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On the species status of the root-knot nematode *Meloidogyne ulmi* Palmisano & Ambrogioni, 2000 (Nematoda, Meloidogynidae)

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Abstract

The root-knot nematode *Meloidogyne ulmi* is synonymised with *Meloidogyne mali* based on morphological and morphometric similarities, common hosts, as well as biochemical similarities at both protein and DNA levels. *M. mali* was first described in Japan on *Malus prunifolia* Borkh.; and *M. ulmi* in Italy on *Ulmus chenmoui* W.C. Cheng. Morphological and morphometric studies of their holo- and paratypes revealed important similarities in the major characters as well as some general variability in a few others. Host test also showed that besides the two species being able to parasitize the type hosts of the other, they share some other common hosts. Our study of the esterase and malate dehydrogenase isozyme phenotypes of some *M. ulmi* populations gave a perfectly comparable result to that already known for *M. mali*. Finally, phylogenetic studies of their SSU and LSU rDNA sequence data revealed that the two are not distinguishable at DNA level. All these put together, leave strong evidences to support the fact that *M. ulmi* is not a valid species, but a junior synonym of *M. mali.* Brief discussion on the biology and life cycle of *M. mali* is given. An overview of all known hosts and the possible distribution of *M. mali* in Europe are also presented.

Keywords

Morphological, morphometrics, esterase, malate dehydrogenase, Japan, Italy, Mierenbos, *Malus prunifolia*, *Ulmus chenmoui*, SSU rDNA, LSU rDNA

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Introduction

The genus *Meloidogyne* comprises all root-knot nematodes. It contains over 100 described species (Karssen et al. 2013). Its members are without a doubt the most widely distributed of all plant-parasitic nematodes (Sasser 1977). This widespread distribution and their economic importance are primarily the reasons why the genus has been the subject of more research than any other plant-parasitic nematodes, including the cyst-forming nematodes (Sasser and Carter 1982). Despite the numerous studies about their biology and taxonomy, their identification to the species level still pose a huge challenge to many diagnosticians (Blok and Powers 2009) mostly because of their very small inter-specific morphological variation (Jepson 1987).

In 2000, Palmisano and Ambrogioni described from Italy the root-knot nematode, *Meloidogyne ulmi*, from *Ulmus chenmoui* W.C. Cheng on which it was found to induce large galls. For many years, elm remained the only known host of *M. ulmi*. According to the authors, the tree at the type locality was introduced from the Netherlands as part of a breeding programme focussed on resistance to the Dutch elm disease. The Netherlands, like many other countries in Europe and North America, as well as New Zealand, has for years been battling against the notorious Dutch elm disease. It was for this reason that the former Dutch phytopathological laboratory "Willie Commelin Scholten" (WCS), based in Baarn, was mandated with the research on Dutch elm disease. This breeding programme was later on moved to Wageningen at the former institute the Dorschkamp Research Institute for Forestry & Landscape Planning; and in this programme, elm trees from all over the world were tested. Trial field "Mierenbos", a part of the Dorschkamp Research Institute for Forestry & Landscape Planning, was used for growing and improving resistant elm cultivars. It was from this trial field that resistant elm seedlings were sent to ten other European countries at the end of the breeding programme, among others, Italy in 1992 (Heybroek 1993).

The first observation of galls on elm trees was already in 1960 at Baarn, and the associating nematode was diagnosed as *M. arenaria* (Neal, 1889) Chitwood, 1949 by the National Plant Protection Organization (Oostenbrink 1961). Interestingly, about that same period, a *Meloidogyne* species found parasitizing apple trees in Japan was also inadvertently misidentified as *M. arenaria,* because this nematode species, like the one on elm bore some resemblance to *M. arenaria* perineal patterns (Itoh et al. 1969). This Japanese species would later be described and named *M. mali* by Itoh et al. (1969). In his comprehensive study on the host range of *M. mali*, Toida (1979) associated this species with several other plant species belonging to different families, particularly the Rosaceae. Following its description, several studies have also been conducted on its taxonomy, ecology, damage and control (Inagaki 1978), SEM studies of male and second-stage juvenile head morphology, and morphological variability of its different populations (Okamoto et al. 1983). At the trial field "Mierenbos", the first report of galling symptoms on *Ulmus* trees was in 1979 (Brinkman 1980). Presently, all the *Ulmus* trees there are infected with *Meloidogyne* and are showing severe symptoms of root galling (Karssen et al. 2008 and Karssen 2009).

In 2006, root samples of the dying type host apple containing *M. mali* from the type locality in Japan sent by Dr. Takayuki Mizukubo were received at the Dutch National Plant Protection organization. About the same time, galled root samples of the type host of *M. ulmi* were obtained from Italy. They were propagated and maintained on the *Ulmus* × *hollandica* variety "Wredei". Juveniles isolated from the Japanese apple root samples were used for sequencing and the resulting SSU rRNA sequence was discovered to be almost identical to that of *M. ulmi* (Holterman et al. 2009). Additionally, isozyme phenotypes of *M. ulmi* population from the trial field in Wageningen were also compared to that of *M. mali* from Japan (Karssen unpublished; Sakai and Mizukubo 2009). Those also revealed similar patterns of esterase and malate dehydrogenase to that obtained for *M. mali* (Sakai and Mizukubo 2009). With these observed similarities, a closer look needed to be taken into these two species. Based on the evidences available to us now, we hypothesize that *M. ulmi* probably entered Europe as *M. mali* with elm rootstocks imported from Japan. Supporting this is the report that *M. mali*, in addition to its numerous hosts, can also infect *Ulmus davidiana* var. *japonica* (Toida 1979).

The original description of *M. ulmi* differentiates it from *M. mali* on the basis of characters that generally show high intraspecific variations. With the original description being the only paper written about *M. ulmi*, all the known features so far are ones from the original description. On *M. mali*, however, there have been quite a lot of research on the hosts, life cycle, ecology, detailed morphology, as well as their variations within species (Toida 1979; Inagaki 1978; Okamoto et al. 1983).

The objectives of this current research, therefore, are:

i) to evaluate the morphological similarities between *M. mali* and *M. ulmi*.
ii) to search for other host plants, than *Ulmus* sp. present at the trail field "Mierenbos".
iii) to test *M. ulmi* on selected host plants on which *M. mali* is already known to reproduce.
iv) analyze their biochemical similarities, at the protein and DNA levels.

Materials and methods

Morphology and morphometrics

Paratype slides of *Meloidogyne ulmi* used for morphological and morphometric studies were obtained from Dr. Z.A. Handoo of the USDA Nematode Collection. In addition to these, we obtained *M. mali* specimens on slides taken to the USDA by Dr. Ichinohe during his visit in 1958 as well as additional specimens of males, second-stage juveniles and females stored in formalin that were only recently isolated from root samples sent to USDA by Ichinohe during that same visit. Also, by courtesy of Dr. Hiromichi Sakai and Shigeyuki Sekimoto, paratypes that were deposited at the National Agriculture and Food Research Organization, Agricultural Research Center (Kannondai, Tsukuba, Ibaraki, Japan), the then Central Agricultural Experiment Station were also obtained. All slides were observed

Table 1. The various forms of type specimens of *Meloidogyne mali* and *M. ulmi* studied and their sources.

Form	*Meloidogyne mali*		*Meloidogyne ulmi*	
	Sex/stage	**Source**	**Sex/stage**	**Source**
Holotype	1 female	Shigeyuki Sekimoto	–	–
Allotype*	1 male	Shigeyuki Sekimoto	–	–
Paratype	17 perineal patterns	Dr. Zafar A. Handoo	2 PP & 1 anterior part	Dr. Zafar A. Handoo
Paratype	3 males	Dr. Zafar A. Handoo	2 males	Dr. Zafar A. Handoo
Paratype	4 juveniles	Dr. Zafar A. Handoo	3 juveniles	Dr. Zafar A. Handoo
Paratype	1 male	Dr. Hiromichi Sakai	–	–
Paratype	1 juvenile	Dr. Hiromichi Sakai	–	–

*Slide marked as allotype, however at present not recognized by the ICZN, i.e. it is a paratype.

Table 2. Plant species included in the host plant test with *M. ulmi* in the greenhouse.

Family	Plant species
Brassicaceae	*Brassica oleracea* L. var. Gemmifera (cabbage)
	Brassica pekinensis (Lour.) Rupr. (celery cabbage)
Rosaceae	*Malus pumila* "M9" (apple)
	Rosa hybrida L. (rose)
Fabaceae	*Trifolium repens* L. (white clover)
Solanaceae	*Solanum lycopersicum* L. (tomato)
Ulmaceae	*Ulmus glabra* Huds. (wych elm)

using compound light microscope (DM 2500, LEICA) equipped with differential interference contrast (DIC), and camera (DC 300F, LEICA) for taking images. Comparisons of morphological and morphometric characters were based on the most differential characters, previously used by Karssen (2002).

Host test

This is a combination of sampling undertaken in 2011 and 2012 at the former trial field "Mierenbos" on several plant species and a subsequent greenhouse experiment involving some important plant species already associated with *M. mali* in previous studies (Itoh et al. 1969; Toida 1979). Host herein is defined as a plant on which the nematode can reproduce, after a successful penetration.

Isozyme analysis

Esterase and malate dehydrogenase isozymes were analysed for *M. ulmi* sampled at "Mierenbos", following the method described by Karssen et al. (1995). In summary, young females were isolated from roots into an isotonic (0.9%) salt solution. This was followed by a desalting step which involved transfer of the females from the NaCl solution to a

reagent–grade water on ice for few minutes. Females were then singly transferred into sample wells containing 0.6 µl extraction buffer. With the aid of a small glass rod, the females in the wells were crushed; and the macerated females were then loaded into sample applicators (0.3 µl per well). All twelve wells, with the exception of 6 and 7, were loaded with our test samples of *M. ulmi*. *M. javanica* was used as reference in wells 6 and 7.

Electrophoresis was run using the PhastSystem (Pharmacia Ltd, Uppsala, Sweden) and the gels were subsequently stained in a Petri dish and placed in an incubator at 37 °C. Staining for non-specific esterase (EST; EC 3.1.1.1) was allowed to stand for 60 minutes whiles that for malate dehydrogenase (MDH; EC 1.1.1.37) stayed for 5 minutes.

Following staining, the gels were rinsed with distilled water and fixed for 5 minutes in a 10% acetic acid / 10 % glycerol/ 80 % distilled water solution. Pictures of the gels were taken by placing them on a glass surface illuminated from below.

Molecular analysis

Already published sequences of both *M. mali* and *M. ulmi* (Holterman et al. 2009) together with our own sequence of the latter were included in this analysis.

DNA extraction

Nucleic acids were isolated from single male or second–stage juveniles of *M. ulmi* populations taken from "Mierenbos" and type populations kept in culture at the Dutch National Plant Protection Organization on an elm tree (*Ulmus* × *hollandica* Mill "Wredei"). Genomic DNAs were isolated from these samples using High Pure PCR Template Preparation Kit (www.roche-applied-science.com, Cat. No. 11796828001, Version 16.0) protocol for isolation of nucleic acids from Mammalian Tissue with slight modification in the first step to suit nematode DNA isolation (150 µl tissue lysis buffer added to 50 µl sterile water containing nematodes, minimum protease incubation time of 16 hours and elution volume of 50 µl).

PCR and sequencing

Amplification of 1000 base pairs (bp) of the large ribosomal subunit (LSU) (28S) was performed using primer set 28–81for (forward) 5'–TTAAGCATATCATTTAGCGGAGGAA–3' and 28–1006rev (reverse) 5'–GTTCGATTAGTCTTTCGCCCCT–3' described by Holterman et al. (2008).

To amplify the nearly full length sequence of the small ribosomal subunit (SSU) (18S), two partially overlapping fragments were generated using three universal primers and one nematode–specific primer (1912R) described by Holterman et al. (2006). The latter's inclusion was to avoid amplification of non–target eukaryotic SSU rDNA, for ex-

ample from fungal spores attached to the nematode cuticle. The primers 988F (forward) (5'–CTCAAAGATTAAGCCATGC–3') and 1912R (reverse) (5'–TTTACGGTCAGAACTAGGG–3') were used to amplify the first fragment. The second fragment was amplified with primers 1813F (foward) (5'–CTGCGTGAGAGGTGAAAT–3') and 2646R (reverse) (5'–GCTACCTTGTTACGACTTTT–3). Each PCR reaction mixture contained Molecular Grade Water (MGW)–DNase RNase free water (Sigma–Aldrich, Saint Louis, USA), 1x PCR buffer (incl. 2.0 mM $MgCl_2$, Roche), dNTPs (0.2 mM each), 0.24 µM of each primer, FastStart Taq DNA polymerase (1 U/µl, Roche) and 1 µl of the template DNA. The final reaction volume was 25 µl. PCR was performed in C1000 touch thermal cycler (Bio–Rad) with the following amplification condition: 15 min at 95°C; 5 cycles of 30 sec at 94°C, 30 sec at 45°C and 30 sec at 72°C; 35 cycles of 30 sec at 94°C, 30 sec at 54°C and 30 sec at 72°C; final extension for 5 min at 72°C. To test for amplification and the quality of PCR products, 5 µl of the PCR products mixed with 1 µl 6x Bromophenol Blue Loading solution (Promega, Madison, USA) were subjected to electrophoresis and SYBR safe (Invitrogen, Carlsbad, USA) staining on a 1.5 % agarose gel by standard methods (Sambrook et al. 1989) along with a 1kb-plus DNA ladder (Invitrogen, Carlsbad, USA) to size fragments. PCR products were imaged under UV light using a GeneGenious gel imaging system (Syngene, Cambridge, United Kingdom).

PCR products were purified after amplification using QIAquick PCR Purification Kit (Qiagen), and the genomic DNA concentration measured using a ND1000 spectrophotometer (NanoDrop). This was followed by a cycle sequencing reaction in a final volume of 20 µl (molecular grade water (Sigma–Aldrich, Saint Louis, USA), BigDye Terminator v1.1, 1x sequencing buffer, purified PCR product and 0.5 µM template–specific forward or reverse primers). Cycling reactions were carried out separately for each of forward and reverse primers. The reaction programme was set for 1 min at 96°C, 25x (10 sec 96°C, 5 sec 50°C, 2.5 min 60°C), 1 min 20°C. The cycle sequence products were cleaned up using DyeEx 2.0 Spin Kit (Qiagen) and run on a multi–capillary 3500 Genetic Analyzer DNA sequencer (Applied Biosystems, Carlsbad, USA).

Sequence alignment and phylogenetic analyses

Trace files of D2–D3 expansion segments of 28S and 18S–rRNA genes were assembled into contigs and amplification primer sequences trimmed using Geneouis 6.1.6 (Biomatters, New Zealand). Additional trimming was performed when needed, to obtain high quality consensus sequence data. Conflicts in the consensus sequence were assessed visually and corrected where possible. The sequences were aligned with selected sequences of other species from GeneBank using MAFFT alignment (Katoh et al. 2002) within the programme Geneious 6.1.6 (Biomatters New Zealand) for both 28S and 18S–rRNA. Alignments were improved manually. Analysis of phylogeny of the sequence data set was performed with Bayesian inference (BI) using MrBayes 3.2.1 (Huelsenback and Ronquist 2001). The optimal model for nucleotide substitution was obtained using JModelTest ver. 2.1.3 (Darriba et al. 2012) with AIC, AICc, BIC and

DT defaulted in JModelTest. For SSU sequence, analysis of Bayesian inference was performed with a random starting tree and four Markov chains for 1×10^6 under the model TYMef + I. Trees were sampled at interval of 100 generations. Two independent runs were performed for each analysis. The first 100,000 generations were discarded as burn–ins, and the remaining trees combined to generate 50% majority rule consensus tree which represent posterior probabilities. The same parameter settings were used for LSU phylogenetic analysis, but under the model TYM + G.

Results

Morphology

The following are the observations made on selected features considered to be the most differential for species discrimination among members of the genus *Meloidogyne* (Jepson 1987; Karssen 2002). Table 3 shows a comparison of our observations of the most important characters with the ones mentioned in the original descriptions.

Female

Perineal pattern

The general shape of the perineal pattern in both species studied ranged from low rounded to oval. The dorsal arch of *M. mali* and *M. ulmi* was mostly low rounded with very few instances where some specimens showed relatively high square patterns. Lateral field was marked by change in direction or breaks in striae resulting in what would appear as weak lateral lines. The double lateral lines mentioned in the description of *M. mali* were not observed in the studied specimens. The interphasmidial distance in both species was about the same as their corresponding vulva slit lengths. As mentioned in the description, the phasmids were distinct but did not appear large when observed at the correct focus. However, attempting to observe them at the same (relatively deeper) focus as the vulva slit makes them look larger and even farther apart than they really are, due to the diagonally sloping phasmid canals.

Stylet

Same variations in stylet knobs shape as described in *M. mali* were observed for *M. mali* paratypes i.e. slightly backwardly sloping to anteriorly concave, with the former being the more frequent. Such variations, however, cannot be mentioned about the *M. ulmi* paratype since there was only a single anterior part of the female on the slides we obtained. We therefore supplemented it with specimens taken from samples from the "Mierenbos", where the type host originated from. This population showed similar variation as described for *M. mali,* but not reported in Table 3. Our observation of the shape of the stylet itself was typical of the genus, i.e. straight shaft with a slightly dorsally curved cone.

Table 3. Observations of the differential characteristics of female, male and second–stage juveniles of *Meloidogyne mali* and *M. ulmi* types in comparison with their interpretation in the original description.

Species	*M. mali*		*M. ulmi*	
Character	**Described**	**Observed**	**Described**	**Observed**
		Female		
Stylet knobs	Well developed knobs that tend to slope backward or forward in the ratio of 16 to 8	Rounded to pear-shaped knobs, set off and slightly anteriorly concave to backwardly sloping	Knobs rounded to transversely ovoid, slightly concave anteriorly	Rounded knobs that are slightly anteriorly concave and offset
Perineal pattern	Oval, made up of smooth striae, finely spaced, dorsal arch low and flat. Phasmids large, lateral field clearly marked with single or double incisures	Oval, dorsal arch low to slightly high, rounded to square shaped. Phasmids distinct. Lateral field marked by breaks in the striae or showing indistinct lateral lines	Oval, dorsal arch flattened to medium high, rounded or somewhat square, phasmids conspicuous, lateral field indistinct or marked by folds, sometimes by lateral lines on one or both sides	Oval, dorsal arch low to slightly high, rounded to square shaped. Phasmids distinct. Lateral field marked by breaks in the striae or showing indistinct lateral lines
		Male		
Head shape	–	Head weakly offset, head cap low and slightly narrower than the postlabial region. Postlabial incisures absent	Head slightly set off, labial cap shallowly rounded, one–fifth to one–fourth as high as postlabial region	Head weakly offset, head cap low and slightly narrower than the postlabial region. Postlabial incisures absent
Stylet knobs	Knobs rounded	Backwardly sloping with rounded to pear shaped knobs	Knobs rounded to pear shaped more or less backwardly sloping	Backwardly sloping with rounded to pear shaped knobs
		Second–stage juvenile		
Stylet knobs	Knobs backwardly sloped	Small rounded knobs, slightly backwardly sloping	Knobs rounded and set off from shaft	Small rounded knobs, backwardly sloping
Tail shape	Short	Conical with a broad to finely pointed tip	Conical, tapering to a finely rounded almost pointed terminus or broader and rounded at the tip	Conical and tapers to a broadly or finely pointed tip
Hyaline tail part	–	Constrictions present along hyaline part, length short or long. Anterior part clearly delimitated	Cuticular constrictions present along hyaline tail terminus, variable in length	Constrictions present along hyaline part, anterior part clearly delimitated

Secretory-excretory pore

S-E pore position measured from the anterior end showed quite some variations. Nevertheless, all measurements taken for both species fell within the range described for *M. ulmi*. This character in *M. mali* description was measured on the basis of the number of annuli counted from the anterior end to the one bearing the S-E pore.

Male

Head region
Under light microscope, both species have the same head outline. This was already illustrated in the descriptions of the two species (Itoh et al. 1969; Palmisano and Ambrogioni 2000). The head cap in both species is low. The presence of lip annuli mentioned in *M. ulmi* was observed on some of the paratypes studied as well as in some of the additional specimens included later from "Mierenbos". The post–labial cephalic region slightly set off from the remainder of the body. SEM observation of the *en face* view of the lip region was not part of this study. Nevertheless, this will be discussed further on in this work based on previous study conducted by Yaegashi and Okamoto (1981) as well as the original description of *M. ulmi*.

Stylet
The stylet moderately slender. Conus with bluntly pointed tip. The shaft width the same along its entire length, although in some specimens it appeared to be broader close to the junction with the knobs. Individual knobs rounded to pear shaped. Knobs backwardly sloping in both species.

Lateral field
The lateral field marked by four incisures. In most of the specimens studied, the outer lines appeared areolated along most part of the body. No difference in the number of lateral incisures was observed along the body, except at the anterior part where it reduces to two and gradually fades out further anterior.

Hemizonid position relative to S-E pore
Although not considered to be of any diagnostic significance, this character remained fairly consistent in all specimens studied. The hemizonid always occurred anterior to the S-E pore, at slightly varying distances.

Second-stage juveniles
Examination of the second-stage juvenile characters was based on six *M. mali* type specimens and two of *M. ulmi*.

Head region
Head slightly set off from the rest of the body, with a low lip. Post-labial region lacking any annule.

Stylet
Stylet somewhat slender, with conus terminating in a fine tip, in both species. Stylet knobs small and rounded; slightly backwardly sloping.

Hemizonid position relative to S-E pore
Contrary to the condition in males, hemizonid always located behind the S-E pore in second-stage juveniles. However, the exact position is variable.

Tail

Tail mostly straight, ranging from short to medium; with a fine to bluntly rounded tip. Hyaline tail terminus with varying length, anterior part distinctly delimitated.

Morphometrics

Females

Almost all our average measurements were within the range of those in the original descriptions (Table 4–6). In the case of *M. ulmi*, measured values of the female anterior part are based only on a single paratype specimen. Useful differential characters like the stylet length, stylet knob widths and stylet knob heights showed great similarities. From the perineal patterns, measurements of all the known important features also gave comparable values with those in the descriptions. Interphasmidial distance and the vulva slit were in most cases similar, rarely significantly different. In *M. mali*, these two measurements were almost identical. There was however, a slight difference in these two measurements from *M. ulmi* types (Table 4), probably because only two perineal patterns were studied.

Males

Three male paratypes of *M. mali* and two of *M. ulmi* were measured. Some of the studied characters were only visible enough for measurement on single specimens, and therefore for such characters absolute values were taken rather than their averages. The stylet knobs widths and heights were examples of characters for which measurements were not taken on either species (Table 5) due to the fact that they appeared slightly degenerated on all slides, and so may give false measurements. Nevertheless there were still some outstanding similarities in the stylet length, spicule length and DGO between the observed and the described values.

Second-stage juveniles

Similar to the observations made in the females and the males, the second–stage juvenile morphometrics was very comparable in many features between the two species studied. There was, however an unaccountable difference between stylet length as described for *M. mali* (14µm (12–15µm)) and that which was measured (12.1 ± 1.5µm (10.9–13.8µm)). Values of body width at anus level between the two descriptions were very similar. Some measurements taken from *M. ulmi*, likewise were quite similar to those in the original descriptions, particularly, the Demanian ratios a and c', while others such as stylet lengths showed slight differences (Table 6).

Host test

The ability of *M. ulmi* to reproduce on various plant species was examined under greenhouse conditions. Host statuses of the various plants used in the greenhouse test are presented in Table 7. *M. ulmi* population from "Mierenbos" used as inoculum was

Table 4. Morphometrics of *M. mali* and *M. ulmi* females in comparison with the original descriptions. All measurements are in µm and in the form: mean ± sd. (range).

Species	***Meloidogyne mali***		***Meloidogyne ulmi***	
Character	**Described**	**Observed**	**Described**	**Observed**
N	25	17	30	2*
Body length	847 (684–1044)	762 ± 115 (608–890)	771 ± 140 (568–1043)	–
Body width	660 (540–864)	570 ± 122 (372–700)	618 ± 152 (357–1007)	–
Neck length	166 ± 43.7 (90–252)	165 ± 62 (60–265)	165 ± 67 (58–382)	205
Neck diameter	–	100 ± 34.3 (48–160)	–	152
Stylet length	15 (13–17)	11.9 ± 1.8 (7.7–15.4)	14.2 ± 1.0 (12.0–15.7)	13.4
Stylet knob height	–	1.6 ± 0.3 (1–2.2)	1.8 ± 0.6 (1.1–3.9)	1.6
Stylet knob width	–	3.2 ± 0.4 (2.6–3.8)	3.5 ± 0.7 (2.6–5.2)	3.2
DGO	5.5 (4–7)	4.3 ± 1.5 (2.2–6.7)	4.6 ± 0.8 (3.3–6.5)	3.9
S-E pore	–	32.8 ± 5.5 (25–43.5)	32.3 ± 7.8 (15.7–45.1)	36.5
Metacorpus	110 (90–147)	103 ± 7.9 (90–117)	–	92.8
Metacorpus length	39 (32–44)	40.4 ± 4.5 (32–50)	42.6 ± 6.5 (32.7–58.8)	39.7
Metacorpus diameter	49 (40–73)	39.7 ± 6.5 (29–47)	40.9 ± 7.0 (31.3–59.0)	36.5
Metacorpus valve length	12 (11–13)	13.0 ± 1.1 (11.5–15.4)	12.4 ± 1.0 (11.1–14.4)	17.9
Metacorpus valve width	10 (9–11)	9.5 ± 1.3 (7–11.2)	9.7 ± 1.4 (7.2–12.4)	10.2
Vulva – anus distance	17 ± 1.8 (14–22)	19.1 ± 2.6 (12.8–22.4)	19.0 ± 1.9 (15.0–22.2)	19.2 ± 0.8 (18.8–19.8)
Interphasmidial distance	22 ± 3.5 (17–29)	24.8 ± 4.7 (17.6–35.2)	19.2 ± 3.8 (13.7–28.9)	22.4 ± 4.5 (19.2–25.6)
Level of phasmids to vulva	25 ± 2.4 (19–31)	27.4 ± 2.8 (24–33.9)	25.1 ± 4.2 (15.7–39.2)	27.6 ± 0.9 (26.9–28.2)
Level of phasmids to anus	–	8.1 ± 2.5 (5.1–12.8)	6.9 ± 2.2 (2.6–15.7)	8.7 ± 1.3 (7.7–9.6)
Vulva slit length	18 ± 2.5 (12–24)	24.4 ± 3.3 (16–28.2)	22.0 ± 2.9 (17–28.7)	24.5 ± 1.1 (23.7–25.3)

*Two perineal patterns and a single anterior part.

able to induce galls and reproduce on both *Ulmus glabra* and *U. hollandica* 'belgica'. The apple 'M9' also had galls which contained egg-laying females. Although galls were induced by *M. ulmi* on *Brassica oleracea* var. *gemmifera,* most of these galls contained

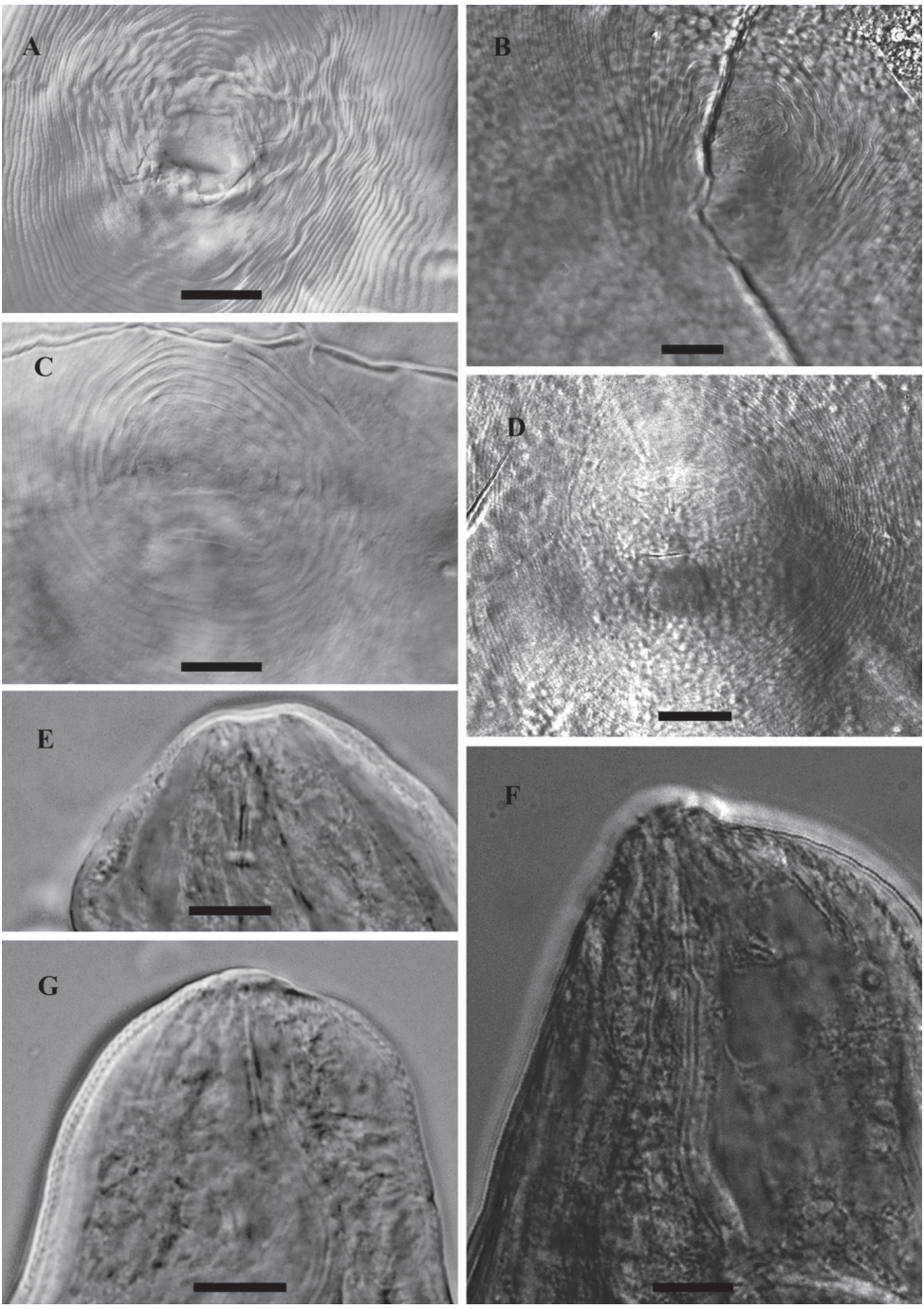

Figure 1. LM photograph of perineal patterns and anterior parts of female *Meloidogyne mali* (**A, C, E, G**) and *Meloidogyne ulmi* (**B, D, F**), bar = 10 µm.

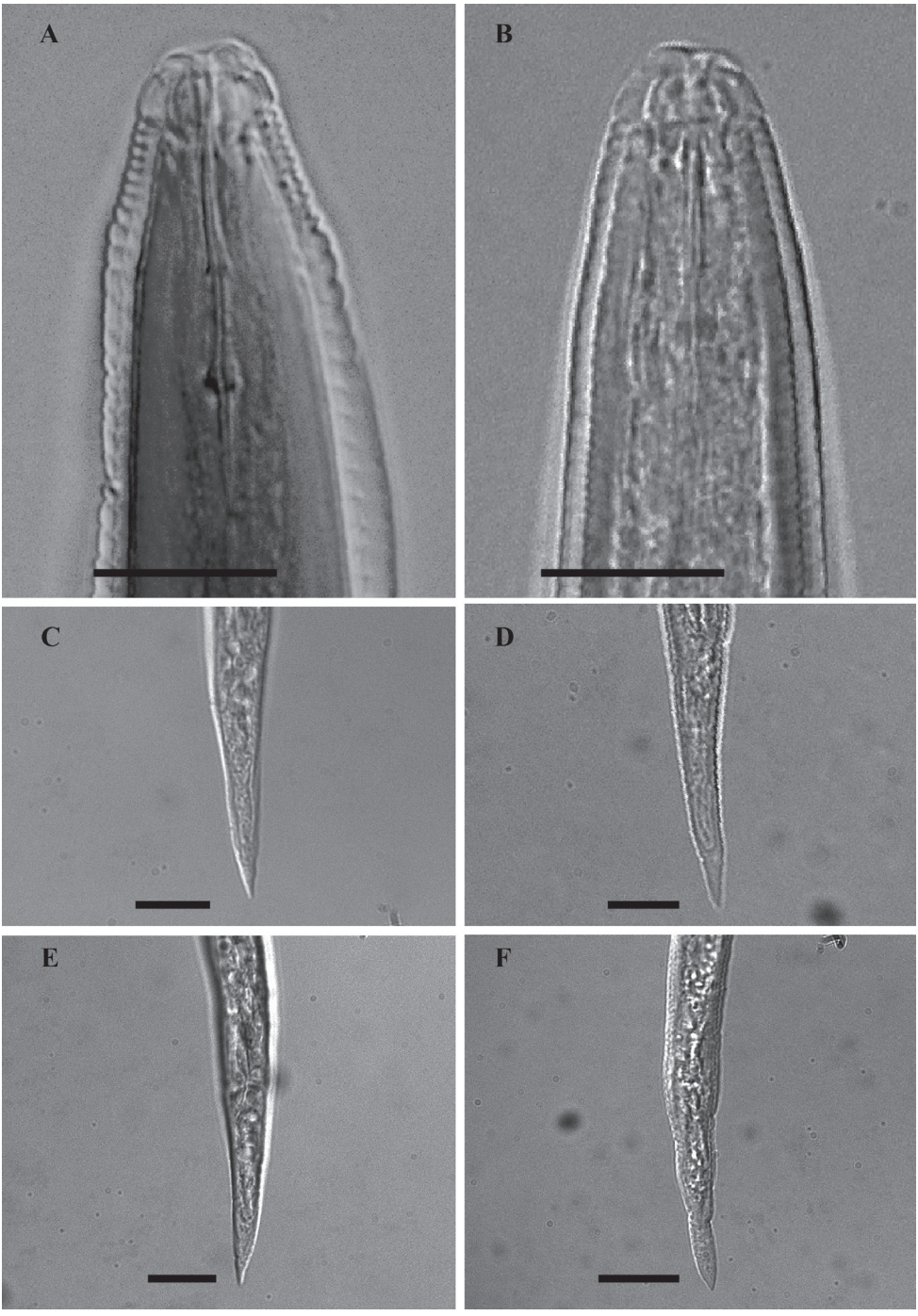

Figure 2. LM photographs of males anterior part and second- stage juvenile tails of *Meloidogyne mali* (**A, C, E**) and *Meloidogyne ulmi* (**B, D, F**), bar = 10 µm.

Table 5. Morphometrics of *M. mali* and *M. ulmi* males in comparison with the original descriptions. All measurements are in µm and in the form: mean ± sd. (range).

Species	*Meloidogyne mali*		*Meloidogyne ulmi*	
Character	**Described**	**Observed**	**Described**	**Observed**
N	25	3	30	2
Body length	1447 (1270–1630)	1428 ± 41.0 (1380–1452)	1462 ± 190 (1053–1776)	1455 ± 64 (1410–15.0)
Body width	38 (30–47)	34.8 ± 9.6 (28.0–41.8)	36.9 ± 4.3 (26.6–48.4)	40.5 ± 0.7 (40.0–41.0)
Body width at stylet knobs	–	15.7 ± 0.4 (15.4–16.0)	16.7 ± 1.3 (14.5–19.4)	17.6 ± 1.1 (16.8–18.4)
Body width at S.E pore	–	24.5 ± 6.1 (20.2–28.8)	27.6 ± 2.6 (23.0–31.5	28.4 ± 0.6 (28.0–28.8)
Stylet length	20 18–22	19.9 ± 1.8 (18.6–21.1)	19.4 ± 1.2 (17.5–22.9)	19.9 ± 0.9 (19.2–20.5)
Stylet knob height	–	–	2.4 ± 0.1 (2.0–3.0)	–
Stylet knob width	–	–	3.9 ± 0.4 (3.0–4.8)	–
DGO	8 (6–13)	9	6.3 ± 0.8 (4.8–8.5)	7.4 ± 0.5 (7.0–7.7)
S-E pore*	–	135.2	147 ± 18.8 (97–187)	139 ± 7.1 134–144
Metacorpus**	–	98 ± 21.5 (83–114)	99 ± 9.8 (76–119)	83 ± 12.7 (134–144)
Spicule	32 (28–35)	28.1 ± 10.3 (20.8–35.3)	33.8 ± 1.9 (30.0–37.5)	29.8
Gubernaculum	8.5 (7–10)	10.1	9.0 ± 0.9 (7.3–9.8)	8.4 ± 0.4 (8.1–8.7)
Testis length	788 (540–970)	803 ± 125.9 (714–892)	716 ± 167 (324–977)	752 ± 79 (696–808)
T	55 (34–65)	55.3 ± 8.6 (49.2 – 61.4)	48.7 ± 9.7 (27.9–71)	52 ± 3.2 (49–54)

* Distance from anterior end to S-*E* pore. ** Distance from anterior end to valve plate of median bulb.

small non–gravid females whose development seemed to have ceased at some point. Therefore, it is herein not considered as a host. There were no galls on *Rosa hybrida* and the other cabbage species, *B. pekinensis*.

Additionally, samples collected during 2011 and 2012 revealed that *M. ulmi* is able to parasitize one or more species of *Acer* (Aceraceae), *Impatiens* (Balsaminaceae), *Taraxacum* (Compositae), *Dryopteris* (Dryopteridaceae), *Fagus* (Fagaceae), *Quercus* (Fagaceae), *Geranium* (Geraniaceae), *Geum* (Rosaceae), *Rubus* (Rosaceae), *Sorbus* (Rosaceae), *Taxus* (Taxaceae), *Urtica* (Urticaceae), as shown in Table 7.

Table 6. Morphometrics of *M. mali* and *M. ulmi* second–stage juveniles in comparison with the original descriptions. All measurements are in μm and in the form: mean ± sd. (range).

Species	*Meloidogyne mali*		*Meloidogyne ulmi*	
Character	**Described**	**Observed**	**Described**	**Observed**
N	25	5	30	3
Body length	418 (390–450)	420 ± 21.7 (390–446)	413 ± 20.6 (373–460)	384 ± 9.5 (374–394)
Body width	14.5 (14–16)	14.0 ± 1.1 (12.2–15.2)	14.2 ± 1.8 (12.1–18.2)	12.7 ± 3.8 (8.6–16.9)
Body diameter at anus	8.5 (7–9)	9.4 ± 1.8 (8.3–11.5)	8.4 ± 1.0 (7.3–10.9)	6.5 ± 0.7 (6.0–7.0)
Stylet length	14 (12–15)	12.1 ± 1.5 (10.9–13.8)	10.0 ± 0.8 (8.5–11.1)	11.1 ± 0.6 10.6–11.5
Tail length	31 (30–34)	30.2 ± 4.3 (24.3–33.9)	31.3 ± 3.1 (24.2–37.5)	24.2 ± 0.8 (23.4–25.0)
Tail terminus length	–	7.0 ± 2.1 (5.1–9.8)	8.2 ± 1.8 (4.8–12.7)	5.7 ± 1.1 (4.5–6.7)
Anus–primordium	–	139 ± 11.4 (125–152)	–	126 ± 21.8 (111–151)
a	28.5 (27–31)	30.2 ± 3.2 (27.1–34.8)	29.5 ± 3.4 (22.3–35.5)	32.5 ± 10.9 (23.4–44.7)
c	13.3 (12–15)	14.4 ± 2.3 (12.5–17.4)	13.3 ± 1.2 (11.5–16.6)	16.3 ± 0.7 (15.8–16.8)
c’	3.7 (3–5)	3.3 ± 0.7 (2.5–3.9)	3.7 ± 0.5 (2.5–4.7)	3.7 ± 0.5 (3.3–4.1)

Isozyme analysis

Samples taken from the trial field “Mierenbos” all gave the same type of esterase isozyme pattern of weak single bands, corresponding to the VS1 type (Esbenshade and Triantaphyllou 1985). When analysed for MDH, some individuals gave single–banded patterns of the H1 type (Esbenshade and Triantaphyllou 1985), while others revealed a three–banded pattern, herein designated H3. Usually, the H1 type had two additional weaker bands at the same level as the upper two H3 bands. There was also an additional observation in the types of single bands some of the specimens produced (Fig. 3). These single bands were positioned at the same level as the upper H3 band, which herein are given the name H1a.

Phylogenetic relationship between *Meloidogyne mali* and *M. ulmi*

The obtained SSU rDNA and LSU rDNA sequence lengths for *Meloidogyne ulmi* were 781bp (including gaps) and 698bp (including gaps) respectively. In addition to our four SSU rDNA sequences of *M. ulmi* “Mierenbos” (KF895397, KF895398, KF895399

Table 7. Plants species identified as host of *M. ulmi* from the green house experiments and field survey at "Mierenbos".

Family	Plant species
Greenhouse test	
Ulmaceae	*Ulmus glabra* Huds.
	Ulmus hollandica 'belgica'
Rosaceae	*Malus pumila* 'M9'
Solanaceae	*Solanum lycopersicum* L.
Field hosts	
Sapindaceae	*Acer pseudoplatanus* L.
Balsaminaceae	*Impatiens parviflora* DC.
Asteraceae	*Taraxacum officinale* F.H. Wigg.
Dyopteridaceae	*Dryopteris filix-mas* (L.) Schott
	Dryopteris carthusiana (Vill.) H.P. Fuchs
Fagaceae	*Fagus sylvatica* L.
	Quercus robur L.
Geraniaceae	*Geranium robertianum* L.
Rosaceae	*Geum coccineum* Lindl.
	Rubus idaeus L.
	Sorbus aucuparia L.
Taxaceae	*Taxus baccata* L.
Ulmaceae	*Ulmus davidiana* var. *japonica* Rehder
Urticaceae	*Urtica dioica* L.

and KF895400), 69 accessions belonging to other species of *Meloidogyne* from GeneBank were included in the local alignment (781 aligned positions, including gaps). For LSU rDNA, we had only one sequence of *M. ulmi* "Mierenbos" (KF895396) due to poor data, resulting in lack of consensus sequence. Therefore the multiple sequence alignment included this sequence and 69 GeneBank accessions from other species of *Meloidogyne*. *Pratylenchus vulnus* Allen & Jensen, 1951 was selected as outgroup for constructing gene trees using Bayesian inference from both SSU rDNA and LSU rDNA sequences. SSU rDNA–based phylogenetic analysis put all sequences of *M. ulmi* obtained together with those of *M. mali* and *M. ulmi* from GeneBank in one strongly supported polytomous branch. Despite the relatively short sequence length of SSU rDNA, the tree was able to resolve relationship between certain species in a way comparable with that of Holterman et al. (2009). LSU rDNA-based Bayesian analysis revealed higher resolution within the group containing our sequence and sequences of *M. mali* and *M. ulmi* from GeneBank. Our sequence of *M. ulmi* was positioned in a branch that contained three other sequences of *M. mali*, forming a sister group to another branch composed also of two sequences of *M. ulmi* and one of *M. mali*. As would be expected, there was higher resolution in the overall topology of LSU rDNA-based tree than that of SSU rDNA.

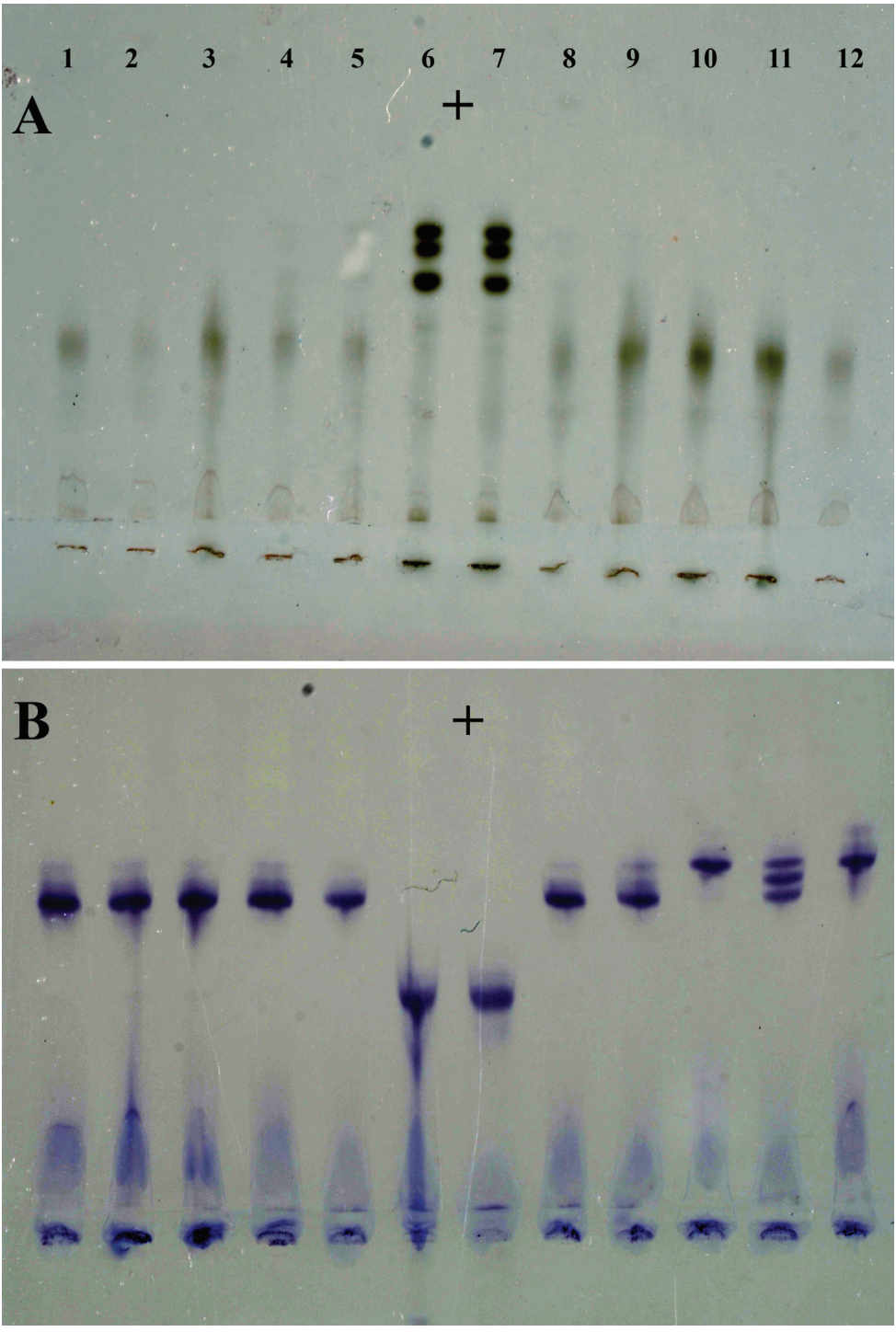

Figure 3. Isozyme phenotypes from ten individual females of *Meloidogyne ulmi* from "Mierenbos". **A** Esterase **B** Malate dehydrogenase. *M. ulmi* (1–5 and 8–12); *M. javanica* (6 and 7) as reference marker.

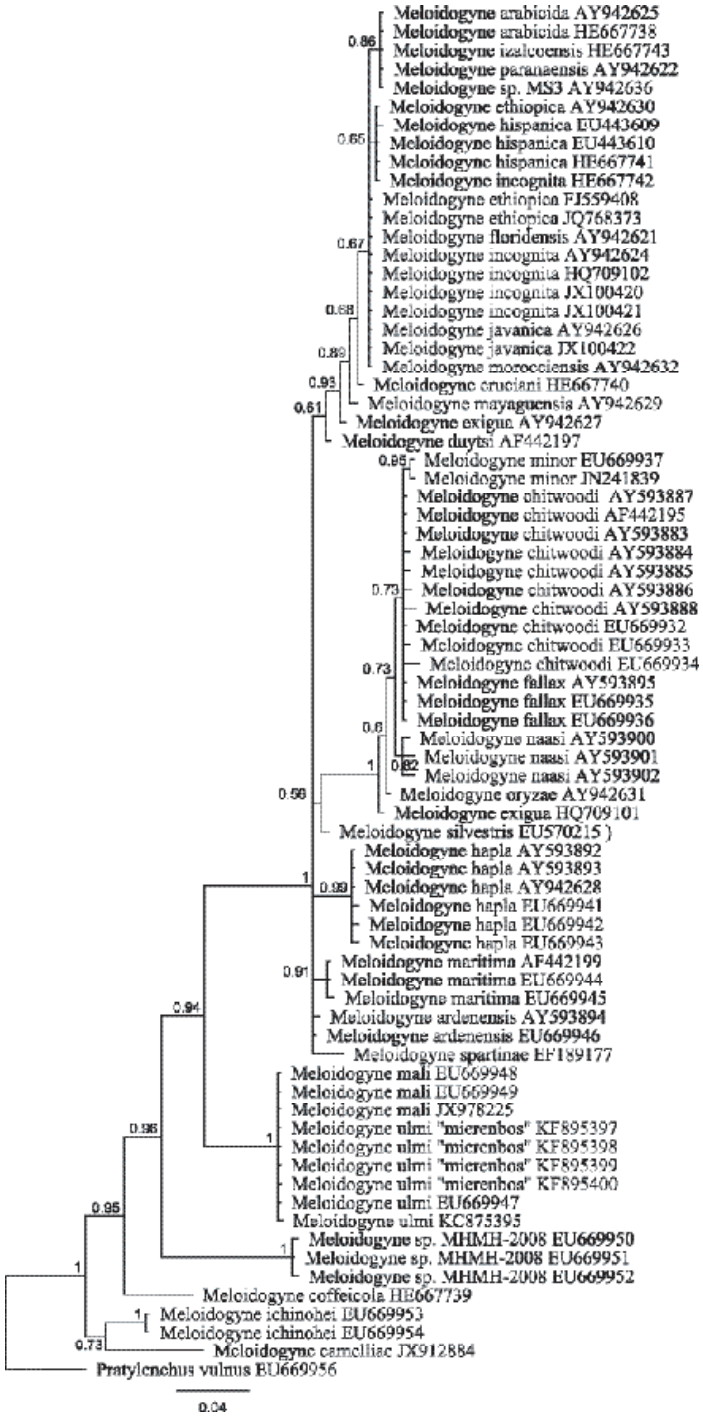

Figure 4. Bayesian tree inferred from part of 18S rRNA using TYMef + I model. Sequences were aligned with MAFFT alignment. Numbers near the nodes indicate posterior probabilities. NCBI accession numbers are listed with the species names.

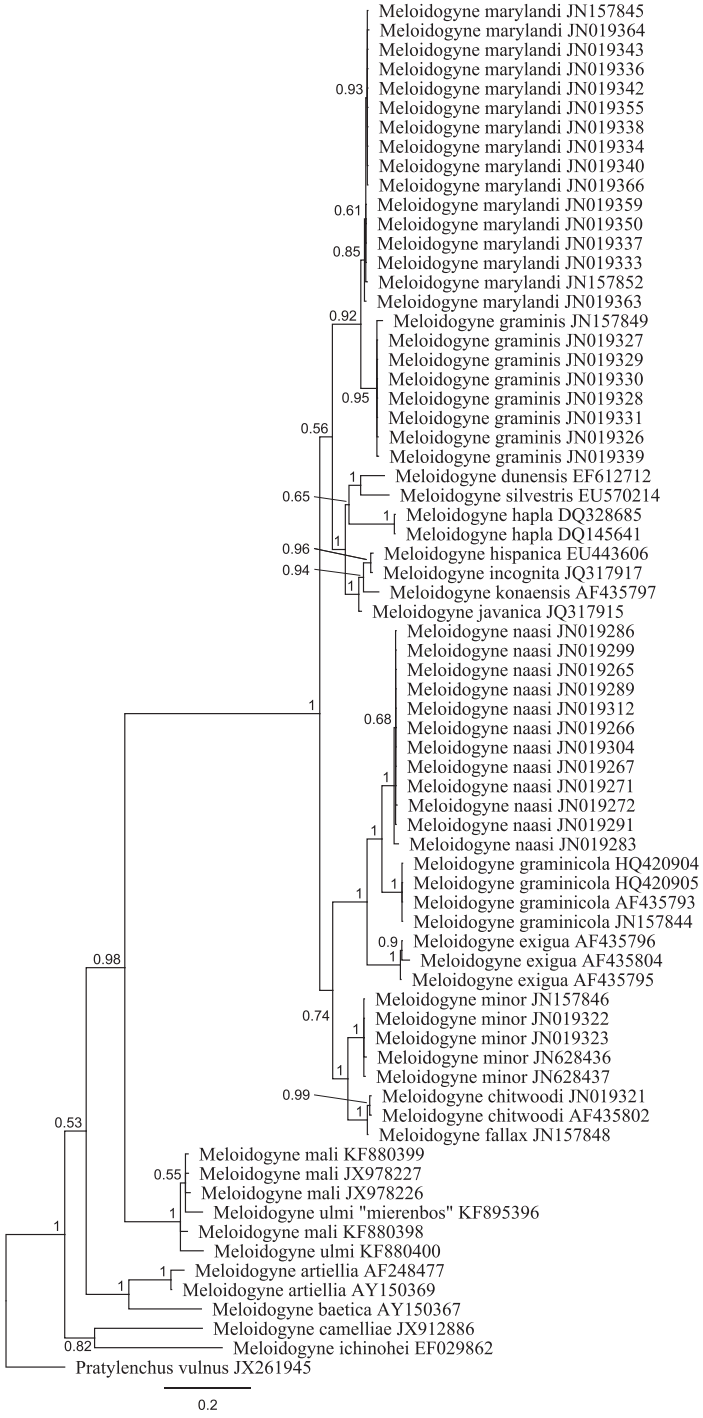

Figure 5. Bayesian tree inferred from part of D2 D3 of 28S rRNA using TYM + G model. Sequences were aligned with MAFFT alignment. Numbers near the nodes indicate posterior probabilities. NCBI accession numbers are listed with the species names.

The sequence identity between the closest sequences of *M. mali* and *M. ulmi* was 98.8 % with one gap. Interestingly, the same percentage was obtained between two sequences of *Meloidogyne mali* from GeneBank (JX978226 and JX978227).

Discussion

Type specimens representing holotypes and paratypes of the two *Meloidogyne* species were analysed in order to demonstrate the morphological similarities that existed between them. Most of the slides we received were in good conditions except for some few individuals that showed some signs of deterioration, either due to long period of storage or poor conditions at the time they were prepared. Nevertheless, the general states of the important characters were still maintained.

On the morphology, an important character like the occurrence of double lateral lines mentioned in the description and by Jepson (1987) was not observed in all specimens. In fact this area was marked by breaks in the striae on some of the specimens studied. Morphometric values of some characters for the two species fell within the range of values reported in the original description of *M. mali* (Itoh et al. 1969), for example position of DGO in females, as well as in males, vulva–anus distance, level of phasmids to vulva, vulva slit length, male stylet length, testis length, spicule length gubernaculum length, J2 body length, and J2 c' values (Tables 4–6). For some characters, however, morphometric values recorded agreed more with those reported for *M. ulmi*. For example, the stylet length measured in females and J2s was significantly lower than the values given for *M. mali*, but comparable with that of *M. ulmi*. A possible explanation might be the fact that stylet in juveniles and sometimes in females appear less visible, causing the anterior end to be mistaken for the tip of the conus. This leads to misleadingly higher values for the stylet length.

Already in the original description of *M. ulmi*, only a few differences could be found to separate it from *M. mali*. And in some cases, the differences emanated from some apparent mistakes in the original description of *M. mali*. An example is the use of male tail length of the two species to draw differences. Tail length in males of *M. mali* was given as ranging between 28 and 44 µm, making it extremely longer than that of *M. ulmi* 10.9 µm. However, it is important to mention that tail length values as long as the range of between 28 and 44 µm never exists among males of species of the genus *Meloidogyne*.

The DGO position in males with reference to the stylet knobs according to Jepson (1987) bears some broad interspecific variation, making it very useful for species discrimination. *M. mali* is by far the species with the most farther DGO position (6–13 µm) within the genus *Meloidogyne*. The observation of similar values for both species studied here therefore separates the two from all other species that have relatively shorter DGO position. Additional *M. ulmi* specimens studied also gave DGO position values averaging 8 µm (data not shown).

Eisenback and Hirschmann (1981) highlighted the significance of SEM studies of male head shapes in *Meloidogyne* taxonomy, outlining the role SEM has played

in raising the value of males for use in comparison of species. Head and stylet shape morphologies of males and juveniles are the most useful supplemental taxonomic characters that SEM studies have given new insights into (Eisenback and Hirschmann 1979; 1981). It is not surprising that a number of variability in these characters were outlined to separate *M. ulmi* from *M. mali* by Palmisano and Ambriogioni (2000). It was mentioned (p. 288) that "under SEM lateral lips absent or vestigial (in *M. mali* lateral lips apparent)". Interestingly, this contradicted the comparison made by Toida and Yaegashi (1984) when they attempted to point out the differentiating characters between *M. suginamiensis* and *M. mali*. In their comparison, the *en face* view of the lip region of *M. mali* was mentioned as having no or obscure lateral lips to separate it from *M. suginamiensis* in which lateral lips were described as clear. One would not expect such contradicting accounts especially with the possibility that both works referred to the same publication (Okamoto et al. 1983). Referring to a separate work (Yeagashi and Okamoto 1981), the account given by Toida and Yaegashi (1984) seems to us more probable, the first reason being that they published the same work which is being referred to. Therefore they understand the details of their results more. And the second reason is that our observations of SEM images of (Yeagashi and Okamoto 1981) agree more with the account that lateral lips were vestigial and not apparent in *M. mali*.

Both apple and elm trees supported *M. ulmi* reproduction. This does not only provide an additional support for the synonymization of *M. ulmi* with *M. mali*, but represents the first and only test involving the former on an apple plant. In principle, however, the first actual report was the description of *M. mali* on apple in Japan (Itoh et al. 1969). Contrary to the finding in the original description, the status of white clover as host to *M. mali* could not be confirmed with *M. ulmi*. Again, although representatives of the family Rosaceae form the larger part of the plants *M. mali* parasitizes (Itoh et al. 1969; Toida 1979), rose (*Rosa hybrida*) could not support the reproduction of *M. ulmi*. This contradicts earlier finding, Itoh et al. 1969, who identified rose as host. *M. ulmi* was also able to induce galls on *Prunus yodoensis* grown in the field, confirming the earlier report of the latter's status as a host for *M. mali* by Toida (1979). Results of the sampling have also revealed new natural hosts for *Meloidogyne ulmi* like *Acer pseudoplatanus* L., *Fagus sylvatica* L., *Quercus robur* L., *Rubus idaeus* L., *Sorbus aucuparia* L., *Taxus baccata* L., *Dryopteris filix–mas* (L.) Schott, *Dryopteris carthusiana* (Vill.) Fuchs, *Geranium robertianum* L., *Urtica dioica* Rehder., *Impatiens parviflora* DC., *Taraxacum officinale* F.H. Wigg., and *Geum coccineum* Lindl. The most relevant evidence deduced from this host plant test is the ability of *M. ulmi* to reproduce on apple.

It is interesting to mention that the observed variability of the MDH isozyme phenotypes among the different specimens was similar to the findings of Sakai and Mizukubo (2009) when they studied two populations of *M. mali* from Hokkaida on apple and Saitama on cherry in Japan. The populations from Hokkaida gave phenotypes with single MDH bands whereas those from Saitama on cherry produced variable patterns with single and triple bands. PCR–RFLP of D2/D3 expansion segment of 28S rDNA and mtDNA intergenic region with *Alu* I was able to confirm that population from Saitama were all identical, despite their expression of variable MDH isozyme pheno-

types. Similar observations of intraspecific phenotype variations were made by Dalmasso and Bergé (1978) among a certain *M. arenaria* population where there were three MDH bands instead of two. Such type of variable isozyme patterns were also observed within one population of the sexually reproducing species *M. microtyla* Mulvey, Townshend & Potter, 1975 (Karssen unpublished). This indicates that *M. mali* could also be a sexually reproducing species or a meiotic parthenogenetic one, a claim which is further supported by the frequency at which males are encountered in galled root samples—at least one male per female in a gall. Meanwhile, the esterase phenotypes were rather stable across all studied specimens and were characterised by weak indistinct single bands.

Trimming the SSU and LSU datasets to high quality sequence data may have caused a loss in phylogenetic signal. For SSU rDNA, over half of the target sequence length was trimmed out because of the poor quality of the dataset obtained. Although not ideal for reconstruction of phylogeny, it was still sufficient to resolve the taxa on a species level. Moreover, it has to be emphasized that the purpose here is not to reconstruct any formal phylogeny of *Meloidogyne*, a subject which is well covered already in previous studies (Tandingan De Ley et al. 2002; Holterman et al. 2009), but only to demonstrate that *M. mali* and *M. ulmi* are highly similar at the molecular level and belong to the same clade. A recent phylogenetic analyses involving these two species has already pointed to the fact that the two can not be separated based on their SSU rDNA sequences (Rybarczyk-Mydłowska et al. in press). The SSU rDNA sequence once again gave resolution till the species level, confirming previous proposition that SSU rDNA sequence signatures can be defined at species level for a wide range of parasitic and non-parasitic nematodes (Holterman et al. 2006). As was expected, LSU rDNA-based analysis gave even higher resolution and more clearly defined the relationship between *M. mali* and *M. ulmi*. On the SSU rDNA based tree, it is unquestionable that our sequence of *M. ulmi* with all the other sequences of *M. mali* and *M. ulmi* are the same (Fig. 4). The clustering of our sequence of LSU rDNA for *M. ulmi* with those for *M. mali* may be an indication that the branching could only be due to intraspecific sequence variation.

Conclusion

In conclusion, the evidence from morphological and morphometrical studies of holo– and paratype materials of *Meloidogyne mali* and *M. ulmi* as well as host plant studies, isozyme analysis and DNA analysis all confirm the status of *M. ulmi* as a junior synonym of *M. mali*.

Notes on the life cycle and biology of *Meloidogyne mali* on *Ulmus* spp.

The life cycle of *Meloidogyne mali* is in many respects typical of the genus. *Meloidogyne mali* requires 18–22 weeks to complete one full generation on apple and does so only once in a year (Inagaki 1978). The study also reported that adult males and females

Table 8. A compilation of all known host plants of *Meloidogyne mali* to date.

Family	Plant species	Reference
Rosaceae	*Malus pumila* Mill.	Itoh et al. 1969
	Malus prunifolia Borkh.	Itoh et al. 1969
	Malus sieboldii Rehd.	Itoh et al. 1969
	Malus pumila "M9"	Current work
	Prunus yedoensis Matsum	Itoh et al. 1969
	Rosa hybrida Hort.	Itoh et al. 1969
	Geum coccineum Lindl.	Current work
	Vitis vinifera L.	Itoh et al. 1969
	Rubus idaeus L.	Current work
	Sorbus aucuparia L.	Current work
Moraceae	*Morus bombycis* Koidz.	Itoh et al. 1969
	Ficus carica L.	Toida 1979
	Maclura tricuspidata (Carriere) Bureau	Toida 1979
	Broussonetia papyrifera (L.) Vent	Toida 1979
	Broussonetia kazinoki Seibold.	Toida 1979
Fagaceae	*Castanea crenata* Seib. Et Zucc	Itoh et al. 1969
	Fagus sylvatica L.	Current work
	Quercus robur L.	Current work
Ulmaceae	*Ulmus davidiana* var. *japonica*	Toida 1979
	Ulmus chenmoui W.C. Cheng	Palmisano and Ambrogioni 2000
	Ulmus glabra Hud.	Palmisano and Ambrogioni 2000
	Ulmus × *hollandica* "belgica"	Current work
Sapindaceae	*Acer palmatum* Thunb.	Itoh et al. 1969
	Acer pseudoplatanus L.	Current work
	Trifolium repens L.	Itoh et al. 1969
Taxaceae	*Taxus baccata* L.	Current work
Fabaceae	*Impatiens parviflora* DC.	Current work
Solanaceae	*Solanum lycopersicum* L.	Toida 1979
	Solanum melongena L.	Toida 1979
	Capsicum annuum L.	Toida 1979
Cucurbitaceae	*Cucumis sativus* L.	Toida 1979
	Cucurbita spp.	Toida 1979
	Citrillus vulgaris Schrad. Ex Eckl. & Zeyh.	Toida 1979
Cruciferae	*Brassica pekinensis* Rupy.	Toida 1979
	Brassica oleracea var. *capitata* L.	Toida 1979
	Brassica napus var. *oleifera* L.	Toida 1979
Compositae	*Arcutium lappa* L.	Toida 1979
	Taraxacum officinale F.H. Wigg.	Current work
Umbelliferae	*Daucus carota* var. *sativa* L.	Toida 1979
Leguminaceae	*Glycine max* (L.) Merr.	Toida 1979
Urticaceae	*Urtica dioica* L.	Current work
Dryopteridaceae	*Dryopteris filix-mas* (L.) Schott	Current work
	Dryopteris carthusiana (Vill.) H.P. Fuchs	Current work
Geraniaceae	*Geranium robertianum* L.	Current work

Figure 6. Root gall symptoms of *Meloidogyne mali* infection on (**A, B**) *Malus pumila* "M9" (**C, D**) *Ulmus davidiana* var. *japonica* and (**E, F**) *Solanum lycopersicum.*

first were observed after twelve weeks and continued to increase till the twentieth, when egg masses began to appear. There was also some reports on the distribution of *M. mali* in the field, both vertically and horizontally. However, nothing is known so far about its survival on apple or any other plant during frost conditions of winter. Regarding this, a very interesting observation was made during early spring of 2013 at the trial field "Mierenbos". Egg-laying females were already found in most galls that were examined, a rare phenomenon known to occur only in *M. ardenensis* (Stephan and Trudgill 1982). The only plausible explanation to why egg-laying females can be observed so early in the year is that, like reported for *M. ardenensis*, the nematodes overwintered in the roots. Additional observations need to be made to find out exactly what stage in the development overwinters in the root.

Host plants and distribution of *M. mali* in Europe

Meloidogyne mali induces a similar type of galls as do *M. arenaria* on tomatoes, a type of gall commonly referred to as bead-like galls (Fig. 6). Concerning the current distribution of the nematode in Europe, no study has yet been done to investigate this. However, it would be rational to speculate that *M. mali* may be found in all the ten European countries to which rooted seedlings were sent after the breeding programme. These countries include Belgium, England, France, Ireland, Italy, Spain, Denmark, Germany, Slovakia and Romania (Heybroek 1993). Elsewhere in Asia, it has also been found in *Acer palmatum* trees from Japan that were intercepted in China (Gu unpublished). Sequence data from these were also included in the analysis.

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Beetles that live with ants (Carabidae, Pseudomorphini, *Pseudomorpha* Kirby, 1825): A revision of the *santarita* species group

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Abstract

The Western Hemisphere genus *Pseudomorpha* Kirby 1825 was last revised by Notman in 1925 based on only a few known species (22) and paltry few specimens (73); other authors have added an additional six species represented by 53 additional specimens since 1925. Baehr (1997) assigned three species from Australia to this genus, albeit in a new subgenus, *Austropseudomorpha* Baehr 1997. A recent study of collections from throughout the Americas (1757 specimens) has revealed numerous new species that can be arrayed across 19 species groups based on a suite of attributes, some used by Notman and others newly discovered. A taxonomic revision of the species contained in one of these species groups, *santarita*, is provided herein, as well as a distributional synopsis of the remaining 18 species groups. New species described herein are as follows, each with its type locality: *Pseudomorpha huachinera* **sp. n.**, Arroyo El Cocono, Sierra Huachinera, Sonora, México; *P. patagonia* **sp. n.**, Madera Canyon, Santa Rita Mountains, Arizona; *P. penablanca* **sp. n.**, Peña Blanca Lake, Arizona; *P. pima* **sp. n.**, Madera Canyon (lower), Santa Rita Mountains, Arizona; *P. santacruz* **sp. n.**, Madera Canyon, Santa Rita Mountains, Arizona; and *P. santarita* **sp. n.**, Santa Rita Ranch, Santa Rita Mountains, Arizona.

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Resumen

El género *Pseudomorpha* Kirby 1825 del hemisferio occidental fue revisado la última vez por Notman en 1925 basado en solo unas pocas especies conocidas (22) y pocos especímenes muy pobres (73); desde 1925 otros autores añadieron 6 especies representadas por 53 especímenes adicionales. Baehr, en 1997, asignó tres especies de Australia a este género, aunque en un subgénero nuevo, *Austropseudomorpha* Baehr 1997. Un estudio reciente de las colecciones a través de las Américas (1757 especímenes) ha revelado numerosas especies nuevas que pueden ser ordenadas en 19 grupos de especies basadas en una serie de atributos, algunos usados por Notman y otros recién descubiertos. Una revisión taxonómica de las especies contenidas en uno de estos grupos de especies, *santarita*, se provee aquí, así como una sinopsis distribucional de los otros 18 grupos. Las nuevas especies descritas aquí son las siguientes, cada una con su localidad tipo: *Pseudomorpha huachinera* **sp. n.**, Arroyo El Cocono, Sierra Huachinera, Sonora, México; *P. patagonia* **sp. n.**, Madera Canyon, Santa Rita Mountains, Arizona; *P. penablanca* **sp. n.**, Peña Blanca Lake, Arizona; *P. pima* **sp. n.**, Madera Canyon (bajo), Santa Rita Mountains, Arizona; *P. santacruz*, **sp. n.**, Madera Canyon, Santa Rita Mountains, Arizona; and *P. santarita* s**p. n.**, Santa Rita Ranch, Santa Rita Mountains, Arizona.

Keywords

False-form beetles, new species, new species groups, identification key, distributions, male genitalia, female ovipositor, Hymenoptera: Formicidae

Palabras clave

Carábidos atípicos, nuevas especies, nuevos grupos de especies, clave de identificación, distribuciones, genitalia del macho, ovipositor de la hembra, Hymenoptera: Formicidae

Introduction

Species of *Pseudomorpha* and some related genera are obligatory myrmecophiles in their larval stages. All known species of *Pseudomorpha* are terrestrial and their ant hosts live in the soil; however, adults of the pseudomorphine genus *Samiriamorpha* have been found in the arboreal nests of *Azteca* ants (Erwin and Geraci 2008). The genus *Pseudomorpha* currently includes 27 described species in the Western Hemisphere and more than 125 undescribed species (Erwin in prep.). The present contribution provides information on six undescribed species in the new *santarita* species groups with a key for identification of those species. Notman (1925) did not have specimens of this group; therefore, they do not run to any couplet he provided in his key. With the current treatment, we start bringing organization to one of the last poorly known carabid lineages in North America particularly, but also in Middle and South America. This information will begin to aid those interested in ants and their commensals, as well as collection managers in understanding what is present in their collections and how it is to be ordered.

Erwin and Geraci (2008) provided a complete history of work on this group of carabid beetles in the Western Hemisphere; Baehr (1992, 1997) did the same for the

Eastern Hemisphere species. The only monograph published of the Western Hemisphere species is that of Notman (1925). His key to the species known to him at the time, as it turns out, is more of a key to species groups now that we know there are over 125 species in *Pseudomorpha*, alone. Lenko (1972) and Erwin (1981) described larvae and Liebherr and Kavanaugh (1985) noted that species of *Pseudomorpha* are ovoviviparous. Since Erwin and Geraci (2008), an additional new genus was discovered in Guyane (French Guiana) (Erwin 2013)

Specimens and methods

Included in the overall study of this genus are a total of 1757 specimens from the National Museum of Natural History, Washington, DC (NMNH, Terry L. Erwin, Curator) and several other institutions and private collections (see Appendix 1 for the specimens covered in the current paper).

Methods and species concepts follow those previously described (Ball 1959; Erwin and Kavanaugh 1981; Kavanaugh and Erwin 1991). The species validation and diagnosis format follows as closely as possible that suggested in Erwin and Johnson (2000). Measurements of length (ABL, SBL) and width (TW) follow those of Ball (1972) and Kavanaugh (1979): ABL (apparent body length), measured from apex of labrum to apex of the abdomen; SBL (standardized body length), equals the sum of the lengths of the head (measured from apex of clypeus to a point on midline at level of the posterior edge of compound eyes), PL (pronotal length), measured from apical to basal margin along midline, and LE (elytron length), measured from apex of scutellum to apex of the longer elytron; and TW (total width), measured across both elytra at their widest point with suture closed. Measures and ratios are presented in the tables in Appendix 2.

Habitus and attribute images of the adult beetles portray most of the character states referred to in the key provided. Male and female genitalic presentations are standard for descriptive taxonomy of carabid beetles, and in this case are digital photo-illustrations (Erwin 2011). The images of the adult and its parts were made with a Visionary Digital™ high resolution imaging system. Figure captions include an ADP number, which is a unique identification number for the specimen that was illustrated or imaged and links the specimen and associated illustrations and/or image to additional information in electronic databases at the NMNH.

Geographical data are presented based on all known specimens of each species available at the time of manuscript preparation. Georeferences have been determined from locality information provided on specimen labels. Latitude and longitude are reported in decimal degrees. A distribution map is provided for the species (Fig. 18). Herein, an English vernacular name is proposed, as vernacular names are becoming increasingly needed in conservation and/or agricultural and forestry applications, as well as for the Encyclopedia of Life (www.eol.org).

Accounts of taxa

Pseudomorphini Newman, 1842
http://species-id.net/wiki/Pseudomorphini
False-form beetles

Pseudomorphini Newman, 1842:365 (as Pseudomorphites)

Taxonomy. Stable at the generic level.

Classification. According to Ober and Maddison (2008), Pseudomorphini appears as a branch of the higher Carabidae and associated with Graphipterini and Orthogonini; according to Erwin and Geraci (2008), the adelphotaxon is the tribe Orthogonini. All three tribes are associated in some way with ants or termites. Male genitalia of pseudomorphines have a bonnet-shaped phallobase like the lebiomorphs, yet their accompanying parameres are large and nearly symmetrical (and in some species the parameres are sparsely setiferous, as in some primitive lineages of the family). Many known lineages of Pseudomorphini have been so highly selected for life with ants (and possibly termites) that external structures do not help much in discovering more normal carabid relatives.

References. Baehr (1992, 1997); Erwin and Geraci (2008); Moore (1964, 1974, 1983); Ogueta (1967); Notman (1925).

***Pseudomorpha* Kirby, 1825**
http://species-id.net/wiki/Pseudomorpha

Pseudomorpha Kirby, 1825:98
Heteromorpha Kirby, 1825:109
Axinophorus Dejean, 1829:174
Drepanus Dejean, 1831:434
Heteromorphus Chaudoir, 1852:63

Type species. *Pseudomorpha excrucians* Kirby, 1825:101

Proposed English vernacular name. Western False-form beetles

Number of described Western Hemisphere species. 27

Current known number of undescribed Western Hemisphere species. 125

Number of described Australian species. 3 (Subgenus *Austropseudomorpha* Baehr, 1997)

Adelphotaxon. *Tuxtlmorpha* Erwin & Geraci, 2008 + *Samiriamorpha* Erwin & Geraci, 2008 (see Erwin and Geraci 2008 for phylogeny).

Taxonomy. Stable at the generic level (Erwin 2013; Erwin and Geraci 2008), although many undescribed species need to be treated (Erwin in prep.). All of these undescribed species have been assigned to the species groups listed herein and their male genitalia have been illustrated, their label data entered into a database, and their localities mapped using Google Earth Pro.

Diagnosis. Form moderately depressed or rarely subcylindrical, narrow or broad, lean or robust, head visible from above, legs concealed beneath when in repose. Color ranges from black to light brown, rarely slightly rufous; only adults of *P. excrucians* Kirby, *Yasunimorpha piranhna* Erwin & Geraci, *Guyanemorpha spectablis* Erwin from Guyane are markedly bicolored. Head with mouthparts visible in dorsal aspect; ventrally beneath eye with deeply recessed groove for insertion of antennal base; mandibular scrobe nearly effaced, delimited by row of short stout setae; mentum and submentum fused; antennal scape partially visible in dorsal aspect. Anterior coxal cavities closed, median coxal cavities conjunct, metepimeron visible. Abdomen with six visible sterna, sternum III with broad medial emargination on posterior margin; sterna V and VI in male with dense row of decumbent and yellowish robust setae medially. Male parameres long, nearly of same length (more or less symmetrical), glabrous or setose, not balteate; phallobase bonnet-shaped, crested or not.

Way of life. As far as is known, adults are found in and around ant nests and in the surrounding vicinity; females are ovoviviparous (Liebherr and Kavanaugh 1985); larvae are known to be ant nest inquilines (Lenko 1972; Erwin 1981), or perhaps living with termites (Ogueta 1967). Of adults found at lights (UV, MV, and white light), most are males.

Geographic distribution. Members of this genus are known to occur from Oregon, Idaho, and Colorado in the north to Argentina in the south, including the Caribbean area, and in southern Australia. They should be looked for in southern Wyoming, where they are also likely to occur. The only eastern species, *P. excrucians* Kirby, is related to species from the Caribbean and South America, not to those lineages from the American west and southwest.

Habitat. Dry loamy or sandy soil where ants prefer to build nests from MASL -72m to 2606m altitude in deserts, grasslands, and open and closed forests.

Description. Head (cf. Figs 7–12) with two supraorbital setigerous punctures per eye near their posterior corner, however, numerous accessory setae in some groups obscure them; frontal impressions absent. Clypeus markedly wide, trapezoidal with rounded anterior angles and shallowly lobed posterior margin; posterior margin in some adults very shallow, or effaced, bearing a single long seta each side near anterior corner. Eyes flat, or slightly convex; small gena with numerous stout setae. Antenna of varying length, either shorter, or longer than distance from antennal base to anterior coxae; antennomeres 3–9 slightly wider distally and appearing flattened. Labrum visible, about 2/3 as wide as clypeus, rectangulate, bearing six setae along anterior margin. Mandible markedly flattened with a very short and acute apex; outer margin ventral of the scrobe with short stout setae. Maxillary palpi markedly short, 3-segmented, palpomeres slightly depressed, palpomere 3 truncate apically. Labial palpus with short bisetose palpomere 2; palpomere 3 markedly securiform and robust, its distal margin mostly membranous with sensory organs.

Prothorax. Pronotum (cf. Figs 1–6) wider than head, transverse, with broadly explanate margins, or in cylindrical species narrowly explanate margins; without a pair of setigerous punctures each side, apical, lateral and posterior margins with border of stout setae; hind angles obtuse, broadly rounded. Proepisternum with prosternal process multisetiferous apically, intercoxal process feebly margined.

Pterothorax. Metepisternum elongate though not exceptionally so, the outer margin about 1.5 times greater in length than the anterior margin, posterior margin about 0.5 times anterior margin.

Elytra. Elytron rectangulate, slightly narrower apically, wider or narrower (depending on species group) than pronotum at widest point, apical margin subtruncate, outer margin broadly rounded, interneurs present or effaced, of fine or course punctures; parascutellar stria present or absent, parascutellar puncture present, marked; intervals flat to slightly convex without fixed setae, rather variously setiferous, or glabrous. Lateral marginal (umbilical) series of 10–15 setae, concentrated and narrowly spaced in anterior third, widely spaced in posterior two-thirds; lateral margin with border of stout setae.

Hind wings. Macropterous. Venation not studied (see Baehr 1997 for illustration of related species, and Erwin 2013).

Legs. Short and depressed, femur posteriorly channeled for reception of tibia in repose; antennal comb notch very shallow; tibial spurs normal; anterior tarsi of male with tarsomeres 1–2 dilated slightly, ventrally with two rows of adhesive articulo-setae.

Abdomen. Abdominal sterna III-VII with patches of short setae and each of IV–VII with a single row of erect ambulatory setae numbering 2 to 8 setae; V and VI in male with dense row of yellowish robust setae medially.

Male genitalia (cf. Figs 13–16). Phallobase hooded with small orifice, dorsum crested or not; phalloshaft straight or markedly arched at basal third, diameter subrounded or somewhat depressed dorso-ventrally; phalloapex produced, acute or rounded, depressed dorso-ventrally; endophallus with scattered microtrichia, not in patches. Parameres large, nearly equal in length, left slightly longer and broader than right, each apically glabrous or setiferous.

Female ovipositor (cf. Fig. 17). Gonocoxite 2 (**gc 2**) falcate, base (**b**) about as long as blade (**bl**), latter relatively short, pointed distally; margins with several ensiform setae (**en**); with or without short preapical nematiform setae (**n**).

The species groups of *Pseudomorpha* Kirby 1825 and their known distributions (note that some species group names are based on yet undescribed species in Erwin in prep.)

Alleni group. AZ, UT
Augustata group. AZ, CA, NV, NM, TX, UT, México
Behrensi group. CA, CO, ID, NV, NM, OR, UT
Caterinoi group. CA
Consanguinea group. AZ, CA
Cronkhitei group. AZ, CA
Chumash group. CA
Cylindrica group. NM, TX, México
Excrucians group. AR, GA, LA, MS, SC, Argentina, Brazil, Dominican Republic
Falli group. CA
Hubbardi group. AZ, NM, TX
Parallela group. CA, Haiti
Peninsularis group. AZ, CA, CO, NV, NM, OR, UT, México

Phiara group. TX
Pilatei group. TX, Costa Rica, Guatemala, México
Santarita group. AZ, NM, México
Subsulcata group. NM
Tenebroides group. AZ, CA, NV, NM, UT
Vindicata group. CO, ID, UT

Key to the species of the *santarita* group of *Pseudomorpha* Kirby 1825

(Taxa referred to in the key are arranged alphabetically in the Species Group Account below)

1 Pronotum planar, aspect apparently flat with anterior margin on same plane as posterior margin (Figs 1, 2, 4, 5, 6).....**2**

1' Pronotum not planar, aspect humped, anterior margin lower (in lateral view) than posterior margin (Fig. 3)...***P. penablanca* Amundson & Erwin, sp. n.**

2(1) Elytron with intervals slightly convex and easily observed with low power magnification (Figs 2, 4).....**3**

2' Elytron with intervals effaced and not obvious with low power magnification (Figs 1, 5, 6) **4**

3(2) Small-sized for group, ABL = 4.9 to 5.2 mm, and dark rufous with forebody paler than elytra; margins of elytra parallel in basal two-thirds (Fig. 2)..... ..... ***P. patagonia* Erwin & Amundson, sp. n.**

3' Large-sized for group, ABL = 6.3 to 6.8 mm, and completely piceous; margins of elytra tapered toward apex (Fig. 4).....***P. pima* Amundson & Erwin, sp. n.**

4(2') Eye flat in dorsal view, not protruding beyond gena/preocular lobe plane (Figs 7, 11) **5**

4' Eye slightly convex in dorsal view, protruding beyond gena/preocular lobe plane (Fig. 12) .....***P. santarita* Erwin & Amundson, sp. n.**

5(4) Pronotum wider than elytra across humeri (Fig. 1); preocular lobe of even width throughout (Fig. 7).....***P. huachinera* Amundson & Erwin, sp. n.**

5' Pronotum slightly narrower than elytra across humeri (Fig. 5); preocular lobe slightly wider anteriorly (Fig. 11)....***P. santacruz* Erwin & Amundson, sp. n.**

Santarita group

Diagnosis. With the attributes of the genus as described above and easily recognized by the absence of obvious dorsal setae on head, disc of pronotum, and elytra. Form broad and short, elytra markedly or subtly narrowed toward apex; pronotum coequal or broader than elytra across humeri. Vertex of head without transverse in-line row of coarse setigerous pores, or a band of small setigerous punctulae between eyes, entire

surface smooth with sparse minutely setigerous punctulae (cf. Figs 7–12). Eye setiferous or not. Clypeal suture distinct. Pronotum sparsely microsetiferous, without stout setae along lateral margin. Elytron with scutellar setae slightly foveate, interneurs minutely punctulate, punctulae mostly connected by fine longitudinal zigzag striae (high magnification); sterna V and VI of male with broad rows of dense in-line setae, width of rows subequal to length of posterior basitarsomere + 2nd tarsomere; antenna long, extended beyond apex of prosternal process by about the length of last antennomere. Male phallobase without sagittal crest; parameres without setae.

Status. At present this group contains six new species described herein.

The species of the *santarita* group and their known general distributions.

Pseudomorpha huachinera Amundson & Erwin, sp. n., Arizona, México (Sonora)
Pseudomorpha patagonia Erwin & Amundson, sp. n., Arizona
Pseudomorpha penablanca Amundson & Erwin, sp. n., Arizona
Pseudomorpha pima Amundson & Erwin, sp. n., Arizona
Pseudomorpha santacruz Erwin & Amundson, sp. n., Arizona
Pseudomorpha santarita Erwin & Amundson, sp. n., Arizona, New Mexico.

Pseudomorpha (*Pseudomorpha*) *huachinera* Amundson & Erwin, sp. n.

http://zoobank.org/DD519173-5E06-420C-92E9-51AC6EF8CE36
http://species-id.net/wiki/Pseudomorpha_huachinera
Figures 1, 7, 13, 18

Holotype. México. Sonora, Nacori Chico, 86.2 km NE Arroyo El Cocono, Sierra Huachinera, 30.044°N, 108.537°W, 1660m, 7–8 August 1982 (G.E. Ball)(NMNH: ADP110112, female). Paratypes are listed below; see other specimens examined.

Derivation of scientific epithet. The epithet "huachinera" is a singular feminine noun used in apposition and refers to the name of the mountain range in which these beetles were collected. The area was once the home of the Ópata Amerindians until the Spanish missionary Cristóbal García founded the town of Juan Evangelista de Huachinera in 1645.

Proposed english vernacular name. Huachinera False-form beetle.

Diagnosis. Color tone of dorsum castaneous and uniform; body rectangulate, lateral margins of elytra parallel, slightly tapering to an apically truncated and laterally slightly rounded apex; dorsum mostly glabrous with irregularly and wide-spaced short erect setae; pronotum with lateral margins broadly explanate, disc convex and medially planar; elytral interneurs and intervals nearly effaced, faint zig-zag interneurs apparent under high magnification, 10 umbilicate setae present near lateral margin, dorsal edge of epipleuron lined with long laterally erect setae.

Description. (Figs 1, 7, 13). Table 1. Size: Medium to large for genus, ABL = 5.9 to 6.4 mm, SBL = 5.9 to 6.4 mm, TW = 4.8 to 5.0 mm. Preocular lobe-eye ratio 0.63 to 0.69. Pronotum ratio (L/W): 0.27 to 0.31. Elytron ratio (L/W): 1.6 to 1.7. *Color*: Dorsum castaneous, explanate margins of pronotum and elytra slightly translucent. *Luste*r:

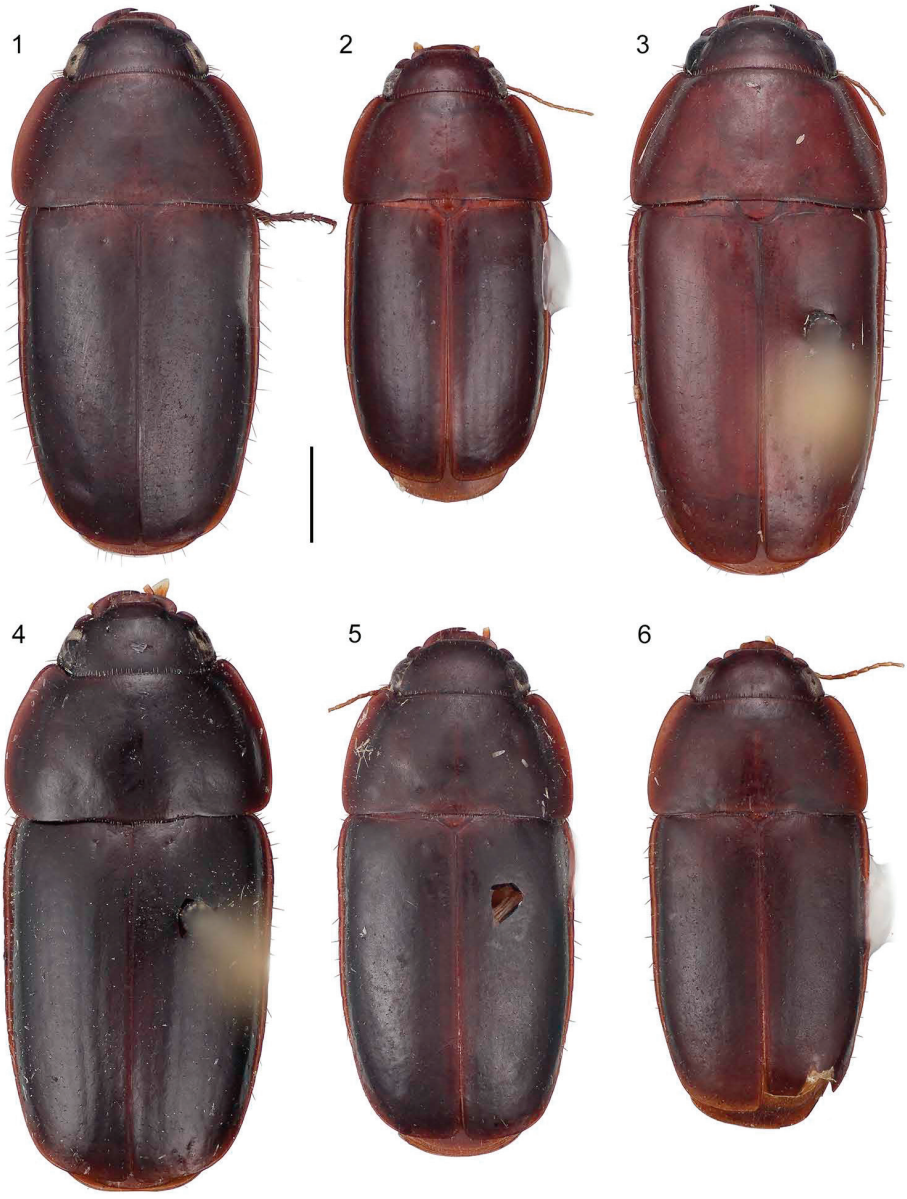

Figure 1–6. 1 *Pseudomorpha huachinera* sp. n., male holotype, ADP110112; Arroyo El Cocono, Sierra Huachinera, Sonora, México. Habitus, dorsal aspect, ABL = 5.88mm **2** *Pseudomorpha patagonia* sp. n., male holotype, ADP110694; Madera Canyon, Santa Rita Mountains, AZ. Habitus, dorsal aspect, ABL = 4.39mm **3** *Pseudomorpha penablanca* sp. n., female holotype, CAS8111005; Peña Blanca Lake, Arizona. Habitus, dorsal aspect, ABL = 6.37mm **4** *Pseudomorpha pima* sp. n., female holotype, CAS8111006; Madera Canyon (lower), Santa Rita Mountains, Arizona. Habitus, dorsal aspect, ABL = 6.76mm **5** *Pseudomorpha santacruz* sp. n., male holotype, ADP111870; Madera Canyon, Santa Rita Mountains, Arizona. Habitus, dorsal aspect, ABL = 5.78mm **6** *Pseudomorpha santarita* sp. n., male holotype, ADP110817; Pajarito Mountains, AZ. Habitus, dorsal aspect, ABL = 5.33mm.

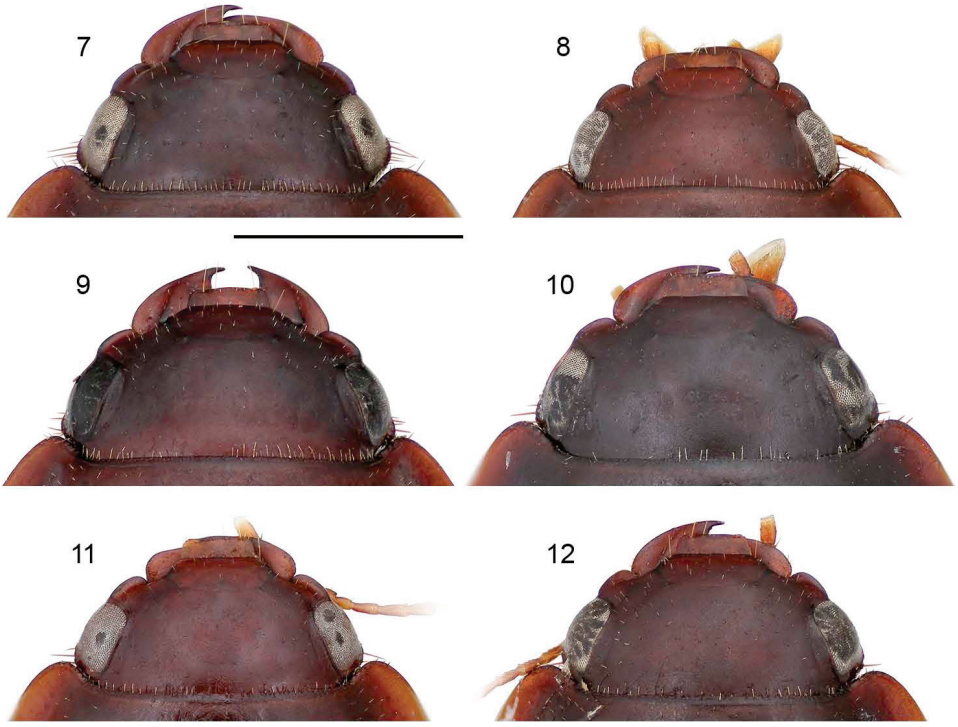

Figure 7–12. 7 *Pseudomorpha huachinera* sp. n., male holotype, ADP110112; Arroyo El Cocono, Sierra Huachinera, Sonora, México. Head, dorsal planar aspect **8** *Pseudomorpha patagonia* sp. n., male paratype, ADP110694; Madera Canyon, Santa Rita Mountains, AZ. Head, dorsal planar aspect **9** *Pseudomorpha penablanca* sp. n., female holotype, CAS8111005; Peña Blanca Lake, Arizona. Head, dorsal planar aspect **10** *Pseudomorpha pima* sp. n., female holotype, CAS8111006; Madera Canyon (lower), Santa Rita Mountains, Arizona. Head, dorsal planar aspect **11** *Pseudomorpha santacruz* sp. n., male holotype, ADP111870; Madera Canyon, Santa Rita Mountains, Arizona. Head, dorsal planar aspect **12** *Pseudomorpha santarita* sp. n., male holotype, ADP110817; Pajarito Mountains, AZ. A Head, dorsal planar aspect.

Dorsum dull, slightly matte. *Microsculpture*: Small isodiametric sculpticells throughout dorsal surface. **Head:** Genal lobe obsolete, rim posteriad and below eye bearing at least five robust setae directed perpendicular to head; preocular lobe distinct and slightly arching (Fig. 7); eye barely exceeding preocular lobe/gena boundary, barely arcuate; clypeus fused to frons with pigmented furrow slightly effaced medially, bisetose, setae laterad on margin; labrum with four setae projecting anteriorly (Fig. 7); antennal flagellum markedly setose, antennomeres 1-3 bisetose. **Prothorax:** Pronotum mostly glabrous with irregularly and wide-spaced short erect setae, apex slightly rounded medially and narrower than ocular boundary, disk markedly convex and medially planar, width coequal to or slightly wider than elytra across humeri, base and apex fringed with more or less evenly spaced setae, pigmented median line ending about ¾ before basal margin, lateral margins of pronotum with wide explanate sides, anterior angle 72.06°; prosternal apex fringed with short, evenly spaced setae. **Pterothorax:** Scutellum visible, small, triangulate with slightly rounded lat-

eral margins; elytra smooth, interneurs nearly effaced, markedly zig-zagged under high magnification, lateral margin slightly sinuate at basal third, 10 umbilicate erect setae on the ventrally directed curvature of the elytral lateral portion (Fig. 1). **Abdomen:** All sterna sparsely setiferous, sternum III densely so; male sternum IV with broad median dense row of posteriorly decumbent setae, sternum VII with two pair of two setae each along posterior edge; female with 2 pairs of 4 setae on sternum, and numerous longer setae on sterna IV, V, and VI. **Legs:** Legs flattened, setiferous, tibia bearing fringed ring of setae on distal end, femur with distinct lateral sulcus, femora and tibia sparsely setose. **Male Genitalia:** (Fig. 13) Basal orifice hooded by phallobase, orifice recessed and small, phalloshaft arching, shaft narrows toward apex and slightly constricted at apical third; parameres co-equal in length, with the left paramere only slightly longer than right, both asetose; apical orifice small, about 1/5 the length of shaft. **Female Genitalia:** Not investigated.

Dispersal potential. These beetles are macropterous and have been recorded at lights, they are capable of flight; they are swift and agile runners. Accordingly, the species may be expected to be more broadly distributed across a wider geographical range than current records indicate.

Way of life. Adults are likely found in ant nests and the surrounding vicinity; females are ovoviviparous (Liebherr and Kavanaugh 1985); larvae are ant nest inquilines (Erwin 1981). Members of *P. huachinera* occur at midland and upland altitudes in between the Sonoran and Chihuahuan Deserts in the riparian vegetation zones and in oak-pine forests. Adults are active in July–August, very hot months in this area.

Other specimens examined. México, Sonora, Yécora, 16 km NW Rancho Aguajia, and 2 km S Old Hwy, 28.403°N, 109.094°W, 1311m, 28–29 July 1987 (S. McCleve) (CAS: 8111009, male paratype). **USA**, Arizona, *Santa Cruz County*, Pajarito Mountains, Pena Blanca Canyon, 31.386°N, 111.093°W, 1191m, 2 July 1980 (S. McCleve)(UATC: ADP110961, male paratype), Pajarito Mountains, Peña Blanca, 31.409°N, 111.085°W, 1283m, 15 August 1964 (R.H. Arnett Jr.)(FSCA: ADP112631, female paratype).

Geographic distribution. (Fig. 18). This species is currently known from Arizona and northern México.

***Pseudomorpha* (*Pseudomorpha*) *patagonia* Erwin & Amundson, sp. n.**
http://zoobank.org/B32D721B-B86C-4A56-8D4A-CCAAAF8A1318
http://species-id.net/wiki/Pseudomorpha_patagonia
Figures 2, 8, 14, 18

Holotype. USA. Arizona, *Santa Cruz County*, Patagonia Mountains, Harshaw Creek, 31.439°N, 110.696°W, 1577m, 1 August 1979 (S. McCleve)(UATC: ADP110694, male).

A paratype is listed below; see other specimens examined.

Derivation of scientific epithet. The epithet "patagonia" is a singular feminine noun used in apposition and refers to the Patagonian Mountain range in Arizona where the type specimen was collected. The area was part of the Apache homeland before being settled by those interested in mining the wealth of minerals nearby.

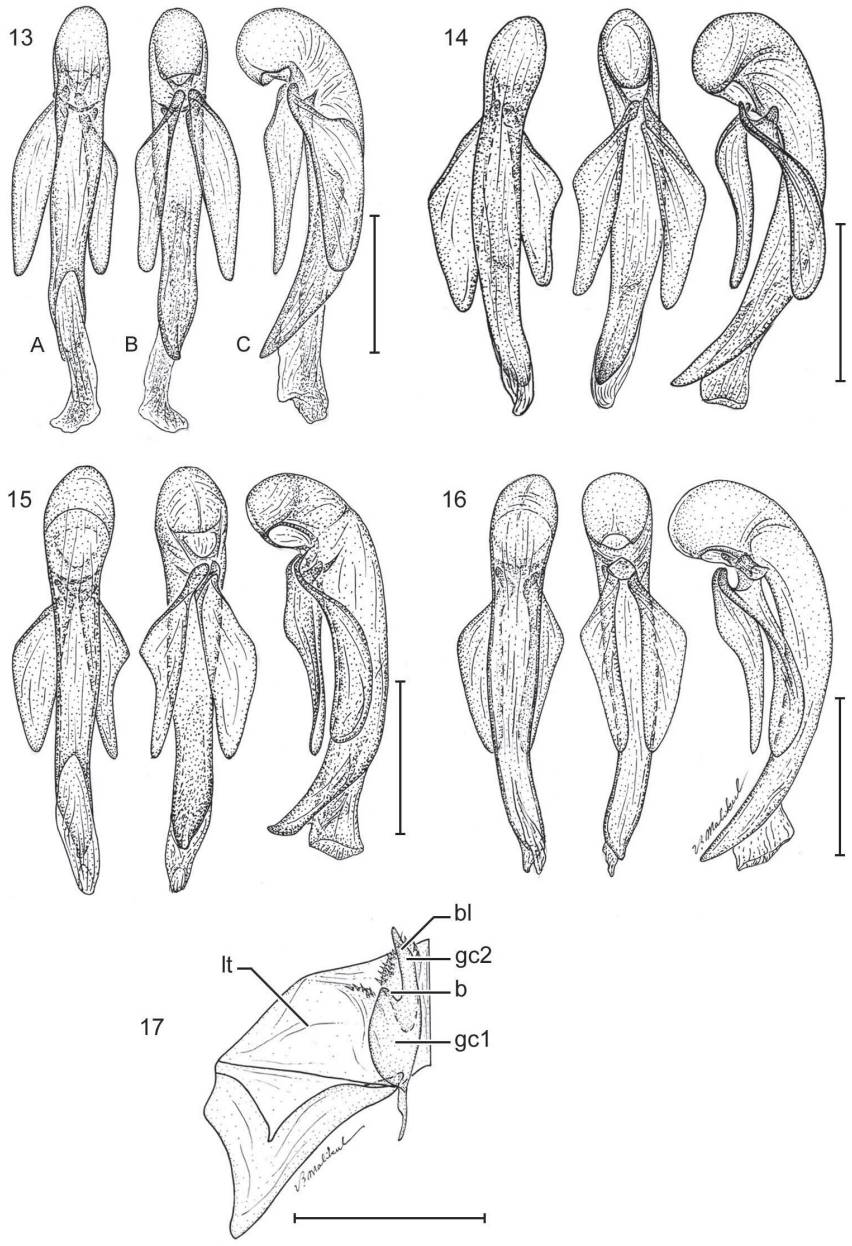

Figure 13–17. 13 *Pseudomorpha huachinera* sp. n., male paratype, ADP110961; Pajarito Mountains, AZ. Male genitalia, median lobe and parameres labeled as in repose in male, **A** right lateral aspect, **B** left lateral aspect, and **C** dorsal aspects. **14** *Pseudomorpha patagonia* sp. n., male paratype, ADP110694; Harshaw Creek, Patagonia Mountains, AZ **15** *Pseudomorpha santacruz* sp. n., male holotype, ADP111870; Madera Canyon, Santa Rita Mountains, AZ **16** *Pseudomorpha santarita* sp. n., male paratype, ADP110388; Santa Rita Ranch, Santa Rita Mountains, AZ **17** *Pseudomorpha pima* sp. n., female paratype, ADP109219; Bog Springs, Santa Rita Mountains, AZ. Ovipositor sclerites, Legend: **gc1** gonocoxite 1; **gc2** gonocoxite 2; **lt** laterotergite; **b** base of gonocoxite 2; **bl** blade of gonocoxite 2. Scale lines = 0.5 mm.

Proposed English vernacular name. Patagonia False-form beetle.

Diagnosis. Color tone of dorsum alutaceous with head, pronotum and elytral suture paler; body rectangulate, lateral margins of elytra parallel, slightly tapering to an apically truncated and laterally slightly rounded apex; dorsum mostly glabrous with irregularly and wide-spaced short erect setae; pronotum with lateral margins broadly explanate, wider than elytra across humeri, disc markedly convex and medially planar; elytral interneurs minimally impressed yet easily visible under low magnification, 10 umbilicate setae present near lateral margin, dorsal edge of epipleuron lined with long laterally erect setae.

Description. (Figs 2, 8, 14). Table 2. *Size*: Medium for genus, ABL = 4.9 to 5.2 mm, SBL = 4.9 to 5.1 mm, TW = 4.0 to 4.2 mm. Preocular lobe-eye ratio: 0.3 to 0.39. Pronotum ratio (L/W): 0.29. Elytron ratio (L/W): 1.7. *Color*: Dorsum alutaceous with head, pronotum and elytral suture paler. *Luster*: Dorsum dull, slightly matte. *Microsculpture*: Small isodiametric sculpticells throughout dorsal surface.

Head: Genal lobe obsolete, rim posteriad and below eye bearing at least five robust setae directed perpendicular to head; preocular lobe distinct and slightly arching (Fig. 8); eye exceeding preocular lobe/gena boundary, shallowly arcuate; clypeus fused to frons with pigmented furrow entire and visible, bisetose, setae laterad on margin; labrum with four setae projecting anteriorly (Fig. 7); antennal flagellum markedly setose, antennomeres 1-3 bisetose.

Prothorax: Pronotum (Fig. 2) mostly glabrous with irregularly and wide-spaced short erect setae, apex slightly rounded medially and narrower than ocular boundary, disk markedly convex and medially planar, width coequal to or slightly wider than elytra across humeri, base and apex fringed with more or less evenly spaced setae, pigmented median line ending about ¾ before basal margin, lateral margins of pronotum with wide explanate sides, anterior angle 77.82°; prosternal apex fringed with short, evenly spaced setae. **Pterothorax:** Scutellum visible, small, triangulate with slightly rounded lateral margins; elytra smooth, interneurs very shallow, clearly visible under low magnification, markedly zig-zagged, intervals slightly convex on disc, lateral margin slightly sinuate at basal third or not, 10 umbilicate erect setae on the ventrally directed curvature of the elytral lateral portion (Fig. 2). **Abdomen:** All sterna sparsely setiferous, sternum III densely so; male sternum IV with broad median dense row of posteriorly decumbent setae, sternum VII with two pair of two setae each along posterior edge; female with 2 pairs of 4 setae on sternum, and numerous longer setae on sterna IV, V, and VI. **Legs:** Legs flattened, setiferous, tibia bearing fringed ring of setae on distal end, femur with distinct lateral sulcus, femora and tibiae sparsely setose. **Male Genitalia:** (Fig. 14) Basal orifice hooded by phallobase, orifice recessed and small, phalloshaft arching, shaft narrows toward apex and slightly constricted at apical third; parameres co-equal in length, with the left paramere only slightly longer than right, both asetose; apical orifice small, about 1/5 the length of shaft. **Female Genitalia:** Not investigated.

Dispersal potential. These beetles are macropterous and have been recorded at lights, hence capable of flight; they are swift and agile runners. Accordingly, it is expected that this species be more broadly distributed across a wider geographical range than current records indicate.

Way of life. Adults are likely found in ant nests and the surrounding vicinity; females are ovoviviparous (Liebherr and Kavanaugh 1985); larvae are ant nest inquilines (Erwin 1981). Members of *P. patagonia* occur at upland altitudes in between the Sonoran and Chihuahuan Deserts on oak dominated slopes. See: http://hikearizona.com/photo.php?ZIP=259631. Adults are active in July–August, very hot months in this area.

Other specimens examined. USA, Arizona, *Cochise County,* Huachinera Mountains, Copper Canyon, 31.363°N, 110.300°W, 1882m, 16 July 1979 (S. McCleve) (UATC: ADP110736, male paratype).

Geographic distribution. (Fig. 18). This species is currently known from Arizona.

Pseudomorpha (*Pseudomorpha*) *penablanca* Amundson & Erwin, sp. n.

http://zoobank.org/DE1AD618-8FD9-4138-871F-56ECF6D2B8C9
http://species-id.net/wiki/Pseudomorpha_penablanca
Figures 3, 9, 18

Holotype. USA: Arizona, *Santa Cruz County*, 3.2 km S of Peña Blanca Lake, 31.473°N, 110.849°W, 1283m, 14–15 August 1971 (W.H. Tyson)(CAS: 8111005, female). Unique.

Derivation of specific epithet. The epithet "penablanca" is a singular feminine noun used in apposition and refers to the lake in Santa Cruz County near the locality at which the holotype was collected. Peña Blanca was built in 1957 by the Arizona Game and Fish Department, and is bordered by oak-savannah hills, some of which are topped with bluffs of limestone.

Proposed English vernacular name. Peña Blanca False-form beetle.

Diagnosis. Color tone of dorsum pale castaneous with head slightly darker; body robust and rectangulate, lateral margins of elytra tapering to an apically truncated and laterally slightly rounded apex; dorsum mostly glabrous with irregularly and wide-spaced short erect setae; pronotum with lateral margins moderately explanate, wider than elytra across humeri, disc markedly convex and medially sloped markedly anteriorly; elytral interneurs minimally impressed yet more or less visible under low magnification, 10 umbilicate setae present near lateral margin, dorsal edge of epipleuron lined with long laterally erect setae.

Description. (Figs 3, 9). Table 3. *Size*: Large for genus, ABL = 6.4 mm, SBL = 6.3 mm, TW = 5.6 mm. Preocular lobe-eye ratio: 0.53. Pronotum ratio (L/W): 0.28. Elytron ratio (L/W): 1.5. *Color*: Dorsum evenly pale rufopiceous except head with notable color gradation from piceous over eyes to rufopiceous medially. *Luster*: Dorsum dull, slightly matte. *Microsculpture*: Small isodiametric sculpticells throughout dorsal surface. **Head:** Genal lobe obsolete, rim posteriad and below eye bearing at least five robust setae directed perpendicular to head; preocular lobe distinct and slightly arching (Fig. 9); eye not exceeding preocular lobe/gena boundary, shallowly arcuate; clypeus fused to frons with pigmented furrow entire and visible, bisetose, setae laterad on margin; labrum with four setae projecting anteriorly (Fig. 9); antennal flagellum markedly setose, antennomeres 1-3 bisetose. **Prothorax:** Pronotum (Fig. 3) mostly

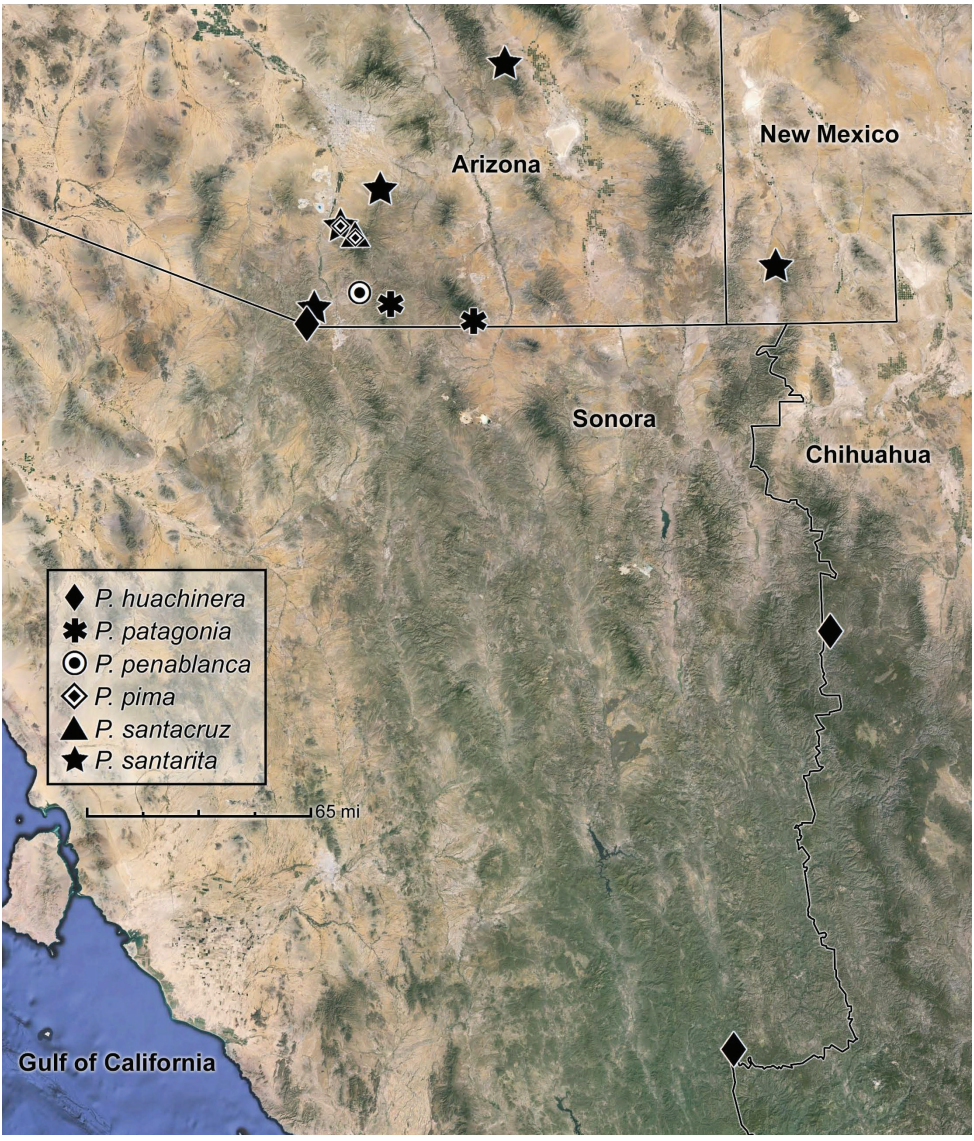

Figure 18. Distribution map for species of the *santarita* group of Pseudomorpha.

glabrous with irregularly and wide-spaced short erect setae, apex straight medially and narrower than ocular boundary, disk markedly convex and medially sloped markedly anteriorly, width slightly wider than elytra across humeri, base and apex fringed with more or less evenly spaced setae, pigmented median line ending about ¾ before basal margin, lateral margins of pronotum with wide explanate sides, anterior angle 71.22°; prosternal apex fringed with short, evenly spaced setae. **Pterothorax:** Scutellum visible, moderate sized, distinctly rounded apically; elytra smooth, interneurs very shallow, clearly visible under medium magnification, markedly zig-zagged, intervals flat on

disc, lateral margin very slightly sinuate at basal third, 10 umbilicate erect setae on the ventrally directed curvature of the elytral lateral portion (Fig. 3). **Abdomen:** All sterna sparsely setiferous, sternum III densely so; male unknown; female with 2 pairs of 4 setae on sternum, and numerous longer setae on sterna IV, V, and VI. **Legs:** Legs flattened, setiferous, tibia bearing fringed ring of setae on distal end, femur with distinct lateral sulcus, femora and tibia sparsely setose. **Female Genitalia:** Not investigated.

Dispersal potential. These beetles are macropterous, they are probably capable of flight; they are swift and agile runners. Accordingly, the species is expected to be more broadly distributed across a wider geographical range than current records indicate.

Way of life. Adults are likely found in ant nests and the surrounding vicinity; females are ovoviviparous (Liebherr and Kavanaugh 1985); larvae are ant nest inquilines (Erwin 1981). Members of *P. penablanca* occur at midland altitudes in mountainous areas of Arizona; the holotype was found at night on a dead oak tree. Adults are active in August, a very hot month in this area.

Other specimens examined. None.

Geographic distribution. (Fig. 18). This species is currently known from Arizona.

***Pseudomorpha* (*Pseudomorpha*) *pima* Amundson & Erwin, sp. n.**
http://zoobank.org/0040741D-5DEE-4BE0-8C86-7C3242251E8D
http://species-id.net/wiki/Pseudomorpha_pima
Figures 4, 10, 17, 18

Holotype. USA: Arizona, *Pima County*, Santa Rita Mountains, Lower Madera Canyon, 31.745°N, 110.919°W, 1174m, 14–16 July 1978 (W.H. Tyson)(CAS: 8111006, female). A paratype is listed below; see other specimens examined.

Derivation of specific epithet. The epithet "*pima*" is a singular feminine noun used in apposition and is the name of Aztecan descended peoples that live along the Gila and Salt rivers in southern Arizona.

Proposed english vernacular name. Pima False-form beetle.

Diagnosis. Color tone of dorsum piceous with head slightly darker over eyes; body robust and rectangulate, lateral margins of elytra tapering to an apically truncated and laterally slightly rounded apex; dorsum mostly glabrous with irregularly and wide-spaced short erect setae; pronotum with lateral margins moderately explanate, about coequal in width to that of elytra across humeri, disc markedly convex and planar; elytral interneurs moderately impressed and visible under low magnification, interneurs slightly convex; 10 umbilicate setae present near lateral margin, dorsal edge of epipleuron lined with long laterally erect setae.

Description. (Figs 4, 10, 17). Table 4. *Size*: Large for genus, ABL = 6.3 to 6.8 mm, SBL = 6.3 to 6.7 mm, TW = 5.1 to 5.7 mm. Preocular lobe-eye ratio: 0.56 to 0.57. Pronotum ratio (L/W): 0.31. Elytron ratio (L/W): 1.5 to 1.6. *Color*: Dorsum piceous, slightly lighter brown along explanate edges of dorsum. *Luster*: Dorsum dull, slightly matte. *Microsculpture*: Small isodiametric sculpticells throughout dorsal surface. **Head:** Genal lobe obsolete, rim posteriad and below eye bearing at least five robust setae directed perpen-

dicular to head; preocular lobe distinct, moderately prominent, and more or less straight (Fig. 10); eye not exceeding preocular lobe/gena boundary, shallowly arcuate; clypeus fused to frons with pigmented furrow entire and visible, bisetose, setae laterad on margin; labrum with four setae projecting anteriorly (Fig. 10); antennal flagellum markedly setose, antennomeres 1-3 bisetose. **Prothorax:** Pronotum (Fig. 4) mostly glabrous with irregularly and wide-spaced short erect setae, apex slightly arcuate medially and narrower than ocular boundary, disk markedly convex and planar, width slightly wider than elytra across humeri, base and apex fringed with more or less evenly spaced setae, median line ending about ¾ before basal margin, lateral margins of pronotum with wide explanate sides, anterior angle 89.22°; prosternal apex fringed with short, evenly spaced setae. **Pterothorax:** Scutellum (normally) visible, moderate sized, narrowly rounded apically; elytra smooth (Fig. 4), interneurs very shallow, clearly visible under low magnification, markedly zigzagged, intervals slightly convex on disc, lateral margin very slightly sinuate at basal third, 10 umbilicate erect setae on the ventrally directed curvature of the elytral lateral portion. **Abdomen:** All sterna sparsely setiferous, sternum III densely so; male unknown; female with 2 pairs of 4 setae on sternum, and numerous longer setae on sterna IV, V, and VI. **Legs:** Legs flattened, setiferous, tibia bearing fringed ring of setae on distal end, femur with distinct lateral sulcus, femora and tibiae sparsely setose. **Female Genitalia:** (see Fig. 17).

Dispersal potential. These beetles are macropterous and have been recorded at lights, hence capable of flight; they are swift and agile runners. Accordingly, the species may be expected to be more broadly distributed across a wider geographical range than current records indicate. Female adults are attracted to lights.

Way of life. Adults are likely found in ant nests and the surrounding vicinity; females are ovoviviparous (Liebherr and Kavanaugh 1985); larvae are ant nest inquilines (Erwin 1981). Members of *P. pima* occur at midland and upland altitudes near the Sonoran Desert. Adults are active in early to mid-July, a very hot month in this area. For images of habitats at the paratype locality (Bog Springs) see: http://www.meetup.com/phoenix-atheists/events/109850282/.

Other specimens examined. USA: Arizona, *Pima County,* Santa Rita Mountains, Bog Springs, 31.726°N, 110.874°W, 1524m, 3 July 1958 (J. von Bloeker Jr.)(SBNHM: ADP109219, female paratype).

Geographic distribution. (Fig. 18). This species is currently known from Arizona.

***Pseudomorpha* (*Pseudomorpha*) *santacruz* Erwin & Amundson, sp. n.**
http://zoobank.org/7D9C4F9B-B6DD-4AEC-A850-6E7F4CFE3C67
http://species-id.net/wiki/Pseudomorpha_santacruz
Figures 5, 11, 15, 18

Holotype. USA, Arizona, *Pima County*, Santa Rita Mountains, Madera Canyon, 31.724°N, 110.880°W, 1487m, 11 July 1963 (V.L. Vesterby)(UCDC: ADP111870, male). Unique.

Derivation of scientific epithet. The epithet "santacruz" is a singular masculine noun used in apposition and refers to a river in Arizona where the beetles were found.

Before the arrival of Spanish, the area was home to the Apache, Yaqui, and Hohokam peoples who built their communities along what are now called the Santa Cruz River and the Sonoita and Harshaw Creeks.

Proposed english vernacular name. Santa Cruz False-form beetle.

Diagnosis. Color tone of dorsum rufopiceous, lateral margins of pronotum and elytra rufo-translucent; body robust and rectangulate, lateral margins of elytra slightly tapering to an apically truncated and laterally rounded apex; dorsum mostly glabrous with irregularly and wide-spaced short erect setae; pronotum with lateral margins moderately explanate, about coequal in width to that of elytra across humeri, disc markedly convex and planar; elytral interneurs effaced and not visible under medium magnification, intervals flat; 10 umbilicate setae present near lateral margin, dorsal edge of epipleuron lined with long laterally erect setae.

Description. (Figs 5, 11, 15). Table 5. *Size*: Medium for genus, ABL = 5.8 mm, SBL = 5.7 mm, TW = 3.5 mm. Preocular lobe-eye ratio: 0.53. Pronotum ratio (L/W): 0.30. Elytron ratio (L/W): 1.4. *Color*: Dorsum rufopiceous, slightly lighter along explanate edges of pronotum and elytra. *Luster*: Dorsum dull, slightly matte. *Microsculpture*: Small isodiametric sculpticells throughout dorsal surface. **Head:** Genal lobe obsolete, rim posteriad and below eye bearing at least five robust setae directed perpendicular to head; preocular lobe distinct, moderately prominent, and more or less very slightly arcuate (Fig. 11); eye slightly convex, exceeding preocular lobe/gena boundary; clypeus fused to frons with pigmented furrow barely visible, bisetose, setae laterad on margin; labrum with four setae projecting anteriorly (Fig. 11); antennal flagellum markedly setose, antennomeres 1-3 bisetose. **Prothorax:** Pronotum (Fig. 5) mostly glabrous with irregularly and wide-spaced short erect setae laterally, apex very slightly arcuate medially and narrower than ocular boundary, disk markedly convex and planar except for slightly lower apex, width coequal to that of elytra across humeri, base and apex fringed with more or less evenly spaced setae, median line ending about ¾ before basal margin, lateral margins of pronotum with wide explanate sides, anterior angle 77.36°; prosternal apex fringed with short, evenly spaced setae. **Pterothorax:** Scutellum visible, moderate sized, narrowly rounded apically; elytra smooth (Fig. 5), interneurs effaced, not visible under low magnification, intervals flat, lateral margin very slightly sinuate at basal third, 10 umbilicate erect setae on the ventrally directed curvature of the elytral lateral portion. **Abdomen:** All sterna sparsely setiferous, sternum III densely so; male characteristic of species group, see above. Female unknown. **Legs:** Legs all same castaneous color, tibia setiferous with ring of erect yellow setae on distal end. **Male Genitalia:** (Fig. 15) Basal orifice hooded by phallobase, orifice recessed and small, phalloshaft arching, shaft narrows toward apex and slightly constricted at apical third, extreme apex acute and slightly bent; parameres co-equal in length, with the left paramere only slightly longer than right, both asetose; apical orifice small, about 1/5 the length of shaft. **Female Genitalia:** Not investigated.

Dispersal potential. These beetles are macropterous and probably fly; they are swift and agile runners. Accordingly, the species may be expected to be more broadly distributed across a wider geographical range than current records indicate.

Way of life. Adults are likely found in ant nests and the surrounding vicinity; females are ovoviviparous (Liebherr and Kavanaugh 1985); larvae are ant nest inquilines (Erwin 1981). Members of *P. santacruz* occur at midland altitudes near the Sonoran Desert. Adults are active in July, a very hot month in this area.

Other specimens examined. None.

Geographic distribution. (Fig. 18). This species is currently known from Arizona.

***Pseudomorpha* (*Pseudomorpha*) *santarita* Erwin & Amundson, sp. n.**
http://zoobank.org/2CF69165-EC7A-49E4-8E75-3FC288BAB924
http://species-id.net/wiki/Pseudomorpha_santarita
Figures 6, 12, 16, 18

Holotype. USA: Arizona, *Pima County*, Santa Rita Ranch, 31.946°N, 110.758°W, 1080m, July 1978 (R. Lenczy)(NMNH: ADP110388, male). Paratypes are listed below; see other specimens examined.

Derivation of specific epithet. The epithet "*santarita*" is a singular feminine noun used in apposition and is based on the name of the upland range, Santa Rita Mountains in the Coronado National Forest, which includes the type locality of this species. This area was once the home of the indigenous peoples, Papago.

Proposed english vernacular name. Santa Rita False-form beetle.

Diagnosis. With the attributes of the species group as described above and color tawny (Fig. 6), color tone of dorsum uniform; form broad and stout; head with preapical lobe prominent, slightly exceeding gena-eye line; pronotum (Fig. 6) slightly wider at base than elytra across humeri; elytron slightly tapered from humerus to narrower truncated apex and with a bare trace of costae, interneurs of finely impressed zig-zag striae, intervals micropunctate, setae very short, fine, and wide-spaced.

Description. (Figs 6, 12, 16) Table 6. *Size*: Medium for genus, ABL = 5.3 to 5.7 mm, SBL = 5.1 to 5.7 mm, TW = 4.4 to 4.5 mm. Preocular lobe-eye ratio (L/L): 0.551 to 0.693. Pronotum ratio (L/W): 0.225 to 0.286. Elytron ratio (L/W): 1.545 to 1.681. *Color*: Head, pronotum and elytra tawny, their lateral margins somewhat diaphanous rufous, appendages flavotestaceous. *Luster*: Dorsal surface moderately alutaceous, moderately matte. *Microsculpture*: Dorsal surface with very fine flat isodiametric sculpticells. **Head:** (Fig. 12) Eye setiferous. Clypeal suture effaced at middle. Frons and vertex with very sparse micropunctulate, setigerous pores with very short setae widely scattered, no transverse line of setae present. Occiput medial to hind margin of eye without small group of coarse setiferous pores. **Prothorax:** Pronotum (Fig. 6) moderately convex with broad explanate sides, wider than long, without fringe of long stout setae along lateral margin although present at both anterior and hind angles, fringe of short setae present along anterior and posterior margins; anterior margin bead effaced medially, posterior margin discolored but not beaded; disk with longitudinal pigmented line**. Pterothorax:** Elytron (Fig. 6) with interval micropunctate, setigerous pores very widely spaced, finely impressed; interneurs very finely zig-zag striate.

Metepisternum longer than wide, surface sparsely setiferous anteriorly. Metasternum sparsely setiferous medially. Metathoracic wing fully developed. **Abdomen:** Sternum III broadly and shallowly incised medially. All sterna sparsely setiferous, IV broadly and densely so medially; male with dense patches of setae medially on sterna V and VI, their width coequal to the combined length of posterior basitarsomere plus tarsomere 2. **Male genitalia:** (Fig. 16) Phallobase crested; phalloshaft arched nearly 90°, then straight and depressed in lateral aspect to phalloapex; phalloapex narrowed both in lateral and dorsal aspects to acute tip. Parameres in ventral aspect with left shorter than right and somewhat narrower, distal margins of both narrowly rounded, asetose.

Dispersal potential. These beetles are macropterous and have been recorded at lights, hence capable of flight; they are swift and agile runners. Accordingly, the species may be expected to be more broadly distributed across a wider geographical range than current records indicate.

Way of life. Adults are likely found in ant nests and the surrounding vicinity; females are ovoviviparous (Liebherr and Kavanaugh 1985); larvae are ant nest inquilines (Erwin 1981). Members of *P. santarita* occur at midland and upland altitudes in between the Sonoran and Chihuahuan Deserts in the riparian vegetation zones with Sycamore (*Platanus occidentalis* L.) and Cottonwood (*Populus Fremontii* S. Wats.) and desert scrub on the slopes. Adults are active in July –August, very hot months in this area.

Other specimens examined. USA: Arizona, *Santa Cruz County*, Pajarito Mountains, Peña Blanca Canyon, 31.386°N, 111.093°W, 1191m, 2 July 1980 (S. McCleve) (UATC: ADP110817, male paratype); *Graham County*, Galiuro Mountains north, Ash Creek, 32.514°N, 110.139°W, 1400m, 16–17 August 1982 (D.R. Maddison, G.E. Ball & S. McCleve)(DRMC: ADP110591, male paratype); *Pima County*, Santa Rita Mountains, Madera Canyon, 31.724°N, 110.880°W, 1487m, 11 July 1963 (V.L. Vesterby)(UCDC: ADP111898, female paratype), Madera Canyon, 1499m, 31.724°N, 110.880°W, 8 July 1970 (K. Stephan)(FSCA: ADP112570, male paratype). New Mexico, *Hidalgo County*, Animas Mountains, Double Adobe Creek, 31.614°N, 108.779°W, 1755m, 11 July 1981 (S. McCleve)(UATC: ADP110861, male paratype).

Geographic distribution. (Fig. 18). This species is currently known from Arizona and New Mexico.

Concluding statement

In studies of one the of top five most speciose families of beetles, the Carabidae, with nearly 40,000 described species (Lorenz 2005), focusing on beetles that live with ants provides several additional dimensions of field work and commensal investigations beyond that of studying free roaming predators (most carabids) and the seed-eaters (Harpalini and Zabrini). The present revision, in tandem with Erwin and Geraci (2008), provides a starting point in getting many names and descriptions for several new species described so they can be included in an upcoming synopsis of the genus for the Western Hemisphere (Erwin in prep.). Although the genus will be rather straight-for-

ward, learning more about the ways of life of included species will be far more difficult. Future students of "beetles that live with ants" will be digging up ant nests to determine host specificity of the beetle species and to begin the task of understanding the way of life of the immature stages. Given that far more males than females have been collected and they are overwhelmingly the ones coming to the UV, MV, and white lights of collectors, one must wonder how much fidelity females have to their host ant's nest. Do females really disperse much at all? What chemical magic do larvae have that keep them safe and fed in the brood chambers of ants? What role do the unique cephalic setae (Erwin 1981) of larvae play inside the nest? With the ability to "tuck everything in" (i.e., legs and antennal attributes of adult pseudomorphines), it seems they are well adapted to living with aggressive ants. Does this mean that males also frequent ant nests? Is that where mating occurs? The pseudomorphines are a very interesting evolutionary off-shoot of the typical carabid morphotype in both form and function and are only just now beginning to be understood in North America. The fact that species of related genera in South America are living with arboreal ants will make learning about those species even more difficult. Insecticidal fogging of the canopy produces adults of these species, but only tearing apart arboreal *Azteca* ant nests, while suspended in a tree, will produce their larvae; and that is not for carabidologists faint of heart.

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Appendix 1

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UCDC Lynn Kimsey, Bohart Museum of Entomology, University of California, One Shield Ave., Davis, CA 95616 USA

Appendix 2

Table 1. Tables with measurements and ratios for *Pseudomorpha huachinera* sp. n.; all measurements are in millimeters.

Total length					
Males			Females		
N	Range	Mean	N	Range	Mean
2	6.29–6.414	6.352	2	5.866–6.022	5.944
Maximum width					
Males			Females		
N	Range	Mean	N	Range	Mean
2	4.798–4.82	4.809	2	4.784–5.018	4.901
W of head/w of l. Elytron					
Males			Females		
N	Range	Mean	N	Range	Mean
2	1.257–1.258	1.257	2	1.185–1.227	1.206
Pronotum: width (at widest part)/length					
Males			Females		
N	Range	Mean	N	Range	Mean
2	3.177–3.466	3.321	2	3.294–3.694	3.496
Length of pronotum / length of head					
Males			Females		
N	Range	Mean	N	Range	Mean
2	2.068–2.327	2.197	2	2.170–2.977	2.574

Table 2. Tables with measurements and ratios for *Pseudomorpha patagonia* sp. n.; all measurements are in millimeters.

Total length					
Males			Females		
N	Range	Mean	N	Range	Mean
2	4.899–4.964	4.932	0		
Maximum width					
Males			Females		
N	Range	Mean	N	Range	Mean
2	3.98–4.206	4.093	0		
W of head/w of l. Elytron					
Males			Females		
N	Range	Mean	N	Range	Mean
2	1.196–1.249	1.223	0		
Pronotum: width (at widest part)/length					
Males			Females		
N	Range	Mean	N	Range	Mean
2	3.450–3.523	3.487	0		
Length of pronotum / length of head					
Males			Females		
N	Range	Mean	N	Range	Mean
2	2.261–2.753	2.507	0		

Table 3. Tables with measurements and ratios for *Pseudomorpha penablanca* sp. n.; all measurements are in millimeters.

Total length					
Males			Females		
N	Range	Mean	N	Range	Mean
0			1	6.37	
Maximum width					
Males			Females		
N	Range	Mean	N	Range	Mean
0			1	5.642	
W of head/w of l. Elytron					
Males			Females		
N	Range	Mean	N	Range	Mean
0			1	1.119	
Pronotum: width (at widest part)/length					
Males			Females		
N	Range	Mean	N	Range	Mean
0			1	3.414	
Length of pronotum / length of head					
Males			Females		
N	Range	Mean	N	Range	Mean
0			1	2.566	

Table 4. Tables with measurements and ratios for *Pseudomorpha pima* sp. n.; all measurements are in millimeters.

Total length					
Males			Females		
N	Range	Mean	N	Range	Mean
0			2	6.338–6.72	6.529
Maximum width					
Males			Females		
N	Range	Mean	N	Range	Mean
0			2	5.124–5.66	5.392
W of head/w of l. Elytron					
Males			Females		
N	Range	Mean	N	Range	Mean
0			2	1.148–1.195	1.172
Pronotum: width (at widest part)/length					
Males			Females		
N	Range	Mean	N	Range	Mean
0			2	3.164–3.284	3.224
Length of pronotum / length of head					
Males			Females		
N	Range	Mean	N	Range	Mean
0			2	2.221–2.358	2.289

Table 5. Tables with measurements and ratios for *Pseudomorpha santacruz* sp. n.; all measurements are in millimeters.

Total length					
Males			Females		
N	Range	Mean	N	Range	Mean
1	5.7866		0		
Maximum width					
Males			Females		
N	Range	Mean	N	Range	Mean
1	5.138		0		
W of head/w of l. Elytron					
Males			Females		
N	Range	Mean	N	Range	Mean
1	1.122		0		
Pronotum: width (at widest part)/length					
Males			Females		
N	Range	Mean	N	Range	Mean
1	3.432		0		
Length of pronotum / length of head					
Males			Females		
N	Range	Mean	N	Range	Mean
1	2.441		0		

Table 6. Tables with measurements and ratios for *Pseudomorpha santarita* sp. n.; all measurements are in millimeters.

Total length					
Males			Females		
N	Range	Mean	N	Range	Mean
4	5.133-5.733	5.443	1	5.636	
Maximum width					
Males			Females		
N	Range	Mean	N	Range	Mean
4	3.958-4.428	4.202	1	4.466	
W of head/w of l. Elytron					
Males			Females		
N	Range	Mean	N	Range	Mean
4	1.229-1.365	1.282	1	1.258	
Pronotum: width (at widest part)/length					
Males			Females		
N	Range	Mean	N	Range	Mean
4	3.071-3.545	3.334	1	3.471	
Length of pronotum / length of head					
Males			Females		
N	Range	Mean	N	Range	Mean
4	1.800-2.471	2.161	1	2.675	

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RESEARCH ARTICLE

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Revision of the Chinese *Cleptes* (Hymenoptera, Chrysididae) with description of new species

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Abstract

The genus *Cleptes* Latreille, 1802 from China is revised and illustrated for the first time. Seventeen species of *Cleptes* are recorded. Nine species are new to science, *Cleptes albonotatus* **sp. n.**, *Cleptes eburnecoxis* **sp. n.**, *Cleptes flavolineatus* **sp. n.**, *Cleptes helanshanus* **sp. n.**, *Cleptes niger* **sp. n.**, *Cleptes shengi* **sp. n.**, *Cleptes sinensis* **sp. n.**, *Cleptes tibetensis* **sp. n.**, and *Cleptes villosus* **sp. n.**, and two species are reported as new to China, *Cleptes metallicorpus* Ha, Lee & Kim, 2011, and *Cleptes seoulensis* Tsuneki, 1959.

Keywords

Chrysididae, Cleptinae, revision, *Cleptes*, new species, China

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Introduction

The small subfamily Cleptinae is considered to be the most plesiotypic group within Chrysididae. Its members are parasitoids of the prepupae of sawflies (Hymenoptera, Symphyta) in the families Tenthredinidae and Diprionidae (Tsuneki 1982; Kimsey and Bohart 1991; Móczár 1998b; Sheng et al. 1998; Wang et al. 2000).

Cleptinae includes three genera, *Cleptes* Latreille, 1802, *Cleptidea* Mocsáry, 1904, and *Lustrinia* Kurian, 1955, with 111 valid species (Kimsey and Bohart 1991; Móczár 1996a, 1997a, 1997b, 1998a, 1998b, 2000a, 2000b, 2001, 2009; Rosa 2003; Ha et al. 2011). Up to now only the genus *Cleptes* has been recorded from China.

The genus *Cleptes* can be distinguished from *Cleptidea* and *Lustrinia* by head as wide as long, eyes small and not bulging in frontal view, and claws with one small perpendicular submedial tooth.

Cleptes is mainly a Holarctic genus (Kimsey and Bohart 1991), with 90 recognized species (Kimsey and Bohart 1991; Móczár 1996a, 1996b, 1997a, 1997b, 1998a, 1998b, 1998c, 2000a, 2000b, 2001, 2009; Rosa 2003; Ha et al. 2011). Before this study, eight species were considered to be known from China (Table 1), of these, six are valid and two are misidentified.

Relatively thorough studies on *Cleptes* have been carried out in Europe and North America, compared with only few and non-systematic studies in Asia: Japan (Tsuneki 1959, 1982), Korea (Kim 1970; Kim and Ha 2009; Ha et al. 2011), Thailand (Tsuneki 1982), and China (Hammer 1950; Móczár 1968; Tsuneki 1982; Kimsey 1987; Rosa 2003). In China, the fauna of *Cleptes* is still poorly known. In this study, seventeen species of *Cleptes* are recognized, with nine of these are new to science, and two new to China.

Materials and methods

All the specimens were examined and described under a stereomicroscope (Olympus SZ61). All the photos were taken with a digital camera (CoolSNAP) attached to a Zeiss Stemi 2000-CS stereomicroscope. Images were processed using Image-Pro Plus software.

Table 1. List of the Chinese species of Cleptinae before this study.

Species	Distribution
Cleptes asianus Kimsey, 1987	Taiwan (Oriental)
Cleptes mandsuricus Móczár, 1968	Northeast China (=Mandchuria) (Palaearctic)
Cleptes mareki Rosa, 2003	Shanxi (Palaearctic)
Cleptes nitidulus (Fabricius, 1793)	Northeast China (=Mandchuria) (Palaearctic) [misidentification]
Cleptes semiauratus (Linnaeus, 1761)	Jilin (Palaearctic) [misidentification]
Cleptes sjostedti Hammer, 1950	Jiangsu (=Kiangsu) (Palaearctic), Taiwan (Oriental)
Cleptes taiwanus Tsuneki, 1982	Taiwan (Oriental)
Cleptes townesi Kimsey, 1987	Taiwan (Oriental)

Morphological terminology of this study mainly follows that of Kimsey and Bohart (1991), Móczár (1998b), and Tsuneki (1959).

The abbreviations used in the descriptions are as follows: ASD= antennal socket diameter; F-I, F-II, F-III, etc. = flagellum I, flagellum II, flagellum III and so on; HH= head height, the maximum distance from the lowest margin of clypeus to the uppermost margin of frons in frontal view; HL= head length, the maximum distance across the head in lateral view; HW= head width, the maximum distance between compound eyes in frontal view; L/W = relative length to width; MOD= midocellar diameter; MS= malar space, the shortest distance between the base of mandibles and margin of the compound eyes; OCL= ocellar-occiputal line, the shortest distance between posterior ocellus and occipital carina; OOL= oculo-ocellar line, the shortest distance between posterior ocellus and compound eye; PD= puncture diameter; Ped= pedicel; POL= posterior ocellar line, the shortest distance between posterior ocelli; T-I, T-II, T-III, etc. = metasomal tergum I, tergum II, tergum III and so on.

Types and other specimens from the following institutions and private collections have been examined:

GA Gian Luca Agnoli private collection, Bologna, Italy.
MCNM Museo Civico di Storia Naturale, Milan, Italy.
MP Maurizio Pavesi private collection, Milan, Italy.
NHRS Swedish Museum of Natural History, Stockholm, Sweden.
NMW Naturhistorisches Museum, Zoologische Abteilung, Vienna, Austria.
PRC Paolo Rosa private collection, Bernareggio, Italy.
SCAU Hymenopteran Collection, South China Agricultural University, Guangzhou, China.
SHEM Shanghai Entomological Museum, Chinese Academy of Science, Shanghai, China.
ZJUH Parasitic Hymenoptera Collection of Zhejiang University, Hangzhou, China.

Systematics

Genus *Cleptes* Latreille, 1802
http://species-id.net/wiki/Cleptes

Cleptes Latreille, 1802: 316. Type species: *Sphex semiaurata* Linnaeus 1761. Latreille 1802: 316; Aaron 1885: 211; Linsenmaier 1959: 7; Tsuneki 1959: 1; Móczár 1962: 115; Kimsey 1981: 801; Bohart and Kimsey 1982: 3; Kimsey and Bohart 1991: 43; Móczár 1996a: 153; 1996b: 134; 1997b: 26; 1998b: 502; 2000a: 319; 2000b: 297; 2001: 905; Rosa 2006: 82; Móczár 2009: 131; Ha et al. 2011: 491.

Diagnosis. *Cleptes* can be distinguished from all other genera of Cleptinae by metasoma convex beneath, four visible tergites in females and five in males.

Other distinctive characteristics are: face convex; eyes not bulging and following the head profile in frontal view; malar space usually longer than 1 MOD; mandible robust, with two or more subapical teeth; clypeus usually emarginated beneath the antennal socket; pronotum narrowed anteriorly, and divided by a transverse crenate sulcus which delineates a bulbous collar; mesopleuron with subalar fossa and scrobal pit, scrobal sulcus and omaulus occasionally present; propodeum with long dorsal surface and vertical posterior declivity, posterolaterally angulate to dentate; claws with one small perpendicular submedial tooth; T-I and T-II dorsally subequal to or shorter than T-III and T-IV; forewing with weakly defined discoidal cell and an incomplete, or lacking, radial sector vein; ovipositor long and robust.

Distribution. There are 90 valid *Cleptes* species in the world, 83 of which are found in the Holarctic region, eight in the Oriental region (two of which are in both the Holarctic and Oriental regions), and one in the Neotropical region.

Remarks. Móczár (1962) and Kimsey (1981) divided the genus *Cleptes* into subgenera, which later were downgraded by Kimsey and Bohart (1991) into species groups. Recently Móczár (1997a, 1997b, 1998a, 1998b, 1998c, 2000a, 2000b, 2001) reviewed the genus by studying all the available types, and adopted the subgeneric and species group system. In this study we consider *Cleptes* subdivided into species groups, without subgeneric distinctions.

Keys to the Chinese species of the genus *Cleptes* Latreille

Females. Unknown for *C. eburnecoxis* sp. n., *C. mandsuricus*, *C. sinensis* sp. n., *C. tibetensis* sp. n., *C. townesi*, and *C. villosus* sp. n. Males. Unknown for *C. albonotatus* sp. n., *C. asianus*, *C. flavolineatus* sp. n., *C. helanshanus* sp. n., *C. metallicorpus*, *C. niger* sp. n., *C. shengi* sp. n., and *C. taiwanus*.

1 Female: metasoma with four segments **2**
– Male: metasoma with five segments **12**
2 Mesopleuron with V-shape loop (Plates 7D, 12D) **3**
– Mesopleuron without V-shape loop (Plates 1D, 3D, 4D, 6D, 8D, 10D) **7**
3 Pronotum with longitudinal median sulcus complete (Plate 9C) or incomplete (Plate 12C) **4**
– Pronotum without longitudinal median sulcus (Plate 7C) **5**
4 Posterior pit row of pronotum without considerably larger median pits; longitudinal median sulcus complete ..... ***Cleptes seoulensis*** **Tsuneki**
– Posterior pit row of pronotum with two median pits considerably larger than the others (Plate 12C); longitudinal median sulcus incomplete..... ..... ***Cleptes sjostedti*** **Hammer**
5 Posterior pit row of pronotum with round pits and two median pits considerably larger than the others..... ***Cleptes asianus*** **Kimsey**
– Posterior pit row of pronotum with elongated pits and two median pits not considerably larger than the others (Plate 7C) **6**

6 Mandibles with distinct striatopunctures; metanotum with two foveae along the posterior margin (Plate 7E) ..... ***Cleptes metallicorpus*** **Ha, Lee & Kim**

– Mandibles without striatopunctures; metanotum with a broad fovea along the posterior margin ..... ***Cleptes taiwanus*** **Tsuneki**

7 Body without metallic colouration (Plates 1A, 3A, 8A) **8**

– Body with metallic colouration (Plates 4A, 6A, 10D) **10**

8 Antennae with pedicels and F-I–F-III testaceous (Plate 3B) and rest of flagellum black; vertex with two oblique yellow stripes; mesosoma mostly black, with yellow stripes on pronotum and mesoscutellum (Plates 3C, 3E) ... . ***Cleptes flavolineatus*** **sp. n.**

– Antennae with pedicels, F-I–F-III black (Plate 1B) or F-I blackish-brown and rest of flagellum black (Plate 8B); vertex and mesosoma entirely black (Plates 1A, 8A) **9**

9 Metapleuron polished and weakly striate (Plate 8D); dorsal surface of propodeum with six longitudinal ridges and numerous weak transverse wrinkles (Plate 8E); propodeal angles long and blunt (Plate 8E) ..... ***Cleptes niger*** **sp. n.**

– Metapleuron transversely striate (Plate 1D); dorsal surface of propodeum with dense and irregular wrinkles (Plate 1E); propodeal angles short and blunt (Plate 1E) ..... ***Cleptes albonotatus*** **sp. n.**

10 Pronotum with distinct posterior pit row (Plate 10C); metanotum with a big anteromedian pit and two foveae along the posterior margin (Plate 10E)..... ..... ***Cleptes shengi*** **sp. n.**

– Pronotum without posterior pit row (Plates 4C, 6C); metanotum without anteromedian pit and fovea along the posterior margin (Plates 4E, 6C) **11**

11 Pronotum golden, with green tints on lateral sides (Plate 4A); mesopleuron and metanotum golden-red (Plate 4E); mesopleuron somewhat polished, scrobal sulcus well defined (Plate 4D) ..... ***Cleptes helanshanus*** **sp. n.**

– Pronotum and mesopleuron metallic blue, metanotum dark metallic blue (Plate 6A); mesopleuron with aligned and elongated punctures, scrobal sulcus not well defined (Plate 6D) ..... ***Cleptes mareki*** **Rosa**

12 Body entirely metallic green to blue; mesopleuron with V-shape loop complete (Plates 13D, 14D, 16D), or incomplete, missing of upper branch, not reaching anterior corner (Plate 9D) **13**

– Body not entirely metallic, only head and part of mesosoma with metallic colouration; mesopleuron without V-shape loop (Plates 2D, 11D, 15D) ... **16**

13 Pronotum with complete or incomplete longitudinal median sulcus (Plates 9C, 13C); metanotum with a big anteromedian pit (Plates 9E, 13E) **14**

– Pronotum without longitudinal median sulcus (Plates 14C, 16C); metanotum with an indistinct or small anteromedian pit (Plates 14E, 16E) **15**

14 Pronotum with longitudinal median sulcus complete (Plate 9C); posterior pit row of pronotum without considerably larger median pit (Plate 9C); mesopleuron with V-shape loop incomplete, missing of upper branch, not reaching anterior corner (Plate 9D) ..... ***Cleptes seoulensis*** **Tsuneki**

– Pronotum with longitudinal median sulcus incomplete (Plate 13C); posterior pit row of pronotum with two median pits considerably larger than the others (Plate 13C); mesopleuron with complete and strong V-shape loop (Plate 13D) ..... ***Cleptes sjostedti* Hammer**

15 Face with sparse punctures (1.0–5.0 PD) (Plate 14B); frontal sulcus absent (Plate 14B); lower margin of clypeus with acute teeth at corners; head with sparse hairs on clypeus and vertex (Plate 14B); metanotum with transverse depression anteriorly and a broad fovea along the posterior margin (Plate 14E).. ..... ***Cleptes tibetensis* sp. n.**

– Face with dense punctures (0.5–1.0 PD) (Plate 16B); frontal sulcus complete but weak (Plate 16B); lower margin of clypeus without acute teeth at corners; head with dense hairs on clypeus and vertex (Plate 16B); metanotum without transverse impression anteriorly, with two medially fused foveae along the posterior margin (Plate 16E) ..... ***Cleptes villosus* sp. n.**

16 Pronotum with complete and narrow longitudinal median sulcus..... ..... ***Cleptes mandsuricus* Móczár**

– Pronotum without longitudinal median sulcus (Plates 2C, 5D, 11C, 15C) 17

17 Body mostly blackish, with metallic colour restricted to face (Plate 15B) or head (Plate 2B) **18**

– Body with metallic blue colour on head and mesosoma (Plates 5A, 11A) .. **19**

18 Face with metallic colour (Plate 15B); face and vertex with small and sparse punctures; dorsal surface of propodeum irregularly reticulate (Plate 15E); propodeal angles short and stumpy (Plate 15E) ..... ***Cleptes townesi* Kimsey**

– Head entirely with metallic colour (Plates 2B, 2C); face with deep and dense punctures; dorsal surface of propodeum with six longitudinal ridges, with numerous and weak transverse wrinkles (Plate 2E); propodeal angles long and blunt (Plate 2E) ..... ***Cleptes eburnecoxis* sp. n.**

19 Metanotum with a broad fovea along the posterior margin (Plate 11E); metapleuron smooth and polished (Plate 11D)..... ***Cleptes sinensis* sp. n.**

– Metanotum without fovea along the posterior margin (Plate 5D); metapleuron transversally striate in upper part ..... ***Cleptes mareki* Rosa**

Cleptes asianus Kimsey, 1987

http://species-id.net/wiki/Cleptes_asianus

Cleptes asianus Kimsey, 1987: 56; Kimsey and Bohart 1991: 59; Móczár 2000a: 325.

Material examined. None.

Diagnosis. Body entirely purple, including femora and tibiae. Flagellum dark brown to black. Tegulae and tarsi brown. Lower margin of clypeus truncate. Dorsal surface of propodeum coarsely punctuate, with propodeal angles obtuse (Kimsey 1987; Móczár 2000a).

Distribution. Oriental part of China (Taiwan).
Biology. Collected in May.
Remarks. *Cleptes asianus* Kimsey belongs to the *asianus* species-group (Móczár 2000a).

***Cleptes albonotatus* sp. n.**
http://zoobank.org/0481B833-7702-471B-8575-66D66C4570C2
http://species-id.net/wiki/Cleptes_albonotatus
Plate 1

Material examined. Holotype ♀ (SCAU), Guangdong, Nanling National Nature Reserve (24°55'43"N, 113°1'1"E), 10–14.V.2006, Zai-fu Xu leg., No. SCAU-C0001.

Diagnosis. *Cleptes albonotatus* sp. n. is similar to *C. satoi* Tosawa based on the blackish colour of the body, coarse punctures on head, and irregular punctures along the posterior margin of pronotum; it resembles *C. japonicus* Tosawa based on the transversely punctuate mesopleuron. However, *C. albonotatus* sp. n. can be distinguished from these two species and others of the *satoi* species-group (*C. flavolineatus* sp. n. and *C. niger* sp. n.) by the combination of the following characteristics: body mostly blackish, without metallic reflections, face with close and coarse punctures, pronotum with indistinct posterior pit row, metanotum without anteromedian pit and pale tints on lateral sides of T-II.

Description. *Female.* Holotype. Body length 6.1 mm (Plate 1A). Forewing length 4.1 mm. HW : HH : HL = 37 : 25 : 50. POL : OOL : OCL = 8 : 17 : 18. MS = 1 MOD. Width of clypeal lower margin = 1.4 ASD. L/W of Ped, F-I, F-II, and F-III are 1.8, 1.3, 1.0, and 0.9, respectively.

Head. Face, ocellar area, and vertex with big, deep, close and coarse punctures (0–0.5 PD). Clypeus with lower margin truncate, without acute teeth at corners. Frontal sulcus complete (Plate 1B). Mandibles mostly polished, with few fine punctures and with four teeth. Ocellar triangle isosceles, without post-ocellar sulcus.

Mesosoma. Pronotum with punctures slightly smaller and sparser than those on vertex. Pronotum with distinct anterior pit row and indistinct posterior pit row; with irregular punctures along the posterior margin (Plate 1C); without longitudinal median sulcus (Plate 1C). Mesonotum and mesoscutellum with punctures similar to pronotum; notauli complete; parapsidal lines incomplete, 2/3 length of notauli; admedian lines incomplete and indistinct, 1/5 length of notauli (Plate 1C); axillary trough longitudinally striate. Mesopleuron transversely punctate, with short and indistinct scrobal sulcus (Plate 1D). Metanotum without anteromedian pit, with two foveae along the posterior margin; axillary trough longitudinally striate (Plate 1E). Metapleuron transversely striate (Plate 1D). Dorsal surface of propodeum with dense and irregular wrinkles. Propodeal angles short and blunt, slightly divergent (Plate 1E).

Metasoma. T-I impunctate; T-II–T-IV with small punctures (Plate 1F). Punctures on T-III denser than those on T-II and T-IV.

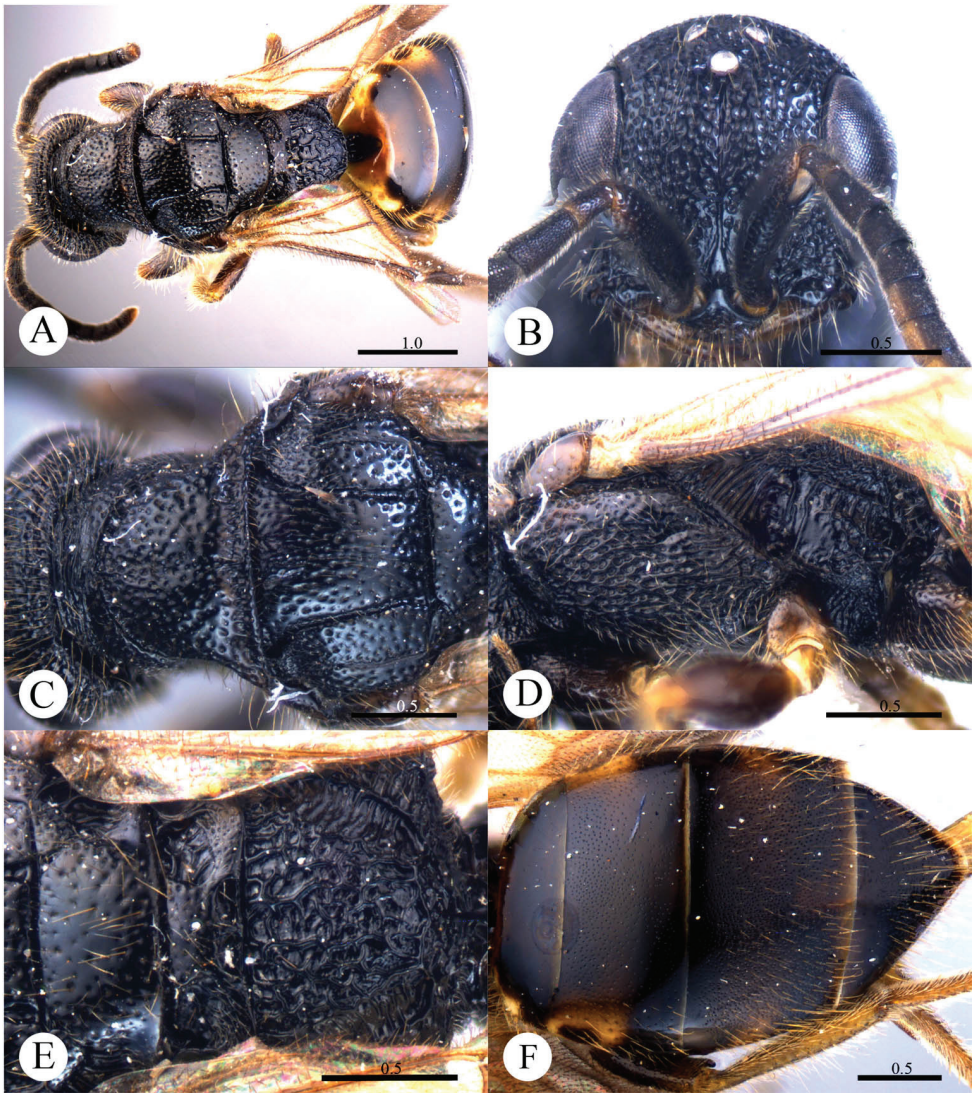

Plate 1. *Cleptes albonotatus* sp. n., holotype, female. **A** Habitus dorsal **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Pubescence. Head on vertex and clypeus with long (2.0–2.5 MOD), sparse and whitish hairs. Metasoma laterally on T-I and T-II with short (1 MOD), sparse and white hairs; dorsally and laterally on T-III and T-IV with long (2.2 MOD) and dense hairs.

Colouration. Head and mesosoma black, without metallic reflections. Mandibles black, with anterior half testaceous. Antennae black, with ventral sides of F-IV to F-XI testaceous. Tegulae blackish-brown. Legs blackish-brown, with trochanters, tibiae and tarsi testaceous. Metasoma blackish-brown, T-I laterally and on the anterior half testaceous, T-II laterally with distinct pale torus.

Male. Unknown.

Distribution. Oriental part of China (Guangdong).

Biology. Collected in May.

Etymology. The specific name is referring to the pale torus on lateral T-II.

Remarks. According to Móczár (2000b), *Cleptes albonotatus* sp. n. belongs to the *satoi* species-group based on the typical irregular punctures along the posterior margin of pronotum and black body.

***Cleptes eburnecoxis* sp. n.**

http://zoobank.org/74601C23-7620-47B5-BA8F-DEDB6B54EEB6

http://species-id.net/wiki/Cleptes_eburnecoxis

Plate 2

Material examined. Holotype ♂ (SCAU), Zhejiang, Mt. Tianmu, Xianrending (30°20'56"N, 119°26'03"E), 25–29.VII.2011, Hua-yan Chen & Cheng-yuan Jin leg., No. SCAU-C0022. Paratypes: 2 ♂ (SCAU), Zhejiang, Mt. Tianmu, Xianrending, 25–29.VII.2011, Hua-yan Chen & Cheng-yuan Jin leg., No. SCAU-C0023, C0024; 5 ♂ (SCAU), Zhejiang, Mt. Tianmu, Xianrending, 25–29.VII.2011, Hua-yan Chen leg., No. SCAU-C0025–C0029; 1 ♂ (SCAU), Zhejiang, Mt. Tianmu, Xianrending, 29.VII.2003, Qiong Wu leg., No. 20034557; 2 ♂ (SCAU), Zhejiang, Mt. Tianmu, Xianrending, 28.VII.2003, Xue-xin Chen leg., No. 20038501, 20038502; 1 ♂ (SCAU), Mt. Tianmu, Xianrending, 27.VII.1999, Ming-shui Zhao leg., No. 997013; 1 ♂ (SCAU), Mt. Tianmu, Xianrending, 9.VIII.1998, Ming-shui Zhao leg., No. 994206; 1 ♂ (SCAU), Mt. Tianmu, Xianrending, 16.VIII.1999, Xue-xin Chen leg., No. 997278; 1 ♂ (SCAU), Guangxi, Longsheng, Huaping National Nature Reserve (32°52'36.84"N, 106°36'13.17"E), 25–26.VI.1982, Jun-hua He leg., No. 823647.

Diagnosis. *Cleptes eburnecoxis* sp. n. is closely related to *C. townesi* Kimsey based on the similar colouration, short MS (0.4 MOD), absence of posterior pit row on pronotum, polished mesopleuron, and posteriorly emarginate T-V. However, it can be distinguished by head being entirely metallic green (the metallic colour is restricted to face in *C. townesi*), dorsal surface of propodeum with six longitudinal ridges (irregularly reticulate in *C. townesi*), propodeal angles long and blunt (short and stumpy in *C. townesi*).

Description. *Male*. Holotype. Body length 6.6 mm (Plate 2A). Forewing length 5.1 mm. HW : HH : HL = 36.5 : 28 : 17.5. POL : OOL : OCL = 8.5 : 15 : 19.5. MS = 0.4 MOD. Width of clypeal lower margin = 1.5 ASD. L/W of Ped, F-I, F-II, and F-III are 1.4, 2.4, 2.0, and 1.8, respectively.

Head. Face with deep and dense punctures (0–0.5 PD) on lateral sides, with shallow and sparse (0.5–1.0 PD) punctures medially. Clypeus with lower margin slightly convex medially, without acute teeth at corners. Frontal sulcus complete (Plate 2B). Mandibles with sparse punctures and three teeth. Ocellar area with dense punctures (0–0.5 PD). Ocellar triangle equilateral, with post-ocellar sulcus. Vertex with shallow and sparse punctures (0.5–1.0 PD).

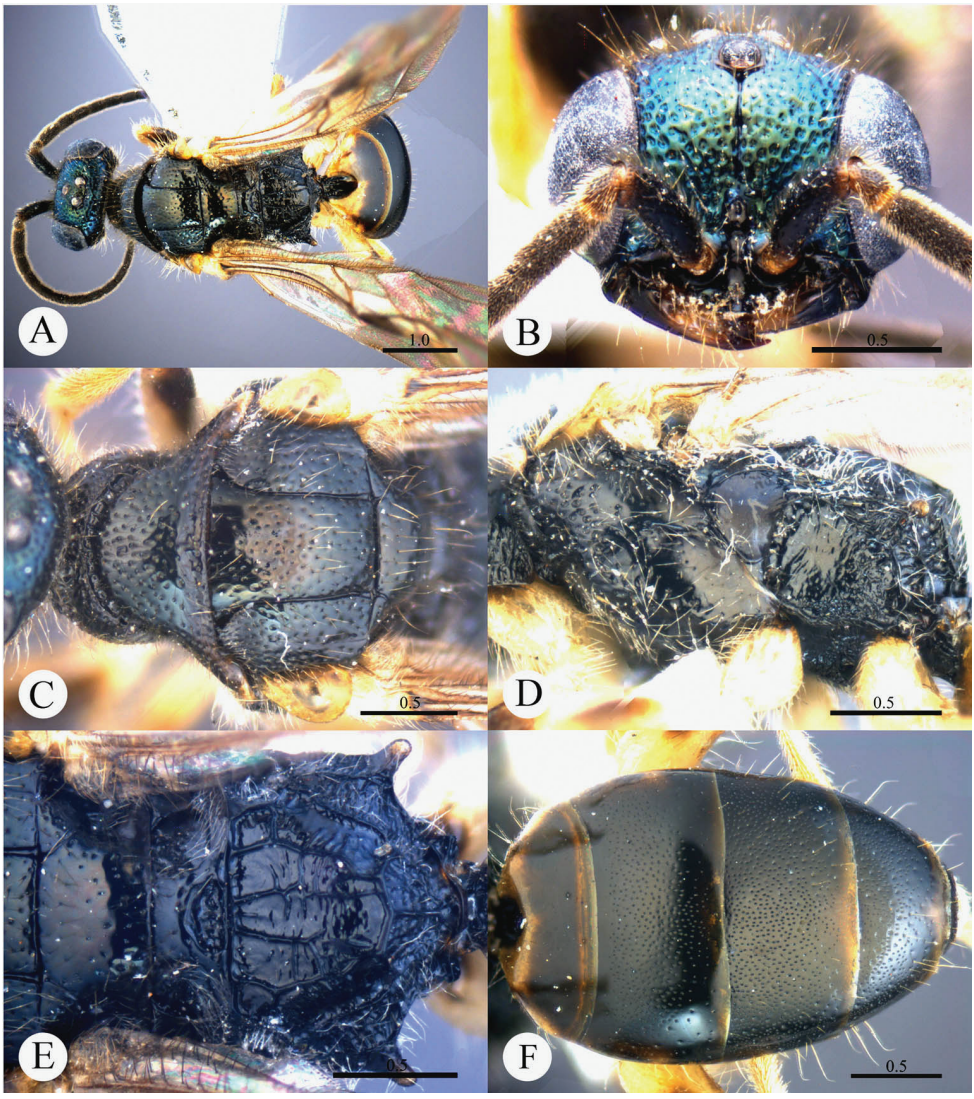

Plate 2. *Cleptes eburnecoxis* sp. n., holotype, male. **A** Habitus dorsal **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Mesosoma. Pronotum with shallow and sparse punctures similar to those on vertex; with distinct anterior pit row, without posterior pit row (Plate 2C); without longitudinal median sulcus (Plate 2C). Mesonotum with small and shallow punctures, smaller and sparser on mesoscutellum; notauli complete; parapsidal lines incomplete, 3/4 length of notauli; admedian lines incomplete and indistinct, 1/4 length of notauli (Plate 2C); axillary trough polished, with few transverse wrinkles. Mesopleuron polished, with short scrobal sulcus, and with sparse punctures anteriorly (Plate 2D).

Metanotum without anteromedian pit, with a big fovea along the posterior margin; axillary trough polished (Plate 2E). Metapleuron smooth and polished (Plate 2D). Dorsal surface of propodeum with six longitudinal ridges, with some weak transverse wrinkles. Propodeal angles long and blunt (Plate 2E).

Metasoma. T-I and T-V nearly impunctate; T-II–T-IV with small and dense punctures (Plate 2F). Punctures on T-III denser than those on T-II and T-IV. T-V with the posterior margin emarginate medially.

Pubescence. Head on clypeus, face, and vertex with long (1.5 MOD), sparse and brown hairs. Metasoma with few brown hairs scattered laterally. T-I and T-II laterally with short (0.8 MOD) hairs. T-III and T-IV laterally with long (1.5 MOD) hairs.

Colouration. Head entirely metallic green, rest of body without metallic reflections. Mandibles brown, with testaceous tints. Antennae blackish-brown. Mesosoma black, with basolateral angles of pronotum testaceous to white, with apex of propodeal angles brown. Tegulae testaceous. Legs with coxae, trochanters, and base of femora whitish; rest of femora, tibiae and tarsi testaceous. Metasoma blackish-brown, with anterior half of T-I, and lateral sides of T-I and T-II testaceous.

Variation. Body length 6.3–8.0 mm. Forewing length 4.3–5.5 mm. Head metallic greenish-blue or bluish-green. Clypeus with lower margin less convex than holotype, nearly truncate. Frontal sulcus complete, but indistinct on lower half. Pronotum black, with testaceous near the posterior margin. Admedian lines almost absent.

Female. Unknown.

Distribution. Oriental part of China (Zhejiang, Guangxi).

Biology. Collected from June to August.

Etymology. The specific name refers to the whitish coxae.

Remarks. According to Móczár (2000a), *Cleptes eburnecoxis* sp. n. would be the second member of the *townesi* species-group based on the short MS (0.4 MOD), blackish body and metallic tint on face.

***Cleptes flavolineatus* sp. n.**

http://zoobank.org/05E04406-5077-435B-9C39-010893A59209

http://species-id.net/wiki/Cleptes_flavolineatus

Plate 3

Material examined. Holotype ♀ (ZJUH), Zhejiang, Hangzhou Botanical Garden (30°15'7.94"N, 120°7'40.48"E), 18.VI.1993, Jun-hua He leg., No.934793.

Diagnosis. *Cleptes flavolineatus* sp. n. is similar to *C. satoi* Tosawa, *C. albonotatus* sp. n. and *C. niger* sp. n. based on the blackish body, coarse punctures on head and rugose on pronotum. However, it can be easily distinguished by the combination of the following characteristics: with distinct yellow stripes on head, pronotum and mesoscutellum (absent in *C. satoi*, *C. albonotatus* sp. n. and *C. niger* sp. n.); without anteromedian pit on metanotum (with an anteromedian pit in *C. satoi*); with four longitudinal ridges and numerous transverse wrinkles dorsal surface of propodeum (propodeum coarsely striate in *C. satoi*).

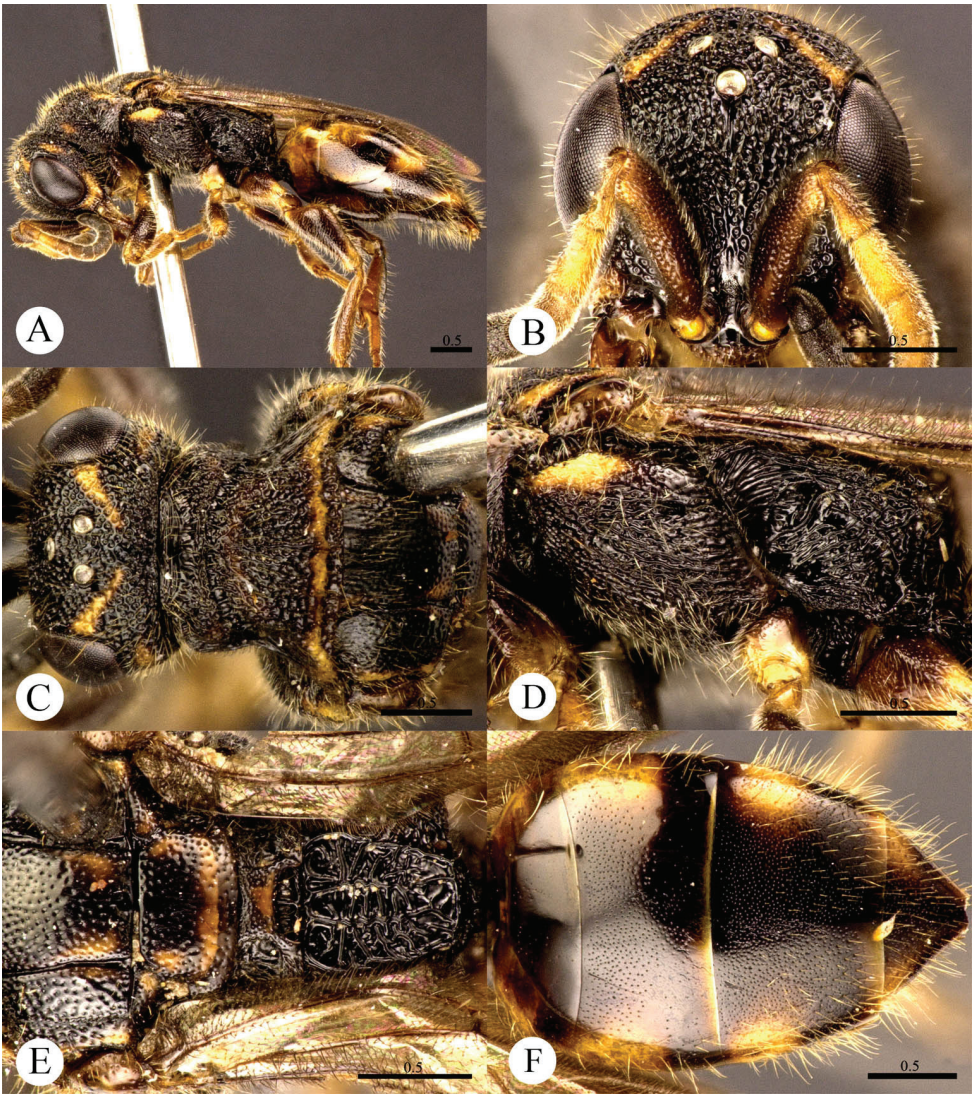

Plate 3. *Cleptes flavolineatus* sp. n., holotype, female. **A** Habitus lateral **B** Head anterior **C** Head, pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutum, mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Description. *Female*. Holotype. Body length 5.7 mm (Plate 3A). Forewing length 4.1 mm. HW : HH : HL = 3.3 : 2.9 : 1.4. POL : OOL : OCL = 4 : 10 : 9. MS = 1.3 MOD. Width of clypeal lower margin = 1.4 ASD. L/W of Ped, F-I, F-II, and F-III are 1.9, 2, 1, and 0.78, respectively.

Head. Face with dense and coarse punctures (0–0.5 PD). Clypeus with lower margin indistinctly convex medially, without acute teeth at corners. Frontal sulcus incomplete, interrupted by coarse punctures (Plate 3B). Mandibles with few punctures

and two teeth. Ocellar area with punctures similar to those on face. Ocellar triangle equilateral, without post-ocellar sulcus. Vertex with punctures similar to those on face.

Mesosoma. Pronotum rugose, with punctures merging in irregular lines. Pronotum with distinct anterior pit row and indistinct posterior pit row; with irregular punctures along the posterior margin (Plate 3C); without longitudinal median sulcus (Plate 3C). Mesonotum and metanotum with smaller, sparser and shallower punctures than those on pronotum; notauli complete; parapsidal lines incomplete, 3/4 length of notauli; admedian lines incomplete, 1/4 length of notauli (Plate 3C). Mesopleuron with dense and coarse punctures and transversely striate, with short scrobal sulcus (Plate 3D). Mesoscutellum longitudinally polish in the middle; axillary trough irregularly reticulate (Plate 3E). Metanotum without anteromedian pit, with a broad fovea along the posterior margin; axillary trough longitudinally and weakly striate (Plate 3E). Metapleuron strongly striate (Plate 3D). Dorsal surface of propodeum with four longitudinal ridges, with numerous transverse wrinkles. Propodeal angles short and blunt (Plate 3E).

Metasoma. T-I and posterior half of T-II nearly impunctate. Anterior half of T-II–T-IV with dense punctures (Plate 3F).

Pubescence. Head with long (1–1.5 MOD) and brown hairs. Metasoma dorsally and laterally on T-III and T-IV with short (0.8–1.0 MOD) and brown hairs.

Colouration. Head black, with two oblique yellow stripes dorsally. Mandibles brown. Antennae blackish-brown, with pedicels, F-I–F-III and ventral sides of F-IV–F-XI testaceous. Mesosoma mostly black, with a transverse yellow stripe near the posterior margin of pronotum, a transverse brown stripe on posterior mesoscutellum, and brown tints on mesoscutum between notauli and metanotum. Mesopleuron and metapleuron mostly black, with yellow tint on anterior corner of mesopleuron. Tegulae brown. Legs brown, with apical coxae and apical femora pale, tibiae and tarsi testaceous. Metasoma blackish-brown, with pale tint laterally on each segment.

Male. Unknown.

Distribution. Oriental part of China (Zhejiang).

Biology. Collected in June.

Etymology. The specific name refers to the yellow stripes on head and pronotum.

Remarks. According to Móczár (2000b), *Cleptes flavolineatus* sp. n. belongs to the *satoi* species-group based on the typical irregular punctures along the posterior margin of pronotum and black body.

***Cleptes helanshanus* sp. n.**

http://zoobank.org/B5329EF8-9EFA-4FBF-B74C-5ED9C60FCE79

http://species-id.net/wiki/Cleptes_helanshanus

Plate 4

Material examined. Holotype ♀ (SCAU), Inner Mongolia, Mt. Helan (39°2'5.27"N, 106°1'38.09"E), 27.VII.2010, Hong-fei Chai leg., No. SCAU-C0002.

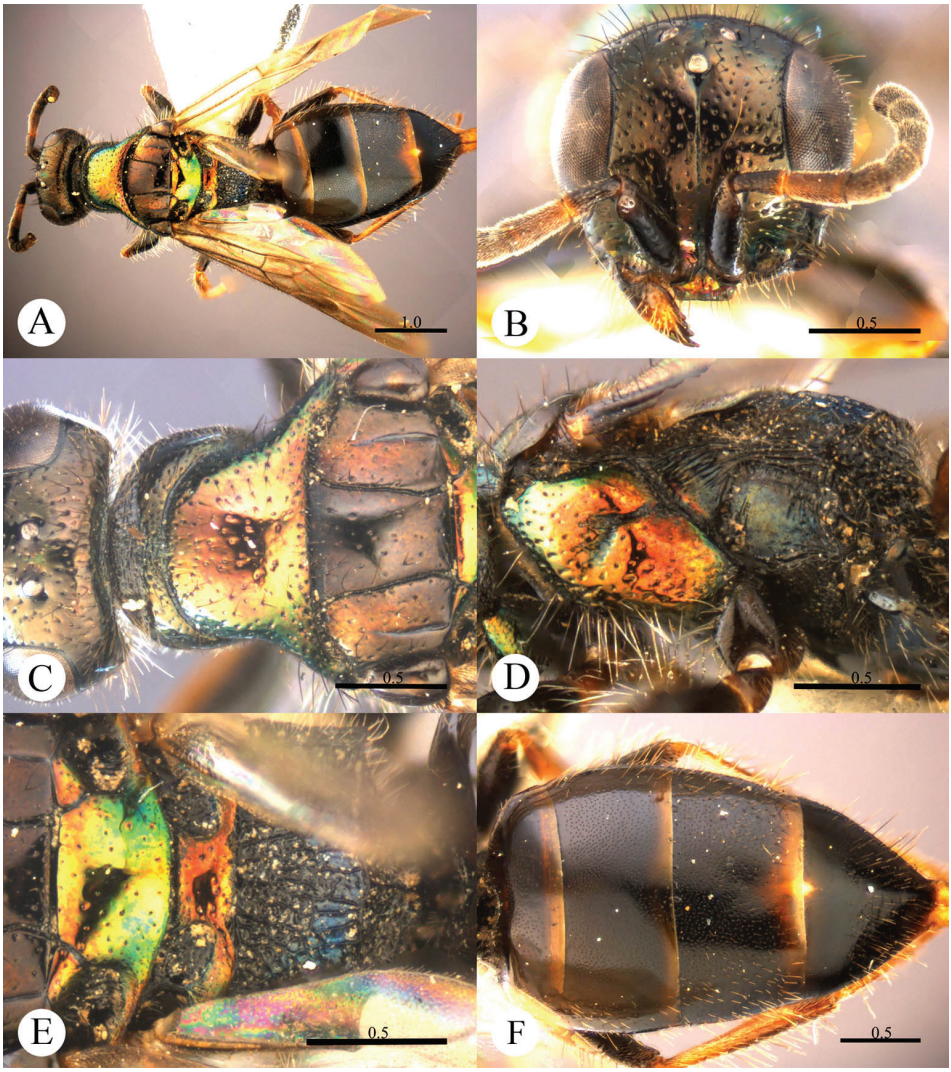

Plate 4. *Cleptes helanshanus* sp. n., holotype, female. **A** Habitus dorsal **B** Head anterior **C** Head, pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Diagnosis. This species resembles *C. mareki* Rosa based on the pronotum without posterior pit row and metanotum without pit or fovea. However, *C. helanshanus* sp. n. can be quickly separated from this species by the colouration: pronotum golden, laterally with green tints, mesopleuron and metanotum golden red, and mesoscutellum greenish-golden.

Description. *Female.* Holotype. Body length 5.9 mm (Plate 4A). Forewing length 3.9 mm. HW : HH : HL = 79 : 81 : 38. POL : OOL : OCL = 10 : 13 : 18. MS = 1.7 MOD. Width of clypeal lower margin = 1.7 ASD. L/W of Ped, F-I, F-II, and F-III are 2.1, 2.1, 1.2, and 1.0, respectively.

Head. Face with small, shallow and sparse punctures (1–4 PD). Clypeus with lower margin truncate, without acute teeth at corners. Frontal sulcus complete, even if somewhat indistinct towards the clypeus (Plate 4B). Mandibles with sparse punctures and four teeth. Ocellar area and vertex with slightly denser punctures (1–3 PD). Ocellar triangle isosceles, without post-ocellar sulcus.

Mesosoma. Pronotum with small and sparse punctures similar to those on vertex; anterior pit row somewhat interrupted medially, without posterior pit row (Plate 4C); without longitudinal median sulcus (Plate 4C). Mesonotum and metanotum almost impunctate, with very sparse and shallow punctures. Mesoscutum with notauli complete; parapsidal lines incomplete, 3/4 length of notauli; admedian lines absent (Plate 4C); axillary trough indistinctly and longitudinally striate. Mesopleuron somewhat polished, with scrobal sulcus, and with sparse punctures on anterior half (Plate 4D). Transverse narrow sulcus present between mesoscutellum and metanotum (Plate 4E). Metanotum without pit or fovea; axillary trough weakly and irregularly reticulate (Plate 4E). Metapleuron polished, with some weak and transverse wrinkles on the upper part (Plate 4D). Dorsal surface of propodeum irregularly reticulate, with lateral margin straight and parallel. Propodeal angles short and stumpy (Plate 4E).

Metasoma. T-I with small and sparse punctures. T-II and T-III with dense punctures. T-IV with anterior half impunctate, and posterior half with sparse punctures (Plate 4F).

Pubescence. Head with long (2 MOD) and erect black bristles on vertex. Metasoma on T-III and T-IV dorsally and laterally with long (1.5 MOD) and white hairs; with very long (3–4 MOD) and erect black bristles laterally on T-III and T-IV.

Colouration. Head black, without metallic reflections. Mandibles blackish-brown, with teeth testaceous. Antennae black, with testaceous between pedicel and F-I. Pronotum golden, with green tints on lateral sides. Mesopleuron and metanotum golden-red. Mesoscutum black. Mesoscutellum greenish-golden. Metapleuron, propodeum and tegulae black. Legs blackish-brown, with tibiae and tarsi testaceous. Metasoma blackish-brown, with posterior margins of all segments testaceous, with small pale spot present between T-III and T-IV.

Male. Unknown.

Distribution. Palaearctic part of China (Inner Mongolia).

Biology. Collected in July.

Etymology. The species is named after the type locality.

Remarks. According to Móczár (1997b), *Cleptes helanshanus* sp. n. belongs to the *nitidulus* species-group based on the pronotum without posterior pit row and longitudinal median sulcus, and the blackish-brown metasoma.

***Cleptes mandsuricus* Móczár, 1968**

http://species-id.net/wiki/Cleptes_mandsuricus

Cleptes mandsuricus Móczár, 1968: 171; Kimsey and Bohart 1991: 61; Móczár 1998a: 337.

Material examined. None.

Diagnosis. Head and mesosoma metallic bluish-green, with violet reflection. Tibiae metallic bluish, with violet reflection, tarsi brown. Pronotum with both anterior and posterior pit rows. Metanotum with an anteromedian pit and a broad fovea along the posterior margin (Móczár 1968, 1998a).

Distribution. Palaearctic part of China (Northeast China).

Biology. Collected in June.

Remarks. *Cleptes mandsuricus* Móczár belongs to the *aerosus* species-group (Móczár 1998a).

Cleptes mareki Rosa, 2003

http://species-id.net/wiki/Cleptes_mareki
Plates 5, 6

Cleptes mareki Rosa, 2003: 407.

Material examined. Holotype ♂ (MCNM), "China c., 27.V., Zhongtiao Shan mt. c., 45 km W of Sanmenxia, Leg. J. Halada 1996", "Holotypus, *Cleptes* (*Leiocleptes*), *mareki* n. sp., Paolo Rosa det. 2003". Paratypes: 43 ♀+2 ♂ (PRC, GA and MP), "China c., 27.V., Zhongtiao Shan mt. c., 45 km W of Sanmenxia, Leg. J. Halada 1996", "Paratypus, *Cleptes* (*Leiocleptes*), *mareki* n. sp., Paolo Rosa det. 2003". Other material examined: 1 ♂ (SHEM), Gansu, Jiuquan, Huangnibao (39°43'0.60"N, 98°49'58.06"E), 1700 m, 15.VII. 2010, Xu-feng Zhang & Feng-li Cui leg.

Diagnosis. Addition to the original description. *Males.* Mesopleuron covered with sparse elongated punctures, almost polished towards metapleuron; without well-defined scrobal sulcus, but with enlarged fovea, more or less deeply excavated; metapleuron polished, transversally striate in upper part (Plate 5). *Females.* Punctuation on mesopleuron similar to the those of the males, with more aligned punctures; short scrobal sulcus, ending in a big and deep fovea; metapleuron entirely transversally striate (Plate 6).

Variation. The specimen from Gansu with head and mesosoma metallic greenish-blue.

Distribution. Palaearctic part of China (Shanxi, Gansu).

Biology. Collected in May and July at 1700 m.

Remarks. *Cleptes mareki* Rosa belongs to the *nitidulus* species-group (Rosa 2003).

Cleptes metallicorpus Ha, Lee & Kim, 2011 (New to China)

http://species-id.net/wiki/Cleptes_metallicorpus
Plate 7

Cleptes metallicorpus Ha, Lee & Kim, 2011: 489.

Material examined. 1 ♀ (SCAU), Guangdong, Nanling National Nature Reserve (24°55'43"N, 113°1'1"E), 10–14.V.2006, Zai-fu Xu leg., No. SCAU-C0004; 1 ♀

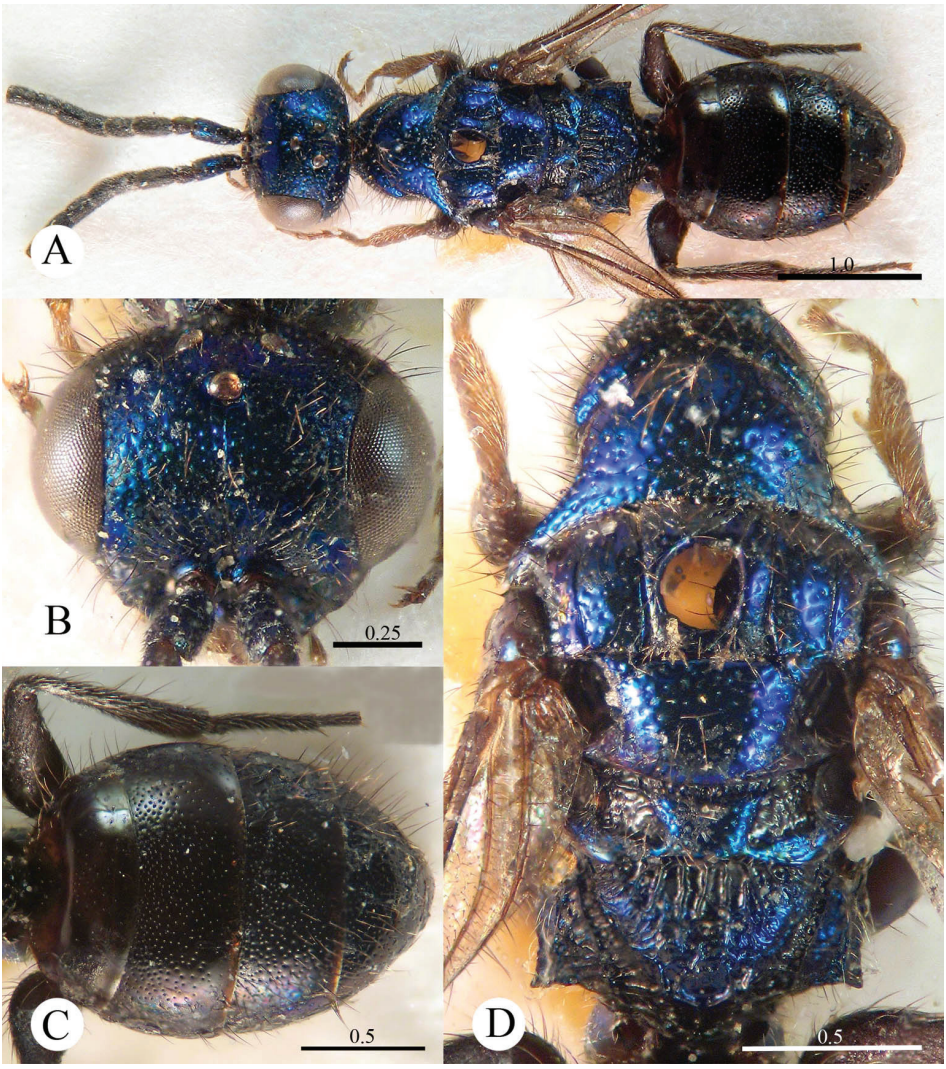

Plate 5. *Cleptes mareki* Rosa, 2003, holotype, male from Shanxi. **A** Habitus dorsal **B** Head anterior **C** Metasoma dorsal **D** Mesosoma dorsal. Scale bars in mm. (Photos by Michele Zilioli & Fabrizio Rigato).

(SCAU), Zhejiang, Mt. Tianmu, Xianrending (30°20'56"N, 119°26'03"E), 25–29. VII.2011, Hua-yan Chen & Cheng-yuan Jin leg., No. SCAU-C0005; 1 ♀ (ZJUH), Mt. Tianmu, Qiliting (30°20'N, 119°26'E), 13.VI.1998, Xue-xin Chen leg., No. 980875; 1 ♀ (PRC), Shaanxi, Quing Ling Shan mts, Road Baoji – Taibal vill pass, 40 km S Baoji Zd, 21–23.June.1998, Jindra lgt.

Diagnosis. Frontal sulcus complete. Pronotum with distinct anterior and posterior pit rows, with elongated pits of posterior pit row. Mandibles with distinct striatopunctures. Mesopleuron with distinct V-shape loop. Metapleuron mostly smooth and polished.

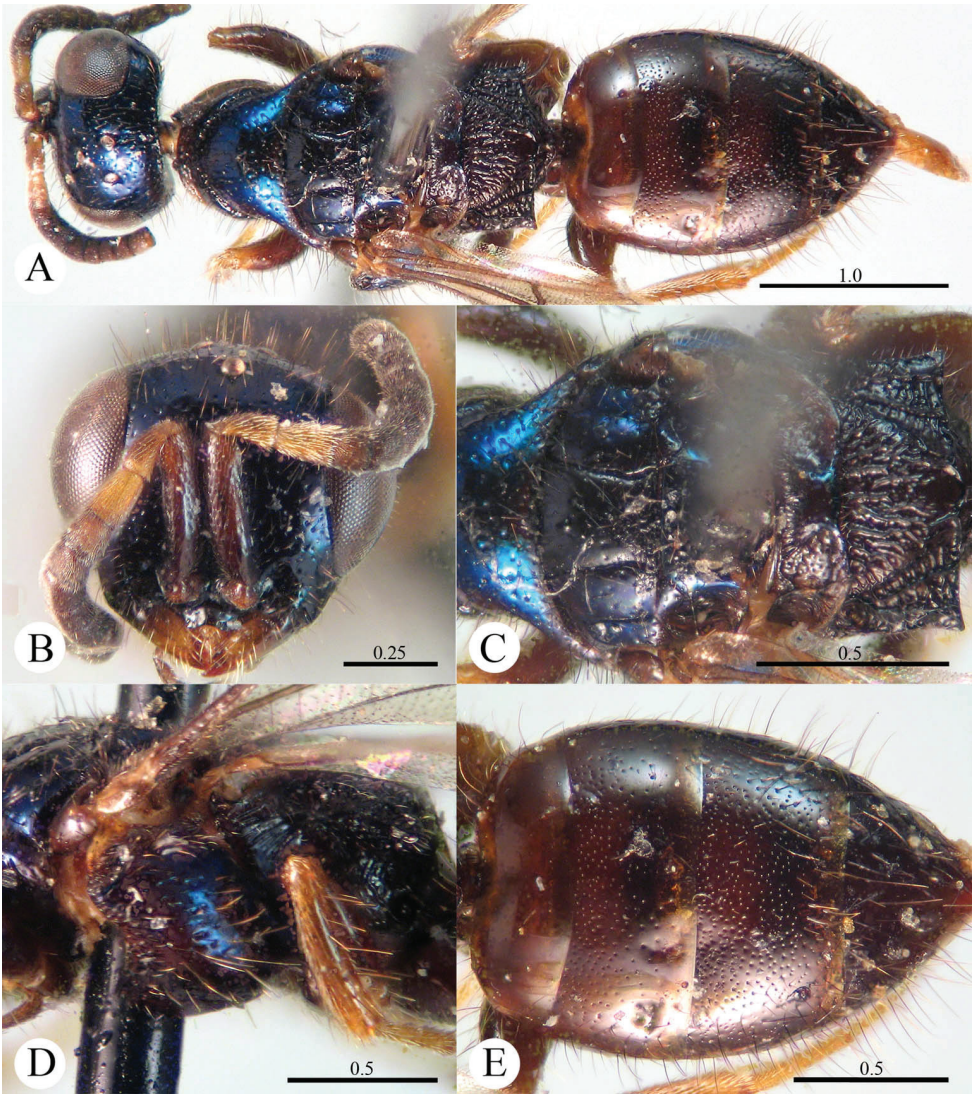

Plate 6. *Cleptes mareki* Rosa, 2003, paratype, female from Shanxi. **A** Habitus dorsal **B** Head anterior **C** Mesosoma dorsal **D** Mesopleuron and metapleuron lateral **E** Metasoma dorsal. Scale bars in mm. (Photos by Michele Zilioli & Fabrizio Rigato).

Description. Redescribed after a female from Guangdong. Body length 9.4 mm (Plate 7A). Forewing length 6.1 mm. HW : HH : HL = 22.8 : 18.5 : 13.8. POL : OOL : OCL = 6 : 8 : 16.8. MS =1 MOD. Width of clypeal lower margin = 1.4 ASD. L/W of Ped, F-I, F-II, and F-III are 2, 3, 1.2, and 0.9, respectively.

Head. Face, ocellar area and vertex with small, shallow and sparse punctures (0.5–1.5 PD). Clypeus with lower margin truncate medially and concave laterally before short acute teeth at corners. Frontal sulcus complete (Plate 7B). Mandi-

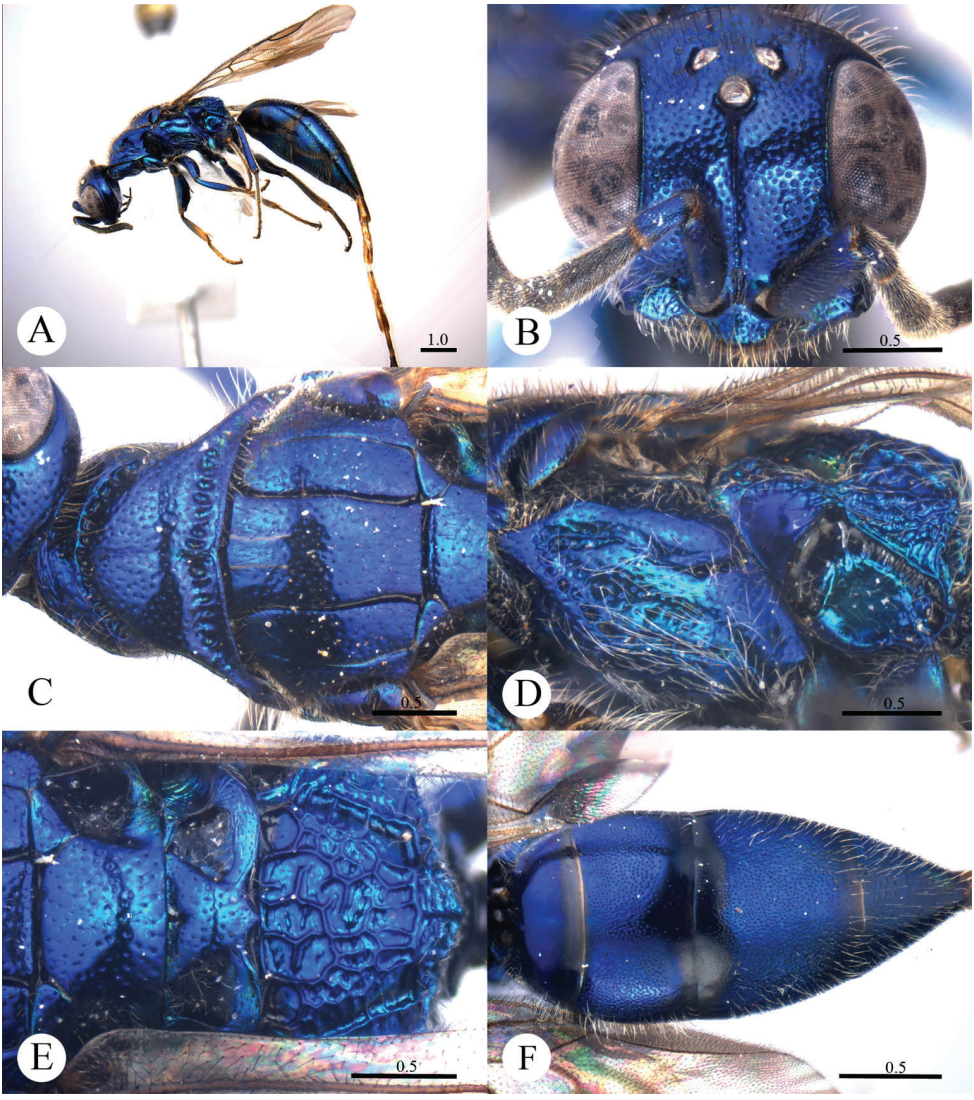

Plate 7. *Cleptes metallicorpus* Ha, Lee & Kim, 2011, female from Guangdong. **A** Habitus lateral **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

bles with distinct striatopunctures. Ocellar triangle isosceles, without post-ocellar sulcus.

Mesosoma. Pronotum with punctures similar to those on vertex. Pronotum with distinct anterior and posterior pit rows, with pits of posterior pit row elongated (Plate 7C); without longitudinal median sulcus (Plate 7C). Mesonotum and metanotum with smaller, shallower and sparser punctures than those on pronotum. Mesoscutum notauli complete; parapsidal lines nearly complete; admedian lines

incomplete, 1/3 length of notauli (Plate 7C); axillary trough smooth. Mesopleuron with distinct V-shape loop (Plate 7D). Metanotum with a small anteromedian pit, with two foveae along the posterior margin; axillary trough smooth (Plate 7E). Metapleuron mostly smooth and polished (Plate 7D). Dorsal surface of propodeum irregularly reticulate; lateral margins parallel. Propodeal angles short and nearly right-angled (Plate 7E).

Metasoma. T-I nearly impunctate; T-II–T-IV with dense punctures (Plate 7F). Punctures on T-III denser than those on T-II and T-IV.

Pubescence. Head with erect, short (0.5–1.0 MOD), sparse and black bristles, but with short (1 MOD) and brown hairs on the posterior margin of vertex. Clypeus with sparse, long (2 MOD) and white hairs. Metasoma dorsally and laterally with long (1.0–1.5 MOD) and white hairs.

Colouration. Head and mesosoma metallic bluish-green with purple tints. Mandibles metallic greenish-blue, with teeth blackish-brown. Antennae blackish-brown, with scapes and pedicels metallic bluish-green. Legs metallic blue, with tarsi testaceous. Metasoma metallic bluish-purple, with black streak on segmental margins.

Variation. Body length 6.7–9.7 mm. Forewing length 4.5–6.4 mm. Face with small, shallow and slightly denser punctures (0.5–1.5 PD). Clypeus with less distinct acute teeth at corners of lower margin. Metasoma with some metallic green tints.

Male. Unknown.

Distribution. China (Shaanxi, Zhejiang, Guangdong); Korea.

Biology. Collected from May to July.

Remarks. According to Móczár (2000a), *Cleptes metallicorpus* Ha et al. belongs to the *asianus* species-group based on two distinct pit rows on pronotum, longitudinal median sulcus absent and mesopleuron with V-shape loop.

Cleptes niger sp. n.

http://zoobank.org/DF7C665C-7A5F-4112-AA88-1789CAC0CB59
http://species-id.net/wiki/Cleptes_niger
Plate 8

Material examined. Holotype ♀ (SCAU), Shaanxi, Mt. Taibai (34°5'12.41"N, 107°42'41.77"E), 1100 m, 12–13.VII.2012, Na-sen Wei leg., No. SCAU-C0030. Paratype: 1 ♀ (SCAU), Shaanxi, Mt. Taibai (34°5'12.41"N, 107°42'41.77"E), 1100 m, 12–13.VII.2012, Na-sen Wei leg., No. SCAU-C0031.

Diagnosis. *Cleptes niger* sp. n. is related to *C. albonotatus* sp. n., *C. flavolineatus* sp. n. and *C. satoi* Tosawa based on the blackish body, coarse punctures on head, rugose pronotum and similar sculptures on the mesopleuron. However, it can be distinguished by the combination of the following characteristics: body without metallic tints or yellow stripes (mesopleuron partly metallic blue in *C. satoi*, body with yellow stripes in *C. flavolineatus* sp. n.); metanotum without anteromedian pit (with an anteromedian pit in *C. satoi*); dorsal surface of propodeum with six longitudinal ridges and numer-

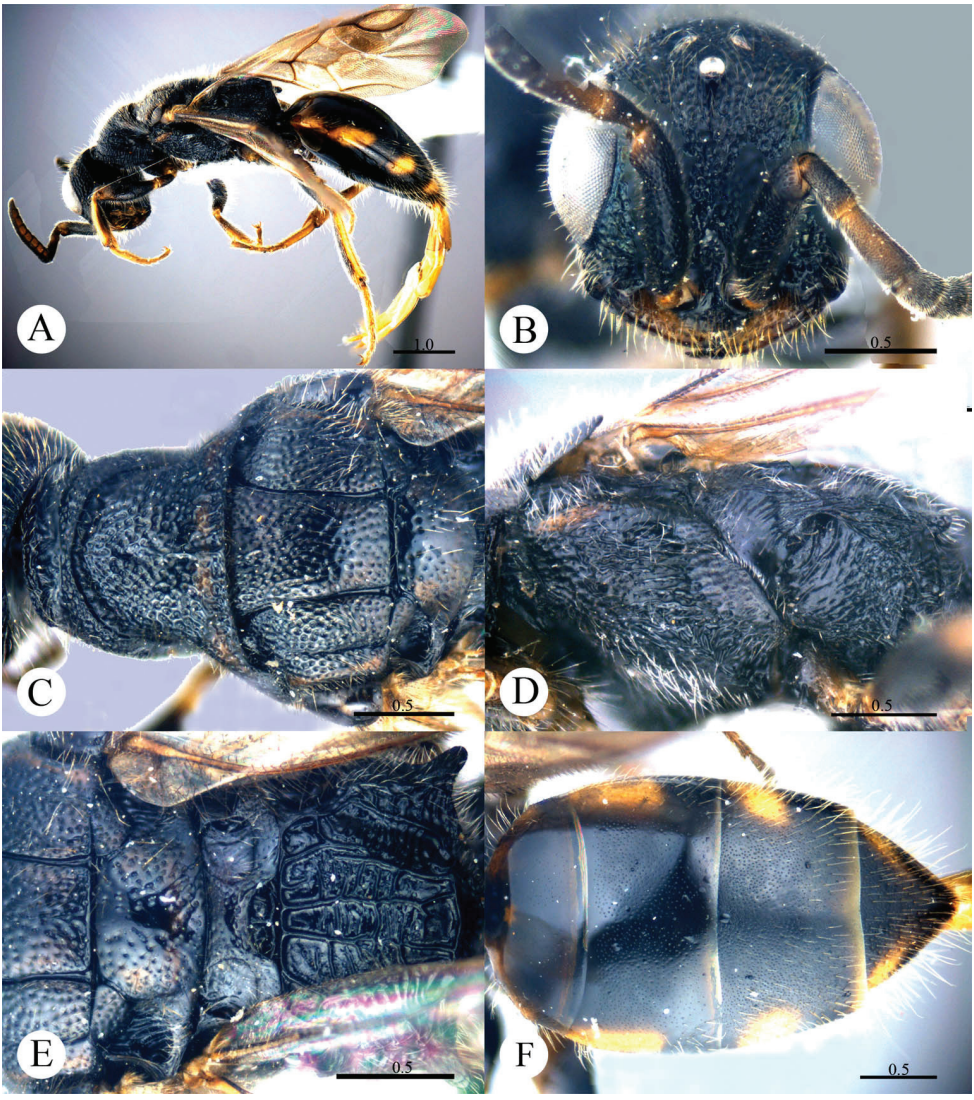

Plate 8. *Cleptes niger* sp. n., holotype, female. **A** Habitus lateral **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

ous and weak transverse wrinkles (irregularly reticulate with dense wrinkles in *C. satoi* Tosawa and *C. albonotatus* sp. n.,); metapleuron polished and weak striate on upper part (entirely and strongly striate in *C. albonotatus* sp. n. and *C. flavolineatus* sp. n.).

Description. *Female.* Holotype. Body length 7.3 mm (Plate 8A). Forewing length 4.8 mm. HW : HH : HL = 14 : 12.5 : 8. POL : OOL : OCL = 9 : 19 : 23. MS = 1.2 MOD. Width of clypeal lower margin = 1.4 ASD. L/W of Ped, F-I, F-II, and F-III are 2.1, 2.4, 1.1, and 0.8, respectively.

Head. Face, ocellar area and vertex with dense and coarse punctures (0–0.5 PD). Frontal sulcus complete, indistinct on lower face (Plate 8B). Clypeus with lower margin convex medially, without acute teeth at corners. Mandibles with sparse punctures and three teeth. Ocellar triangle isosceles, with post-ocellar sulcus indistinct and curvate.

Mesosoma. Pronotum rugose, with coarse and dense punctures. Pronotum with a distinct anterior pit row, without posterior pit row and defined pits, but with shallow depression with irregular punctures along the posterior margin (Plate 8C); without longitudinal median sulcus; with a small depression in the middle of pronotum (Plate 8C). Mesonotum and metanotum with punctures smaller and sparser than on pronotum. Mesoscutum with notauli complete; parapsidal lines incomplete, 1/2 length of notauli; admedian lines absent (Plate 8C). Mesopleuron with dense and coarse punctures and transverse wrinkles; scrobal sulcus short (Plate 8D). Mesoscutellum longitudinally polish in the middle; axillary trough longitudinally striate (Plate 8E). Metanotum without anteromedian pit, with a broad fovea along the posterior margin; axillary trough mostly smooth, longitudinally and weakly striate (Plate 8E). Metapleuron polished and weakly striate on upper part (Plate 8D). Dorsal surface of propodeum with six longitudinal ridges, with numerous and weak transverse wrinkles. Propodeal angles long and blunt (Plate 8E).

Metasoma. T-I nearly impunctate. T-II–T-IV with dense punctures (Plate 8F).

Pubescence. Head with long (1.5–2.0 MOD) and white hairs. Metasoma on T-III and T-IV dorsally and laterally with very long (2.0–2.5 MOD) and brownish hairs.

Colouration. Head and mesosoma entirely black, without metallic reflections. Mandibles testaceous. Antennae blackish-brown, with ventral sides of F-IV to F-XI testaceous. Tegulae black. Legs with coxae and femora blackish-brown, tibiae and tarsi testaceous. Metasoma black, with T-I blackish-brown anteriorly, T-I to T-III with distinct testaceous tint laterally.

Variation. Paratype: Body length 7.1 mm. Forewing length 4.8 mm.

Male. Unknown.

Distribution. China (Shaanxi).

Biology. Collected in July at 1100 m.

Etymology. The specific name refers to the black colouration.

Remarks. According to Móczár (2000b), *Cleptes niger* sp. n. belongs to the *satoi* species-group based on the typical irregular punctures along the posterior margin of pronotum, and black body.

Cleptes seoulensis Tsuneki, 1959 (New to China)

http://species-id.net/wiki/Cleptes_seoulensis

Plate 9

Cleptes seoulensis Tsuneki, 1959: 13; Kim 1970: 506; Kimsey and Bohart 1991: 64; Móczár 1998a: 340; Ha et al. 2011: 492.

Material examined. 1 ♂ (SCAU), Anhui, Jinzhai, Tiantangzhai (31°8'19.23"N, 115°46'35.82"E), 1000 m, 2.VI.2006, Hu Zhou leg., No. SCAU-C0007.

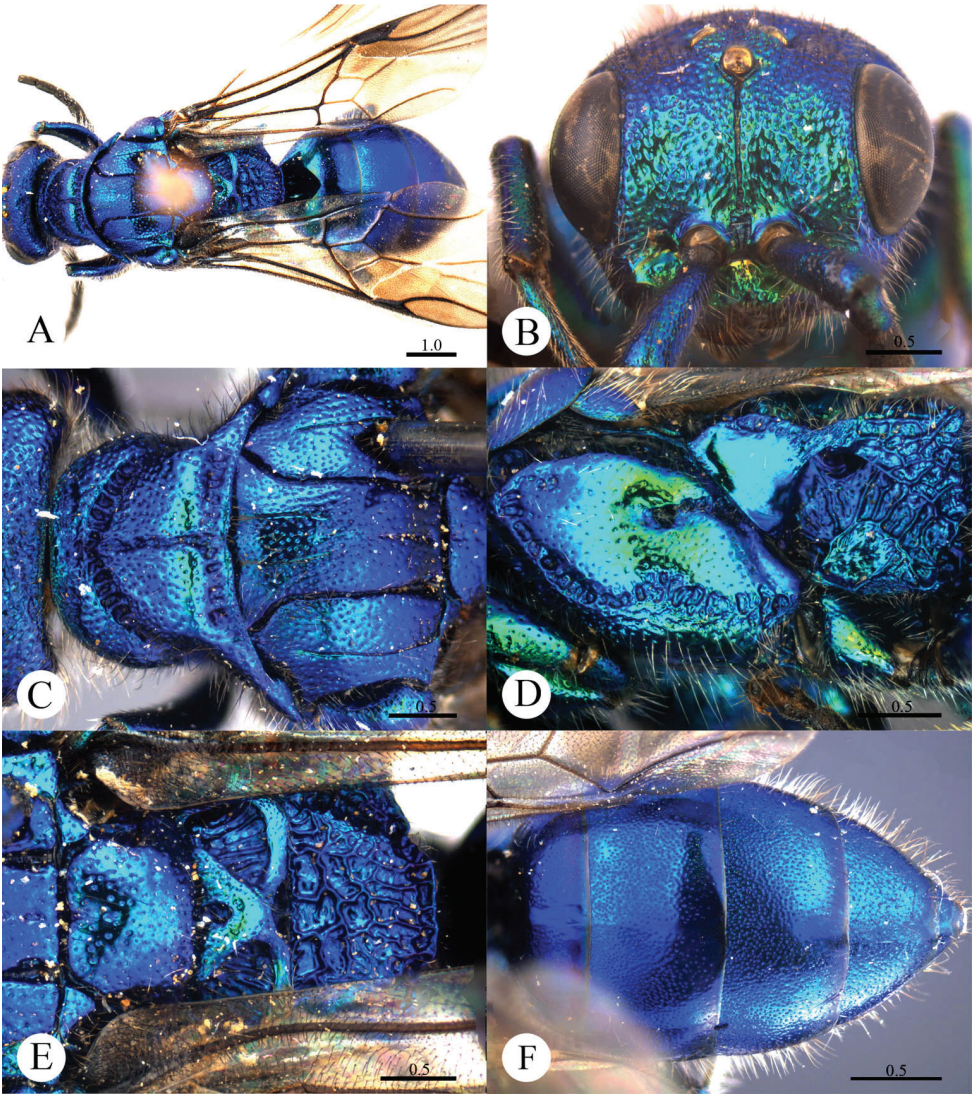

Plate 9. *Cleptes seoulensis* Tsuneki, 1959, male from Anhui. **A** Habitus dorsal **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Diagnosis. Body mostly metallic greenish-blue, with some purple tints. Ocellar area yellowish-green. Pronotum with longitudinal median sulcus complete and foveate. Female with complete V-shape loop on mesopleuron. Male with incomplete V-shape loop, missing the upper branch, not reaching anterior corner. Metanotum with a big and oval anteromedian pit, with a fovea along the posterior margin. Metapleuron mostly smooth and polished.

Description. Redescribed after a male from Anhui. Body length 10.0 mm (Plate 9A). Forewing length 7.5 mm. HW : HH : HL = 30.3 : 24.3 : 15. POL : OOL : OCL

= 7 : 12 : 16. MS = 1.6 MOD. Width of clypeal lower margin = 1.3 ASD. L/W of Ped, F-I, F-II, and F-III are 1.2, 2, 1.4, and 1.5, respectively.

Head. Face and ocellar area with dense and coarse punctures (0–0.5 PD), punctures shallower on lower face. Frontal sulcus complete (Plate 9B). Clypeus with lower margin truncate, with shallow and sparse punctures (1 PD), without acute teeth at corners. Mandibles with sparse punctures and four teeth. Ocellar triangle isosceles, without post-ocellar sulcus. Vertex with punctures similar to those on face, but shallower.

Mesosoma. Pronotum with punctures smaller and sparser (0.5–1.0 PD) than those on vertex. Pronotum with distinct anterior and posterior pit rows (Plate 9C); with longitudinal median sulcus complete and foveate (Plate 9C). Mesonotum and metanotum with punctures gradually smaller and sparser than those on pronotum. Mesoscutum with notauli complete; parapsidal lines incomplete, 4/5 length of notauli; admedian lines incomplete, 2/5 length of notauli; indistinct longitudinal and slightly foveate sulcus present medially on posterior part of mesoscutum, 1/4 length of notauli (Plate 9C); axillary trough longitudinally striate. Mesopleuron with foveate V-shape loop incomplete, missing of upper branch, not reaching anterior corner (Plate 9D). Metanotum with a big and oval anteromedian pit, with a fovea along the posterior margin; axillary trough longitudinally striate (Plate 9E). Metapleuron mostly smooth and polished (Plate 9D). Dorsal surface of propodeum irregularly reticulate; lateral margins parallel, slightly concave before propodeal angles (Plate 9E).

Metasoma. T-I, T-IV and T-V with sparse punctures. T-II and T-III with dense punctures (Plate 9F).

Pubescence. Head with long (1–2 MOD) and brown hairs, except upper face, and vertex with short (0.8–1.0 MOD), erect and black bristles. Metasoma on T-III and T-IV dorsally and laterally with long (1.0–1.5 MOD), sparse and white hairs.

Colouration. Body mostly metallic greenish-blue, with some purple tints. Ocellar area yellowish-green. Mandibles metallic blue, with teeth blackish-brown. Antennae black, with scapes and pedicels metallic bluish-green. Tegulae metallic bluish-green. Legs metallic bluish-green, with tarsi testaceous.

Female. Not available specimens for this study.

Distribution. China (Anhui); Korea.

Biology. Collected in June at 1000 m.

Remarks. *Cleptes seoulensis* Tsuneki belongs to the *fudzi* species-group (Móczár 1998a).

***Cleptes shengi* sp. n.**

http://zoobank.org/0D21B062-BAF9-43E0-9401-215500ADE0CD
http://species-id.net/wiki/Cleptes_shengi
Plate 10

Cleptes semiauratus: Sheng et al. 1998: 7 (misidentification).

Material examined. Holotype ♀ (SCAU), Jilin, Maoershan National Forest Park (42°51'23.72"N, 129°28'12.36"E), 15.VI.2010, Mao-ling Sheng leg., No. SCAU-C0035.

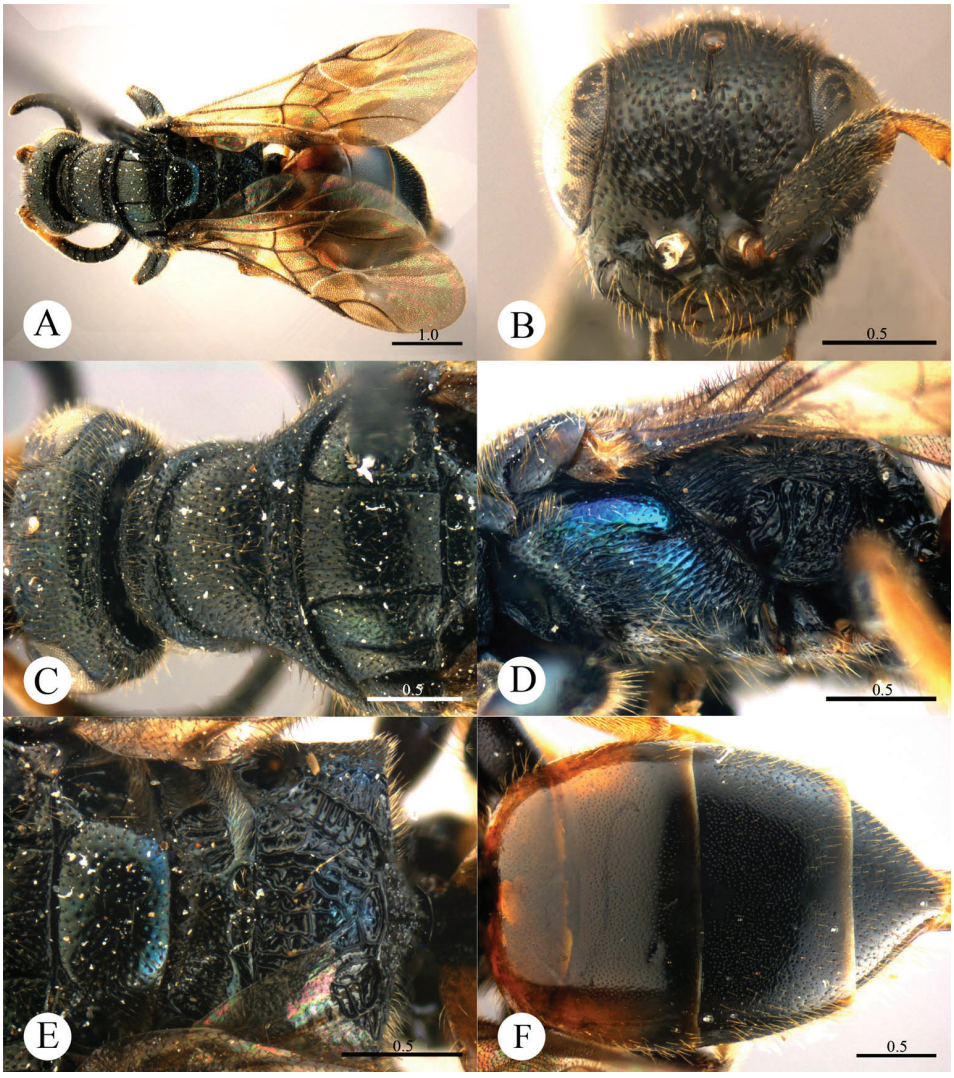

Plate 10. *Cleptes shengi* sp. n., holotype, female. **A** Habitus dorsal **B** Head anterior **C** Head, pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Diagnosis. *C. shengi* sp. n. is related to *C. semiauratus* (Linnaeus), based on the similar sculptures on pronotum and mesopleuron. However, it can be separated by the evident differences in colouration: head and mesosoma mostly black, mesopleuron with metallic blue (head and pronotum flame red, mesonotum and metanotum golden red or golden green in *C. semiauratus*).

Description. *Female.* Holotype. Body length 6.7 mm (Plate 10A). Forewing length 4.6 mm. HW : HH : HL = 15 : 14 : 8. POL : OOL : OCL = 4.8 : 6 : 8.8. MS = 1.4 MOD. Width of clypeal lower margin = 1.2 ASD. L/W of Ped, F-I, F-II, and F-III are 1.9, 2.0, 1.0, and 0.8, respectively.

Head. Head with dense punctures (1 PD), and slightly denser and coarser on vertex. Frontal sulcus incomplete, interrupted medially (Plate 10B). Clypeus with lower margin truncate, with indistinct acute teeth at corners. Mandible with three teeth. Ocellar triangle isosceles, without post-ocellar sulcus.

Mesosoma. Pronotum with similar punctures to those on vertex. Pronotum with a distinct anterior and posterior pit rows (Plate 10C); without longitudinal median sulcus (Plate 10C). Mesonotum with shallow and sparse punctures. Mesoscutum with notauli complete; parapsidal lines incomplete, 3/4 length of notauli; admedian lines absent; axillary trough with tubercle-like process (Plate 10C). Mesopleuron transversely striate, with short scrobal sulcus (Plate 10D). A foveate transverse sulcus present between mesoscutellum and metanotum (Plate 10E). Metanotum with a big and oval anteromedian pit, with two foveae along the posterior margin (Plate 10E). Metapleuron obliquely and strongly striate (Plate 10D). Dorsal surface of propodeum irregularly reticulate. Propodeal angles short and blunt (Plate 10E).

Metasoma. T-I and T-IV with sparse punctures. T-II and T-III with dense punctures (Plate 10F).

Pubescence. Face and vertex with short (0.8–1.0 MOD) and black hairs. Clypeus and mandibles with long (1.5–2.0 MOD), sparse and testaceous bristles. Metasoma on T-I and T-II laterally with very short (0.5 MOD), sparse and whitish hairs; on T-III and T-IV laterally, and on T-IV dorsally with long (1.0–1.3 MOD) hairs.

Colouration. Head, mandibles, scapes, mesosoma, tegulae, coxae, and femora black, with mesopleuron metallic blue. Antennae black, with pedicels, F-I, partly F-II testaceous. Legs black, with tibiae and tarsi testaceous. Metasoma black, with testaceous on T-I anteriorly and laterally and T-II laterally.

Male. Unknown.

Distribution. Palaearctic part of China (Jilin).

Biology. Parasitoids of *Pachynematus itoi* Okutani (Sheng et al. 1998). Collected in June.

Etymology. The species is named after the collector.

Remarks. According to Móczár (2001), *C. shengi* sp. n. belongs to the *semiauratus* species-group based on the pronotum without longitudinal median sulcus and with both anterior and posterior pit rows distinct, and the colouration of metasoma.

Cleptes sinensis sp. n.

http://zoobank.org/F84DCD2C-7730-49B3-AC88-766E36B3D5D5
http://species-id.net/wiki/Cleptes_sinensis
Plate 11

Material examined. Holotype ♂ (SCAU), Shaanxi, Liping National Forest Park (32°51'43"N, 106°34'56"E), 23.VII.2004, Hong-ying Zhang leg., No.SCAU-C0010. Paratypes: 1 ♂ (SCAU), Shaanxi, Mt. Taibai (34°5'12.41"N, 107°42'41.77"E), 12–13.VII.2012, Na-sen Wei leg., No. SCAU-C0011; 6 ♂ (SCAU), Shaanxi, Li-

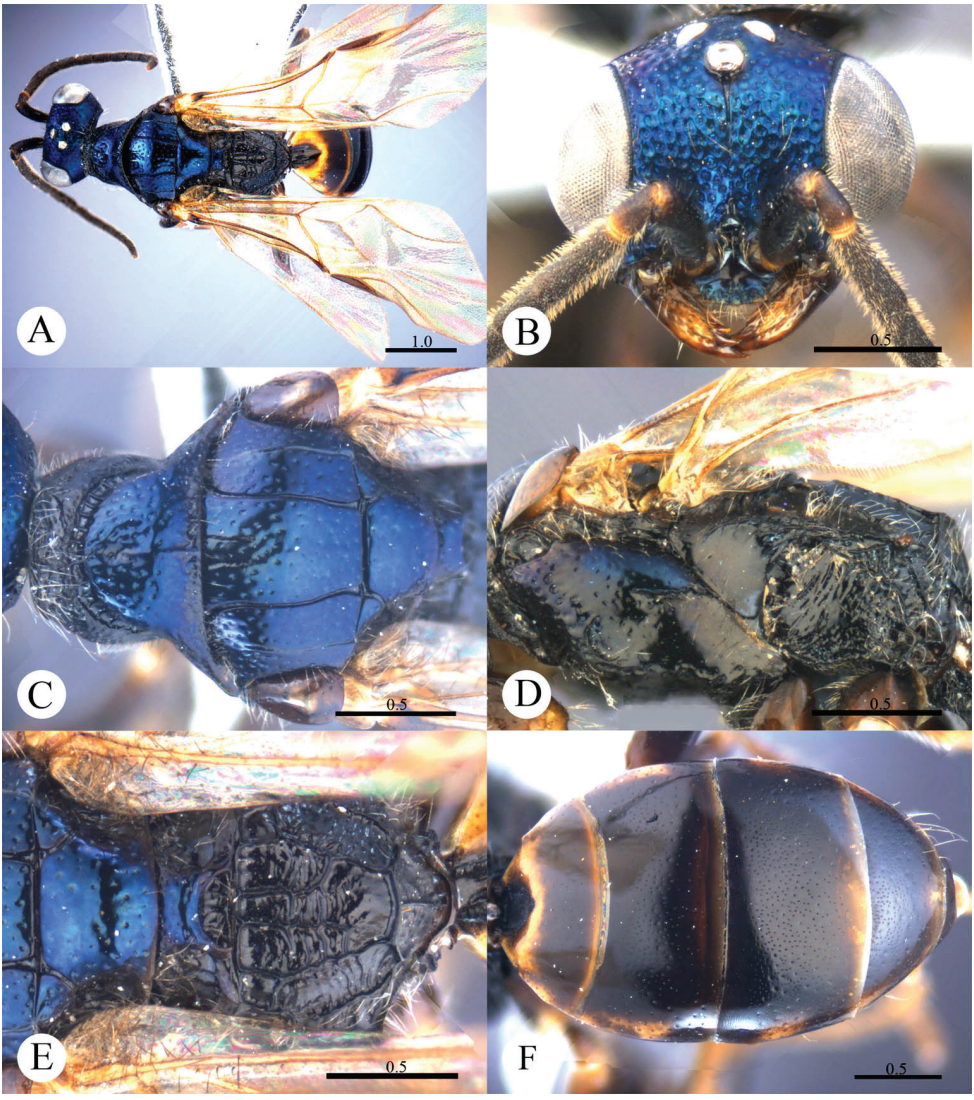

Plate 11. *Cleptes sinensis* sp. n., holotype, male. **A** Habitus dorsal **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

ping National Forest Park (32°52'36.84"N, 106°36'13.17"E), 1344 m, 23.VII.2004, Qiong Wu leg., No. 20046895–20046900; 1 ♂ (SCAU), Shaanxi, Liuba, Mt. Zibo (33°39'24.42"N, 106°46'48.70"E), 1632 m, 4.VIII.2004, Xue-xin Chen leg., No. 20047129; 1 ♂ (SCAU), Hainan, Jianfengling National Nature Reserve (18°45'26.19"N, 108°53'6.75"E), 9.V.2008, Jing-xian Liu leg., No. 200800141; 1 ♂ (SCAU), Sichuan, Wolong National Nature Reserve (31°8'25.07"N, 103°8'36.32"E), 21.VII.2006, Hong-ying Zhang leg., No. 200610800; 1 ♂ (SCAU), Hubei, Wufeng,

Houhe National Nature Reserve (30°4'40.64"N, 110°37'32.89"E), 11.VII.1999, Wen-jun Bu leg., No. 200104521.

Diagnosis. *Cleptes sinensis* sp. n. shares the metallic blue colouration on head and part of mesosoma, pronotum without posterior pit row, and polished mesopleuron with *C. nitidulus* (Fabricius) and *C. mareki* Rosa. However, it can be distinguished by metasoma blackish-brown (T-I and T-II testaceous in *C. nitidulus* and black with weak blue reflections in *C. mareki*); metanotum with a broad fovea along the posterior margin (without broad fovea in *C. nitidulus* and *C. mareki*); dorsal surface of propodeum with six longitudinal ridges and numerous and weak transverse wrinkles (irregularly reticulate in *C. nitidulus* and *C. mareki*).

Description. *Male*. Holotype. Body length 6.2 mm (Plate 11A). Forewing length 4.9 mm. HW : HH : HL = 13 : 10 : 7.5. POL : OOL : OCL = 8.5 : 15.5 : 15. MS = 0.6 MOD. Width of clypeal lower margin = 1.3 ASD. L/W of Ped, F-I, F-II, and F-III are 2.1, 3.2, 2.1, and 2.1, respectively.

Head. Face with dense and coarse punctures (0–0.5 PD). Clypeus with lower margin indistinctly convex medially, without acute teeth at corners. Frontal sulcus complete (Plate 11B). Mandibles mostly polished, with few punctures and three teeth. Ocellar area with sparser punctures (0.5 PD) than those on face. Ocellar triangle isosceles, with post-ocellar sulcus. Vertex with punctures shallower and sparser (0.5–1.0 PD).

Mesosoma. Punctures small, shallow and sparse (0.5–1.5 PD) on pronotum, and even sparser on mesonotum and metanotum. Pronotum with a distinct anterior pit row, without posterior pit row (Plate 11C); without longitudinal median sulcus, with shallow depression in the middle of pronotum (Plate 11C). Mesoscutum with notauli complete; parapsidal lines incomplete, 3/4 length of notauli; admedian lines incomplete, 1/3 length of notauli (Plate 11C); axillary trough longitudinally striate. Mesopleuron polished, with short scrobal sulcus and sparse punctures (Plate 11D). Metanotum without anteromedian pit, with a broad fovea along the posterior margin; axillary trough polished (Plate 11E). Metapleuron smooth and polished (Plate 11D). Dorsal surface of propodeum with six longitudinal ridges, with numerous and weak transverse wrinkles. Propodeal angles long and blunt (Plate 11E).

Metasoma. T-I nearly impunctate. T-II–T-IV with small and dense punctures. Punctures on T-III denser than those on T-II and T-IV. T-V with posterior margin emarginate medially (Plate 11F).

Pubescence. Head on clypeus with short (0.5–1.0 MOD), sparse and white hairs; on vertex nearly without hairs. Metasoma nearly without hairs, only with few on T-IV and T-V laterally.

Colouration. Head metallic blue. Mandibles blackish-brown, with testaceous in the middle. Antennae blackish-brown, with pedicels brown. Mesosoma metallic blue, with propodeum, mesopleuron and metapleuron black. Tegulae brown. Legs blackish-brown, with tarsi testaceous. Mesopleuron, metapleuron and propodeum black. Metasoma blackish-brown, with T-I anteriorly and all segments laterally and along the posterior margin testaceous.

Variation. Body length 4.3–6.6 mm. Forewing length 3.9–5.3 mm. Vertex metallic blue, with some purple tints. Mesonotum and metanotum metallic blue, with more

or less blackish-brown tints. One specimen from Hainan with blackish-brown mesosoma, and indistinct metallic blue reflections. Pronotum with irregular and shallow punctures along the posterior margin. Metasoma with few 1.5–2.0 MOD long and sparse hairs on T-I, T-II, and T-III laterally.

Female. Unknown.

Distribution. China (Shaanxi, Zhejiang, Hubei, Hainan, Sichuan).

Biology. Collected from May, July and August at 1344 m to 1632 m.

Remarks. According to Móczár (1997b), *Cleptes sinensis* sp. n. belongs to the *nitidulus* species-group based on the pronotum without posterior pit row and longitudinal median sulcus, and the blackish-brown metasoma.

***Cleptes sjostedti* Hammer, 1950**

http://species-id.net/wiki/Cleptes_sjostedti
Plates 12, 13

Cleptes sjostedti Hammer, 1950: 2; Kimsey and Bohart 1991: 64.
Cleptes pinicola Lin, 1959: 205. Synonymized by Móczár 1998a.
Cleptes sjoestedti (writing in error) Hammer: Móczár 1998a: 340.

Material examined. Holotype ♀ (NMW), "Provins Kiangsu [= Jiangsu]", "China *Kolthoff*", "okt", "Type", "*Cleptes sjostedti*, ♀, det. Hammer", "Holotype, ♀, *Cleptes sjostedti* Hammer, P. Rosa vidit 2012", "NHRS-HEVA, 000001124". Other material examined: 1 ♀ (SCAU), Hunan, Liuyang City (28°09'N 113°38'E), 1548 m, 14.VIII.1984, Xin-wang Tong leg., No. SCAU-C0008; 1 ♀ (SCAU), Hunan, Liuyang City, 1959 m, 19.X.1984, Xin-wang Tong leg., No. SCAU-C0009; 1 ♀ (ZJUH), Yunnan, Xiangyun (25°28'19.93"N, 100°33'13.11"E), V.1980, Hai-lin Wang leg., host: Diprionidae, No. 888669; 1 ♀ (ZJUH), Zhejiang, Mt. Mogan (30°35'53.09"N, 119°54'6.15"E), 12.VI.1982, Wei Lin leg., No. 923040; 2 ♀ (ZJUH), Zhejiang, Anji (30°37'47.40"N, 119°40'53.06"E), 1991, Guo-rong Yang leg., host: Diprionidae, No. 916001; 1 ♀ (ZJUH), Guangdong, Xinhui (22°26'52.14"N, 113°2'4.93"E), 25.VIII.1989, Chuan-chuan Lu leg., No. 896511; 4 ♀+1 ♂ (ZJUH), Yunnan, Kunming (24°52'23.65"N, 102°50'0.64"E), 4.VI.1976, Jing-liang Qi leg., host: Diprionidae, No. 771985; 2 ♀+2 ♂ (ZJUH), Anhui, Ningguo (30°37'42.27"N, 118°58'57.58"E), 1991, Zong-ying Wang leg., No. 940436; 1 ♂ (ZJUH), Zhejiang, Gaozhou, Bamen (30°15'N, 120°9'E), 26.V.1984, Jun-hua He leg., host: Diprionidae, No. 844852.

Diagnosis. Posterior pit row of pronotum with two median pits considerably larger than the others. Pronotum with longitudinal median sulcus incomplete, and somewhat foveate. Mesopleuron with strong foveate V-shape loop. Metanotum with a big, deep and triangular anteromedian pit, with two foveae along the posterior margin.

Description. Redescribed after a female from Hunan (Liuyang City). Body length 8.2 mm (Plate 12A). Forewing length 5.0 mm. HW : HH : HL = 37.5 : 30.5 : 19. POL : OOL : OCL = 16 : 16 : 27.5. MS = 1.4 MOD. Width of clypeal lower margin = 1 ASD. L/W of Ped, F-I, F-II, and F-III are 2.0, 2.0, 0.9, and 1.0, respectively.

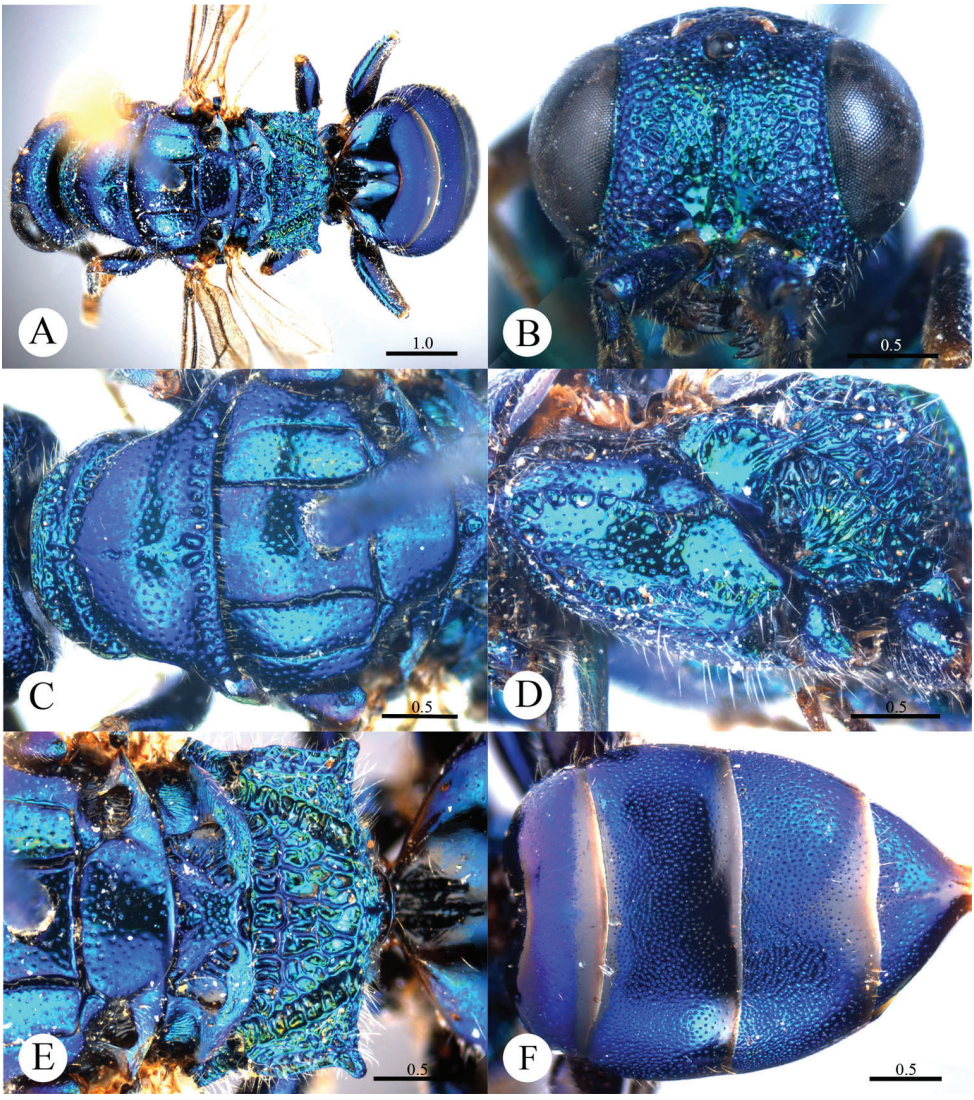

Plate 12. *Cleptes sjostedti* Hammer, 1950, female from Hunan. **A** Habitus dorsal **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Head. Face with dense and coarse punctures (0–0.5 PD) merging laterally, with big polish area above clypeus. Clypeus with lower margin slightly convex medially, with distinct acute teeth at corners. Frontal sulcus complete, but becoming shallow and indistinct on upper 1/3, after reaching pit before midocellus (Plate 12B). Mandibles with sparse punctures and three teeth. Ocellar area and vertex with shallower and sparser punctures (0.5–1 PD). Ocellar triangle isosceles, without post-ocellar sulcus.

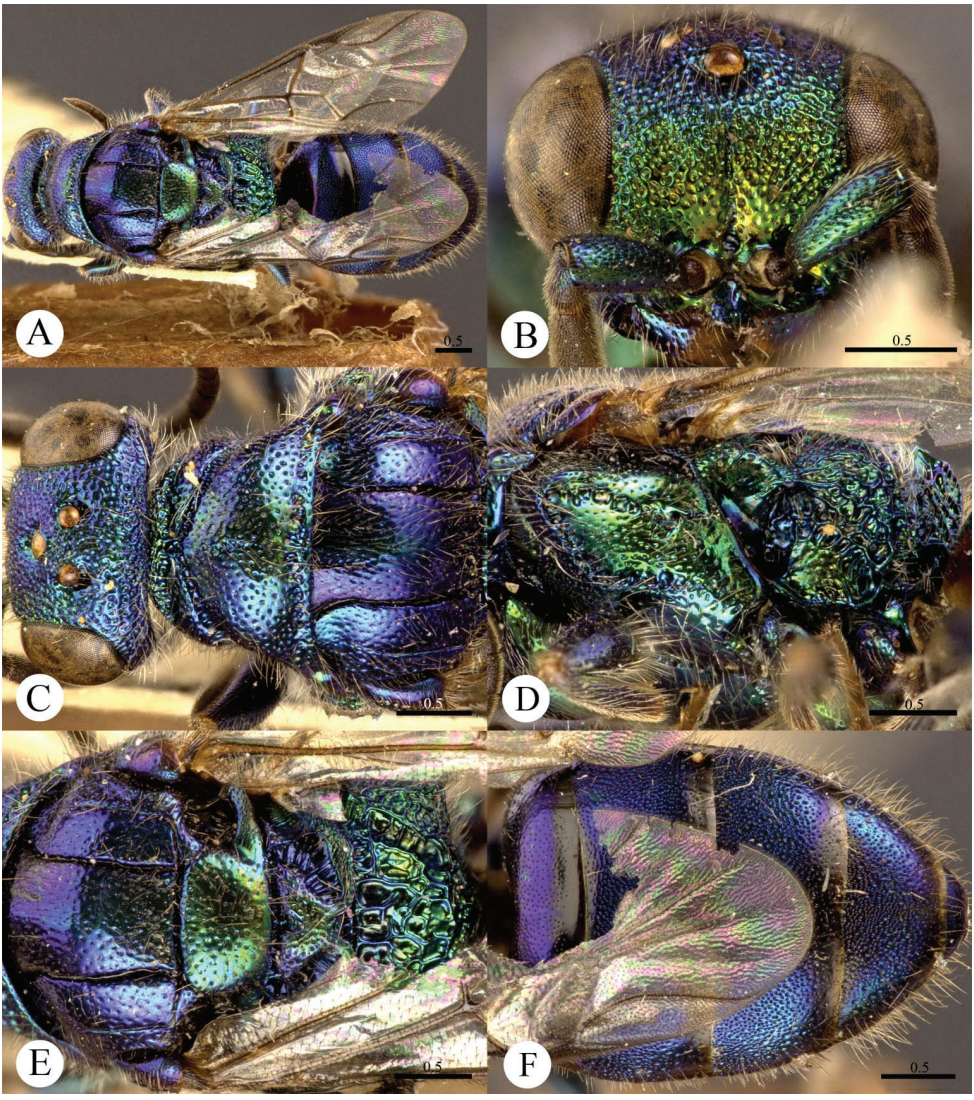

Plate 13. *Cleptes sjostedti* Hammer, 1950, male from Zhejiang. **A** Habitus dorsal **B** Head anterior **C** Head, pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutum, mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Mesosoma. Mesosoma with small and shallow punctures, and gradually sparser from pronotum to metanotum. Pronotum with distinct anterior and posterior pit rows, with two median pits of posterior pit row considerably larger than the others (Plate 12C); longitudinal median sulcus incomplete, and somewhat foveate. Mesoscutum with notauli complete; parapsidal lines nearly complete; admedian lines incomplete, 1/8 length of notauli (Plate 12C); axillary trough longitudinally striate. Mesopleuron with strong foveate V-shape loop (Plate 12D). A transverse foveate sulcus present between mesoscutellum

and metanotum (Plate 12E). Metanotum with a big, deep and triangular anteromedian pit, with two foveae along the posterior margin; axillary trough with several oblique wrinkles (Plate 12E). Metapleuron polished, with big and triangular pit on upper part (Plate 12D). Dorsal surface of propodeum rectangular, with width longer than length (L : W = 1 : 3), reticulate, with aligned areolae along the anterior and lateral margins. Propodeal angles big and blunt produced obliquely (Plate 12E).

Metasoma. T-I with small and sparse punctures. T-II–T-IV with bigger and denser punctures (Plate 12F). Punctures on T-IV double than those on T-II and T-III, with bigger punctures deeply incised. T-IV with apex medially incised.

Pubescence. Head with short (0.5–1.0 MOD), sparse and brownish hairs, scattered on clypeus and posterior half of vertex. Metasoma nearly without hairs dorsally, with only few very short (0.5 MOD) hairs laterally.

Colouration. Head and mesosoma metallic blue, with purple reflections. Mandibles testaceous, with teeth blackish-brown. Antennae black, with scapes and pedicels metallic blue, ventral sides of F-IV to F-XI testaceous. Tegulae metallic blue, with brown tint. Legs metallic blue, with ventral side of tibiae and tarsi brown. Metasoma metallic bluish-purple.

Male. Body length 6.1–6.7 mm (Plate 13A). Forewing length 3.6– 4.3 mm. Differing from female as follows: pronotum with longitudinal median sulcus deeper (Plate 13C); posterior pit row less distinct, with median pair of pits bigger than the others (Plate 13C); body largely purple with metallic blue reflections (Plate 13B, 13D–F).

Variation. Females. Body length 5.8–8.2 mm. Forewing length 3.6–5.0 mm. Clypeus almost truncate medially, with distinct acute teeth at corners. Males. Body length 6.1–6.7 mm. Forewing length: 3.6–4.3 mm. Body largely purple with metallic blue reflections.

Distribution. China (Jiangsu, Anhui, Zhejiang, Taiwan, Hunan, Guangdong, Yunnan); Korea.

Biology. Parasitoid of Diprionidae. Collected from May, June, August and October at 1548 m to 1959 m.

Remarks. *Cleptes sjostedti* Hammer belongs to the *fudzi* species-group (Móczár 1998a). The correct writing of the name is *sjostedti* and not *sjoestedti* as reported in Móczár (1998a). The species was dedicated to Yngve Sjöstedt, former director of the Naturhistoriska Riksmuseum in Stockholm. According to the ICZN (Art. 32.5.2.1) only in the case of a German name would the correct form be *sjoestedti*.

Cleptes taiwanus Tsuneki, 1982

http://species-id.net/wiki/Cleptes_taiwanus

Cleptes taiwanus Tsuneki, 1982: 2; Móczár 2000a: 329.

Material examined. None.

Diagnosis. Body mostly metallic greenish-blue, with propodeum, part of mesonotum and partly T-I–IV purple. Tegulae metallic greenish-blue basally, brown

apically with purple tint. Lower margin of clypeus with acute teeth at corners. Ocellar triangle isosceles. Parapsidal lines complete. Metanotum with an anteromedian pit and a broad fovea along the posterior margin (Tsuneki 1982; Móczár 2000a).

Distribution. Oriental part of China (Taiwan).

Biology. Collected in August.

Taxonomic remarks. *Cleptes taiwanus* Tsuneki belongs to *asianus* species-group (Móczár 2000a).

***Cleptes tibetensis* sp. n.**

http://zoobank.org/5C856F83-1F7D-4752-A0E0-D19E3D51659C

http://species-id.net/wiki/Cleptes_tibetensis

Plate 14

Material examined. Holotype ♂ (SCAU), Tibet, Pailongxiang, Daxiagu (30°1'10.56"N, 94°59'49.92"E), 2054 m, 15.VI.2009, Mei-cai Wei leg., No. SCAU-C0003.

Diagnosis. *Cleptes tibetensis* sp. n. is similar to *C. crassiceps* Tsuneki, *C. metallicorpus* Ha, Lee & Kim, and *C. villosus* sp. n. based on the posterior pit row on pronotum, V-shape loop on mesopleuron, and short propodeal angles. However, it can be distinguished by the combination of the following characteristics: metallic bluish-purple metasoma (metasoma black, only partly with metallic reflections in *C. crassiceps*); absence of frontal sulcus (present in *C. crassiceps*, *C. metallicorpus* and *C. villosus* sp. n.); lower margin of clypeus with acute teeth at corners (absent in *C. crassiceps* and *C. villosus* sp. n.); mandibles without striatopunctures (with striatopunctures in *C. metallicorpus*); metanotum with transverse depression anteriorly (absent in *C. crassiceps*, *C. metallicorpus*, and *C. villosus* sp. n.); metanotum with a broad fovea along the posterior margin (with two foveae along the posterior margin in *C. metallicorpus*).

Description. *Male.* Holotype. Body length 6.7 mm (Plate 14A). Forewing length 5.6 mm. HW : HH : HL = 18.8 : 12.5 : 10.5. POL : OOL : OCL = 5 : 9.8 : 12.3. MS = 0.9 MOD. Width of clypeal lower margin = 1 ASD. L/W of Ped, F-I, F-II, and F-III are 1.5, 2.1, 1.7, and 1.7, respectively.

Head. Face, ocellar area and vertex with small and sparse punctures (1–5 PD). Clypeus with lower margin slightly convex medially, with acute teeth at corners. Frontal sulcus absent (Plate 14B). Mandibles with sparse punctures. Ocellar triangle equilateral, without post-ocellar sulcus.

Mesosoma. Mesosoma with punctures similar to those on vertex. Pronotum with distinct anterior and posterior pit rows (Plate 14C); without longitudinal median sulcus (Plate 14C). Mesoscutum with notauli complete; parapsidal lines nearly complete; admedian lines incomplete, 1/6 length of notauli (Plate 14C); axillary trough smooth. Mesopleuron with distinct V-shape loop (Plate 14D). Metanotum with transverse depression anteriorly, with a small and oval anteromedian pit; with a broad fovea along the posterior margin; axillary trough smooth and polished (Plate 14E). Metapleuron polished, with some indistinct transverse wrinkles on upper part (Plate 14D). Dorsal

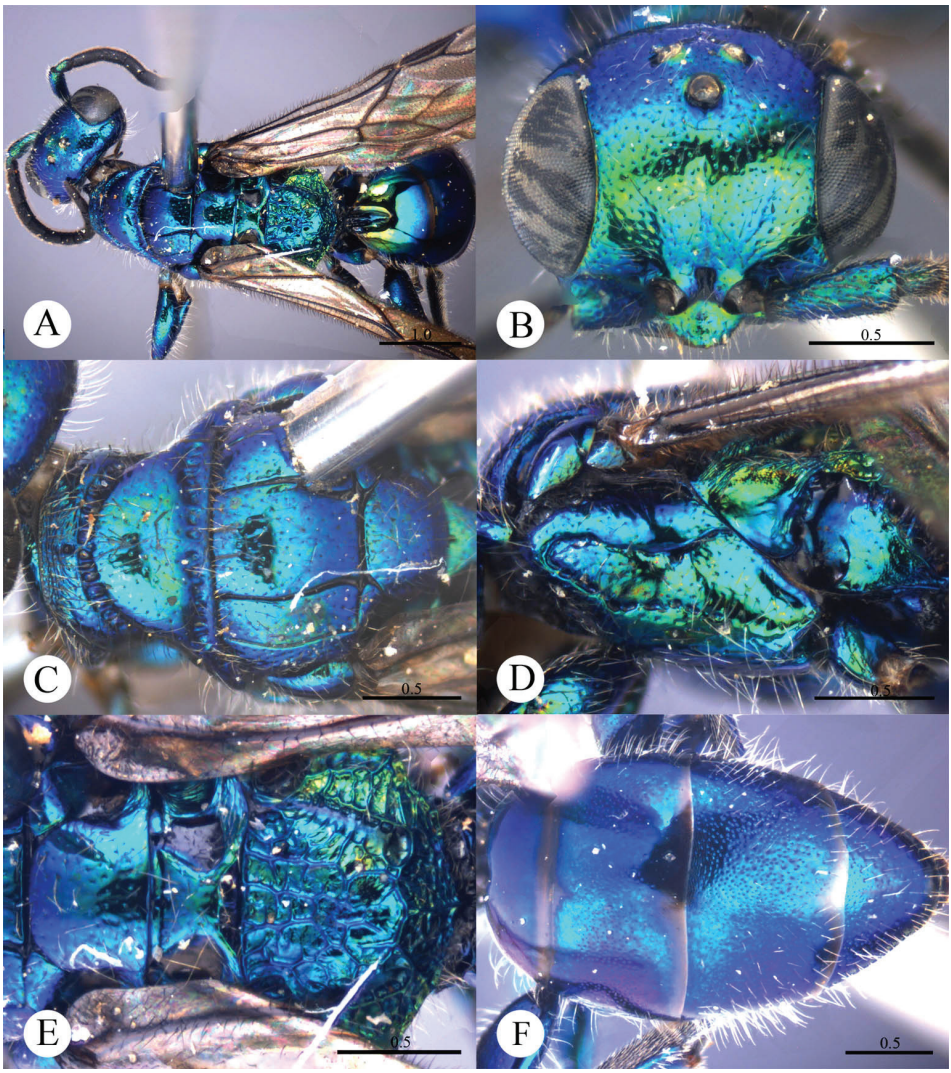

Plate 14. *Cleptes tibetensis* sp. n., holotype, male**. A** Habitus dorsal **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

surface of propodeum with irregular ridges; lateral margins parallel. Propodeal angles short and stumpy (Plate 14E).

Metasoma. T-I and T-V impunctate. T-II–T-IV with dense punctures (Plate 14F). Punctures on T-III denser than those on T-II and T-IV.

Pubescence. Head with long (1.0–1.3 MOD), sparse and whitish hairs. Metasoma laterally and on T-III and T-IV also dorsally with long (1.5–2.0 MOD) and whitish hairs.

Colouration. Face and clypeus yellowish-green. Vertex metallic green, with purple tints. Mandibles metallic green, with teeth blackish-brown. Antennae blackish-brown,

with scapes and pedicels metallic green. Mesosoma mostly metallic green, with some purple tints. Tegulae metallic green. Legs metallic green, with tarsi testaceous. Metasoma metallic bluish-purple, with T-I yellowish-green tints anteriorly, with T-I bluish-green tints laterally; T-V black.

Female. Unknown.

Distribution. China (Tibet).

Biology. Collected in June at 2054 m.

Etymology. The species is named after the type locality.

Remarks. According to Móczár (2000a), *Cleptes tibetensis* sp. n. belongs to the *asianus* species-group based on the two distinct pit rows on pronotum, longitudinal median sulcus absent, and mesopleuron with V-shape loop.

***Cleptes townesi* Kimsey, 1987**

http://species-id.net/wiki/Cleptes_townesi
Plate 15

Cleptes townesi Kimsey, 1987: 58; Kimsey and Bohart 1991: 64; Móczár 2000a: 330.

Material examined. 2 ♂ (SCAU), Zhejiang, Hangzhou (30°16'32.72"N, 120°9'16.38"E), 21.V.1981, Yun Ma leg., No. 810679; 1 ♂ (SCAU), Fujian, Chong'an, Mt. Wuyi, Jiuqu (27°39'12.88"N, 117°56'24.43"E), 27.IV.1984, Xiu-fu Zhao leg., No. 20007514.

Diagnosis. Metallic blue reflection restricted to face. Pronotum with anterior pit row distinct and posterior pit row absent. Mesopleuron polished, with sparse, shallow and aligned punctures on anterior half, with short scrobal sulcus. Metanotum without anteromedian pit, with a broad fovea along the posterior margin. T-V with posterior margin emarginate medially.

Description. Redescribed after a male from Zhejiang. Body length 5.6 mm (Plate 15A). Forewing length 4.6 mm. HW : HH : HL = 13.5 : 10 : 5.5. POL : OOL : OCL = 9.5 : 16.5 : 15.5. MS = 0.6 MOD. Width of clypeal lower margin = 1.7 ASD. L/W of Ped, F-I, F-II, and F-III are 1.2, 2.6, 2.0, and 2.1, respectively.

Head. Face and vertex with small and sparse punctures (0.5–1.0 PD). Clypeus with lower margin truncate, without acute teeth at corners. Frontal sulcus complete (Plate 15B). Mandibles mostly polished, with few punctures and four teeth. Ocellar area with punctures similar to those on vertex but denser (0.5 PD). Ocellar triangles isosceles, almost equilateral, bulging in frontal view, without post-ocellar sulcus.

Mesosoma. Pronotum with shallow and sparse punctures (1–2 PD). Pronotum with anterior pit row distinct and posterior pit row absent (Plate 15C); without longitudinal median sulcus (Plate 15C). Mesonotum and metanotum with smaller punctures than those on pronotum. Mesoscutum with notauli complete; parapsidal lines incomplete, 3/4 length of notauli; admedian lines incomplete, 1/4 length of notauli (Plate 15C); axillary trough weakly reticulate. Mesopleuron polished, with sparse, shallow

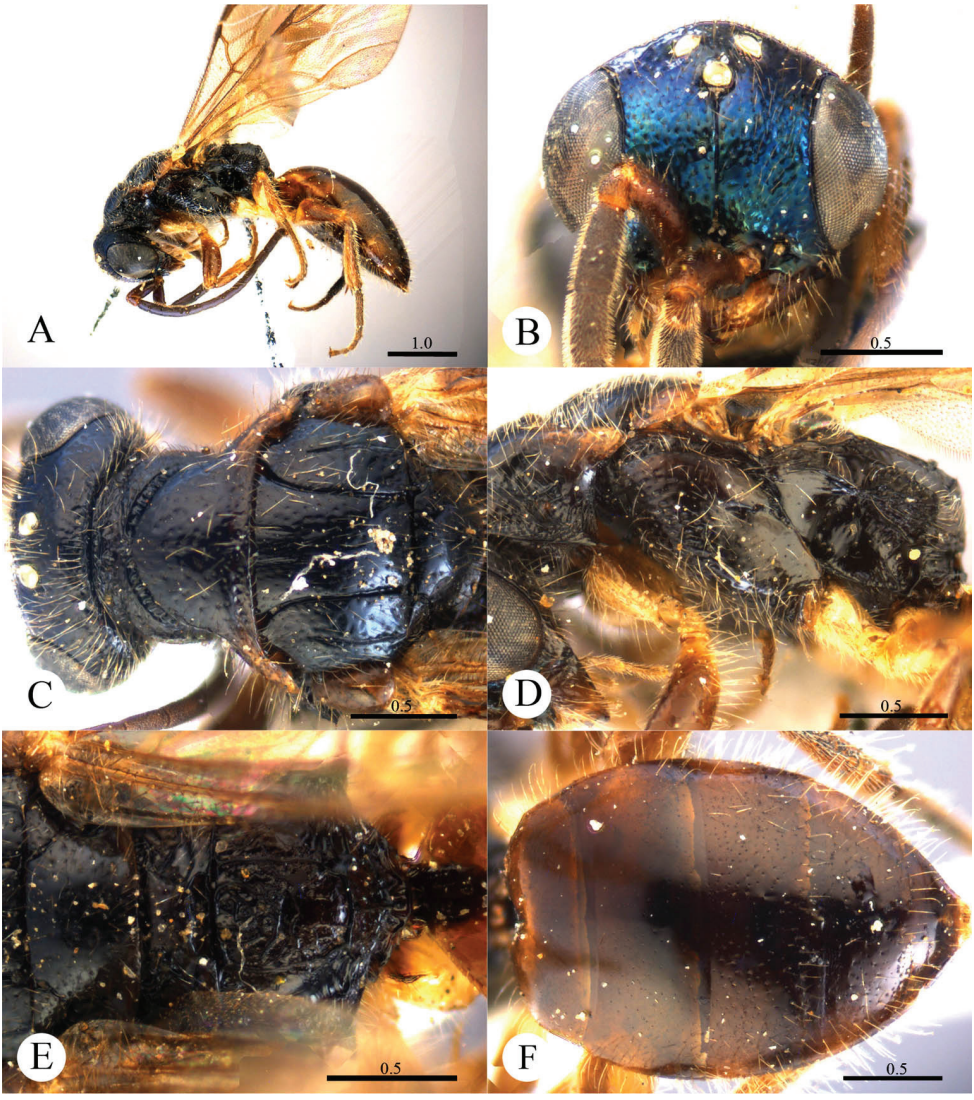

Plate 15. *Cleptes townesi* Kimsey, 1987, male from Zhejiang. **A** Habitus lateral **B** Head anterior **C** Head, pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

and aligned punctures on anterior half, with scrobal sulcus short (Plate 15D). A foveate transverse sulcus present between mesoscutellum and metanotum (Plate 15E). Metanotum without anteromedian pit, with a broad fovea along the posterior margin; axillary trough with few weak and oblique transverse wrinkles (Plate 15E). Metapleuron mostly smooth and polished (Plate 15D). Dorsal surface of propodeum irregularly reticulate; lateral margins parallel. Propodeal angles short and stumpy, slightly divergent (Plate 15E).

Metasoma. T-I and T-V nearly impunctate. T-II with sparse punctures. T-III and T-IV with dense punctures (Plate 15F). T-V with posterior margin emarginate medially.

Pubescence. Head on vertex with long (1.0–1.5 MOD), sparse and brownish hairs. Metasoma on T-I and T-II laterally, on T-III to T-V laterally and dorsally with long (1.0–1.5 MOD) and brownish hairs.

Colouration. Metallic blue reflections restricted to face. Vertex and mesosoma black, without metallic reflections. Mandibles brown, with teeth testaceous. Antennae blackish-brown, with scapes and pedicels brown. Tegulae brown. Legs brown, with coxae and trochanters testaceous. Metasoma brown.

Variation. Body length 5.6–6.7 mm. Forewing length 4.4–5.1 mm.

Female. Unknown.

Distribution. Oriental part of China (Zhejiang, Fujian, Taiwan).

Biology. Collected in April and May.

Remarks. *Cleptes townesi* Kimsey belongs to the *townesi* species-group (Móczár 2000a).

***Cleptes villosus* sp. n.**
http://zoobank.org/F4FC46FB-2B2F-4195-BA3A-B0FB02A5BE56
http://species-id.net/wiki/Cleptes_villosus
Plate 16

Material examined. Holotype ♂ (SCAU), Guizhou, Suiyang, Kuankuoshui National Nature Reserve (28°1'23.16"N, 107°7'45.29"E), 8.VI.2010, Jie Zeng leg., No. SCAU-C0006. Paratype: 1 ♂ (ZJUH), Guizhou, Daozhen, Dashahe, Xiannvdong (29°2'38.19"N, 107°30'31.13"E), 644 m, 24.VIII.2004, Shu-jun Wei leg., No. 20047405.

Diagnosis. *Cleptes villosus* sp. n. is similar to *C. metallicorpus* Ha, Lee & Kim, *C. taiwanus* Tsuneki, *C. thaiensis* Tsuneki and *C. tibetensis* sp. n. based on the mesopleuron with V-shape loop, metanotum with an anteromedian pit and short propodeal angles. However, it can be separated by the combination of the following characteristics: the metallic bluish-green body (purple with greenish golden or blue tints in *C. thaiensis*); lower margin of clypeus without acute teeth (present in *C. metallicorpus*, *C. taiwanus* and *C. tibetensis* sp. n.); mandibles without striatopunctures (with distinct striatopunctures in *C. metallicorpus*); ocellar triangle equilateral, without post-ocellar sulcus (ocellar triangle isosceles in *C. metallicorpus* and *C. taiwanus*, with post-ocellar sulcus in *C. taiwanus*); and long, dense hairs on head and mesosoma.

Description. *Male*. Holotype. Body length 6.4 mm (Plate 16A). Forewing length 5.0 mm. HW : HH : HL = 21 : 13 : 8.8. POL : OOL : OCL = 5.5 : 7.8 : 12. MS = 1 MOD. Width of clypeal lower margin = 1 ASD. L/W of Ped, F-I, F-II, and F-III are 1.6, 1.8, 1.7, and 1.4, respectively.

Head. Face and ocellar area with small, shallow and dense punctures (0.5–1.0 PD). Clypeus with lower margin truncate, without acute teeth at corners. Frontal sulcus complete but weak (Plate 16B). Mandibles with sparse punctures and four teeth.

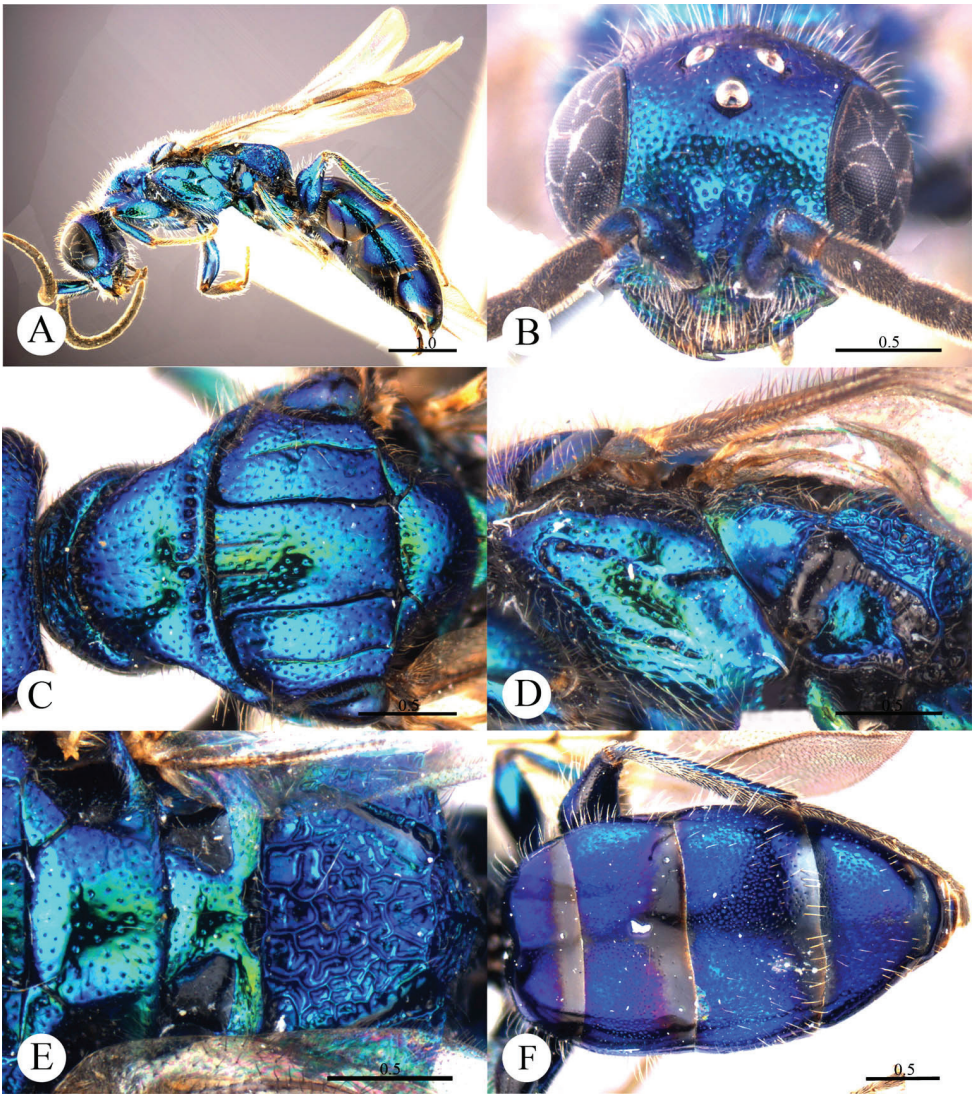

Plate 16. *Cleptes villosus* sp. n., holotype, male. **A** Habitus lateral **B** Head anterior **C** Pronotum and mesoscutum dorsal **D** Mesopleuron and metapleuron lateral **E** Mesoscutellum, metanotum and propodeum dorsal **F** Metasoma dorsal. Scale bars in mm.

Ocellar triangle equilateral, without post-ocellar sulcus. Vertex with shallower and sparser punctures (1.0–1.5 PD).

Mesosoma. Mesosoma with small and sparse punctures (1.5–3.0 PD). Pronotum with distinct anterior and posterior pit rows (Plate 16C); without longitudinal median sulcus (Plate 16C). Mesoscutum with notauli complete; parapsidal lines nearly complete; admedian lines incomplete, 1/3 length of notauli (Plate 16C); axillary trough smooth. Mesopleuron with foveate V-shape loop (Plate 16D). Metanotum with a small

and oval anteromedian pit, with two medially fused foveae along the posterior margin; axillary trough smooth (Plate 16E). Metapleuron mostly smooth and polished (Plate 16D). Dorsal surface of propodeum irregularly reticulate. Propodeal angles short and blunt (Plate 16E).

Metasoma. Posterior margin of each segment of metasoma impunctate. T-I and T-V nearly impunctate. T-II with small and dense punctures, only scattered on anterior 2/3 (Plate 16F). T-III with punctures twice as dense as on T-II, with very small dots in intervals between the larger punctures. T-IV with punctures on slightly sparser than on T-III.

Pubescence. Head with long (1.5 MOD), dense and white hairs. Mesosoma with long (1.5–2.0 MOD), dense and whitish hairs. Metasoma laterally on T-I and T-II and on T-III with long (1.5–2.0 MOD), sparse and white hairs; T-IV with short (0.5–0.8 MOD) and sparse hairs; T-V with only few short (0.5–0.8 MOD) hairs.

Colouration. Body mostly metallic bluish-green, with vertex mostly purple and with metallic blue tints. Mandibles metallic bluish-green, with teeth blackish-brown. Antennae black, with scapes and pedicels metallic bluish-green. Tegulae metallic bluish-green. Legs metallic bluish-green, with tibiae and tarsi testaceous. Metasoma purple, with metallic blue tints, posterior margin of each segment black, T-V blackish-blue.

Variation. Paratype. Body length 5.7 mm. Forewing length 4.7 mm. Clypeus covered with sparser and shorter setae.

Female. Unknown.

Distribution. Oriental part of China (Guizhou).

Biology. Collected in June and August.

Etymology. The specific name refers to the whitish, dense relatively long hairs on the head and mesosoma.

Remarks. According to Móczár (2000a), *Cleptes villosus* sp. n. belongs to the *asianus* species-group based on the two pit rows on pronotum, longitudinal median sulcus absent, and mesopleuron with V-shape loop.

Discussion

We consider the occurrence of *C. nitidulus* in China reported by Tsuneki (1959) as a misidentification (Table 1). Tsuneki (1959) examined only one male *C. nitidulus* from Manchuria (Northeast China), but its description does not match the current interpretation of the species based on the holotype or to any other *C. nitidulus* described by other authors (Móczár 1997b; Rosa 2006). Moreover, an earlier report of *C. nitidulus* in the East Palaearctic (Uchida 1926) was also considered debatable by Ha et al. (2011). Therefore, *C. nitidulus* is temporarily excluded from the checklist of the Chinese *Cleptes* until a new examination of Tsuneki's specimen.

Similarly, Sheng et al. (1998) reported *C. semiauratus* as a new record to China. After examining the specimens, it evidently belongs to an undescribed species (*C. shengi* sp. n.). Despite of other characteristics, *C. shengi* sp. n. can be quickly distinguished

from *C. semiauratus* by the dark colouration, while the latter usually with the head and pronotum flame red, mesonotum and metanotum golden red or golden green (Móczár 2001; Rosa 2006).

Interestingly, the *Cleptes* species in China show a convergence to green, blue and black in all studied species, while those in the Western Palaearctic show various metallic and non-metallic colours (such as green, blue, orange, red, golden tinge, and so on) with different combinations. The reason of this phenomenon needs further research.

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