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A new spineless *Myrmica* species from China, with the reinstatement of *M. zhengi* Ma & Xu (Hymenoptera: Formicidae)

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ABSTRACT

A new species of the *pachei*-group, *M. inermis* **sp. nov.**, from Sichuan, China, which is unique in the Chinese fauna due to its short-spined character. The new species is similar to *M. huaii* Chen et al., 2016, *M. phalacra* Radchenko & Elmes, 2009, *M. schulzi* Radchenko & Elmes, 2009 and *M. sculptiventris* Radchenko & Elmes, 2009 resulted from clustering analysis, and the main morphological differences and diagnostic characters between this species and all species of the *pachei*-group are listed in this study. Considering the morphological differences between *M. zhengi* Ma & Xu, 2011 and *M. luteola* Kupyanskaya, 1990, especially in the cephalic posterior marginal hairs of the workers and the propodeal spines of the queens, we propose that *M. zhengi* be reinstated.

Introduction

The genus *Myrmica* was established by Latreille (1804) based on the type-species, *M. rubra* (Linnaeus, 1758). It is a diverse and widely distributed genus, comprising 187 valid species and 14 fossil species (Bolton, 2023). *Myrmica* species have been observed to inhabit diverse environments, including stone formations, rotted logs, wood fragments, and soil around tree bases (Eguchi et al., 2011). Their global distribution spans Eurasia and North America, with limited in Africa (Weber, 1947, 1948, 1950; Radchenko and Elmes, 2003, 2010).

Myrmica species are widely distributed in China (Fig. 8), with 54 valid species recorded (Chen et al., 2016). The study of Chinese *Myrmica* began with Wu and Wang (1995), which classified eight species, including three new records species: *M. lobicornis* Nylander, 1846, *M. sulcinodis* Nylander, 1846, *M. angulinodis* Ruzsky, 1905, and one new species: *M. sinica*. However, Radchenko et al. (2008) later synonymised *M. sinica* with *M. excelsa* Kupyanskaya, 1990. Wei et al. (2001) provided a taxonomic discussion of eleven *Myrmica* species from China, which included one new record species, *M. gallienii* Bondroit, 1920, and one new species, *M. taibaiensis*. However, in this taxonomic system, five of the remaining nine species were identified by Radchenko and Elmes (2010) as disidentification. Chen et al. (2016) conducted a comprehensive study of the genus *Myrmica* in China, which described one new record species: *M. forcipata* Karawaiew, 1931, and seven new species: *M. dongi*, *M. huaii*, *M. liui*, *M. mifui*, *M. oui*, *M. wangi*, and *M. yani*.

The *pachei*-group was initially recognized by Radchenko and Elmes (2001) based on two species, *M. pachei* Forel, 1906 and *M. villosa* Radchenko & Elmes, 1999, which considered are rare and unusual in the Himalayas. In the revision of this group by Radchenko and Elmes (2009), fourteen additional *pachei*-group species were added, and they compiled an identification key with thirteen couplets. The group's workers are characterised by the rounded or slightly prominent anterior clypeal margin without a notch, the scape that is gradually though distinctly curved basely without a lobe or carina, the mesosomal dorsum that is partly transversally rugose, and the petiole with a relatively short peduncle. Bharti and Sharma (2011) provided detailed ecological information on the group with described a new Indian *pachei*-group species, *M. elmesi*. Chen et al. (2016) compiled an identification key of eighteen couplets encompassing nineteen species, including four new *pachei*-group species: *M. yani*, *M. dongi*, *M. mifui* and *M. huaii*.

Normally, both social parasites such as the queens of *M. luteola* Kupyanskaya, 1990 (workers spined) and the *M. colax* (Cole, 1957) show distinctive short-spined characters. However, the variant individuals of *M. rugulosa* Karavaiev, 1849 recorded by Czechowski et al. (2008) suggest that the presence of short propodeal spines may be a mutation in a species that normally has long spines.

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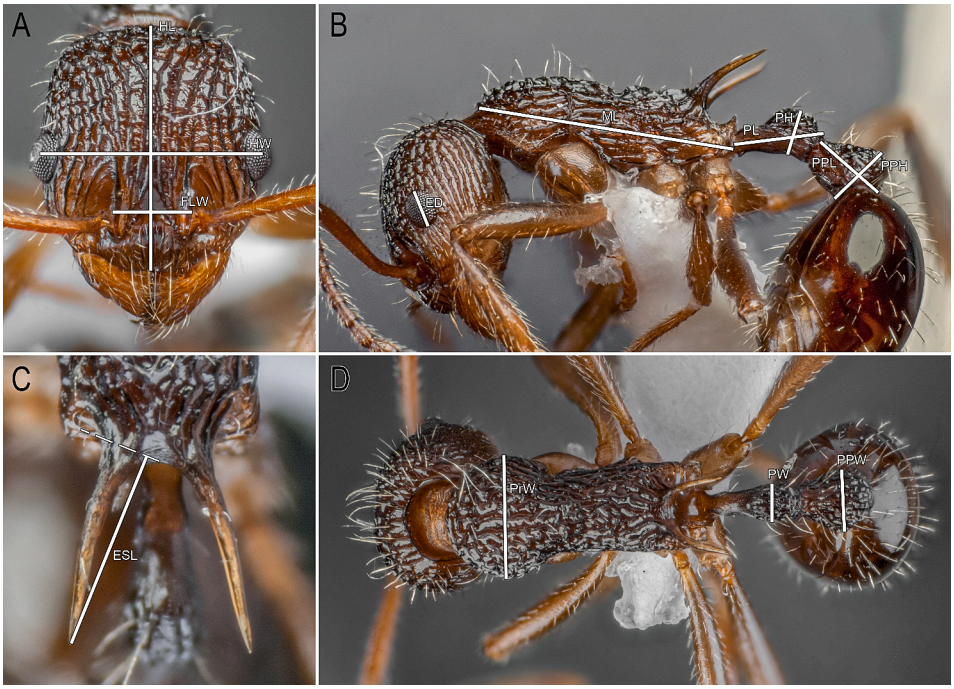

Fig. 1. Illustrations of measurements of *Myrmica* nr. *urbanii* Radchenko & Elmes, 1998. A, head in full-face view; B, body in lateral view; C, propodeal spines in dorsal view; D, body in dorsal view.

In this study, all the species in the *pachei*-group were analysed by clustering based on morphological characters, and a matrix of diagnostic characters is provided. A non-parasitic short-spined species of the *pachei*-group is described, and the relationship between this species and social parasites needs further investigation. In addition, the taxonomic problem of *M. zhengi* is noted in this study and is discussed in detail.

Materials and methods

All materials examined were collected from Yunnan Province, China, and deposited in the Kunming Natural History Museum of Zoology, Kunming Institute of Zoology (KIZ), Chinese Academy of Sciences, Kunming City, Yunnan Province, China. Observations and measurements were conducted using the HAYEAR software with a Hayear HY-800B digital camera coupled with a Hayear 0745 lens. The specimens were photographed using a Nikon D3000 digital camera attached to a Phenix Plan 4x microscope objective. Multifocal montage processing is carried out using Adobe Photoshop and Helicon Focus. Diagnostic characters were clustered based on the Ward's method using PAST 4.15 software (Hammer et al., 2001) and visualised using tvBOT (Xie et al., 2023). The morphological terminology used in this study follows Bolton (1994) and Harris (1979).

Abbreviations for measurements and indices in morphometrics follow Chen et al. (2016), with all measurements in millimeters (Fig. 1):

TL Total length. Measured the maximum length of the body from the apex of the mandible to the end of the gaster in perfect spreading position. Which is equal to HL + ML + PL + PPL + the length of gaster.
HL Head length. In standard full-face view, the maximum length from the posterior margin of the head to the anterior margin of the clypeus.
HW Head Width. The maximum width of the head (excluding eyes) in full-face view.
FLW Frontal Lobes Width. Measure the distalmost distance between the frontal lobes in full-face view.
ED Eye Diameter. The maximum diameter of the eye in lateral view.
SL Scape Length. The maximum length of the antennal scape excluding the articular condyle and its neck.
ML Mesosoma Length. The maximum diagonal length of mesosoma in profile view, which measured from the inflection of pronotal cervical shield to the posterior inferior margin of the metapleuron.
PrW Pronotum Width. Measured the maximum width of the pronotum in dorsal view.
ESL Propodeal Spine Length. In profile view, measure the straight distance of the propodeal spine from its apex to the lowest point of the propodeal concavity between the spines.
PL Petiole Length. The maximum length of the petiole in lateral view.
PH Petiole Height. The maximum height of the petiolar node in lateral view.
PW Petiole Width. The maximum width of the petiole in dorsal view.
PPL Postpetiole Length. The maximum length of the postpetiole in lateral view.
PPH Postpetiole Height. The maximum height of the postpetiole in lateral view.
PPW Postpetiole Width. The maximum width of the postpetiole in dorsal view.
CI Cephalic Index. HL/HW
ESLI Propodeal Spine Index. ESL/HW
FI Frontal Index. FW/HW
FLI Frontal Lobes Index. FLW/FW
PI1 Petiolar Index 1. PL/PH
PI2 Petiolar Index 2. PL/HW
PI3 Petiolar Index 3. PW/HW
PPI1 Postpetiolar Index 1. PPL/PPH
PPI2 Postpetiolar Index 2. PPH/PPW
PPI3 Postpetiolar Index 3. PPW/PW
PPI4 Postpetiolar Index 4. PPW/HW
SI1 Scape Index 1. SL/HL
SI2 Scape Index 2. SL/HW

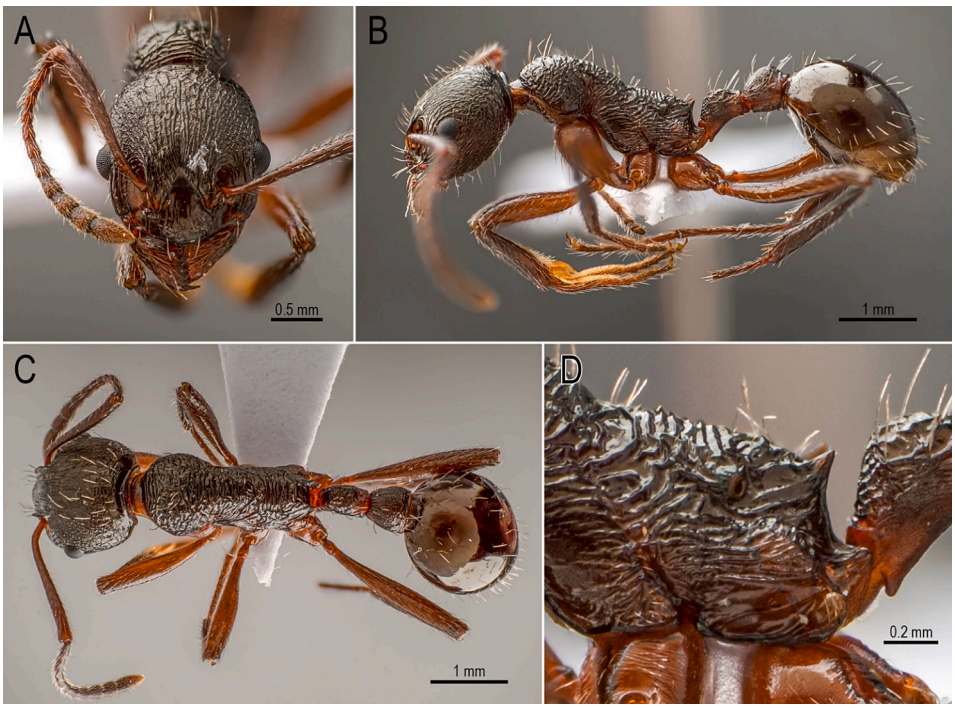

Fig. 2. *Myrmica inermis* **sp. nov.** holotype worker (KIZ0132782). A, head in full-face view; B, body in lateral view; C, body in dorsal view; D, propodeum in lateral view.

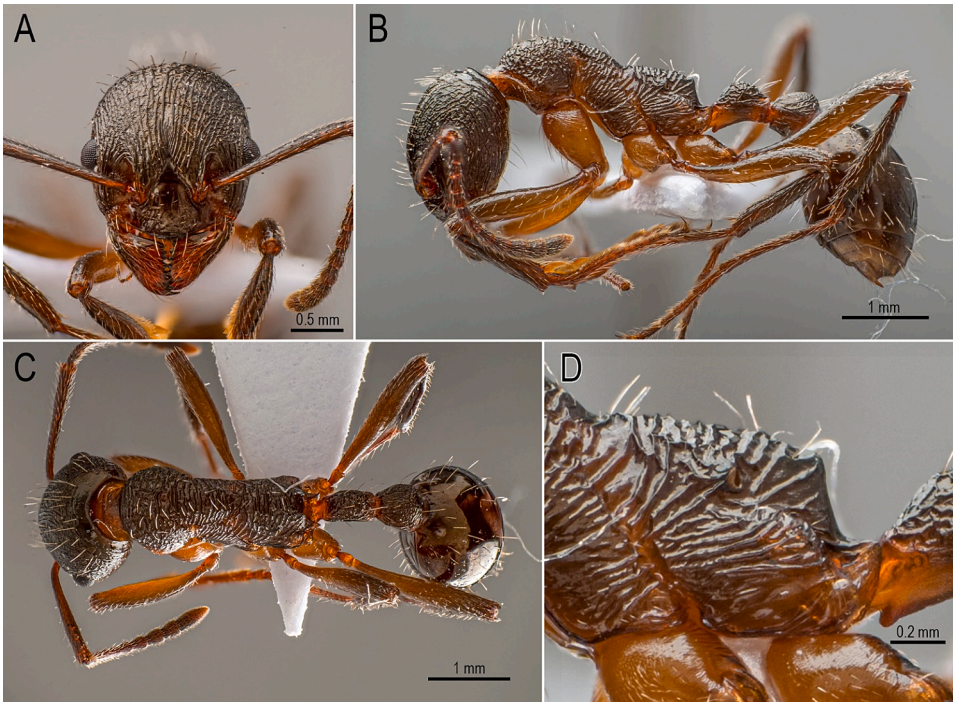

Fig. 3. *Myrmica inermis* **sp. nov.** paratype worker (KIZ0132783). A, head in full-face view; B, body in lateral view; C, body in dorsal view; D, propodeum in lateral view.

Systematics

Genus Myrmica Latreille, 1804

Myrmica Latreille, 1804: 179. Type-species: *Formica rubra* Linnaeus, 1758, by subsequent designation of Latreille, 1810: 437.
= *Sifolinia* Emery, 1907: 49. As junior synonym by Brown, 1973: 183.
= †*Nothomyrmica* Wheeler, 1915: 60. As junior synonym by Radchenko et al., 2007: 1495.
= *Sommimyrma* Menozzi, 1925: 25. As junior synonym by Brown, 1973: 183.
= *Symbiomyrma* Arnol'di, 1930: 267. As junior synonym by Bolton, 1988: 3.

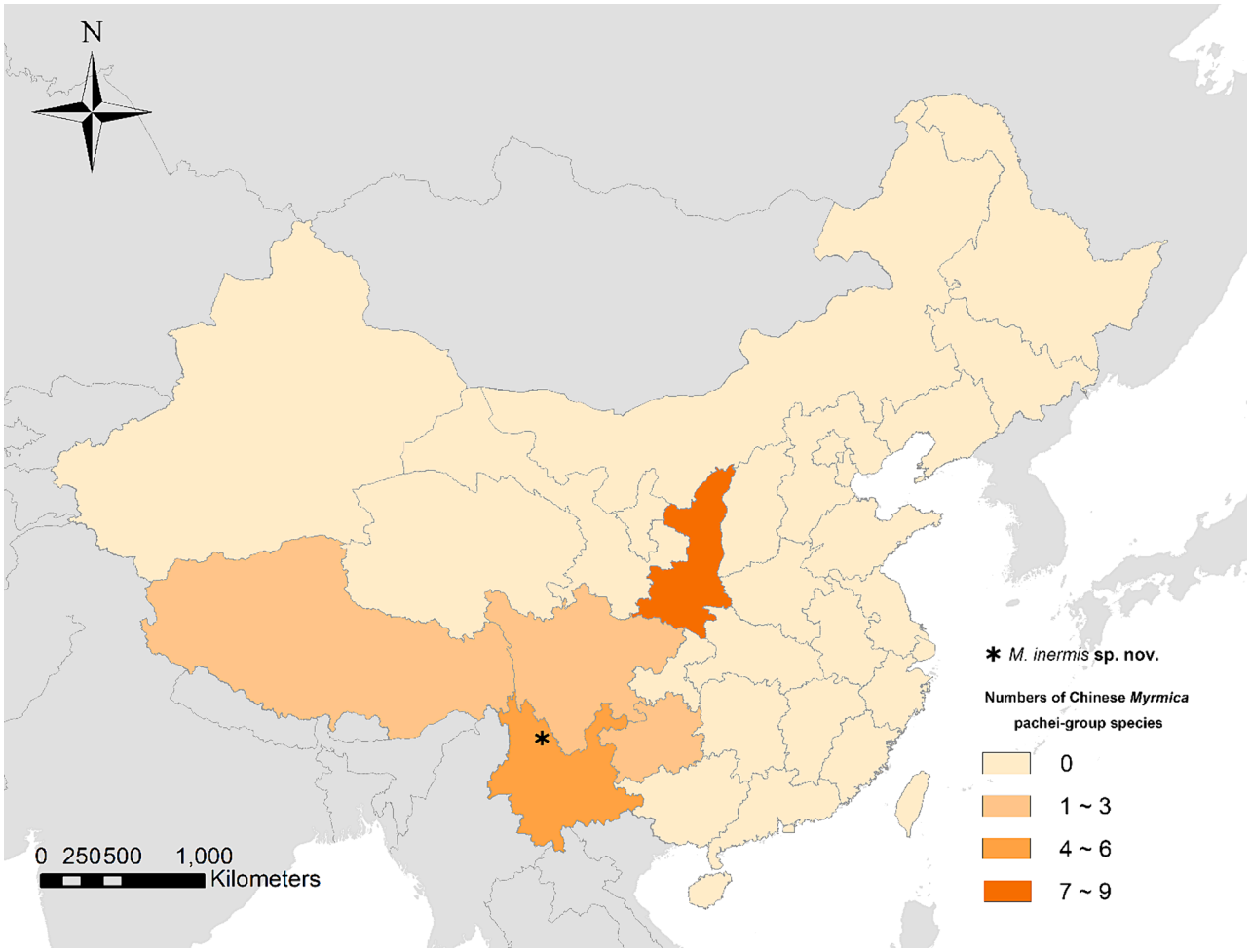

Fig. 4. Map showing the distribution of *Myrmica inermis* **sp. nov.** and the current distribution of *pachei*-group species. Data were available from Chen et al. (2016).

= *Paramyrmica* Cole, 1957: 37. As junior synonym by Brown, 1973: 183.
= *Myrmica (Dodecamyrmica)* Arnol'di, 1968. As junior synonym by Brown, 1973: 180.

Myrmica inermis sp. nov.

Figs. 2 and 3.

Type material. Holotype. **CHINA:** 1 worker, Yunnan Province, Lijiang City, Yongsheng County, 26°54′04″N, 100°34′29″E, alt. 2800 m, in deadwood, 5.XII.2022, leg. Jincai Gu, KIZ0132782 (KIZ). Paratypes. 8 workers, from the same colony with the same data as holotype, KIZ0132783, KIZ0132784, KIZ0132785, KIZ0132786, KIZ0132787, KIZ0132788, KIZ0132789 and KIZ0132790 (KIZ).

Measurements and descriptions. Holotype worker. TL 7.8, HL 1.69, HW 1.47, FLW 0.66, ED 0.35, SL 1.64, ML 2.59, PrW 1.04, ESL 0.13, PL 0.67, PH 0.58, PW 0.39, PPL 0.54, PPH 0.57, PPW 0.60, CI 1.15, ESLI 0.09, FI 0.44, FLI 1.02, PI1 1.16, PI2 0.46, PI3 0.27, PPI1 0.95, PPI2 0.95, PPI3 1.54, PPI4 0.41, SI1 0.97, SI2 1.12. Paratype workers ($n = 8$) (average in parentheses). TL 7.8–7.9 (7.8), HL 1.67–1.80 (1.72), HW 1.46–1.56 (1.50), FLW 0.65–0.67 (0.66), ED 0.34–0.36 (0.35), SL 1.58–1.69 (1.63), ML 2.53–2.68 (2.60), PrW 1.04–1.08 (1.06), ESL 0.06–0.15 (0.12), PL 0.65–0.73 (0.69), PH 0.53–0.59 (0.56), PW 0.38–0.41 (0.39), PPL 0.55–0.57 (0.56), PPH 0.55–0.62 (0.58), PPW 0.57–0.61 (0.59), CI 1.12–1.16 (1.15), ESLI 0.04–0.10 (0.08), FI 0.42–0.44 (0.44), FLI 0.99–1.02 (1.01), PI1 1.12–1.30 (1.23), PI2 0.44–0.48 (0.46), PI3 0.25–0.26 (0.26), PPI1 0.89–1.00 (0.95), PPI2 0.96–1.04 (0.99), PPI3 1.49–1.58 (1.53), PPI4 0.38–0.40 (0.39), SI1 0.93–0.96 (0.94), SI2 1.06–1.11 (1.08).

Holotype worker (Fig. 2). Head. In full-face view, subelliptical, slightly longer than wide (CI: 1.15); posterior margin noticeably rounded, forming semi-circle after eyes; eyes protruding and visible, large and rounded, placed in midline of head; antennal scape long (SI1: 0.97, SI2: 1.12), which beyond the posterior margin for nearly 1/3 length of scape, gradually thickens upward from base to apex, weakly curved sub-basally, basal surface flat, lobate on both sides, but without shield-like dorsal plate; antennal funiculus 11-segmented, with each segment all longer than broad, with a 4-segmented unobtrusive antennal club; frontal carinae curve outwards and merge with rugae, which surround antennal sockets; frontal lobes developed and larger than frontal carinae (FI: 0.44), and with subparallel margins (FLI: 1.02); antennal socket shorter, but elongated, forming a subellipse; anterior margin of clypeus rounded, convex, not extended to malar region, posterior margin of clypeus convex related to frontoclypeal sulcus, rounded, supraclypeal area steep; mandible triangular, angle of base and masticatory margin of mandible about 113°, with 8 teeth regularly enlarged towards the apex, the apical tooth much larger than other teeth, apical angle of basal teeth 60°–75°, and angle of apex 3 teeth significantly lower than 60°, tapering toward apex (Fig. 2A). In lateral view, eyes large and oval, occupying 5 % of lateral cephalic surface area; clypeus arcuate but not obviously protruding; frontal lobes upturned, exposing large antennal socket; occipital carina visible, slightly elongated posteriorly, not with a retracted neck (Fig. 2B).

Mesosoma in lateral view, pro-mesonotal dorsum curved and slightly higher than propodeum; pronotum weakly convex dorsally, ventrolateral portion anteriorly rounded and posteriorly angulated; pro-

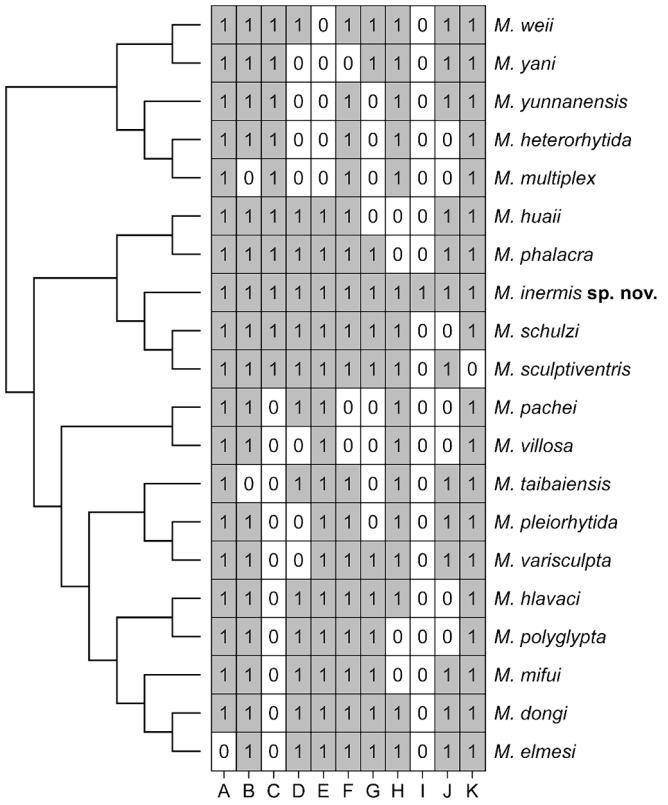

Fig. 5. Diagnostic characters of *Myrmica inermis* **sp. nov.** and clustering based on Ward's method from the *M. pachei*-group. Values indicate the presence (1) or absence (0) of a character. Abbreviations: A, head extensively punctated; B, dense rugae between frontal carinae; C, posterior cephalic margin distinctly rounded; D, lateral margins of head without long suberect hairs; E, head slightly longer than broad, not elongated; F, pronotal dorsum reticulate sculpture; G, metanotal groove weak depression; H, mesopleuron with monotonous regular horizontal rugae; I, propodeal spines strongly shortened; J, petiole distinctly longer than high; K, first gastral tergite smooth.

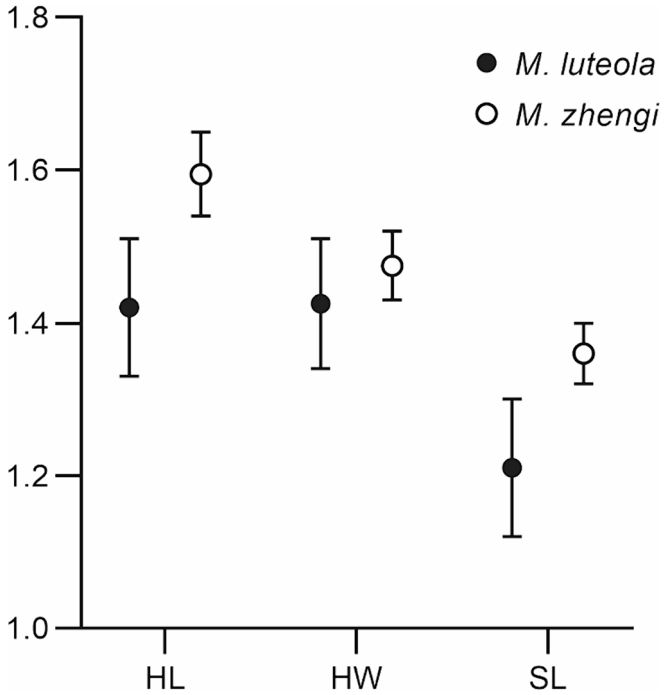

Fig. 6. Morphometric differences in three characters of *Myrmica zhengi* and *M. luteola*, points indicate mean values, lines indicate maximum and minimum values. Data available from Ma and Xu (2011) and Radchenko (1994).

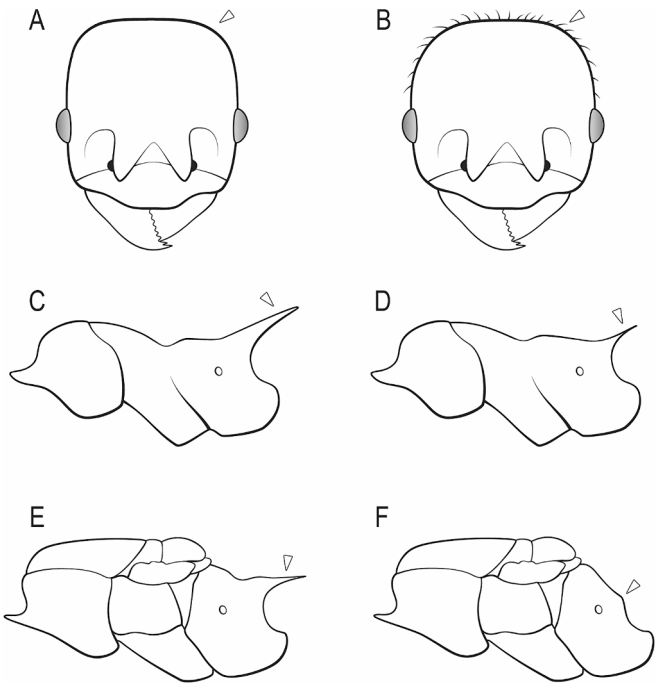

Fig. 7. Morphological differences. A, C, E, *Myrmica zhengi*; B, D, F, *M. luteola*; A, B, head in full-face view; C–F, mesosoma in lateral view; A–D, workers; E, F, queens.

mesonotum weakly contiguous or fused, pro-mesonotal suture undeveloped, indistinct dorsally, slightly visible laterally; mesonotum flattened, dorsally slightly convex; metanotal groove weakness, not distinctly concave, only with a weak angle between mesonotum and propodeum; metathoracic spiracle invisible (probably subtle extremely); mesopleural anterior margin slightly concave, projection present but small; propodeum quadrilateral and elongate, basal face about 1.3 × longer than declivity; propodeal lobe protruding, forming a triangle with a ca. 90° apical angle, lower margin 1.6 × as long as upper margin; propodeal spine short (ESLI: 0.09), forming nearly 50° apical angle; propodeal spiracle inclined posteriorly, anteriorly elevated (Fig. 2B, D). In dorsal view, pronotum widest and rounded; mesonotum elongated, ellipsoid, anterior and posterior margins fused to its connecting parts, border with only minute grooves present as traces; propodeum widest at bottom than dorsum, metapleural gland bulla moderately enlarged, and declivity face depressed between propodeal spines or propodeal lobe (Fig. 2C). Front tibiae with well-developed pectinate spur, but spur on middle and hind tibiae reduced and delicate.

Metasoma in lateral view, peduncle of petiole extremely short and thick; petiole nearly triangular, longer than high, with a spiny shape ventral process, pointed ventroanteriorly, node lower and rounded; postpetiole shorter than petiole, subglobular, as long as high; gaster oval, 1st segment largest, remaining segments gradually narrow (Fig. 2B). In dorsal view, postpetiole 1.5 × as wide as petiole (PPI3: 1.54); petiole subrectangular, which length 2 × as width; postpetiole subtrapeziform, as long as wide (Fig. 2C).

Sculpture. Head punctate and lineate, frontal area longitudinally costulate; sides rugose; clypeus largely smooth, only with several weak longitudinal costae; mandible lineate transversely; antennal socket smooth and shining; malar region with strongly thick longitudinal costae; with enveloping curved costae around eyes; occipital carina smooth and shining (Fig. 2A, B). Mesosoma not punctate, pronotum irregularly rugose and slightly shining, anterior margin of dorsum

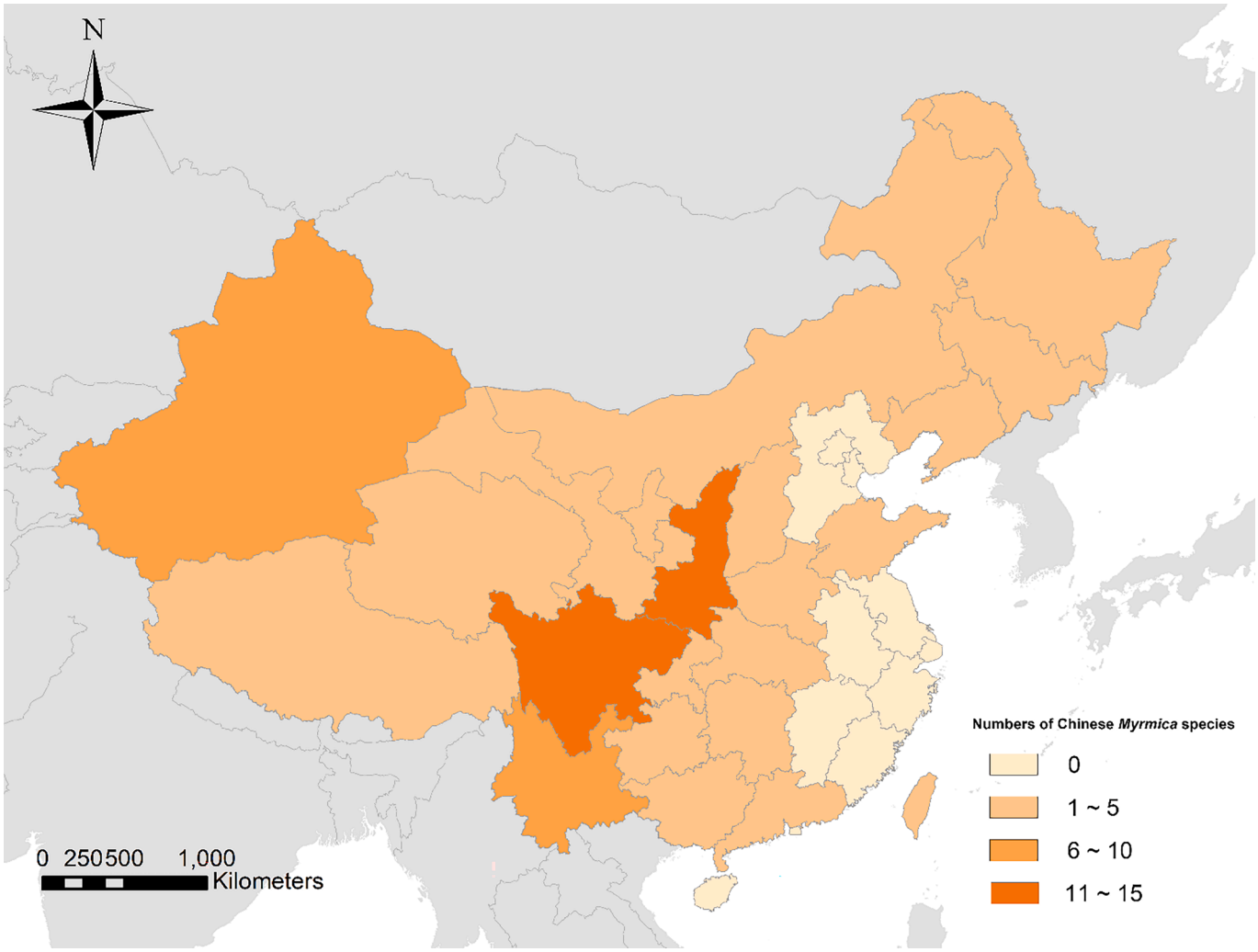

Fig. 8. Map showing the distribution of *Myrmica* species. Data were available from Chen et al. (2016).

slightly transverse; mesonotum transversely regular costate dorsally; mesopleuron transversely costate, slightly smooth laterally; propodeum with transverse or oblique costae on dorsum, and with tortuousness costae laterally (Fig. 2B, C, D). Petiole irregularly rugose dorsally and finely imbricate ventrally; postpetiole densely punctate dorsally (Fig. 2B). Gaster, smooth and shining (Fig. 2B).

Pilosity and color. Whole body with suberect pilosity, head in full-face view with a circle of suberect hairs on outline. Unicolourly dark, legs and antennae reddish (Fig. 2).

Paratype workers. (Fig. 3). Same as holotype, but body size fluctuates slightly, propodeal spine is sometimes shorter or even absent (Fig. 3B, D).

Queens and males. Unknown.

Distribution. (Fig. 4). Only known in Yunnan, China.

Biology. Limited information is available regarding this new species, except that workers build nests in dead wood, and it heavily feeds on small arthropods.

Comparative diagnosis. Based on the strongly rounded clypeus, the lobeless antennal scape, the partially transversely rugose mesosomal dorsum, and the short petiolar peduncle of this species, it belongs to the *pachei*-group. The new species significantly recognizable from all other species by its short propodeal spines from China. The clustering analysis inferred that this species is similar to *M. huaii*, *M. phalacra*, *M. schulzi* and *M. sculptiventris*, as shown in diagnostic details in Fig. 5 which includes all species of the *pachei*-group.

Etymology. The Latin name "*inermis*" is composed of "*in-*" + "*arma*" + "*-is*", which means toothless, and in this new species refers to the very short spines on the propodeum.

Myrmica zhengi Ma & Xu, 2011 reinstated

Fig. 7A, C, E.

M. zhengi Ma and Xu, 2011: 795, Fig. 1 – 5 (w.m.) CHINA. Palearctic. [Queen description: Zhang et al., 2012: 539, Fig. 1 – 4.].

Distribution. Shaanxi, China (type locality).

Comments. This species was established by Ma and Xu (2011) based on worker and male castes. In their justification for the synonymization of this species, however, Chen et al. (2016) mentioned that *M. luteola* is characterized by the strongly reduced and simple non-pectinate spurs on the middle and hind tibiae, and somewhat developed ventral petiolar and postpetiolar processes. They examined five worker paratypes and one queen paratype of *M. zhengi*, but found no differences with *M. luteola* and therefore suggested that the species be synonymised. Although it is unclear whether the queen paratype is the queen caste described by Zhang et al. (2012), only four worker paratypes, three workers and one identified worker were seen in the material examined by Chen et al. (2016), but not their mentioned queen paratype. While we did not verify the type specimens of the two species, the color photographs and detailed descriptions of the three castes of *M. zhengi* by Ma and Xu (2011) and Zhang et al. (2012), along with the finely hand-drawn illustrations of *M. luteola* by Radchenko and Elmes (2003, 2010), are sufficient to demonstrate their distinct morphological differences:

(1) Workers. The head in full-face view of *M. zhengi* elongated (Fig. 6), the posterior margin behind the eyes lacks hairs (Fig. 7A), whereas *M. luteola*, on the contrary, with dense hairs (Fig. 7B); the propodeal spines of *M. zhengi* slightly longer than *M. luteola* (Fig. 7C, D), and in dorsal view *M. zhengi* tends to be more rectilinear and pointing toward the posterior; the petiolar peduncle of *M. zhengi* longer than *M. luteola*.
(2) Queens. Verification of the geographic information (same address and collector, with only three days difference in collection time) and morphological characteristics of the type specimen and the queen of *M. zhengi* suggests that the authenticity of the queen is extremely high. Therefore, if the description of the queen is correct, the most significant distinction between the two species is in the propodeal spines of the queen, specifically, *M. zhengi* is long and thick (Fig. 7E), whereas *M. luteola* is a shortened, angulated "spineless" species (Fig. 7F); and the subpetiolar process of *M. zhengi* is dentate, whereas *M. luteola* is large and broad; the other differences are identical to those of the workers.
(3) Males. Differences within this caste are minimal, and the current variations may include the more protruding angulated propodeum of *M. zhengi*.

Considering these highly conspicuous and readily identifiable differences, we believe that *M. zhengi* and *M. luteola* should be recognized as two distinct species. Therefore, we propose to reinstate *M. zhengi* as a valid species and remove *M. luteola* from its distribution in China.

CRediT authorship contribution statement

Ying Zhong: Supervision, Visualization, Writing – original draft, Writing – review & editing. **Yuyuan Huang:** Writing – original draft, Writing – review & editing. **Tianqi Wu:** Supervision, Writing – original draft, Writing – review & editing. **Zhiyu Liu:** Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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