

Three new species and two new records of the genus *Phaenocarpa* Foerster (Hymenoptera, Braconidae, Alysiiinae) from South Korea

Ju-Hyeong Sohn^{1*}, Cornelis van Achterberg^{2*}, Gyeonghyeon Lee¹, Hyojoong Kim¹

1 *Animal Systematics Lab., Department of Biology, Kunsan National University, Gunsan, 54150, Republic of Korea* **2** *State Key Laboratory of Rice Biology and Ministry of Agriculture / Key Lab of Agricultural Entomology, Institute of Insect Science, Zhejiang University, Hangzhou, 310058, China*

Corresponding author: Hyojoong Kim (hkim@kunsan.ac.kr)

Academic editor: Jose Fernandez-Triana | Received 11 June 2021 | Accepted 3 October 2021 | Published 29 October 2021

<http://zoobank.org/5E60582B-54FE-4856-8195-8BB4A3E1A264>

Citation: Sohn J-H, van Achterberg C, Lee G, Kim H (2021) Three new species and two new records of the genus *Phaenocarpa* Foerster (Hymenoptera, Braconidae, Alysiiinae) from South Korea. *Journal of Hymenoptera Research* 86: 1–17. <https://doi.org/10.3897/jhr.86.69998>

Abstract

The species of the genus *Phaenocarpa* Foerster, 1863 (Braconidae: Alysiiinae) from South Korea are revised, and the genus is recorded for the first time from South Korea. Three species, *Phaenocarpa artotemporalis* **sp. nov.**, *P. brachyura* **sp. nov.** and *P. lobata* **sp. nov.**, are new to Science, and two species, *P. masha* Belokobylskij, 1998 and *P. fidelis* Fischer, 1970, are newly recognized in South Korea. They are described and illustrated herein with a provision of the identification key to the Korean species. In addition, the DNA barcode region of the mitochondrial cytochrome c oxidase subunit I (*COI*) has been analyzed for the six species including *P. ruficeps* for genetic comparison.

Keywords

COI barcode, cyclostome, koinobiont, natural enemy, parasitoid wasp, systematics, taxonomy

Introduction

The subfamily Alysiiinae is a relatively large taxon among the family Braconidae, and is subdivided into two tribes; the tribes Alysiiini with 76 genera and Dacnusiini with 31

* The authors contributed equally to this paper.

genera (Yu et al. 2016). The two tribes are distinguished by the presence (or absence) of fore wing vein r-m as a main key character (Shaw and Huddleston 1991). Alysini occurs worldwide and contains over 2,440 valid species (Yu et al. 2016), of which 180 species in 21 genera are listed in the National Species List of South Korea (NIBR 2019). This group is known as koinobiont endoparasitoids of dipterous larvae, using their mandible (with three or four teeth, rarely more or less) to break open the puparium of the host. Some of them, such as *Dacnusa sibirica* in Dacnini, are commercially utilized in biological control for *Liriomyza trifolii* (Abd-Rabou 2006).

The genus *Phaenocarpa* Foerster, 1863 is a large and worldwide distributed genus of Alysini, which includes 228 species with nine subgenera (Yu et al. 2016; Zhu et al. 2017). *Phaenocarpa* species are known as koinobiont endoparasitoids, mainly in larvae of Dipteran species of Anthomyiidae, Chloropidae, Clusiidae, Drosophilidae, Muscidae, Scathophagidae, Sciomyzidae, Syrphidae and Muscidae (Wharton 1984; van Achterberg 1998, 2009).

In the Korea, Papp (1968, 1994) has recorded four species thus far; *Phaenocarpa* (*Discphaenocarpa*) *angustipera* Papp, 1968, *P. (Phaenocarpa) eunice* (Haliday, 1838), *P. (P.) picinervis* (Haliday, 1838) and *P. (P.) ruficeps* (Nees, 1812). In this study, we present new morphological characters and the barcoding sequences of the *COI* region of three new species (*P. artotemporalis* sp. nov., *P. brachyura* sp. nov. and *P. lobata* sp. nov.) and two newly recorded species (*P. masha* Belokobylskij, 1998, *P. fidelis* Fischer, 1970) plus one previously recorded species, *P. ruficeps*. Descriptions, diagnoses, an identification key and photographs of the diagnostic characters are also provided.

Materials and methods

Samples used in this study were collected with Malaise traps in South Korea at the DMZ Botanical Garden, Mandae-ri, Haean-myeon, Yanggu-gun, Gangwon-do. Sorting and preparation were done at the Animal Systematics Lab. (ASL), Department of Biology, Kunsan National University (KSNU) at Gunsan. For morphological identification, Wharton et al. (1997) and Zhu et al. (2017) were used. Morphological characters were observed with a Leica M205C stereo microscope. The Taxapad database (Yu et al. 2016) was used for references. We followed the terminology of Wharton (2002) and van Achterberg (1993). The type specimens are deposited KNA (Korea National Arboretum).

A Leica DMC2900 digital camera and a Leica M205 C microscope (Leica Geosystems AG) were used for photography and several pictures being taken for each height using multi-focusing technology. LAS V4.11 (Leica Geosystems AG) and Helicon-Focus 7 (Helicon Soft) software were used for stacking work. After stacking work, illustrations were created using Adobe Photoshop CS6.

Extraction of DNA was done in ASL, KSNU. Whole genomic DNA was extracted from the specimens by using a DNeasy Blood & Tissue kit (QIAGEN Inc., Dusseldorf, Germany) following the manufacturer's protocol. In order to conserve morphologically complete voucher specimens, DNA extraction method was used slightly modified from

‘non-destructive method’ by Favret (2005) and ‘freezing method’ by Yaakop et al. (2009). In the original protocol, the sample was crushed or wounded, and then soaked with 180 µl of buffer ATL + 20 µl of proteinase, following by three hours over incubation at 55 °C. In the slightly modified DNA extraction methods, samples were soaked with 180 µl of buffer ATL + 20 µl of proteinase K without destroying the sample, followed by 10 minutes incubation at 55 °C and then kept in a freezer at -22 °C overnight. After that the general protocol was used for the remaining steps. The primer set of LCO-1490 (5'-GGT-CAACAAATCATAAAGATATTGG-3') and HCO-2198 (5'-TAAACTTCAGGGT-GACCAAAAAATCA-3') was used to amplify approximately 658 bp as the partial front region of the *COI*. The polymerase chain reaction (PCR) products were amplified by using AccuPowerH PCR PreMix (BIONEER, Corp., Daejeon) in 20 µl reaction mixtures containing 0.4 µM of each primer, 20 µM of the dNTPs, 20 µM of the MgCl₂, and 0.05 µg of the genomic DNA template. PCR amplification was performed using a GS1 thermo-cycler (Gene Technologies, Ltd., U.K) according to the following procedure: initial denaturation at 95 °C for 5 min, followed by 34 cycles at 94 °C for 35 sec; an annealing temperature of 48 °C for 25 sec; an extension at 72 °C for 45 sec, and a final extension at 72 °C for 5 min. The PCR products were visualized by electrophoresis on a 1.5% agarose gel. A single band was observed, purified using a QIAquick PCR purification kit (QIAGEN, Inc.), and then sequenced directly using an automated sequencer (ABI Prism 3730 XL DNA Analyzer) at Macrogen Inc. (Seoul, South Korea).

Sequence alignment was performed in MEGA version 7 (Kumar et al. 2016) with ClustalW tool. To estimate the pairwise genetic distances, the *P*-distance model was conducted using MEGA version 7.

Results

A total of 589 bp of the *COI* fragments were sequenced from *P. fidelis*, *P. masha*, *P. lobata* sp. nov., *P. artotemporalis* sp. nov., *P. brachyura* sp. nov., *P. ruficeps*, which were deposited in GenBank (accession numbers [MZ318083–MZ318088](#)). Pairwise distances were estimated by using the *P*-distance model with the option for pairwise deletion. As results, the morphologically very similar *P. artotemporalis* sp. nov. showed a large genetic difference by 12% either from *P. brachyura* sp. nov. or from *P. lobata* sp. nov. In addition, *P. brachyura* sp. nov. differed by 7% from *P. lobata* sp. nov.

Table 1. *COI* pairwise genetic distances between the *Phaenocarpa* species known from South Korea.

| | <i>Phaenocarpa fidelis</i> | <i>Phaenocarpa masha</i> | <i>Phaenocarpa lobata</i> | <i>Phaenocarpa artotemporalis</i> | <i>Phaenocarpa brachyura</i> | <i>Phaenocarpa ruficeps</i> |
|-----------------------------------|----------------------------|--------------------------|---------------------------|-----------------------------------|------------------------------|-----------------------------|
| <i>Phaenocarpa fidelis</i> | 0.00 | | | | | |
| <i>Phaenocarpa masha</i> | 0.122 | 0.00 | | | | |
| <i>Phaenocarpa lobata</i> | 0.053 | 0.126 | 0.00 | | | |
| <i>Phaenocarpa artotemporalis</i> | 0.124 | 0.151 | 0.127 | 0.00 | | |
| <i>Phaenocarpa brachyura</i> | 0.071 | 0.136 | 0.071 | 0.122 | 0.00 | |
| <i>Phaenocarpa ruficeps</i> | 0.097 | 0.121 | 0.087 | 0.139 | 0.107 | 0.00 |

***Phaenocarpa* Foerster, 1863**

Phaenocarpa Foerster, 1863: 267; Papp 1968: 570; Fischer 1970: 409; Shenefelt 1974: 1003; Wharton 1980: 96; Chen and Wu 1994: 114; Belokobylskij 1998: 233.
Type species: *Alysia picinervis* Haliday, 1838.

Synonymy. *Homophyla* Foerster, 1863 (subgenus); *Mesothesis* Foerster, 1863; *Sathra* Foerster, 1863; *Idiolexis* Foerster, 1863 (subgenus); *Asynaphes* Provancher, 1886; *Kahlia* Ashmead, 1900 (subgenus); *Stiralysia* Cameron, 1910; *Rhopaloneura* Stelfox, 1941; *Discphaenocarpa* Belokobylskij, 1998 (subgenus); *Neophaenocarpa* Belokobylskij, 1998 (subgenus); *Sibphaenocarpa* Belokobylskij, 1998 (subgenus); *Uncphaenocarpa* Belokobylskij, 1998 (subgenus); *Ussurphaenocarpa* Belokobylskij, 1998 (subgenus); *Clistalysia* Zhu, van Achterberg & Chen, 2017 (subgenus).

Diagnosis. Third antennal segment shorter than fourth segment; fore wing vein 2–SR shorter than vein 3–SR, vein CU1b longer than vein 3–CU1.

Biology. Koinobiont endoparasitoids of larvae of Dipteran species (Wharton 1984).

Distribution. Cosmopolitan.

Identification key to the Korean *Phaenocarpa* species

- 1 Temples distinctly striate ventrally; mesopleuron largely coarsely sculptured; face laterally extensively and finely striate; [wing membrane distinctly infuscate]..... ***P. angustiptera* Papp, 1968**
- Temples smooth ventrally; mesopleuron largely smooth, except for area of precoxal sulcus; face laterally smooth or nearly so **2**
- 2 Vein r-m of fore wing bordered with blackish setae, resulting in an infuscated patch..... ***P. picinervis* (Haliday, 1838)**
- Vein r-m of fore wing normal, not bordered with blackish setae (Fig. 6C) .. **3**
- 3 Mandible very slender, approx. 2.3 times longer than wide..... ***P. eunice* (Haliday, 1838)**
- Mandible more robust, at most 1.9 times longer than wide (Fig. 6L)..... **4**
- 4 Scutellar sulcus evenly narrowed medially, 3–5 times wider than its median length (Fig. 6F); head more or less reddish or yellowish brown (Fig. 6D)..... ***P. ruficeps* (Nees, 1812)**
- Scutellar sulcus wide medially, 2–3 times wider than long medially (Fig. 4F); head dark brown or black (Fig. 1D)..... **5**
- 5 First tooth of mandible gradually connected to second tooth, forming a straight or arcuate connection (Fig. 4L); first metasomal tergite subparallel-sided, 1.7–2.0 times longer than its apical width (Fig. 4H); [ovipositor sheath as long as hind tibia] ***P. fidelis* Fischer, 1970**
- First tooth of mandible separated from second tooth by incision (Fig. 1L); first tergite gradually widened posteriorly, 1.1–1.8 times longer than its apical width (Figs 1H, 2H, 3H)..... **6**

- 6 Eye in dorsal view 4.0–4.5 times as long as temple (Fig. 1D); propleuron reddish brown (Fig. 1F); notauli reduced posteriorly (Fig. 1G) *P. artotemporalis* sp. nov.
- Eye in dorsal view 2.0–3.0 times as long as temple (Fig. 2D); propleuron black or orange brown (Fig. 2F); notauli usually complete (up to medio-posterior depression (Fig. 2G) or nearly so 7
- 7 Mandible subparallel-sided (Fig. 2L); ovipositor sheath approx. 0.7 times as long as hind tibia (Fig. 2I); first metasomal tergite slenderer, approx. 1.4 times longer than its apical width (Fig. 2H) *P. brachyura* sp. nov.
- Mandible distinctly widened dorsally (Fig. 5L); ovipositor sheath 1.2–1.3 times as long as hind tibia (Fig. 5I); first tergite very robust, 1.1–1.2 times longer than its apical width (Fig. 5H) 8
- 8 Tarsal claws slender (Fig. 5J); third and fourth antennal segments dark brown and slender (Fig. 5B); metanotum more or less tooth-shaped protruding dorsally in lateral view (Fig. 5G); pterostigma approx. 4.2 times longer than wide (Fig. 5C); middle tooth of mandible not widened dorsally (Fig. 5L) *P. masha* Belokobylskij, 1998
- Tarsal claws robust (Fig. 3J); third and fourth antennal segments yellow and robust (Fig. 3B); metanotum obtuse dorsally in lateral view (Fig. 3F); pterostigma approx. 5.5 times longer than wide (Fig. 3C); middle tooth of mandible widened dorsally (Fig. 3L) *P. lobata* sp. nov.

***Phaenocarpa artotemporalis* Sohn & van Achterberg, sp. nov.**

<http://zoobank.org/D973E619-5FB8-4956-A043-0574073C41EB>

Figure 1A–L

Type material. *Holotype*, ♀ (KNA), **South Korea**, DMZ Botanical Garden, Mandae-ri, Haean-myeon, Yanggu-gun, Gangwon-do, 38°15'09.3"N, 128°06'40.6"E, 08–21. VIII.2017, Shin, Kim. GenBank accession no. [MZ318086](https://www.ncbi.nlm.nih.gov/nuclot/MZ318086) for the barcoding sequence of the COI region

Comparative diagnosis. Differs from other species in the group of *Phaenocarpa* species by notauli reduced posteriorly by having the eye in dorsal view 4.0–4.5 times as long as temple (2.0–3.0 times in other species). Closely related to *P. brachyura* sp. nov., for differences see key above.

Description. *Holotype*, ♀: length of body in lateral view 2.0 mm, length of antenna 3.2 mm, and length of fore wing 2.6 mm.

Colour. Body (Fig. 1A) entirely reddish brown; antenna brown basally, medially dark brown, Mandible pale orange.

Head. Head (Fig. 1D) width 1.9 times median length in dorsal view. Antenna (Fig. 1B) 1.6 times longer than body in female, 25-segmented. Fourth segment 1.5 times longer than third segment, 1.2 times longer than fifth segment. Eye slightly oval, 1.1 times as long as wide in lateral view. Width of face (Fig. 1E) 1.6 times its

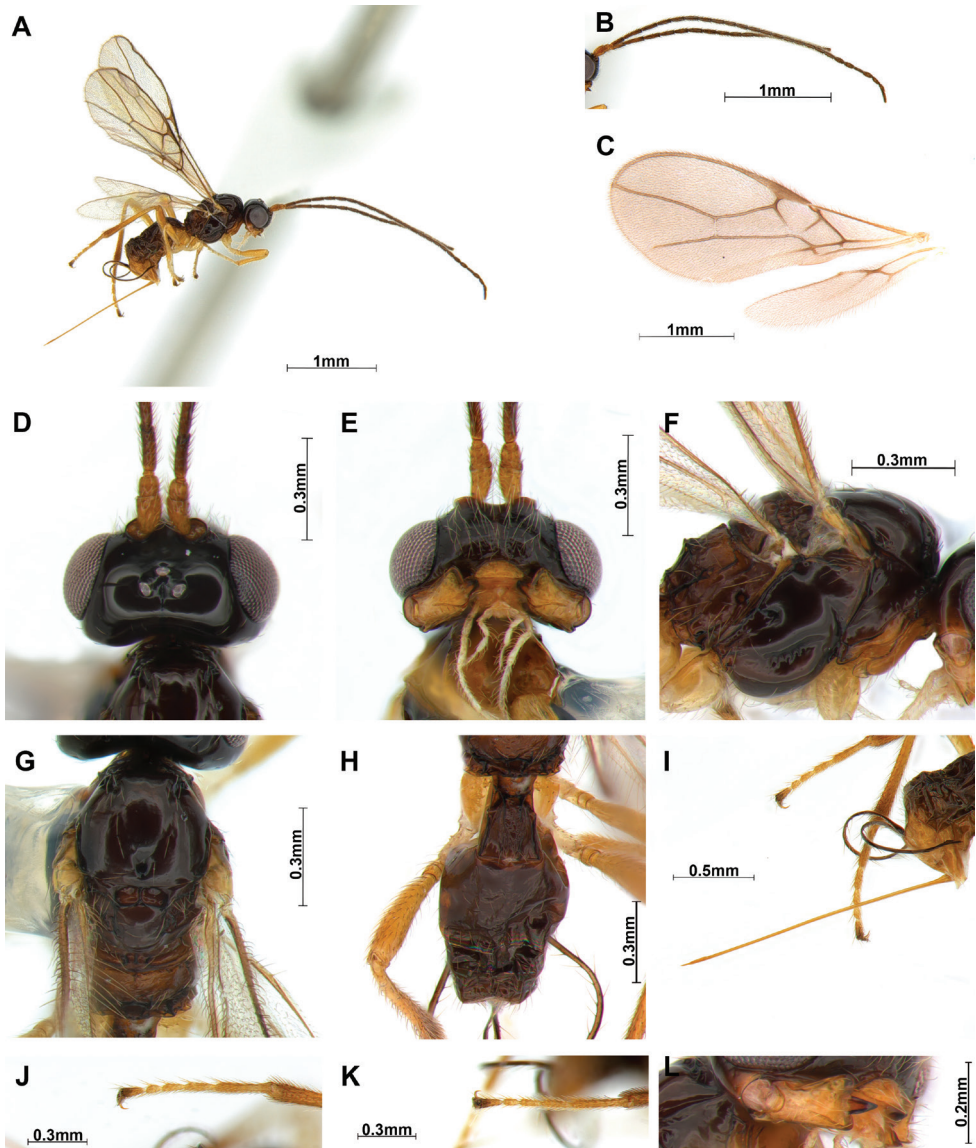


Figure 1. *Phaenocarpa artotemporalis* sp. nov., ♀ **A** body **B** antennae **C** wings **D** head, dorsal **E** head, anterior **F** mesosoma, lateral **G** mesosoma, dorsal **H** propodeum and metasoma, dorsal **I** ovipositor and its sheaths, lateral **J** tarsus, lateral **K** tarsus, dorsal **L** mandible, lateral.

height from ventral rim of antennal sockets to upper margin of clypeus; face with long setae. Eye in dorsal view 4.2 times as long as temple. Ocello-ocular line (OOL) 3.4 times longer than diameter of anterior ocellus; OOL:antero-posterior ocellar line (AOL):postero-ocular line (POL)= 15:4:6. Stemmaticum concave. Vertex smooth and polish with fine groove. Mandible with three teeth (Fig. 1L); second tooth narrow and sharp with dark brown tip and separated from first tooth by incision. Labrum 2.5 times longer than wide. Maxillary palp 0.7 times longer than mesosoma.

Mesosoma. Mesosoma 1.9 times longer than wide in dorsal view. Mesosoma (Fig. 1G) with medio-posterior depression; notauli reduced posteriorly; scutellar sulcus with two carinae; small basal bump on hind coxa. Propodeum (Fig. 1H) entirely smooth, propodeal areola with bumpy sculpture; precoxal sulcus (Fig. 1F) distinct, with about five crenulae. Fore wing (Fig. 1C) 2.3 times as long as wide; pterostigma long and narrow, 4.4 times longer than wide; vein r of fore wing 2.0 times longer than wide; vein 1-SR+M slightly bent; 2-SR+M sclerotized; 1-SR+M:2-SR+M = 10:4; vein 2-SR:vein r:vein 3-SR = 12:3:24; first subdiscal cell of fore wing ca 0.9 times longer than wide.

Leg. Hind coxa compressed, grooved and 1.4 times longer than hind trochanter; hind femur 0.8 times longer than hind tibia; hind tibia 1.2 times longer than hind tarsus.

Metasoma. First tergite widened posteriorly, striate, and 1.8 times longer than its apical width; T1:T2 = 32:36. Setose part of ovipositor sheath (Fig. 1I) 1.4 times longer than mesosoma, 1.3 times as long as hind tibia and with long setae.

Male. Unknown.

Distribution. South Korea.

Etymology. From “artus/arctus” (Latin for narrow) and “tempus” (Latin for area behind eyes) because of the enlarged temples.

***Phaenocarpa brachyura* Sohn & van Achterberg, sp. nov.**

<http://zoobank.org/5E43A497-EC93-4868-AF70-09603EE830F7>

Figure 2A–L

Type material. *Holotype*, ♀ (KNA), **South Korea**, DMZ Botanical Garden, Mandae-ri, Haean-myeon, Yanggu-gun, Gangwon-do, 38°15'09.3"N, 128°06'40.6"E, 21.VIII–05.IX.2017, Shin, Kim. GenBank accession no. [MZ318087](#) for the barcoding sequence of the COI region

Comparative diagnosis. Runs to the East Palaearctic *P. basarukini* Belokobylskij, 1998 and to the West Palaearctic *P. curticauda* van Achterberg, 1998 because of the short ovipositor sheath (approx. 0.7 times as long as hind tibia). The new species differs from *P. basarukini* by the slightly longer ovipositor sheath (0.5–0.6 times as long as hind tibia in *P. basarukini*), first mandibular tooth distinctly lobe-shaped and middle tooth slenderer, pterostigma and hind femur wider. Differs from *P. curticauda* by the wider pterostigma, longer 1r-m of hind wing and 1-CU1 of fore wing, second tooth less widened dorsally, complete notauli, first tergite 1.4 times longer than its apical width and areola of propodeum wider.

Colour. Head black, around eye brown; antenna yellowish brown; mandible brown and apically dark brown. First tergite dark brown and mesonotum entirely black.

Head. Head (Fig. 2D) width 1.6 times median length in dorsal view. Antenna (Fig. 2B) twice as long as body, 41 segmented. Fourth segment 1.4 times longer than third segment and 1.2 times longer than fifth segment. Eye slightly oval, 1.2 times as long as wide in lateral view. Width of face (Fig. 2E) 1.6 times its height from ventral rim of antennal sockets to upper margin of clypeus; face with long setae. Eye in dorsal view 2.4 times as long as temple. Ocello-ocular line 3.0 times longer than diameter

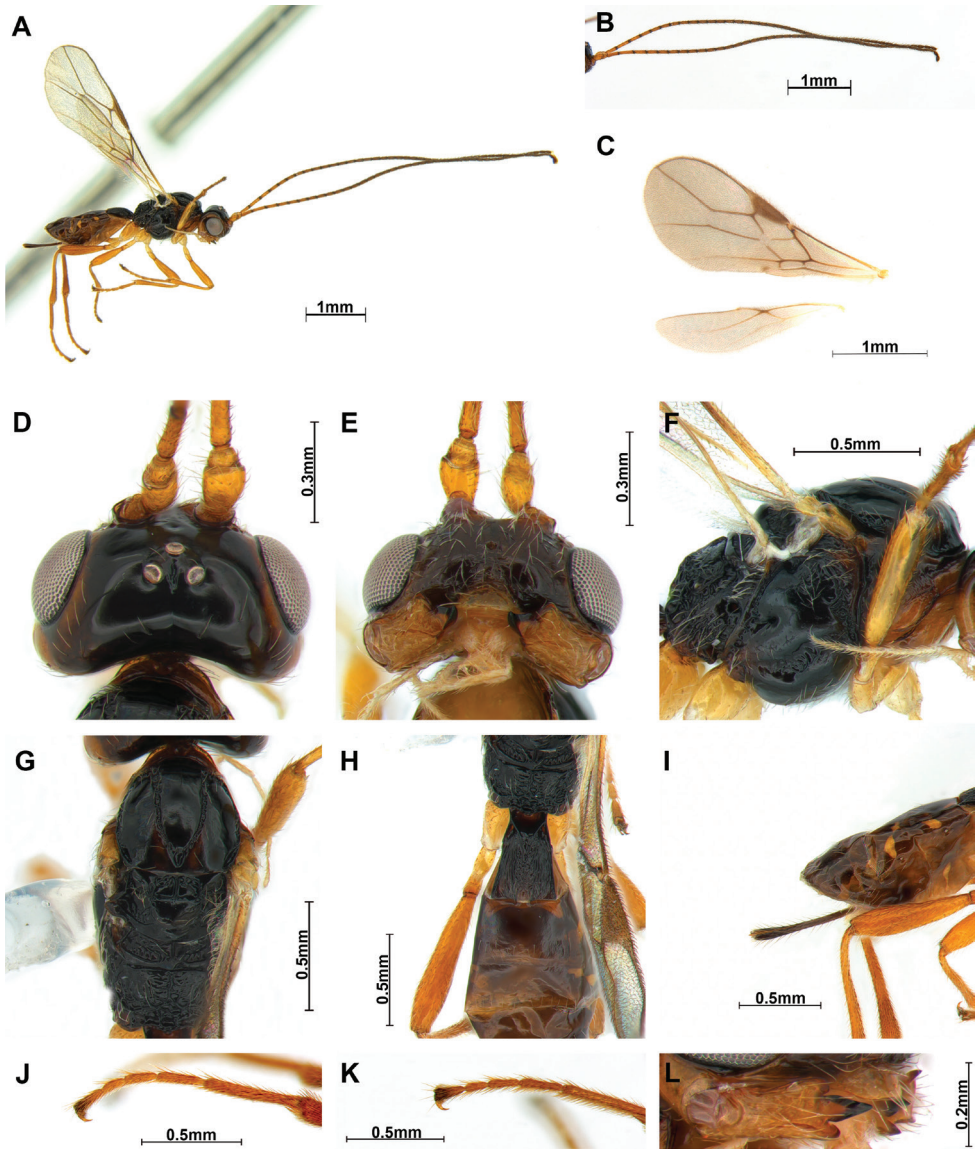


Figure 2. *Phaenocarpa brachyura* sp. nov., ♀ **A** body **B** antennae **C** wings **D** head, dorsal **E** head, anterior **F** mesosoma, lateral **G** mesosoma, dorsal **H** propodeum and T1 to T3, dorsal **I** ovipositor and its sheaths, lateral **J** tarsus, lateral **K** tarsus, dorsal **L** mandible, lateral.

of anterior ocellus; OOL:AOL:POL = 21:5:7. Stemmaticum concave. Mandible with three teeth (2L), subparallel-sided, first mandibular tooth distinctly lobe-shaped and separated from second tooth by incision. Labrum 2.9 times longer than wide. Maxillary palp 0.4 times longer than mesosoma.

Mesosoma. Mesosoma (Fig. 2G) 2.1 times longer than wide in dorsal view. Notauli crenulated, reaching medio-posterior depression; scutellar sulcus with two cari-

nae; in lateral view, mesopleuron and metapleuron with long setae. Anterior half of propodeum smooth, posterior of median carina strongly wrinkled (Fig. 2H), lateral view of propodeum not curved dorsally; precoxal sulcus (Fig. 2F) shallow and with 10 crenulae. Fore wing (Fig. 2C) 2.3 times longer than wide; pterostigma long and narrow, 2.9 times longer than wide; vein r of fore wing 1.9 times longer than wide; vein 2-SR slightly bent; vein 2-SR+M and r-m not sclerotized; vein 2-SR:vein r:vein 3-SR = 10:2:18; first subdiscal cell of fore wing ca 0.6 times longer than wide.

Leg. Hind coxa compressed, grooved and 1.3 times longer than hind trochanter; hind femur 0.7 times longer than hind tibia; hind tibia 0.8 times longer than hind tarsus.

Metasoma. First tergite widened posteriorly, striate and narrow, 1.4 times longer than its apical width; T1:T2 = 48:37. Setose part of ovipositor sheath (Fig. 2I) 0.6 times as long as mesosoma, 0.7 times as long as hind tibia and with setae.

Male. Unknown.

Distribution. South Korea.

Etymology. From “brachys” (Greek for short) and “oura” (Greek for tail) because of the comparatively short ovipositor sheath.

***Phaenocarpa lobata* Sohn & van Achterberg, sp. nov.**

<http://zoobank.org/39495B6E-B87D-4947-99BF-1B8C768A8320>

Figure 3A–L

Type material. *Holotype*, ♀ (KNA), **South Korea**, DMZ Botanical Garden, Mandae-ri, Haean-myeon, Yanggu-gun, Gangwon-do, 38°15'09.3"N, 128°06'40.6"E, 19.IX–10.X.2017, Shin, Kim. GenBank accession no. [MZ318085](#) for the barcoding sequence of the COI region.

Comparative diagnosis. Differs from other species treated in this paper by the long pterostigma of the fore wing (approx. 5.5 times as long as wide; 2.9–4.4 times in other species). The orange antenna and the yellow and robust third and fourth antennal segments distinguish it from other *Phaenocarpa* species. Closely related to *P. masha* Belokobylskij, 1998, for differences see key above.

Description. *Holotype*, ♀; length of body in lateral view 3.3 mm (Fig. 3A), length of antenna 6.1 mm and length of fore wing 3.6 mm.

Colour. Head (Fig. 3D) black; antenna orange (third and fourth antennal segments yellow); mandible orange brown. First tergite dark brown and mesonotum entirely reddish brown, area around of medio-posterior depression orangish brown.

Head. Width 1.9 times median length in dorsal view. Antenna (Fig. 3B) twice as long as body, 39 segmented. Fourth segment 1.5 times longer than third segment and 1.3 times longer than fifth; third and fourth segments robust. Eye slightly oval, 1.3 times as long as wide in lateral view. Width of face (Fig. 3E) 1.6 times its height from ventral rim of antennal sockets to upper margin of clypeus. Eye in dorsal view 2.6 times as long as temple. Ocello-ocular line 4.1 times longer than diameter of anterior ocellus;

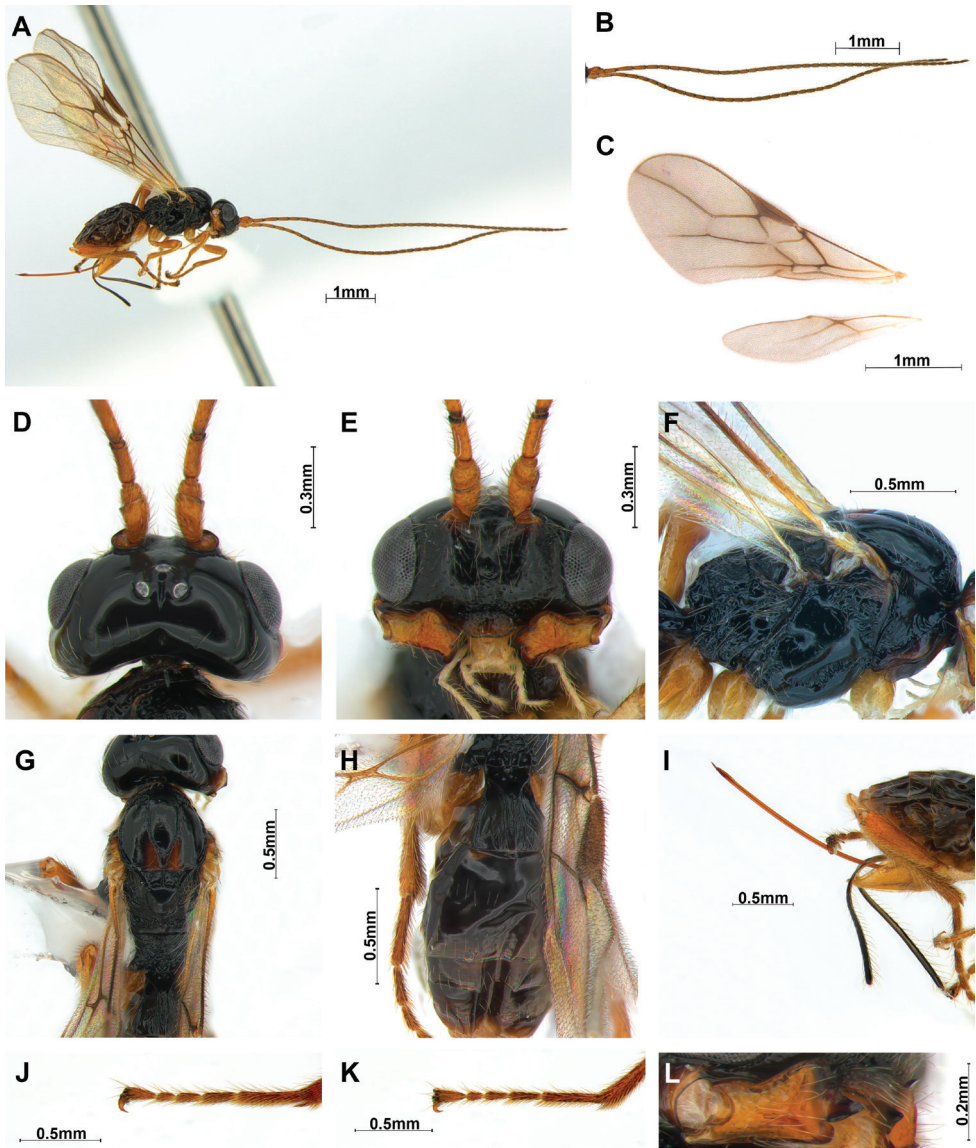


Figure 3. *Phaenocarpa lobata* sp. nov., ♀ **A** body **B** antennae **C** wings **D** head, dorsal **E** head, anterior **F** mesosoma, lateral **G** mesosoma, dorsal **H** propodeum and metasoma, dorsal **I** ovipositor and its sheaths, lateral **J** tarsus, lateral **K** tarsus, dorsal **L** mandible, lateral.

OOL:AOL:POL = 25:6:9. Stemmaticum concave. Vertex smooth, glossy. Mandible with three teeth and first tooth separated from second tooth by incision (Fig. 3L); middle tooth of mandible widened dorsally, with black tip. Labrum 2.0 times longer than wide. Maxillary palp 0.8 times longer than mesosoma.

Mesosoma. Mesosoma (Fig. 3G) 1.8 times longer than wide in dorsal view. Notauli comparatively coarsely crenulate near middle of mesoscutum and reaching

medio-posterior depression; medio-posterior depression nearly reaching transscutal articulation; scutellar sulcus with two carinae; metanotum obtuse dorsally in lateral view; small bump on hind coxa adjacent to metapleuron; in lateral view metapleuron with distinct setae. Anterior half of propodeum less sloping; propodeum bent in lateral view; precoxal sulcus (Fig. 3F) deep and distinct, with about eight crenulae. Fore wing (Fig. 3C) 2.4 times as long as wide; pterostigma long and narrow, 5.5 times longer than wide; vein r of fore wing 1.5 times longer than wide; vein 2-SR slightly bent; vein r-m not sclerotized; vein 2-SR:vein r:vein 3-SR = 11:2:16; first subdiscal cell of fore wing ca 0.9 times longer than wide.

Leg. Hind coxa compressed, grooved and 1.2 times longer than hind trochanter; hind femur 0.6 times longer than hind tibia; hind tibia 1.2 times longer than hind tarsus; tarsal claws robust.

Metasoma. First tergite very robust, 1.2 times longer than its apical width; T1:T2 = 44:54. Setose part of ovipositor sheath (Fig. 3I) 1.2 times longer than mesosoma, as long as hind tibia and with long setae (Fig. 3I).

Male. Unknown.

Distribution. South Korea.

Etymology. From “lobus” (Latin for lobe), because of the lobe-shaped third mandibular tooth.

Phaenocarpa fidelis Fischer, 1970

Figure 4A–L

Examined material. 1 ♀ (KNA), **South Korea**, DMZ Botanical Garden, Mandae-ri, Haean-myeon, Yanggu-gun, Gangwon-do, 38°15'09.3"N, 128°06'40.6"E, 20.VI.–4.VII.2017, H.T. Shin, S.J. Kim. GenBank accession no. [MZ318083](#) for the barcoding sequence of the COI region.

Description. ♀; length of body in lateral view 2.9 mm (Fig. 4A), length of antenna 4.7 mm, length of fore wing 3.1 mm.

Colour. Head (Fig. 4D) entirely black; mandible yellowish brown. Antenna entirely brown (first and second segments orangish brown). First tergite dark brown.

Head. Width 1.9 times median length in dorsal view. Antenna (Fig. 4B) 1.6 times longer than body, 28 segmented. Fourth segment 1.6 times longer than third segment, 1.1 times longer than fifth. Eye slightly oval, 1.2 times longer than wide in lateral view. Width of face (Fig. 4E) 1.3 times its height from ventral rim of antennal sockets to upper margin of clypeus. Face with dense setae. Eye in dorsal view 2.6 times longer than temple. Ocello-ocular line 2.6 times longer than diameter of anterior ocellus; OOL:AOL:POL = 17:5:7. Stemmaticum concave. Mandible robust with three teeth (Fig. 4L) and first tooth gradually connected to second tooth, forming a straight or arcuate connection. Labrum 1.8 times longer than wide. Maxillary palp 0.7 times longer than mesosoma.

Mesosoma. Mesosoma (Fig. 4G) 2.3 times longer than wide in dorsal view, with medio-posterior depression and setae near it; notauli narrowly crenulate near middle

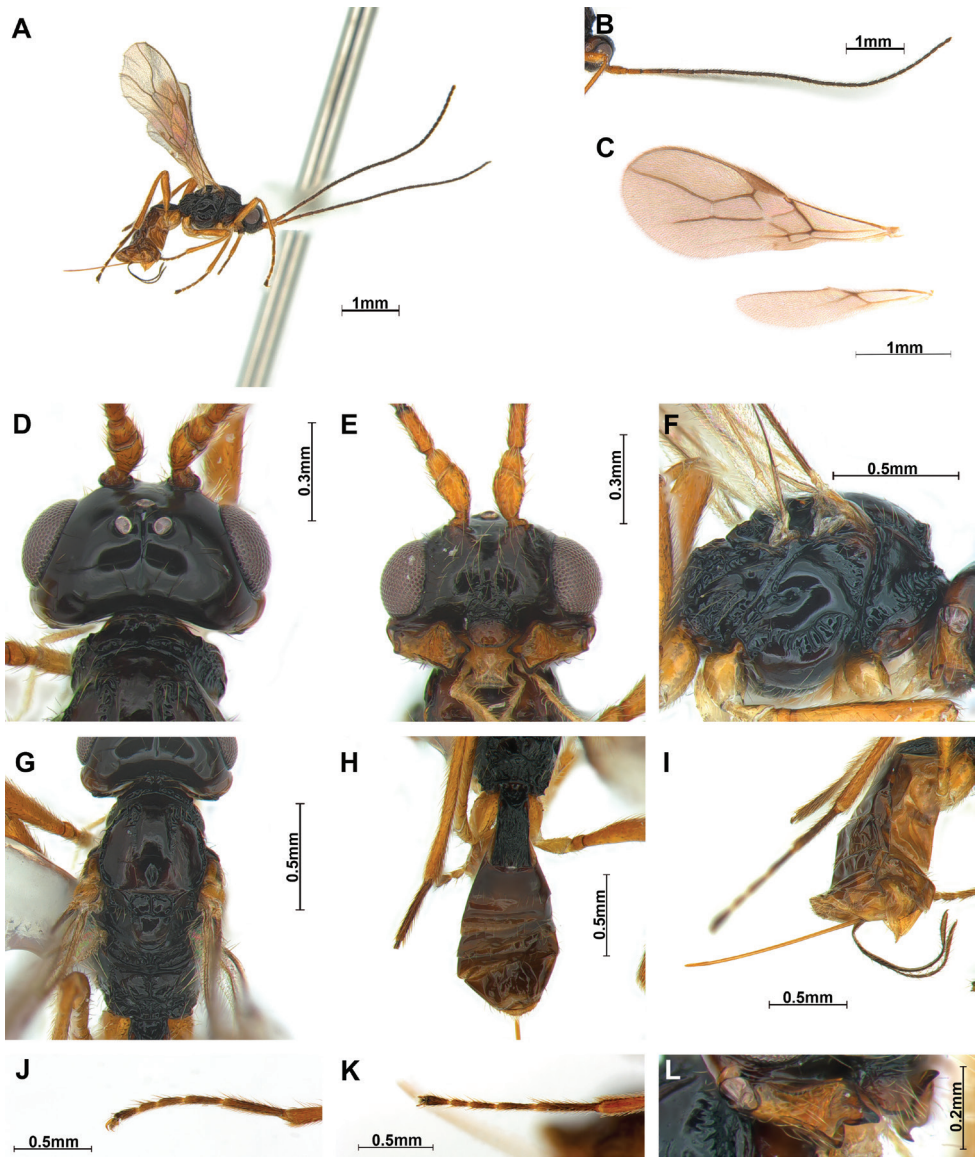


Figure 4. *Phaenocarpa fidelis* Fischer, 1970, ♀ **A** body **B** antenna **C** wings **D** head, dorsal **E** head, anterior **F** mesosoma, lateral **G** mesosoma, dorsal **H** propodeum and metasoma, dorsal **I** metasoma, ovipositor and its sheaths, lateral **J** tarsus, lateral **K** tarsus, dorsal **L** mandible, lateral.

of mesoscutum, not reaching medio-posterior depression; scutellar sulcus with two carinae, 2.4 times wider than long medially; metanotum sculptured; with small bump on hind coxa adjacent to metapleuron; metapleuron with long setae; in lateral view mesoscutum with anterior bump. Propodeum (Fig. 4H) extensively rugose medially and in lateral view not bent; precoxal sulcus (Fig. 4F) complete and with 12 crenulae;

scutellum with setae partially. Fore wing (Fig. 4C) 2.4 times longer than wide; pterostigma long and narrow, 4.3 times longer than wide; vein r of fore wing 2.3 times longer than wide; vein 2-SR slightly bent; vein r-m not sclerotized; vein 2-SR:vein r:vein 3-SR = 9:2:15; first subdiscal cell of fore wing ca 1.1 times longer than wide; second submarginal cell robust.

Leg. Hind coxa compressed, grooved and 1.1 times longer than hind trochanter; hind femur 0.7 times longer than hind tibia; hind tibia 0.9 times longer than hind tarsus.

Metasoma. First metasomal tergite subparallel-sided (Fig. 4H), 2.0 times longer than apical width; T1:T2 = 50:24. Setose part of ovipositor sheath (Fig. 4I) 0.5 times as long as mesosoma, 0.4 times as long as hind tibia and with long setae.

Male. Unknown.

Distribution. Eastern Palearctic, Western Palearctic, Europe; South Korea (new record).

Phaenocarpa masha Belokobylskij, 1998

Figure 5A–L

Examined material. 1 ♀ (KNA), **South Korea**, DMZ Botanical Garden, Mandae-ri, Haean-myeon, Yanggu-gun, Gangwon-do, 38°15'09.3"N, 128°06'40.6"E, 20.VI.–4.VII.2017, H.T. Shin, S.J. Kim. GenBank accession no. [MW376066](#) for the barcoding sequence of the COI region.

Description. ♀; length of body in lateral view 2.8 mm (Fig. 5A), length of antenna 4.7 mm and length of fore wing 3.3 mm.

Colour. Head (Fig. 5D) entirely black; mandible orangish brown. Antenna entirely brown (third and fourth segments dark brown). First tergite reddish brown and mesonotum orangish brown.

Head. Width 1.7 times median length in dorsal view. Antenna (Fig. 5B) 1.6 times longer than body, 27-segmented. Fourth segment 1.6 times longer than third segment and 1.2 times longer than fifth, third and fourth segments dark brown and slender. Eye slightly oval, 1.2 times as long as wide in lateral view. Width of face (Fig. 5E) 1.5 times its height from ventral rim of antennal sockets to upper margin of clypeus. Face with dense setae. Eye in dorsal view 3.0 times as long as temple. Ocellular line 4.1 times longer than diameter of anterior ocellus; OOL:AOL:POL = 21:5:7. Stemmaticum concave. Mandible with three teeth (Fig. 5L) and first tooth separated from second tooth by incision; third tooth bent outside, middle tooth not widened dorsally. Labrum 2.4 times longer than wide. Maxillary palp 0.9 times longer than mesosoma.

Mesosoma. Mesosoma (Fig. 5G) 1.9 times longer than wide in dorsal view, with medio-posterior depression and setae near it; notauli line-shape, reaching medio-posterior depression; scutellar sulcus with two carinae; metanotum more or less tooth-shaped protruding dorsally in lateral view; small bump on hind coxa adjacent to

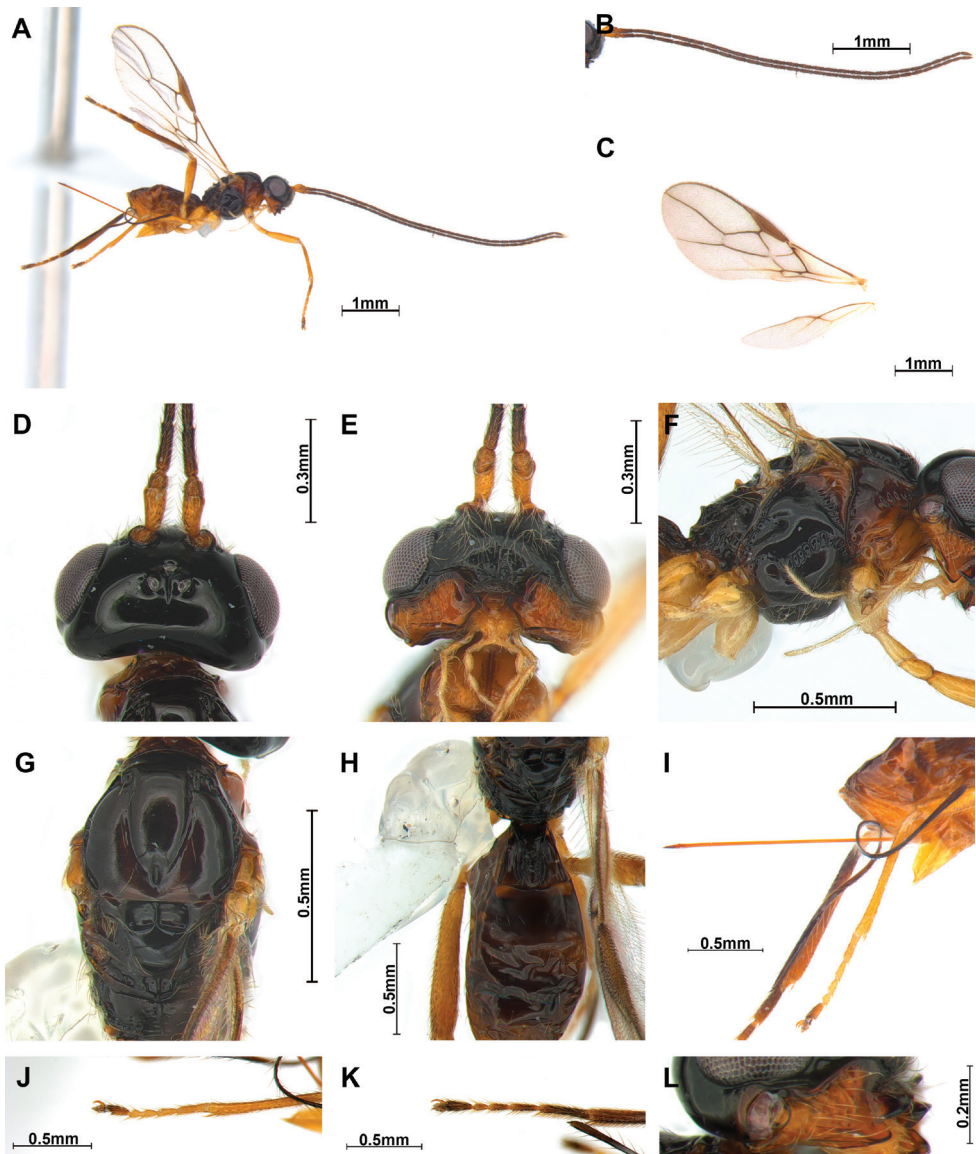


Figure 5. *Phaenocarpa masha* Belokobylskij, 1998, ♀ **A** body **B** antennae **C** wings **D** head, dorsal **E** head, anterior **F** mesosoma, lateral **G** mesosoma, dorsal **H** propodeum and T1 to T3, dorsal **I** metasoma, ovipositor and its sheaths, lateral **J** tarsus, lateral **K** tarsus, dorsal **L** mandible, lateral.

metapleuron. Propodeum (Fig. 5H) 0.7 times longer than width, more extensively rugose medially; lateral view of propodeum not bent; precoxal sulcus (Fig. 5F) completed with 11 crenulae; scutellum with setae partially. Fore wing (Fig. 5C) 2.5 times as long as wide; pterostigma long and narrow, 4.2 times longer than wide; vein r of fore wing 3.0 times longer than wide; vein r-m not sclerotized; vein 2-SR:vein r:vein 3-SR = 10:2:14; first subdiscal cell of fore wing ca 0.7 times longer than wide; second submarginal cell robust.

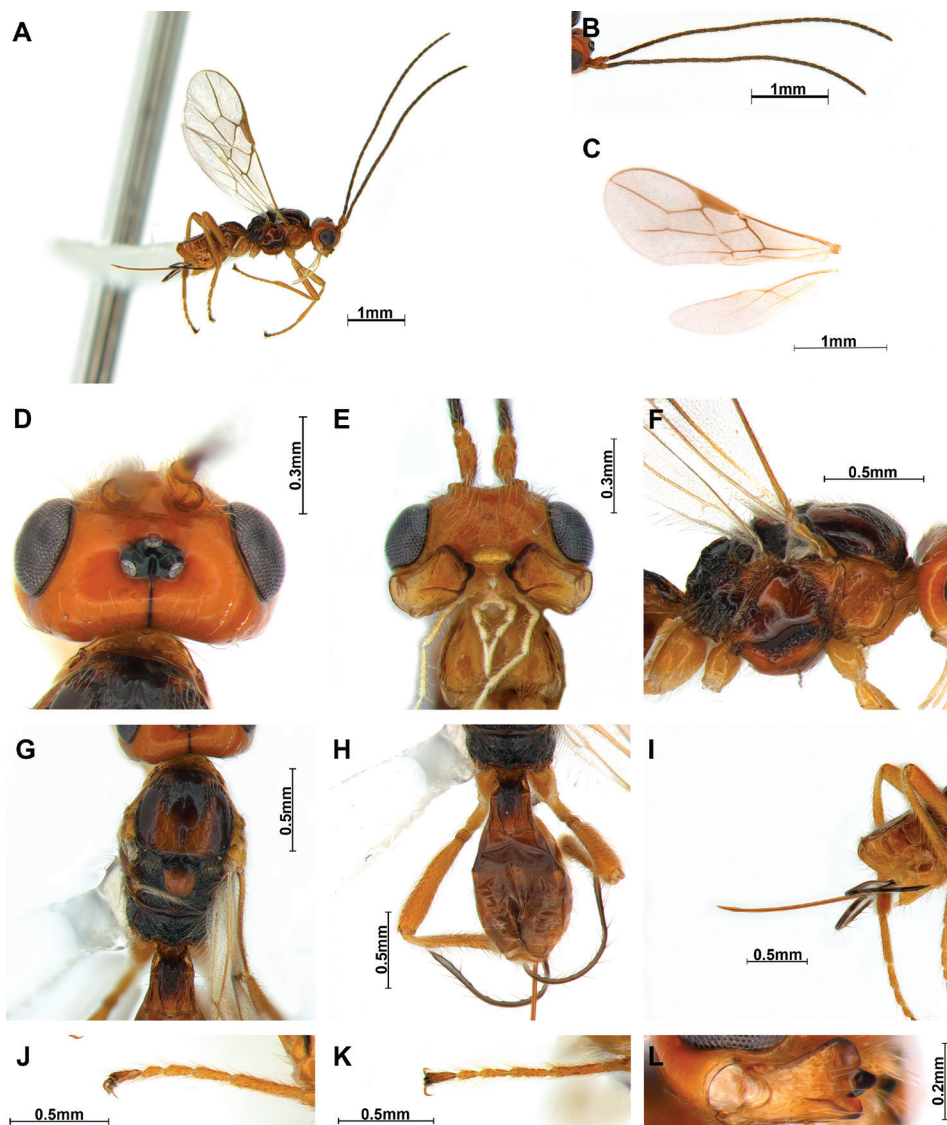


Figure 6. *Phaenocarpa ruficeps* (Nees, 1812), ♀ **A** body **B** antennae **C** wings **D** head, dorsal **E** head, anterior **F** mesosoma, lateral **G** mesosoma, dorsal **H** propodeum and metasoma, dorsal **I** metasoma, ovipositor and its sheaths, lateral **J** tarsus, lateral **K** tarsus, dorsal **L** mandible, lateral.

Leg. Hind coxa compressed, grooved and 1.4 times longer than hind trochanter; hind femur 0.6 times longer than hind tibia; hind tibia 1.2 times longer than hind tarsus; tarsal claws slender.

Metasoma. First tergite robust, widened posteriorly, 1.2 times longer than apical width; T1:T2 = 32:30. Setose part of ovipositor sheath (Fig. 5I) 1.2 times longer than mesosoma, 1.1 times longer than hind tibia and with long setae.

Male. Unknown.

Distribution. Eastern Palearctic; South Korea (new record).

Acknowledgements

This work was supported by the Korean National Arboretum (KNA1-1-20) and a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR202130203). This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR202102204).

References

- Ashmead WH (1900) Classification of the Ichneumon flies, or the superfamily Ichneumonoidea. Proceedings of the United States National Museum 23(1206): 1–220. <https://doi.org/10.5479/si.00963801.23-1206.1>
- Abd-Rabou S (2006) Biological control of the leafminer, *Liriomyza trifolii* by introduction, releasing, evaluation of the parasitoids *Diglyphus isaea* and *Dacnusa sibirica* on vegetables crops in greenhouses in Egypt. Archives of Phytopathology and Plant Protection 39: 439–443. <https://doi.org/10.1080/03235400500356079>
- Belokobyl'skij SA (1998) Tribe Alysiini. In: Ler PA (Ed.) Key to the Insects of Russian Far East. Dal'nauka, Vladivostok, 163–298. [In Russian]
- Cameron P (1910) On some Asiatic species of the Braconid subfamilies Rhogadinae, Agathinae, and Macrocentrinae and of the Alysiidae. Wiener Entomologische Zeitschrift 29: 1–10. <https://doi.org/10.5962/bhl.part.23337>
- Chen JH, Wu ZS (1994) The Alysiini of China: (Hymenoptera: Braconidae: Alysiinae). China Agricultural Press, Fuzhou, 218 pp. [In Chinese, with summary in English]
- Favret C (2005) New non-destructive DNA extraction and specimen clearing technique for aphids (Hemiptera). Proceedings of the Entomological Society of Washington 107: 469–470.
- Fischer M (1970) Zur Kenntnis der europäischen *Phaenocarpa*-Arten mit besonderer Berücksichtigung der Fauna Niederösterreichs (Hymenoptera, Braconidae, Alysiinae). Zeitschrift für Angewandte Zoologie 57: 409–498.
- Foerster A (1863) Synopsis der Familien und Gattungen der Braconiden. Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande und Westfalens 19: 225–288.
- Haliday AH (1838) Essay on parasitic Hymenoptera. Entomological Magazine 5(3): 209–249.
- Kumar S, Stecher G, Tamura K (2016) MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. Molecular, Biology and Evolution. 33: 1870–1874. <https://doi.org/10.1093/molbev/msw054>
- NIBR (2019) National List of Species of Korea. National Institute of Biological Resources. <http://kbr.go.kr> [accessed on 11/08/08]
- Papp J (1968) A survey of the *Phaenocarpa* Foerster species of the Carpathian Basin, Central Europe (Hymenoptera, Braconidae: Alysiinae). Beiträge zur Entomologie 18(5/6): 569–603.
- Papp J (1994) Braconidae (Hymenoptera) from Korea, XV. Acta Zoologica Academiae Scientiarum Hungaricae 40(2): 133–156.

- Provancher L (1886) Additions et corrections au Volume II de la Faune Entomologique du Canada. Traitant des Hyménoptères. Québec, 475 pp.
- Shenefelt RD (1974) Braconidae 7. Alysiinae. Hymenopterorum Catalogus. Pars 11: 985–1113.
- Shaw MR, Huddleston T (1991) Classification and biology of Braconid wasps (Hymenoptera: Braconidae). Handbooks for the identification of British Insects 7(11): 1–126.
- Stelfox AW (1941) Descriptions of five new species of Alysiidae (Hymenoptera) and notes on some others. Proceedings of the Royal Irish Academy 47(B): 1–16.
- van Achterberg C (1993) Illustrated key to the subfamilies of the Braconidae (Hymenoptera: Ichneumonoidea). Zoologische Verhandelingen Leiden 283: 1–189.
- van Achterberg C (1998) *Bobekoides* gen. n. (Hymenoptera: Braconidae: Alysiinae) from South Africa. Zoologische Mededelingen, Leiden 72(9): 105–111.
- van Achterberg C (2009) A new species of the genus *Phaenocarpa* Foerster from Madagascar (Hymenoptera: Braconidae: Alysiinae). Zoologische Mededelingen, Leiden 83(3): 667–671.
- Wharton RA (1980) Review of the Nearctic Alysiini (Hymenoptera, Braconidae): with discussion of generic relationships within the tribe. University of California Press, Berkeley, 112 pp.
- Wharton RA (1984) Biology of the Alysiini (Hymenoptera: Braconidae), parasitoids of cyclorhaphous Diptera. Texas Agricultural Experimental Station. Technical Monograph 11: 1–39.
- Wharton RA, Marsh P, Sharkey M (1997) Manual of the New World Genera of the Family Braconidae (Hymenoptera). The International Society of Hymenopterists, Washington DC, 439 pp.
- Wharton RA (2002) Revision of the Australian Alysiini (Hymenoptera: Braconidae). Invertebrate Systematics 16: 7–105. <https://doi.org/10.1071/IT01012>
- Yaakop S, van Achterberg C, Idris AB (2009) Heratemis Walker (Hymenoptera: Braconidae: Alysiinae: Alysiini): revision and reconstruction of the phylogeny combining molecular data and morphology. Tijdschrift voor Entomologie 152: 1–64. <https://doi.org/10.1163/22119434-900000268>
- Yu DSK, van Achterberg C, Horstmann K (2016) Taxapad 2016, Ichneumonoidea 2015. Database on flash-drive, Nepean, Ontario. www.taxapad.com
- Zhu J-C, van Achterberg C, Chen X-X (2017) An illustrated key to the genera and subgenera of the Alysiini (Hymenoptera, Braconidae, Alysiinae), with three genera new for China. ZooKeys 722: 37–79. <https://doi.org/10.3897/zookeys.722.14799>