Zootaxa 3637 (3): 394–400
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.3637.3.11
http://zoobank.org/urn:lsid:zoobank.org:pub:B719972D-E572-42F0-BEDD-8F3810709877

The description of *Alloxysta chinensis*, a new Charipinae species from China (Hymenoptera, Figitidae)

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Abstract

A new figitid species, *Alloxysta chinensis* Fülöp & Mikó sp nova, based on females, is described from China and South Korea. The functional morphology and the phylogenetic implication of some anatomical structures frequently used in Charipinae and the validity of the genus *Carvercharips* is discussed. This manuscript is the first of its kind linking descriptive terminology to Hymenoptera Anatomy Ontology classes, which provides persistent links to definitions for terms used within this manuscript.

Key words: hyperparasitoid, description, taxonomy, Hymenoptera Anatomy Ontology

Introduction

Alloxysta Förster species are common hyperparasitoids of aphid pests (Raworth *et al*. 2009, MacFadyen *et al.* 2009) and hence they are important in serving as model systems for studying trophic interactions (Traugott *et al*. 2008) and biocontrol research (Hougardy & Mills 2009).

Besides a few endemic species (three Australian (Carver 1992), two New Zealandian (Ferrer-Suay *et al.* 2012a), five South American (Pujade-Villar *et al*. 2002, Ferrer-Suay *et al.* 2011), three African (Andrews 1978), one Oriental (Paretas-Martínez *et al*. 2005), all members of the genus are known from the Holarctic Region, most of them from the Palearctic (78), and particularly Europe (65) (Andrews 1978, Ferrer-Suay *et al*. 2012b). Ten *Alloxysta* species are known from Asia: three from Japan (Andrews 1978), five from the Far East of Russia (Belizin 1962, 1973), one from Taiwan (Paretas-Martinez *et al*. 2005, 2007b) and one from India (Singh & Sinha 1979). All, except *A. pleuralis* (Cameron) and *A. mara* Paretaz-Martínez & Pujade-Villar, are known from the Eastern Palaearctic only (Table 1).

Alloxysta species are easy to distinguish from other charipine genera by the presence of the posterior carina on the subaxillular bar, presence of mesopleural triangle, absence of the precoxal sulcus, absence of a notch on the forewing margin and the cylindrical pedicel (Paretas-Martínez *et al*. 2007a). *Carvercharips* was erected for one species, *Alloxysta carinata* Carver by Kovalev (1995) based on the unique structure of the posterior part of the mesoscutellum and the metapectal-propodeal complex. Later it was synonymised with *Alloxysta* based on the homoplasious nature of the mentioned apomorphies (Paretas-Martínez *et al*. 2007a). *Alloxysta chinensis* Fülöp & Mikó, **sp**. **nova** shares all the diagnostic characters of *Carvercharips* and *A. carinata* and the two species might compose a monophyletic group within or outside *Alloxysta*.

 Accepted by M. Buffington: 4 Mar. 2013; published: 11 Apr. 2013

TABLE 1. List of the Asian species of *Alloxysta*.

Species	Distribution	Reference
A. aurata Belizin	Vladivostok, Russia	Belizin, 1968
A. capillata Belizin	Iturup Island, Russia	Belizin, 1962
A. chinensis, **new species**	Fujian, China; South Korea	Present paper
A. contineus (Belizin)	Chukotka, Russia	Belizin, 1962
A. ishizawai (Watanbe)	Honshû, Japan	Watanbe, 1950
A. japonicus (Ashmead)	Honshû, Japan	Ashmead, 1904
A. mara Paretas-Martínez & Pujade-Villar	Taiwan	Paretas-Martínez & Pujade-Villar, 2005
A. pleuralis (Cameron, 1879)	India	Singh & Sinha, 1979
A. proxima Belizin	Komandorski Islands, Russia	Belizin, 1962
A. salicicola Belizin	Paramushir Island, Russia	Belizin, 1973
A. simplex (Watanabe)	Hokkaidô, Japan	Watanabe, 1950

Material and methods

Morphological terminology, except that for wing veins, follows version "24:01:2011 9:40" of the Hymenoptera Anatomy Ontology (HAO, Yoder *et al.* 2011). Identifiers to HAO concepts (e.g. HAO:0000107) are analogous to a GenBank accession numbers. They represent unique and persistent identifiers within the HAO and as such allow taxonomists to clarify the concepts they are refering to. Wing vein nomenclature follows Ronquist and Nordlander 1989. The text includes links as Uniform Resource Identifiers (URIs), which provide additional functionality for software based parsing and reasoning, in parenthesis at the first mention of morphological features. URI will differentially resolve to both human or machine readable responses based on the request type. The URI links from this manuscript resolves to the Hymenoptera Glossary where definitions for terms used within this manuscript are presented.

General observations were made by stereomicroscope (Leica MZ6) at 160× magnification. Wing venation was studied on slide mounts embedded in Canada balsam (Prinsloo 1980). For scanning electron microscopy (SEM) examination, dried specimens were rehydrated, cleaned with fluid detergent, transferred to 96% ethanol in ethanol series, critical point dried, gold coated, and mounted with double sided adhesive tape on stub. The pictures were taken by HITACHI S-2600 VP-SEM using low vacuum (15–25Pa, 15–20kV) mode. Digital images were taken by Nikon coolpix 4500 attached to Olympus BH2 compound microscope. A series of photographs were prepared by focusing on different sequential levels of the specimen. Images were combined by CombineZP (Hadley 2010) and processed in Adobe Photoshop 6.0 and are deposited in Morphbank (http://www.morphbank.net) under the access number 790974-81.

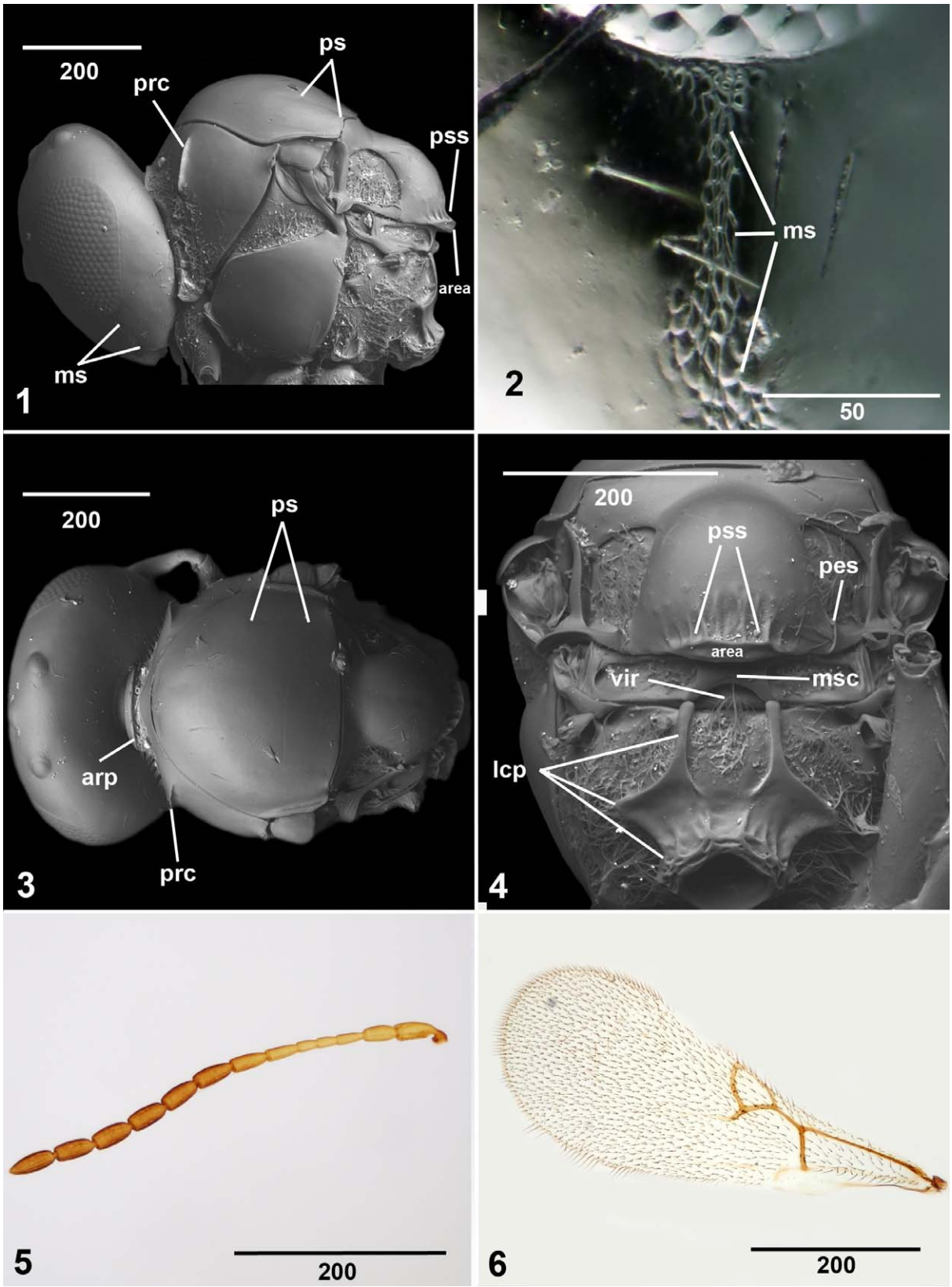
Type materials are deposited in the following institutions: **BPDL**, Budapest Pest Diagnostic Laboratory, National Food Chain Safety Office, Budapest, Hungary (curator G. Melika); **USNM**, U.S. National Museum of Natural History, Smithsonian Institution, Washington, DC, U.S.A. (curator Matthew Buffington); **UB**, Univesitat de Barcelona, Spain (curator J. Pujade-Villar).

The first two authors made the description, G. Melika checked and corrected the terminology and the HAO links were done by K. Seltmann and Z. Pénzes.

Alloxysta chinensis Fülöp & Mikó, sp. nova

Figs 1–6

Type material. HOLOTYPE female: China, Fujian prov., Fuzhou, 07.V.1995., leg: Lin Naiquan. Seven female paratypes: 2 females: China, Fujian prov., Lianchen, 12.VII.1996., leg: Lin Naiquan; 2 females, Shouning, 05.VIII.1992., leg: Lin Naiquan; 1 female: Korea, NIAST, 27.V.1993., leg. D.S. Ku; 1 female: Korea, NIAST, 14.VI.1997., leg: J.Y. Choi. 1 female: Korea, NIAST, 10.Oct. 1997, leg. J.Y. Choi. The holotype and 5 paratypes are deposited in BPDL (Budapest, Hungary); 1 paratype in UB and 1 paratype in the USNM.



FIGURES 1–6. *Alloxysta chinensis*, **sp. nova**, female: 1, head and mesosoma, lateral view (ms, malar groove; prc, lateral pronotal carina; ps, parapsidal signum; pss, posterior mesoscutellar sulci; area, vertical posterior area of mesoscutellum). 2, head, lateral, view, part (ms, malar groove), 3, head and mesosoma, dorsal view (arp, anterior rim of pronotum; prc, lateral pronotal carina; ps, parapsidal signum). 4, metascutellum and propodeum, posterodorsal view (area, vertical posterior area of mesoscutellum; lpc, lateral propodeal carina; msc, metascutellum; pes, posterior carina of subaxillular bar; pss, posterior mesoscutellar sulcus; vir, ventral impressed area of metanotum), 5, antenna. 6, forewing.

Etymology. The species is named after the country, China, where the species was first collected.

Diagnosis. *Alloxysta chinensis* **sp. nova** is most similar to *A. carinata* and shares the following characters: presence of the posterior mesoscutellar sulcus (**pss,** Figs 1, 4) (http://purl.obolibrary.org/obo/HAO_0000757) and the area (http://purl.obolibrary.org/obo/HAO_0000146) delimited by the posterior mesoscutellar sulcus, elongate pronotal carina (**prc,** Figs 1, 3) (http://purl.obolibrary.org/obo/HAO_0001031), absence of the posterolateral tooth-like section of the anterior part of the pronotal plate (http://purl.obolibrary.org/obo/HAO_0001851), medially constricted metascutellum (http://purl.obolibrary.org/obo/HAO_0000625) and the presence of an acute point on the lateral margin of the lateral propodeal carina (**lpc,** Fig. 4) (http://purl.obolibrary.org/obo/HAO_0000486). However, *A. chinesis* differs from *A. carinata* in the presence of the malar sulcus (**ms,** Figs 1,d 2) (http://purl.obolibrary.org/obo/HAO_0001394) and a more acute point on the lateral margin of the lateral propodeal carina.

Description. Female. Reddish-brown; mandible (http://purl.obolibrary.org/obo/HAO_0000506), labiomaxillary complex (http://purl.obolibrary.org/obo/HAO_0000452), legs (http://purl.obolibrary.org/obo/HAO_0000494), antenna (http://purl.obolibrary.org/obo/HAO_0000101) light brown.

Head. (http://purl.obolibrary.org/obo/HAO_0000397) (Fig. 1) Broadest part of cranium (http://purl.obolibrary.org/obo/HAO_0000234) distinctly above vertical midline in anterior view, smooth, except reticulate malar sulcus (Fig. 2); distal rim of clypeus (http://purl.obolibrary.org/obo/HAO_0000209) absent; distal margin (http://purl.obolibrary.org/obo/HAO_0000510) with median, shallow notch (http://purl.obolibrary.org/obo/HAO_0000648); epistomal sulcus (http://purl.obolibrary.org/obo/HAO_0000306) absent; clypeo-pleurostomal line (http://purl.obolibrary.org/obo/HAO_0000211) not marked by impression (http://purl.obolibrary.org/obo/HAO_0000417); distance between anterior tentorial pits (http://purl.obolibrary.org/obo/HAO_0000126) equal with clypeus (http://purl.obolibrary.org/obo/HAO_0000212) height; lower face (http://purl.obolibrary.org/obo/HAO_0000502) with dense, long setae (http://purl.obolibrary.org/obo/HAO_0000935) medially; row of short setae (http://purl.obolibrary.org/obo/HAO_0000903) along inner orbit (http://purl.obolibrary.org/obo/HAO_0000419) of compound eye (http://purl.obolibrary.org/obo/HAO_0000217) present; distance between medial margin of toruli (http://purl.obolibrary.org/obo/HAO_0000103) about 1.5 times as long as clypeus height; distance between median margins of toruli equal to distance between antennal foramen (http://purl.obolibrary.org/obo/HAO_0001022) and inner orbit of eye; vertex (http://purl.obolibrary.org/obo/HAO_0001077) and interocellar area (http://purl.obolibrary.org/obo/HAO_0000430) with very thin, sparse, short setae; maximum height of eye equal with maximum width.

Antenna (Fig. 5) as long as body (http://purl.obolibrary.org/obo/HAO_0000182); filiform, with 11 flagellomeres (http://purl.obolibrary.org/obo/HAO_0000342); ratios of antennal sclerites (http://purl.obolibrary.org/obo/HAO_0000107) (scape (**s**) (http://purl.obolibrary.org/obo/HAO_0000908):pedicel (**p**) (http://purl.obolibrary.org/obo/HAO_0000706):f1:f2:f3:f4:f5:f6:f7:f8:f9:f10:f11): length: 1.4:1.4:1.0:0.7:0.7:1.2:1.4:1.4:1.4:1.4:1.4. Width: 1.0:1.0:0.71:0.5:0.5:0.86:1.0:1.0:1.0:1.0:1.0:1.0:1.36.

Mesosoma. (http://purl.obolibrary.org/obo/HAO_0000576) Pronotal carina well developed; pronotum (http://purl.obolibrary.org/obo/HAO_0000853) anteriorly with dense setae, posteriorly almost bare; anterior rim of pronotum (**arp,** Fig. 3) (http://purl.obolibrary.org/obo/HAO_0000125) simple, posterolateral tooth-like section of anterior part of pronotal plate absent; anteromesoscutum (http://purl.obolibrary.org/obo/HAO_0001490) smooth, bare except rare row of setae along notaulus (http://purl.obolibrary.org/obo/HAO_0000647); antero-admedian line (http://purl.obolibrary.org/obo/HAO_0000128) absent; parapsidal signum (**ps,** Figs 1, 3) (http://purl.obolibrary.org/obo/HAO_0000694) marked by shallow impression; mesoscutal suprahumeral sulcus (http://purl.obolibrary.org/obo/HAO_0000570) absent; mesoscutal humeral sulcus (http://purl.obolibrary.org/obo/HAO_0000569) present, not foveolate; mesoscutellum (**msc,** Fig. 4) (http://purl.obolibrary.org/obo/HAO_0000574) smooth and bare medially of axillulae (http://purl.obolibrary.org/obo/HAO_0000160), except some elongate setae submedially on disc of mesoscutellum (http://purl.obolibrary.org/obo/HAO_0000915); scutellar fovea (http://purl.obolibrary.org/obo/HAO_0000916) absent; axillulae with dense setae; posterior carina of subaxillular bar (**pes,** Fig. 4) (http://purl.obolibrary.org/obo/HAO_0001857) present; posterior mesoscutellar sulcus present, foveoleate; narrow, more or less vertical posterior area of mesoscutellum delimited by posterior mesoscutellar sulcus present; mesoscutellum overlapping metanotum (http://purl.obolibrary.org/obo/HAO_0000603); mesopleural triangle (http://purl.obolibrary.org/obo/HAO_0000562) present, densely setaceous; mesopleuron (http://purl.obolibrary.org/obo/HAO_0000566) smooth, ventrally of mesopleural triangle bare except rare setae on intercoxal space (http://

purl.obolibrary.org/obo/HAO_0000426); metascutellar arm (http://purl.obolibrary.org/obo/HAO_0000623) and metascutellum bare; metanotal trough (http://purl.obolibrary.org/obo/HAO_0000600) densely setaceous; ventral impressed area of metanotum (**vir,** Fig. 4) (http://purl.obolibrary.org/obo/HAO_0001854) with setae medially, as high as metascutellum in posterior view; metapectal-propodeal complex (http://purl.obolibrary.org/obo/HAO_0000604) densely setose laterad of lateral propodeal carina; lateral propodeal carina broad with increasing width ventrally, broadest dorsad of ventral-most point, with acute lateral margin.

Forewing (http://purl.obolibrary.org/obo/HAO_0000351) (Fig. 6) longer than body; maximum length 2.7 times maximum width; densely setose, except bare submedian area closed at costal margin, about 0.1 times as long as maximum forewing length; radial cell 1.7–2.0 times as long as broad; Rs strongly curved, reaches forewing margin at nearly right angle; forewing veins pale; proportions of forewing 2rm:2r:Rs+M as follows: 1:1.7–2:2.5–3.

Metasoma. (http://purl.obolibrary.org/obo/HAO_0000626) Slightly shorter than head+mesosoma; slightly higher than long in lateral view; third abdominal tergum (http://purl.obolibrary.org/obo/HAO_0000056) smooth, shiny, occupying nearly entire length of metasoma, anteriorly with white dense felt-like ring (http://purl.obolibrary.org/obo/HAO_0001760), interrupted dorsally. Ventral spine of hypopygium (http://purl.obolibrary.org/obo/HAO_0001856) very short.

Body length 1.55–2.20 mm.

Male unknown.

Host unknown.

Discussion

In *Alloxysta*, the structure of the median area of the metapectal-propodeal complex anteriorly of propodeal foramen (http://purl.obolibrary.org/obo/HAO_0000865) is frequenty used in species identifications. Evenhuis (1976) has proposed 3 character states describing this area: (i) median propodeal carina (http://purl.obolibrary.org/obo/HAO_0000529) absent, (ii) one median propodeal carina present, and (iii) two median propodeal carina present.

In the first state, the median area is not delimited by any line from the lateral areas of the metapectal-propodeal complex. In the second state, the metapectal-propodeal complex bears a raised, median area that is well-delimited by its sharp, lateral edge (http://purl.obolibrary.org/obo/HAO_0000285) (fig. 10A in Paretaz-Martínez *et al*. 2007a). In the third state, the well-delimited median area possesses a median, concave area delimited laterally by sharp edges (Fig. 4). Although the sharpness of the median and lateral limits of the raised median and submedian areas on the metapectal-propodeal complex might be variable, the shape is constant and usable for species separation. The lateral and median margins of the median, raised area are concave and strongly diverging posteriorly ending in acute points in *Alloxysta carinata* and *A. chinensis* (the lateral acute point is more developed in *A. chinensis* than in *A. carinata*). The median and lateral margins, even if they are slightly converging posteriorly, are never concave and never ending in acute points in other *Alloxysta* species.

The malar sulcus is absent in *A. carinata* while in *A. chinensis* the sulcus is represented by a linear, slightly concave, delicately sculptured area (Fig. 2) However, both the concavity and sculpture of the sulcus varies from being slightly impressed and smooth to strongly impressed and heavily sculptured within *Alloxysta* and other Cynipoidea.

Carvercharips was erected for one species, *Alloxysta carinata* by Kovalev (1995) based on the elongated lateral pronotal carina, presence of the posterior mesoscutellar area, elongated posterior longitudinal carinae on the mesoscutellum, and posteriorly diverging lateral margins of the lateral propodeal carina. According to Paretaz-Martínez *et al*. (2007a), *Carvercharips* forms a monophyletic clade with *Alloxysta*, however, with a weak support (< 50%). Paretaz-Martínez *et al*. (2007a) considered the length of the lateral pronotal carina and the structure of the posterior part of the mesoscutellum (presence of posterior longitudinal carinae) to be continuous and thus phylogenetically not informative. Although the absence of the malar sulcus was reported as the only synapomorphy for *Carvercharips*, Paretaz-Martínez *et al*. (2007a), doubt the utility of this homoplasious character, and synonymised *Carvercharips* to *Alloxysta*. In addition to the aformentioned characters, the absence of the posterolateral tooth-like section of the anterior part of the pronotal plate, the absence of the process behind the submedian pronotal impression (http://purl.obolibrary.org/obo/HAO_0001762), and the presence of the ventral impressed area of the metascutellum, are also autapomorphies for *Alloxysta carinata* and possible synapomorphies

for *Carvercharips* on the basis of their data matrix. Paretas-Martínez et al. (2007a) did not include the presence of the acute point on the lateral margin of the lateral propodeal carina (Carver 1992) or the presence of the posterior carina of subaxillular bar, nor did they include the presence of the posterior mesoscutellar area as a separate character.

All *Alloxysta* species form a monophyletic clade with low support (< 50%), which is consistant with the inclusion of *Alloxysta carinata*. The absence of the process behind the submedian pronotal impression [1], absence of the posterolateral tooth-like section of the anterior part of the pronotal plate [2], well developed lateral pronotal carina forming a well upraised pronotal plate [3], presence of the posteriorly delimited area on the mesoscutellum [4], presence of the posterior carina of subaxillular bar [5], very short, narrow metascutellum [6] and the presence of an acute point on the lateral margin of the lateral propodeal carina [7] are synapomorphies for the hypothetic clade composed of *Alloxysta carinata* and *A. chinensis*. Based on the high number of shared synapomorphies between *A. carinata* and *A. chinensis* it is possible that they form a distinct lineage within or outside of *Alloxysta*, however, this requires confirmation with detailed molecular phylogenetic analyses.

Acknowledgements

We thanks Sándor Csősz (Hungarian Natural History Museum, Budapest) for his assistance with scanning electron microscopy. This research was enabled by the National Science Foundation (DBI-0850223) and TÁMOP-4.2.1/B-09/1/KONV-2010-0005, HURO/0901/205/2.2.2 and KTIA-OTKA CNK 80140 for Z. Pénzes.

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