

## ***Aulacidea manchuria* Nastasi sp. nov., a new herb gall wasp from China (Hymenoptera: Cynipoidea: Aulacideini), with commentary on hawkweed (Asteraceae: Hieraciinae) gall wasps**

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### **Abstract**

We describe *Aulacidea manchuria* Nastasi sp. nov., a new species of herb gall wasp from China and the second species of *Aulacidea* Ashmead, 1897 to be described from the country. Based on morphological data, *A. manchuria* belongs to the *Aulacidea hieracii* group, which is known to induce galls on the stems, leaves, and stolons of *Hieracium* L. and *Pilosella* Hill; we provide a key to Eastern Palearctic females of this species group to better enable identification of these species. We discuss records of herb gall wasps from China, the recognition of hawkweed gall wasp species, and further issues with taxonomy of this species group and of *Aulacidea*.

**Key words:** Cynipidae, Heilongjiang, *Hieracium*, *Pilosella*

### **Introduction**

Recent studies of cynipids in China have resulted in the description of new taxa across several major lineages of gall wasps (Wang *et al.* 2012a, 2012b, 2013; Pujade-Villar *et al.* 2016; Tang *et al.* 2016; Fang *et al.* 2020; Pang *et al.* 2020; Yang *et al.* 2020). However, only two species of herb gall wasps (Aylacini sensu lato) are presently known from China (Wang *et al.* 2012b). Considering the high diversity of herb gallers in the Eastern Palearctic (Melika 2006), especially that of taxa now placed in Aulacideini, it is likely that many more undiscovered herb gallers exist in China. In line with this idea, we recently located an undescribed species of the genus *Aulacidea* Ashmead, 1897 collected from China's Heilongjiang Province among undetermined Cynipoidea from the California Academy of Sciences (San Francisco, California, USA) that we herein describe. This species, *Aulacidea manchuria* Nastasi sp. nov., is the third member of the tribe Aulacideini known from China and is the second member of an herb gall wasp taxon to be described from the country. We also provide a key to Eastern Palearctic females to species of *Aulacidea* closely related to *A. manchuria*, and discuss recognition, status, and applied interest in closely related species.

### **Materials and methods**

#### *Imaging*

We performed morphological observations of the holotype of *A. manchuria* using an Olympus SZX16 stereo microscope (Olympus Life Science, Tokyo, Japan) fitted with an optical micrometer. We measured antenna segments at a resolution of 0.005 (1/200) millimeters using 10× magnification in combination with the 2× objective. Other measurements were taken at an appropriate magnification using the 1× objective. Our lighting setup consisted of a gooseneck illuminator fitted with mylar strips to diffuse light, and we used an additional mylar strip fashioned into a ring to further diffuse light around the specimen itself.

We imaged the holotype using a Macroscopic Solutions 'microkit' (Tolland, CT) imaging station. Photos were

stacked using Zerene Stacker LLC (Richland, WA). We edited images and prepared plates using Adobe Photoshop and Adobe Illustrator (Adobe Inc.).

### *Morphological terminology*

We follow the Hymenoptera Anatomy Ontology (HAO) (Yoder *et al.* 2010) for morphological terminology. Other terms relating to phenotypes are derived from the Phenotype and Trait Ontology (PATO curators 2023). We selected morphological characters for examination and description from various recent taxonomic studies concerning herb gall wasps (Melika 2006; Azmaz & Katılmış 2020; Nieves-Aldrey 2022; Tavakoli *et al.* 2022; Nastasi *et al.* 2024b).

### *Abbreviations and terms used in text and figures*

F1–F3: First through third antennal flagellomeres.

LOL: Lateral ocellar line, shortest distance between margins of median and lateral ocelli.

OOL: Ocular ocellar line, shortest distance between inner orbit and outer margin of posterior ocellus.

POL: Posterior ocellar line, shortest distance between inner margins of posterior ocelli.

T1–T3: First through third metasomal tergites.

### *Abbreviation of depository institution*

CAS: California Academy of Sciences (San Francisco, California, USA). Curator: Brian L. Fisher.

## Results

### *Aulacidea manchuria* Nastasi sp. nov.

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**Material examined.** Holotype female—China: Manchuria, Maoershan, 100 km east of Harbin on Chinese Eastern Railway; 8 June 1941; VN Alin leg.; CASENT 8520652. Deposited in CAS.

**Etymology.** Named for Manchuria, the region of Northeast China from which the holotype was collected.

**Diagnosis.** *A. manchuria* is easily distinguished from other females of the *hieracii* species group by F1 being equal in length to F2 and the absence of placodeal sensilla on F2.

**Female**—Body length 1.9 mm. Head and mesosoma entirely black. Metasoma reddish, perceptibly infuscated distally. Antennae and legs rufous to dark rufous. Antennae with 13 antennomeres. Pedicel 1.0× as long as wide. F1 2.3× as long as wide, 1.8× as long as pedicel, and equal in length to F2. F2 2.1× as long as wide. Apical flagellomere indistinctly subdivided medially; 4.1× as long as wide. Placodeal sensilla apparent on F3 and all following flagellomeres. Head sculpture coriaceous throughout. Facial radiating striae complete and distinct throughout. Compound eye longer than malar space. Clypeus subtrapezoidal, wider than tall, and slightly projecting ventrally over base of mandibles; clypeo-pleurostomal lines divergent ventrally. POL:LOL:OOL=15:8:12 in holotype; POL longer than OOL and slightly less than twice LOL; OOL 1.5× as long as LOL. Mesosoma strongly convex dorsally in lateral view. Pronotal plate poorly developed, with lateral sutures terminating far before reaching anterior margin of mesoscutum. Mesoscutum coriaceous; moderately pilose, with short, scattered setae throughout. Notauli complete, narrow throughout, and not strongly arched. Median mesoscutal impression distinct, extending about halfway across mesoscutum. Mesoscutellar disc subcircular, about 1.1× as long as wide, and with sculpture coriaceous anteriorly and medially to strongly rugose around outer margins. Mesoscutellar foveae subtriangular, occupying about anterior third of mesoscutellar disc, with anterior margins forming a straight line. Mesopleuron transversely striate throughout. Propodeal carinae apparent as two slightly curved lateral carinae. Wings hyaline, with veins dark brownish. Marginal cell closed, 2.6× as long as wide. Areolet distinct. Marginal cilia distinct; short. Tarsal claws simple, without conspicuous lobes. Metabasitarsus distinctly shorter than combined length of following tarsomeres. Metasoma with distinct anterolateral patch of dense setae on T2. T2 apparently impunctate; T3 and following tergites perceptibly punctate throughout. Ovipositor sheaths distinctly surpassing apex of metasoma.

**Male**—Unknown.

**Biology**—Unknown.

**Distribution**—Heilongjiang Province, China.



**FIGURE 1.** *Aulacidea manchuria* Nastasi sp. nov., holotype female (CASENT 8520652). A: lateral habitus. B: head, dorsal. C: proximal antennomeres. D: mesosoma, dorsal.

#### Key to Eastern Palearctic females of the *Aulacidea hieracii* group

A complete key to the *Aulacidea hieracii* group is beyond the scope of this work due to widespread taxonomic issues (see discussion). As a result, we have opted to provide a key for only females of species known in the Eastern Palearctic. We have ensured that the included characters work for all specimens of these species we have examined at present, although employing this restriction did reduce the characters available for use in couplet 3. Further revisionary studies of the *Aulacidea hieracii* group would be needed to produce a more robust key to all species.

1. F1 equal to F2 (Fig. 1A & 1C). F2 without apparent placodeal sensilla (Fig. 1A) ..... *manchuria* Nastasi sp. nov.
- F1 not equal to F2; F1 either shorter or longer. F2 with apparent placodeal sensilla ..... 2
2. Mesoscutellar foveae subquadrate. POL longer than OOL. Galls on stems of *Hieracium* or leaves of *Pilosella* ..... 3
- Mesoscutellar foveae transversely subtriangular to subovate. POL equal to OOL. Galls on stolons of *Pilosella* ..... *subterminalis* Niblett, 1946
3. POL twice LOL. Galls on stems of *Hieracium* ..... *hieracii* (Bouché, 1834)
- POL less than twice LOL. Galls on leaves of *Pilosella* ..... *pilosellae* (Kieffer, 1901)

## Discussion

*Aulacidea manchuria* is the second species of *Aulacidea* and the third species of Aulacideini to be described from China. The first records of Aulacideini from China were given by Wang *et al.* (2012b), including one new species of *Aulacidea*, *A. hei* Wang, Liu, & Chen, 2012, and *Isocolus tinctorius* Melika & Gharaei, 2006. The host plant and gall of *A. hei* are unknown. However, based on morphological similarity to some described *Aulacidea*, including *A. phlomica* Belizin, 1959 and *A. parvula* Diakontschuk, 1984, *A. hei* will likely be found to induce galls on a plant in the families Asteraceae or Lamiaceae, but further study is needed to determine the actual host plant. *I. tinctorius* was apparently reared from galls on the previously known host plant, *Carthamus tinctorius* L. Before being recorded from China, *I. tinctorius* was known only from Iran and Iraq (Melika & Gharaei 2006).

While the gall and host plant of *Aulacidea manchuria* are unknown, this species belongs to a group of species known to induce galls on hawkweeds (*Hieracium* L. and *Pilosella* Hill.) on the basis of morphological similarity. This group of species (herein named the *Aulacidea hieracii* group) includes *A. hieracii* (Bouché, 1834), *A. nibletti* Quinlan & Askew, 1969, *A. pilosellae* (Kieffer, 1901), *A. subterminalis* Niblett, 1946, and *A. turguti* Azmaz & Katilmiş, 2021; these species all have complete notauli, a moderately pilose mesoscutum, an entirely transversely striae mesopleuron, a distinct setose patch on T2, a distinct and narrow median mesoscutal impression, subquadrate to ovate mesoscutellar foveae with straight anterior margins, 13-segmented antennae in females, and 14-segmented antennae in males, among other characters. These species form a monophyletic clade according to preliminary data from ongoing revisionary work, including morphological, UCE, and DNA barcode data (Nastasi *et al.*, unpublished data). In line with these observations, *Aulacidea manchuria* will likely be found to induce galls on a species of hieraciine Asteraceae, of which numerous species are present in northern areas of China, including the region from which *A. manchuria* was collected (Sennikov 2008; Sennikov 2014; Shih & Gottschlich 2011).

While no species of this group have been previously reported from China, numerous species are known from western Russia (e.g., Melika 2006), suggesting that southeastern Russia and other parts of China may also have members of the *Aulacidea hieracii* group. Similarly, it stands to reason that many additional species of *Aulacidea* await discovery in China, as other Eastern Palearctic countries have proven to support a diverse array of herb gall wasps (Melika 2006). Given geographic proximity of other east Asian countries, further studies of herb gall wasps should also consider the faunas of Mongolia, North Korea, South Korea, and Japan.

The *Aulacidea hieracii* group is arguably the most consequential group of Aulacideini at present, due to widespread interest in using these species as biological control agents of invasive hawkweeds (Syrett *et al.* 2000; Moffat 2012; Hayes *et al.* 2013; Moffat *et al.* 2013; Moffat & Smith 2014; Grosskopf *et al.* 2022). The true species limits of *hieracii* group species other than *A. manchuria* are unclear; this is especially true among species of biocontrol interest. We examined vouchers of *Aulacidea pilosellae* deposited at USNM (Washington, DC, USA) from biocontrol lab cultures, while developing the above key to species, and identified two very distinct morphospecies among the vouchers, each corresponding to a different host plant of the genus *Pilosella*. Careful taxonomic verification should always be considered during selection of suitable biocontrol agents, as indicated by our observations of *A. pilosellae*; it is unclear whether just one or both putative morphospecies we examined have been introduced to North America or elsewhere for biocontrol purposes. While a previous study considered *A. pilosellae*'s potential to represent cryptic species (Moffat 2012), a detailed taxonomic revision including the use of molecular data will ultimately be needed to fully stabilize the taxonomy of these important herb gall wasps. Similarly, specimens of *Aulacidea hieracii* also exhibit morphological variability depending on host plant and collection locality (Nastasi *et al.*, unpublished data; see also Nastasi *et al.* 2024a). Some other closely related species such as *A. turguti* appear intermediate to the current broad circumscription of *A. hieracii*, further suggesting that *A. hieracii* is a complex of morphologically distinct cryptic species in need of careful taxonomic revision. Given the taxonomic uncertainties present in these *Aulacidea* species, we ensured that the characters given in the key to species allowed for identification of all specimens we examined. Beyond the gall wasps, there are also taxonomic uncertainties involving hawkweeds themselves, with potential to impact biocontrol (Ensing *et al.* 2012; Wilson *et al.* 1997; Wilson *et al.* 2006). As a result of these factors, integrative taxonomic approaches on both host plants and gall wasps could yield significant benefits for hawkweed control.

Additionally, *A. turcica* Azmaz & Katilmiş, 2020, a species recently described from Turkey, belongs to this group. While *A. turcica* was originally reported as inducing galls on *Digitalis* Tourn (Plantaginaceae) (Azmaz & Katilmiş 2020), the morphology of the adult wasp coincides with the characters defining the clade of species

inducing galls on hieraciine plants. The galls figured by Azmaz & Katilmiş also resemble typical galls of *Aulacidea* species on stems of *Hieracium*. Given this evidence, we question the validity of their association of *Aulacidea* with *Digitalis*; we find it likely that the host plant from which *A. turcica* was described was a misidentified hieraciine rather than a plant of the family Plantaginaceae. Despite these considerations, *A. turcica* does appear to represent a distinct, valid species of *Aulacidea*, and will likely be found to induce stem galls on a species of *Hieracium* in future studies.

We are aware of several additional undescribed species inducing galls on *Hieracium* and *Pilosella*, including a western Nearctic species inducing galls on leaves of *Hieracium albiflorum* Hook. (Nastasi, pers. obs.) and a Palearctic species inducing galls on stems of *Pilosella* (José Luis Nieves-Aldrey, in litt.). When including these observations and others noted herein, at least nine total species of *Aulacidea* are likely associates of hawkweeds, and further sampling of galls on these plants will undoubtedly reveal additional new species. As previously mentioned, cryptic species are almost certainly present in this group, and all factors indicate that hawkweed gall wasps constitute a highly diverse lineage, especially given that hawkweeds may be among the most diverse of all plant taxa (Beaman 1990; Chrtekjun *et al.* 2007; Gaskin *et al.* 2007).

Lastly, the genus *Aulacidea* itself is in need of taxonomic revision due to uncertain generic limits. *Aulacidea* includes around 50 described species (Nieves-Aldrey 2022; Tavakoli *et al.* 2022) and has long been regarded as a polyphyletic assemblage (Liljeblad & Ronquist 2002; Ronquist *et al.* 2015; Nieves-Aldrey 2022). The genus is overall rather heterogeneous in terms of morphology and host plant identity, especially relative to other genera in the tribe such as *Isocolus*. The genera of Aulacideini will be revised by a forthcoming study, and it is likely that the genus *Aulacidea* will be restricted to a group of Nearctic species inducing galls on plants of the genus *Lactuca* L. (Nastasi *et al.*, in prep.) due to the identity of the type species *Aulacidea mulgediicola* Ashmead, 1896 (=*A. harringtoni* Ashmead, 1887; Nastasi & Deans 2021).

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