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A new species of *Airaphilus* Redtenbacher and new record of fossil Silvanidae (Coleoptera) from Eocene Baltic amber of the Sambian Peninsula

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A new fossil species of the silvanid flat bark beetle, *Airaphilus simulacrum* Alekseev, Bukejs et McKellar sp. nov. (Coleoptera: Silvanidae) is illustrated and described based on two specimens from Eocene Baltic amber. A second specimen of the confamilial fossil taxon *Mistran ot* Alekseev et Bukejs, 2016 is reported and imaged using synchrotron X-ray micro-CT observations.

Key words: Cucujoidea, palaeontology, Cenozoic, Tertiary, fossil resin, SR X-ray micro-CT

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INTRODUCTION

Descriptive research dealing with assemblages of different beetle groups in fossil resin has noticeably accelerated within the last few years. The small family Silvanidae consists of approximately 500 extant species within 58 genera and two subfamilies in recent ecosystems. However, the group is comparatively rare as fossils. Until now, only two Mesozoic and six Cenozoic fossil

silvanid species have been described (Ermisch 1942; Kirejtshuk 2011; Kirejtshuk & Nel 2013; Alekseev & Bukejs 2016; Alekseev 2017; Cai & Huang 2019; Liu et al. 2019; Alekseev et al. 2019). Among these known taxa are four species of Brontinae: *Dendrobrontes popovi* Kirejtshuk, 2011 from Eocene Baltic amber; *Antiphloeus stramineus* Kirejtshuk et Nel, 2013 from Eocene Oise amber, France; *Cretoliota cornutus* Liu, Slipiñski, Wang et Pang, 2019, and *Protoliota antennatus* Liu, Slipiñski, Wang et Pang, 2019, both from Upper Cretaceous Burmese amber. Three species of Silvaninae are known as well: *Mistran ot* Alekseev et Bukejs, 2016, *Cathartosilvanus necromanticus* Alekseev, 2017, and *C. siteiterralevis* Alekseev, Bukejs et McKellar, 2019, all from Eocene Baltic amber. There is also one species that has been placed in Silvanidae with uncertain subfamily affiliations pending further research, "*Airaphilus*" *denticollis* Ermisch, 1942 from Eocene Baltic amber.

The species-rich extant genus *Airaphilus* Redtenbacher, 1858 was first reported from Baltic succinite amber by Klebs (1910), and one species under this generic name was described by Ermisch (1942). Since that time no descriptions or additional reports have been published on the taxon. In connection with the doubtful generic placement of "*Airaphilus*" *denticollis* Ermisch, 1942 (Alekseev & Bukejs 2016), the presence of *Airaphilus* representatives in the Eocene of Europe has been considered questionable. This situation is clarified in the current paper, where the new species, *Airaphilus simulacrum* sp. nov. is described and figured.

MATERIAL AND METHODS

The material examined is deposited in the Palaeontology Collection of the Royal Saskatchewan Museum (Regina, Saskatchewan, Canada) [RSM, RSKM specimen prefix].

Observations of this specimen were made using a Nikon SMZ 745T stereomicroscope. Photographs were taken using a Visionary Digital imaging system, consisting of a Canon EOS 5D camera with a Canon MP-E 65 mm macrophotography lens, attached to an automated camera lift with studio flash lighting. Extended depth of field at high magnifications was achieved by combining multiple images from a range of focal planes using Helicon Focus 6.8.0 software, and the resulting images were edited to create figures using Adobe Photoshop CS5.

Specimen RSKM_P3300.81 was subjected to Synchrotron X-ray micro-CT observations at the BioMedical and Imaging Therapy (BMIT) Insertion Device (ID) beamline of the Canadian Light Source (CLS) synchrotron facility (Wysokinski et al. 2008). This imaging work involved a customized micro-CT system developed by Bruker (Kontich, Belgium), which operates at a voxel size of 0.9 µm. Tomographic slices were generated from 900 rotational steps through 180 degrees (0.2 degree step) using NRecon (Bruker software). The sample was temporarily attached to a brass pin on the rotating stage using dental wax, which is a removable mountant that is X-ray translucent. Images were captured at 30 keV with a sample to detector distance of approximately 16 cm, resulting in significant phase contrast in the final images. The image data were binned (2 x 2 x 2) to 1.8 µm isotropic voxels and imported into the AMIRA (ver. 6.3) software platform for interactive segmentation and 3D visualization. Z-Brush software (ver. 4R7 P3) was used to complete renderings.

The following sources were used for the comparison with recent genera and species: Reitter (1879), Thomas (1993), Sengupta & Pal (1996), Wurst & Lange (1996); Thomas & Nearns (2008), Friedman (2015), Fancello et al. (2017a, 2017b), and Yoshida et al. (2019).

SYSTEMATIC PALAEONTOLOGY

Family Silvanidae Kirby, 1837
Subfamily Silvaninae Kirby, 1837
Genus *Airaphilus* Redtenbacher, 1858

Note. The studied amber specimens show the combination of characters unequivocally corresponding to the subfamily Silvaninae: pentamerous tarsi with tarsomere 4 the smallest; procoxal cavities closed; antennae non-filiform; antennal scape comparatively short (slightly longer than pedicel); dorsal side of head without longitudinal grooves or striae between eyes; and frontoclypeal suture absent. The beetle under consideration is assigned to the genus *Airaphilus* based on the combination of the following characters: (1) anterior margin of clypeus slightly rounded; (2) tarsomere 3 strongly lobed ventrally; (3) lateral margin of prothorax with more than six, small, regular denticles; (4) pronotal lateral denticles with long, posteriorly directed setae; (5) compound eyes large; (6) head without temples; (7) terminal maxillary palpomere elongate; and (8) antennal club indistinct, antennae gradually thickened towards apex.

***Airaphilus simulacrum* Alekseev, Bukejs et McKellar sp. nov.**
Figs. 1–2

Type material. Holotype: RSKM_P3300.64; adult, sex unknown. Rather complete beetle (antennomere 11 of right antenna partially truncated) included in transparent, yellow amber piece with dimensions 19×16×4 mm, and preserved without supplementary fixation. Syninclusions: few small detritus particles and gas vesicles.
Paratype: RSKM_P3300.83; adult, sex unknown. Rather complete beetle included in small, transparent yellow amber piece embedded in block of Epo-Tek 301 resin with overall dimensions 11×5×4 mm. Inclusion was partially damaged during epoxy embedding under vacuum: crack connecting inclusion to surface of amber piece allowed epoxy to enter body cavity and obscure many surface details originally visible in external mould within surrounding amber. Syninclusions: few small detritus particles.

Type strata. Baltic amber from Eocene amber-bearing Blue Earth layers (mostly Bartonian age, as interpreted for extinct Central European resin-producing forests according to Bukejs et al. 2019).

Type locality. Yantarny settlement (formerly Palmnicken), Sambian (Samland) Peninsula, Kaliningrad region, Russia.

Etymology. Specific epithet is Latin word *simulacrum*, used as noun in apposition and meaning "image, likeness, phantom, shadow of dead".

Diagnosis. *Airaphilus simulacrum* sp. nov. distinctly differs from other currently known Baltic amber Silvanid flat bark beetles in following characters: dorsal side of head without longitudinal grooves or striae; antennae non-filiform, gradually thickened towards apex with antennal club indistinct; lateral margin of prothorax with more than six, small, regular denticles bearing long, posteriorly directed setae; and tarsomere 3 strongly lobed.

New fossil species can be reliably differentiated from extant species of *Airaphilus* based on following combination of characters: exposed part of head strongly transverse, pronotum distinctly transverse, lateral pronotal margin with 12 equally-formed denticles, antennal club indistinct, humeral denticle absent, femoral lines on ventrite 1 closed, and body size comparatively large (4.0–4.5 mm).

Description. Body length about 4.0 mm, maximum width 1.4 mm; head length 0.4 mm, head width (including eyes) 0.9 mm; pronotal length 0.9 mm, pronotal maximum width 1.1 mm; elytral length 2.8 mm, elytral maximum width 1.5 mm. Habitus elongate-oval, subparallel-sided, flattened and distinctly pubescent dorsally, slightly convex and with less conspicuous pubescence ventrally; unicolorous dark brown.

Head strongly transverse, about 2× as wide as long, with weak constriction behind eyes; densely covered with small punctures, distance between punctures smaller than diameter of one puncture; with sparse, short, semierect setae (that are more conspicuous than setation on pronotal disc). Anterior margin of clypeus slightly and widely rounded. Fronto-clypeal suture ab-

Fig. 1. *Airaphilus simulacrum* sp. nov., holotype, RSKM_P3300.64: A – dorsal habitus; B – ventrolateral habitus. Scale bars represent 1.0 mm.

sent. Forehead almost flat, without grooves or striae between eyes. Temples absent. Compound eyes large, hemispherical, prominent, with coarse facets; eyes widely separated, with distance between eyes about 3× transverse diameter of one eye. Antennal grooves absent. Antennal insertions hidden under lateral projections of frons. Maxillary palpi short; terminal palpomere elongate, spindle-shaped, about 1.8× as long as penultimate palpomere. Antenna moderately long, extending to anterior one-fifth of elytra; 11-segmented, with indistinct club gradually thickening towards apex; sparsely covered with fine, semierect setae; scape subcylindrical, about 1.6× as long as wide; pedicel elongate, 1.5× as long as wide, and about 0.7× as long as scape; antennomeres 3–6 elongate, subequal in length and shape; antennomeres 7–8 slightly elongate, about 1.2× as long as wide, slightly dilated apically; antennomeres 9–10 as wide as long, distinctly dilated apically; antennomere 11 ovoid, 1.5× as long as wide.

Pronotum slightly transverse, 1.2× as wide as long, widest in anterior one-third of its length, distinctly narrowed posteriad and slightly narrowed anteriad; disc flat dorsally. Anterior pronotal edge almost straight; posterior edge convex, bordered; lateral edges slightly convex, with 12 small, sharp, regular denticles; anterior denticle not differentiated and not larger than other denticles. Anterior angles nearly rectangular, not produced anteriorly; posterior angles obtuse. Pronotal punctation large and dense, each puncture distinctly larger than compound eye facet; punctures at sides coarser than on pronotal disc; distance between punctures

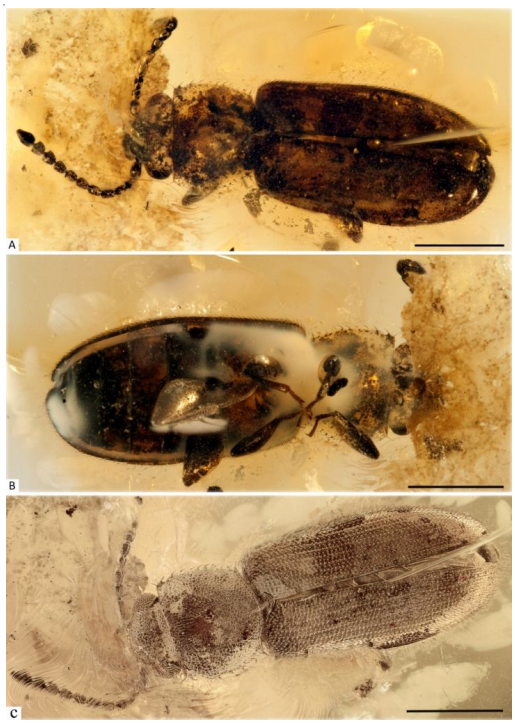

Fig. 2. *Airaphilus simulacrum* sp. nov., paratype, RSKM_P3300.83: A – dorsal habitus; B – ventral habitus; C – condition of specimen before epoxy infilling obscured surface details, dorsal habitus. Scale bars represent 1.0 mm.

smaller than diameter of one puncture, interspaces slightly convex. Dorsal pubescence fine, short, semierect, and more conspicuous laterally; each pronotal lateral denticle with one posteriorly directed, moderately long, stout, and erect seta.

Scutellar shield large, suboval, distinctly transverse, 1.4× as wide as long, with dense, small punctation, and with sparse, short, semierect setae. Elytra elongate, 1.7× as long as wide, subparallel-sided, and striate-punctate; slightly wider than pronotum; without distinct carinae. Elytral punctation dense and small (smaller than pronotal punctures); striae distinct almost throughout entire length of elytra, smoothed in apical one-third; distance between punctures in striae about 0.5–1.5× diameter of one strial puncture; interstriae almost flat (only weakly convex at base), shiny, with fine secondary punctation, distance between striae about 1.5–2.0× diameter of one puncture. Scutellary striole apparently present. Elytral pubescence composed of fine, short, semierect setae; setation more conspicuous along lateral surfaces. Humeri rounded, not protruding; humeral denticle absent. Epipleura well developed, widest at humeri, gradually narrowing posteriorly, apparently reaching elytral apex; sparsely covered with fine punctures.

Prohypomera with few, fine punctures, and strong microreticulation; prothorax with sparse, fine punctation (distinctly sparser than punctures on metaventrite). Prosternal process narrow, narrower than diameter of procoxa. Procoxal cavities apparently widely closed. Mesoventrite densely covered with large punctures, distance between punctures smaller than diameter of one puncture, interspaces slightly convex. Metaventrite impressed medially; with moderately dense cover of fine punctation, distance between punctures distinctly larger than diameter of one puncture, interspaces microreticulate; pubescence composed of fine, sparse, recumbent setae. Metepisterna long and narrow, slightly widened anteriorly; inner lateral margin almost straight, outer lateral margin slightly concave; sparsely covered with fine punctation and fine, recumbent pubescence.

Legs moderately short and robust; sparsely covered with fine, recumbent setae. Procoxa nearly round, mesocoxa widely oval, metacoxa transverse, oval; all coxae separated from each other. Trochanters without spines. Femora widened medially, simple (without teeth), with deep, longitudinal groove apicoventrally; metafemora more widened medially than pro- and mesofemora. Tibiae almost straight, not dilated apically, nearly as long as femora; without denticles or spines; with fringe of spinules apically. Tarsi pentamerous, long; tarsomeres 2–3 slightly dilated apically, tarsomere 3 ventrally produced in front to form lobe; tarsomere 4 very small; tarsomere 5 longest, nearly as long as tarsomeres 1–3 combined. Tarsal claws simple, apparently slightly widened basally, equal in size, long, about 0.35× as long as apical tarsomere.

Abdomen with five visible, similarly articulated ventrites; ventrite 1 with closed postcoxal line (forming margin of metacoxal cavities); densely covered with fine punctation, distance between punctures about 0.7–2.0× diameter of one puncture, interspaces microreticulate; abdominal pubescence moderately dense, composed of fine, short, recumbent setae; sutures straight; ventrite 5 rounded apically. Intercoxal process of abdominal ventrite 1 triangular, narrow, and acute. Relative length ratio (medially) of ventrites 1–5 equal to 18:12:10:8:5.

Paratype. Body length about 4.5 mm, maximum width 1.8 mm; head length (?)0.5 mm, head width (including eyes) 1.1 mm; pronotal length 1.0 mm, pronotal maximum width 1.3 mm; elytral length 3.0 mm, elytral maximum width 1.8 mm. Relative length ratio of antennomeres 1–11 equal to 13:10:10:11:10:10:10:10:10:9:11.

ADDITIONAL FOSSIL RECORD OF SILVANIDAE

Genus *Mistran* Alekseev et Bukejs, 2016
***Mistran ot* Alekseev et Bukejs, 2016**
Figs. 3–4

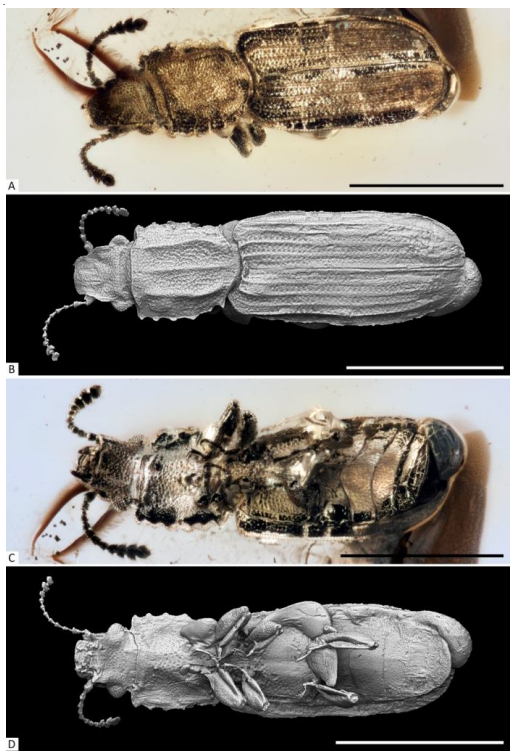

Fig. 3. *Mistran ot* Alekseev et Bukejs from Baltic amber, RSKM_P3300.81: A, B – dorsal habitus photomicrograph, and corresponding SR x-ray μCT rendering; C, D – ventral habitus photomicrograph, and corresponding SR x-ray μCT rendering. Scale bars represent 1.0 mm.

Material examined. One specimen with collection number RSKM_P3300.81, in Baltic amber, Yantarny, Kaliningrad region, Russia. Complete beetle included in small, transparent, yellow amber piece with dimensions of 8×4×3 mm. Syninclusions absent. Body length of beetle is 2.7 mm, maximum width is 0.9 mm, and preserved colour is black.

Note. The postcoxal lines of ventrite 1 were not described in the holotype of *Mistran ot*; they are closed in specimen RSKM_P3300.81. The body size variability is established based on the presented material: the body length varies 2.55 mm (holotype) – 2.7 mm (the specimen RSKM_P3300.81).

DISCUSSION

In a molecular phylogenetic study (McElrath et al. 2015), *Airaphilus* was shown to be the basal clade of the subfamily Silvaninae. The new amber inclusions presented here prove the occurrence of *Airaphilus* in the 'Baltic amber forest', giving this clade at least an Eocene age.

The genus *Airaphilus* currently contains about 37 described species (Yoshida et al. 2019). The extant representatives of the genus inhabit the Old World only: 30 species are listed in the Palaearctic Region (Halstead et al. 2007), with an especially rich fauna in the Mediterranean area,

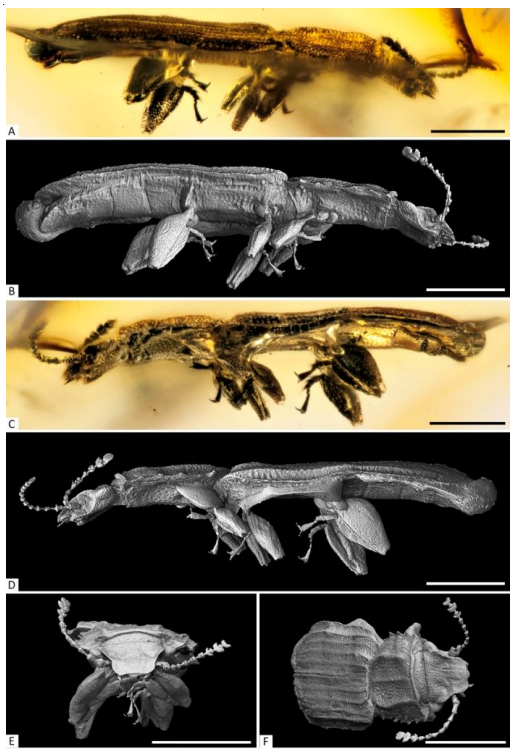

Fig. 4. *Mistran ot* Alekseev et Bukejs from Baltic amber, RSKM_P3300.81: A, B – right lateral habitus photomicrograph, and corresponding SR x-ray μCT rendering; C, D – left lateral habitus photomicrograph, and corresponding SR x-ray μCT rendering; E – anterior habitus SR x-ray μCT renderin

and a few species are known from Africa and Southeast Asia (Sengupta & Pal 1996). Little detail is known about the biology of the species. Members of the genus have been reported from haystacks and leaf litter (Sengupta & Pal 1996); under stones and in detritus near Mediterranean dwarf palms and grasses (Fancello et al. 2017a); in roots of dune grass, in damp meadows, and near the base of dying plants in a coastal sand dune, within humus and leaf litter, under bark of dead trees, and on plants from marshy places (especially from flowers of *Carex* in wetlands or at lakesides) (Yoshida et al. 2019). Besides swampy habitats and habitats with mixed mesophytic communities, light and comparatively drier areas were possibly presented in the 'Baltic amber forest' habitat area (Sadowski et al. 2017). Such semi-open and light patches were possibly inhabited by shrubs and graminids (sedges and grasses). This habitat seems to be the most appropriate for the Eocene *Airaphilus simulacrum* sp. nov., matching well with an uniformitarian approach to the ecology of the group.

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REFERENCES

Alekseev V.I. 2017. First record of *Cathartosilvanus* Grouvelle (Coleoptera: Silvanidae) from Baltic amber with description of a new species. Baltic Journal of Coleopterology 17 (1): 43–48.

Alekseev V.I., Bukejs A. 2016. New fossil genus of Silvanidae (Insecta: Coleoptera) from Baltic amber (Tertiary, Eocene). Zootaxa 4144 (1): 101–108.

Alekseev V.I., Bukejs A., McKellar R.C. 2019. The second fossil species of *Cathartosilvanus* (Coleoptera: Cucujoidea: Silvanidae) from Eocene Baltic amber. Fossil Record 22: 111–118.

Bukejs A., Alekseev V.I., Pollock D.A. 2019. Waidelotinae, a new subfamily of Pyrochroidae (Coleoptera: Tenebrionoidea) from Baltic amber of the Sambian peninsula and the interpretation of Sambian amber stratigraphy, age and location. Zootaxa 4664 (2): 261–273.

Cai C., Huang D. 2019. Sexual dimorphism in mid-Cretaceous silvanid beetles from northern Myanmar (Coleoptera, Silvanidae, Brontinae). Palaeoentomology 2 (3): 289–296.

Ermisch K. 1942. *Airaphilus denticollis* n. sp. (*Donacia* spec. Helm). Entomologische Blätter 38 (4): 128–129.

Fancello L., Verdugo A., Torres J.L. 2017a. Notas sobre *Airaphilus ferrugineus* (Kraatz, 1862) (Coleoptera, Silvanidae, Silvaninae). Revista gaditana de Entomología 8 (1): 187–200.

Fancello L., Verdugo A., Torres J.L. 2017b. Nota sistemática sobre *Airaphilus peyerimhoffi* Cobos, 1950 (Coleoptera, Silvanidae, Silvaninae). Revista gaditana de Entomología 8 (1): 235–243.

Friedman A.-L.-L. 2015. The Silvanidae of Israel (Coleoptera: Cucujoidea). Israel Journal of Entomology 44: 75–98.

Halstead D.G.H., Löbl I., Jelínek J. 2007. Silvanidae. In: Löbl I., Smetana, A. (eds.): Catalogue of Palaearctic Coleoptera. Vol. 4., Apollo Books, Stenstrup. pp. 496–501.

Kirejtshuk A. 2011. The oldest representatives of the subfamilies Meligethinae (Coleoptera: Nitidulidae) and Brontinae (Coleoptera: Silvanidae) from Baltic amber and some evolutionary notes. Polskie Pismo Entomologiczne 80 (4): 729–745.

Kirejtshuk A.G., Nel A. 2013. Current knowledge of Coleoptera (Insecta) from the Lowermost Eocene Oise amber. Insect Systematics and Evolution 44: 175–201.

Klebs R. 1910. Über Bernsteineinschlüsse im allgemeinen und die Coleopteren meiner Bernsteinsammlung. Schriften der Physikalisch-ökonomischen Gesellschaft zu Königsberg i. Pr. 51: 217–242.

Liu Z., Slipiński A., Wang B., Pang H. 2019. The oldest silvanid beetles from the Upper Cretaceous Burmese amber (Coleoptera, Silvanidae, Brontinae). Cretaceous Research 98: 1–8.

McElrath T.C., Robertson J.A., Thomas M.C., Osborne J., Miller K.B., McHugh J.V., Whiting M.F. 2015. A molecular phylogenetic study of Cucujidae s.l. (Coleoptera: Cucujoidea). Systematic Entomology 40: 705–718.

Reitter E. 1879. Bestimmungs-Tabellen der Europäischen Coleopteren. I. Cucujdae, Telmatophilidae, Tritomidae, Mycetaeidae, Endomychidae, Lyctidae und Sphindidae. Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien 29 (1): 71–100.

Sadowski E.-M., Schmidt A.R., Seyfullah L.J., Kunzmann, L. 2017. Conifers of the 'Baltic amber forest' and their palaeoecological significance. Stapfia 106: 1–73.

Sengupta T., Pal T.K. 1996. Fauna of India and the adjacent countries. Calvicornia: Coleoptera. Family Silvanidae. Zoological Survey of India, Calcutta, p. 262.

Thomas M.C. 1993. The flat bark beetles of Florida (Laemophloeidae, Passandridae, Silvanidae). Arthropods of Florida and Neighboring Land Areas 15: 1–93.

Thomas M.C., Nearns E.H. 2008 A new genus of telephanine Silvanidae (Coleoptera: Cucujoidea), with a diagnosis of the tribe and key to genera. Insecta Mundi 48: 1–14.

Yoshida T., Halstead D.G.H., Hirowatari T. 2019 Discovery of the genus *Airaphilus* (Coleoptera: Silvanidae) in Japan, with a description of a potentially endangered new species. Acta Entomologica Musei Nationalis Pragae 59 (1): 211–216.

Wurst C., Lange F. 1996. *Airaphilus doramas* n. sp., ein neuer Plattkäfer von den Kanarischen Inseln (Coleoptera, Silvanidae). Mitteilungen des Entomologischen Vereins Stuttgart 31: 59–64.

Wysokinski T.W., Chapman D., Adams G., Renier M., Suortti P., Thomlinson W. 2015. Beamlines of the biomedical imaging and therapy facility at the Canadian Light Source-Part 3. Nuclear Instruments and Methods in Physics Research A 775 (1): 1–4.

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