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Review of the *Crematogaster popohana*-group with the description of a new species from the Indochinese Peninsula (Hymenoptera: Formicidae)

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ABSTRACT. The *Crematogaster popohana*-group is reviewed and two species and one subspecies, including one new species, *C. fumikoae* sp. nov. are recognized. The *C. popohana*-group is distinguished from other Asian *Crematogaster* species by the slender petiole with weakly convex sides. A key to the species based on the worker caste is also provided. Morphological features of the unique slender petiole are discussed.

Keywords: *Crematogaster popohana*, taxonomy, new species, petiole, Southeast Asia.

INTRODUCTION

Crematogaster popohana was described by Forel (1912) based on the worker caste from collections made in Taiwan. Subsequently, one subspecies of *C. popohana* has been recognized: *C. popohana amia* by Forel (1913) based on queens and males from Taiwan. *C. popohana* is presently assigned to the subgenus *Crematogaster* (Blaimer 2012a). The subgenus *Crematogaster* is a huge group including more than 200 species and is highly morphologically variable (Blaimer 2012a). Generally, workers of the subgenus have a dorsoventrally flattened and broadened petiole, but workers of *C. popohana* possess a slender petiole with weakly convex sides. Therefore this species can be easily distinguished from the remainder of the species in the subgenus fauna by the unique morphological feature.

In the course of our recent examination of *Crematogaster* specimens collected from Southeast Asia, we found one related species to *C. popohaha*, which is apparently new to science and is described here as a new species.

MATERIALS AND METHODS

Specimens were examined and/or deposited in the collections listed below. Codes for public institutions mainly follow those in Brandão (2000).

BMNH The Natural History Museum, London, U. K.

CASC California Academy of Sciences, San Francisco, CA, USA

FRIM Forest Research Institute Malaysia, Kepong, 52109 Kuala Lumpur, Malaysia.

KUM Kyushu University, Fukuoka, Japan.

MHNG Musee d'Histoire Naturelle, Geneva, Switzerland.

MZB Museum Zoologicum Bogoriense, Cibinong, Java, Indonesia.

NHMB Naturhistorisches Museum, Basel, Switzerland.

SKYC Seiki Yamane Collections, Kagoshima University, Japan.

THNHM Thailand Natural History Museum, Technopolis, Khlong Luang, Pathum Thani, Thailand.

Most observations were made using a Leica M205C microscope. Images were taken using a Canon EOS 50D with a Canon MP-E 65 mm 1-5 x Macro lens, then processed using Combine ZM.

Measurements were made under a Leica M205C stereomicroscope using micrometers. All measurements are expressed in millimeters, recorded to the second decimal place.

Head Width (HW): Maximum width of head in full-face view, excluding the eyes.

Head Length (HL): Perpendicular distance from vertex margin to a line at a tangent to the anteriormost projections of clypeus in full-face view.

Cephalic Index (CI): HW/HL x 100.

Scape Length (SL): Length of the first antennal segment, excluding the neck and basal condyle.

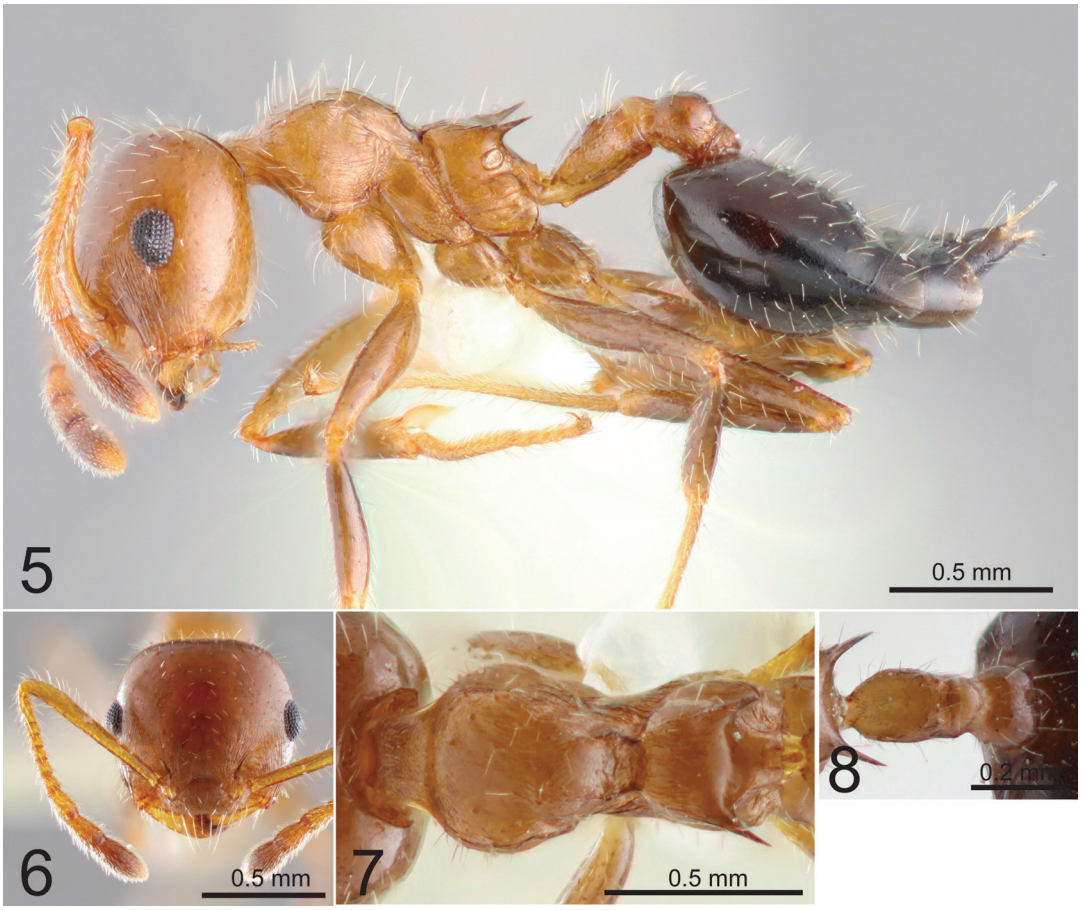
Scape Index (SI): SL/HW x 100.

Eye Length (EL): Maximum length of the compound eye.

Pronotal Width (PW): Maximum width of the pronotum in dorsal view.

Weber's Length of the mesosoma (WL): Diagonal length, measured in lateral view from the anterior margin of the pronotum (excluding the collar) to the posterior extremity of the propodeal lobe.

Figs 1 – 4. *Crematogaster fumikoae* sp. nov. [Doi Suthep, nr. Chiang Mai, Thailand]. 1, lateral view; 2, full-face view of head; 3, dorsal view of mesosoma; 4, dorsal view of petiole and postpetiole.



Figs 5 – 8. *Crematogaster popohana* [Fushan, Wulai, Taipei, Taiwan]. 5, lateral view; 6, full-face view of head; 7, dorsal view of mesosoma; 8, dorsal view of petiole and postpetiole.

Propodeal Spine Length (PSL): measured from the tip of propodeal spine to the closest point on the outer rim of the propodeal spiracle.
Petiole Length (PtL): Length of the petiole in lateral view.
Petiole Width (PtW): Maximum width of petiole in dorsal view.
Petiole Height (PtH): Height of the petiole in lateral view.
Postpetiole Length (PpL): Length of the postpetiole in dorsal view.
Postpetiole Width (PpW): Maximum width of postpetiole in dorsal view, excluding the helcium.
Petiole Height Index (PtHI): PtH/PtL x 100.
Petiole Width Index (PtWI): PtW/PtL x 100.
Postpetiole Width Index (PpWI): PpW/PpL x 100.
Waist Index (WI): PpW/PtW x 100.

Synonymic list of the *Crematogaster popohana*-group

fumikoae **sp. nov.**
popohana Forel, 1912.
popohana amia Forel, 1913.

Key to species based on the worker caste

Mesopleuron densely sculptured. Propodeal spines curved upward at tips. Subpetiolar process developed as a distinct process (Fig. 9) ....*fumikoae* sp. nov.
Mesopleuron relatively smooth in central region,

but weakly sculptured in surrounding region. Propodeal spines not curved at tips. Subpetiolar process undeveloped or weakly developed as a small edge (Fig. 10) ..... *popohana* Forel

TAXONOMY

Crematogaster fumikoae sp. nov.

(Figs 1-4, 9)
HOLOTYPE worker from THAILAND: Doi Suthep, nr Chiang Mai, 21. xii. 1997 (*F. Yamane*) (THNHM). Fifteen paratype workers, same data as holotype (BMNH, CASC, FRIM, KUM, MHNG, MZB, SKYC)

Measurements and indices.
HW 0.75; HL 0.75; CI 100; SL 0.65; SI 87; EL 0.17; PW 0.42; WL 0.88; PSL 0.13; PtL 0.26; PtW 0.21; PtH 0.19; PpL 0.15; PpW 0.20; PtHI 73; PtWI 81; PpWI 133; WI 95 (HOLOTYPE worker measured).
HW 0.62-0.82; HL 0.64-0.80; CI 96-103; SL 0.60-0.72; SI 87-97; EL 0.15-0.18; PW 0.35-0.48; WL 0.75-0.94; PSL 0.10-0.15; PtL 0.23-0.29; PtW 0.18-0.23; PtH 0.17-0.21; PpL 0.14-0.17; PpW 0.18-0.22; PtHI 64-77; PtWI 67-81; PpWI 127-150; WI 90-105 (Seven paratype workers measured).

General description of worker. Workers with weak polymorphism.

Head appearing subquadratic; posterior corners of head rounded. Anterior clypeal margin almost straight and slightly concave medially. Compound eyes slightly projecting beyond lateral margins of head in full face view. Scape reaching posterior corner of head, with erect setae.

Anterior margin of pronotal collar weakly concave in dorsal view. Pronotal dorsum with ridges laterally. Mesonotal dorsum with lateral ridges; the ridges forming flat dorsal outline in lateral view; the ridges extending posteriorly to the metanotal groove and anterior propodeal dorsum. Pronotum not forming same dorsal outline with mesonotum in lateral view. Metanotal groove almost straight on median portion in dorsal view, not so deep, dorsolateral ridges connecting the region between the mesonotum and propodeum. In lateral view, dorsal outline of anterior portion of propodeum to propodeal spines appears straight. Propodeal spiracles elliptical and large, situated at posterolateral corners of propodeum, some distance from the metapleural gland bulla. Propodeal spines long, curved upward at tips; length greater than diameter of propodeal spiracles.

Petiole slender elliptical, median portion slightly broader. Posterior portion of petiole with ridges dorsolaterally. Subpetiolar process acutely developed anteriorly; thin lobe developed posteriorly. Postpetiole weakly bilobed with feeble longitudinal median sulcus. Petiole as wide as postpetiole in dorsal view.

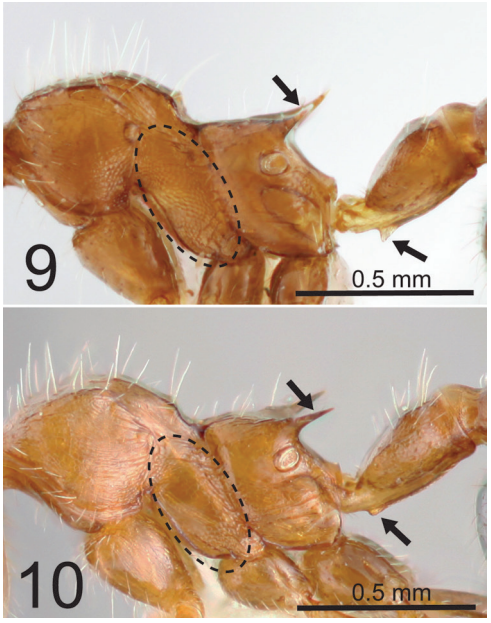
Dorsal surface of head sparsely punctate, but with longitudinal rugulae on gena and surrounding antennal sockets. Clypeus striated with longitudinal rugulae; rugulae extending to posterior clypeal margin. Anterolateral margin of pronotum with rugulae. Lateral surface of pronotum weakly sculptured with feeble rugulae. The lamellate-like rugulae not covering metanotal groove dorsolaterally. Mesopleuron densely sculptured. Dorsal surface of propodeum generally smooth, but striated with rugulae dorsolaterally. Lateral surface of propodeum generally smooth and shiny. Lateral sides of petiole weakly punctate. Dorsal surface of postpetiole weakly punctate.

Standing pilosity sparse. Dorsum of head with abundant erect setae. Clypeus with two pairs of long setae on anterior portion; one pair of setae directed upwards and one pair directed downwards. Anterior clypeal margin with longer setae on median portion, and shorter setae on sides. Mesosoma with sparse erect setae. Petiole and postpetiole with sparse erect to suberect setae. Fourth abdominal tergite with sparse erect setae.

Body color reddish-brown except for dark brown gaster.

Distribution.
This species is known from N. Thailand and N. Vietnam (Fig. 11).

Etymology.
This species is dedicated to Ms. Fumiko Yamane, who collected the type material.



Figs 9 – 10. Worker characters of mesosoma and petiole. 9, *C. fumikoae* sp. nov.; 10, *C. popohana*.

Remarks.
This species is similar to *C. popohana* Forel, 1912, but can be distinguished by the propodeal spines curved upward at tips, densely sculptured mesopleuron, and acutely developed subpetiolar process (Fig. 9).

This species corresponds to *Crematogaster* sp. 76 of SKY (Eguchi *et al*. 2005).

Additional material examined.
VIETNAM: 3 workers, Tam Dao (1000 m a.s.l), Tam Duong District, Vinh Phuc Province [21 28 N, 105 39 E], 6. xi. 2001 (*K. Ogata*).

***Crematogaster popohana* Forel, 1912**

(Figs 5-8, 10)
Crematograster popohana Forel, 1912: 69, LECTOTYPE worker (by present designation) from TAIWAN: Akau, Kosempo I. 08 (*H. Sauter*) and one paralectotype queen from TAIWAN: Taihorin (MHNG) [examined]. Description of queen and male by Forel, 1913: 193. Combination in *C.* (*Acrocoelia*): Emery, 1922: 151; in *C.* (*Crematogaster*) by Blaimer, 2012a: 55.

Measurements and indices.
HW 0.73-0.85; HL 0.73-0.84; CI 100-105; SL 0.69-0.81; SI 90-100; EL 0.15-0.18; PW 0.44-0.49; WL 0.87-0.99; PSL 0.12-0.15; PtL 0.27-0.33; PtW 0.19-0.27; PtH 0.18-0.23; PpL 0.16-

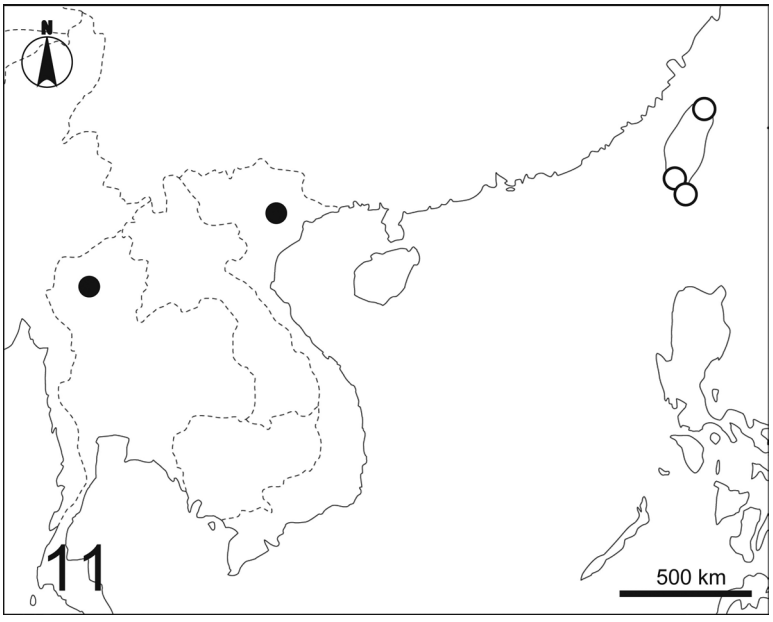


Fig. 11. Distribution map of *Crematogaster fumikoae* sp. nov. and *C. popohana*. Closed circles indicate *C. fumikoae* sp. nov., open circles *C. popohana*.

0.18; PpW 0.20-0.27; PtHI 63-75; PtWI 68-84; PpWI 117-150; WI 95-111 (Twelve workers measured).

General description of worker. Workers with weak polymorphism.

Head appearing subquadratic; posterior corners of head rounded. Anterior clypeal margin almost straight and slightly concave medially. Compound eyes slightly projecting beyond lateral margins of head in full face view. Scape reaching posterior corner of head, with erect setae.

Anterior margin of pronotal collar weakly concave in dorsal view. Pronotal dorsum with ridges laterally. Mesonotal dorsum with lateral ridges posteriorly; dorsum forming flat dorsal outline in lateral view; ridges extending posteriorly to metanotal groove and anterior propodeal dorsum. Pronotum not clearly forming same dorsal outline with mesonotum in lateral view. Metanotal groove almost straight on median portion in dorsal view, not so deep, dorsolateral ridges connecting region between mesonotum and propodeum. In lateral view, dorsal outline of anterior portion of propodeum to propodeal spines seemingly straight. Propodeal spiracles elliptical and large, situated at posterolateral corners of propodeum, some distance from from metapleural gland bulla. Propodeal spines long, straight; length greater than diameter of propodeal spiracles.

Petiole slender elliptical, median portion slightly broader. Posterior portion of petiole with ridges dorsolaterally. Subpetiolar process undeveloped or weakly developed anteriorly as small edge; thin lobe developed posteriorly. Postpetiole weakly bilobed with feeble longitudinal median sulcus. Petiole as wide as postpetiole in dorsal view.

Dorsal surface of head sparsely punctate, but with longitudinal rugulae on gena and surrounding antennal sockets. Clypeus striated with longitudinal rugulae; rugulae extending to posterior clypeal margin. Anterolateral margin of pronotum with rugulae. Lateral surface of pronotum weakly sculptured with feeble rugulae. Lamellate-like rugulae not covering metanotal groove dorsolaterally. Central region of mesopleuron smooth, but surrounding region weakly sculptured. Dorsal and lateral surfaces of propodeum generally smooth and shiny. Lateral sides of petiole sparsely punctate. Dorsal surface of postpetiole sparsely punctate.

Standing pilosity sparse. Dorsum of head with abundant erect setae. Clypeus with two pairs of long setae on anterior portion; one pair of setae directed upwards and one directed downwards. Anterior clypeal margin with longer setae on median portion, and shorter setae on sides. Mesosoma with sparse erect setae. Petiole and postpetiole with sparse erect to suberect setae. Fourth abdominal tergite with sparse erect setae.

Body color reddish-brown except for dark brown gaster.

Distribution.
This species is known from Taiwan (Fig.11).

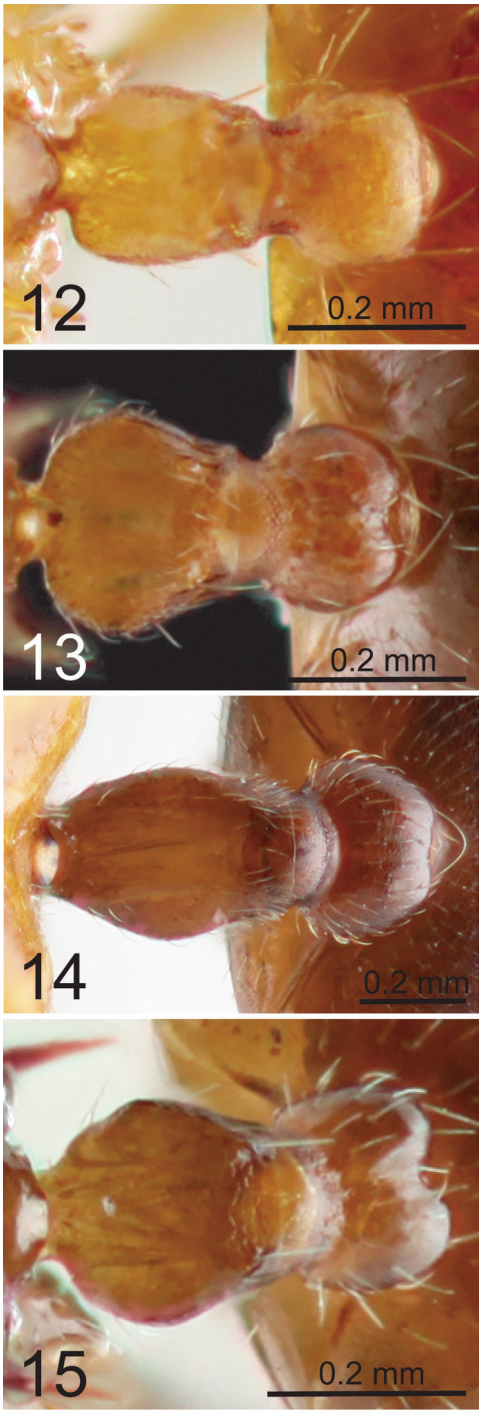
Remarks.
This species is similar to *C. fumikoae*, but can be distinguished by the straight propodeal spines, smooth mesopleuron, and undeveloped or weakly developed subpetiolar process (Fig. 10).

Additional material examined.
TAIWAN: 5 workers, Jiaxian (435 m a.s.l.), Kaoshiung, 22. iv. 2010 (TW10-SKY-08) (*Sk. Yamane*); 12 workers, Fushan, Wulai (500 m. a.s.l), Taipei, 20. iv. 2010 (TW10-SKY-07) (*Sk. Yamane*).

***Crematogaster popohana amia* Forel, 1913**

Crematogaster popohana r. *amia* Forel, 1913: 194. Three syntype queens and three syntype males from TAIWAN: Taihorin (MHNG) and one syntype queen (NHMB) [examined]. Combination in *C.* (*Acrocoelia*): Emery, 1922: 151.

Remarks.
Examination of syntype queens in MHNG and NHMB reveals that *C. popohana amia* Forel, 1913 is quite different from *C. popohana* Forel, 1912. In the original description, Forel (1913) also suggested that the males of *C. popohana amia* Forel, 1913 are distinctly larger than the ones of *C. popohana* Forel, 1912. The taxonomic status of this subspecies will remain uncertain until the worker caste of the nest series can be examined or the DNA barcoding analysis is carried out.



Figs 12 – 15. Petiole in dorsal view. 12, *C. osakensis*; 13, *C. teranishii*; 14, *C. inflata*; 15, *C. fraxatrix*.

DISCUSSION

Unique slender petiole

Workers of the genus *Crematogaster* have highly variable shape of the petiole, but the observed patterns are mostly consistent within each subgenus. Workers of the subgenus *Orthocrema* generally have a petiole with subparallel sides in dorsal view (Fig. 12), whereas most species of the subgenus *Crematogaster* have a petiole that is broader anteriorly (Fig. 13). Among the subgenus *Crematogaster*, some species in the *C. inflata*-group and related species have an elliptical petiole (Fig. 14), which correspond to the former subgenera *Paracrema* and *Physocrema* (Hosoishi & Ogata 2009), or a diamond-like petiole (Fig. 15) that is broader on the middle portion in the *C. fraxatrix*-group (Hosoishi & Ogata 2014) and the *C. ferrarii*-group. In the same way as the species of the subgenus *Orthocrema*, the *C. popohana*-group has a slender petiole with weakly convex sides (Figs 4, 8). Molecular phylogeny has revealed that the subgenus *Orthocrema* is a sister-group to the remaining global and Australo-Asian *Crematogaster* clades (Blaimer, 2012b). A recent molecular phylogeny of Myrmicinae indicated that *Meranoplus* is a sister group to *Crematogaster* in the tribe Crematogastrini (Ward et al. 2014). Phylogenetic relationships and outgroup comparisons based on the petiole found in other myrmicine ants suggest that the character state of the petiole in the *C. popohana*-group might be plesiomorphic in the subgenus *Crematogaster*.

However, the phylogenetic position of the *C. popohana*-group is unknown because Blaimer (2012b) did not include the related species in her molecular phylogenetic analysis. Unfortunately, PCR and sequencing were not successful from the dried material because our collections of *C. fumikoae* and *C. popohana* were relatively old specimens. Molecular phylogenetic analysis using the fresh material will shed light on the phylogenetic positon of the *C. popohana*-group in the future.

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