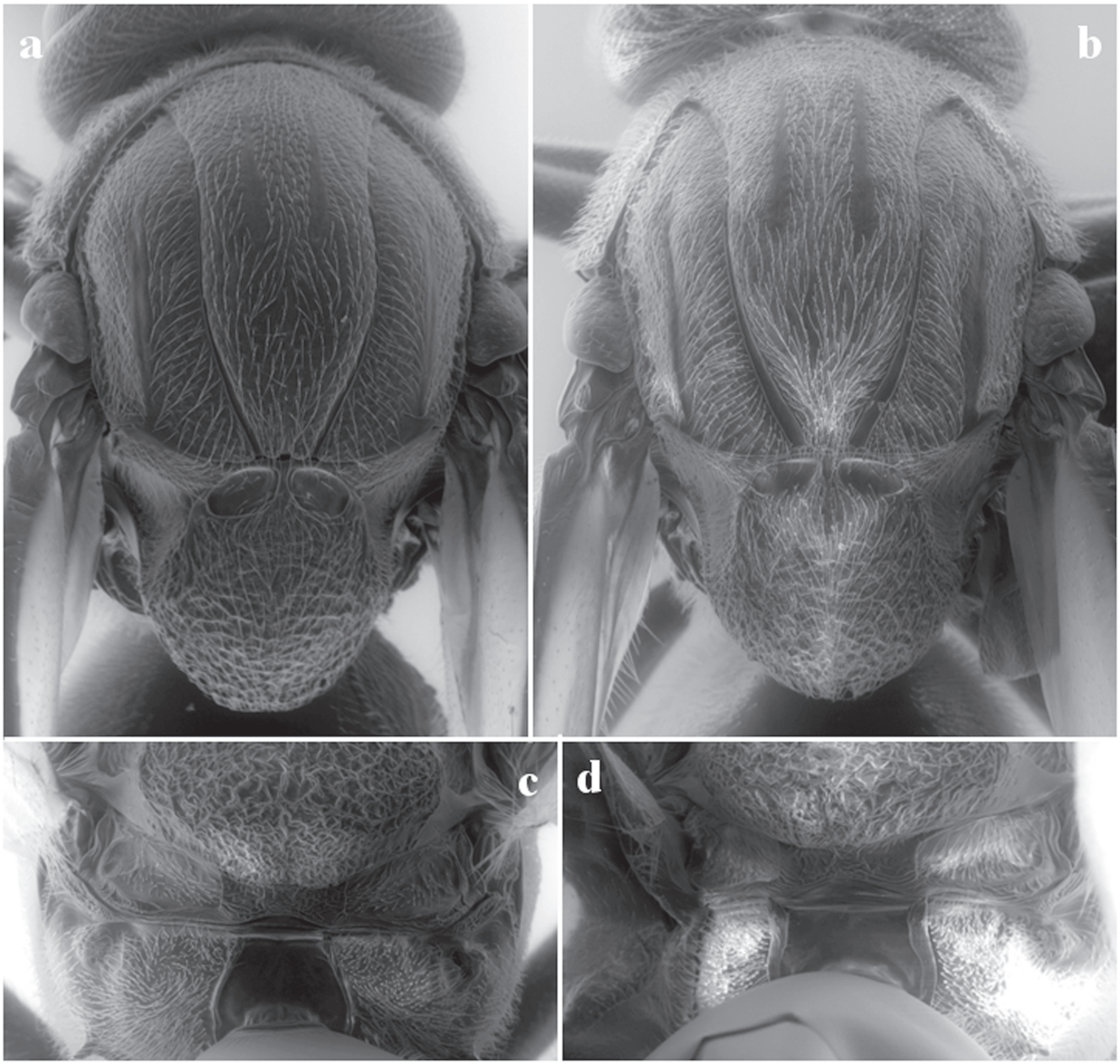

Figura 2. SEM pictures of *A. mukaigawae* (a, c) and *A. kashiwaphilus* (b, d). Mesosoma in dorsal view (a-b) and propodeum (c-d).

compact leaf clusters, developed from axillary bud. Larval chamber oval (4×6 mm), situated inside basis of leaf clusters.

Hosts

Quercus of the section *Quercus*: *Q. dentata* Thunb.

Distribution (Fig. 4c)

China: species previously mentioned by Weih (1965) from Shenyang (Liaoning province) on *Q. dentata* Thunb., here in Hebei province (new record); Japan (Abe 1986, 1988, 1991, 1998); Far East of Russia (Khazan Lake, Primorskij Kraj: Schwéger *et al*., 2015b).

Biology

Alternating asexual and sexual generations were reported (Abe *et al*., 2007) on *Q. dentata*.

Comments

An inquiline species have been obtained from these galls: *Ceroptres masudai* Abe, 1997, in 3.xi.2015: 3♂. This species were previously mentioned from Japan and Korea (Abe, 1997). *Andricus kashiwaphilus* represent a new host of *C. masudai* because the Wang *et al.* (2012) mentions is uncertain according to the characters mentioned (third metasomal tergite without punctures dorso-posteriorly and mesopleuron with faint striae dorso-anteriorly).

Discussion

Cynipid gallwasp fauna of the Eastern Palaearctic and Oriental region is poorly known (Abe *et al*., 2007). Only

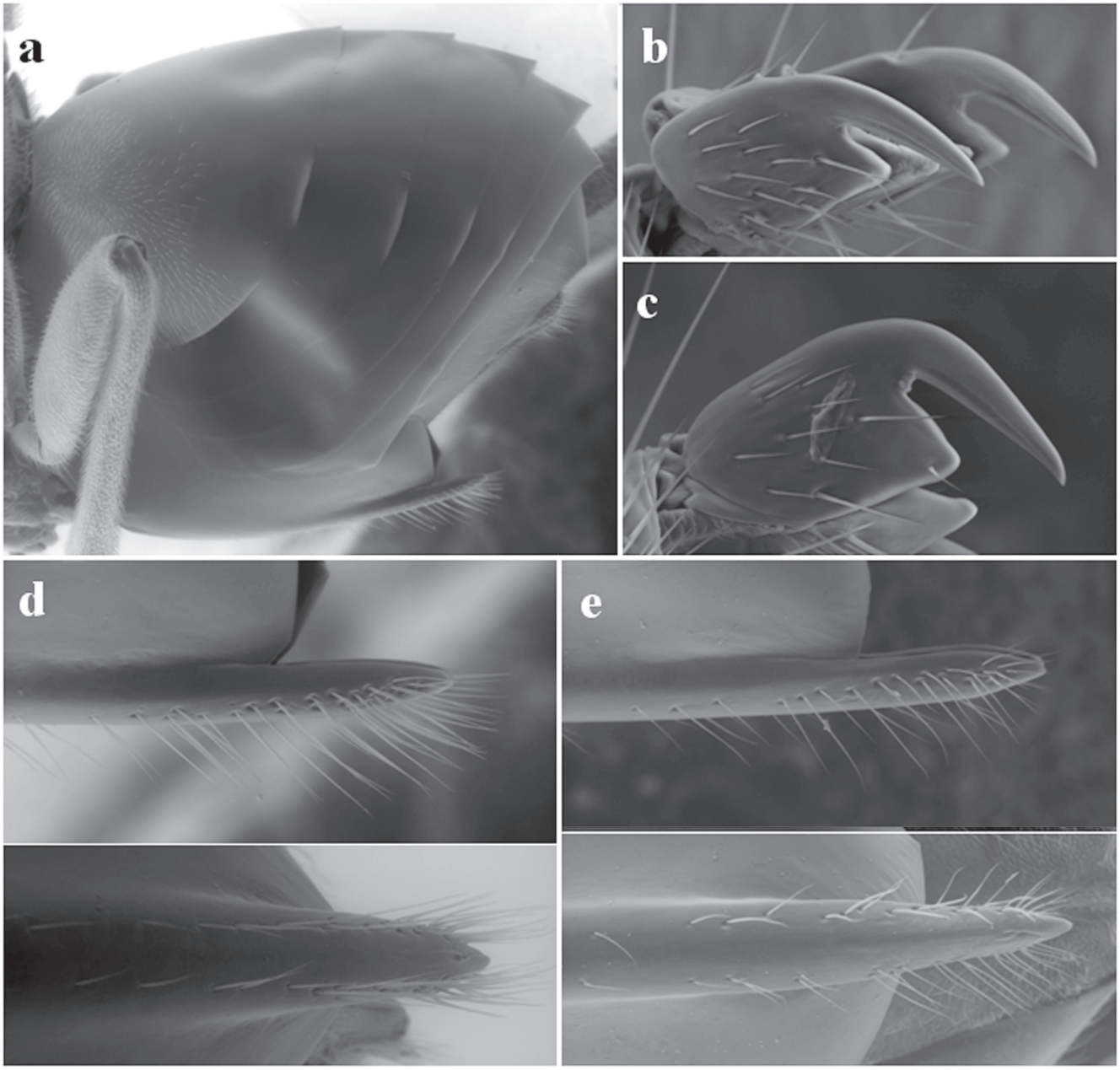

Figura 3. SEM pictures of *A. mukaigawae* (a, b, d) and *A. kashiwaphilus* (c, e). Metasoma in lateral view (a), tarsal claws (b-c), ventral spine of hypopygium (d-e) in lateral view (superior picture) and in ventral view (inferior).

51 valid species are recognized from the Eastern Palaearctic and Oriental areas, mostly from Taiwan, Japan and the Russian Far East (Abe *et al*., 2007; Melika & Tang, 2011; Melika *et al*., 2009, 2010, 2013; Pujade-Villar *et al*., 2014; Tang *et al*., 2009, 2011a, 2011b, 2012a, 2012b; Wang *et al*., *in press*). Currently, 8 species of cynipid gallwasps from the tribe Cynipini (Cynipidae), associated with Fagaceae, are known from the mainland China; 7 of them are known from Japan and/or the Far East of Russia and the North-Eastern part of China, which belongs to the Eastern Palaearctic region (Tang *et al*., 2012): *Andricus mukaigawae* (Mukaigawa, 1913), *A. kashiwaphilus* Abe, 1998, *A. pseudoflos* (Monzen, 1954), *A. targionii* Kieffer, 1903, *Biorhiza nawai* (Ashmead, 1904), *Trichagalma serratae* (Ashmead, 1904) and according to Wang *et al*. (2016) *T. acutissimae* (Monzen, 1953); 3 are known from Oriental region only: *Andricus mairei* (Kieffer, 1906), *A. xishuangbannaus* Melika & Tang, 2012 and *A. flavus* Pujade-Villar, Wang, Guo & Chen, 2014. A single species, *Dryocosmus kuriphilus* Yasumatsu, 1951, occurs in *Castanea* spp. in the North-Eastern of Palaearctic region; it has been accidentally introduced in Northern Hemisphere (Japan, Korea and Nepal), North America and Europe.

The species here studied belong to *Andricus mukaigawae* complex. It is represented by four species (Abe, 2007) distributed in Eastern of Palaearctic region: *A. mukaigawae* and *A. kashiwaphilus* (with parthenogenetic cycle) and, *A.*

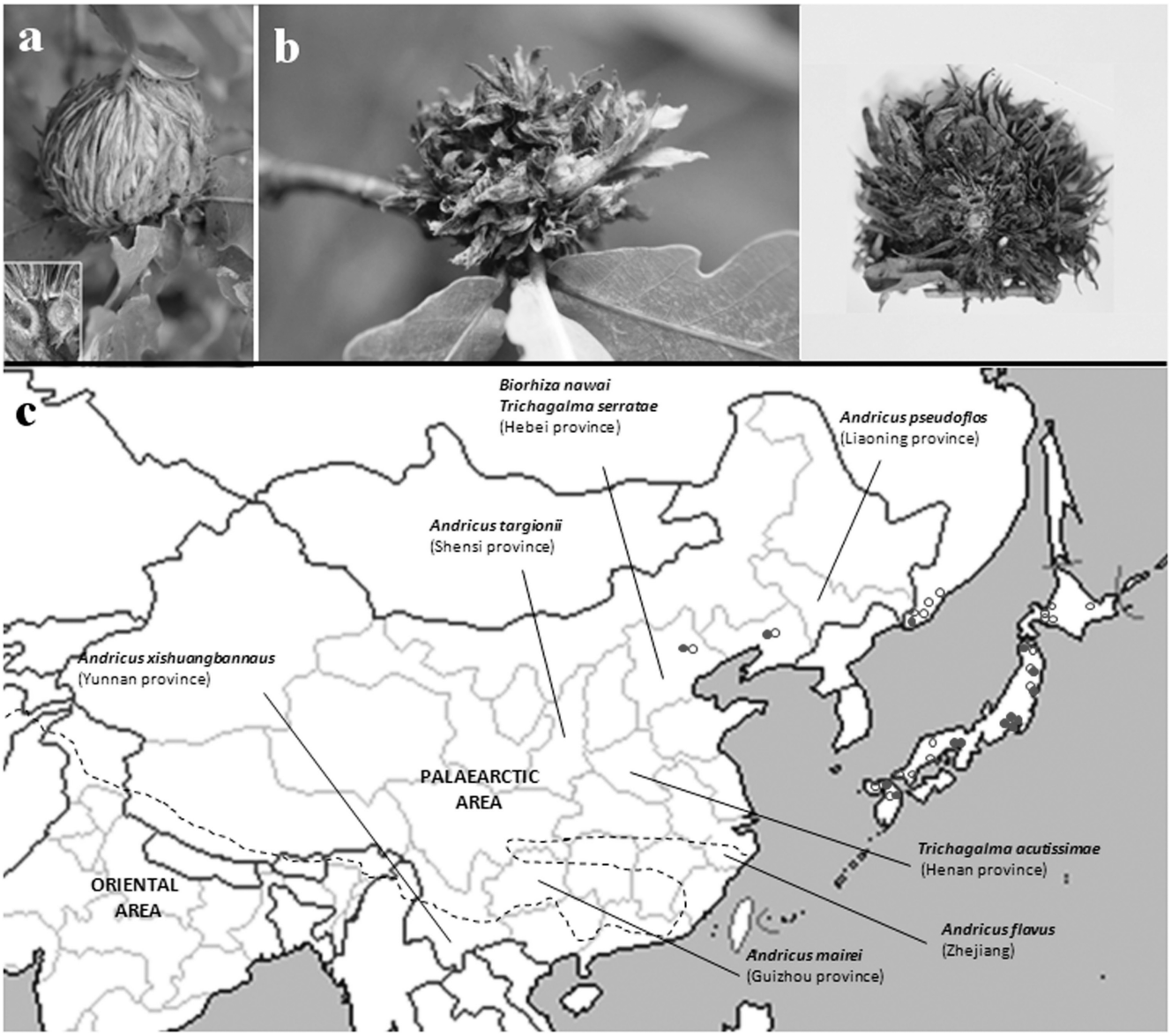

Figura 4. Distribution of *A. mukaigawae* (a, ●) and *A. kashiwaphilus* (b, ○) according to Kovalev (1965), Weih (1965); Abe (1986, 1988, 1991, 1998, 2007) and Schwéger *et al*. (2015b), including the areas (provinces) where the other species of galls wasps on *Quercus* are mentioned in China.

targionii and *A. pseudoflos* (with univoltine cycle). The taxonomical position of these species was largely studied by Abe (1986, 1988, 1991, 1998, 2007).

Two different bud galls (bud-shaped or flower-shaped) with identical obtained adults were considered as two different races of *A. mukaigawae* species (Abe, 1986). These two races were regarded as distinct species in Abe (1998), who described a new species *A. kashiwaphilus*. These species with Eastern Palaearctic distribution (Fig. 4c) are the second record from China and they represent the most Western distribution of these species.

On the basis of the original description and figures the name *Andricus mukaigawae* (s. str.) was applied to the race that produces bud-shaped unisexual galls on *Q. aliena*, *Q. mongolica* and *Q. serrata* (Fig. 4a), in front of *A. kashiwaphilus* which produces flower-shaped unisexual galls on *Q. dentata* (Fig. 4b). Nevertheless, *A. mukaigawae* (s. str.) can produce galls also on *Q. dentata* and the bud-shaped galls co-existed with the flower-shaped galls on the branches of *Q. dentata* (Abe, 1988; 2007). The close relationship between *A. mukaigawae* and *A. kashiwaphilus* was confirmed by Rokas *et al.* (2003).

Morphologically these species are very similar and indistinguishable on the basis of their morphology (Abe, 1986). The only character mentioned by Abe (1998) useful to distinguish between the adults is the different karyotype: *A. mukaigawae* (2n = 12) and *A. kashiwaphilus* (2n = 10). According to Abe (1998), the karyotype was uniform within each race, and no structural heterozygosity of chromosomes occurred in individuals from localities where the two species coexist (Abe, 2007).

Based on SEM pictures of these species and comparing pair a pair the images of both species two principal differ-

ences have been obtained to recognise these species: (i) the shape and length of ventral spine pubescence (Figs. 3d-e) and (ii) the shape of the internal area of propodeal carinae (Figs. 2c-d). These characters invariably present in all specimens studied belonging to China and Japan. Also, the relative characters as: relation between POL: OOL: OCO distances (Figs. 1c-d), density of mesoscutum pubescence (Figs 2a-b), morphology of scutellar foveae (Figs 2a-b) and the relative length of radial cell can be also used to discriminate between these two species. Finally, a new character is here mentioned for the first time to differentiate between these gall wasps species: the shape of tarsal claws (Figs. 3b-c); in this case, these species have a big tarsal claws and its morphology is easily recognisable with 40x magnification. Although all the characters mentioned are present, as it is mentioned, in all the studied specimens, we must remember that the studied sample is not large (23 specimens from China and 4 from Japan). However the data here provided can be tested from now on with more specimens, which will allow knowing, in the future, whether they are valid or if some of them correspond to intraspecific variability or population variability.

Chinese inquilines gall wasps fauna are also poorly known. Only 14 species are known from 57 mentioned in Eastern of Palaearctic and Oriental areas (Bozsó *et al*., 2015, online 2013; Melika *et al.*, 2012; Nieves-Aldrey & Butterill, 2014; and Pénzes *et al*., 2009; Schwéger *et al*., 2015a, b) belonging to *Saphonecrus*, *Synergus*, *Ceroptres*, *Ufo* and *Lithosaphonecrus*. Several species of *Synergus* and *Saphonecrus* genera collected in China by Chinese coauthors are pending to be described in the future, although the recent papers published by Schwéger *et al*. (2015a, b) describe numerous new species in Easter Palaearctic.

The inquilines species also obtained from both *Andricus* galls studied, *Ceroptres masudai*, *Synergus khazani* and *Saphonecrus laleyi* are mentioned for the first time in China. Also, *Andricus mukaigawae* is the first host known for *S. laleyi*, and *A. kashiwaphilus* is a new host for *C. masudai*. *Ceroptres* genus is cited for the first time in China because the previous referenced species (*C. distinctus* Wang, Liu & Chen, 2012 and *C. setosus* Wang, Liu & Chen, 2012) did not belong to *Ceroptres* genus (Pujade-Villar, *unpublished data*).

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