



The tribal placement of *Urocorthylus* Petrov, Mandelshtam & Beaver, with a description of the male of *U. hirtellus* Petrov *et al.*, and notes on its biology (Coleoptera: Curculionidae: Scolytinae)

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Abstract

We show, using molecular data, that the enigmatic genus *Urocorthylus* Petrov, Mandelshtam & Beaver from Southeast Asia belongs in the scolytine tribe, Dryocoetini, and not in the almost wholly American tribe Corthylini, where it was originally placed. The male of *Urocorthylus hirtellus* Petrov, Mandelshtam & Beaver is described and figured for the first time, and new records from China are presented. *Urocorthylus hirtellus* is a bark beetle, and not an ambrosia beetle as originally hypothesised. Keys are provided to the genus within the Dryocoetini, and to the two species included in the genus.

Key words: Corthylini, Dryocoetini, *Gnatharus*, bark beetle, keys, new records

Introduction

Petrov, Mandelshtam & Beaver (2007) described the monotypic genus *Urocorthylus* with the type species *Urocorthylus hirtellus* Petrov, Mandelshtam & Beaver, from a single female specimen from the mountains of northern Vietnam. The genus exhibited unusual morphology with very long and dense plumose setae, and an elongate pronotum. Based on the external morphology, it was placed in the tribe Corthylini, subtribe Corthyлина, and assumed to be an ambrosia beetle like the rest of the Corthyлина (Wood 1986). The Corthyлина is a diverse subtribe with over 500 species (Alonso-Zarazaga & Lyal 2009). Almost all are endemic to the Americas, with only two genera described from Asia, *Gnatharus* Wood & Yin and *Urocorthylus*. A second female specimen of *U. hirtellus* was recorded from northern Thailand, but the male has not been described (Beaver *et al.* 2014). Later, Wang *et al.* (2017) described both sexes of a second species, *Urocorthylus fanii* Wang, Beaver & Hulcr, from Taiwan.

In the present paper, using molecular data, we show that *Urocorthylus* belongs in the scolytine tribe Dryocoetini, and not in the Corthylini. We describe the male of *U. hirtellus* for the first time, from specimens collected in China (Yunnan) and Thailand (Chaiphaphum). The species is shown to be a bark beetle, and not an ambrosia beetle as had been assumed by earlier authors (Petrov *et al.* 2007; Beaver *et al.* 2014; Wang *et al.* 2017). We provide keys to the genus within the Dryocoetini, and to the two species included in the genus.

Materials and methods

Specimens of *U. hirtellus* and *U. fanii* were collected in the field from traps, or from host plants. Type material of *U. fanii* in TFRI, UFFE and RABC has been examined by AJJ and RAB. The holotype of *U. hirtellus* was not available for study, but specimens have been carefully compared with the description and illustrations in Petrov *et al.* (2007). Body length was measured from the apex of the pronotum to the apex of the declivity; width was measured at the widest part of the specimen; pronotal length included the anterior serrations and elytral length was measured from anterior margin to apex. The number of funicular segments excludes the pedicel.

DNA extracts of *U. hirtellus* were obtained from specimens collected in China (Yunnan); extracts of *U. fanii* were taken from fragments of a crushed specimen collected along with the type series. Five genes were sequenced based on use in past studies incorporating taxonomic breadth of scolytines. These are the cytochrome oxidase I (COI), elongation factor 1-alpha (EF1a), nuclear large subunit ribosomal gene (28S), carbamoyl phosphate synthetase, aspartate transcarbamylase and dihydroorotase (CAD), and arginine kinase (ArgK). Primers and PCR conditions were as described in Jordal & Cognato (2012).

A preliminary assessment of the sequence similarity was done using BLAST (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>), specifically “megablast”, with default settings, to search the NCBI Nucleotide collection (nr/nt).

For a phylogenetic placement, the sequences from a previous Scolytinae-wide phylogeny (Gohli *et al.* 2017) were used in addition to the sequences here. GenBank accession numbers were extracted from supplement 2 of Gohli *et al.* (2017). This dataset was selected for its taxonomic breadth and overlap with the sequenced genes for *Urocorthylus*. Sequences were downloaded from GenBank, and re-sorted to individuals by voucher id, or other specimen classifiers. Several specimens were omitted from the dataset because the data was not present in GenBank, or few loci were represented. A summary of the sequences used is presented in Supplementary Table 1.

Protein coding genes were trimmed to coding regions only, and to complete codons. Protein coding genes were translated then aligned using their amino acid sequence with MAFFT (Katoh & Standley 2013) using local alignment “linsi” with default settings, and custom python scripts to transfer the alignment to nucleotide sequences). The nuclear large ribosomal subunit gene (28S) was also used, aligned using MAFFT local alignment. The final alignment was then trimmed further to exclude all regions with less than 25% coverage over the whole alignment.

The data was partitioned by gene and by codon (1+2 combined and 3) for protein coding genes. Trees were then inferred with Exabayes (Aberer *et al.* 2014) with a GTR model, 2 runs and 4 chains. This was run until the average standard deviation of split frequencies (excluding a 25% burn-in) was less than 0.05, which took 20 390 000 generations. A nexus file containing the alignment, run parameters and the final phylogeny, is available in a supplementary data file (Johnson *et al.* 2023).

The following abbreviations are used for collections:

JXAU	College of Agricultural Sciences, Jiangxi Agricultural University, Nanchang, China.
NHMW	Naturhistorisches Museum Wien, Wien, Austria.
RABC	R.A. Beaver private collection, Chiangmai, Thailand.
TFRI	Taiwan Forest Research Institute, Taipei, Taiwan.
UFFE	University of Florida, Forest Entomology collection, Gainesville, FL, USA.
WSTC	W. Sittichaya private collection, Songkhla, Thailand.

Results

Phylogenetic placement of *Urocorthylus*

All BLAST searches on the NCBI Nucleotide collection (nr/nt), for all 5 loci sequenced from *Urocorthylus* spp., gave *Taphrorychus* (Dryocoetini) as highest scoring match. A Bayesian phylogeny was made to test the placement of *Urocorthylus* spp., (supplementary file 2, in Fig. 1), in which *Urocorthylus* were consistently placed among Dryocoetini, sister to *Taphrorychus* (posterior probability (p.p.) = 1.0). Besides the placement of *Urocorthylus* spp., phylogenetic analyses inferred the tribes Corthylini, Micracidini, Ipinini, and Dryocoetini + Xyleborini as monophyletic with high confidence (p.p. = 1.0), typical of previous studies. Deeper phylogenetic nodes, long branches and likely

rapid radiation events (e.g. *Coccotrypes* + *Xyleborini*) show much more variation between the trees inferred (i.e. a low posterior probability), similar to studies using the same genes with a similarly broad taxonomic scope (e.g. Jordal & Cognato 2012; Gohli *et al.* 2017).

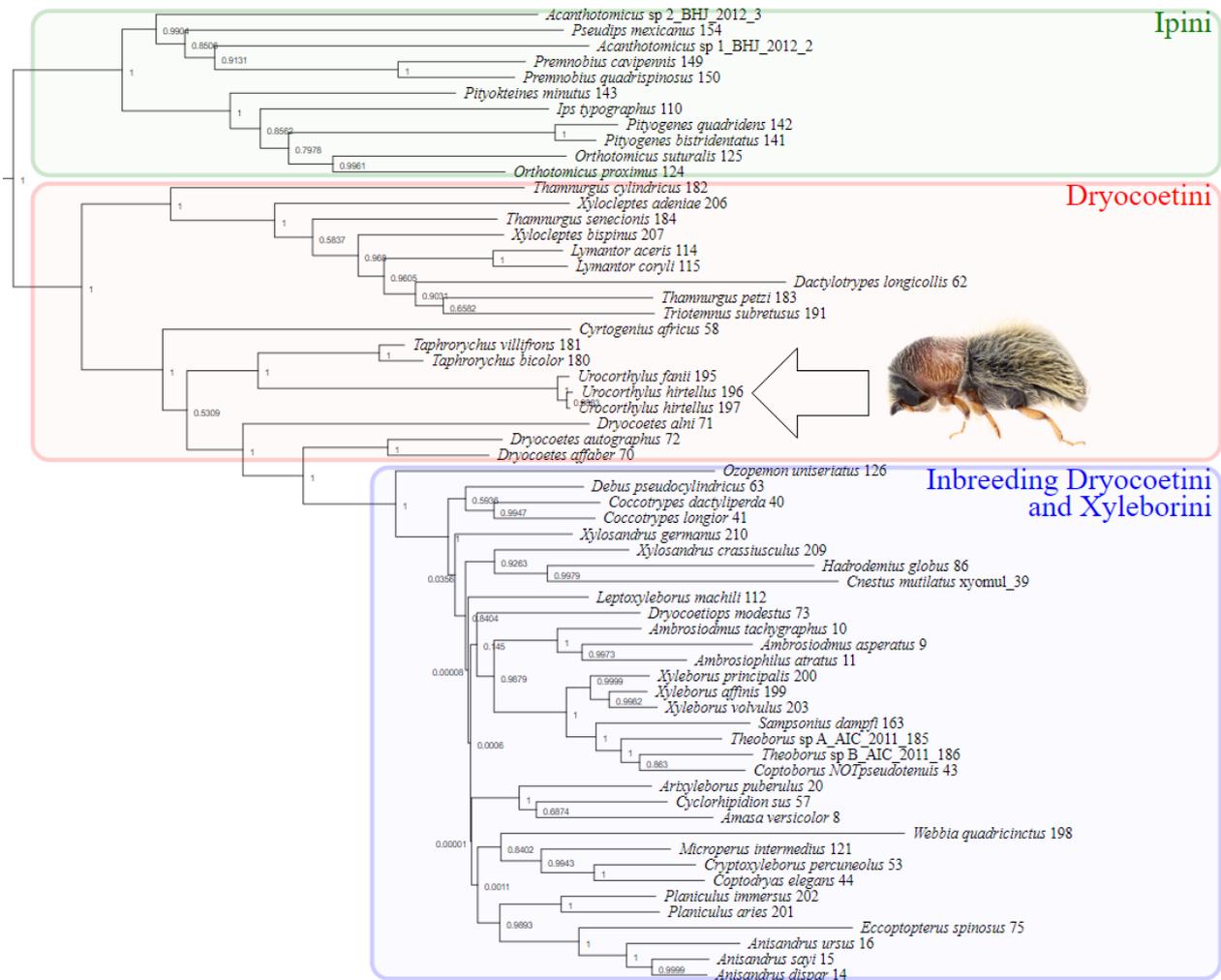


FIGURE 1. Excerpt of phylogenetic tree of Scolytinae showing phylogenetic placement of *Urocorthylus* within Dryocoetini. For the full tree in nexus format, see supplementary file 2, Johnson *et al.* (2023).

Morphological characters corroborate the phylogenetic placement. As part of the elytral locking mechanism, the metanepisternal spine is present (Fig. 2A) which is typical of most Scolytines including Dryocoetini, but is absent and replaced by a callus or groove in all Corthylini (Wood 1986). The proventriculus also corroborates the phylogenetic placement outside of Corthylini. All Corthylini have poorly developed apical plates (e.g. Lopez *et al.* 2001 give examples of 9 Corthylini genera), which is typical of Scolytinae with an ambrosia-fungus feeding system. The ‘open’ apical plate of the proventriculus, which is a non-sclerotized median line on each apical plate, is present in both *Dryocoetes* and some Pityophthorina as well as other genera. Nobuchi (1969) describes and illustrates the proventriculus of *Taphrorychus striatus* Nobuchi, which is very similar to that of *Urocorthylus hirtellus* (Fig. 2B).

The aedeagi of most Scolytinae, especially Corthylini and most Dryocoetini genera, have not been extensively described, and we cannot draw firm conclusions from that character. However, we note that the aedeagi of *Taphrorychus bicolor* (Herbst), illustrated by Nüsslin (1912), and *Thamnurgus* spp. illustrated in Jordal *et al.* (2002) and Mandelshatm *et al.* (2012) are very similar to the aedeagus of *Urocorthylus hirtellus* (Fig. 2C, D). The aedeagus lacks a sclerotized, recurved flagellum present in *Dryocoetes*, *Ozopemon*, *Coccotrypes* and *Euwallacea*, as illustrated in Jordal *et al.* (2002), corroborating that it is a derived character within Dryocoetini.

Tribe Dryocoetini Lindemann, 1877

***Urocorthylus* Petrov, Mandelshtam & Beaver, 2007**

Urocorthylus Petrov, Mandelshtam & Beaver 2007: 249.

Type of genus: *Urocorthylus hirtellus* Petrov, Mandelshtam & Beaver, 2007. Original designation.

Diagnosis. Within the Dryocoetini, *Urocorthylus* can be distinguished by the following combination of characters: 2-segmented antennal funiculus (excluding pedicel), antennal club flat, pubescent and without sutures, pronotum with well-developed summit and disc, elytra with striae obsolete, and very long, dense, plumose setae on pronotum and elytra.

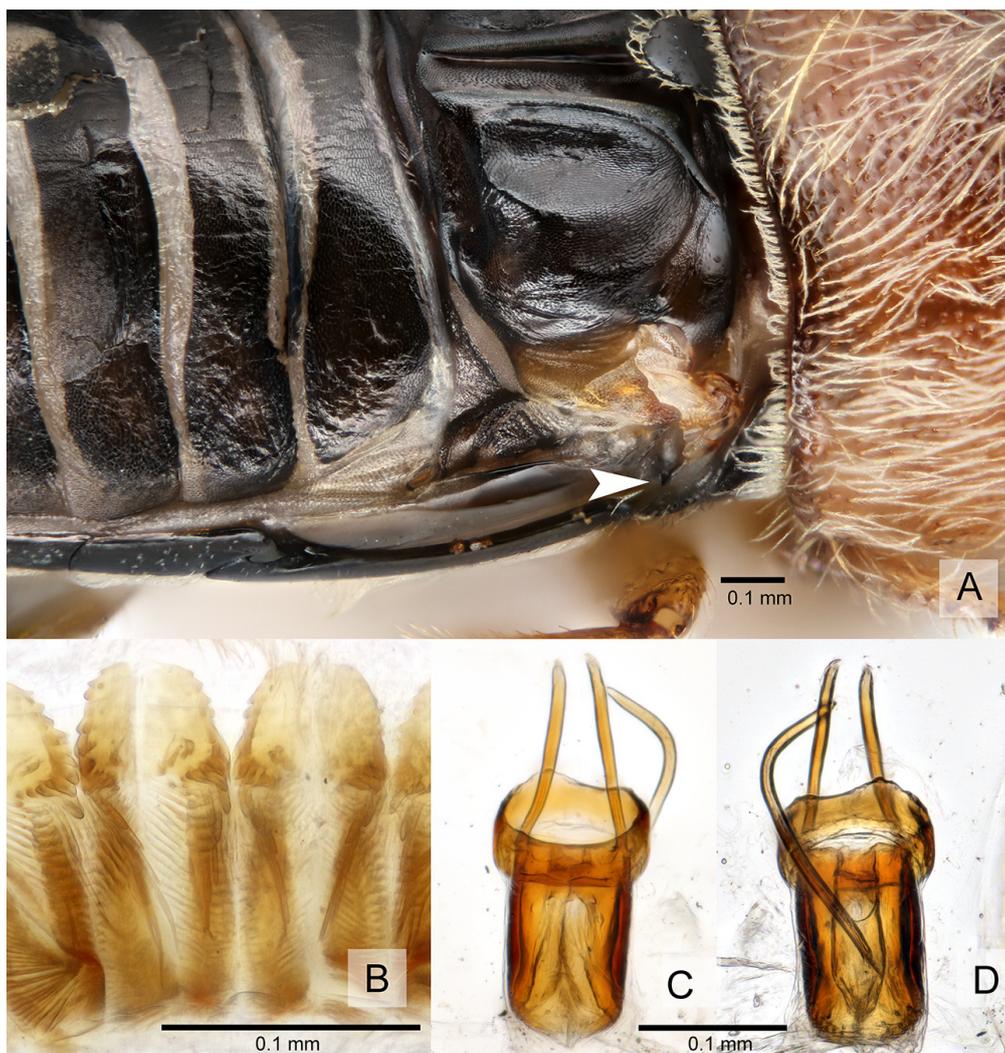


FIGURE 2. *Urocorthylus hirtellus* male, A) Lateral view with elytron removed showing metanepisternal spine (UFFE:30356), B) Proventriculus (UFFE:30356), C–D) Aedeagus (UFFE:30363).

***Urocorthylus hirtellus* Petrov, Mandelshtam & Beaver, 2007**

Figs 2–6

Urocorthylus hirtellus Petrov, Mandelshtam & Beaver, 2007: 251.

The species was described from the female only (Fig. 3). Here, we describe the male (Fig. 4), based on specimens collected in Yunnan province in south-western China, and in Chaiyaphum province in the northeastern region of Thailand.

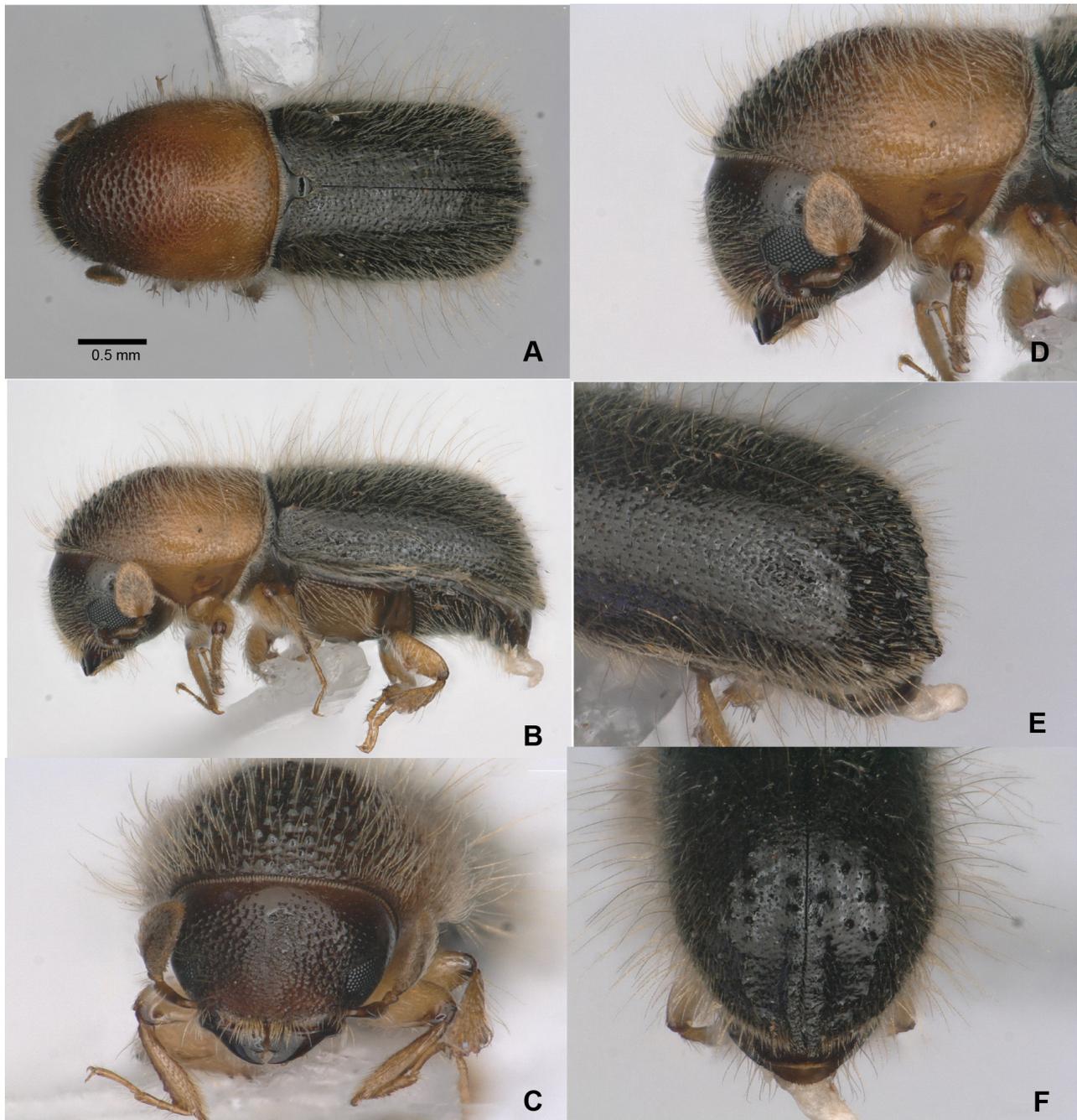


FIGURE 3. *Urocorthylus hirtellus* female, JXAU_S20180128001, A) dorsal view, B) lateral view, C) frons, D) antenna, E) declivital oblique, F) declivital face.

Masc. nov. 2.58–3.15 mm long (mean 2.82, n=5), 2.36–2.52 times as long as wide (mean 2.43, n=5). **Coloration.** Bicolored, pronotal base (or pronotum as a whole) and appendages ferruginous, pronotal anterior slope and elytra black. Head brown, paler ventrally, pronotum brown ventrally, abdomen blackish brown, antennae and legs yellowish. **Head.** Epistoma entire, weakly sinuate above, with a row of moderately long hair-like setae. Frons below upper margin of eyes flat, upper part slightly convex, subshining, without longitudinal medial line; coarsely, densely rugose-punctate, punctures smaller, denser and shallower toward epistoma, bearing long, erect hair-like setae. Eye moderately large, broad, with a small, shallow emargination just above antennal insertion, upper portion distinctly smaller than lower part. Submentum moderately sized, triangular, punctate, with short erect hairlike setae. **Antenna.** Scape clavate, shorter than club. Pedicel slightly narrower than scape, shorter than funicle. Funicle 2-segmented, segment 1 shorter than pedicel, segment 2 small, inconspicuous. Antennal club oval, about 1.5 times as long as wide, compressed, without visible sutures or septa, densely and uniformly pubescent, except for triangular

or parallel-sided area at the base), glabrous, shining area extending about half length of club. **Pronotum.** 1.04–1.11 times as long as wide (mean 1.08, n=5), sides parallel in basal half, then narrowing to rounded apex, without a distinct pre-apical constriction; anterior margin with 4 or 5 small serrations; anterior slope with subcontiguous small asperities, flatter, more transverse and almost imbricate in middle, smaller and more widely separated towards sides, becoming lower and narrower towards summit, slope with a mixture of less numerous, fine, long, erect, hair-like setae, and similar but more numerous, shorter, semi-recumbent setae; disc densely granulate-punctate behind summit becoming punctate towards base; sides densely, finely punctate; surface smooth, shining between punctures; disc and sides with dense, very fine, forwardly-directed, appressed hairs of variable length, and less dense scattered, long, erect, hair-like setae; posterior margin sinuate with a fringe of short, posteriorly-directed setae below the margin. **Scutellum.** Large, tongue-shaped, shining, impunctate, contrasting with subshining, strongly punctured elytra. **Elytra.** 1.28–1.54 times as long as wide (mean 1.42, n=5), 1.27–1.52 times as long as pronotum (mean 1.40, n=5); elytral bases slightly concave, as wide as pronotum, subparallel in basal 2/3, then strongly angled to apex, broadest at upper margin of declivity. Disc slightly convex, subshining, striae and interstriae obsolete near base, very densely rugulose-punctate, except laterally where deeply punctured; apical half of disc with impressed striae and ridged interstriae, the latter with an irregular row of tubercles; disc with a dense covering comprising sparser, long, erect hair-like setae, and more numerous, shorter, semi-recumbent, plumose setae, the latter extremely dense on posterior half of elytra giving a woolly appearance. Declivity abruptly truncate, beginning in posterior 2/3 of elytra; striae impressed, narrow, with 3 or 4 irregular rows of short, plumose setae; interstriae ridged, each with a row of shining, rounded tubercles, interstriae 1 broader than outer interstriae and with additional scattered granules and rugosities, interstitial setae distinctly shorter than on disc; interstriae 1 at apex of elytra with a pair of small, weakly tapering processes with rounded tips, the size and form varying between individuals, dorsal face of processes, densely punctured with minute, very short setae. **Legs.** Procoxae slightly separated, Protibia not flattened, armed by 3 or 4 socketed denticles on anterior margin. Meso- and metatibiae flat, with denticles on the apical third. **Proventriculus.** Apical plate approximately 1/3 of the length. Median suture open, with teeth along medial margin. **Aedeagus.** Penis apodemes separate, and about a third of the total length. Penis body broad, about 3.0 times as long as wide. Tegmen broad, strongly sclerotized, appearing to be sclerotized over its entire circumference. Spiculum gastrale narrow. Base of flagellum membranous with no sclerotization.

Material examined for description of male. CHINA, Yunnan, Jing-Hong city, Menghai co., Na-ban-he Nat. Res., Guo-men-shan, 22°14'46.54"N, 100°36'10.2"E, 1033 m, ex *Cyclobalanopsis* sp., 28.i.2020, S-C. Lai (RABC, 2). THAILAND, Chaiyaphum, Phu Khieo Wildlife Sanctuary headquarters, 16°23'00.4"N 101°33'27.0"E, 900 m, Dry-dipterocarp forest with pine subtype, ex. semi-dry branch of *Lithocarpus* sp., 21.vii.2019, W. Sittichaya (WSTC, 2; RABC, 1).

Additional new records. CHINA: Yunnan, near Pu'er city, ex sticky trap on tree trunk, 10.v.-07.vi.2012, T. Petrice & R. Haack (UFFE 19886: 1); Yunnan, Meng-hai Co., Jing-hong city, Guo-men-shan, Na-ban-he Nature Reserve, mixed forest, ex *Quercus glauca*, c.60 cm diameter, 28.i.2018, S-C. Lai (UFFE 35169-35170: 1 male, 1 female (sequenced by S-C. Lai); JXAU, 18); as previous except: reared from bark, Y. Li (UFFE 30354–30355, 30357–30363; 32072–32073: 41).

Distribution. China (Yunnan), Thailand (Chiang Mai, Chaiyaphum), Vietnam (Vinh Phuc).

Biology. As noted earlier, it had been assumed that the species was an ambrosia beetle (Petrov *et al.* 2007; Beaver *et al.* 2014; Wang *et al.* 2017). A large series was collected from a fallen *Quercus glauca*, approximately 60 cm in diameter in China (Yunnan). The larval galleries were within the thick bark (Fig. 5), although the nuptial gallery and early development was not evident. No symbiotic fungi were observed in the galleries. Pupation chambers were in the thick bark away from the parental galleries, as in other related Dryocoetini such as *Taphrorychus* (e.g. Balachowsky 1949; Schönherr & Krautwurst 1979). The adults emerge through individual exit holes in the bark (Fig. 6). The species has also been collected in *Lithocarpus* sp. in Thailand (see above). The only other species in the genus, *U. fanii* Wang, Beaver & Hulcr was collected from *Lithocarpus hancei* (Wang *et al.* 2017). All host records are from trees in the family Fagaceae. It appears likely that the genus is specific to this family. Both species are montane species, collected at altitudes from 650–1030 m, and probably largely confined to the hill evergreen forests of the region, in which Fagaceae is the dominant tree family.

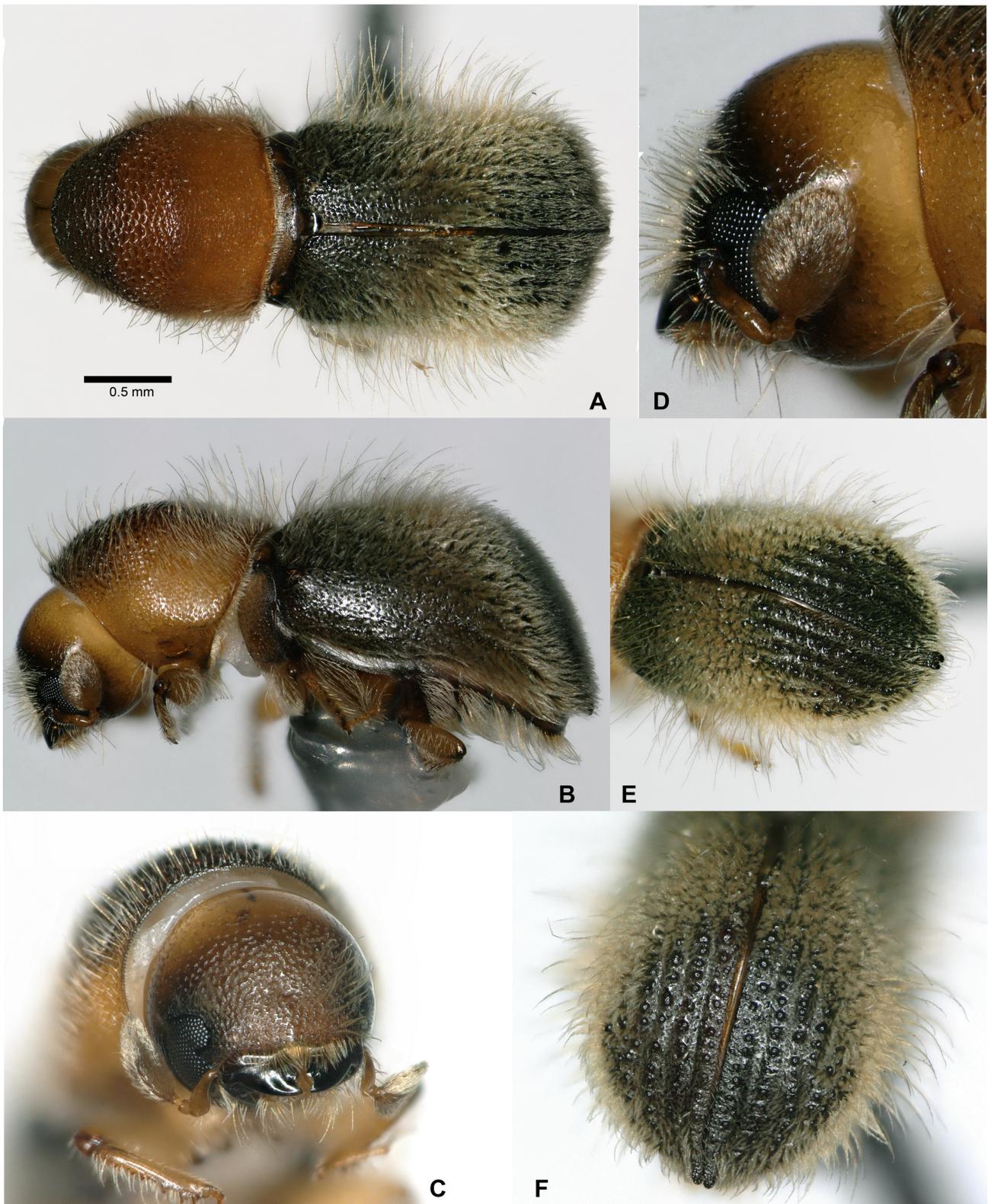


FIGURE 4. *Urocothylus hirtellus* male, JXAU_S20180128001, A) dorsal view, B) lateral view, C) frons, D) antenna, E) declivital oblique, F) declivital face.

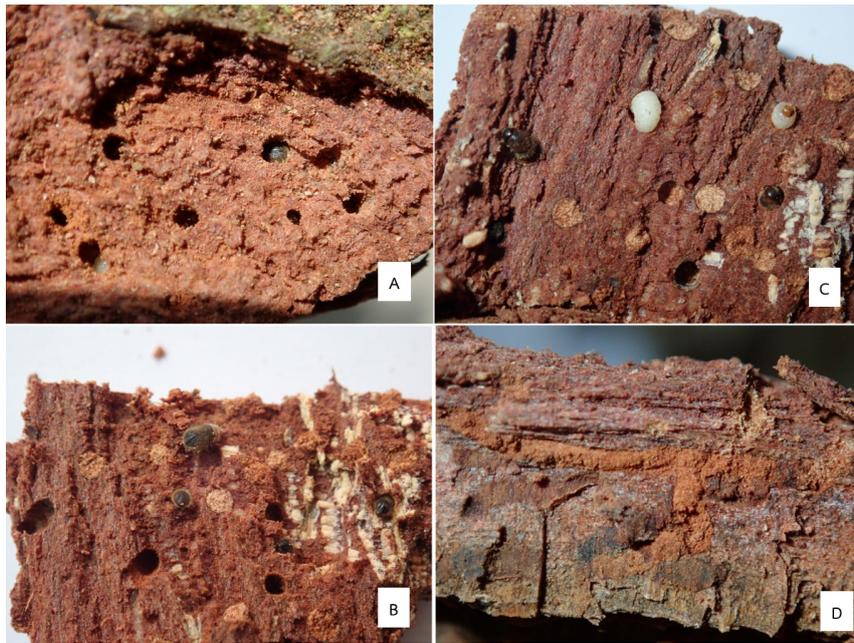


FIGURE 5. *Urocorthylus hirtellus* larval galleries in bark of *Quercus glauca*.



FIGURE 6. *Urocorthylus hirtellus* emergence holes of adults in bark of *Quercus glauca*.

Keys for the identification of *Urocorthylus* Petrov, Mandelshtam & Beaver, 2007

We provide here two keys, the first to distinguish the genus within the tribe Dryocoetini, the second to the two species and sexes of the genus.

The only key available to Dryocoetini genera worldwide is that included in Wood (1986), which contains several inaccuracies. When keyed out using the key to genera within Dryocoetini (Wood 1986, p. 71), the diagnosis may fail at the first couplet since the antennal club is without visible sutures, not accommodated in either statement. Ignoring that, the key then fails at couplet 10, given its distribution (Southeast Asia) and the small number of funicular segments (pedicel plus 2 segments). Forgiving that, keying out fails on couplet 11. This corroborates its phylogenetic placement, closely related to *Taphrorychus*, some species of which also possess fine, unusually long hairs on the pronotum and elytra (Wood 1986), although never as strongly developed as in *Urocorthylus*. Wood's (1986) key can be modified to include *Urocorthylus* as follows:

- 10 (5) Antennal funicle (excluding pedicel) 3-segmented, sutures of club strongly procurved; male frons shallowly to moderately impressed, female frons less distinctly impressed; slender species with punctures on elytral disc confused, partly xylophagous, North America, N Asia, Europe. 1.6–2.0 mm *Lymantria*
- Antennal funicle (excluding pedicel) 4-segmented (rarely 1-, 2-, or 3-segmented in Southeast Asian, Indonesian and New Guinean species), sutures on club (if present) procurved or not; male frons usually convex, female frons frequently pubescent. 11a
- 11a(10) Pronotum with summit elevated near middle of pronotum, often a moderate transverse impression behind summit; antennal club strongly flattened, basal area slightly corneous. Meso- and metatibia more slender, hair on pronotum and elytra fine, unusually long; Europe and Asia, broadleaf hosts 11b
- Pronotum with dorsal profile feebly arched, summit inconspicuous or else on basal fourth; basal area of antennal club less strongly flattened, more strongly corneous or if not corneous, then sutures obsolete and pubescence extending to base; meso- and metathoracic tibiae usually more broadly flattened, pronotal and elytral setae of more normal length 12
- 11b(11a) Antennal funicle (excluding pedicel) 2-segmented. Anterior face of antennal club with sutures not visible, finely pubescent except medially near the base of the anterior face. Ground vestiture exceptionally long and plumose, especially on the declivity. Southeast Asia only *Urocorthylus*
- Antennal funicle (excluding pedicel) 4-segmented. Anterior face of antennal club with suture 1 distinct, straight to strongly bisinuate, its lateral extremities reaching basal fourth, median portion never exceeding middle of club, 2 sutures on posterior face. Broadly distributed over palaeartic Eurasia to Vietnam *Taphrorychus*

Key to species and sexes of *Urocorthylus* Petrov, Mandelshtam & Beaver, 2007

- 1 Frons below upper margin of eyes with a distinct shining, impunctate median line. Antennal club subcircular, 1.2–1.3 times as long as wide. Smaller species, 1.80–2.35 mm long. (*U. fanii*) 2
- Frons median area with longitudinal rugosities and punctures, without impunctate median line. Antennal club oval, 1.5 times as long as wide. Larger species, 2.40–3.10 mm long. (*U. hirtellus*) 3
- 2 Body short and stout, 2.5–2.6 times as long as wide. Pronotum less elongate, 0.9–1.0 times as long as wide. Interstriae 1 and 3 on elytral declivity without tubercles. Pubescence denser and longer, with a woolly appearance *U. fanii* (male)
- Body more elongate, 2.75–2.80 times as long as wide. Pronotum more elongate, 1.0–1.1 times as long as wide. Interstriae 1 and 3 on elytral declivity each with a row of small, pointed tubercles. Pubescence sparser and shorter, giving a less woolly appearance *U. fanii* (female).
- 3 Body short and stout, 2.36–2.52 times as long as wide. Elytral declivity truncate, its face flat, interstriae each bearing a row of small tubercles, striae weakly impressed. Pubescence very dense on whole elytra, giving a very woolly appearance. *U. hirtellus* (male)
- Body more elongate, 2.5–2.7 times as long as wide. Elytral declivity steep, but not truncate, weakly convex, interstriae 1 raised, and it and interstriae 3 with a row of small granules, interstriae 2 flat, without granules. Pubescence less dense *U. hirtellus* (female)

Discussion

Bark beetles show strong phylogeographic patterns, with deep evolutionary lineages restricted to particular continents or biogeographic regions. For example, Bothrosternini and Hexacolini are diverse lineages restricted to the Americas, Scolytoplatypodini are only found in Africa, Asia and New Guinea, Phrixosomatini are only present in South America and Africa, and Micracidini are very diverse but only present in Africa and the Americas, with the exception of two species of *Pseudothysanoes* in Asia.

The tribe Corthylini shows similar patterns. The paraphyletic subtribe Pityophthorina is especially diverse in the Americas, with only *Pityophthorus* also present in Asia and Africa. The subtribe Corthyliina, which includes all of the xylem-inhabiting fungus-farming species, are even more restricted. Those that are found outside the Americas are either recent invasives (*Gnathotrichus materiarius* (Fitch) and *Monarthrum mali* (Fitch) in Europe (Kirkendall & Faccoli 2010; Rassati *et al.* 2016), a species represented by a single specimen, possibly introduced or mislabelled (*Monarthrum meuseli* (Reitter) from Eastern Siberia (Mandelshtam 2001; Petrov *et al.* 2007), or rare Oriental genera with one or two species. We can now remove one of the rare genera, *Urocorthylus*, from the list of Indomalayan genera, having shown that it does not belong in the Corthyliina, but in the Dryocoetini, a diverse tribe with a wide distribution in the Afrotropical, Oriental and Australian regions, but relatively few species native to the Americas. The placement in the Corthyliina of the other rare genus, *Gnatharus* Wood and Yin, with a single species, *G. tibetensis* Wood & Yin, found in China and Thailand, appears to be correct, but further study of this little-known genus is needed.

Other interesting evolutionary patterns remain to be studied further. Some Scolytinae show high evolutionary fidelity to relationships with a particular host tree family. *Urocorthylus* and the great majority of species in its sister taxon, *Taphrorychus*, breed in Fagaceae or Betulaceae (Wood & Bright 1992; Pfeffer 1995). Both families are included in the angiosperm order Fagales (Angiosperm Phylogeny Website 2023). However, many species are poorly known and further work on the taxonomy, phylogeny and host data are needed to test this pattern in a phylogenetic context.

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