

Passaloecus taigaensis sp. nov., a northern sibling of *Passaloecus insignis* (Vander Linden, 1829)

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A new species of *Passaloecus* Shuckard, 1837 (Hymenoptera: Pemphredonidae) is described from Fennoscandia. The species is similar to *Passaloecus insignis* (Vander Linden, 1829) with which it has been confused previously, but differs morphologically and in having a more northerly distribution. The species status is supported by DNA barcoding.

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The genus *Passaloecus* Shuckard, 1837 is a moderately large genus of the digger wasp family Pemphredonidae (formerly subfamily Pemphredoninae of Crabronidae) including more than 40 species worldwide (Fox 1892, Yasumatsu 1934b, Gussakovskij 1952, Tsuneki 1955, 1967, 1974, Merisuo 1973b, Lomholdt 1975, Bohart & Menke 1976, Vincent 1979, Ma & Li 2012, Bashiri et al. 2019, Pulawski 2021). So far, fourteen species are known to occur in the Western Palaearctic of which ten are known from Fennoscandia (Lomholdt 1975, Hellqvist et al. 2014). The existence of an 11th Fennoscandian species, *Passolecus longiceps* Merisuo, 1973, is possible (Merisuo 1973a). However, the type has been studied by the second author and it is most likely conspecific with *Passaloecus singularis* Dahlbom, 1844 (Paukkunen in prep.).

Passaloecus are generally small, quite slender black species (Fig. 1A), usually with more or less whitish marks on the scapus, the humeral tubercle

and the mandibles. The legs also usually have pale brownish markings. They are distinguished from similar genera by having two recurrent veins and three discoidal cells in the fore wing, one well developed vertical crenulate furrow anteriorly and one or two horizontal crenulate furrows on the mesopleuron, as well as an episternal sulcus. The clypeus of the female has a rather strongly projecting straight or emarginated central lobe. The labrum is often strongly protruding with a rounded central lobe. The pygidium in female is entirely absent and the male has an upwards curved, stinger-like appendage (pseudo-stinger) at the tip of the metasoma. The nest is constructed in pith-filled stems, reed, abandoned galls or preexisting cavities in dead wood such as the larval galleries of saproxylic beetles and provisioned with Aphididae or Lachnidae (Lomholdt 1975, Blösch 2000).

We here describe a new species of *Passaloecus* from Fennoscandia. *Passaloecus taigaensis* sp. nov. is closely related to *P. insignis* (Vander Linden,



Figure 1. *Passaloecus taigaensis* sp. nov. female paratypes. – A) habitus lateral view; – B) head, anterior view. Photos: Niklas Johansson.

Figur 1. *Passaloecus taigaensis* sp. nov. honor, paratyper. – A) habitus från sidan; – B) huvud framifrån. Foton: Niklas Johansson.

1829) and *P. monilicornis* Dahlbom, 1842, with which it shares features such as the presence of a single horizontal pitted furrow centrally on the mesopleuron, the lack of constriction between the first and second tergite and, in the male sex, a pair of spine-like processes posteriorly on tergum 6. The new species is especially similar to *P. insignis* and has previously been reported under that name (e.g. Nilsson 1992). It was included in the Swedish digger wasp catalogue (Hellqvist et al. 2014) as *Passaloecus* sp. Besides morphological and genetical differences, the new species differs from *P. insignis* also by its distribution and ecology. *Passaloecus taigaensis* sp. nov. occurs in boreal pine-dominated forests while *P. insignis* is predominantly found in nemoral broadleaved forests.

Material and methods

We studied high resolution pictures of the female lectotype of *Passaloecus insignis* (Vander Linden, 1829), deposited in the Royal Belgian Institute of Natural Sciences in Bruxelles and designated by Yarrow (1970), and found it to be in accordance with the current interpretation of the species and not conspecific with *P. taigaensis* sp. nov. *P. insignis* was described on a specimen collected near Bruxelles in the lowlands of Central Europe (Vander Linden 1829, p. 79). See Yarrow (1970) for a review on how *P. insignis* previously was interpreted.

The holotype female of the Nearctic *Passaloecus ithacae* Krombein, 1938 (currently considered to be a subspecies of *P. monilicornis*) housed in the Smithsonian National Museum of Natural History

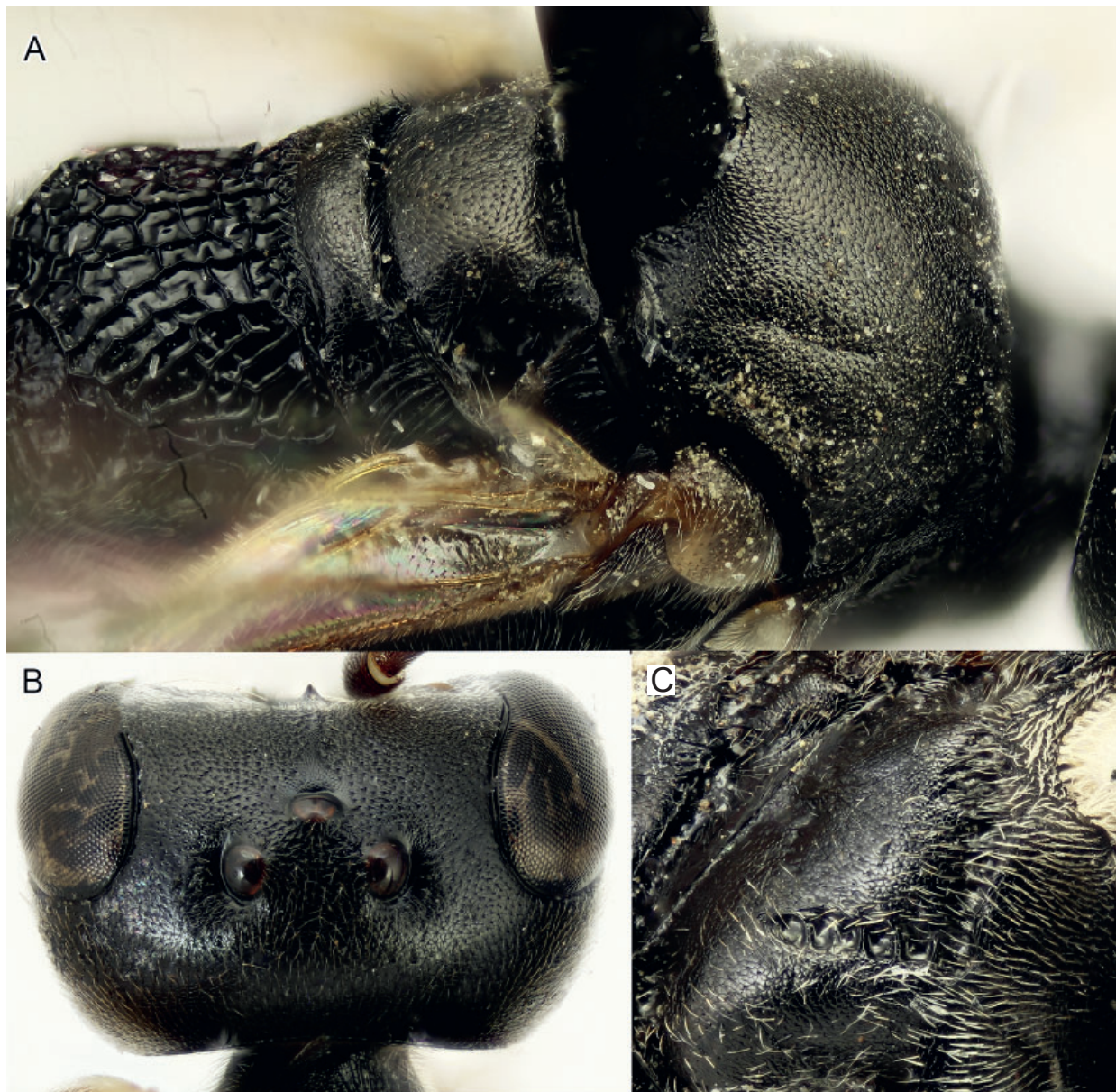


Figure 2. *Passaloecus taigaensis* **sp. nov.** female paratype. – A) mesonotum, postnotum and propodeum, laterodorsal view; – B) head, dorsal view; – C) mesopleuron, lateral view. Photos: Niklas Johansson.

Figur 2. *Passaloecus taigaensis* **sp. nov.** paratyp, hona. – A) mesonotum, postnotum och propodeum, snett från sidan; – B) huvud, ovanifrån; – C) mesopleuron från sidan. Foton: Niklas Johansson.

was studied via high resolution pictures and has the labrum black and narrower and the clypeus longer than in *P. taigaensis* **sp. nov.** We also tried to access the holotype of *Passaloecus roettgeni* C. Verhoeff, 1890 listed as a synonym of *P. insignis* in Pulawski's online catalog (Pulawski 2021), but unfortunately the specimen could not be located. The description of *P. roettgeni* was based on a single male specimen collected in Remagen (Verhoeff

1890), and since this locality is located in the lowlands of western Germany, it is very likely that *P. roettgeni* is not conspecific with *P. taigaensis* **sp. nov.** The description and illustrations of *P. shuckardi* Yasumatsu, 1934 show that this species cannot be conspecific with *P. taigaensis* **sp. nov.** due to the shape and colour of the labrum. Notably, *P. shuckardi* was synonymized with *P. monilicornis* var. *dahlbomi* Kohl, 1905 by the author himself

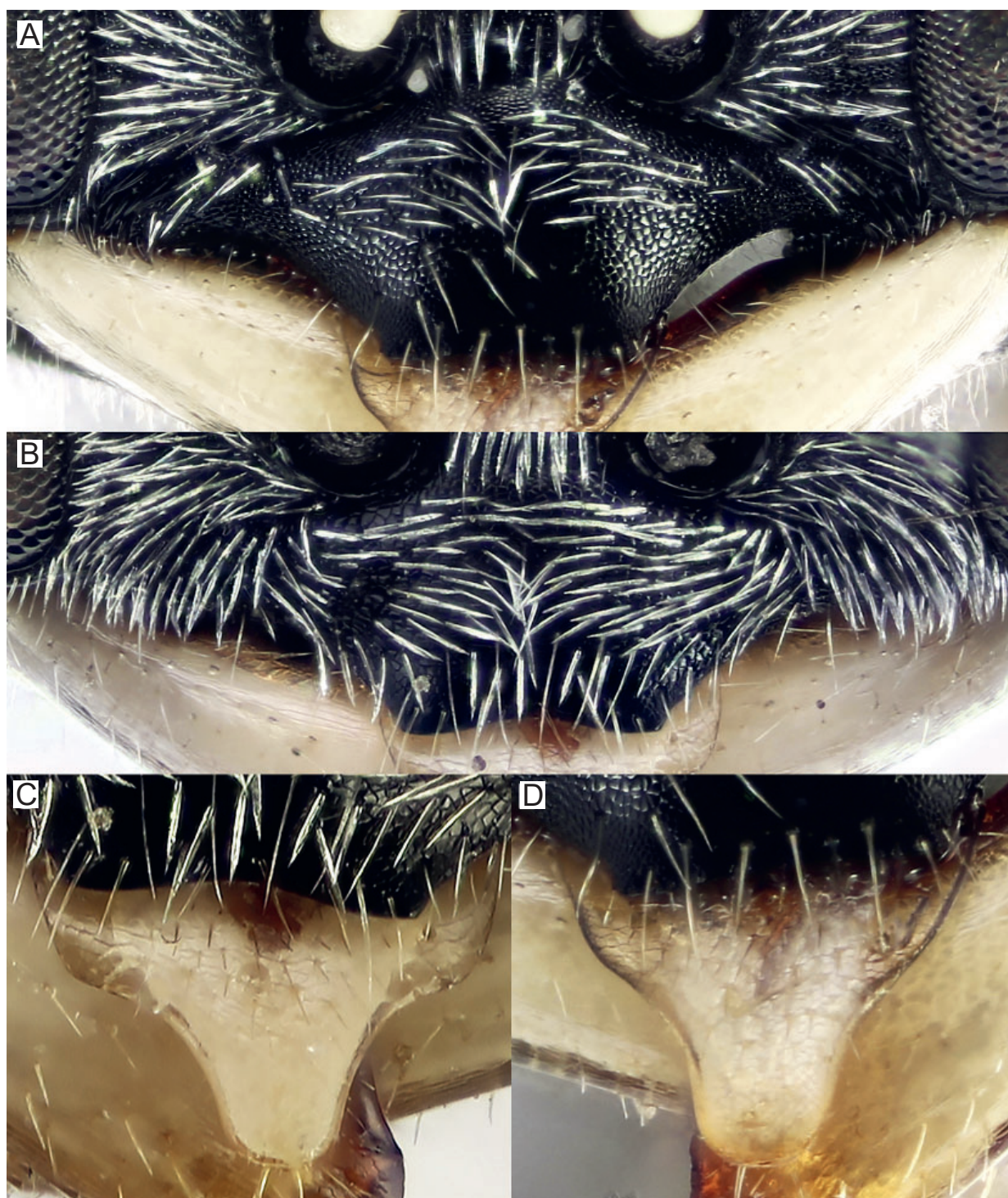


Figure 3. A–B: clypeus in female in anterior view. – A) *Passaloecus insignis* (Vander Linden, 1829); – B) *Passaloecus taigaensis* sp. nov. C–D: labrum of female in anterior view. – C) *Passaloecus taigaensis* sp. nov.; – D) *Passaloecus insignis* (Vander Linden, 1829). Photos: Niklas Johansson.

Figur 3. A–B: munsköld (clypeus) hos hona framifrån. – A) *Passaloecus insignis* (Vander Linden, 1829); – B) *Passaloecus taigaensis* sp. nov. C–D: överläpp (labrum) hos hona framifrån. – C) *Passaloecus taigaensis* sp. nov.; – D) *Passaloecus insignis* (Vander Linden, 1829). Foton: Niklas Johansson.

soon after its description (Yasumatsu 1934b). We also studied approximately 160 males and 320 females of *P. insignis* from all over Fennoscandia.

Apart from the authors' own collections, specimens from the following institutions were studied:

MZH = Finnish Museum of Natural History, Helsinki, Finland (Juho Paukkunen)

NHRS = Swedish Museum of Natural History, Stockholm, Sweden (Hege Vårdal)

MZLU = Zoological Museum, Lund University, Lund, Sweden (Christoffer Fägerström, Rune Bygebjerg)

NTNU = University Museum NTNU, Trondheim, Norway (Frode Ødegaard)

Four specimens of *P. taigaensis* **sp. nov.** and three specimens of *P. insignis* were DNA barcoded in order to study genetic divergence among these and other *Passaloecus* species. In animals, a DNA barcode is a DNA segment of 658 base pairs of the mitochondrial gene cytochrome oxidase I (COI), and is commonly used for species identification and delimitation. DNA extraction from a single mid leg, PCR amplification and sequencing of the samples were conducted at the Canadian Centre for DNA Barcoding (CCDB) using standardized high throughput protocols (Ivanova et al. 2006). The evolutionary relationships among all Fennoscandian *Passaloecus* species were studied by constructing a phylogenetic tree based on their DNA barcode sequences. Only full-length sequences from specimens of Fennoscandian origin were used for the analysis. The sequences were aligned using BOLD Aligner (Amino Acid based HMM) and the tree was built using the MEGA X program (Kumar et al. 2018). A neighbor-joining method (Kimura 2-parameter distances) was selected for tree reconstruction (Saitou & Nei 1987) and support values for the branch nodes were calculated using a bootstrap test with 1000 replicates (Felsenstein 1985). Evolutionary distances were computed using the Maximum Composite Likelihood method (Tamura et al. 2004). All ambiguous positions were removed for each sequence pair (pairwise deletion option). There were a total of 654 positions in the final dataset.

Morphological terminology follows Hymenoptera Anatomy Consortium (2021).

Pictures were taken by the first author using a Canon 6D either with a Nikon microscope objective M-Plan 10 x 0.25 or a Canon 35 mm f/2.8 Macrophoto lens mounted on a bellows. The pictures were then stacked in Zerene stacker and processed in Photoshop.

Passaloecus taigaensis **sp. nov.**

Figs 1A–B, 2A–C, 3B–C, 4A, 4C

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Holotype

SWEDEN: Lule lappmark: 1 ♀, Muddus, 66.7704°N 20.1725°E, 12 Jun.–22 Aug. 2009, pine in burned forest, R. Pettersson leg. (Specimen id: FACU-000500, GenBank ID: MW807610).

Paratypes

FINLAND (5 ♀♀ and 5 ♂♂): Regio aboensis: 1 ♀, Rymättylä, 60.38°N 21.94°E (coordinates interpreted), 3 Aug. 1968, A. Merisuo leg. (MZH: GP.43359); 1 ♀, 15. Jul. 1969, A. Merisuo leg. (MZH: GP.43231); 1 ♂, 11 Jul. 1972, A. Merisuo leg. (MZH: GP.43440); Tavastia australis: 1 ♂, Hattula, 61.06°N 24.39°E (coordinates interpreted), 21 Jul. 1974, J. Kangas leg. (MZH: GP.43378); 1 ♂, Nokia [“P.-Pirkkala”], 61.48°N 23.52°E (coordinates interpreted), 1930s, Th. Grönblom leg. (MZH: GP.43486); 1 ♂, Pälkäne, Onkkaala, Tervapirtti, 61.35°N 24.26°E (coordinates interpreted), 27 Jun. 1974, M. Viitasari leg. (MZH: GP.43484); Savonia australis: 1 ♀, Lappeenranta, Varsakallio, 61.0413°N 28.6907°E, 4 Jul.–1. Aug. 2019, by window-trap on aspen trunk, J. Vilén leg. (MZH: NK.39490); Tavastia borealis: 1 ♂, Keuruu, 62.26°N 24.71°E (coordinates interpreted), W. Hellén leg. (MZH: GP.43485); Karelia borealis: 1 ♀, Liperi, Käsämä, 62.63°N 29.32°E, 27 Jun. 2016, A. Karhu leg. (MZH: GP.98466, GenBank ID: MW807606); 1 ♀, 1 ♂, Liperi, Pärnävaara, 62.64°N 29.54°E, 2013, reared from trap nest, A. Karhu leg. (MZH: GP.110982 and GP.98467, GenBank ID: MW807611);

NORWAY: (1 ♀): Oppland: 1 ♀, Faksfall, 62.03658°N 9.16840°E, Malaise trap 23 Jun.–30 Jul. 2009, F. Ødegaard & O. Hanssen leg. (NTNU: NOSPH367).

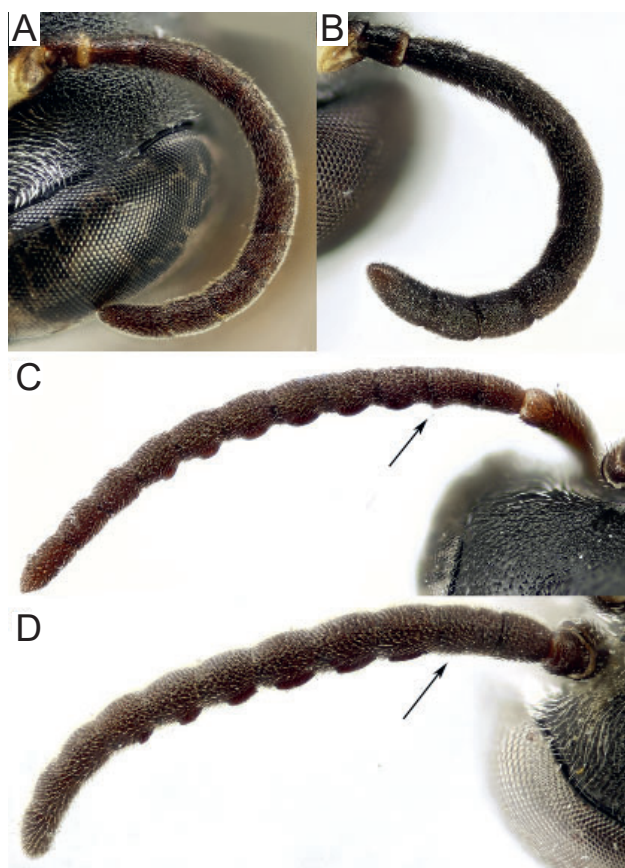


Figure 4. A–B: antenna in female, lateral view. – A) *Passaloecus taigaensis* sp. nov.; – B) *Passaloecus insignis* (Vander Linden, 1829). C–D: antenna in male, lateral view, arrows pointing at the presence/absence of a tyloid on the fourth antennal segment. – C) *Passaloecus taigaensis* sp. nov.; – D) *Passaloecus insignis* (Vander Linden, 1829). Photos: Niklas Johansson.

Figur 4. A–B: antenn hos hona från sidan: – A) *Passaloecus taigaensis* sp. nov.; – B) *Passaloecus insignis* (Vander Linden, 1829). C–D: antenn hos hane från sidan, pil pekandes på frånvaron/närvaron av tyloid på det fjärde antennsegmentet. – C) *Passaloecus taigaensis* sp. nov.; – D) *Passaloecus insignis* (Vander Linden, 1829). Foton: Niklas Johansson.

RUSSIA: (1 ♀): Republic of Karelia: 1 ♀, Petrozavodsk [“Äänislinna”], 61.78°N 34.34°E (coordinates interpreted), 1943, W. Hellén leg. (MZH: GP.43192).

SWEDEN: (17 ♀♀, 4 ♂♂): Småland: 1 ♂, Nybro, Orrefors, Hälleskog, 2012, SVEAskog M. Larshagen leg.; Dalarna: 1 ♀, Saxheden, 4 km SW Snöån, 60.0462°N 15.2937°E, 16 Aug.–13 Sep. 2012, S. Kirppu leg. (NHRS-SVHE000100806); Hälsingland: 1 ♀, Enånger, Agön, 61.5450°N 17.4200°E 19 Aug. 1998, U. Strandberg leg.,

(NHRS-SVHE000100804); 1 ♀, Hudiksvall, Hornslandet, 61.6804°N 17.4546°E, window trap in clearcut, 4 Jun.–1 Aug. 2010, SVEAskog M. Larshagen leg.; 1 ♀, 1 ♂, Ytterhogdal: Fåssjö, 62.1785°N 15.1406°E, 24 Jun.–12 Jul. 2020, S. Hellqvist leg., yellow pan trap in kettle hole in burned pine heath. (NHRS-SVHE000017086, NHRS-SVHE000017087); Medelpad: 1 ♀, Getryggen N of Lombäcken, 62.6073°N 15.6629°E, 17 Jul.–31 Aug. 2012. S. Hellqvist leg. (NHRS-SVHE000011870); Ångermanland: 1 ♀, Nordingrå, Rävsn, Dalsberget, 62.9112°N 18.4702°E, 15 May–27 Jul. 2010, window trap on birch in burned forest, Norrlands Entomologiska Förening leg.; 1 ♀, Hemsön, Porsmyrsberget, 62.6911°N 18.0596°E, 7 Jul.–4 Sep. 2015, K. Wörler leg., (NHRS-SVHE000100803); Västerbotten: 1 ♀, Tjäderberget MP: Spolberget, 64.460516°N 19.074805°E, 17 Jun.–30 Sep. 2019; window trap in rocky pine forest, M. Dynesius leg. (NHRS-SVHE000104281); 1 ♀, Umeå, Salomonsbesök, 63.9142°N 20.1411°E, 9–23 Jul. 2020., yellow pan trap in deserted sand pit in pine heath forest, S. Hellqvist leg. (NHRS-SVHE000016844); 1 ♀, Umeå, Umåker, 63.825344°N 20.170112°E, 16 Jul.–4 Aug. 2013, yellow pan trap in sand pit in pine heath, S. Hellqvist leg.; 2 ♀♀, 1 ♂, Vindeln, Åtmyrberget, 64.1805°N 19.2246°E, 4 Jun.–1 Aug., window trap, leg. SVEAskog M. Larshagen leg. (male: FACU-000498, Genbank id: MW807605; one female NHRS-SVHE000100808); Vindeln, Nyland, 64.1938°N 19.4683°E, 10 May–2 Aug. 1992, R. Pettersson leg. (NHRS-SVHE 000100805); 1 ♀, Nordmaling, Fäbodbacken N of Mullsjö, 63.7319°N 19.7643°E, 26 Jul.–1 Aug. 2009, A. N. Nilsson leg., (NHRS-SVHE000100802); 1 ♀, Nordmaling, Fäbodbacken N of Mullsjö, 63.7319°N 19.7643°E, 9–25 Aug. 2009, A. N. Nilsson leg., (FACU-000499); 1 ♂, Byske, Romelsön, W of Klubben, 64.8766°N 21.2785°E, 2003, Malaise-trap, pine forest, R. Pettersson leg.; Lycksele lappmark: Sorsele: Liksgelisen NR, 65.5991°N 17.2529°E, 16 Jun.–6 Jul. 2017, window trap in burned spruce forest, A. Garpebring leg. (NHRS-SVHE000102804); Lule lappmark: 1 ♀, Muddus, 66.7704°N 20.1725°E, 29 May–16 Aug. 2008, burned forest, R. Pettersson leg., (NHRS-SVHE000100807); 1 ♀, Messauredammen, 66.6914°N 20.3573°E, 25 Jun.–25 Jul. 1990, B. Viklund leg.

Table 1. Distinguishing characters between *Passaloecus taigaensis* **sp. nov.** and *P. insignis* (Vander Linden, 1829).Tabell 1. Särskiljande karaktärer mellan *Passaloecus taigaensis* **sp. nov.** och *P. insignis* (Vander Linden, 1829).

	<i>Passaloecus insignis</i>	<i>Passaloecus taigaensis</i>
Labrum in female	Longer, with base relatively narrow and having more converging lateral margins. Lateral corners less pronounced (Fig. 3D)	Shorter, with base relatively wide and having almost parallel-sided lateral margins. Lateral corners more angular (Fig. 3C)
Clypeus in female	Longer, about 2.8–3.0 times as wide as high (Fig. 3A)	Shorter, about 3.2 times as wide as high (Fig. 3B)
Clypeal pubescence	Sparser, with narrower setae (Fig. 3A).	Denser, with broader setae (Fig. 3B).
Colour of scapus in male	Less than ventral half white, usually with only whitish spots ventrally	At least ventral half entirely white.
Tyloidea	On segment 5–10, abruptly ending in an angle in profile (Fig. 4D)	On segment 4–11. Central tyloidea more evenly rounded (Fig. 4C)
Colour of humeral tubercle in male	Black, brown or white	White
Apical and central antennal segments in female	Stouter (Fig. 4B)	Slenderer (Fig. 4A)
Antennal segment 3 and 4 in male	Stouter, about 1.1 times as long as wide (Fig. 4D).	Slenderer, about 1.3 times as long as wide (Fig. 4C)

Type depositories

All Finnish and Russian types are housed in MZH in Helsinki, Swedish types in NHRS in Stockholm and the Norwegian type in NTNU in Trondheim.

Etymology

The specific epithet *taigaensis* is to be treated as a noun and refers to the boreal taiga as the main habitat for this species.

Diagnosis

Passaloecus taigaensis **sp. nov.** (Fig. 1A) is characterized by the single horizontal pitted furrow centrally on the mesopleuron (Fig. 2C), the shape of labrum and clypeus in the female, the lack of constriction between the first and second tergite and the distribution of the tyloidea in the male. The similar *Passaloecus monicornis* Dahlbom, 1842 has the labrum black or brown in the female and tyloidea on antennal segments 3–11 in the male. In *Passaloecus taigaensis* **sp. nov.**, the labrum in the female is transparent with a distinct white V-shaped pattern centrally and the males have tyloidea on antennal segments 4–11. It is most similar to and previously confused with *Passaloecus insignis* (Vander Linden, 1829) (Tab. 1.) from which the female is distinguished primarily by the narrower

antennae (Fig. 4A–B) and the shorter and wider labrum (Fig. 3C–D). The male is distinguished by the additional tyloidea on the fourth and eleventh antennal segments, which are lacking in *P. insignis*, and the, in profile, more evenly rounded tyloidea (Fig. 4C–D). It is noteworthy that the scapus in the male of *Passaloecus taigaensis* **sp. nov.** is entirely whitish in the ventral half or more, while in *P. insignis* the male has the pale mark more restricted, frequently only present by a whitish spot basally. In a similar fashion the humeral tubercle in the male of *P. taigaensis* **sp. nov.** is entirely white in all studied specimens, while it frequently is black or only with the hind margin narrowly white in *P. insignis*. The mesoscutum and scutellum of *P. taigaensis* **sp. nov.** usually have less distinct punctures than in *P. insignis*, but there is some overlap.

Description

Female and male

Body length 5–5.5 mm, on average slightly smaller than *Passaloecus insignis*. Head almost round in anterior view (Fig. 1B). Temples in dorsal view weakly narrowed behind compound eyes (Fig. 2B), slightly narrower in the male. Ocellar triangle strongly obtuse (Fig. 2B). The distance between lateral ocelli equal to the distance between lateral

ocellus and inner margin of compound eye. Head dorsally shagreened with quite indistinct punctures, the interstices between punctures about three times their diameter (Fig. 2B). Frons above antennae with stronger irregular microsculpture. Interantennal tubercle very short (Fig. 2B) or absent. Face with dense silvery pubescence in lower half (Fig. 1B, 3B), which is slightly denser in the male. Inner orbits converging ventrally. Clypeus about 3.2 times wider than high in anterior view, protruding in the middle with anterior margin centrally straight or weakly concave (Fig. 3B). Labrum basally wide, with the sides of the central protrusion weakly concave (Fig. 3C). Mandibles overlapping, with the edge forming an isolated apical tooth and a more irregular inner tooth. Female antennae relatively

slender with the third segment about 2.0 times as long as wide and tenth and eleventh segment about 1.5 times as long as wide (Fig. 4A). Antennal segments 4–10 in male with distinct tyloidea which are convex and evenly curved in lateral view (Fig. 4C). Additionally, segment 11 has a very small tyloid basally (Fig. 4C). Tyloidea on segment 4 and 10 ending in a more abrupt angle. Basal antennal segments in male stout, third and fourth segment about 1.3 times as long as wide (Fig. 4C). Mesoscutum, scutellum and postscutellum distinctly shagreened with quite indistinct punctures, the interstices between punctures about two times their diameter (Fig. 2A). Mesopleuron shagreened with indistinct punctures and a vertical crenulate furrow anteriorly and a single horizontal

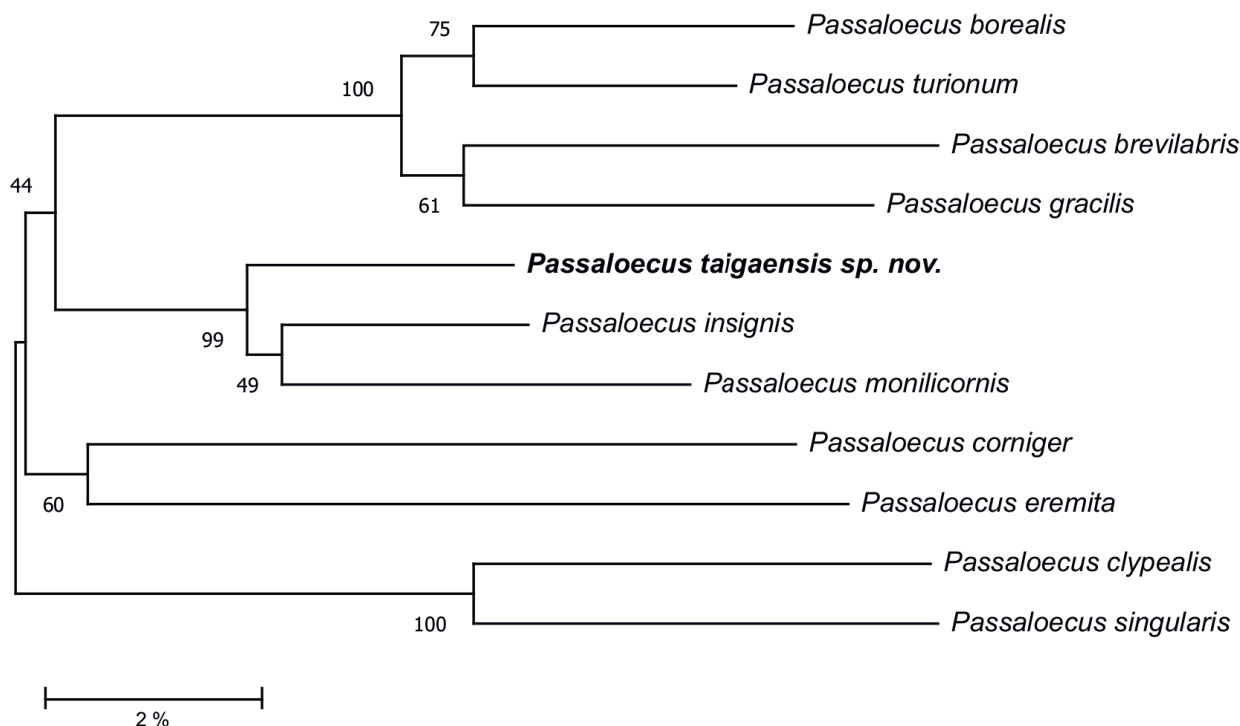


Figure 5. Evolutionary relationships among Fennoscandian species of *Passaloecus* Shuckard, 1837 according to their DNA barcodes. The neighbor-joining phylogenetic tree was constructed based on Kimura 2-parameter distances. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. All samples are from Finland, except *P. brevilabris* Wolf, 1958, *P. gracilis* (Curtis, 1834) and *P. singularis* Dahlbom, 1844, which are from Norway. The scale line indicates 2% sequence divergence.

Figur 5. Släktskap hos fennoskandiska representanter för släktet *Passaloecus* Shuckard, 1837 utifrån DNA-streckkoder. Det fylogenetiska trädet konstruerades genom att bedöma avståndet mellan Kimura-2 parametrar. Procentsatsen för replikerade fylogenetiska träd vid vilka de närbesläktade arterna klustrade tillsammans i bootstrap-testet (1000 repetitioner) visas invid respektive gren. Trädet är skalenligt angivet, med grenlängd angivet i samma enhet som de evolutionära avstånden som använts vid konstruktionen av det fylogenetiska trädet. Alla provtagna exemplar härrör från Finland, utom *P. brevilabris* Wolf, 1958 och *P. gracilis* (Curtis, 1834) och *P. singularis* Dahlbom, 1844, som kommer från Norge. Skalstreckket indikerar 2% skillnad i gensekvenser.

crenulate furrow centrally (Fig. 2C). Propodeum with low carinae, which form an irregular reticulate pattern on a polished surface (Fig. 2A). Metasoma polished with indistinct quite dense punctation or punctures. Male metasoma with a pair of spine-like processes posteriorly on tergum six.

Colouration

Body black. Mandibles, scapus ventrally, palpi and humeral tubercle whitish. Labrum in male entirely whitish yellow, in female transparent with a white V-pattern centrally. Legs black, tibiae brownish

with pale spots basally/dorsally, paler dorsally and apically. Tarsi pale brownish.

Ecology

Passaloecus taigaensis **sp. nov.** has mainly been collected by window traps during projects surveying saproxylic insects. Series of specimens have been collected by traps mounted on sun-exposed high stumps of scots pine *Pinus sylvestris* L and in single cases, Norway spruce *Picea abies* (L.) H. Karst, aspen *Populus tremula* L. and birch *Betula* sp. Several specimens have also been reared



Figure 6. Distribution of *Passaloecus taigaensis* **sp. nov.** (black dots) and *Passaloecus insignis* (Vander Linden, 1829) (grey shading) in Fennoscandia.

Figur 6. Utbredningskarta för *Passaloecus taigaensis* **sp. nov.** (svarta punkter) och *Passaloecus insignis* (Vander Linden, 1829) (grått skuggat område) i Fennoskandien.

from a trap nest constructed of reed stems and placed on a scots pine trunk. These observations indicate that the nest is constructed in abandoned larval galleries of saproxylic beetles. Most records are from sun-exposed habitats dominated by scots pine, such as burned forests, open, semi-open or sunny pine forests on rocky grounds, margins of gravel pits and sandy light pine heaths. The period of flight is between mid-June to mid-August.

DNA barcode

The full DNA barcode sequences of two Swedish and two Finnish specimens of *P. taigaensis* **sp. nov.** and two Swedish and one Finnish specimen of *P. insignis* are available at GenBank (accession numbers: MW807605, MW807606, MW807607, MW807608, MW807609, MW807610, MW807611). With a minimum between-species distance of 4.58% (Kimura 2 parameter distance model), *P. insignis* was found to have the most similar DNA barcode of all *Passaloecus* species with *P. taigaensis* **sp. nov.** (Fig. 5). *P. monilicornis* is also closely related, since the barcodes of *P. insignis* and *P. monilicornis* are more similar to each other than any of them are with *P. taigaensis*. Additionally, an unidentified Nearctic *Passaloecus* species, was observed to have a nearly similar distance as *P. insignis* (ca 5%). These large divergences indicate a long evolutionary differentiation of *P. taigaensis* **sp. nov.** from other congeneric species. The two DNA barcoded Swedish specimens belonged to the same haplotype, whereas the two Finnish specimens belonged to two different haplotypes, both distinct from the Swedish haplotype. All haplotypes were assigned to the barcode index number (BIN) BOLD:ACG7336 due to small intraspecific variation (maximum within-species distance of 0.32%). All DNA barcodes of the most similar species, *Passaloecus insignis*, were included in the BIN BOLD:AAM3639.

Distribution

So far *P. taigaensis* **sp. nov.** is known from Finland, Norway, Russia and Sweden (Fig. 6). Compared to *P. insignis*, the new species has a more northerly distribution and only a slight overlap in their ranges is noticeable. A notable exception is a record from Nybro municipality in Småland in the southern Swedish highlands. This is a small area which houses a discrete occurrence of

another more northerly aculeate species, *Anoplius tenuicornis* (Tournier, 1889). This may indicate that *Passaloecus taigaensis* **sp. nov.** also occurs in high altitude areas of Central Europe.

Discussion

The digger wasp fauna of Fennoscandia and northwestern Europe is generally considered to be very well known and the discovery of a hitherto unknown species was therefore quite surprising. Apparently, the morphological similarities with *Passaloecus insignis* has allowed the species to remain undescribed. On the other hand, several digger wasps with their main distribution in boreal taiga forests, such as *Crossocerus lundbladi* Kjellander, 1954, *Pemphredon fennica* Merisuo, 1972 and *Nitela borealis* Valkeila, 1974 have been discovered and described quite recently, indicating that the vast taiga may still harbor undescribed species. It is noteworthy that all Swedish and Norwegian specimens of *P. taigaensis* **sp. nov.** have been found after 1990, while a vast majority of the Finnish and Russian specimens were found before 1990. Probably this is primarily an artefact due to historical differences in collecting activities in boreal forests in Western and Eastern Fennoscandia.

The numerous records from traps mounted on sun-exposed high stumps indicate that *Passaloecus taigaensis* **sp. nov.**, along with other wood-nesting aculeates, benefit from the nature conservation measure where artificial high stumps are left on clear-cuts. These high stumps mimic an important substrate, which naturally occurs in areas where the taiga forests are formed by natural disturbances such as forest fires and storms, which create semi-open forests with an abundance of dead wood. However, as most of the timber is removed at one occasion by the clear cutting method, the continuous accumulation of dead wood, significant of natural and semi-natural forests, is interrupted and the clear cuts soon turn into dense, shady plantations. Today the natural and semi-natural taiga forests and their inhabitants are facing a two way threat. The lack of forest fires and natural disturbance regimes, suppressed by modern forestry on one hand, and the intensified forestry practices, officially motivated by actions on tackling climate change, on the other.

The known records indicate that *Passaloecus taigaensis* **sp. nov.** is able to maintain viable

populations in Sweden and Finland and that the emphasis towards valuable natural forests in Sweden is most likely a result of a more intense collecting effort targeting these forest types compared to conventional commercial forests. However, the biology of the species is still poorly known and more data needs to be collected before any definitive conclusion regarding the conservation status of the species is made. Recently, *Passaloecus taigaensis* sp. nov. met the criteria for vulnerable (VU) on a preliminary assessment of the red-list in Norway (as *Passaloecus* n. sp.), indicating that the species conservation status in Norway is regarded as unfavourable.

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Sammanfattning

En ny art inom rovkälsläktet *Passaloecus* Shuckard, 1837, *P. taigaensis* sp. nov., beskrivs utifrån material insamlat i Fennoskandien. Arten är till det yttre snarlik, och har tidigare sammanblandats med den i södra Sverige utbredda *P. insignis* (Vander Linden, 1829). Utbredningen är företrädesvis nordlig och utbredningsområdet förefaller endast i mycket liten omfattning överlappa det för *P. insignis*. Den nya artens habitat utgörs av ljusöppna boreala tallskogar och arten anlägger sannolikt framför allt sitt bo i övergivna larvgångar av vedlevande skalbaggar på solbelysta högstubbar. *Passaloecus taigaensis* sp. nov. stöds av DNA-barcoding.