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Photo
The cover picture shows habitus of *Ampedus cardinalis* (Schiødte, 1865) and *Ampedus elegantulus* (Schönherr, 1817) captured in the Geneva basin. See paper of **Blanc M, Breitenmoser S, Rochet C** Liste commentée des Cerophytidae, Elateridae, Eucnemidae et Throscidae du bassin genevois (Coleoptera).

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Alpine Entomology

The Psyllinae (Hemiptera, Psyllidae) from Gunung Kinabalu (Malaysia, Sabah)

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Abstract

Five species of Psyllinae are recognised from Gunung Kinabalu, all previously unknown, and are formally described and named: *Cacopsylla graciliforceps* **sp. nov.**, *C. kinabaluensis* **sp. nov.**, *C. myrsines* **sp. nov.**, *C. photiniae* **sp. nov.** and *Psylla cirrita* **sp. nov.** Another species similar to *P. cirrita* remains undescribed due to lack of sufficient material. Two Philippine species closely related to *C. kinabaluensis* are transferred to *Cacopsylla* as *Cacopsylla aranetae* (Miyatake, 1972), **comb. nov.** and *Cacopsylla bakeri* (Crawford, 1919), **comb. nov.** (both from *Psylla*). Three of the *Cacopsylla* species probably represent Palaearctic faunal elements (*Cacopsylla graciliforceps*, *C. myrsines* and *C. photiniae*). Host information is available only for *Cacopsylla myrsines* and *C. photiniae*, viz. *Myrsine dasyphylla* (Primulaceae) and *Photinia davidiana* (Rosaceae), respectively. *Myrsine* has not been previously reported as host genus of Psylloidea. The five new species bring the number of known Psylloidea species from Gunung Kinabalu to 22. The biogeographic relationships found in the flora, i.e. Oriental elements predominate at lower altitudes, and Himalayan and Australian elements are dominant at altitudes above 2500 m, are reflected in the psyllid fauna (Oriental 4 spp.; Australian 13 spp., Himalayan 3 spp.; unknown 2 spp.). Of the 22 species known from Gunung Kinabalu, 18 are only known from there. This high number is probably only partly due to endemism and is partly due to insufficient knowledge of the psyllid fauna of Borneo and of the tropics in general.

Key Words

Sternorrhyncha, Psylloidea, *Cacopsylla*, *Psylla*, systematics, phytophagy, distribution

Introduction

Psyllids (Psylloidea) constitute a superfamily of plant lice (Sternorrhyncha) characterised by their usually narrow host ranges within the eudicots, magnoliids and, exceptionally, monocots and conifers (Burckhardt et al. 2014; Ouvrard et al. 2015). Unlike the related aphids, adult psyllids, which are always winged, can survive for extended periods without feeding, allowing them to find and successfully colonise even rare hosts (Taylor and Moir 2009; Zhang et al. 2019). This may be one of the reasons why psyllids are most species-rich in the tropics and the southern hemisphere (Burckhardt et al. 2021), rather than in the northern temperate zones where aphids predominate (Dixon et al. 1987). Currently, just over 4000 species of psyllids have been described worldwide, but based on undescribed material available in museum collections, this is likely to be less than half of the species that actually exist (Burckhardt and Queiroz 2020). While the psyllid fauna of the temperate northern hemisphere, in particular the Palaearctic region, is reasonably well known, that of the tropics is not, and current ideas about host and distributional patterns of psyllids may change with a better knowledge on the tropical faunas.

Gunung Kinabalu in Borneo (Sabah, Malaysia), is well known for its high plant diversity rich in endemics.

With almost 4100 m altitude, it is the highest mountain between the Himalayas and Mount Wilhelm in New Guinea. While its flora below 2500 m, most of which has been destroyed by human activities, is composed mostly of Oriental elements, that above 2500 m shares taxa with the Himalayas (e.g. Ericaceae) and Australia (e.g. Myrtaceae) (Cockburn 1978; Corner 1978; Beaman and Beaman 1990). These relationships seem to be reflected by the psyllid fauna of which 17 species have been reported. The Oriental genus *Paurocephala* Crawford, 1913 is represented by four species found at altitudes between 500–1850 m, developing on species of *Pterospermum* (Malvaceae), *Artocarpus* and *Ficus* (Moraceae) (Mifsud and Burckhardt 2002; Burckhardt et al. 2023). The other 13 species, representing the Australian faunal element, are associated with Myrtaceae and are members of the subfamily Spondyliaspidinae (Aphalaridae): *Boreioglycaspis* Moore, 1964 (7 spp. on *Syzygium* and *Tristaniopsis*) at altitudes from 1460–2700 m and *Ctenarytaina* Ferris & Klyver, 1932 (6 spp. on *Leptostermum* and *Syzygium*) at altitudes from 1700–3300 m (Burckhardt 1991; Burckhardt et al. 2020; Burckhardt 2021). So far, no psyllids with close relatives in the Himalayas have been reported from Gunung Kinabalu.

Here, species of Psyllinae (Psyllidae) collected on Gunung Kinabalu are described and their phylogenetic and biogeographic relationships are discussed. They belong to the predominantly north temperate genera *Cacopsylla* Ossiannilsson, 1970 and *Psylla* Geoffroy, 1762. The former is with over 450 species one of the largest psyllid genera (Ouvrard 2023) and is probably monophyletic apart from a few ill-placed species (Percy et al. 2018). The majority of the species develop on Elaeagnaceae, Rhamnaceae and Rosaceae (Rosales), Ericaceae (Ericales) and Salicaceae (Malpighiales). *Psylla* was redefined by Burckhardt et al. (2021) to include 24 species associated with Betulaceae. Prior to this narrow concept, the genus was used to include many unrelated species of Psyllidae that could not be assigned to other genera (Li 2011).

Material and methods

Material is deposited in the following institutions: **MHNG**–Muséum d'histoire naturelle, Genève, Switzerland; **NCHU**–National Chung Hsing University, Taiwan; **NHMB**–Naturhistorisches Museum, Basel, Switzerland. The morphological terminology follows Bastin et al. (2023). Measurements were taken as follows: adult body length from dry mounted specimens measuring the distance between fore margin of head and tip of forewings when folded over body; the other measurements were taken from slide mounted (*Cacopsylla*) or dry mounted (*Psylla*) specimens. The measurements and ratios are given as range. The psyllid nomenclature follows Ouvrard (2023) and the classification Burckhardt et al. (2021). The plant nomenclature accords with POWO (2023).

Results

Taxonomy

Cacopsylla graciliforceps sp. nov.

https://zoobank.org/FC470759-154A-417B-AE8F-F652BBF682B2

Figs 1, 2, 9, 13–15, 25–28

Type locality. Malaysia, Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail, Panar Laban, 6.0594°N, 116.5665°E, 3300 m.

Material examined. *Holotype*. Malaysia • ♂; Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m, 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8759; moss forest with Ericaceae and Myrtaceae, on *Vaccinium* (Ericaceae); MHNG, dry. ***Paratypes*.** Malaysia • 1 ♀; Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail; 6.0475°N, 116.5620°E; 2830 m, 29.iv.1982; D. Burckhardt leg.; #F8274; *Leptospermum* forest; MHNG, dry. • 5 ♂, 5 ♀; same data but summit trail; 6.0578°N, 116.5662°E; 3230 m, 29.iv.1982; D. Burckhardt leg.; #F8277; *Leptospermum* forest, on *Leptospermum* (Myrtaceae); MHNG, NCHU, NHMB, dry. • 2 ♂; same data but summit trail; 6.0578°N, 116.5662°E; 3230 m, 29.iv.1982; D. Burckhardt leg.; #F8279; *Leptospermum* forest, on *Myrsine dasyphylla* (Primulaceae); MHNG, dry. • 6 ♂, 3 ♀; same data but summit trail; 6.0578°N, 116.5662°E; 3230 m, 29.iv.1982; D. Burckhardt leg.; #F8280; *Leptospermum* forest, on *Vaccinium coriaceum* (Ericaceae); MHNG, dry. • 1 ♂, 5 ♀; same data but summit trail; 6.0578°N, 116.5662°E; 3230 m, 29.iv.1982; D. Burckhardt leg.; #F8286; *Leptospermum* forest, Common trap; MHNG, dry. • 1 ♀; same data but summit trail near Lyang Lyang; 6.0430°N, 116.5591°E; 2620 m, 2.v.1987; D. Burckhardt and I. Löbl leg.; #F8751; open *Podocarpus*/*Leptospermum* forest; MHNG, dry. • 2 ♂, 8 ♀; same data but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m, 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8756; moss forest with Ericaceae and Myrtaceae, on *Leptospermum recurvum* (Myrtaceae); MHNG, dry. • 1 ♀; same data but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m, 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8757; moss forest with Ericaceae and Myrtaceae, on *Myrica javanica* (Myricaceae); MHNG, dry. • 15 ♂, 14 ♀; same data as holotype but MHNG, NHMB, dry, slide. • 4 ♂; same data but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m, 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8761; moss forest with Ericaceae and Myrtaceae, on *Styphelia* sp. (Ericaceae); MHNG, dry. • 1 ♂, 4 ♀; same data but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m, 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8762; moss forest with Ericaceae and Myrtaceae, on *Rhododendron* sp. (Ericaceae); MHNG, dry. • 3 ♂; same data but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m, 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8764; moss forest with Ericaceae and Myrtaceae, on *Rhododendron* sp. (Ericaceae); MHNG, dry. • 2 ♂, 8 ♀; same data but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m, 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8765; moss forest with Ericaceae and Myrtaceae, on *Rhododendron rugosum* (Ericaceae); MHNG, dry. • 1 ♂; same data but headquarters; 1500 m, 8–16.v.1987; A. Smetana leg.; interception trap; MHNG, dry. • 14 ♂, 8 ♀; same data but below Laban Rata; 3155 m, 5.v.1987; A. Smetana leg.; MHNG, dry. • 8 ♂, 4 ♀; same data but Laban Rata; 3200 m, 9–20.v.1987; A. Smetana leg.; interception trap; MHNG, NHMB, dry, slide. • 5 ♂, 11 ♀; same data but Laban Rata; 3200 m, 4–8.v.1987; A. Smetana leg.; interception trap; MHNG, dry. • 2 ♂; same data but base of St. John's Peak; 3450–4000 m, 20.v.1987; A. Smetana leg.; MHNG, dry.

Diagnosis. Adult. Vertex 0.5 times as long as wide; genal processes 1.0–1.1 times as long as vertex along midline, slender, in basal third strongly, in apical two thirds weakly tapering to apex which is obliquely truncate or irregularly rounded, distinctly separated in the middle. Antenna 1.6–1.7 times as long as head width; relative length of flagellar segments as 1.0 : 0.7 : 0.6 : 0.6 : 0.5 : 0.5 : 0.2 : 0.3. Metatibia bearing small genual spine. Forewing oblong oval, widest in apical third, 3.4–3.8 times as long as head width, 2.3–2.5 times as long as broad; pterostigma moderately long, irregularly narrowing to apex, ending level with bifurcation of vein M; vein Rs weakly sinuous; m_1 cell value 2.1–2.4, cu_1 cell value 2.0–2.5; surface spinules present in all cells, relatively evenly spaced, forming irregular rhombs or squares; leaving broad spinule-free stripes along veins, absent from basal half of cell r_2; fields of surface spinules of marginal cells evenly widening to wing margin. Male proctiger tubular, weakly curved, 0.5–0.6 times as long as head width. Subgenital plate, in lateral view, subglobular, with relatively straight dorsal margin; sparsely beset with long setae in distal half. Paramere shorter than proctiger, in lateral view, digitiform, almost straight. Distal segment of aedeagus with lens-shaped apical dilation. Female proctiger 1.3–1.4 times as long as head width; dorsal margin slightly sinuous, irregularly narrowing to pointed apex. Female subgenital plate 0.5–0.6 times as long as proctiger, in lateral view, irregularly narrowing to pointed apex.

Description. Adult. ***Colouration.*** General body colour dark brown to almost black (Fig. 1). Head (Fig. 2) ochreous; vertex white along posterior margin medially and along base of coronal suture, each half with triangular dark brown patch. Antennal segments 1 and 2 light reddish brown, segments 3–8 yellow with dark apex becoming more extended from segment 3 to 8, segments 8 and 9 dark brown or black. Pronotum white in the middle and with two lateral white dots on either side. Mesopraescutum black with orange pattern consisting of a narrow, longitudinal orange line in the middle, a transverse band at the base and each a lateral patch on either side; lateral and posterior edges each with a white spot on either side. Mesoscutum with light brown longitudinal stripes. Legs yellow; profemora partly, and meso- and metafemora entirely dark brown. Forewing (Fig. 9) membrane transparent, almost colourless; veins ochreous to brown, becoming darker towards apex; apex of clavus brown. Younger specimens with more extended ochreous and brown colour.

Structure. Conforming to the generic description of Ossiannilsson (1992). Body length ♂ 2.8–3.1 mm, ♀ 2.9–3.4 mm (10 ♂, 10 ♀). Head deflexed 45° from longitudinal body axis (Fig. 1); slightly narrower than mesoscutum. Vertex rhomboidal, 0.5 times as long as wide, weakly concave at base, bearing short sparse setae and imbricate microsculpture; preocular sclerite not developed; genal processes 1.0–1.1 times as long as vertex along midline, slender, in basal third strongly, in apical two thirds weakly tapering to apex which is obliquely truncate or irregularly rounded, distinctly separated in the middle, evenly beset with sparse long setae, those along lateral margin near apex slightly longer than the others (Fig. 2); eyes hemispherical. Rostrum 0.4–0.5 times as long as head width, in lateral view mostly hidden by mesosternum and only apical segment visible. Antenna 1.6–1.7 times as long as head width; relative length of flagellar segments as 1.0 : 0.7 : 0.6 : 0.6 : 0.5 : 0.5 : 0.2 : 0.3; antennal segment 3 longest; relative length of segment 10 and terminal antennal setae as 1.0 : 1.6 : 1.4. Metatibia 0.7–0.8 times as long as head width, bearing small genual spine, weakly widening to apex, with 1+3+1 apical spurs. Forewing (Fig. 9) oblong oval, widest in apical third, 3.4–3.8 times as long as head width, 2.3–2.5 times as long as broad, costal margin irregularly curved, relatively evenly rounded apically; pterostigma moderately long, at base narrower than adjacent part of cell r_1, irregularly narrowing to apex, ending level with bifurcation of vein M; vein C+Sc weakly, relatively evenly curved; vein M+Cu longer than half length of R; vein Rs weakly sinuous; m_1 cell value 2.1–2.4, cu_1 cell value 2.0–2.5; surface spinules present in all cells, relatively evenly spaced, forming irregular rhombs or squares; leaving broad spinule-free stripes along veins, absent from basal half of cell r_2; fields of surface spinules of marginal cells evenly widening to wing margin.

Male terminalia as in Figs 13–15. Proctiger tubular, weakly curved, 0.5–0.6 times as long as head width; beset with long, dense setae in apical two thirds. Subgenital plate, in lateral view, subglobular, with relatively straight dorsal margin; sparsely beset with long setae in distal half. Paramere shorter than proctiger, in lateral view, digitiform, almost straight; weakly, slightly irregularly narrowing to rounded apex; apex, in dorsal view, with sclerotised toothlet pointing antero-mediad; in caudal view curved; outer face relatively evenly beset with moderately long setae; inner face densely beset with long bristles, denser basally along posterior margin. Aedeagus long and slender; distal segment of aedeagus slender in basal three quarters, lens-shaped in apical quarter; sclerotised end tube of ductus ejaculatorius short, weakly curved. – Female terminalia as in Figs 25–28. Proctiger 1.3–1.4 times as long as head width, 4.8–5.0 times as long as circumanal ring which consists of two unequal rows of pores; dorsal margin slightly sinuous, irregularly narrowing to pointed apex; sparsely beset with short setae in basal half and with

Figures 1–8. *Cacopsylla* spp. **1, 3, 5, 7.** Habitus, in lateral view; **2, 4, 6, 8.** Head, in dorsal view; **1, 2.** *C. graciliforceps*; **3, 4.** *C. kinabaluensis*; **5, 6.** *C. myrsines*; **7, 8.** *C. photiniae*.

a submedian longitudinal row of moderately long setae and a lateral band of peg setae on either side in apical half. Subgenital plate 0.5–0.6 times as long as proctiger, in lateral view, irregularly narrowing to pointed apex; apical three quarters beset with short setae laterally and long setae ventrally. Dorsal and ventral valvulae weakly curved; lateral valvula narrowly rounded apically.

Measurements in mm (3 ♂, 3 ♀). Head width 0.68–0.74; antenna length 1.12–1.24; forewing length 2.34–2.76; length of male proctiger 0.36–0.38; paramere length 0.28–0.30; length of distal segment of aedeagus 0.24–0.26; female proctiger length 0.96–1.00.

Fifth instar immature unknown.

Etymology. From Latin gracilis = slender, thin, slim and forceps = pair of tongs, pincers, referring to the slender parameres.

Distribution. Malaysia: Sabah, Gunung Kinabalu, at altitudes between 2600 m and 4000 m. The single male found in a trap at 1500 m was probably blown there by the wind.

Host plant, biology and habitat. Unknown. Almost half of the adults were collected on species of Ericaceae (*Rhododendron*, *Styphelia* and *Vaccinium*) which are likely hosts. The species was found in *Leptospermum* and open *Podocarpus*/*Leptospermum* forests as well as in moss forest with Ericaceae and Myrtaceae.

Comments. *Cacopsylla graciliforceps* resembles 11 Palaearctic *Cacopsylla* species associated with Ericaceae in the antennae shorter than twice head width, the forewing with a weakly curved costal margin and fields of surface spinules widening towards the wing margin, as well as in the slender, simple paramere. It differs from *Cacopsylla borealis* Nokkala & Nokkala, 2019, *C. fraudatrix* Labina & Kuznetsova, 2012, *C. lapponica* Nokkala & Nokkala, 2019, *C. ledi* (Flor, 1861), *C. myrtilli* (Wagner, 1947), *C. rhododendri* (Puton, 1871) and *C. vaccinii* (Miyatake, 1964) in the much longer female terminalia, and from *C. fengqingica* Li, 2011, *C. lyoniae* Li, 2011, *C. nigriantennata* (Kuwayama, 1908) and *C. pieridis* (Li & Yang, 1987) in the straight, digitiform paramere with subparallel margins in lateral view (versus slightly sinuate and irregularly narrowing in the first three species and slightly sinuous and lamellar in the last species).

Cacopsylla kinabaluensis sp. nov.

https://zoobank.org/1D1952C5-58BD-4031-8803-CDBCF930A7BE

Figs 3, 4, 10, 16–18, 29–31

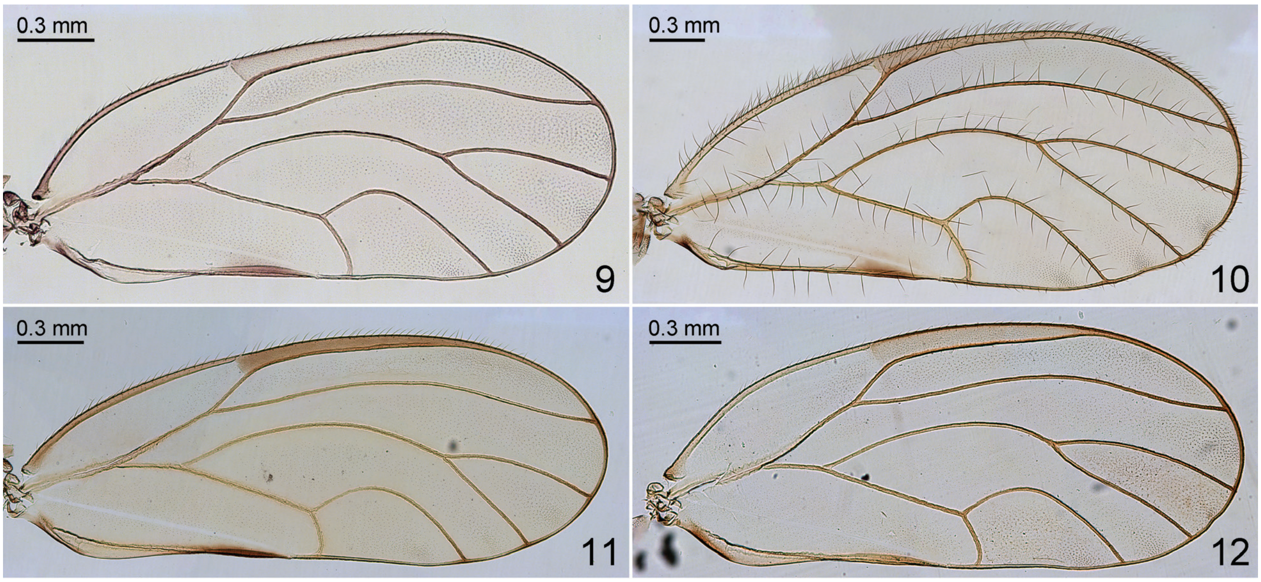
Type locality. Malaysia, Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail below Layang Layang, 6.0439°N, 116.5602°E, 2640 m.

Material examined. ***Holotype.*** Malaysia • ♂; Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail below Layang Layang; 6.0439°N, 116.5602°E; 2640 m; 1.v.1987; D. Burckhardt and I. Löbl leg.; #F8740; moss forest; MHNG, dry. ***Paratypes.*** Malaysia • 1 ♂, 1 ♀; same but summit trail; 6.0416°N, 116.5565°E; 2620 m; 29.iv.1982; D. Burckhardt leg.; #F8285; moss forest; MHNG, dry. • 2 ♂; same but summit trail below Layang Layang; 6.0419°N, 116.5578°E; 2560 m; 1.v.1987; D. Burckhardt and I. Löbl leg.; #F8735; moss forest, on *Syzygium* sp. (Myrtaceae); MHNG, dry. • 10 ♂, 3 ♀; same as holotype; MHNG, NHMB, dry, slide. • 1 ♂; same but below Layang Layang; 2600 m; 28.v.1987; A. Smetana leg.; MHNG, dry.

Diagnosis. Adult. Vertex 0.3–0.4 times as long as wide; genal processes 1.9 times as long as vertex along midline, slender, tubular, widely separated in the middle. Antenna 3.4–3.6 times as long as head width; relative length of flagellar segments as 1.0 : 0.9 : 0.9 : 1.0 : 0.9 : 0.8 : 0.2 : 0.2. Metatibia lacking genual spine. Forewing widest in apical third, 3.4–3.6 times as long as head width, 2.2–2.3 times as long as broad, costal margin curved; pterostigma short, regularly narrowing to apex, ending level with bifurcation of vein M; vein Rs evenly curved, subparallel with costal margin; m_1 cell value 2.4–2.7, cu_1 cell value 2.1; veins beset with very long, conspicuous setae; surface spinules restricted to apices of cells except for cells r_1 and cu_2 where they cover the entire cell leaving broad spinule-free stripes along the veins; relatively evenly spaced forming irregular rhombs or squares, absent from basal half and from base of cell r_2; fields of surface spinules in each of the marginal cells widening to wing margin. Male proctiger narrowly tubular, weakly sinuate, 0.5 times as long as head width. Subgenital plate, in lateral view, subglobular, slightly elongate, with weakly concave dorsal margin. Paramere slightly longer than proctiger, in lateral view, narrowly digitiform, weakly sinuate; inner face with a patch of very dense thick bristles in basal third. Distal segment of aedeagus hardly inflated apically. Female proctiger 1.0 times as long as head width; dorsal margin slightly sinuous, irregularly narrowing to subacute apex. Female subgenital plate 0.6 times as long as proctiger, in lateral view, irregularly narrowing to pointed apex.

Description. Adult. *Colouration.* General body colour ochreous, mixed with white and almost black elements (Fig. 3). Head (Fig. 4) ochreous; vertex white along posterior margin in the middle and along base of coronal suture; each half of vertex with small dark brown patch; area around median ocellus black; genal processes, except for base, ochreous to red. Antennal segments 1 and 2 straw-coloured, segment 3 yellow with brown apical third, segments 4–10 dark brown or black. Pronotum almost black in anterior half and along a narrow stripe in the middle of posterior half, which is white otherwise. Mesopraescutum mostly ochreous with two semicircular patches along posterior margin on either side; the two median white patches are separated from ochreous part by a thick, curved, dark brown transverse line. Mesoscutum with dark brown longitudinal stripes. Mesoscutellum dark brown with wide white margins. Metapostnotum reddish with brown dot in the middle. Femora partly brown, meso- and metatarsi almost black. Forewing membrane transparent, colourless; veins light brown, becoming darker towards apex; apex of clavus brown. Younger specimens with more expanded light colour.

Structure. Conforming to the generic description of Ossiannilsson (1992). Body length ♂ 4.0–4.4 mm, ♀ 4.5–4.8 mm (10 ♂, 3 ♀). Head deflexed 45–90° from longitudinal body axis (Fig. 3); as wide as mesoscutum. Vertex rhomboidal, short, 0.3–0.4 times as long a wide, concave at base, bearing long setae and imbricate microsculpture; preocular sclerite narrow; genal processes 1.9 times as long as vertex along midline, slender, tubular, widely separated in the middle, evenly beset with sparse long setae (Fig. 4); eyes hemispherical. Rostrum 0.3–0.5 times as long as head width, in lateral view mostly hidden by mesosternum and only apical segment visible. Antenna 3.4–3.6 times as long as head width; relative length of flagellar segments as 1.0 : 0.9 : 0.9 : 1.0 : 0.9 : 0.8 : 0.2 : 0.2; antennal segment 3 longest; relative length of segment 10 and terminal antennal setae as 1.0 : 1.2 : 1.2. Metatibia



Figures 9–12. *Cacopsylla* spp., forewing. **9.** *C. graciliforceps*; **10.** *C. kinabaluensis*; **11.** *C. myrsines*; **12.** *C. photiniae*.

0.9 times as long as head width, lacking genual spine, weakly widening to apex, with 1+3+1 apical spurs. Forewing (Fig. 10) oval, widest in apical third, 3.4–3.6 times as long as head width, 2.2–2.3 times as long as broad, costal margin irregularly curved, relatively evenly rounded apically; pterostigma relatively short, at base narrower than adjacent part of cell r$_1$, regularly narrowing to apex, ending level with bifurcation of vein M; vein C+Sc weakly, relatively evenly curved; vein M+Cu longer than half length of R; vein Rs evenly curved, subparallel with costal margin; m$_1$ cell value 2.4–2.7, cu$_1$ cell value 2.1; veins beset with very long, conspicuous setae (Fig. 10); surface spinules restricted to apices of cells except for cells r$_1$ and cu$_2$ where they cover the entire cell leaving broad spinule-free stripes along the veins; relatively evenly spaced forming irregular rhombs or squares, absent from basal half and from base of cell r$_2$; fields of surface spinules in each of the marginal cells widening to wing margin.

Male terminalia as in Figs 16–18. Proctiger narrowly tubular, weakly sinuate, 0.5 times as long as head width; densely beset with long, setae except for base. Subgenital plate, in lateral view, subglobular, slightly elongate, with weakly concave dorsal margin; densely beset with moderately long setae except for basally and dorso-apically. Paramere slightly longer than proctiger, in lateral view, narrowly digitiform, weakly sinuate; irregularly narrowing to blunt apex; apex, in dorsal view, with sclerotised tooth pointing antero-mediad; in caudal view curved, basal half strongly expanded medially and densely beset with thick bristles; outer face beset with moderately long setae; inner face with a patch of very dense thick bristles in basal third and a few sparse bristles apically, otherwise bare except for two long setae. Aedeagus long and very slender; distal segment of aedeagus hardly inflated apically, rounded; sclerotised end tube of ductus ejaculatorius short, weakly curved. – Female terminalia as in Fig. 29–31. Proctiger 1.0 times as long as head width, 3.5 times as long as circumanal ring which consists of two unequal rows of pores; dorsal margin slightly sinuous, irregularly narrowing to subacute apex; densely beset with moderately long setae in median third and with a submedian longitudinal row of long setae and a lateral band of peg setae on either side in apical third. Subgenital plate 0.6 times as long as proctiger, in lateral view, irregularly narrowing to pointed apex; except for base beset with long setae becoming sparser towards apex and, in apical third, with lateral peg setae. Dorsal and ventral valvulae curved; lateral valvula narrowly rounded apically.

Measurements in mm (1 ♂, 1 ♀). Head width 0.98–1.06; antenna length 2.88–3.48; forewing length 3.30–3.80; length of male proctiger 0.50; paramere length 0.56; length of distal segment of aedeagus 0.40; female proctiger length 1.04.

Fifth instar immature unknown.

Etymology. Named after its provenience, the Gunung Kinabalu.

Distribution. Malaysia: Sabah, Gunung Kinabalu, at around 2600 m altitude.

Host plant, biology and habitat. Unknown. Two adults were collected on *Syzygium* sp. (Myrtaceae) which is an unlikely host. All specimens were collected in moss forest.

Comments. *Cacopsylla kinabaluensis* is morphologically similar to *Psylla aranetae* Miyatake, 1972 and *Psylla bakeri* Crawford, 1919, two species described from the Philippines without host data and based only on one and two females, respectively (Crawford 1919; Miyatake 1972). The three species share the multi-coloured body, the short vertex, the long tubular, medially widely separated genal processes, the long antennae (> twice head width), the absence of a genual spine and 1+3+1 apical spurs on the metatibiae, the oval forewings with curved costal margin and narrow, relatively short pterostigma, and the moderately long, cuneate female terminalia with apically subacute or pointed proctiger and subgenital plate. The three morphologically similar species constitute a putatively monophyletic group and are congeneric. Apart from the very long antennae and the tubular, medially widely separated genal processes the three species fit the concept of *Cacopsylla* by Ossiannilsson (1992). For this reason, the two Philippine species are transferred here to *Cacopsylla* as *Cacopsylla aranetae* (Miyatake, 1972), comb. nov. and *Cacopsylla bakeri* (Crawford, 1919), comb. nov. (both from *Psylla*). Immatures will be necessary to test this generic placement.

Cacopsylla kinabaluensis and *C. aranetae* differ from *C. bakeri* in the larger body size (forewing length > 3.3 mm versus 2.3 mm) and the longer cell m_1 (cell m_1 value > 2.0 versus < 2.0; length ratio of veins M/M_{1+2} ca. 1 versus ca. 2) (Crawford 1919). *Cacopsylla kinabaluensis* differs from *C. aranetae* in the longer genal processes (length ratio of vertex/genal processes 1.9 versus 1.3), the longer antenna (antenna length/head width ration > 2.9 versus 2.2) and the sinuate (versus slightly concave) dorsal outline, in lateral view, of the female proctiger (Miyatake 1972).

Cacopsylla myrsines sp. nov.

https://zoobank.org/9CD9AD80-6C64-41F4-82D9-4D69EB5FF86F

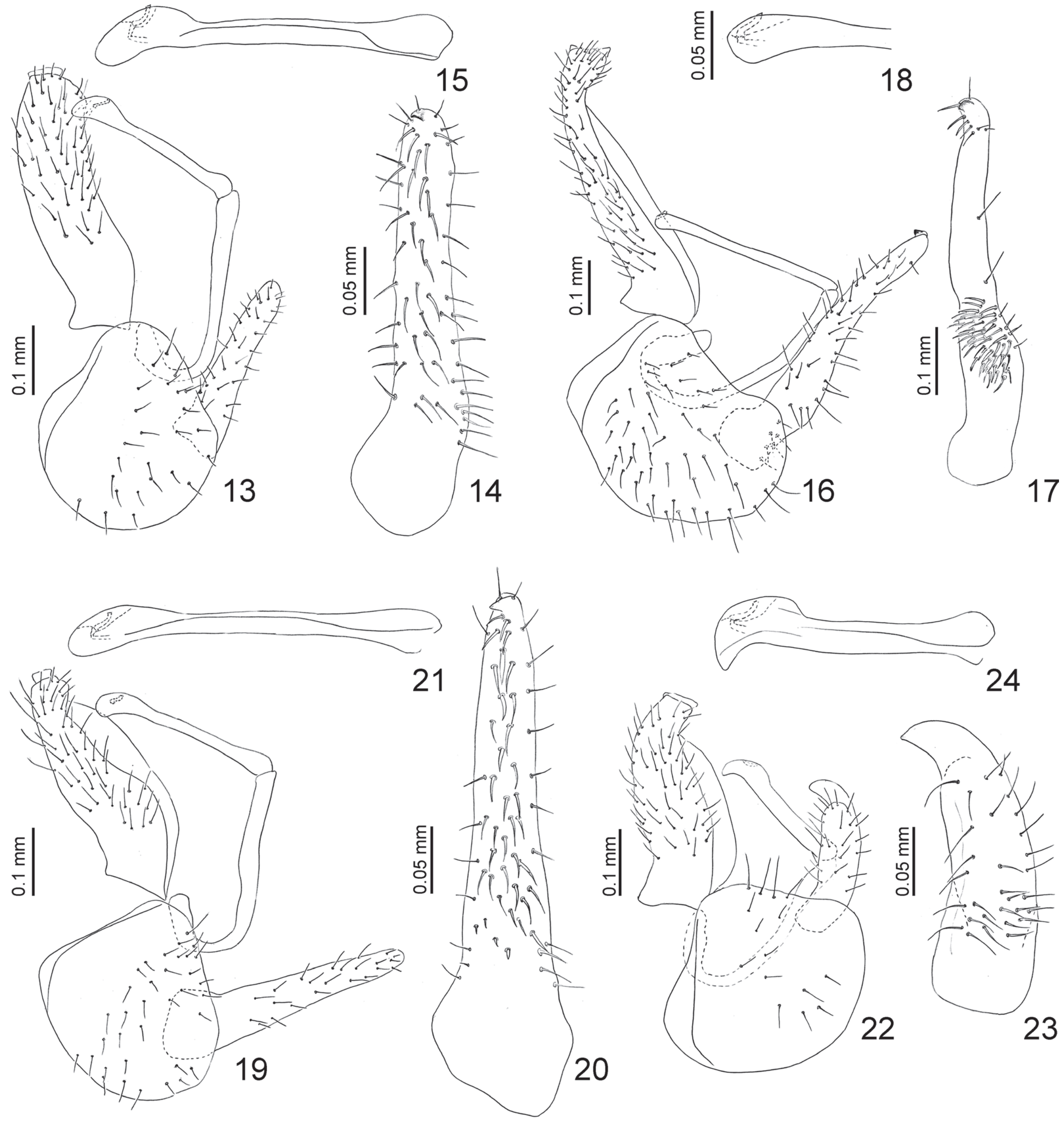
Figs 5, 6, 11, 19–21, 32, 34–36

Type locality. Malaysia, Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail, 6.0578°N, 116.5662°E, 3230 m.

Material examined. ***Holotype.*** Malaysia • ♂; Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail; 6.0578°N, 116.5662°E; 3230 m; 29.iv.1982; D. Burckhardt leg.; #F8279; *Leptospermum* forest, on *Myrsine dasyphylla* (Primulaceae); MHNG, dry. ***Paratypes.*** Malaysia • 3 ♂, 2 ♀, 2 immatures, 3 skins; Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail; 6.0449°N, 116.5604°E; 2670 m; 29.iv.1982; D. Burckhardt leg.; #F8269; *Leptospermum* forest, on *Myrsine dasyphylla* (Primulaceae); MHNG, NHMB, slide, 70% ethanol. • 24 ♂, 11 ♀, same data as holotype; MHNG, NCHU, NHMB, dry, slide. • 2 ♂; same but summit trail; 6.0449°N, 116.5604°E; 2670 m; 4.v.1982; D. Burckhardt leg.; #F82106; *Leptospermum* forest, *Myrsine dasyphylla* (Primulaceae); MHNG, dry. • 1 ♀; same but summit trail near Lyang Lyang; 6.0430°N, 116.5591°E; 2620 m; 2.v.1987; D. Burckhardt leg.; #F8744/45; open *Podocarpus*/*Leptospermum* forest; MHNG, dry. • 2 ♀; same but summit trail near Lyang Lyang; 6.0445°N, 116.5605°E; 2650 m; 2.v.1987; D. Burckhardt leg.; #F8248; open *Podocarpus*/*Leptospermum* forest; MHNG, dry. • 1 ♂, same but summit trail near Lyang Lyang; 6.0430°N, 116.5591°E; 2620 m; 2.v.1987; D. Burckhardt leg.; #F8252; open *Podocarpus*/*Leptospermum* forest; MHNG, dry.

Diagnosis. Adult. Vertex 0.5–0.6 times as long as wide; genal processes 1.0–1.3 times as long as vertex along midline, narrowly conical, separated in the middle, evenly beset with sparse long setae, apex subacute. Antenna 2.1–2.2 times as long as head width; relative length of flagellar segments as 1.0 : 0.6 : 0.6 : 0.6 : 0.6 : 0.5 : 0.3 : 0.3. Metatibia with small indistinct genual spine. Forewing oblong-oval, widest in the middle, 3.8–4.1 times as long as head width, 2.5–2.6 times as long as broad, costal margin curved; pterostigma long, irregularly narrowing to apex, with subparallel margins in the middle, ending distal to bifurcation of vein M; vein Rs evenly curved, subparallel with costal margin except for apex which is slightly curved towards costal margin of wing; m_1 cell value 1.9–2.2, cu_1 cell value 2.9–3.3; veins beset with short setae; surface spinules present in all cells, leaving broad spinule-free stripes along the veins; absent from basal three quarters of cell c+sc and basal third or half of cell r_2; fields of surface spinules in each of the marginal cells widening to wing margin; relatively evenly spaced, forming irregular rhombs or squares. Male proctiger narrowly tubular, weakly sinuate. Subgenital plate, in lateral view, subglobular, with almost straight dorsal margin. Paramere longer than proctiger, in lateral view, narrowly digitiform, almost straight; inner face with a longitudinal stripe of thick bristles except for basal quarter and sparse setae along fore and hind margin. Distal segment of aedeagus weakly inflated apically, rounded. Female proctiger 1.2–1.3 times as long as head width; dorsal margin slightly sinuous, irregularly narrowing to pointed apex. Subgenital plate 0.5 times as long as proctiger, in lateral view, irregularly narrowing to pointed apex. – Fifth instar immature. Body 1.3 times as long as wide. Antenna 1.0–1.1 times as long as forewing pad; segments 4–6 1.0 times as long as segment 7; lacking capitate setae on flagellum. Forewing pad with a single long, thick, apically pointed marginal seta apically, lacking dorsal macroscopic setae; hindwing pad with 2 long, thick, apically pointed, marginal setae subapically, lacking dorsal macroscopic setae. Caudal plate 0.6–0.7 times as long as wide; lacking marginal sectasetae, with 5+5 long and a few short and medium long marginal thick, apically pointed setae, lacking dorsal macroscopic setae. Outer circumanal ring small, its length along longitudinal body axis much larger than its distance from caudal margin of caudal plate; circular, closed anteriorly; consisting of a single row of pores.

Description. Adult. ***Colouration.*** General body colour light orange brown (Fig. 5). Head (Fig. 6) ochreous with brown patches on either side of coronal suture of vertex and yellow genal processes. Antennal segments 1 and 2 light brown, segments 3–5 yellow with brown apices, segments 6–8 dark brown with almost black apices, segments 9 and 10 almost black. Pronotum with each a lateral and sublateral dark brown dot on either side. Mesopraescutum mostly dark brown, orange-yellowish laterally. Mesoscutum with dark brown longitudinal stripes. Metapostnotum almost black, orange-yellowish laterally. Fore and mid legs and metafemora brown. Forewing membrane semitransparent, yellow to light brown; veins light brown, costal margin, pterostigma, apical margin and apex of clavus brown. Younger specimens with more expanded light colour.



Figures 13–24. *Cacopsylla* spp., male terminalia. **13, 16, 19, 22.** Male terminalia, in lateral view; **14, 17, 20, 23.** Inner face of paramere; **15, 21, 24.** Distal aedeagal segment, same scale as paramere; **18.** apex of distal aedeagal segment. **13–15.** *C. graciliforceps*; **16–18.** *C. kinabaluensis*; **19–21.** *C. myrsines*; **22–24.** *C. photiniae*.

Structure. Conforming to the generic description of Ossiannilsson (1992). Body length ♂ 3.1–3.4 mm, ♀ 3.4–3.9 mm (10 ♂, 10 ♀). Head deflexed 45–80° from longitudinal axis of body (Fig. 5); as wide as mesoscutum. Vertex (Fig. 6) rhomboidal, 0.5–0.6 times as long as wide, concave at base, bearing microscopic setae and imbricate microsculpture; preocular sclerite narrow; genal processes 1.0–1.3 times as long as vertex along mid-line, narrowly conical, separated in the middle, evenly beset with sparse long setae, apex subacute (Fig. 6); eyes hemispherical. Rostrum 0.3–0.4 times as long as head width, in lateral view mostly hidden by mesosternum and only apical segment visible. Antenna 2.1–2.2 times as long as head width; relative length of flagellar segments as 1.0 : 0.6 : 0.6 : 0.6 : 0.6 : 0.5 : 0.3 : 0.3; antennal segment 3 longest; relative length of segment 10 and terminal antennal setae as 1.0 : 0.7 : 0.9. Metatibia 0.7–0.8 times as long as head width, with small indistinct genual spine, weakly widening to apex, with 1+3+1 apical spurs. Forewing (Fig. 11) oblong-oval, widest in the middle, 3.8–4.1 times as long as head width, 2.5–2.6 times as long as broad, costal margin irregularly curved, relatively evenly rounded apically; pterostigma relatively long, at base narrower than adjacent part of cell r_1, irregularly narrowing to apex, with subparallel margins in the middle, ending distal to bifurcation of vein M; vein C+Sc weakly, relatively evenly curved; vein M+Cu longer than half length of R; vein Rs evenly curved, subparallel with costal margin except for apex which is slightly curved towards costal margin of wing; m_1 cell value 1.9–2.2, cu_1 cell value 2.9–3.3; veins beset with short setae; surface spinules present in all cells, leaving broad spinule-free stripes along the veins; absent from basal three quarters of cell c+sc and basal third or half of cell r_2; fields of surface spinules in each of the marginal cells widening to wing margin; relatively evenly spaced forming irregular rhombs or squares.

Male terminalia as in Figs 19–21. Proctiger narrowly tubular, weakly sinuate, 0.4 times as long as head width; densely beset with long setae in apical three quarters. Subgenital plate, in lateral view, subglobular, with almost straight dorsal margin; densely beset with moderately long setae along a broad transverse band stretching from dorsal margin to postero-ventral margin and a patch postero-apically. Paramere longer than proctiger, in lateral view, narrowly digitiform, almost straight; evenly narrowing to blunt apex; apex, in dorsal view, with sclerotised apex forming an inward directed, slender process which is obliquely truncate apically; parameres, in caudal view, forming narrow O; outer face beset with moderately long setae in apical two thirds; inner face with a longitudinal stripe of thick bristles except for basal quarter and sparse setae along fore and hind margin; apex forming sclerotised tooth. Aedeagus long and very slender; distal segment weakly inflated apically, rounded; sclerotised end tube of ductus ejaculatorius short, sinuate. – Female terminalia as in Fig. 32. Proctiger 1.2–1.3 times as long as head width, 3.5–3.8 times as long as circumanal ring which consists of two unequal rows of pores; dorsal margin slightly sinuous, irregularly narrowing to pointed apex; beset with moderately long setae in median third, with a submedian longitudinal row of long setae in apical half and a lateral band of peg setae on either side in apical third. Subgenital plate 0.5 times as long as proctiger, in lateral view, irregularly narrowing to pointed apex; except for base beset with long setae laterally and apically, in apical third, and with a lateral band of peg setae. Dorsal and ventral valvulae curved; lateral valvula narrowly rounded apically.

Measurements in mm (2 ♂, 2 ♀). Head width 0.70–0.76; antenna length 1.48–1.68; forewing length 2.74–3.14; length of male proctiger 0.28–0.30; paramere length 0.36–0.40; length of distal segment of aedeagus 0.28; female proctiger length 0.90–0.92.

Fifth instar immature. Colouration of ethanol preserved specimens. Dorsal sclerites brown, membranes colourless. Cephalothorax yellow anteriorly, becoming gradually darker towards rear. Antennal segments 1–3 yellow, segments 4–6 brown, segment 7 dark brown. Thoracic and basal abdominal sclerites slightly darker than wing pads and caudal plate. Legs yellow, tarsi light brown.

Structure. Conforming to the generic description of Ossiannilsson (1992). Body (Fig. 34) 1.3 times as long as wide. Antenna 7-segmented, 1.0–1.1 times as long as forewing pad; segments 4–6 1.0 times as long as segment 7; lacking capitate setae on flagellum. Thoracic tergites small. Forewing pad broad, rounded apically, with a single long, thick, apically pointed marginal seta apically, lacking dorsal macroscopic setae; hindwing pad with 2 long, thick, apically pointed, marginal setae subapically, lacking dorsal macroscopic setae. Caudal plate 0.6–0.7 times as long as wide; lacking marginal sectasetae, with 5+5 long, and a few short and medium long marginal thick, apically pointed setae (Fig. 35), lacking dorsal macroscopic setae. Outer circumanal ring (Fig. 36) small, its length along longitudinal body axis much larger than its distance from caudal margin of caudal plate; circular, complete (closed) anteriorly; consisting of a single row of narrowly oval pores.

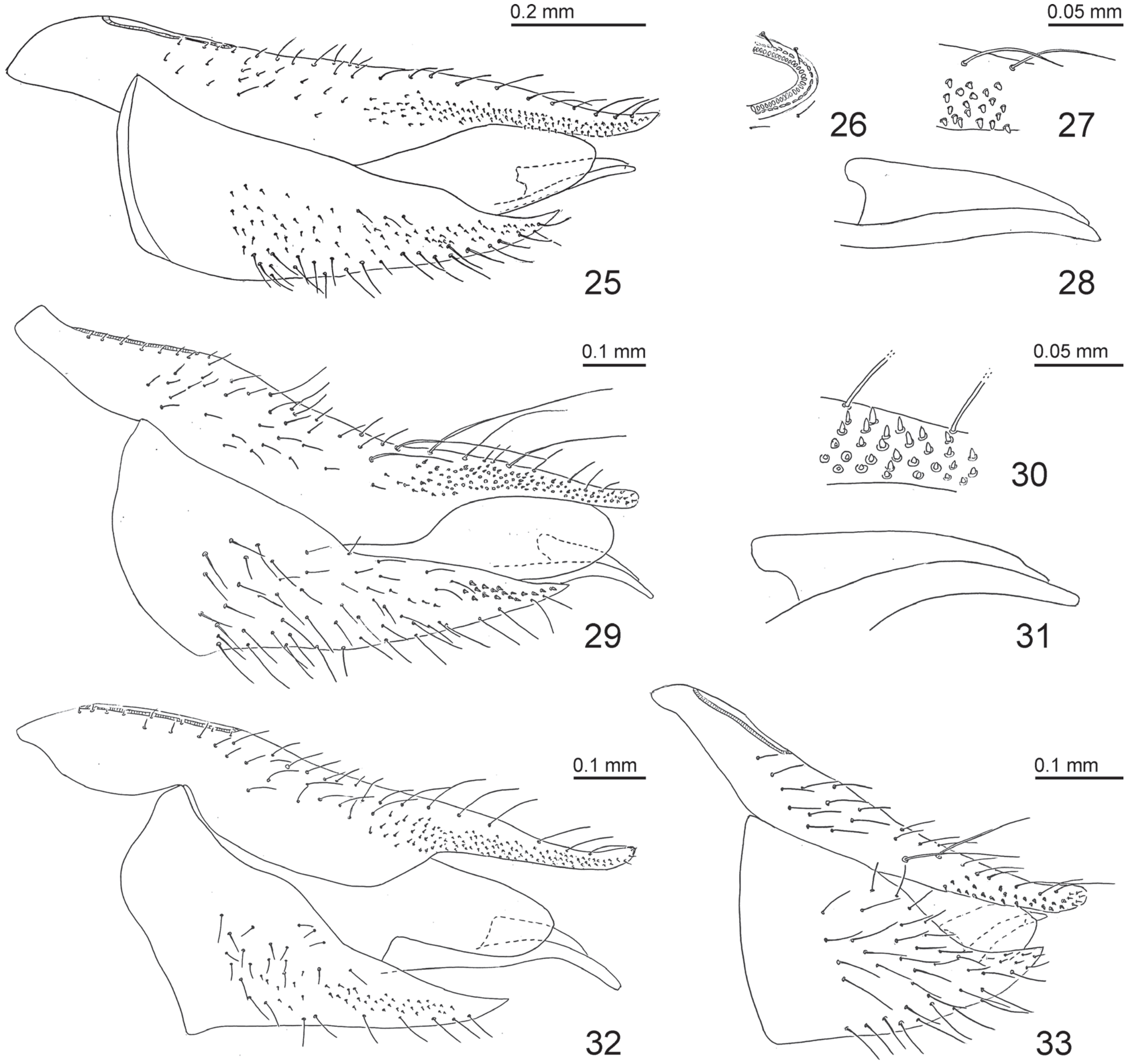
Measurements (in mm) (2 individuals). Body length 1.82–1.92; antennal length 0.80–0.84; length of forewing pad 0.78–0.80.

Etymology. Named after its host, *Myrsine*.

Distribution. Malaysia: Sabah, Gunung Kinabalu, at altitudes between 2600–3300 m.

Host plant, biology and habitat. *Myrsine dasyphylla* Stapf (Primulaceae), an endemic of Borneo (POWO 2023). *Cacopsylla myrsines* was found in *Leptospermum* and open *Podocarpus*/*Leptospermum* forests.

Comments. *Cacopsylla myrsines* shares the slender genal processes which are as long as or longer than the coronal suture, the presence of a small genual spine and 1+3+1 apical spurs on the metatibiae, the lack of a distinct dark pattern on the forewings, the simple slender paramere, and the long female proctiger with a weakly sinuate dorsal margin with following species developing on Elaeagnaceae: *Cacopsylla albiumbellatae* (Li & Yang, 1987), *C. bomihippophaes* (Li & Yang, 1988), *C. foliprominens* Li, 2005, *C. graciscapa* Li, 2005, *C. hippophaes* (Foerster, 1848), *C. jinaphippophae* Li, 2011, *C. longicornis* Li & Yang, 1992, *C. mucronulata* Li, 2011, *C. nasuta* (Horváth, 1904), *C. nigraimaculata* Li, 2011, *C. qinlingielaeagnae* Li, 2005, *C. tingriana* (Li & Yang, 1987), *C. wushanelaeagna* Li, 1997 and *C. zetterstedti* (Thomson, 1877). It differs from *C. albiumbellatae*, *C. bomihippophaes*, *C. foliprominens*, *C. graciscapa*, *C. mucronulata*, *C. qinlingielaeagnae* and *C. nigraimaculata* in the straight paramere, in lateral view (versus sinuate), from *C. hippophaes*, *C. jinaphippophae*, *C. longicornis*, *C. nasuta* and *C. zetterstedti* in the lens-shaped apical inflation of the distal segment of the aedeagus (versus hook-shaped), and from *C. tingriana* and *C. wushanelaeagna* in the relatively narrower forewings (forewing length/width ratio 2.5–2.6 versus 2.2–2.3). Immatures of *C. myrsines* differ from the species listed above, as far as their immatures are known, in the presence of thick, apically pointed (Fig. 35) rather than capitate (Fig. 38) marginal setae on the wing pads and caudal plate. Similar pointed marginal setae are also present in other *Cacopsylla* species associated with Elaeagnaceae (*C. elaeagni* (Kuwayama, 1908) or *C. fulguralis* (Kuwayama, 1908)),



Figures 25–33. *Cacopsylla* spp., female terminalia. **25, 29, 32, 33.** Female terminalia, in lateral view; **26.** Distal part of circumanal ring, in dorsal view; **27, 30.** Subapical portion of proctiger, in lateral view; **28, 31.** Dorsal and ventral valvulae. **25–28.** *C. graciliforceps*; **29–31.** *C. kinabaluensis*; **32.** *C. myrsines*; **33.** *C. photiniae*.

Araliaceae (*C. fatsiae* (Jensen, 1957), *C. boninofatsiae* Inoue & Miyatake, 2001)) or Lardizabalaceae (*C. coccinea* (Kuwayama, 1908)). *Cacopsylla myrsines* differs from these species in details of the male and female terminalia. It is not known whether the *Cacopsylla* species associated with the three plant families are closely related phylogenetically.

Cacopsylla photiniae sp. nov.

https://zoobank.org/0CC3863F-A3E9-413E-B004-00987A9878BC
Figs 7, 8, 12, 22–24, 33, 37–39

Type locality. Malaysia, Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit region, 6.0687°N, 116.5617°E, 3890 m.

Material examined. *Holotype*. Malaysia • ♂; Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit region; 6.0687°N, 116.5617°E; 3890 m; 30.iv.1982; D. Burckhardt leg.; #F8281; subalpine scrub, on *Photinia davidiana* (Rosaceae); MHNG, dry. ***Paratypes*.** Malaysia • 30 ♂, 15 ♀; same as holotype but MHNG, NCHU, NHMB, dry, slide. • 3 ♂, 6 ♀; same but summit region; 6.0687°N, 116.5617°E; 3890 m; 30.iv.1982; D. Burckhardt leg.; #F8282; subalpine scrub, on *Leptospermum recurvum* (Myrtaceae); MHNG, dry. • 6 ♂, 8 ♀; same but summit region; 6.0687°N, 116.5617°E; 3890 m; 30.iv.1982; D. Burckhardt leg.; #F8283; subalpine scrub, on *Coprosma hookeri* (Rubiaceae); MHNG, NHMB, dry, slide. • 1 ♂, 1 ♀; same but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #13a; moss forest with Ericaceae and

Myrtaceae; MHNG, dry. • , 2 ♀; same but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8756; moss forest with Ericaceae and Myrtaceae, on *Leptospermum recurvum* (Myrtaceae); MHNG, dry. • 1 ♂; same but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8757; moss forest with Ericaceae and Myrtaceae, on *Myrica javanica* (Myricaceae); MHNG, dry. • 11 ♂, 14 ♀; same but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8758; moss forest with Ericaceae and Myrtaceae, on *Photinia davidiana* (Rosaceae); MHNG, dry. • 1 ♂; same but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8759; moss forest with Ericaceae and Myrtaceae, on *Vaccinium* sp. (Ericaceae); MHNG, dry. • 1 ♀; same but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8760; moss forest with Ericaceae and Myrtaceae, on *Rhododendron* sp. (Ericaceae); MHNG, dry. • 1 ♂, 1 ♀; same but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8762; moss forest with Ericaceae and Myrtaceae, on *Rhododendron* sp. (Ericaceae); MHNG, dry. • 3 ♂; same but summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8765; moss forest with Ericaceae and Myrtaceae, on *Rhododendron rugosum* (Ericaceae); MHNG, dry. • 35 ♂, 38 ♀; same but below Laban Rata; 3155 m; 5.v.1987; A. Smetana leg.; MHNG, dry. • 4 ♂, 3 ♀; same but Laban Rata; 3200 m; 4–8.v.1987; A. Smetana leg.; interception trap; MHNG, dry. • 1 ♂, 4 ♀; same but Laban Rata; 3200 m; 9–20.v.1987; A. Smetana leg.; interception trap; MHNG, dry. • 3 ♂, 4 ♀; same but base of St. John's Peak; 3450–4000 m; 20.v.1987; A. Smetana leg.; MHNG, dry. • 5 ♂, 4 ♀; same but base of St. John's Peak; 4000 m; 7.v.1987; A. Smetana leg.; MHNG, dry. • 2 ♂, 2 ♀; same but base of St. John's Peak; 4000 m; 8.viii.1988; A. Smetana leg.; #B88; MHNG, dry. • 3 ♀; same but summit trail; 3900 m; 30.iv.1982; B. Hauser leg.; Sab-82/21; Berlese leaf litter; MHNG, dry. • 4 immatures; same but summit trail; 3900 m; 30.iv.1982; B. Hauser leg.; Sab-82/21; Berlese leaf litter; MHNG, slide. • 1 ♂; same but summit trail, near Panar Laban; 3270 m; 30.iv.1982; B. Hauser leg.; Sab-82/22; Berlese leaf litter; MHNG, dry. • 1 ♂; same but summit trail, near Panar Laban; 1850 m; 28.iv.1982; B. Hauser leg.; Sab-82/26; Berlese leaf litter; MHNG, dry.

Diagnosis. Adult. Vertex 0.4–0.5 times as long as wide; genal processes 0.9–1.2 times as long as vertex along midline, strongly narrowing basally, almost cylindrical otherwise, blunt apically, axis subparallel, separated in the middle. Antenna 1.8–2.0 times as long as head width; relative length of flagellar segments as 1.0 : 0.7 : 0.6 : 0.6 : 0.6 : 0.4 : 0.2 : 0.2. Metatibia with very small genual spine. Forewing oblong-oval, widest in the middle, 3.6–3.8 times as long as head width, 2.3–2.5 times as long as broad, costal margin curved; pterostigma moderately long, irregularly narrowing to apex, with subparallel margins in the middle, ending above bifurcation of vein M; vein Rs distinctly curved in the middle; m_1 cell value 2.2–2.7, cu_1 cell value 2.5–3.0; veins beset with short setae; surface spinules present in all cells, leaving narrow spinule-free stripes along the veins; absent from basal third of cell c+sc; fields of surface spinules in each of the marginal cells widening to wing margin; relatively evenly spaced forming irregular rhombs or squares. Male proctiger tubular, weakly sinuate, 0.4 times as long as head width. Subgenital plate strongly sclerotised, in lateral view subglobular, with almost straight dorsal margin. Paramere shorter than proctiger, in lateral view, lamellar, weakly curved, with strongly sclerotised apical hook curved inwards and forwards; inner face with a subapical group of long bristles, and long setae along anterior and posterior margin. Distal segment of aedeagus bearing hook-shaped apical inflation. Female proctiger 0.8 times as long as head width; dorsal margin weakly concave, apex blunt. Female subgenital plate 0.5–0.6 times as long as proctiger, in lateral view, irregularly narrowing to pointed apex. – Fifth instar immature. Body 1.2–1.3 times as long as wide. Antenna 1.1–1.2 times as long as forewing pad; segments 4–6 1.0–1.1 times as long as segment 7; lacking capitate setae on flagellum. Meso and metatibia with two long capitate setae. Forewing pad with 10–14 medium long and long marginal capitate setae, lacking dorsal macroscopic setae; hindwing pad with 2 long, marginal capitate setae subapically, lacking dorsal macroscopic setae. Caudal plate 0.6 times as long as wide; lacking marginal sectasetae; with 7–8 long marginal, 3 long submarginal and 1–3 short dorsal capitate setae (one side only); margin of caudal plate wavy. Outer circumanal ring small, its length along longitudinal body axis much larger than its distance from caudal margin of caudal plate; indented anteriorly, closed anteriorly; consisting of a single row of narrowly oval pores.

Description. Adult. ***Colouration.*** Head and thorax mostly reddish brown, abdomen black (Fig. 7). Head (Fig. 8) with occiput, coronal suture, foveae and fore margin of vertex almost black, base of vertex and anterior tips of vertex white; genal processes yellow. Antennal segments 1–3 dirty yellowish, segment 4 brown, segments 4–10 almost black. Pronotum white with each a lateral and sublateral dark brown dot on either side. Mesopraescutum with two sublateral longitudinal stripes in anterior half and white dots at posterior margin. Mesoscutum with dark brown longitudinal stripes. Mesoscutellum, in anterior half, black medially, white laterally. Metascutellum yellowish. Metapostnotum almost black. Fore and mid legs and metafemora brown. Fore and mid legs with femora basally dark greyish brown and apically yellow, tibiae and basitarsi dirty yellow and apicotarsi dark brown; hind leg with coxa brown anteriorly, ochreous posteriorly, femur and apicotarsus dark brown and tibia and basitarsus whitish. Forewing membrane whitish, transparent; veins light brown in basal half darkening to brown in apical half. Abdominal intersegmental membrane orange brown.

Structure. Conforming to the generic description of Ossiannilsson (1992). Body length ♂ 3.0–3.4 mm, ♀ 2.9–3.9 mm (10 ♂, 10 ♀). Head deflexed 45–80° from longitudinal axis of body (Fig. 7); as wide as mesoscutum. Vertex (Fig. 8) rhomboidal, 0.4–0.5 times as long a wide, concave at base, bearing microscopic setae and imbricate microsculpture; preocular sclerite narrow; genal processes 0.9–1.2 times as long as vertex along midline, strongly narrowing basally, almost cylindrical otherwise, blunt apically, axis subparallel, separated in the middle, evenly beset with sparse long setae, apex blunt (Fig. 8); eyes hemispherical. Rostrum 0.4–0.5 times as long as head width, in lateral view mostly hidden by mesosternum and only apical segment visible. Antenna 1.8–2.0 times as long as head width; relative length of flagellar segments as 1.0 : 0.7 : 0.6 : 0.6 : 0.6 : 0.4 : 0.2 : 0.2; antennal segment 3 longest; relative length of segment 10 and terminal antennal setae as 1.0 : 1.7 : 1.5. Metatibia 0.7–0.8 times as long as head width, with very small genual spine, weakly widening to apex, with 1+3+1 apical spurs. Forewing (Fig. 12) oblong-oval, widest in the middle, 3.6–3.8 times as long as head width, 2.3–2.5 times as long as broad, costal margin irregularly curved, relatively evenly rounded apically; pterostigma moderately long, at base narrower than adjacent part of cell r_1, irregularly narrowing to apex, with subparallel margins in the middle, ending above bifurcation of vein M; vein C+Sc weakly, relatively evenly curved; vein M+Cu longer than half length of R; vein Rs distinctly curved in the middle; m_1 cell value 2.2–2.7, cu_1 cell value 2.5–3.0; veins beset with short setae; surface spinules present in all cells, leaving narrow spinule-free stripes along the veins; absent from basal third of cell c+sc; fields of surface spinules in each of the marginal cells widening to wing margin; relatively evenly spaced forming irregular rhombs or squares.

Male terminalia as in Figs 22–24. Proctiger tubular, weakly sinuate, 0.4 times as long as head width; densely beset with long, setae in apical three quarters. Subgenital plate strongly sclerotised, in lateral view subglobular, with almost straight dorsal margin; sparsely beset with long setae along a broad transverse band stretching from dorsal margin to postero-ventral margin. Paramere shorter than proctiger, in lateral view, lamellar, weakly curved, with strongly sclerotised apical hook which is curved inward and forward; parameres in caudal view, forming O with dorsally widening margins; outer face sparsely beset with long setae in apical two thirds; inner face with a subapical group of long bristles, and long setae along fore and hind margin. Aedeagus long and slender; distal segment bearing hook-shaped apical inflation; sclerotised end tube of ductus ejaculatorius short, sinuate. – Female terminalia cuneate (Fig. 33). Proctiger 0.8 times as long as head width, 3.0–3.5 times as long as circumanal ring which consists of two unequal rows of pores; dorsal margin weakly concave, apex blunt; beset with moderately long setae in basal half, with a transverse row of 4 very long setae in apical third, a submedian longitudinal row of slightly shorter setae in apical third, and a lateral band of peg setae on either side in apical third. Subgenital plate 0.5–0.6 times as long as proctiger, in lateral view, irregularly narrowing to pointed apex; except for base beset with long setae, with a lateral band of peg setae in apical third on either side. Dorsal and ventral valvulae curved, the latter with a ventral denticle; lateral valvula irregularly rounded apically.

Measurements in mm (3 ♂, 3 ♀). Head width 0.70–0.78; antenna length 1.36–1.48; forewing length 2.56–2.80; length of male proctiger 0.28–0.30; paramere length 0.20–0.22; length of distal segment of aedeagus 0.20–0.22; female proctiger length 0.56–0.60.

Fifth instar immature. Colouration of slide mounted specimens. Dorsal sclerites light brown, membranes colourless. Cephalothorax yellow anteriorly, becoming gradually darker towards the rear. Antennal segments 1–3 yellow, segments 4–6 brown, segment 7 dark brown. Thoracic and basal abdominal sclerites slightly darker than wing pads and caudal plate. Legs yellow, tarsi light brown.

Structure. Conforming to the generic description of Ossiannilsson (1992). Body (Fig. 37) 1.2–1.3 times as long as wide. Antenna 7-segmented, 1.1–1.2 times as long as forewing pad; segments 4–6 1.0–1.1 times as long as segment 7; lacking capitate setae on flagellum. Thoracic tergites small. Meso- and metatibia with two long capitate setae. Forewing pad broad, rounded apically, with 10–14 medium long and long marginal capitate setae, lacking dorsal macroscopic setae; hindwing pad with 2 long, marginal capitate setae subapically, lacking dorsal macroscopic setae. Caudal plate 0.6 times as long as wide; lacking marginal sectasetae; with 7–8 long marginal, 3 long submarginal and 1–3 short dorsal capitate setae (one side only) (Fig. 38); margin of caudal plate wavy. Outer circumanal ring (Fig. 39) small, its length along longitudinal body axis much larger than its distance from caudal margin of caudal plate; indented anteriorly, complete (closed) anteriorly; consisting of a single row of narrowly oval pores.

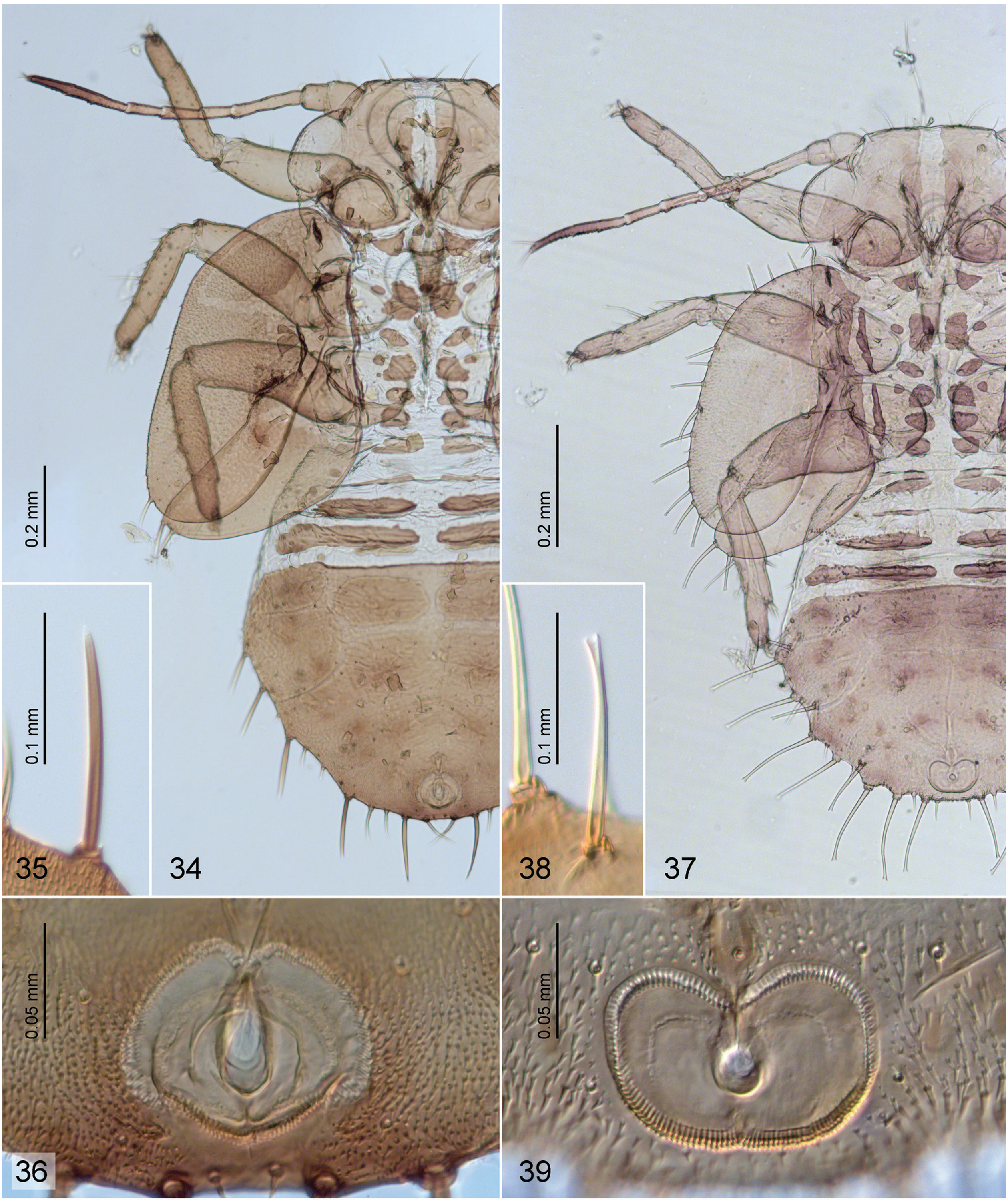
Measurements (in mm) (2 individuals). Body length 1.62–1.66; antennal length 0.84; length of forewing pad 0.70–0.74.

Etymology. Named after its host, *Photinia*.

Distribution. Malaysia: Sabah, Gunung Kinabalu, at altitudes between 3200–4000 m. The single male extracted with Berlese funnels from a sample taken at 1850 m was probably blown there by the wind.

Host plant, biology and habitat. *Photinia davidiana* (Decne.) Cardot (Rosaceae), a shrub or tree that is native to Borneo, Sumatra, Vietnam, the PR China and Taiwan (POWO 2023). *Cacopsylla photiniae* was found in moss forest with Ericaceae and Myrtaceae and in subalpine scrub.

Comments. *Cacopsylla photiniae* resembles *C. laricirubera* Li, 2011 in the lamellar paramere with a large, strongly sclerotised apical hook and the lens-shaped apical dilation of the distal aedeagal segment. The latter species is known only from a few adults from the Ningxia Hui Autonomous Region (PR China) collected on conifers.



Figures 34–39. *Cacopsylla* spp., fifth instar immature. **34, 37.** Habitus, in dorsal view, left side; **35.** Long, thick, apically pointed marginal seta; **38.** Short dorsal capitate seta; **36, 39.** Circumanal ring; **34–36.** *C. myrsines*; **37–39.** *C. photiniae*.

Cacopsylla photiniae differs from *C. laricirubera* in the longer genal processes (about as long as coronal suture versus two thirds length of coronal suture), in the basally hardly (versus strongly) incised apical hook on the paramere, and in the shorter (versus longer) female terminalia. From Palaearctic *Cacopsylla* species associated with Rosaceae, *C. photiniae* differs in the fields of surface spinules of the forewing widening (versus narrowing) to the wing margin and the small (versus moderately large) circumanal ring of the fifth instar immature. In both these characters, it resembles the *Cacopsylla* species associated with Ericaceae with which it may be more closely related (cf. comment under *C. graciliforceps*). *Cacopsylla photiniae* differs from these species in details of the male and female terminalia.

Psylla cirrita sp. nov.

https://zoobank.org/9E5153AE-1D6A-418C-A554-8869C6CE97E7
Figs 40, 41, 44–47

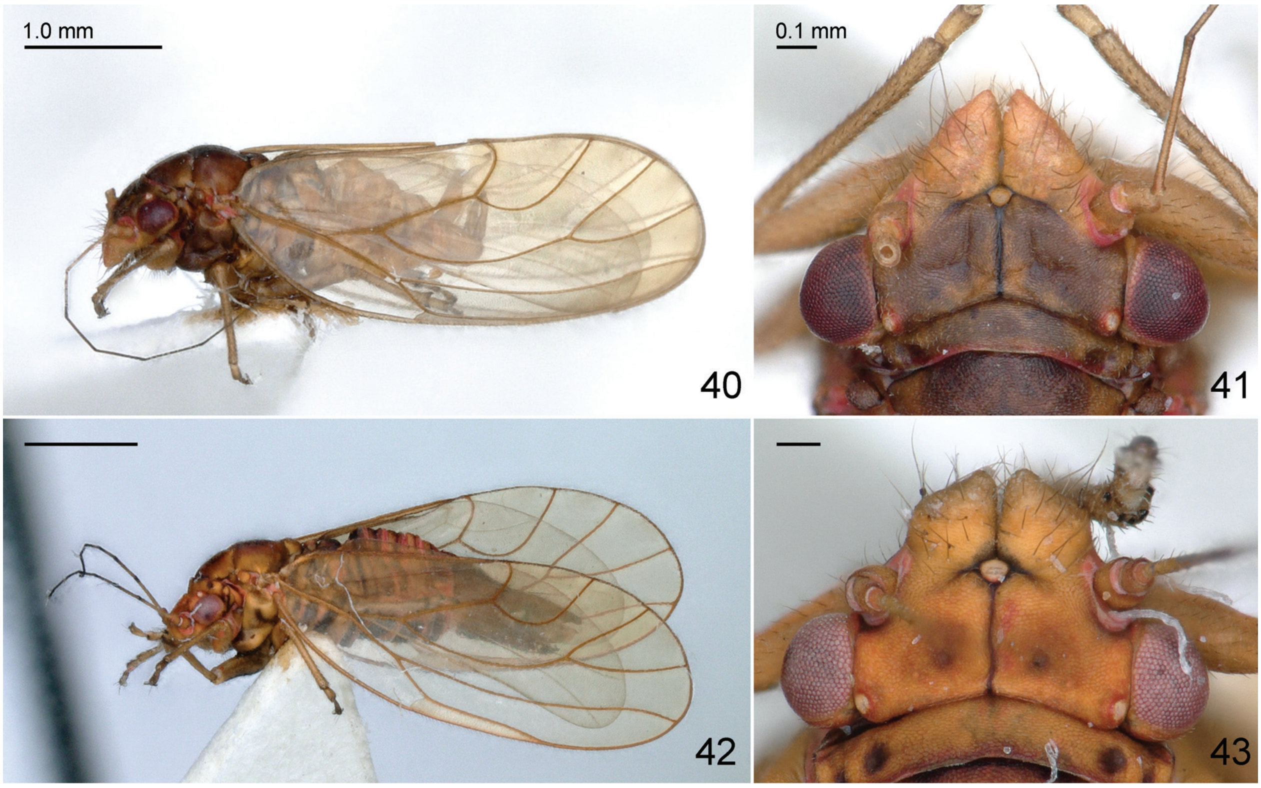
Type locality. Malaysia, Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail, Panar Laban; 6.0594°N, 116.5665°E, 3300 m.

Material examined. ***Holotype.*** Malaysia • ♂; Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8764; on *Rhododendron* sp. (Ericaceae) in moss forest with Ericaceae and Myrtaceae; MHNG, dry.

Diagnosis. Adult. Vertex 0.4 times as long as wide; genal processes 1.0 times as long as vertex along midline, massive, evenly tapering to pointed apex, contiguous medially. Antenna 2.6 times as long as head width; relative length of flagellar segments as 1.0 : 1.0 : 0.9 : 1.1 : 1.2 : 1.2 : 0.2 : 0.3. Metatibia bearing small genual spine. Forewing oblong-oval, widest in the middle, 3.2 times as long as head width, 2.4 times as long as broad; pterostigma regularly narrowing to apex, ending level with the middle of Rs; vein Rs weakly sinuate; vein M long, with relatively short, weakly diverging branches; vein Cu_{1a} strongly curved in basal half. Surface spinules present in all cells, leaving spinule free stripes along the veins; forming irregular transverse rows. Male proctiger tubular, weakly sinuate, 0.4 times as long as head width. Subgenital plate strongly sclerotised, in lateral view subglobular, with almost straight dorsal margin. Paramere shorter than proctiger, in lateral view, lamellar, weakly curved, with strongly sclerotised apical hook, curved inwards and forwards. Distal segment of aedeagus bearing hook-shaped apical inflation.

Description. Adult. ***Colouration.*** Dark reddish brown. Genal processes ochreous. Antenna dark brown, segments 1–3 brown, apices of segments 3–8 and entire segments 9 and 10 almost black. Mesoscutum with four indistinct longitudinal brown stripes; mesoscutellum reddish brown laterally; metanotum and metapostnotum ochreous. Legs irregularly ochreous; apical tarsal segments greyish brown. Forewing colourless at base, becoming yellow towards apex; veins brown. Abdomen including terminalia yellowish; tip of paramere black.

Structure. Conforming to the generic description of Li (2011). Body length 4.7 mm (1 ♂). Head deflexed 45° from longitudinal axis of body (Fig. 40); about as wide as mesoscutum. Vertex (Fig. 41) rhomboidal, 0.4 times as long a wide, weakly concave at base, bearing short sparse setae and fine granular microsculpture; preocular sclerite narrow; genal processes 1.0 times as long as vertex along mid-line, massive, evenly tapering to pointed apex (Fig. 41), contiguous medially, evenly beset with sparse long setae; eyes hemispherical. Rostrum short, in lateral view mostly hidden by mesosternum and only apical segment visible. Antenna 2.6 times as long as head width; relative length of flagellar segments as 1.0 : 1.0 : 0.9 :



Figures 40–43. *Psylla* spp. **40, 42.** Habitus, in lateral view; **41, 43.** Head, in dorsal view. **40, 41.** *P. cirrita*; **42, 43.** *Psylla* sp.

1.1 : 1.2 : 1.2 : 0.2 : 0.3; antennal segments 7 and 8 longest; relative length of segment 10 and terminal antennal setae as 1.0 : 0.6 : 0.6. Metatibia 0.7 times as long as head width, bearing small genual spine, weakly widening to apex, with 1+4+1 apical spurs. Forewing (Fig. 40) oblong oval, widest in the middle, 3.2 times as long as head width, 2.4 times as long as broad, irregularly rounded apically; pterostigma, at base narrower than adjacent part of cell r_1, regularly narrowing to apex, ending level with the middle Rs; vein C+Sc weakly curved, cell c+sc long, widest in the middle; vein Rs weakly sinuate; vein M long, with relatively short, weakly diverging branches; vein Cu_{1a} strongly curved in basal half. Surface spinules present in all cells, leaving spinule free stripes along the veins; forming irregular transverse rows.

Male terminalia as in Figs 44–47. Proctiger tubular, weakly sinuate, 0.4 times as long as head width; densely beset with long setae in apical three quarters. Subgenital plate strongly sclerotised, in lateral view subglobular, with almost straight dorsal margin; sparsely beset with long setae along a broad transverse band stretching from dorsal margin to postero-ventral margin. Paramere shorter than proctiger, in lateral view, lamellar, weakly curved, with strongly sclerotised apical hook which is curved inward and forward; parameres in caudal view, forming O with dorsally widening margins; outer face sparsely beset with long setae in apical two thirds; inner face with a subapical group of long bristles, and long setae along fore and hind margin. Aedeagus long and slender; distal segment bearing rounded apical inflation; sclerotised end tube of ductus ejaculatorius short, sinuate. – Female unknown.

Measurements in mm (1 ♂). Head width 1.12; antenna length 2.88; forewing length 3.56; male proctiger length 0.40; paramere length 0.38; length of distal portion of aedeagus 0.28.

Fifth instar immature unknown.

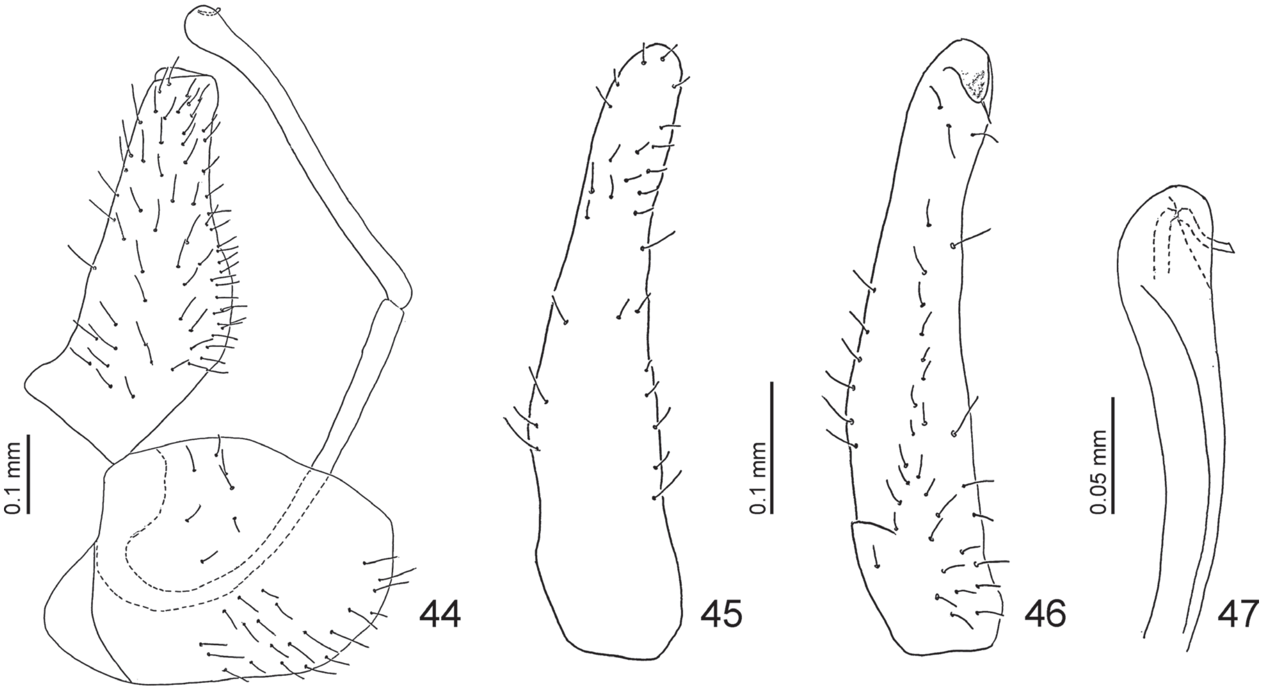
Etymology. From Latin cirritus = having filaments, bearded, referring to the conspicuous setae on the genal processes.

Distribution. Malaysia: Sabah, Gunung Kinabalu, at an altitude of 3300 m.

Host plant, biology and habitat. Unknown; the holotype was collected on *Rhododendron* sp. (Ericaceae) in moss forest with Ericaceae and Myrtaceae.

Comments. *Psylla cirrita* shares with *Psylla turpinae* Li & Yang from the Guangxi Zhuang Autonomous Region (PR China) the reddish body colour, the massive genal processes, the 1+4+1 apical metatibial spurs, the postero-basally expanded male proctiger and the apically hardly expanded distal segment of the aedeagus. It differs from *P. turpinae* in the pointed (versus blunt) genal processes, the antennal segment 3 that is shorter (versus longer) than segments 7 and 8, and the curved (versus sinuate) parameres. If the similarity between the two species reflects a phylogenetic relationship, this needs to be tested with more material and, in particular, with immatures. A related, undescribed species was found on Gunung Kinabalu (see comments under *Psylla* sp.). According to Li (2011), *P. turpinae* develops on *Dalrympelea pomifera* Roxb. (Staphyleaceae), an unusual psyllid host taxon. It is interesting to note, that of the eight species recognised in the Southeast Asian genus *Dalrympelea* six occur in Borneo (POWO 2023).

Psylla cirrita and *P. turpinae* are not congeneric with *P. alni* (Linnaeus, 1758), the type species of *Psylla* Geoffroy, 1762. Based on molecular and morphological evidence, *Psylla* was redefined to include Holarctic species



Figures 44–47. *Psylla cirrita*. **44.** male terminalia, in lateral view; **45.** outer face of paramere; **46.** inner face of paramere; **47.** apex of distal aedeagal segment.

developing on Betulaceae (Burckhardt et al. 2021). The two Asian species possibly constitute a new genus but more material including immatures is necessary to examine their phylogenetic position. Meanwhile, I use the broad concept of *Psylla* by Li (2011).

***Psylla* sp.**

Figs 42, 43

Material examined. Malaysia • 1 ♀; Sabah, Ranau, Gunung Kinabalu, Kinabalu Park, summit trail, Panar Laban; 6.0594°N, 116.5665°E; 3300 m; 4.v.1987; D. Burckhardt and I. Löbl leg.; #F8763; on *Rhododendron* sp. (Ericaceae) in moss forest with Ericaceae and Myrtaceae; MHNG, dry. • 1 ♂; same data but Kinabalu Park, summit trail below Layang Layang; 6.0419°N, 116.5578°E; 2560 m; 1.v.1987; D. Burckhardt and I. Löbl leg.; #F8735; on *Syzygium* sp. (Myrtaceae) in moss forest; MHNG, dry.

Comments. A teneral male and a female (Fig. 42) at hand resemble *Psylla cirrita* in general but differ in the shape of the genal processes (pointed, Fig. 41, versus obliquely truncate, Fig. 43), and the relative lengths of antennal segments 3, 7 and 8 (segment 3 shorter versus longer than segments 7 and 8). There are slight differences in the male terminalia but they are difficult to interpret as the male of *Psylla* sp. is teneral and the terminalia may not be fully developed.

Discussion and conclusions

Only fragments of the diversity of tropical psyllids are known and often new species do not fit, or only partially fit, into described genera. *Cacopsylla graciliforceps*, *C. myrsines* and *C. photiniae* correspond to the putatively monophyletic concept of *Cacopsylla* by Ossiannilsson (1992) and Percy et al. (2018). The presence of immatures in the last two species confirms this generic placement. *Cacopsylla graciliforceps* resembles species associated with Ericaceae, including some undescribed species from Nepal (unpublished NHMB data), and *C. myrsines* is morphologically similar to some Palaearctic species developing on Elaeagnaceae. *Cacopsylla photiniae*, though developing on a rosaceous host, differs morphologically from west Palaearctic species associated with Rosaceae. It is more similar to species developing on Ericaceae with which it may be related. *Cacopsylla kinabaluensis*, *C. aranetae* and *C. bakeri* differ from other *Cacopsylla* species in the short vertex, the tubular, medially separated genal processes and the long antennae. Immatures and molecular data will be necessary to analyse their phylogenetic relationship within the subfamily. The situation of *Psylla cirrita* and *P. turpinae* is similar. The two species probably warrant the erection of a new genus but without additional material, in particular immatures with host information, the two species are kept in the polyphyletic *Psylla* as adopted by Li (2011). The five new species described here bring the total number of known psyllid species from Gunung Kinabalu to 22.

Host plants are only known for two of the five species described here. *Cacopsylla myrsines* develops on *Myrsine dasyphylla* (Primulaceae), an endemic of Borneo. *Myrsine* was previously reported only once as psyllid host: of *Trioza* sp. from New Zealand (Dale 1985). Primulaceae in general is an atypical psyllid host (Ouvrard 2023). Another confirmed host is *Lysimachia ciliata* of *Aphalara steironemicola* Richards, 1970. *Photinia davidiana* (Rosaceae) hosts, apart from *C. photiniae*, also the unrelated Taiwanese *C. stranvaesiae* (Yang, 1984). It is a shrub or tree native to Southeast Asia, Central and South China and Taiwan (POWO 2023). *Cacopsylla graciliforceps* probably develops on Ericaceae, a host taxon utilised also by other *Cacopsylla* species (see comment under *C. graciliforceps*). The hosts of *C. kinabaluensis* and *P. cirrita* are unknown, and as their phylogenetic relationships are unknown, it is impossible to predict their hosts. It is interesting to note that adults of the Chinese *Psylla turpinae*, a possibly close relative of *P. cirrita*, were collected on *Dalrympelea pomifera* Roxb. (Staphyleaceae) (Li 2011), a plant genus comprising eight species of which six are endemic to Borneo (POWO 2023).

Cacopsylla graciliforceps, *C. myrsines* and *C. photiniae* occur at altitudes of 2600–4000 m and are probably most closely related to species in the Himalaya and temperate Palaearctic. They represent Himalayan elements similar to those found in the flora (Cockburn 1978; Corner 1978; Beaman and Beaman 1990). The biogeographical relationships of *C. kinabaluensis* and *P. cirrita* remain unclear as their phylogenetic relationships are unknown.

Psyllid species are usually quite widespread (Ouvrard 2023). The few examples of narrowly endemic species are restricted to mountains (Burckhardt and Queiroz 2021; Burckhardt 2022) or islands (Percy 2000, 2017; Bastin et al. 2023). The vast majority of psyllids known from Gunung Kinabalu, including all the new species described here, are known only from there. Exceptions are three species of *Paurocephala*, which also occur outside Borneo (Mifsud and Burckhardt 2002; Burckhardt et al. 2023), and one species of *Boreioglycaspis*, which is also known from other localities in Borneo (Burckhardt 1991). *Paurocephala* represents an Oriental faunal element characteristic of the lower altitudes. With additional targeted fieldwork in Borneo and other Southeast Asian regions, it is likely that some of the species currently known only from Gunung Kinabalu may be found also elsewhere, although the degree of endemism would still be high.

Acknowledgements

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Ants of Kamchatka: checklist, DNA-barcoding and key (Hymenoptera, Formicidae)

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Abstract

Kamchatka is a remote volcanic peninsula in the sub-arctic Far East of Russia. Its myrmecofauna has been scientifically addressed several times. However, previous species lists are contradictory in part and a modern study seems to be lacking. Based on literature review, I conclude that 12 species and 4 genera (*Camponotus*, *Formica*, *Leptothorax* and *Myrmica*) of ants may be native to Kamchatka. Of those, 9 were found in the field, 3 having a Holarctic, 3 a trans-Palearctic and 3 an East Palearctic distribution. Most species diversity was found at mid-elevations, in pine shrubs and mixed forests, while deciduous forests and open habitats at lower altitudes were surprisingly species poor. DNA-barcoding was performed for 57 specimens/9 species. Genetic diversity (COI) was low for 8/9 species, with the exception of *Leptothorax acervorum*, for which all samples were of a different haplotype and 2 haplogroups were identified. For the encountered Holarctic and trans-Palearctic species, closely related haplotypes (<0.7% raw distance) occur in Europe and/or North America. Some *Formica* ants were morphologically atypical, with workers partially resembling those of *F. fusca*, while gynes identified as *F. lemani*. Morphometric analysis and DNA-barcoding suggested that all these specimens belong to a single species, *F. lemani*. Standard images for all specimens and an illustrated key to the worker caste are provided.

Key Words

Subarctic, boreal zone, COI, mtDNA, Russian Far East, Siberia

Introduction

The entomofauna of the Russian Far East is still relatively understudied (Kirichenko et al. 2019). This region contains some diverse and unique insect communities (Teslenko 2009). High diversity is found in broad-leave forest of its southern regions, while diversity in the northern tundra is much lower (Lelej and Storozhenko 2010). Kamchatka is a large mountainous peninsula in northeastern Russia, located between approximately 51°N–60°N and 156°E–164°E (Fig. 1A). Besides being one of the world's most volcanically active areas, it is also known for its epic landscapes and large populations of wild life. The Kamchatka-peninsula is connected to the Siberian mainland only by a narrow stripe of mountainous land in the northern tundra zone (Fig. 1A). To the West lies the Sea of Okhotsk and the Pacific to the East. Large chains of volcanic mountains shape the centre, North (Sredinny Mountains) and South-East (Vostocny Mountains), while the West, North-East and South are relatively flat (Fig. 1A). The highest volcano (Klyuchevskoy) reaches 4,754 m altitude. The climate is considerd sub-arctic and milder than in mainland Siberia. Kamchatka's fauna has relatively low diversity and there is not much of an endemic flora (Storozhenko et al. 2002; Nazarova et al. 2013; Jones and Solomina 2015). The vegetation of central Kamchatka consists of boreal forests dominated by larch (*Larix cajanderi*) and birch (*Betula platyphylla*) (Eichhorn 2010) (Fig. 1B) up to elevations around 800 m a. s. l., and Siberian dwarf pine (*Pinus pumila*) shrubs are found at elevations between ca. 800–1500 m (Fig. 1C). In southern and peripheral parts of the peninsula, there are open landscapes such as meadows (Fig. 1D) and wetlands, but most widespread are boreal deciduous forests dominated by stone birch (*Betula ermanii*, Fig. 1E), extending up to around 800 m a. s. l. Between 800–1000 m, these humid “snow forests” are replaced by dwarf pine shrubs. Above the dwarf pine zone, only alpine tundra and plantless landscapes remain (Krestov et al. 2008).

The ant fauna of Kamchatka has been described by several authors during the past century. Different sources in sum reported at least 25 different ant taxa from Kamchatka. However, these publications are contradicting each other regarding the presence and absence of species (Table 1). Some of this confusion may have been introduced by the first species list (Ruzsky 1920). This list deviates quite strongly from later studies on ants from Kamchatka (Table 1), casting doubt whether the underlying material truly originated (only) from Kamchatka. Additionally, distributions of species reported from Kamchatka earlier are now better understood due to recent taxonomic revisions. The status of these taxa may therefore require verification. Recent work has also raised the possibility of cryptic diversity in two relevant species (*Formica candida* and *F. gagatoides*) (Zhigulskaya et al. 2022; Chesnokova et al. 2023).

DNA-barcoding has become an important tool for biologists. Its various applications include the identification, molecular taxonomy, classification of poorly known biota, phylogeography and studies of ecological and evolutionary patterns (Hebert et al. 2016). The main repository for DNA-barcodes, the public “Barcoding Of Life Data System” (BOLD) database (Ratnasingham and Hebert 2007) now contains more than 13 million specimens with DNA-barcodes, representing nearly 345,000 species. This resources allows comparison of new sequences to a large amount of reference material.

The aim of this study was to compile a reliable, up to date checklist of ants occurring in Kamchatka, to study their distribution, ecology and genetic relationships as inferred by mtDNA sequences. Additionally, it was the aim to clarify the taxonomic identity of ants from Kamchatka morphologically resembling *Formica fusca* (setae on pronotum absent) and *F. lemani* (setae on pronotum present). Providing high resolution specimen images and an illustrated identification key to the species level was another aim.

Methods

Checklist and field observations

A total of 14 literature sources containing substantial information about ants in Kamchatka, were reviewed. Species records were classified by reliability according to two categories: “reliable” (supported by multiple, including recent sources) and “questionable” (supported by single and/or dated sources, but contradicted by more recent work). Ants were collected manually in >95% ethanol in 8 localities in Kamchatka (Fig. 1A). Geographic coordinates and elevations were recorded for each sample using a Garmin etrex 10 GPS device. Habitats were photographed during field observations. Specimens were pinned for morphological study or kept in >95% ethanol at -20 °C. All specimens are stored in the private collection of the author (Dietikon, Switzerland). A key to the worker caste was developed based on comparative morphology of material in the author’s collection and inspired by literature (Radchenko and Elmes 2010; Seifert 2018). Pictures of specimens were taken using a Samsung Galaxy Xcover 5 cell phone in combination with a Leica EZ4 binocular at 16–70 × magnification. Focus stacking and image processing was performed using the programs align_image_stack v. 2019.0.0, Enfuse 4.2 and GIMP v. 2.10.30.

DNA-barcoding

DNA-barcoding was performed performed *de novo* for 47 ant specimens by the company Sinsoma GmbH (Völs, Austria). For COI, the primer pair LCO1419 und HCO2198 (Folmer et al. 1994) were used, yielding 658 bp of the barcode region of the COI gene. The resulting chromatograms were edited in UGENE 46.0 (Okonechnikov et al. 2012). Sequences were aligned using MAFFT v7.490 (Katoh and Standley 2013). A total of 10 sequences published earlier (Schär et al. 2018) were added, yielding a data set of 57 sequenced specimens in total. A maximum likelihood tree was calculated in IQ-TREE v1.6.12 (Nguyen et al. 2015), selecting the TIM2+F+I model with ModelFinder (Kalyaanamoorthy et al. 2017). Monophyly of the subfamilies was enforced by constraint. Sequences were collapsed into haplotypes and a haplotype network was visualized using the R package “pegas” (Paradis 2010) in R v4.2.3 (R Core Team 2023). Within species raw genetic distances were calculated using the R package “ape” (Paradis and Schliep 2019). All retrieved unique COI sequences were compared to sequences on BOLD.

Formica lemani or *F. fusca*?

Worker specimens of suspected *F. lemani* from Kamchatka displayed some morphological traits intermediate between *F. lemani* and *F. fusca*. Therefore, a morphometric analysis was performed to clarify their identity. Measurements were taken using a Leica EZ4 binocular with graticule at 70× magnification. A total of 110 specimens from the author’s private collection were examined: 67 specimens of *Formica lemani*, 31 workers and 3 gynes from Kamchatka and 28 workers and 5 gynes from Europe. For comparison, 43 specimens (39 workers and 4 gynes) of *F. fusca* from Europe were measured as well. The following measurements were taken as suggested and defined by Seifert (2018): SL, EYE, OceD, nPn and nHFfl (workers) and SL, nPn and nMFfl (gynes). The discriminant given by Seifert (2018) to separate *F. lemani* (positive values) from *F. fusca* (negative values) was calculated for workers ($D = 0.385 * nPn + 0.51 * nHFfl - 6.546 * SL - 27.22 * EYE + 38.46 * OceD + 10.578$) and gynes ($-D = 0.215 * nPn + 0.666 * nMFfl - 7.179 * SL + 8.657$).

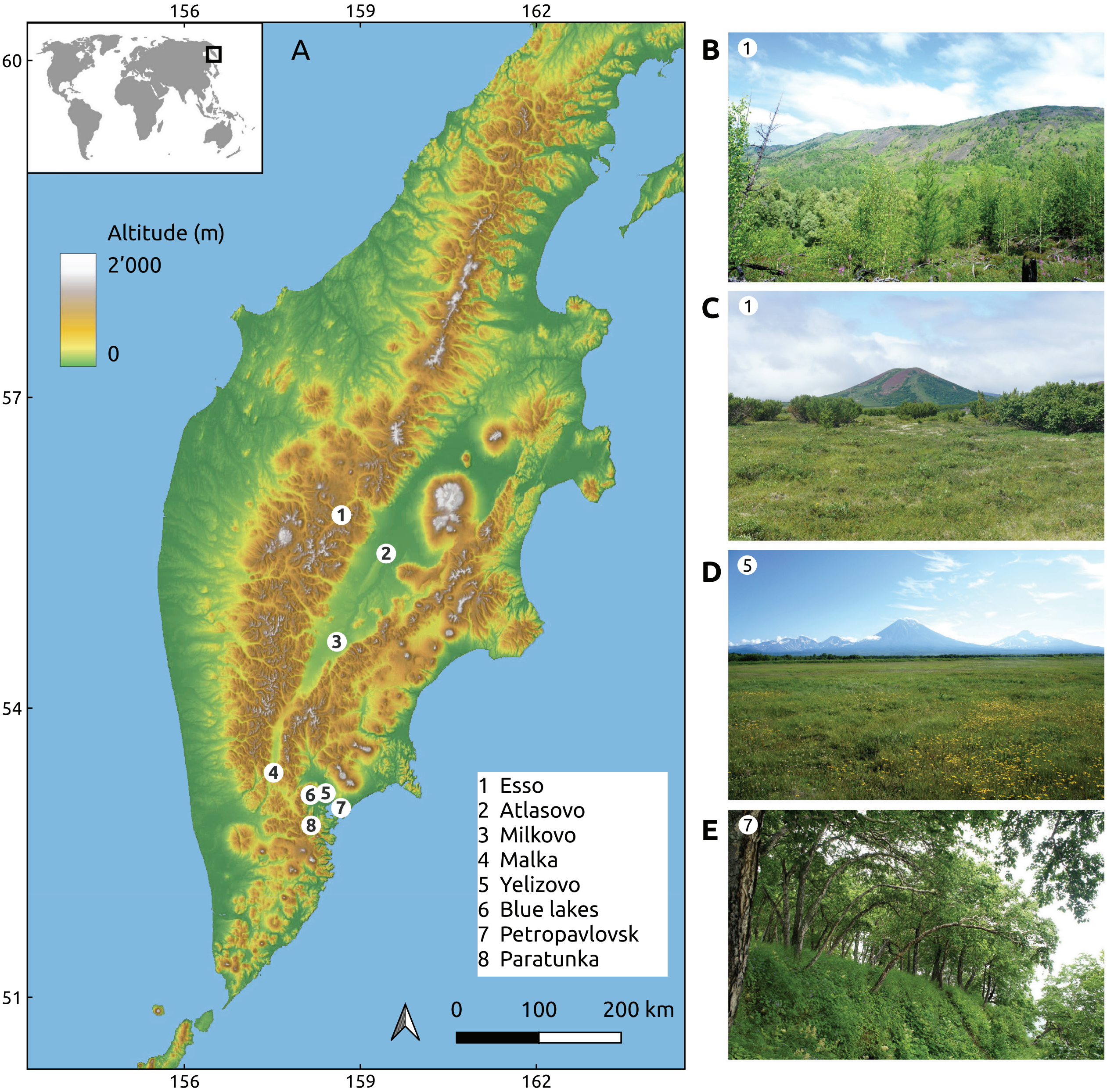

Figure 1. A. Map of Kamchatka and the study sites (numbered 1–8). The main types of habitats along with their location on the map (numbers) are given as well: **B.** Larch/birch forest near Esso; **C.** Dwarf pine zone near Esso; **D.** Open lowland meadow near Yelizovo; **E.** Stone birch forest near Petropavlovsk. Pictures: S. Schär.

Results

Checklist and field observations

Literature review suggested a relatively clear distinction between reliable and questionable records among the 25 species of ants reported from Kamchatka (Table 1). For a total of 12 reported species, presence in Kamchatka seems reliable. These taxa were mentioned by at least 2 independent sources and including sources published within the last two decades. They belong to 4 genera (*Camponotus* Mayr, 1861, *Formica* Linnaeus, 1758, *Leptothorax* Mayr, 1855, and *Myrmica* Latreille, 1804). For the other 13 species and 1 genus (*Lasius* Fabricius, 1804), reports from Kamchatka appear questionable and these taxa are considered absent from Kamchatka for the remaining manuscript. These questionable records were reported by a single (n = 11) or multiple (n = 2) dated sources, but have all been contradicted by more recent work (Table 1).

A total of 9 species of ants were found across 8 localities in Kamchatka (Fig. 1A) during a search of the author in the year 2016 (Table 1). Of those, 3 species are restricted to the East Palearctic, 3 have a (trans-) Palearctic and 3 a Holarctic distribution range (Table 2). Ants were found from sea level up to an altitude of approximately 1000 m. At low and intermediate elevations, they inhabited meadows (Fig. 1D), stone birch- (Fig. 1E) and larch/birch forests (Fig. 1B). At higher altitudes they were found in the dwarf pine zone (Fig. 1C). Ant species compositions

Table 1. Checklist of ants reported from Kamchatka grouped by reliability, ordered alphabetically. Meaning of symbols: + present; (+) presence indicated by a different name; - absent/out of range.

Count	Species	Source											
		(Ruzsky 1920)	(Collingwood 1962)	(Dlussky 1965)	(Kupianskaya 1990)	(Radchenko 1997)	(Terayama et al. 2000)	(Czechowski et al. 2002)	(Goropashnaya et al. 2004, 2007)	(Radchenko and Elmes 2010)	(Antropov et al. 2017)	(Seifert 2007, 2018)	(Schär et al. 2018); this study
reliable													
1	*Camponotus herculeanus* (Linnaeus, 1758)		+		+	+		+			(+)		+
2	*Formica candida* Smith, 1878				+			+				+	+
3	*Formica exsecta* Nylander, 1846			-	+			-	+		+	+	+
4	*Formica gagatoides* Ruzsky, 1904			+	+						+		+
5	*Formica lemani* Bondroit, 1917				+		+	+			+	+	+
6	*Formica lugubris* Zetterstedt, 1838		+		+		+	+	+		+	+	+
7	*Leptothorax acervorum* (Fabricius, 1793)	+			+		+	+			+		+
8	*Leptothorax muscorum* (Nylander, 1846)	+			+			+				+	
9	*Myrmica displicentia* Bolton, 1995				(+)					+	+		+
10	*Myrmica kamtschatica* Kupyanskaya, 1986				+		+			+	+		+
11	*Myrmica ruginodis* Nylander, 1846									+		+	
12	*Myrmica sulcinodis* Nylander, 1846	+			+					+		+	
questionable													
13	*Camponotus japonicus* Mayr, 1866	+				-							
14	*Camponotus saxatilis* Ruzsky, 1895	+				-							
15	*Formica aquilonia* Yarrow, 1955							+				-	
16	*Formica fusca* Linnaeus, 1758	+			+			+				-	-
17	*Formica picea* Nylander, 1846	+										-	
18	*Formica rufa* Linnaeus, 1761	+						-				-	
19	*Formica sanguinea* Latreille, 1798				+			-				-	
20	*Lasius flavus* (Fabricius, 1782)	+						+				-	
21	*Lasius myops* Forel, 1894	+										-	
22	*Lasius niger* (Linnaeus, 1758)	+										-	
23	*Myrmica angulinodis* Ruzsky, 1905		+							-			
24	*Myrmica kasczenkoi* Ruzsky, 1905				+					-			
25	*Myrmica rubra* (Linnaeus, 1758)	+						-		-		-	

Table 2. Biogeography, ecology and genetics of 9 common species of ants from Kamchatka. Abbreviations of biogeographic regions: H: Holarctic; P: Palearctic; EP: East-Palearctic.

Species	N	Distribution	Ecology					No. of haplotypes	Genetic raw distance (%)		
			Open (lowland)	Stone birch forest	Larch/birch forest	Dwarf pine zone	Altitude (m)		Within Kamchatka	vs Europe	vs North America
Camponotus herculeanus	3	H			+		503–599	1	0	≥1.67	≥0.69
Formica lemani	12	P	+	+	+	+	18–841	2	0–0.15	≥0.64	
Formica lugubris	6	P	+	+	+	+	48–841	1	0	≥0	
Formica candida	5	EP	+				34–503	1	0		
Formica exsecta	4	P			+	+	526–951	1	0	≥0.15	
Formica gagatoides	7	H			+	+	575–951	1	0	≥1.37	≥0.52
Leptothorax acervorum	7	H			+	+	28–833	7	0.15–2.13	≥0.15	≥0.15
Myrmica displicentia	5	EP	+				25–148	2	0–0.31		
Myrmica kamtschatica	8	EP		+	+	+	14–834	1	0		

in these habitat types are shown in Table 2. Larch/birch forests at mid-elevations harbored the highest number of species, while the widespread stone birch communities at low elevations were species poor, with only 3 ant species observed (Table 2). No ants were observed in alpine tundra and plant-less habitats above 1200 m a. s. l.

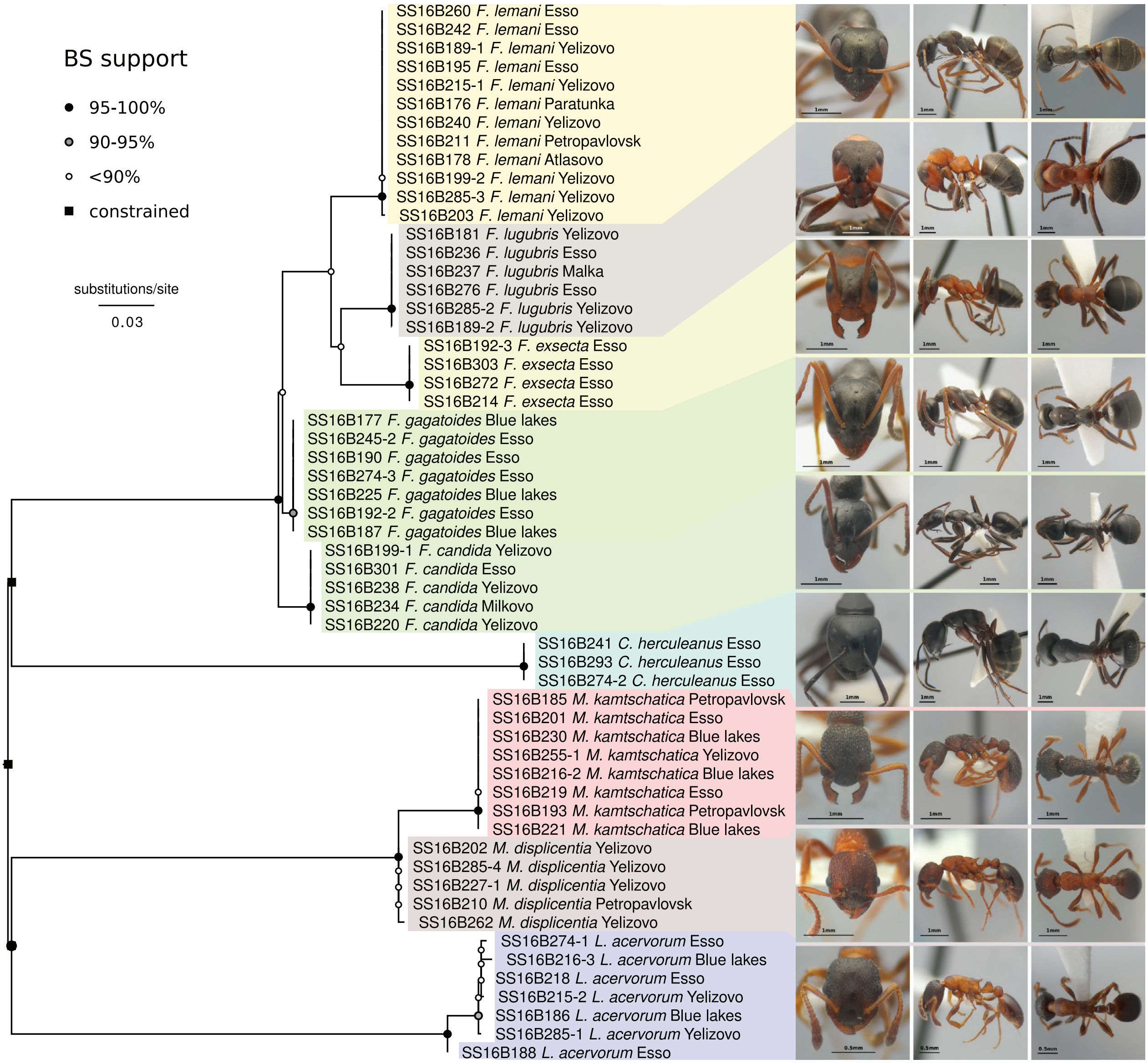

Figure 2. Maximum-likelihood tree of 57 COI DNA-barcode sequences representing 9 species of ants from Kamchatka. Pictures: S. Schär.

DNA-barcoding

DNA-barcoding succeeded in high quality for all 9 species and 57 specimens examined. For all but 2 specimens, the full length DNA-barcode (658 bp) could be retrieved. The exceptions were a specimen of *M. kamtschatica* and one of *M. displicentia*, for which sequences of 651 and 647 bp length were obtained. All 9 studied species were separated by a clear DNA-barcoding gap (Fig. 2). Interspecific genetic raw distance ranged from 2.3% (*F. candida* vs. *F. gagatoides*) to 22.5% (*C. herculeanus* vs. *L. acervorum*). Genetic diversity was low and for 6 of the 9 investigated species, only a single COI haplotype was found. Another 2 species (*Formica lemani* and *Myrmica displicentia*) were represented by 2 haplotypes each. The exception was *Leptothorax acervorum*, for which all 7 sequenced specimens displayed a different haplotype, and two haplogroups were detected (Fig. 3). Genetic raw distances within *L. acervorum* ranged between 0.15%–2.13% (Table 2). Genetic comparison to sequences on BOLD revealed that all except one encountered haplotypes of ants from Kamchatka were private, not found anywhere else so far. The exception is the only haplotype found for *F. lugubris*, which also occurs in Finland (Roslin et al. 2022). Closely related sequences were found for all observed haplotypes (Table 2), with the exception of the two *Myrmica* species endemic to East Asia. For those, the most closely related sequences were from unidentified *Myrmica* from the Primorje region of Far Eastern Russia (*M. displicentia*: 97.22%; *M. kamtschatica*: 97.41% similarity). Sequences were made accessible via the European Nucleotide Archive (see ESM for accession numbers).

Formica lemani or *F. fusca*?

The discriminant D suggested by Seifert (2018) to distinguish *F. lemani* from *F. fusca* in Europe allowed almost complete separation between the two species for samples

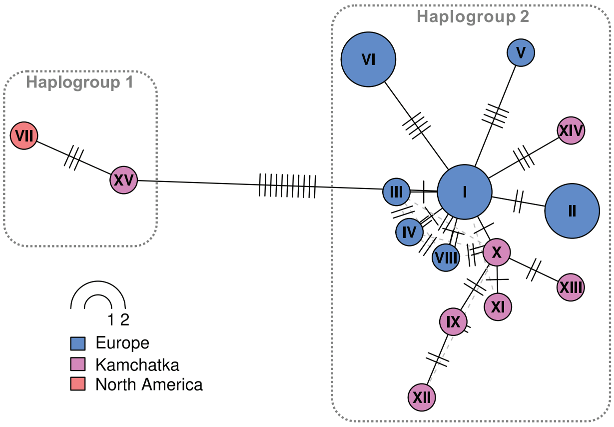

Figure 3. Haplotype network for 18 COI DNA-barcode sequences of *Leptothorax acervorum*. Sequences not from Kamchatka are from Schär et al. (2018).

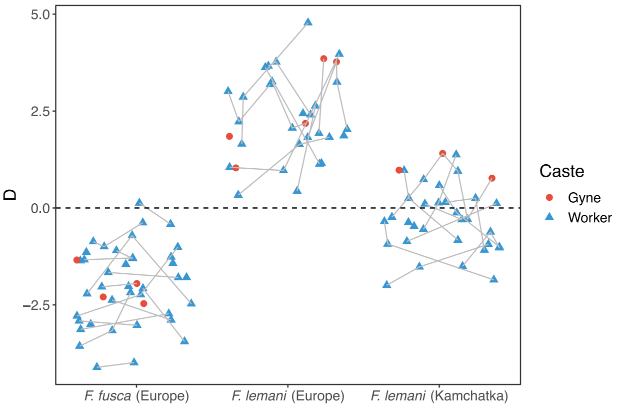

Figure 4. Scatterplot showing a morphometrical comparison of 34 *Formica lemani* ants from Kamchatka with 33 *F. lemani* specimens from from Europe and 43 *F. fusca* specimens from Europe. The discriminant D has been calculated according to Seifert (2018). For gynes, D was multiplied by -1 in order to match directionality of the discriminant used for workers. Symbols connected by lines are specimens from the same nests.

from Europe. Only a single *F. fusca* worker had a value for D slightly surpassing 0 (Fig. 4). For the investigated workers from Kamchatka, values of D were intermediate between European *F. lemani* and *F. fusca* (Fig. 4). About two-thirds (68%) of these workers had negative values of D, as European *F. fusca*, while the remaining third (32%) had positive values of D, as European *F. lemani*. None of the colonies from Kamchatka contained only workers with positive values of D, unlike European *F. lemani*. A different result was found for the 3 available gynes from Kamchatka, all of which yielded discriminant values suggestive of *F. lemani*. Additionally, they also showed a trait of *F. lemani*-gynes not included in the discriminant calculation, namely a shiny tergite I (covered by dense pubescence in *F. fusca*). Two of these gynes were found in the same nest with workers with partially negative values of D, as in European *F. fusca* (Fig. 4).

Key to the worker caste for the ants of Kamchatka

1 Waist 2 segmented 2
– Waist 1 segmented 7
2 Antenna 11 segmented 3
– Antenna 12 segmented 4
3 Tibiae with standing setae .... *Leptothorax acervorum*
– Tibiae with adjacent hairs only .... *Leptothorax muscorum*
4 In face view, frontal carinae curved around antennal sockets (Fig. 5A). In caudal view, antennal scape gently curved, long and slender proximally, continuously increasing in width distally (Fig. 5C) .... *Myrmica ruginodis*
– In face view, frontal carinae extend along head (curved rugae may be present underneath, Fig. 5B). In caudal view, antennal scape strongly curved or angled, robust, more or less equally wide along its length (Fig. 5D–F) 5
5 In caudal view, antennal scape sharply angled near insertion, its foot with a narrow, vertical fold (Fig. 5D). Mesosoma usually dark brown, propodeal spines short (Fig. 5G) .... *Myrmica kamtschatica*
– In caudal view, antennal scape curved near insertion, its foot without a vertical fold (a dark vertical line may be present) (Fig. 5E, F). Mesosoma yellowish to reddish brown, propodeal spines may be short or long (Fig. 5H, I) 6
6 In lateral view, propodeal spines long and slender. Sides of petiole with distinct horizontal rugae (Fig. 5H) .... *Myrmica sulcinodis*
– In lateral view, propodeal spines short. Sides of petiole smooth or with weak, irregular sculpture (Fig. 5I) .... *Myrmica displicentia*
7 In lateral view, dorsal outline of mesosoma not interrupted, convex or straight. Large, massive species, total length 7–10 mm .... *Camponotus herculeanus*
– In lateral view, dorsal outline of mesosoma interrupted, promesonotum bulged above level of propodeum. Smaller species, total length 4–8 mm 8
8 In full face view, posterior margin of head distinctly concave .... *Formica exsecta*
– In full face view, posterior margin of head straight or convex 9
9 In full face view, posterior margin of head with abundant setae. Body bicolored (black/reddish) .... *Formica lugubris*
– In full face view, posterior margin of head without or only scattered setae. Body concolorous dark 10

10 In dorsal view, entire gaster smooth and glossy. All tergites only with single, scattered microscopic pubescence hairs (Fig. 5J). Pronotum with setae .... *Formica candida*

– In dorsal view, at least tergite I matt, covered by a dense carpet of microscopic pubescence hairs (Fig. 5K, L) Pronotum often without setae 11

11 In dorsal view, tergite III shiny, with notably less dense pubescence than tergite I (Fig. 5K) .... *Formica gagatoides*

– In dorsal view, tergite III matt, with pubescence similarly dense as on tergite I (Fig. 5L) .... *Formica lemani*

Discussion

Checklist, biogeography and altitudinal patterns

Based on literature review, field work and DNA-barcoding, I conclude that the ant species diversity of Kamchatka is lower than could be assumed based on the published record. Unreliable, earlier species records may be based on incorrect collection information, taxonomic changes or misidentifications of taxonomically difficult taxa. However, Kamchatka is a large peninsula and most of it is poorly explored. Thus, the 12 species recognized here may be a conservative estimate. The low observed number of ant species encountered may be explained by the cold climate of Kamchatka in combination with its geographic isolation. The only land bridge connecting it to the mainland is mountainous and located at around 60°N (Fig. 1A). Most ant species are sensitive to low temperatures and only exceptionally cold resistant species are likely to have colonized the peninsula via this route. The southern part of the landmass is separated from the mainland by several hundreds of kilometers of ocean. Therefore, in contrast to boreal species, species adapted to more temperate climate may not have been able to colonize Kamchatka. This may also explain why only moderate altitudinal variation in ant communities was observed. Of the 9 species encountered in the field, 4 (*F. lemani*, *F. lugubris*, *L. acervorum* and *M. kamtschatica*) were found across the entire altitudinal range observed to be inhabited by ants (0–1000 m). Two species (*F. candida* and *M. displicentia*) were observed only below and 3 (*C. herculeanus*, *F. exsecta* and *F. gagatoides*) only above roughly 500 m a. s. l. (Table 2). The highest number of species was found at an intermediate altitude of around 500 m a. s. l., where all of these species could potentially co-occur. The low species and genetic diversity of ants also support the previous notion, that the fauna of Kamchatka resembles that of an island rather than that of a mainland peninsula (Jones and Solomina 2015).

DNA-barcoding

Similar to the low observed species diversity, genetic diversity and within species divergence in mtDNA was low too (Table 2). This could be a result of an edge effect due to recent colonization of Kamchatka by the investigated species. The exception was *L. acervorum*, which displayed a surprising level of COI diversity, with every sequenced sample being of a different haplotype and genetic distance raging up to 2.13% (Table 2). The latter high genetic distance was found due to a divergent *L. acervorum* sample (Figs 2, 3), belonging to a haplogroup previously only known from North America (Smith et al. 2016; Schär et al. 2018) (Fig. 3). The high genetic diversity found within *L. acervorum* in Kamchatka is surprising. Possible explanations include that Kamchatka has been a long term refuge for this species. Alternatively, it could be suggestive of a strong dispersal ability of *L. acervorum*, i. e. wind dispersal of the small sexual castes over long distances. This latter theory is also supported by a previous observation of an *L. acervorum*-haplotype occurring in both Canada and Europe (Ojeda et al. 2021). For the 3 Holarctic species (*C. herculeanus*, *F. gagatoides* and *L. acervorum*), comparison of DNA-barcodes with sequences on BOLD revealed the existence of closely related haplotypes (<1% distance) in North America (*C. herculeanus* and *F. gagatoides*) or in Europe and North America (*L. acervorum*). This suggests more recent gene-flow across Beringia than between West and East Palearctic in these taxa. On the other hand, low or even lack of genetic distances were found for the three *Formica* species with trans-Palearctic distributions (*F. exsecta*, *F. lemani* and *F. lugubris*). This could mean that the latter have expanded their distribution ranges more recently than the former three Holarctic species. It is less likely to be caused by better dispersal ability of *F. exsecta*, *F. lemani* and *F. lugubris*, because they are absent from the Nearctic. The two *Myrmica* species endemic to East Asia (*M. displicentia* and *M. kamtschatica*) have not been represented on BOLD before. Comparison to other BOLD specimens supported the current placement of both taxa within the *M. lobicornis* species group (Radchenko and Elmes 2010) and their separate status from other sequenced members of this group.

Formica lemani or *F. fusca*?

Among the questionable ant species records from Kamchatka, *F. fusca* is the one mentioned by the the most (3) literature sources (Table 1). Two of these sources also mentioned *F. lemani* from Kamchatka. Among the worker specimens examined here, two-thirds showed morphological traits more suggestive of *F. fusca*, while one third was suggestive of *F. lemani* (Fig. 4). Thus, the presence of both species appears plausible at first. However, two observations lead to the conclusion that all of these specimens belong to the same species:

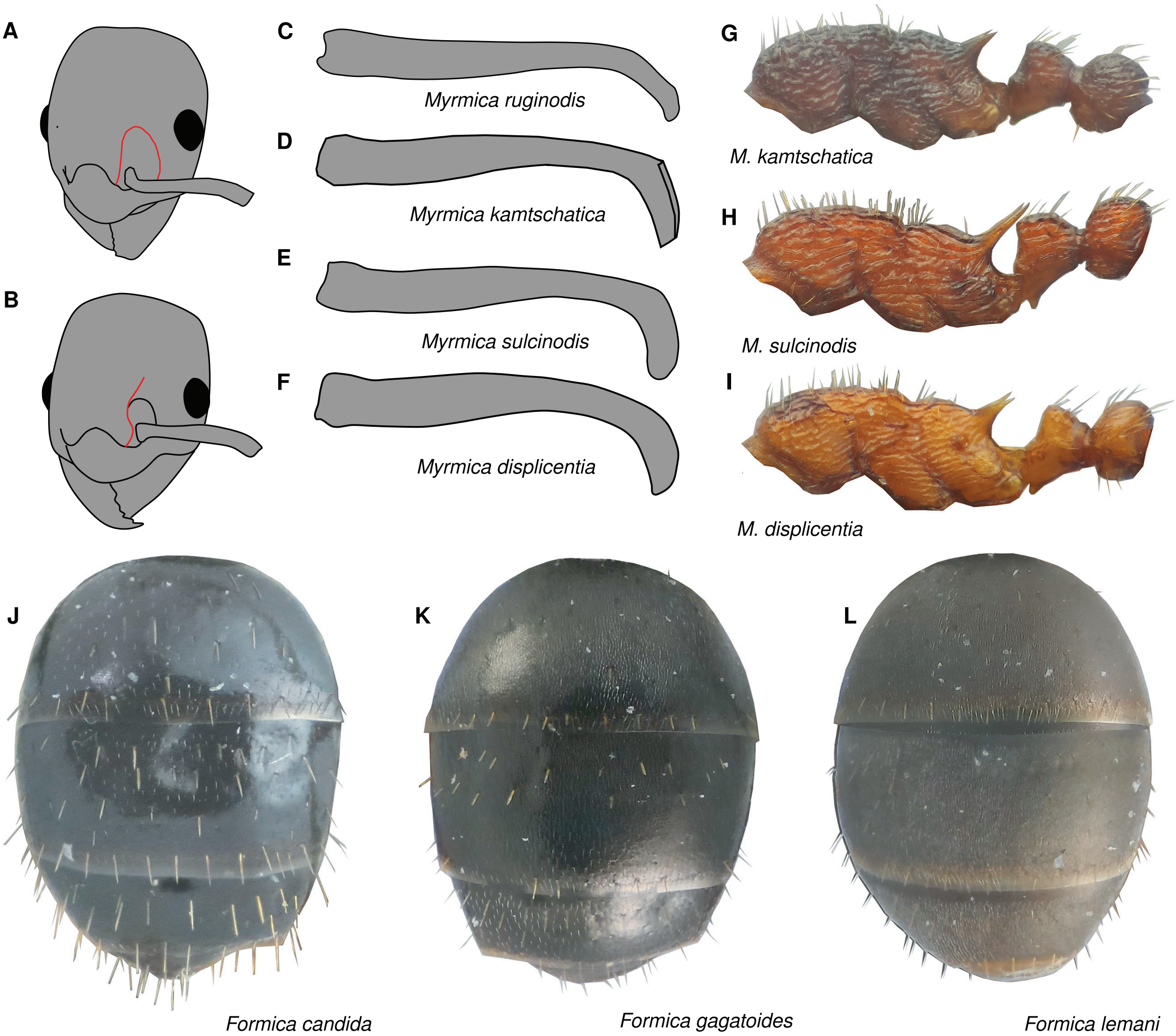

Figure 5. Morphological traits used for the identification of ants found in Kamchatka (see identification key).

1. Specimens with both morphologies are found in the same nests (Fig. 4), and no nest contained exclusively specimens with the traits of *F. lemani*.
2. All but one sequenced colonies had the same COI haplotype (Fig. 2). The remaining sequence differed from the others by just a single nucleotide change (0.15%, Table 2).

Additionally, despite the majority of workers resembling *F. fusca*, it is argued here that the name of this species is *F. lemani* rather than *F. fusca*, unless *F. lemani* would be revealed as a junior synonym of *F. fusca* in the future. This conclusion is entirely based on the morphology of gynes. Gynes of the two taxa are more distinguishable than workers. Workers differ almost only by the number of macro-setae, a trait that can vary within species in Hymenoptera (Sandrock et al. 2011) and therefore should be viewed as insufficient for taxonomic decision making. In gynes, the pubescence density on the first tergite is an additional trait used for discrimination of the two taxa: the first tergite of *F. fusca* gynes is covered by dense pubescence dorsally, leading to a matt appearance, while this body part is smooth and shiny due to low pubescence density in *F. lemani* gynes (Seifert 2018). The three gynes found from Kamchatka all had a shiny first tergite, along with high numbers of setae typical for *F. lemani* (Fig. 4). Two of these gynes were found in the same nest with workers resembling *F. fusca* (Fig. 4). In previous investigations, *F. fusca* and *F. lemani* could not be separated based on nuclear microsatellite markers (Seppä et al. 2011) and mitochondrial COI sequences (Schär et al. 2018). Similarly, rather low support for heterospecificity of these two taxa was also found for the mitochondrial Cyt-b gene (Antonov and Bukin 2016). It is therefore possible that *F. fusca* and *F. lemani* are morphs of the same species and this should be investigated in the future. If so, the name *F. fusca* Linnaeus, 1758 would have priority over *F. lemani* Bondroit, 1917.

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Supplementary material 1

Collection data, GenBank accession numbers and specimen images

Authors: Sämi Schär
Data type: pdf

Link: https://doi.org/10.3897/alpento.8.114185.suppl1

Supplementary material 2

Morphometric data for *Formica lemani* and *F. fusca*

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Data type: xlsx

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Alpine Entomology

First detection of ‘*Candidatus* Phytoplasma ulmi’ in Switzerland and in *Orientus ishidae* Matsumura, 1902

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Abstract

‘*Candidatus* Phytoplasma ulmi’ (*Ca.* P. ulmi) belongs to the ribosomal subgroup 16SrV-A and is associated with dieback, shoot proliferation and yellows disease on various *Ulmus* spp. Other plant species, such as *Carpinus betulus* and *Prunus* spp. have also been reported infected by the same pathogen. In 2021, in the frame of research activities focused on grapevine’s Flavescence dorée (FD), one specimen of *Orientus ishidae* - an East Palearctic leafhopper that was identified as an alternative vector of FD phytoplasmas - was found harboring *Ca.* P. ulmi in southern Switzerland. No phytoplasmas were detected in plant samples taken in the same location. *Orientus ishidae* has already been reported to be able to acquire diverse phytoplasmas associated with other plant diseases, such as Peach X-disease. This is the first report of *Ca.* P. ulmi in Switzerland, as well as in *O. ishidae*. *Ca.* P. ulmi may potentially be present in the wild compartment of the Swiss Pre-alpine and Alpine range, but no dedicated survey has so far been conducted. In the case of *O. ishidae*, this finding highlights the broad affinity of such a species for the acquisition of several phytoplasmas. This calls for a further investigation regarding its potential role as a vector on various pathosystems of agronomic importance.

Key Words

alien species, leafhopper, Neobiota, phytoplasma, vector

Introduction

Phytoplasmas are cell wall-less bacteria associated with the degradation of plant tissues and the manipulation of metabolic activity often leading to important agronomic losses (Bertaccini 2022). The infection of healthy plants is caused by the feeding activity of insect vectors, which passively acquire the pathogen from infected plant specimens. Once acquired, phytoplasmas multiply inside the insect’s organs. The infected vector becomes potentially infectious once the phytoplasmas reach the salivary glands (Bertaccini et al. 2019).

Among the diseases associated with phytoplasmas, grapevine’s Flavescence dorée (FD) is one of the most insidious and destructive ones, causing important economic losses to European viticulture (Tramontini et al. 2020). The phytoplasmas associated with FD and provisionally classified as ‘*Candidatus* Phytoplasma vitis’ (FDp) belong to the ribosomal subgroups 16SrV-C and D (Firrao et al. 2004; Lee et al. 2004). Considering the high risk of spread and the detrimental losses linked to FD, FDp is a quarantine organism in the European Union and Switzerland (Fedlex 2018; Tramontini et al. 2020). The epidemic spread of FD is caused by the Nearctic leafhopper *Scaphoideus titanus* Ball, 1932 (Hemiptera, Cicadellidae, Deltocephalinae) (Schvester et al. 1961; Chuche and Thiéry 2014). However, alternative host plant species, as well as alternative and putative vectors were identified. Among these, the leafhopper *Orientus ishidae* Matsumura, 1902 (Hemiptera, Cicadellidae, Deltocephalinae) was identified as an alternative vectoring agent of FDp in trials conducted by Lessio et al. (2016).

Moreover, and most importantly for the particular case of southern Switzerland, several studies showed that *O. ishidae* may locally play a role in the maintenance of FD, mostly in the landscape (Casati et al. 2017; Jermini et al. 2019; Malembic-Maher et al. 2020; Rizzoli et al. 2021). *Orientus ishidae* is native to Asia and was found in 1998 for the first time in Europe (Guglielmino 2005), where it now spread to most of the continent (EPPO Global Database 2023). Some of the host plants of *O. ishidae* are *Corylus avellana*, *Acer* spp., *Alnus glutinosa*, *Salix* spp. and *Carpinus betulus* (Nickel 2010; Rizzoli et al. 2021), which are very common in European forests and thus, quite often found near vineyards. Some of these species, such as *A. glutinosa* and *C. avellana* have already been reported harboring FDp genotypes (Arnaud et al. 2007; Casati et al. 2017; Malembic-Maher et al. 2020; Rizzoli et al. 2021; Kogej Zwitter et al. 2023) and may thus be involved in alternative epidemiological cycles of FDp. Moreover, *O. ishidae* is able to oviposit on grapevines and gone-wild grapevines, thus exacerbating the risk of FDp flow between the cultivated and the wild compartment when newly hatched nymphs have a direct access to infected plant material (Lessio et al. 2019; Oggier et al. 2023). In addition to FDp, *O. ishidae* is able to acquire '*Candidatus* Phytoplasma pruni' belonging to subgroup 16SrIII-A and associated with Peach X-disease (Rosenberg and Jones 1978). Recently, Dalmaso et al. (2023) also reported the capability of *O. ishidae* to acquire '*Candidatus* Phytoplasma mali' associated with Apple Proliferation (16SrX-A) in field trials conducted in Trentino-Alto Adige (Italy), the most important region for apple production in Italy and the Alpine region.

This manuscript reports the first finding of '*Candidatus* Phytoplasma ulmi' (*Ca.* P. ulmi, ribosomal subgroup 16SrV-A) in Switzerland and in *O. ishidae*. *Ca.* P. ulmi is associated with dieback, shoot proliferation and yellows disease on various *Ulmus* spp. (Lee et al. 2004). So far, it has been recorded in several European countries, such as Italy (Pisi et al. 1981), Germany (Mäurer et al. 1993), and France (Boudon-Padieu et al. 2004). In addition to *Ulmus* spp., *Ca.* P. ulmi may infect other plant species, as recently observed by Rigamonti et al. (2023), who found infected hosts belonging to the species *Carpinus betulus*, *Prunus domestica*, and *P. ulmifolius* in Northwestern Italy. To date, *Scaphoideus luteolus* Van Duzee, 1894 (Hemiptera, Cicadellidae, Deltocephalinae), *Macropsis glandacea* Fieber, 1868 (Hemiptera, Cicadellidae, Eurymelinae, syn. *Macropsis mendax*), and *Amplicephalus curtulus* Linnavuori & DeLong, 1977 (Hemiptera, Cicadellidae, Deltocephalinae) have been identified as competent vectors of *Ca.* P. ulmi in the United States of America, Italy, and Chile, respectively (Baker 1949; Carraro et al. 2004; Arismendi et al. 2014). To our knowledge, no previous studies were ever conducted on the Palearctic species *M. glandacea* in relation to phytoplasmas in Switzerland. As for *S. luteolus* and *A. curtulus*, no further indication regarding their potential presence in continental Europe is known.

Materials and methods

Study area and experimental design

The study area comprised Canton Ticino (southern slope of the Swiss Alps). In the frame of current research activities regarding the FD epidemics in vineyards and their surroundings, experimental plots are monitored for the presence of FDp vectors and grapevines carrying symptoms linked to Grapevine Yellows are routinely marked and sampled for molecular analysis. Leafhopper populations in vineyards are surveyed with a minimum amount of six yellow sticky traps (YST; Rebell Giallo, Andermatt Biocontrol AG, Switzerland) hanged on the highest wire of the training system. In the surrounding landscape, at least four YST mounted on wooden sticks (ca. 1.50 m off the ground) are placed in the direct proximity of spontaneous plant species, such as *A. glutinosa*, *C. avellana*, *Acer* spp., etc., which are known to host alternative FDp vectors (e.g., *O. ishidae*). In 2021, 16 new plots were added to the standard design to monitor the possible presence of FDp vectors in the surroundings of gone-wild grapevines and/or rootstock resprouts originating from incorrect or incomplete rogueing of former vineyards located in the direct proximity of currently cultivated vineyards (Oggier et al. 2023). In these additional plots, YST were generally placed in fewer amounts and later during the season (from August onwards). The following year, the monitoring design was enhanced by adding additional YST and by extending the sampling period, which started in mid-July, in order to increase the chances of capturing FDp vectors imagoes during the population peak. The landscape surrounding each plot was described using parameters, such as dominant tree species, including presence and abundance of known host plant species of either FDp and/or alternative vectors, such as *O. ishidae* (e.g., *A. glutinosa*, *C. avellana*, *Salix* spp., etc.). If available, a set of random leaves originating from rootstocks and gone-wild grapevines was collected during the month of September in 2021 and 2022.

Insect and leaf processing

Leafhoppers determination was conducted using a stereo microscope (Olympus SZX16 with SDF PLAPO 1XPF objective lenses, made in Japan). For the particular case of *O. ishidae*, the morphological key provided by Günthart and Mühlethaler (2002) was used. After detaching target insects from YST using Glurex forte (D-Limonene 50–100%; Andermatt Biocontrol AG, Switzerland) and Ethanol (70% v/v), the specimens were transferred into tubes with Ethanol (99% v/v) and stored at −20 °C. Grapevine leaves were excised with scissors. The petioles and the major veins were then frozen at −20 °C until further processing.

Nucleic acid extraction and phytoplasma detection

Each insect was individually homogenized in 900 µL of extraction buffer (3% Cetyltrimethylammonium bromide CTAB, 1.4 M NaCl, 25 mM EDTA, 1 M Tris-HCl, 2 µL β-Mercaptoethanol, pH 8.0) and shaken for 30 min at 600 rpm and 65 °C. 900 µL of Chloroform/Isoamylalcohol was added, homogenized by vortexing for 5 s and centrifuged for 5 min at 3000× *g*. The aqueous layer was carefully transferred to a new tube, mixed with an equal volume of cold Isopropanol, and incubated 60 min at −20 °C for DNA precipitation. Precipitated material was recovered by 2 min of centrifugation at 10000× *g* and washed with 1 mL of 70% Ethanol. A DNA pellet was dried overnight at room temperature and resuspended into 100 µL of PCR-grade water. For plant samples, 0.5 to 1 g of petioles and midribs from 3 to 4 different leaves per specimen were ground in 6 mL of extraction buffer using a Homex grinder (Bioreba). Subsequently, 2 mL of this homogenate was centrifuged for 10 min at 1000× *g*. 900 µL of the supernatant was processed as described above.

The presence of 16SrV group phytoplasma in the samples was assessed by quantitative PCR analysis according to Hodgetts et al. (2009). Cycling conditions were 5 min at 95 °C followed by 42 cycles of 15 sec at 95 °C and 1 min at 60 °C, using a CFX96 real-time PCR instrument (Bio-Rad). PCR amplifications were carried out in 25 µL reactions using 20 pmol of forward and reverse primer, 1 to 2 µL of DNA template, with GoTaq G2 Flexi DNA polymerase (Promega) following manufacturer's instructions. The *map* and *imp* genes loci were amplified by nested PCR according to Arnaud et al. (2007) and Trivellone et al. (2019), respectively.

Sequencing and data analysis

PCR products were controlled by electrophoresis on a 1% agarose gel and purified by ultrafiltration with NucleoFast 96 PCR plates (Macherey-Nagel). Products were sent to Fasteris (Plan-les-Ouates, Switzerland) for forward and reverse sequencing using Sanger technology. Trees were inferred by maximum likelihood method in MEGA using the General Time Reversible model and bootstrapping with 500 replicates. All trees were visualized with iTOL (https://itol.embl.de, accessed on 14 September 2023; Letunic and Bork 2021).

Results

In the frame of the research activities associated with FD, we analyzed 16 *O. ishidae* specimens caught in 2021 (out of 26 YST) and 267 caught in 2022 (out of 85 YST) for a total of 283 insects. One of the three specimens of *O. ishidae* caught in 2021 in the additional plot of Cugnasco (WGS84 coordinates 46.18037, 8.91938) was found harboring *Ca.* P. ulmi. The infected insect was captured between 1 and 14 October 2021. All specimens caught the following year in the same plot resulted free of *Ca.* P. ulmi ($N = 6$, $N_{YST} = 1$). No other tested insect species, such as *S. titanus* was found infected by *Ca.* P. ulmi (data not shown). The four grapevines sampled in the plot of Cugnasco in 2021 resulted free of external symptoms linked to Grapevine Yellows and phytoplasma.

The sequence of the *secY-map* gene obtained from the infected *O. ishidae* is 100.00% identical to the reference strain AM384900 *Ca.* P. ulmi, isolate E04-D438 found in France, Loire Atlantique, previously reported by Arnaud et al. (2007). The comparison of the *imp* gene also confirmed the detection of *Ca.* P. ulmi (isolates MT668492, MT668497, MT668435). The amplicon has 1 single nucleotide polymorphism (99.78% identity) compared to the sequence of MT668492 (*Ca.* P. ulmi isolate 4319 Ug from Germany). The sequence was deposited on the NCBI database under accession number OR594266. The phylogenetic trees in Fig. 1 show the relationship between the sequences of the *secY-map* and the *imp* genes, respectively, obtained in this work and reference strains (see Table 1 for GenBank Accession no. and further details).

Discussion

This communication reports the first account of *Ca.* P. ulmi in Switzerland, as well as the first record of *O. ishidae* harboring such phytoplasmas, in general. *Ca.* P. ulmi was identified during routine molecular analyses conducted in the frame of an ongoing research project focused on FDp in vineyards and in the adjacent wild compartment in the Swiss southern Alps.

'*Candidatus* Phytoplasma ulmi' may already be present in Swiss *Ulmus* spp., as well as in other host plant species both on the Alpine range and on the Swiss Plateau. However, no proper surveys have so far been conducted in order to confirm its presence and potential impact on mountainous and Alpine ecosystems. Most interestingly, *O. ishidae* appears to be able to acquire other phytoplasma strains in addition to genotypes belonging to the ribosomal subgroups 16SrV-C and 16SrV-D (Mehle et al. 2010; Casati et al. 2017; Rizzoli et al. 2021), 16SrIII-A (Rosenberg and Jones 1978), and 16SrX-A (Dalmaso et al. 2023). However, in the specific case of *Ca.* P. ulmi in the study area, the infection rate for *O. ishidae* seems to be very low (1/283), when considering the molecular analyses conducted in 2021 and 2022. The substantial difference of captured specimens between 2021 and 2022 was mostly due to the period of sampling, which in 2021 was shorter and did not cover the population's peak. *Orientus ishidae* is present in almost all continental Europe including mountainous Pre-alpine and Alpine ranges (EPPO Global Database 2023). Host plant species of particular agronomic importance, such as grapevine and apple (De Meyer 2014; International Organisation of Vine and Wine 2023), are widely cultivated in the same contexts and spontaneous woody plant species, such as *Ulmus* spp.

Table 1. Phytoplasma isolate from *Orientus ishidae* obtained in this work and reference strains along with the relative GenBank accession number, compared genes, host, geographic origin and reference.

Sample ID or reference strain	GenBank accession no.	Gene(s)	Host	Phytoplasma strain and genotype	Geographic origin	Reference
Ca. P. ulmi isolate Cugnasco CH	OR594266	*map imp*	*Orientus ishidae*	*Ca.* P. ulmi	Switzerland, Canton Ticino	This work
Ca. P. ulmi isolate E04-D438	AM384900	*secY map*	*Ulmus minor*	*Ca.* P. ulmi	France, Loire Atlantique	Arnaud et al. (2007)
Ca. P. ulmi isolate EY18_SRB	HM038478	*secY map*	*Ulmus laevis*	*Ca.* P. ulmi	Serbia	Jović et al. (2011)
Ca. P. ulmi isolate NK16	KU202150	*secY map*	*Ulmus laevis*	*Ca.* P. ulmi	Croatia	Katanić et al. (2016)
Ca. P. ulmi isolate E04-D714	AM384901	*secY map*	*Ulmus glabra*	*Ca.* P. ulmi	France, Haute-Vienne	Arnaud et al. (2007)
Ca. P. ulmi isolate EY1	GU004330	*map cds*	Plant leaf material	*Ca.* P. ulmi	USA	Lee et al. (2010)
map M50 isolate VF-06-27-5	LT221945	*map*	*Vitis vinifera*	*Ca.* P. vitis FD1 M50	France, Acquitaine	Malembic-Maher et al. (2020)
map M38 isolate Al-031-08	LT221933	*map*	*Alnus glutinosa*	*Ca.* P. vitis FD2 M38	Italy, Veneto	Malembic-Maher et al. (2020)
map M51 isolate VS-Loza37	LT221946	*map*	*Vitis vinifera*	*Ca.* P. vitis FD3 M51	Serbia	Malembic-Maher et al. (2020)
map M54 isolate VF06-30-18	LT221949	*map*	*Vitis vinifera*	*Ca.* P. vitis FD2 M54	France, Acquitaine	Malembic-Maher et al. (2020)
Ca. P. ziziphi isolate Jwb-nky	CP025121	*map*	*Ziziphus jujuba* Mill	*Ca.* P. ziziphi	China	Wang et al. (2018)
4319_Ug_SN	MT668492	*imp*	*Ulmus glabra*	*Ca.* P. ulmi	Germany	Schneider et al. (2020)
5554_Ug_MV	MT668497	*imp*	*Ulmus glabra*	*Ca.* P. ulmi	Germany	Schneider et al. (2020)
0865_Ug_BYs	MT668435	*imp*	*Ulmus glabra*	*Ca.* P. ulmi	Germany	Schneider et al. (2020)
2261_Ug_HE	MT668459	*imp*	*Ulmus glabra*	*Ca.* P. ulmi	Germany	Schneider et al. (2020)
2226_Ug_HE	MT668458	*imp*	*Ulmus glabra*	*Ca.* P. ulmi	Germany	Schneider et al. (2020)
4167_Ul_SN	MT668491	*imp*	*Ulmus* sp.	*Ca.* P. ulmi	Germany	Schneider et al. (2020)
ULW	MT418908	*imp*	*Ulmus minor*	*Ca.* P. ulmi	Germany	Schneider et al. (2020)
2732_Um_BB	MT668465	*imp*	*Ulmus* sp.	*Ca.* P. ulmi	Germany	Schneider et al. (2020)
FD70	MT668500	*imp*	*Vicia faba*	*Ca.* P. vitis FD70	France	unpublished
ALY1	MT668499	*imp*	*Alder* sp.	Alder yellows phytoplasma	Germany	Schneider et al. (2020)
FD-D	MK614707	*imp*	*Vitis vinifera*	*Ca.* P. vitis FD-D	Italy	Trivellone et al. (2019)
Ca. P. ziziphi isolate Jwb-nky	MG818479	*imp*	Chinese jujube	*Ca.* P. ziziphi	China	unpublished

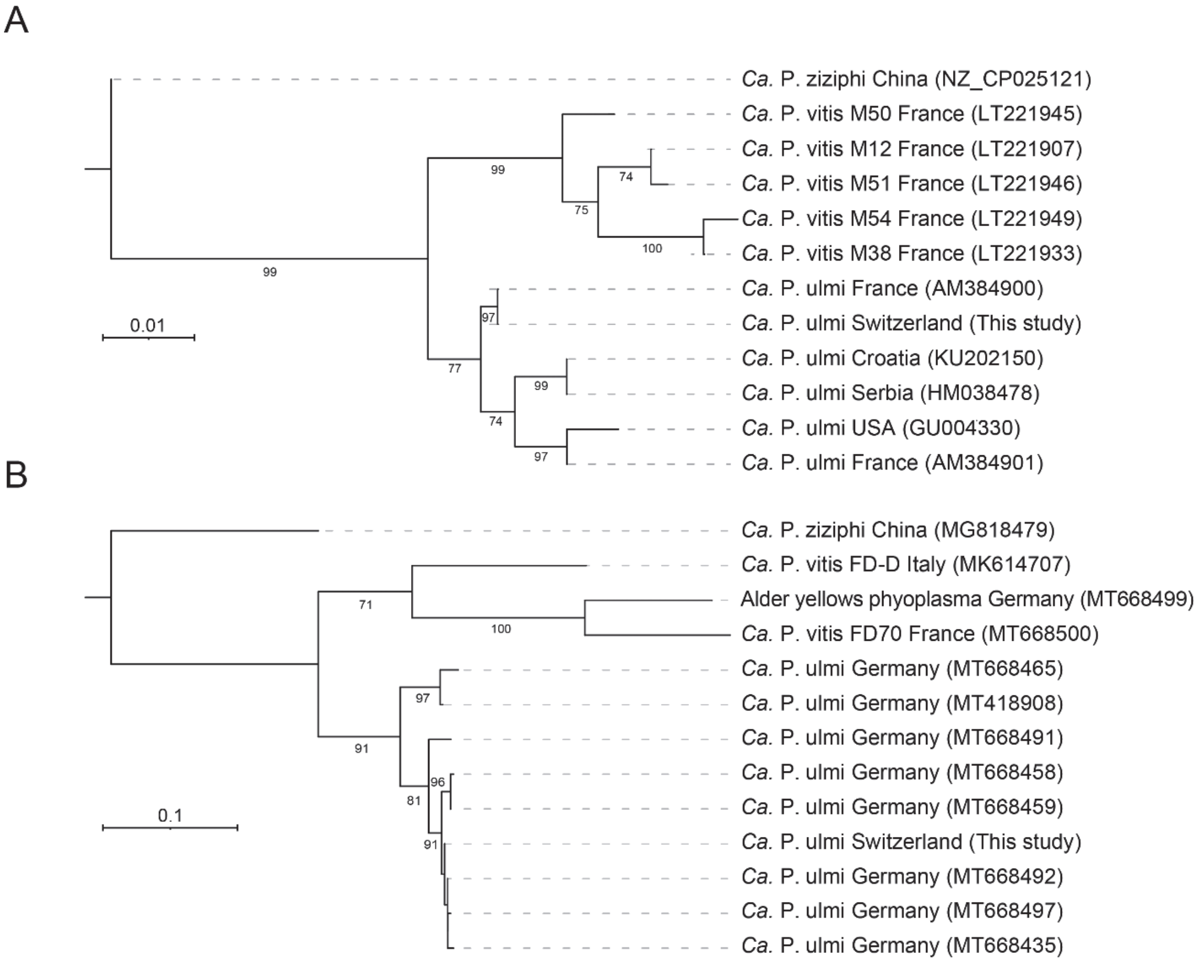

Figure 1. Phylogenetic tree of the *secY-map* (**A**) and *imp* (**B**) genes sequences from *Orientus ishidae* obtained in this work and reference strains from Genbank (see Table 1). Maximum likelihood phylogeny based on nucleotide sequences of (**A**) *map* (543 bp) and (**B**) *imp* (465 bp) genes. The numbers on branches indicate the level of bootstrap support (500 replicates). Support values above 70% are labeled. The scale bar shows the number of substitutions per site.

and *C. avellana* are very common in the whole geographic range. Therefore, *O. ishidae* seems to be a wild-card in several pathosystems and further research is needed in order to better understand its ecology and potential impact on agriculture, as well as on the overall health of spontaneous woody plant species inhabiting different ecosystems, including the whole Alpine range.

Author contributions

Alan Oggier: Conceptualization, investigation, formal analysis, data curation, writing - review and editing. **Christophe Debonneville:** Methodology, investigation, formal analysis, visualization, software, validation, writing - review and editing. **Marco Conedera:** Writing – review and editing, funding acquisition, project administration. **Olivier Schumpp:** Writing – review and editing, resources, validation. **Attilio Rizzoli:** Conceptualization, methodology, writing – original draft, writing – review and editing, validation, supervision.

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Alpine Entomology

Distribution of the invasive ambrosia beetle *Anisandrus maiche* (Coleoptera, Scolytinae) in Switzerland and first record in Europe of its ambrosia fungus *Ambrosiella cleistominuta*

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Abstract

Ambrosia beetles are highly successful as invaders because they are often transported internationally with wood packaging and other wood products and because their inbreeding mating systems facilitates establishment of invading populations. In 2022, two independent insect surveys in canton Ticino (southern Switzerland) revealed the widespread occurrence of the invasive ambrosia beetle *Anisandrus maiche* (Kurentzov, 1941) from southern to central-upper Ticino. This species is native to east Asia and has previously been found as a non-native invasive species in the United States, Canada, western Russia, Ukraine and, in 2021, in northern Italy. Here, we present the results of several trapping studies using different trap types (bottle traps, funnel traps and Polytrap intercept traps) and attractants and a map of the distribution of the species. In total, 715 specimens of *A. maiche*, all female, were trapped, and the identity of selected individuals was confirmed by morphological and molecular identification based on three mitochondrial and nuclear markers (COI, 28S and CAD). Trap samples from early April to early September 2022 in intervals of two to four weeks showed that flights of *A. maiche* occurred mainly from June to mid-August. Isolation of fungal associates of *A. maiche* from beetles trapped alive revealed the presence of four fungal species, including the ambrosia fungus *Ambrosiella cleistominuta*, the known mutualist of *A. maiche*. The identity of *A. cleistominuta* was confirmed by comparing DNA sequences of its nuclear, internal transcribed spacer (ITS) gene with reference sequences in NCBI and BOLDSYSTEMS. This represents the first record of *A. cleistominuta* in Europe. Of the other fungal associates isolated from *A. maiche* in Ticino, *Fusarium lateritium* is of note as there is a possibility that *A. maiche* could act as a vector of this plant pathogen. We highlight several research needs that should be addressed to gain insight into the potential impact of these non-native species and to overcome problems with heteroplasmy in COI sequences in studies of invasion and population genetics of ambrosia beetles.

Key Words

Bark and ambrosia beetles, biological invasions, Ceratocystidaceae, Curculionidae, detection, surveillance

Introduction

Biological invasions are a growing concern due to the continuing increase in establishments of non-native (alien) invasive species and their impacts on native species, natural and modified ecosystems and on plant, animal and human health (Kenis et al. 2009; Brockerhoff et al. 2017; Seebens et al. 2018; Pyšek et al. 2020). Bark and ambrosia beetles (Coleoptera: Curculionidae, Scolytinae) are particularly successful as invaders because they are often transported internationally by trade and transport of wood products and due to the widespread use of wood packaging materials such as pallets and crates (Brockerhoff et al. 2006; Lantschner et al. 2020). In addition, many ambrosia beetles have mating systems that involve inbreeding (Kirkendall 1983) which greatly facilitates the establishment of new populations by very few invading individuals (Kirkendall and Faccoli 2010; Lantschner et al. 2020). Furthermore, because ambrosia beetles feed only on specific ambrosia fungi (on which they are nutritionally dependent and which they carry in their mycangia and cultivate in galleries they excavate in deadwood), these beetles often have a very wide host range (e.g., Ranger et al. 2016; Hulcr and Stelinski 2017). This also contributes to their invasiveness since they are less dependent on the presence of a particular host species. Native ambrosia fungi are typically not pathogenic, but some non-native ambrosia beetles are vectors of severe plant pathogens that can cause tree death. For example, the Asian *Xyleborus glabratus* Eichhoff, 1877 and its symbiotic tree pathogen *Raffaelea lauricola* T.C. Harr., Fraedrich & Aghayeva (Harrington et al. 2008), the causal agents of laurel wilt, are responsible for large-scale mortality of many trees in the Lauraceae family in the southeastern United States (Fraedrich et al. 2008; Hughes et al. 2017).

Anisandrus maiche (Kurentzov, 1941) is an invasive ambrosia beetle native to northeast Asia (i.e., parts of China, Japan, North and South Korea, and the Russian Far East) (Knížek 2011; Terekhova and Skrylnik 2012; Alonso-Zarazaga et al. 2017, 2023; Park et al. 2020; Smith et al. 2020; EPPO 2022). Established non-native populations of *A. maiche* were detected in North America first in 2005 in Pennsylvania, USA, and subsequently in the US states of Ohio, West Virginia, Illinois, Indiana, Maryland, New Jersey, New York, and Wisconsin, and in the Canadian Provinces Ontario and Quebec (Rabaglia et al. 2009; Haack et al. 2013; Gomez et al. 2018; Thurston et al. 2022). In Europe, non-native populations were detected first in 2007 in western Russia and in eastern Ukraine (Moscow oblast, Belgorod oblast, Donetsk oblast, Kharkiv oblast and Sumy oblast (Nikulina et al. 2007; Nikitskii 2009; Terekhova and Skrylnik 2012; Kovalenko and Nikitski 2013; Nikulina et al. 2015)). About 14 years later, in 2021–2022, this beetle was found in the Italian regions Veneto and Lombardy (Colombari et al. 2022; Ruzzier et al. 2022).

In July 2022, we collected several specimens of *A. maiche* in trap catches from two locations in central canton Ticino, in southern Switzerland. Subsequently, many more specimens were found in trap catches from several other locations across the southern half of canton Ticino and in the southwestern part of canton Grisons, suggesting that the species has been established in these areas for several years. As of 2023, *Anisandrus maiche* is regulated as a quarantine pest in Switzerland (PGesV (2018) and PGesV-WBF-UVEK (2019)) and the EU, as are all non-European Scolytinae that are not present in the EU. However, its classification as a quarantine pest is being reviewed.

Here, our objectives are to report the discovery of *Anisandrus maiche* in Switzerland, the locations and forest types where it was found, and the traps and attractants with which the species was caught. Furthermore, we provide information on the fungal and microbial associates which we recorded from *A. maiche* in Switzerland, including its ambrosia fungus *Ambrosiella cleistominuta* C. Mayers & T.C. Harr., and on potential damage caused by this beetle, based on a review of available information.

Materials and methods

Abbreviations used

FPS	Forest Protection Switzerland (Waldschutz Schweiz), Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland;
MCSN	Museo cantonale di storia naturale (Natural History Museum), Lugano, Switzerland;
PHP	Phytopathology, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland;
UPN	Ufficio della Natura e del Paesaggio, Bellinzona, Switzerland;
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland

Study sites of *A. maiche* in cantons Ticino and Grisons, and description of traps and attractants

All study sites in Switzerland where *A. maiche* was found are located in the southern part of the country in the cantons Ticino (40 sites) and Grisons (one site, Roveredo) (Table 1, Fig. 1). The sites were in mixed forests composed mostly of sweet chestnut (*Castanea sativa*), oak (*Quercus* sp.), Scots pine (*Pinus sylvestris*) and other tree species, with varying proportions of broadleaved trees and conifers.

Five trap type and lure combinations were used in 2022 during several insect surveys in which *A. maiche*

Table 1. Study site locations, traps used and the number of *Anisandrus maiche* trapped in 2022. Trap types: BT, bottle trap; FG, funnel trap green; FB, funnel trap black; PT, Polytrap. Lures: E, ethanol; EA, ethanol + alpha-pinene; EA8, ethanol + alpha-pinene + eight-component blend (for details about trap types and lures see methods).

Study site location and Canton*	Swiss coordinates (E, N (LV 95))	Degrees latitude, longitude (WGS84)	Elevation (m a.s.l.)	Trap type and lure	Number of *A. maiche* trapped (total / number per trap day from June to August)
(1) Riviera-Iragna 1, TI	2717293, 1133879	46.3460, 8.9623	286	BT/E	134 / 1.47
(2) Riviera-Iragna 2, TI	2717138, 1134143	46.3484, 8.9604	285	BT/E	50 / 0.53
(3) Serravalle-Leggiuna 1, TI	2718898, 1138748	46.3895, 8.9844	362	BT/E	53 / 0.51
(4) Serravalle-Leggiuna 2, TI	2718937, 1138900	46.3909, 8.9849	386	BT/E	11 / 0.16
(5) Faido-Anzonico 1, TI	2708760, 1144009	46.4386, 8.8539	970	BT/E	0 / 0.00
(6) Faido-Anzonico 2, TI	2708628, 1143968	46.4382, 8.8521	916	BT/E	0 / 0.00
(7) Brusino-Arsizio, TI	2715995, 1086645	45.9215, 8.9338	320	BT/E	36 / 1.20
(8) Bellinzona-Camorino, TI	2722160, 1113855	46.1651, 9.0203	460	BT/E	23 / 0.77
(9) Losone, TI	2700175, 1114515	46.1747, 8.7359	275	BT/E	111 / 3.70
(10) Novazzano, TI	2720790, 1078230	45.8449, 8.9934	268	BT/E	45 / 1.50
(11) Roveredo, GR	2730490, 1120800	46.2260, 9.1301	505	BT/E	41 / 1.37
(12) Rivera-Carona, TI	2714268, 1110343	46.1349, 8.9173	517	FG/EA8	5 / 0.06
(13) Moleno, TI	2720086, 1125929	46.2741, 8.9966	255	FG/EA8	6 / 0.07
(14) Chiasso-Bresciano, TI	2721348, 1077091	45.8346, 9.0003	262	FG/EA8	1 / 0.01
(15) Riviera-Iragna 3, TI	2717083, 1134188	46.3489, 8.9597	286	FB/EA8	1 / 0.01
(16) Chiasso-Pian Pessina, TI	2723687, 1076070	45.8250, 9.0302	440	FB/EA8	0 / 0.00
(17) Chiasso-Bresciano, TI	2721348, 1077091	45.8346, 9.0003	262	FB/EA8	2 / 0.02
(18) Faido-Anzonico 1, TI	2708760, 1144020	46.4387, 8.8539	970	FB/EA	0 / 0.00
(19) Faido-Anzonico 2, TI	2708628, 1143968	46.4382, 8.8522	915	FB/EA	2 / 0.02
(20–134) entire Canton TI	See Sanchez et al. (2023) and Suppl. material 1			PT / –	194 / 0.07

* Two-letter abbreviation for Cantons, TI – Ticino, GR – Grisons.

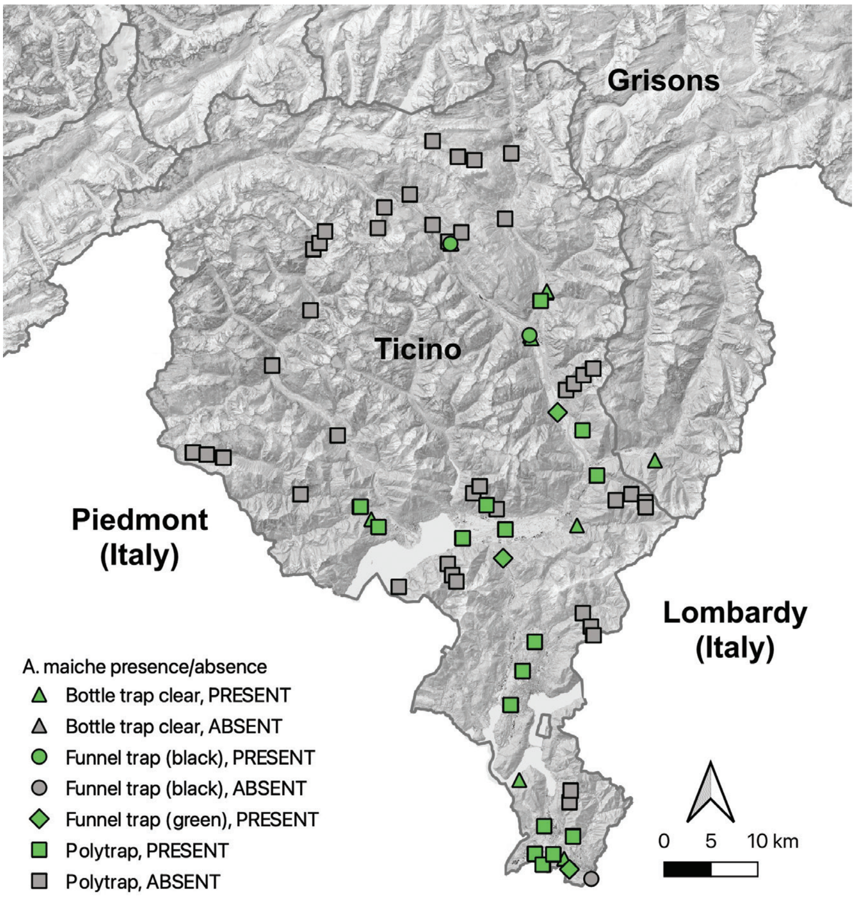

Figure 1. Trap locations in cantons Ticino and Grisons where *Anisandrus maiche* was captured (green symbols) or where no captures were recorded (grey symbols). Symbols vary by trap type (see legend and methods for details). Note that each square represents a pair of two Polytraps which were placed in close proximity to each other (Vector and raster map data https://www.swisstopo.ch).

was caught. **Type 1** (**bottle traps**, "**BT**") traps consisted of bottle traps made at the laboratory based on the design described in Grégoire et al. (2001) and as modified by Gossner et al. (2019) with 70% ethanol as lure and propylene glycol as preservative and installed such that the bottle part was about 1 m above ground (Suppl. material 3: fig. 1a). Two BT were installed at three study sites near Biasca (see Table 1) on 2 April 2022 and taken down on 26 August 2022. Five further single BT were installed at additional study sites (see Table 1) on 18 July 2022 and removed on 30 August 2022. A small number of additional "live bottle traps" were used without propylene glycol to enable live captures for studies of fungal associates (see below).

Type 2 (**funnel traps green**, "**FG**") traps were green multi-funnel traps (ChemTica Internacional, Costa-Rica, Suppl. material 3: fig. 1b) with propylene glycol as preservative and baited with alpha-pinene and ethanol (Econex, Spain) and an 8-component lure blend (fuscumol, fuscumol acetate, geranylacetone, monochamol, 3-hydroxyhexan-2-one, anti-2,3-hexanediol, 2-methylbutan-1-ol, and prionic acid) as described by Fan et al. (2019). FG traps were suspended by a rope inside the canopy of trees at a height of approximately 10 m. One of these traps was installed at each study site (see Table 1) on 12 April 2021 and taken down on 1 or 29 September 2021. These traps, as well as the black funnel traps mentioned below, were part of a separate project aimed at early detection of quarantine pests, especially longhorned beetles (Cerambycidae) but they are also effective for bark and ambrosia beetles (see Roques et al. 2023).

Type 3 (**funnel traps, black**, "**FB**") traps were black multi-funnel traps (ChemTica Internacional, Costa-Rica, Suppl. material 3: fig. 1c) with propylene glycol as preservative and the same lure combination and trapping period as Type 2. FB traps were suspended by a rope below the canopy of trees at a height of 2–3 m above ground. One of these traps was installed at each study site (see Table 1) on 12 April 2021 and taken down on 1 or 29 September 2021. Trapping with funnel traps (FG and FB) in 2021 was undertaken as part of a surveillance programme aimed at priority quarantine pests targeting mainly longhorn beetles.

Type 4 (**Polytrap**, "**PT**") traps were unbaited Polytrap interception traps (as described by Brustel 2012, Suppl. material 3: fig. 1d) with saturated salt solution and neutral detergent as preservative, suspended 2 m above the ground. As part of a biodiversity survey funded by canton Ticino (MCSN and UPN), a total of 114 Polytraps were installed on 10 March 2022 and taken down at the end of 3 October 2022 (see Sanchez et al. (2023) for details).

In addition to the traps described above, collection of ambrosia beetles was also attempted with log sections of European beech (*Fagus sylvatica*), Norway spruce (*Picea abies*) and sweet chestnut ca. 50 cm long, 5–10 cm diameter, baited with 70% ethanol and suspended alongside tree stems at a height of 1.5–2.0 m, as described by Monterrosa et al. (2021). These were installed at study sites (1)–(6) in Ticino (Table 1) from 16 April to 26 August 2022. In addition, short sections of beech branches (about 20 cm long, 2–4 cm diameter) soaked in 70% ethanol were placed on the ground at study sites (1)–(6) in Ticino from 12 June to 25 July 2022 for two periods of approximately three weeks.

Study sites in cantons Valais and Zurich

In addition to the traps placed in cantons Ticino and Grisons, bottle traps with ethanol as lure (as trap type 1 described above) were also used in canton Valais from 18 March 2022 to 25 August 2022 at six locations (Brig 1, 46.2905°N, 7.9601°E, 1260 m a.s.l.; Brig 2, 46.2941°N, 7.9577°E, 1259 m a.s.l.; Lens 1, 46.2677°N, 7.4339°E, 1096 m a.s.l.; Lens 2, 46.2677°N, 7.4339°E, 1097 m a.s.l.; Visp 1, 46.2971°N, 7.8566°E, 676 m a.s.l.; and Visp 2, 46.2967°N, 7.8564°E, 705 m a.s.l.), and in canton Zurich from 4 April 2022 to 31 August 2022 at six locations (Zurich-Hönggerberg 1, 47.4121°N, 8.4978°E, 535 m a.s.l.; Zurich Hönggerberg 2, 47.4196°N, 8.4872°E, 525 m a.s.l.; Stallikon-Uetliberg 1, 47.3364°N, 8.4936°E, 660 m a.s.l.; Stallikon-Uetliberg 2, 47.3367°N, 8.4945°E, 669 m a.s.l.; Birmensdorf-Rameren 1, 47.363°N, 8.4483°E, 540 m a.s.l.; Birmensdorf Rameren 2, 47.3631°N, 8.4483°E, 555 m a.s.l.). The study sites in cantons Valais and Zurich were also in mixed forests with varying proportions of broadleaved trees and conifers and composed mostly of oaks, beech, Norway spruce, Scots pine or other trees.

Curation and morphological and molecular identification of *A. maiche*

All ambrosia and bark beetles from traps with preservative were sorted under a stereomicroscope and kept in 70% ethanol for temporary storage while selected individuals were point mounted. Ambrosia and bark beetles were identified morphologically by J. Ribeiro-Correia, E. Brockerhoff, A. Sanchez and M. Knížek using Grüne (1979), Pfeffer (1995), Stark (1952), Rabaglia et al. (2009) and reference collections held at WSL, by M. Knížek and by Andreas Sanchez. A specimen of *A. maiche* from Serravalle-Leggiuna 1 is shown in Fig. 2.

For molecular diagnostics, genomic DNA from *A. maiche* was extracted from adults using the NucleoSpin Tissue XS Kit (Macherey-Nagel, Düren, Germany) using whole insects or, to preserve the specimens, leg fragments and one elytron. The COI barcode region was amplified and sequenced with primers LCO1490/HCO2198 (Folmer et al. 1994). The nuclear markers, the ribosomal-encoding gene 28S and the CAD gene were targeted with primers 3690s/a4285 (Kambestad et al. 2017) and CADforB2/apCADrevlmod (Dole et al. 2010), respectively. PCR conditions were set as specified in the respective reference papers. Sanger sequencing was performed using the same primers as for PCR and the BigDye Terminator

Figure 2. *Anisandrus maiche* adult trapped at Serravalle-Leggiuna 1 (Ticino), dorsal and lateral. Specimen length 2.0 mm. Photos by Carl-Michael Anderson, WSL.

v3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, California, USA). Sequences were trimmed and assembled using the CLC Main Workbench Version 22.0.2 (QIAGEN, Aarhus, Denmark) and checked manually before being subjected to BLAST searches against the All Barcode database on BOLD (https://www.boldsystems.org) and NCBI (https://blast.ncbi.nlm.nih.gov). All COI barcode sequences from *A. maiche* generated in this study are deposited on BOLD (accession numbers listed below). In addition, a specimen of *A. maiche* (BOLD Sequence ID: SCOL295-12) collected in Primorsky Krai, Russian Far East, was obtained from Bjarte Jordal (University of Bergen, Natural History Collections) and processed for molecular analyses as described above for comparison with our specimens.

Voucher specimens are held at WSL, Birmensdorf, Switzerland, at the MCSN, Lugano, Switzerland, and in the collections of M. Knížek in Prague, Czechia, A. Sanchez in Sion, Switzerland, and Heiko Gebhardt in Tübingen, Germany. Details on individual reference specimens are provided below.

Isolation, cultivation, and identification of fungal species associated with *A. maiche*

Live bottle traps (as described above for trap type 1, but with moistened sterile paper instead of propylene glycol in the collection jar) were installed at six locations in Ticino (locations number (1)–(6), see Table 1) to collect live beetles for isolation and cultivation of associated fungi. Traps were inspected after 2 to 4 days in the field. Beetles present in the traps were removed immediately from the PVC bottle, placed individually in 1.5 mL Eppendorf tubes and, upon arrival at the laboratory, stored at 4 °C for a maximum of one week.

The fungal species present on the surface and inside the collected beetles were identified as follows. First, the individual beetles were taken from the Eppendorf tubes using sterile tweezers and gently placed onto weaker-strength agar medium (SMA; 10g/L malt extract; 15g/L agar; 100 ppm streptomycin added after autoclaving to prevent growth of bacteria). The beetles were allowed to walk freely for 30–45 min so that fungal spores present on their body would eventually deposit on the agar surface. To identify fungal species inside their body (i.e., in the mycangia and in the digestive tract), beetles were subsequently removed from the Petri dish using sterile tweezers, placed in 90% ethanol for 1–2 seconds to kill any spores still present externally on their body, rinsed twice in sterile distilled water, and placed on a sterile paper towel to dry. Once dry, beetles were placed individually in a new 1.5 mL Eppendorf tube containing 0.5 mL distilled sterile water and crushed with a sterile rod. After brief vortexing, 100 µL of this solution was spread on SMA and incubated in the dark at room temperature. Plates were checked daily for up to one week and growing fungal colonies were subcultured on Potato Dextrose Agar (PDA; 39 g l^{-1}, Difco, Voight Global Distribution, Lawrence, MD, USA). When morphologically different colonies were present on a plate, a representative colony of each morphotype was transferred to PDA. After incubation of the PDA plates for two weeks in the dark at room temperature, fungal cultures were grouped into morphotypes based on the macro-morphological features of their mycelia.

For species identification, DNA was extracted from 1–3 representative cultures of each morphotype using LGC reagents and Kingfisher 96/Flex (LGC Genomics GmbH, Berlin, Germany), according to the manufacturer's instructions. The nuclear, internal transcribed spacer (ITS) was then amplified by PCR and sequenced in both directions using the forward ITS5 and reverse ITS4 primers (White et al. 1990) following the general methodology described in Franić et al. (2019). Sequences were assembled and edited using CLC Main Workbench Version 22.0.2 and compared with reference sequences in NCBI and BOLDSYSTEMS databases. Sequences were considered to belong to the same species if they showed at least 99% similarity.

Results

Specimens of *A. maiche* trapped in Switzerland

In 2022, a total of 715 specimens of *A. maiche* were trapped in southern Switzerland (Table 1, Fig. 1), including 504 in bottle trap samples and 194 in Polytrap samples. The first specimens were discovered in bottle trap catches from May 2022 from the vicinity of Biasca (Riviera-Iragna and Serravalle-Leggiuna), which were identified by Miloš Knížek on 1 July 2022 and confirmed by molecular analysis soon after (see below). Over the summer of 2022, 248 specimens of *A. maiche* were trapped with bottle traps (all with ethanol as lure) at Riviera-Iragna and Serravalle-Leggiuna (Table 1). An additional 256 *A. maiche* were trapped at five locations in southern Ticino with additional traps placed there to determine the extent of the distribution of *A. maiche* in Ticino (Table 1).

Two more specimens of *A. maiche* were found in samples from a black funnel trap from Faido-Anzonico in northern Ticino, the northernmost occurrence of the species (Table 1). These traps were part of another project which used funnel traps similar to trap type 3 (FB) but baited only with ethanol and alpha-pinene lures and suspended from pine branches about 2–3 m above ground.

Polytraps (trap type 4) installed in 2022 across the canton of Ticino caught 194 specimens of *A. maiche*. These were captured with 25 traps distributed between Chiasso (southernmost Ticino) and Biasca (central-upper Ticino) out of a total of 114 polytraps placed across Ticino. No specimens were captured in the Polytraps located north of Biasca and in the Maggia Valley north of Terre di Pedemonte (near Ascona) (Fig. 1).

Following the discovery of *A. maiche* in the vicinity of Biasca in June–July 2022, samples collected in a Swiss surveillance programme in 2021 (using green and black funnel traps, trap types 2 and 3) aimed at detecting priority quarantine insects, especially longhorn beetles (Cerambycidae), were re-examined for the presence of *A. maiche*. In these samples, a total of 15 *A. maiche* were found in southern Ticino near the Italian border (two sites near Chiasso), north of Lugano (Rivera), north of Bellinzona (Moleno), and near Biasca (Riviera-Iragna) (Table 1, Fig. 1).

Across all sites and trap types, most specimens of *A. maiche* were trapped at lower elevations in the valleys or lower mountain slopes at elevations between 195 m a.s.l. (near Locarno) and 386 m a.s.l. (near Biasca), but a few were caught at higher elevations such 626 m a.s.l. (Capriasca, north of Lugano) and 916 m a.s.l. (Faido Anzonico). All specimens were trapped in a variety of forest types with sweet chestnut, beech, mixed broadleaved trees and, in a few cases, a mixture with Scots pine.

No *A. maiche* were caught with bottle traps at six sites in canton Valais and six sites in canton Zurich (that were part of the same study using bottle traps described here).

Molecular identification of *A. maiche*

To confirm the identity of selected specimens of *A. maiche*, nucleotide BLAST searches were performed on BOLD and NCBI (as accessed in October 2022). For the mitochondrial COI barcode region, seven out of our 14 samples share 100% identity with accession MN619845 on NCBI, designated as *A. maiche*. For three other samples from Switzerland, a second haplotype was identified sharing 100% identity with a private accession on BOLD, also designated as *A. maiche*. The two haplotypes show a divergence of 5.9% resulting from a remarkable number of base substitutions between the haplotypes. In addition, four specimens show a pattern of heteroplasmy, compatible with the two haplotypes identified. However, assessing the nuclear, ribosomal-encoding gene 28S revealed 100% identity for all specimens to the ribosomal-encoding gene 28S of *A. maiche* (GenBank Accession MK098863, voucher specimen UFIFAS UFFE 28176). In addition, the CAD fragment from three samples (PHP22_0410, PH22_0411, PHP22_0539) displayed 100% identity to a sequence of *A. maiche* (GenBank Accession MN260139, Shanghai, China), but differed by 1bp to accession MN260138 collected in Michigan, USA . The *A. maiche* specimen from the Russian Far East (BOLD Sequence ID: SCOL295-12), which was re-analysed together with our specimens from Switzerland, showed the same pattern of COI heteroplasmy and shared 100% identity to the 28S locus of all our analysed specimens.

List of selected specimens held in collections

Selected specimens from Switzerland, collected by José Ribeiro-Correia, caught in bottle traps with ethanol as lure (see Suppl. material 1 for a complete list):

- 2 females, Leggiuna 1 (Serravalle-Leggiuna), Ticino, LV95: 2718898 E, 1138748 N (46.3895°N, 8.9844°E), 370 m a.s.l., 13–27 May 2022, det. Miloš Knížek, WSL DNA-IDs PHP22_0410 (GenBank: OQ685554) and PHP22_0411 (GenBank: OQ685554), entire specimens used for molecular analysis, DNA held at WSL PHP.
- 1 female, Iragna 1 (Riviera-Iragna), Ticino, LV95: 2717293 E, 1133879 N (46.3460°N, 8.9623°E), 286 m a.s.l., 27 May–10 June 2022, det. Miloš Knížek, WSL DNA-ID PHP22_0539 (GenBank: OQ685552), entire specimens used for molecular analysis, DNA held at WSL PHP.
- 7 females, Iragna 2 (Riviera-Iragna), Ticino, LV95: 2717138 E, 1134143 N (46.3484°N, 8.9604°E), 285 m a.s.l., 10–25 June 2022, det. José Ribeiro-Correia, WSL DNA-IDs PHP22_0627 (GenBank: OQ685551), PHP22_0628 (GenBank: OQ685550), PHP22_0629 (GenBank: OQ685549), PHP22_0630 (GenBank: OQ685548), PHP22_0946 (GenBank: OQ685547), PHP22_0947(GenBank: OQ685546),

PHP22_0952(GenBank: OQ685541), specimens at WSL FPS (ethanol/freezer), DNA held at WSL PHP.
- 1 female, Brusino-Arsizio, Ticino, LV95: 2715995 E, 1086645 N (45.9215°N, 8.9338°E), 320 m a.s.l., 18 July–3 Aug. 2022, det. José Ribeiro-Correia, WSL DNA-ID PHP22_0948 (GenBank: OQ685545), specimen at WSL FPS (ethanol/freezer), DNA held at WSL PHP.
- 3 females, Roveredo, Grisons, LV95: 2730490 E, 1120800 N, (46.2260°N, 9.1301°E), 505 m a.s.l., 18 July–3 Aug. 2022, det. José Ribeiro-Correia, WSL DNA-IDs PHP22_0949 (GenBank: OQ685544), PHP22_0950 (GenBank: OQ685543), PHP22_0951 (GenBank: OQ685542), specimens at WSL FPS (ethanol/freezer), DNA held at WSL PHP.
- 2 females, Leggiuna 1 (Serravalle-Leggiuna), Ticino, LV95: 2718898 E, 1138748 N (46.3895°N, 8.9844°E), 370 m a.s.l., 20 April–13 May 2022 / 13–27 May 2022, det. Miloš Knížek, specimens at WSL FPS (pinned).
- 3 females, Leggiuna 1 (Serravalle-Leggiuna), Ticino, LV95: 2718898 E, 1138748 N (46.3895°N, 8.9844°E), 370 m a.s.l., 13–27 May 2022, det. José Ribeiro-Correia, specimens at WSL FPS (pinned).
- 2 females, Iragna 2 (Riviera-Iragna), Ticino, LV95: 2717138 E, 1134143 N (46.3484°N, 8.9604°E), 285 m a.s.l., 13–27 May 2022, det. Miloš Knížek, specimens at Miloš Knížek collection, Prague, Czechia.
- 11 females, Iragna 1 (Riviera-Iragna), Ticino, LV95: 2717293 E, 1133879 N (46.3460°N, 8.9623°E), 286 m a.s.l., 27 May–10 June 2022, det. Miloš Knížek, specimens at Miloš Knížek collection, Prague, Czechia.
- 2 females, Leggiuna 1 (Serravalle-Leggiuna), Ticino, LV95: 2718898 E, 1138748 N (46.3895°N, 8.9844°E), 370 m a.s.l., 13–27 May 2022, det. Miloš Knížek, specimens at Miloš Knížek collection, Prague, Czechia.

Selected specimens from Switzerland, collected by David Frey, caught with unbaited Polytrap interception traps (see Suppl. material 2 for a complete list):

- 13 females, Ruderi del Castello di Claro (Bellinzona), Ticino, LV95: 2722751 E, 1124011 N (46.2563°N, 9.0306°E), 437 m a.s.l., 14–29 June 2022, det. Andreas Sanchez, specimens at MCSN.
- 11 females, Ciossa Antognini (Cadenazzo), Ticino, LV95: 2714516 E, 1113409 N (46.1624°N, 8.9212°E), 201 m a.s.l., 16 June–15 July 2022, det. Andreas Sanchez, specimens at MCSN.
- 1 female, El Piágn (Cugnasco-Gerra), Ticino, LV95: 2712487 E, 1116016 N (46,1862°N, 8,8956°E), 774 m a.s.l., 31 May–16 June 2022, det. Andreas Sanchez, specimen at MCSN.
- 1 female, Solorónch (Capriasca), Ticino, LV95: 2717651 E, 1101409 N (46.0539°N, 8.9588°E), 626 m a.s.l., 1–13 June 2022, det. Andreas Sanchez, specimen at MCSN.
- 2 females, Solorónch (Capriasca), Ticino, LV95: 2717643 E, 1101393 N (46.0538°N, 8.9587°E), 620 m a.s.l., 11 July–15 August 2022, det. Andreas Sanchez, specimens at MCSN.
- 54 females, Bolette (Locarno), Ticino, LV95: 2709912 E, 1112488 N (46.1549°N, 8.8614°E), 195 m a.s.l., 17 May–13 August 2022, det. Andreas Sanchez, specimens at MCSN and at Andreas Sanchez collection, Sion, Switzerland.
- 31 females, Bolette (Locarno), Ticino, LV95: 2709941 E, 1112476 N (46.1547°N, 8.8618°E), 195 m a.s.l., 2 June–13 August 2022, det. Andreas Sanchez, specimens at MCSN and at Andreas Sanchez collection, Sion, Switzerland.
- 3 females, Colombera (Stabio), Ticino, LV95: 2717680 E, 1078726 N (45.8499°N, 8.9535°E), 339 m a.s.l., 1–27 June 2022, det. Andreas Sanchez, specimens at MCSN.
- 5 females, Ronco del Re (Terre di Pedemonte), Ticino, LV95: 2699033 E, 1115853 N (46.1868°N, 8.7213°E), 372 m a.s.l., 17 May–23 August 2022, det. Andreas Sanchez, specimens at MCSN.
- 9 females, S. Martino (Vezia), Ticino, LV95: 2716328 E, 1098298 N (46.0262°N, 8.9409°E), 431 m a.s.l., 13 June–12 August 2022, det. Andreas Sanchez, specimens at MCSN and at Heiko Gebhardt collection, Tübingen, Germany.

Comparison of trap effectiveness

It was not an objective of the surveys reported here to compare the effectiveness of different trap types in capturing *A. maiche*. Nevertheless, a comparison of *A. maiche* captures per trap per day between trap types showed that bottle traps with ethanol as lure were more effective than green or black funnel traps with ethanol and additional attractants (Table 1). Captures of *A. maiche* during the main flight period (from June to August, see Fig. 3) at sites where the species occurred, averaged 1.02 ± 0.31 specimens per trap per day (mean ± SE, n = 11) for bottle traps with ethanol as lure (BT/E, trap type 1), 0.048 ± 0.018 specimens per trap per day (mean ± SE, n = 3) for green funnel traps with ethanol, alpha-pinene and eight-component blend (FG/EA8, trap type 2), 0.012 ± 0.007 specimens per trap per day (mean ± SE, n = 3) for black funnel traps with ethanol, alpha-pinene and eight-component blend (FB/EA8, trap type 3), and 0.073 ± 0.022 specimens per trap per day (mean ± SE, n = 29) for Polytraps with no lure (PT, trap type 4).

Other collection methods

No *A. maiche* were found infesting log sections (ca. 50 cm long, baited with ethanol) of European beech, Norway spruce and sweet chestnut that had been suspended from branches at study sites (1)–(6) in Ticino. However, five specimens were collected from around the cork used to

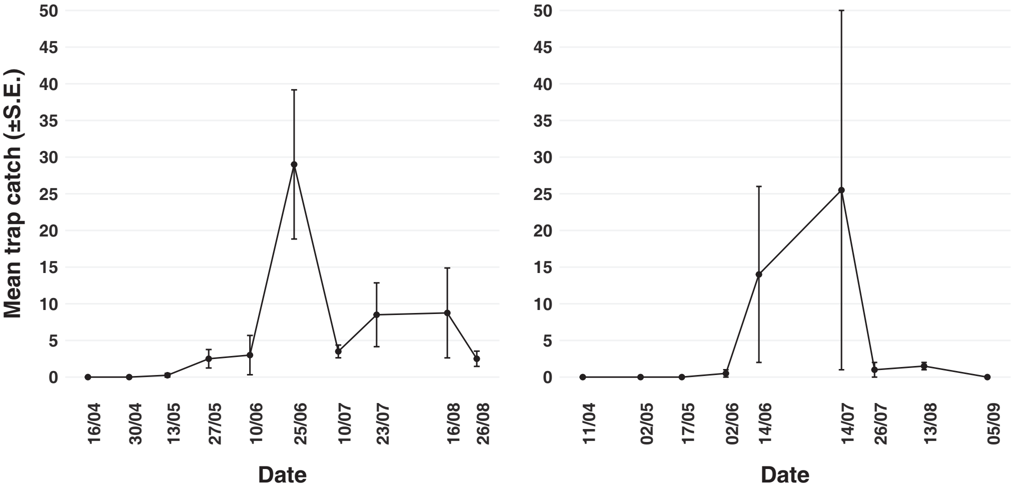

Figure 3. Mean trap captures of *Anisandrus maiche* in central-upper Ticino (left, Riviera-Iragna and Serravalle-Leggiuna, N = 4 ethanol-baited bottle traps) and in central Ticino (right, Bolette, Locarno, N = 2 Polytraps).

seal the ethanol reservoir of beech logs and one spruce log. No colonisation by *A. maiche* occurred of short sections of beech branches (about 20 cm long, 2–4 cm diameter, soaked in 70% ethanol) that had been placed on the ground at the same locations.

Phenology of *A. maiche* in Ticino

Captures of *A. maiche* with ethanol-baited bottle traps in central-upper Ticino (Riviera-Iragna and Serravalle-Leggiuna) (n = 4 traps) revealed that the main flight period was from June (or late May) to August (Fig. 3). This general flight pattern was observed also with the captures with unbaited Polytraps which occurred from mid-May to mid-August (Fig. 3) near Locarno at locations that were mainly at slightly lower elevations than the bottle trap sites in central Ticino. As the Polytraps were used from 10 March (i.e., late winter/early spring) until 3 October (i.e., early autumn), this indicates that no flights were missed, and that there is no second flight period. Therefore, the species is probably univoltine in the study region.

Fungal associates of *A. maiche*

From seven specimens of *A. maiche* that were caught alive, nine fungal cultures were successfully recovered. DNA barcoding confirmed that these cultures belonged to four species. Four cultures of *Ambrosiella cleistominuta* (including WSL DNA-ID PHP22_0914) (Ascomycota, Ceratocystidaceae) were obtained from sites Riviera-Iragna 2 and Serravalle-Leggiuna 1 (Fig. 4). In addition, *Aureobasidium pullulans* (de Bary & Löwenthal) G. Arnaud (Ascomycota, Dothioraceae; three cultures), *Cladosporium cladosporioides* (Fresen.) G.A. de Vries (Ascomycota, Davidiellaceae; one culture), and *Fusarium lateritium* Nees (Ascomycota, Nectriaceae; one culture) were found at Riviera-Iragna and Serravalle-Leggiuna sites. *Cladosporium cladosporioides* was isolated from the beetle surface, whereas the other three species were isolated from crushed beetles.

Figure 4. Culture of *Ambrosiella cleistominuta* (on 15-day old Potato Dextrose Agar, see methods) from *Anisandrus maiche* trapped alive in canton Ticino, Switzerland.

Discussion

Establishment and distribution of *A. maiche* in Switzerland

The detection of over 700 specimens of *Anisandrus maiche* across much of canton Ticino and an adjacent area of canton Grisons revealed that this species is well-established and already common in parts of southern Switzerland. This population appears to be contiguous with a recently detected population in adjacent parts of the Italian region of Lombardy where specimens of *A. maiche* were found about 30 km from the nearest known occurrence in Switzerland (Ruzzier et al. 2022). In northern Italy, *A. maiche* was found in five provinces between Milan and Treviso and appears to be relatively widespread even though the first detection of this species occurred only in 2021 (Colombari et al. 2022; Ruzzier et al. 2022). It is very likely that *A. maiche* has been present in northern Italy and southern Switzerland already for many years. Its superficial resemblance to the common and widespread *Xylosandrus germanus* (Rabaglia et al. 2009), another non-native invasive ambrosia beetle of east Asian origin, probably prevented its earlier detection.

There is no indication that *A. maiche* occurs north of the Alpine divide (i.e., north or northwest of canton Ticino), although sampling and specific surveys for *A. maiche* north of the Alpine divide so far have been carried out only in parts of cantons Valais and Zurich. However, given the abundance of *A. maiche* in Ticino and northern Italy and the considerable volume of international and domestic trade, it is probably only a matter of time until *A. maiche* is established north of the Alpine divide. Most captures occurred at lower elevations in southern Ticino but some individuals were trapped at higher elevations (up to 915 m a.s.l.), indicating that mountain forests are also at risk of invasion by *A. maiche*. Previous studies have found a positive effect of ambient temperature on the number and activity density of non-native ambrosia beetles along with an effect of forest type (Rassati et al. 2016). However, it is likely that these patterns are also influenced by the locations where non-native species arrive, which tend to be urban and commercial areas in mainly warmer locations from where they disperse gradually.

Given that mountain forest habitats are particularly threatened by climate change (Engler et al. 2011), additional impacts by invasive species are a further concern. Although its climatic requirements have not been determined thoroughly, the presence of *A. maiche* in Ukraine (Terekhova and Skrylnik 2012), western Russia near Moscow (Nikitskii 2009) and in far-eastern Russian Siberia (Kurentsov 1941) suggests that the climatic conditions north of the Alps and at higher elevations in the mountains should be climatically suitable. However, species distribution modelling would be required to ascertain this with more certainty.

Effectiveness of different traps and lures

At sites where the species occurred, bottle traps baited with ethanol captured about 15 to 100 times more *A. maiche* individuals on average than funnel traps baited with ethanol and alpha-pinene or ethanol, alpha-pinene and an eight-component blend, or unbaited Polytrap flight interception traps. Previous studies have shown that ethanol by itself is a better lure for species of *Anisandrus* than a combination of ethanol and alpha-pinene, but this does not apply to all ambrosia beetles since species of *Xyleborus* and *Xylosandrus* showed different responses (Rabaglia et al. 2019). Catch rates can also be influenced by the concentration or release rate of ethanol (e.g., Cavaletto et al. 2021; Tobin and Ginzel 2023); however, this has not been studied specifically for *A. maiche*.

The apparent weakness of attraction in our experiments with ethanol-infused branch sections and log sections with an ethanol-reservoir was surprising given that others found similar methods to be effective for *A. maiche* (Reding and Ranger 2020) and other ambrosia beetle species (Monterrosa et al. 2021). It is possible that in our branch and log experiments, the attraction of *A. maiche* was compromised by a sub-optimal concentration and/or release rate of ethanol.

Trap colour and position (i.e., the height above ground level of traps) may also affect capture rates (e.g., Kerr et al. 2017; Cavaletto et al. 2020; Marchioro et al. 2020), although this has not been studied systematically for *A. maiche*. However, the fact that clear bottle traps baited with ethanol were highly attractive in our study suggests that trap colour appears not to be an important factor for *A. maiche*.

Phenology and host plants of *A. maiche*

Captures of *A. maiche* in Ticino occurred between early May and late August 2022. Although this stretches across a period of nearly four months, there was no clear indication of two separate peaks of flight activity, and we assume that the species is univoltine. Observations in Ukraine, Skrylnik et al. (2019) also suggest that *A. maiche* has one generation per year.

To our knowledge, only three infestations by *A. maiche* of trees are known from Ticino. Two were detected in 2023 at the botanic garden on the larger Brissago Island in Lago Maggiore. One concerned a live *Hakea* sp. shrub (Proteaceae), and the other a dead Chinese lacquer tree, *Toxicodendron vernicifluum* (Anacardiaceae). The third infestation was in a twig (5 mm diameter) of a chestnut tree at a forest edge east of Tegna, Ticino. Considering its wide distribution and apparent abundance in Ticino, the lack of any other observed infestations is surprising. However, based on host records from its native and non-native ranges (summarised in Hölling and Brockerhoff 2023; Ruzzier et al. 2023), *A. maiche* is known to be highly polyphagous. In its native range in eastern Asia, host records include trees in the genera *Acer* (maple), *Alnus* (alder), *Betula* (birch), *Carpinus* (hornbeam), *Corylus* (hazel), *Fraxinus* (ash), *Juglans* (walnut), *Quercus* (oak), *Ulmus* (elm), and several other genera, including some conifers (Hölling and Brockerhoff 2023). In the non-native range of *A. maiche*, relatively few host records exist which, nonetheless, confirm that this species has a very wide host range. In Ukraine, attacks of *Betula pendula*, *Populus tremula*, *Quercus robur*, *Quercus rubra* (a North American oak species) and *Ulmus minor* have been reported (Nikulina et al. 2015; Skrylnik et al. 2019). In North America, *A. maiche* has been observed breeding in *Acer rubrum*, *Cercis canadensis*, *Cornus florida*, *Gleditsia triacanthos*, *Quercus imbricaria*, *Sassafras albidum* and *Styrax japonicus* (Mayers et al. 2017; Ranger et al. 2015, 2019, 2020; Reding and Ranger 2020).

Introduction pathways for *A. maiche* and other ambrosia beetles

To our knowledge, no confirmed border interceptions of *A. maiche* with any traded goods have been recorded, neither in Switzerland, anywhere else within the EPPO region, nor in a number of other countries (Brockerhoff et al. 2006; Turner et al. 2021). However, many other ambrosia beetles including species in the genera *Xyleborus*, *Xyleborinus*, *Xylosandrus* and others have been intercepted numerous times (Brockerhoff et al. 2006; Haack et al. 2006, 2013), indicating the existence of pathways that can facilitate invasions of ambrosia beetles. For example, *Xylosandrus crassiusculus* and *Xylosandrus germanus*, two well-known invasive ambrosia beetles that are now established in several continents where they are not native, have been intercepted repeatedly in New Zealand (Brockerhoff et al. 2006). Furthermore, it is possible that specimens of *A. maiche* were intercepted in some countries but not recognised as this species. Pathways known or thought to be involved in invasions of ambrosia beetles include international transport of wood packaging materials (such as pallets and case wood used with ceramic tiles, stone products and numerous other commodities) as well as trade in firewood and live plants (Liebhold et al. 2012; Meurisse et al. 2019). According to Mandelshtam et al. (2018), it may be possible that *A. maiche* extended its distribution by natural spread westwards from its native range in the Russian Far East; however, considering its apparently discontinuous distribution between eastern Asia and central Europe, we regard it as more likely that international trade of infested wood or wood products is responsible for its arrival and establishment in Europe.

Fungal associates of *A. maiche*

Ambrosiella cleistominuta is the ambrosia fungus associated with *Anisandrus maiche* (Mayers et al. 2017). Previously, this association was only known from the United States, where the fungus was isolated and described as a species new to science in 2017 (Mayers et al. 2017). Here, we report for the first time that the fungus is also present in Europe, again in association with *A. maiche* (with four confirmed isolations from *A. maiche* in the present study). The fungus was most likely introduced to Europe together with its beetle host. We are not aware of any studies indicating that this fungus is pathogenic to (live) plants.

Surprisingly, *A. cleistominuta* was also found in association with *Xylosandrus crassiusculus* (Motschulsky 1866) in samples of the same *Hakea* shrub from the larger Brissago Island which was also infested by *A. maiche*. This was first reported by Ribeiro-Correia et al. (2023), and a more detailed publication on this case is in preparation. *Xylosandrus crassiusculus* is a recent invader to Switzerland which was first detected in Ticino in 2013 (Sanchez et al. 2020). *Xylosandrus crassiusculus* is usually always associated with a different ambrosia fungus, *Ambrosiella roeperi* T.C. Harr. & McNew (Harrington et al. 2014; Saragih et al. 2021). Ambrosia beetles and their mutualistic ambrosia fungi typically show a high degree of fidelity, and associations with other ambrosia fungi are rare (Biedermann and Vega 2020). However, new associations between ambrosia beetles and ambrosia fungi can be established experimentally (Menocal et al. 2023) and may thus also occur in nature, in particular as a result of invasions of ambrosia beetles into non-native regions. “Adoptions” of foreign ambrosia fungi of beetles colonizing the same trees in the invasive range may be sufficient for nutrition and development in the foreign gallery, but may not be suitable for transport to other trees because of the evolved specificity of mycangia (Mayers et al. 2022). Successful mycangial transmission should only occur in beetle species with similar mycangial selection processes and that are obligately associated with species in the same fungal clade (Biedermann and Vega 2020). The genus *Ambrosiella* (Ascomycota: Microascales), for example, is mutualistic with scolytine ambrosia beetles in the *Xylosandrus* and *Anisandrus* genera, so fungal exchanges between these beetle species are most likely (Mayers et al. 2015). Newly acquired ambrosia fungi may then lead to reductions or even increases in beetle fitness (e.g., reproductive success) (Menocal et al. 2023).

Three other fungi were isolated from *A. maiche* trapped alive in Ticino: *Aureobasidium pullulans* is a saprophytic yeast-like fungus with a worldwide distribution; it occurs on the leaves of a wide range of plants and is known mainly from crop plants (Deshpande et al. 1992). *Cladosporium cladosporioides* is a member of a genus that includes the most common environmental fungi found worldwide with species of various lifestyles (Bensch et al. 2012). *Cladosporium cladosporioides* is also recognized as a pathogen of grapes and other fruits on which it produces the so-called *Cladosporium* fruit rot (Latorre et al. 2011; Swett et al. 2019). Its isolation from the body surface of *A. maiche* may suggest a coincidental association of the fungus and the beetle. *Fusarium lateritium* is a globally distributed plant pathogen that may cause a variety of symptoms on affected plants. For example, *F. lateritium* can cause chlorotic leaf distortion on sweet potato (Clark et al. 1995) and nut grey necrosis on hazelnut fruits (Vitale et al. 2011). Recently, *F. lateritium* was found to cause shoot dieback of boxelder maple (*Acer negundo*) in Poland (Patejuk et al. 2022). It is not yet known whether any of these three fungi (and their association with *A. maiche*) could pose a problem for forest trees in Switzerland and Central Europe. As they have also only been found sporadically with *A. maiche*, we suspect that these may be coincidental associations. Nevertheless, these examples show that *A. maiche* can be a potential vector of pathogens.

Potential damage to infested trees from *A. maiche* and associated fungi

So far, the only trees (or wood) infested by *A. maiche* that have been found in Switzerland (the vast majority of specimens were trapped) are two non-native plant species at a botanic garden, a *Hakea* sp. shrub (Proteaceae), and a dead Chinese lacquer tree, *Toxicodendron vernicifluum* (Anacardiaceae) and a native chestnut tree at the edge of a semi-natural forest. It is uncertain what other tree or shrub species are attacked in Switzerland. However, most of the trap catches of *A. maiche* in canton Ticino occurred at locations with native forest and native tree species. Based on this as well as previous host records (summarised in Hölling and Brockerhoff (2023) and Ruzzier et al. (2023)), *A. maiche* may attack a wide range of broadleaved tree species both native and non-native present in Ticino.

In general, most ambrosia beetles attack freshly dead wood and thus do not cause much damage of live plants, but there are exceptions, particularly when non-native ambrosia beetles and associated plant pathogenic fungi are involved (Hulcr and Dunn 2011; Eskalen et al. 2013; Hughes et al. 2017; Paap et al. 2018; Morales-Rodríguez et al. 2021). Based on observations from Ukraine, Terekhova and Skrylnik (2012) state that *A. maiche* "has no significant economic impact" in that country. However, "noticeable" damage to birch (*Betula pendula*) trees in Ukraine was described by Skrylnik et al. (2019) who gave *A. maiche* an intermediate impact rating for birch with a "physiological harmfulness score" of 5 out of 14, considering both damage from galleries made by the beetles and their assumed ability to act as vectors of plant pathogens. As of late 2023, there is no indication of any major damage caused by *A. maiche* in Switzerland, neither from its galleries nor from any associated plant pathogens. However, no systematic surveys for damage from *A. maiche* have been carried out yet, and it is not known if *A. maiche* is indeed harmful to trees or shrubs. Nevertheless, its considerable abundance in some locations in Ticino along with the apparent association with at least one plant pathogen (*F. lateritium*, see Patejuk et al. (2022)) suggests that there is some potential for damage, especially if plants are stressed by drought, flooding or fire (Terekhova and Skrylnik 2012; Ranger et al. 2015; Mandelshtam et al. 2018). Ranger et al. (2015) consider that *A. maiche* prefers to attack living, weakened trees over dead trees.

Further research needs

Several aspects of the invasion of *A. maiche* in Europe deserve further study. As this species is already relatively common in southern Switzerland (and probably also in other invaded areas), it is possible that it will become one of the most abundant ambrosia beetles. This has happened at some locations in North America, where *A. maiche* was found to be one of the two most abundant ambrosia beetles, together with *Xylosandrus germanus* (Ranger et al. 2019). An increase in the abundance of *A. maiche* could lead to more noticeable damage of infested trees (given its apparent preference for attacking weakened living trees) and it could also cause competition with native ambrosia beetles which may decline in response. Therefore, having a better understanding of the extent of the distribution of *A. maiche* both at higher elevations in mountain forests of Ticino and beyond canton Ticino is desirable. Likewise, better knowledge of its host plants, fungal associates and their combined potential effect on plant health are required in both lowland and mountain forests. Furthermore, a better understanding of the pathways involved in the invasions and spread of *A. maiche* and other ambrosia beetles could be used to limit the extent of future invasions and impacts. Finally, given the occurrence of heteroplasmy in COI sequences in some of the samples of *A. maiche* we analysed, a known problem with COI barcoding of insects (e.g., Magnacca and Brown 2010; Cognato et al. 2020), further studies on the invasion and population genetics of *A. maiche* should examine the use of additional markers.

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Supplementary material 1

Specimens of *Anisandrus maiche* from Switzerland, collected by José P. Ribeiro-Correia

Authors: José P. Ribeiro-Correia, Simone Prospero, Ludwig Beenken, Peter H. W. Biedermann, Simon Blaser, Manuela Branco, Yannick Chittaro, David Frey, Doris Hölling, Sezer Olivia Kaya, Miloš Knížek, Jana Mittelstrass, Beat Ruffner, Andreas Sanchez, Eckehard G. Brockerhoff

Data type: docx

Explanation note: Specimens of *Anisandrus maiche* from Switzerland, collected by José P. Ribeiro-Correia, caught in bottle traps with ethanol as lure, with information on collection locations and where specimens are held. See the manuscript for explanations of acronyms.

Link: https://doi.org/10.3897/alpento.8.117537.suppl1

Supplementary material 2

Specimens of *Anisandrus maiche* from Switzerland, collected by David Frey

Authors: José P. Ribeiro-Correia, Simone Prospero, Ludwig Beenken, Peter H. W. Biedermann, Simon Blaser, Manuela Branco, Yannick Chittaro, David Frey, Doris Hölling, Sezer Olivia Kaya, Miloš Knížek, Jana Mittelstrass, Beat Ruffner, Andreas Sanchez, Eckehard G. Brockerhoff

Data type: docx

Explanation note: Specimens of *Anisandrus maiche* from Switzerland, collected by David Frey, caught with unbaited Polytrap interception traps, with information on collection locations and where specimens are held. See the manuscript for explanations of acronyms.

Link: https://doi.org/10.3897/alpento.8.117537.suppl2

Supplementary material 3

Photos of traps used in this study

Authors: José P. Ribeiro-Correia, Simone Prospero, Ludwig Beenken, Peter H. W. Biedermann, Simon Blaser, Manuela Branco, Yannick Chittaro, David Frey, Doris Hölling, Sezer Olivia Kaya, Miloš Knížek, Jana Mittelstrass, Beat Ruffner, Andreas Sanchez, Eckehard G. Brockerhoff

Data type: docx

Explanation note: Traps used in Switzerland with which *Anisandrus maiche* was caught.

Link: https://doi.org/10.3897/alpento.8.117537.suppl3

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PENSOFT.

Alpine Entomology

Liste commentée des Cerophytidae, Elateridae, Eucnemidae et Throscidae du bassin genevois (Coleoptera)

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Résumé

Une liste des Cerophytidae, Elateridae, Eucnemidae et Throscidae du bassin genevois est présentée avec quelques commentaires et annotations. Le présent travail est basé sur des prospections de terrain ciblées, sur une analyse critique de la littérature et des recherches dans les collections muséales et privées. Une espèce de Cerophytidae, 102 espèces d'Elateridae, 14 espèces d'Eucnemidae et 9 espèces de Throscidae sont recensées dans le bassin genevois. 13 espèces insuffisamment documentées (Elateridae) sont à considérer comme douteuses et sont donc répertoriées séparément. Enfin, 9 espèces (8 Elateridae et 1 Throscidae) potentiellement présentes dans le bassin genevois mais pour l'heure non recensées, sont également mentionnées et discutées. Les résultats montrent que du point de vue patrimonial, 44 espèces saproxyliques sont de grande valeur, car rares et/ou exigeantes envers leur habitat.

Summary

Annotated checklist of Cerophytidae, Elateridae, Eucnemidae and Throscidae (Coleoptera) of the Geneva Basin. We present an annotated list of species in the families Cerophytidae, Elateridae, Eucnemidae and Throscidae occurring in the Geneva Basin. This inventory is based upon targeted fieldwork, a critical review of existing literature and studies of institutional and private collections. One species of Cerophytidae, 102 Elateridae, 14 Eucnemidae and 9 Throscidae are recorded from the Geneva Basin. Data is lacking for 13 species of Elateridae, whose presence in the area is consequently considered doubtful, and which is reported separately. Nine additional species (8 Elateridae and 1 Throscidae) potentially present in the Geneva Basin are also listed and discussed. From a conservation point of view, our results show that 44 saproxylic species are of high value, as they are rare and/or habitat-demanding.

Zusamenfassung

Kommentierte Liste der Käfer Cerophytidae, Eucnemidae, Throscidae und Elateridae des Genfer Beckens (Coleoptera). Eine Liste der Cerophytidae, Elateridae, Eucnemidae und Throscidae des Genfer Beckens wird mit einigen Kommentaren und Anmerkungen vorgestellt. Die vorliegende Arbeit basiert auf gezielten Feldforschungen, einer kritischen Analyse der Literatur und Recherchen in musealen und privaten Sammlungen. Im Genfer Becken wurden eine Cerophytidae-Art, 102 Elateridae-Arten, 14 Eucnemidae-Arten und 9 Throscidae-Arten nachgewiesen. 13 unzureichend dokumentierte Arten (Elateridae) sind als zweifelhaft zu betrachten und werden daher gesondert aufgeführt. Schliesslich werden 9 Arten (8 Elateridae und 1 Throscidae), von denen angenommen wird, dass sie potenziell im Genfer Becken vorkommen, ebenfalls erwähnt und diskutiert. Die Ergebnisse zeigen, dass aus patrimonialer Sicht 44 saproxylische Arten von hohem Wert sind, da sie selten sind und/oder hohe Habitatansprüche haben.

Key Words

Click beetle, false click beetle, throscid beetle, checklist, Geneva basin, France, Switzerland, faunistics

Introduction

Les Cerophytidae, Elateridae, Eucnemidae et Throscidae des faunes de France et de Suisse ont été plutôt bien étudiées depuis les années 1970 (Leseigneur 1972; Chittaro and Blanc 2012; Leseigneur et al. 2015), à l'exception des départements de l'Ain (F-01) et de la Haute-Savoie (F-74) qui restent sous-échantillonnés. Sauf pour quelques espèces, ces familles sont assez faciles à échantillonner, mais ont la juste réputation d'être difficiles à déterminer. Pourtant, la variété des habitats qu'elles colonisent et leur écologie font de ces familles un sujet d'études de grand intérêt, que ce soient les espèces saproxyliques pour la conservation des milieux naturels (e.g. Speight 1989) ou certaines espèces phytophages pour l'impact qu'elles peuvent avoir sur les plantes cultivées (Jossi et al. 2008; Thibord et al. 2017; Naqqash 2023). Pour ces raisons, il est opportun de mettre en lumière ces quatre familles méconnues et peu prises en compte dans les politiques de conservation de la biodiversité locale et régionale (DETA, DGAN, CCDB 2018).

Matériel et méthodes

Contexte géographique

Le bassin genevois forme une cuvette franco-suisse entourée de massifs montagneux, mais en partie ouverte au nord-est sur le lac Léman, lequel constitue un réservoir d'eau douce – le plus grand d'Europe occidentale – dont le niveau actuel se trouve à 372 m au-dessus de celui de la mer. Le point le plus haut du bassin genevois culmine à 1720 m dans le massif du Jura (Crêt de la neige). À l'ouest le Vuache atteint quant à lui 1105 m, tandis que le Salève au sud-est plafonne à 1380 m et que les Voirons se dressent à l'est à 1480 m. Dans le périmètre d'étude, notons également un autre point haut d'importance dans le massif du Jura : La Dôle (1677 m). Globalement, le périmètre s'arrête aux lignes de crêtes de ces montagnes et couvre une surface de 1223 km² qui comprend la totalité du canton de Genève (23%), l'extrême sud-ouest du canton de Vaud (11%) et une petite partie des départements de l'Ain (24%) et de la Haute-Savoie (42%). Au sud, entre le Vuache et le Salève, les frontières sont moins marquées mais conservent une logique de bassin versant. À l'est, la Dranse et son embouchure au niveau de la ville de Thonon-les-Bains définissent la limite du périmètre. Enfin, en terre vaudoise, une ligne partant de Saint-Cergue et rejoignant la Promenthouse, vient boucler la zone d'étude (Fig. 1). En plaine, le Léman, le Rhône et l'Arve sont les éléments hydrographiques marquants du paysage. Le second de ces cours d'eau rejoint le premier au niveau du quartier de la Jonction (Genève) pour former une artère fluviale qui va s'écouler vers l'ouest jusqu'à sa sortie du bassin entre le Jura et le Vuache. L'ensemble de ces éléments contribue à créer un microclimat particulier, qualifié de subocéanique dégradé (Theurillat et al. 2011), qui se résume à des hivers froids et des étés chauds avec des apparitions fréquentes de canicules. En outre, le Léman est à l'origine d'intenses brouillards hivernaux.

Analyse des données

Pour l'élaboration de la Liste commentée des Cerophytidae, Elateridae, Eucnemidae et Throscidae de Suisse (Chittaro and Blanc 2012), les collections muséales et la plupart des collections privées ont été contrôlées et toutes les données à disposition jusqu'en 2012 ont été saisies. Les données ont été complétées pour la période 2013 à 2023 grâce à l'analyse de nouvelles collections privées et des bases de données suisses et françaises, respectivement d'info fauna, de Faune Genève et de l'Inventaire national du patrimoine naturel (INPN) et du Pôle invertébrés Auvergne-Rhône-Alpes. En outre, des informations sur ces quatre familles ont été extraites des données publiées disponibles (Leseigneur 1972; Roe et al. 2009; Chittaro and Blanc 2012; Chittaro et al. 2013; Blanc 2014a; Leseigneur et al. 2015; Breitenmoser 2017, 2022; Blanc and Rochet 2024). Enfin, des inventaires et des recherches ciblés ont été menés dans le périmètre d'étude de 2018 à 2023.

La nomenclature suivie est celle de TAXREF (version 17.0) (Gargominy et al. 2022) à l'exception de la sous-famille des Cardiophorinae (Elateridae) basée selon la révision de Mertlik (2011). En outre, nous avons considéré le genre *Reitterelater* comme synonyme de *Brachygonus* (Elateridae) d'après Delnatte et al. (2011).

Bien que certaines études (Kundrata and Bocak 2011; Kusy et al. 2020) montrent que les Drilidae devraient être dorénavant considérées comme une tribu (Drilini) de la sous-famille des Agrypninae et les Omalisidae comme une sous famille (Omalisinae) des Elateridae, nous avons préféré opter pour une vision plus conservatrice (Löbl and Smetana 2007) et ne les avons pas incluses dans le présent travail.

L'analyse patrimoniale des espèces se rapporte aux synthèses suivantes : la liste des espèces reliques de forêts primaires d'Europe centrale (Eckelt et al. 2018), la liste rouge des Coléoptères saproxyliques des 27 pays membres de l'Union Européenne (Cálix et al. 2018) et celle des Coléoptères saproxyliques d'Auvergne-Rhône-Alpes (Dodelin and Calmont 2021), la liste française des Coléoptères saproxyliques bioindicateurs (valeur patrimoniale de 3–4 selon Bouget et al. 2019), la liste suisse des Coléoptères saproxyliques emblématiques (indice de spécificité de 4 à 7 selon Sanchez et al. 2016).

Dans le cas de données publiées concernant les espèces commentées, nous nous sommes restreints à ne citer que la première mention d'une localité, celle-ci étant généralement reprise telle quelle dans les publications ultérieures. Les données sur la biologie ou l'écologie des espèces proviennent principalement de Leseigneur (1972), de Bouget et al. (2019) et de nos observations personnelles. Les cantons suisses et les départements français sont mentionnés dans le cas de localités précises et sont abrégés par leur code usuel (GE pour Genève, VD pour Vaud, 01 pour l'Ain et 74 pour la Haute-Savoie). Autres abréviations utilisées : coll. = collection, det. = déterminateur, ex. = exemplaire, leg. = collecteur.

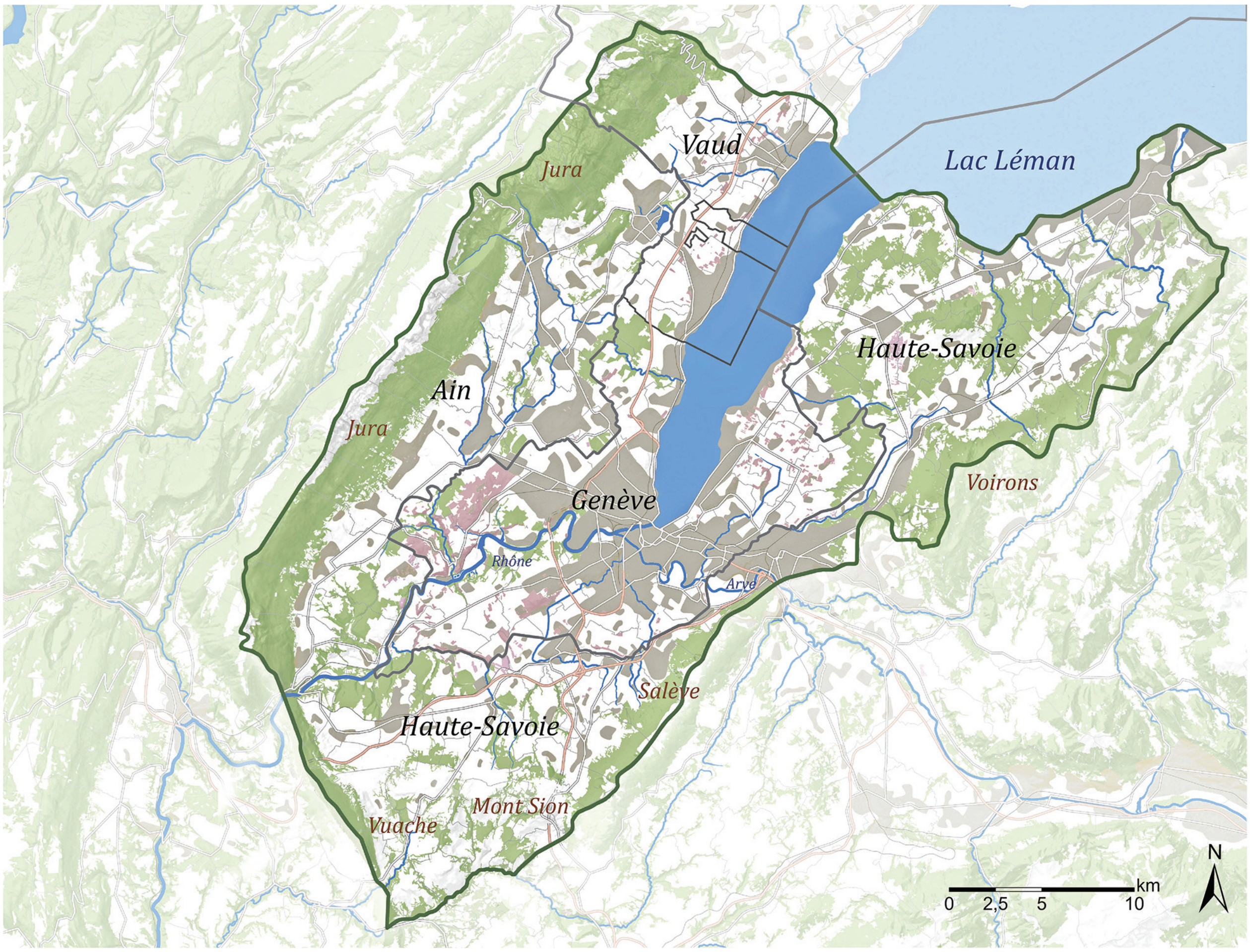

Figure 1. Périmètre du bassin genevois (trait vert foncé). Frontières internationales (trait gris). Frontières cantonales (trait noir). Source: Faune Genève.

Résultats

Liste des espèces du bassin genevois

Ne figurent dans la liste que les espèces dont la présence a pu être validée par au moins un exemplaire en collection, correctement étiqueté et provenant d'une collection jugée fiable, ou par une donnée numérique accompagnée d'une photo présentant les caractères discriminants de l'espèce.

Les taxa sont listés dans l'ordre alphabétique des familles, sous-familles, genres, espèces et sous-espèces. Les espèces suivies d'un astérisque et d'un chiffre ("*1" par exemple) sont commentées.

CEROPHYTIDAE Latreille, 1834

Cerophytum elateroides (Latreille, 1804)

ELATERIDAE Leach, 1815
Agrypninae Candèze, 1857

Agrypnus murinus (Linnaeus, 1758)
Danosoma fasciata (Linnaeus, 1758)
Drasterius bimaculatus (Rossi, 1790)
Lacon querceus (Herbst, 1784) *1

Cardiophorinae Candèze, 1860

Cardiophorus gramineus (Scopoli, 1763)
Cardiophorus rufipes (Goeze, 1777)
Dicronychus cinereus (Herbst, 1784)
Dicronychus equiseti (Herbst, 1784)
Paracardiophorus musculus (Erichson, 1840)

Denticollinae Stein & J. Weise, 1877

Actenicerus sjaelandicus (O.F. Müller, 1764)
Anostirus gracilicollis (Stierlin, 1896)
Anostirus purpureus (Poda, 1761)
Aplotarsus incanus (Gyllenhal, 1827)
Athous bicolor (Goeze, 1777)
Athous emaciatus Candèze, 1860 *2
Athous haemorrhoidalis (Fabricius, 1801)
Athous subfuscus (O.F. Müller, 1764)
Athous tomentosus Mulsant & Guillebeau, 1855 *3
Athous vittatus (Fabricius, 1792)
Athous zebei Bach, 1852
Calambus bipustulatus (Linnaeus, 1767)
Cidnopus aeruginosus (Olivier, 1790)
Cidnopus pilosus (Leske, 1785)
Crepidophorus mutilatus (Rosenhauer, 1847) *4

Ctenicera cuprea (Fabricius, 1775)
Ctenicera pectinicornis (Linnaeus, 1758)
Ctenicera virens (Schrank, 1781)
Denticollis linearis (Linnaeus, 1758)
Denticollis rubens Piller & Mitterpacher, 1783
Diacanthous undulatus (De Geer, 1774)
Hemicrepidius hirtus (Herbst, 1784)
Hemicrepidius niger (Linnaeus, 1758)
Hypoganus inunctus (Lacordaire, 1835)
Limonius minutus (Linnaeus, 1758)
Limonius poneli Leseigneur & Mertlik, 2007
Nothodes parvulus (Panzer, 1799)
Paraphotistus nigricornis (Panzer, 1799)
Pheletes aeneoniger (De Geer, 1774)
Prosternon tessellatum (Linnaeus, 1758)
Selatosomus aeneus (Linnaeus, 1758)
Selatosomus latus (Fabricius, 1801)
Stenagostus rhombeus (Olivier, 1790)

Elaterinae Leach, 1815

Adrastus axillaris Erichson, 1841
Adrastus lacertosus Erichson, 1841
Adrastus limbatus (Fabricius, 1777)
Adrastus montanus (Scopoli, 1763)
Adrastus pallens (Fabricius, 1792)
Adrastus rachifer (Geoffroy in Fourcroy, 1785)
Agriotes acuminatus (Stephens, 1830)
Agriotes gallicus Lacordaire in Boisduval and Lacordaire 1835
Agriotes lineatus (Linnaeus, 1767)
Agriotes obscurus (Linnaeus, 1758)
Agriotes pallidulus (Illiger, 1807)
Agriotes pilosellus (Schönherr, 1817)
Agriotes sputator (Linnaeus, 1758)
Agriotes ustulatus (Schaller, 1783)
Ampedus auripes (Reitter, 1895)
Ampedus brunnicornis Germar, 1844
Ampedus cardinalis (Schiødte, 1865) *5
Ampedus cinnaberinus (Eschscholtz, 1829)
Ampedus elegantulus (Schönherr, 1817) *6
Ampedus elongatulus (Fabricius, 1787)
Ampedus erythrogonus (P.W.J. Muller, 1821)
Ampedus nigerrimus (Lacordaire, 1835)
Ampedus nigroflavus (Goeze, 1777) *7
Ampedus pomonae (Stephens, 1830)
Ampedus pomorum (Herbst, 1784)
Ampedus praeustus (Fabricius, 1792)
Ampedus quercicola (Buysson, 1887)
Ampedus rufipennis (Stephens, 1830)
Ampedus sanguineus (Linnaeus, 1758)
Ampedus sanguinolentus (Schrank, 1776)
Ampedus scrofa Germar, 1844
Ampedus sinuatus Germar, 1844 *8
Betarmon bisbimaculatus (Fabricius, 1803)
Brachygonus bouyoni (Chassain, 1992)
Brachygonus campadellii Platia & Gudenzi, 2000 *9
Brachygonus dubius (Platia & Cate, 1990)
Brachygonus megerlei (Lacordaire in Boisduval and Lacordaire 1835)
Brachygonus ruficeps (Mulsant & Guillebeau, 1855)
Dalopius marginatus (Linnaeus, 1758)
Elater ferrugineus (Linnaeus, 1758)
Idolus picipennis (Bach, 1852)
Ischnodes sanguinicollis (Panzer, 1793)
Megapenthes lugens (Redtenbacher, 1842)
Podeonius acuticornis (Germar, 1823) *10
Porthmidius austriacus (Schrank, 1781)
Procraerus tibialis (Lacordaire in Boisduval and Lacordaire 1835)
Sericus brunneus (Linnaeus, 1758)
Sericus subaeneus (W. Redtenbacher, 1842)
Synaptus filiformis (Fabricius, 1781)

Lissominae Laporte, 1835

Drapetes mordelloides Host, 1789

Melanotinae Candèze, 1859

Melanotus castanipes (Paykull, 1800)
Melanotus punctolineatus (Pélerin, 1829)
Melanotus villosus (Geoffroy in Fourcroy, 1785)

Negastriinae Nakane & Kishii, 1956

Negastrius sabulicola (Boheman, 1854)
Quasimus minutissimus (Germar, 1823)
Zorochros dermestoides (Herbst, 1806)
Zorochros dufouri (Buysson, 1900)
Zorochros flavipes (Aubé, 1850)
Zorochros meridionalis (Laporte de Castelnau, 1840)
Zorochros quadriguttatus (Laporte de Castelnau, 1840)

EUCNEMIDAE Eschscholtz, 1829
Eucneminae Eschscholtz, 1829

Eucnemis capucina Arhens, 1812

Macraulacinae Fleutiaux, 1922

Dromaeolus barnabita (A. Villa & J.B. Villa, 1838)
Nematodes filum (Fabricius, 1801) *11

Melasinae Fleming, 1821

Hylis cariniceps (Reitter, 1902)
Hylis foveicollis (C.G. Thomson, 1874)
Hylis olexai (Palm, 1955)
Hylis simonae (Olexa, 1970)
Isorhipis melasoides (Laporte de Castelnau, 1835)
Melasis buprestoides (Linnaeus, 1761)

Microrhagus emyi (Rouget, 1856)
Microrhagus lepidus Rosenhauer, 1847
Microrhagus pygmaeus (Fabricius, 1792)
Microrhagus pyrenaeus Bonvouloir, 1872 *12
Rhacopus sahlbergi (Mannerheim, 1823)

THROSCIDAE Laporte, 1840
Throscinae Laporte, 1840

Aulonothroscus brevicollis (Bonvouloir, 1859)
Trixagus atticus Reitter, 1921
Trixagus carinifrons (Bonvouloir, 1859)
Trixagus dermestoides (Linnaeus, 1767)
Trixagus elateroides (Heer, 1841)
Trixagus gracilis Wollaston, 1854
Trixagus leseigneuri Muona, 2002
Trixagus meybohmi Leseigneur, 2005
Trixagus obtusus (Curtis, 1827)

Dans le bassin genevois, 44 espèces saproxyliques sont de grande valeur (Table 1), étant soit liées à des forêts primaires selon Eckelt et al. (2018), soit figurant sur la liste rouge des Coléoptères saproxyliques des 27 pays membres de l'Union Européenne (Cálix et al. 2018) ou celle de la région Auvergne-Rhône-Alpes (Dodelin and Calmont 2021), soit obtiennent un indice patrimonial élevé de 3–4 dans la liste française des Coléoptères saproxyliques bioindicateurs (Bouget et al. 2019) ou un indice de spécificité de 6–7 dans la liste suisse des Coléoptères saproxyliques emblématiques (Sanchez et al. 2016). Le grand nombre d'espèces patrimoniales peut s'expliquer selon plusieurs paramètres dont celui évoqué plus haut concernant le contexte biogéographique mais également selon la disponibilité en habitats ou dendro-microhabitats. En effet, beaucoup de ces espèces saproxyliques rares et/ou exigeantes sont liées à des arbres âgés, sénescents ou morts, qu'ils soient isolés, en allées ou en lisière. Les espèces liées aux différents dendro-microhabitats situés sur des chênes centenaires y sont particulièrement représentées car le bassin genevois est bien fourni en chênes séculaires (Giforge 2011; Blanc 2014b; Breitenmoser 2022). Ces espèces saproxyliques patrimoniales indiquent aussi l'intérêt prépondérant de conserver les vieux arbres - notamment les chênes – ainsi que le bois mort de tout diamètre, autant dans les milieux forestiers, les campagnes, que dans les espaces verts urbains. Ces arbres bénéficient de mesures de conservation grâce notamment aux plans d'action pour la sauvegarde du Grand Capricorne (*Cerambyx cerdo* L., 1758) dans les cantons de Genève et Vaud (Blanc 2014b; Maibach et al. 2014). De nombreuses autres espèces saproxyliques, dont celles de valeur patrimoniale (Table 1), bénéficient de la protection de cette espèce parapluie protégée à l'échelon européen (Annexe II de la Convention de Berne relative à la conservation de la vie sauvage et du milieu naturel de l'Europe).

Commentaires sur quelques espèces

*1 *Lacon querceus* (Herbst, 1784)

Fig. 2A

Matériel examiné. 1 ex., Bernex (GE), 31.V.1942, leg. Bertin G.; 1 ex., Veyrier (GE), 11.III.2014, leg. & coll. Blanc M.; 1 ex., Veyrier (GE), 11.III.2014, leg. & coll. Chittaro Y.; 1 ex., Etrembières (74), 11.III.2014, leg. & coll. Blanc M.; 1 ex., Duillier (VD), 28.V.-20.VI.2015, leg. & coll. Breitenmoser S.; 4 ex., Présinge (GE), 21.II.2017, leg. & coll. Blanc M.; 1 ex., Cartigny (GE), 29.V.2018, leg. Blanc M. & Rochet C., coll. Blanc M.; 1 ex., Collonge-Bellerive (GE), 19.III.2022, leg. & coll. Blanc M.; 1 ex., Miolan (GE), 19.III.2022, leg. & coll. Blanc M.; 4 ex., Nernier (74), 22.III.2022, leg. & coll. Blanc M.; 1 ex., Veigy-Foncenex, 18.X.2022, leg. & coll. Blanc M.; 11 ex., Chens-sur-Léman (74), 14.I.2023, leg. & coll. Blanc M.; 1 ex., Versoix (GE), 15.VI.2023, leg. & coll. Chittaro Y.; 1 ex., Vésenaz (GE), 24.VI.2023, leg. & coll. Blanc M.; 3 ex., Excenevex (74), 03.XI.2023, leg. & coll. Blanc M.

Données publiées. Chittaro and Blanc (2012); Blanc (2014a); Leseigneur et al. (2015); Breitenmoser (2017, 2022); Blanc and Rochet (2024).

Commentaire. Adultes et larves s'observent dans la carie rouge pulvérulente des vieux chênes et hêtres colonisés par le Polypore soufré (*Laetiporus sulphureus*). Espèce autrefois considérée comme rare en France et en Suisse, elle semble en expansion dans la région depuis quelques années comme le suggèrent les récentes observations (Blanc and Rochet 2024).

*2 *Athous emaciatus* Candèze, 1860

Fig. 2B

Matériel examiné. 3 ex., Beaumond (74), 17.VI.1982, leg. Besuchet C., coll. Blanc M.; 1 ex., Saxel (74), 05.X.2006, leg. & coll. Blanc M.

Données publiées. Leseigneur et al. (2015).

Commentaire. L'adulte se rencontre principalement sur les sapins, parfois les épicéas ou les saules, exclusivement dans les forêts de montagne entre 1000 et 1800 m. Espèce connue uniquement de France, Suisse et Italie, où elle est largement répandue. Sa distribution dans le bassin genevois reste à préciser mais elle y semble toutefois localisée. À rechercher dans les forêts froides et humides d'altitude.

*3 *Athous tomentosus* Mulsant & Guillebeau, 1855

Fig. 2C

Matériel examiné. Plusieurs ex. des Parcs Bernasconi et Navazza (GE), VI-VII.2005, leg. & coll. Calmont B.; 1 ex. Laconnex (GE), 02.VI.2022, leg. Pétremand G., coll. Chittaro Y.

Table 1. Espèces de valeur patrimoniale présentes dans le bassin genevois liées à des structures forestières primaires (Eckelt et al. 2018), figurant sur la liste rouge européenne (Cálix et al. 2018) ou sur celle de la région Auvergne-Rhône-Alpes " AURA " (Dodelin and Calmont 2021) avec degré de menace : NT = potentiellement menacé, VU = vulnérable, EN = en danger, CR = en danger critique d'extinction, et/ou ayant un indice patrimonial très élevé : 3 – 4 en France (Bouget et al. 2019) et 4 – 7 en Suisse (Sanchez et al. 2016). Espèces par ordre alphabétique des familles puis des espèces.

Espèce	Liée à des structures forestières primaires	Liste rouge (Europe)	Liste rouge AURA	Indice patrimonial FR *	Indice patrimonial CH **
Cerophytidae					
Cerophytum elateroides (Latreille, 1804)	x	VU	VU	3	6
Elateridae					
Ampedus brunnicornis Germar, 1844	x	VU	VU	3	6
Ampedus cardinalis (Schiødte, 1865)	x	NT	NT	3	7
Ampedus cinnabarinus (Eschscholtz, 1829)			VU	3	5
Ampedus elegantulus (Schönherr, 1817)	x		EN	3	6
Ampedus elongatulus (Fabricius, 1787)		NT	NT		4
Ampedus erythrogonus (P.W.J. Muller, 1821)			NT		4
Ampedus nigerrimus (Lacordaire, 1835)		NT	NT		4
Ampedus nigroflavus (Goeze, 1777)			NT	3	6
Ampedus pomonae (Stephens, 1830)			VU	3	4
Ampedus praeustus (Fabricius, 1792)			NT	3	4
Ampedus rufipennis (Stephens, 1830)			NT		5
Ampedus sanguinolentus (Schrank, 1776)			NT		4
Ampedus scrofa Germar, 1844			NT		4
Ampedus sinuatus Germar, 1844			VU	3	4
Brachygonus bouyoni (Chassain, 1992)		NT	EN	3	7
Brachygonus campadellii Platia & Gudenzi			NT		
Brachygonus dubius (Plata & Cate, 1990)	x		VU	4	7
Brachygonus megerlei (Lacordaire in Boisduval & Lacordaire, 1835)		NT	NT		4
Brachygonus ruficeps (Mulsant & Guillebeau, 1855)	x	NT	VU		6
Calambus bipustulatus (Linnaeus, 1767)					4
Cardiophorus gramineus (Scopoli, 1763)	x	NT	NT	3	5
Crepidophorus mutilatus (Rosenhauer, 1847)	x	NT	CR	4	7
Danosoma fasciata Linnaeus, 1758			VU	3	4
Denticollis rubens Piller & Mitterpacher, 1783			NT		4
Drapetes mordelloides Host, 1789			NT	3	4
Elater ferrugineus (Linnaeus, 1758)	x	NT	VU	3	6
Hypoganus inunctus (Lacordaire, 1835)					4
Ischnodes sanguinicollis (Panzer, 1793)	x	VU	VU	3	6
Lacon querceus (Herbst, 1784)	x	NT	EN	3	7
Megapenthes lugens (Redtenbacher, 1842)	x	NT	EN	3	7
Podeonius acuticornis (Germar, 1823)	x	EN	EN	3	7
Porthmidius austriacus (Schrank, 1781)			CR	3	6
Procaerus tibialis (Lacordaire in Boisduval & Lacordaire, 1835)			NT	3	6
Stenagostus rhombeus (Olivier, 1790)					4
Eucnemidae					
Dromaeolus barnabita (A. Villa & J.B. Villa, 1838)					4
Nematodes filum (Fabricius, 1801)	x		VU	3	
Hylis cariniceps (Reitter, 1902)					4
Hylis olexai (Palm, 1955)					4
Hylis simonae (Olexa, 1970)		NT	NT		5
Isorhipis melasoides (Laporte de Castelnau, 1835)					5
Microrhagus emyi (Rouget, 1856)				3	4
Microrhagus pygmaeus (Fabricius, 1792)					4
Microrhagus pyrenaeus Bonvouloir, 1872	x	NT	EN	3	6

Données publiées. Chittaro and Blanc (2012).

Commentaire. Espèce se rencontrant sous les arbres où les mâles se tiennent contre les tiges ou sur les feuilles des graminées à la recherche des femelles. L'espèce se situe en limite d'aire de distribution et fut considérée auparavant comme endémique de la France centrale et d'une partie du Sud-Est (Platia 1994; Leseigneur et al. 2015). Connue également du canton de Vaud (Gland et Prangins), à quelques centaines de mètres de la limite du bassin genevois (leg. S. Breitenmoser). La donnée de 2022 provient d'un piégeage de tente malaise placée dans une parcelle agricole jouxtant un étang en réserve naturelle.

*4 *Crepidophorus mutilatus* (Rosenhauer, 1847)
Fig. 2D

Matériel examiné. 1 ex., Collonge (GE), 22.VI.1980, leg. Besuchet C., coll. MHNG; 1 ex., ex larva, Collonge-Bellerive (GE), 15.IV.2010, leg. & coll. Blanc M.; 1 ex., Gaillard (74), 08.XI.2012, leg. & coll. Chittaro Y.; 1 ex., Gaillard (74), 13.IV.2018, leg. & coll. Blanc M.; 2 ex., Saint-Julien-en-Genevois (74), 20.VII.2019, leg. & coll. Blanc M.; 1 ex., Gaillard (74), 20.IX.2019, leg. & coll. Blanc M.; 1 ex., Chens-sur-Léman (74), 01.II.2020, leg. & coll. Blanc M.; 1 ex., Chens-sur-Léman (74), 29.VI.2020, leg. & coll. Blanc M.; 1 ex., Chens-sur-Léman (74), 01.VIII.2020, leg. & coll. Blanc M.

Données publiées. Chittaro and Blanc (2012); Leseigneur et al. (2015); Chittaro and Sanchez (2017); Blanc and Rochet (2024).

Commentaire. Espèce discrète dont l'observation des adultes est aléatoire, même dans ses habitats de prédilection. Les larves colonisent différentes essences de feuillus dont le chêne, mais elles semblent avoir une préférence marquée pour les vieux peupliers cariés encore en vie, situés dans les milieux humides et les cordons alluviaux. L'espèce se développe dans les cavités hautes ou basses, dans le bois humide et vermoulu, au contact de Coléoptères de la sous-famille des Cossoninae et de fourmis du genre Lasius. Elle est souvent accompagnée d'*Ischnodes sanguinicollis*, de *Cerophytum elateroides* et parfois de *Nematodes filum*. L'examen systématique des vieux feuillus cariés aux abords de ruisseaux ou en milieux humides devrait permettre d'élargir encore sa répartition dans la région.

*5 *Ampedus cardinalis* (Schiödte, 1865)
Fig. 2E

Matériel examiné. 1 ex., Vandœuvres (GE), V.1990, leg. Besuchet C., coll. MHNG; 1 ex., Choully (GE), 13.IV.2017, leg. & coll. Chittaro Y.; 1 ex., Duillier (VD), 15.V.2017, leg. & coll. Breitenmoser S.; 1 ex., Céligny (GE), 26.V.2018, leg. & coll. Breitenmoser S.; 1 ex., Cologny (GE), 18.VI.2018, leg. & coll. Blanc M.; 2 ex., Douvaine (74), 22.III.2022, leg. & coll. Blanc, M.; 6 ex., Nernier (74), 22.III.2022, leg. & coll. Blanc M.; 1 ex., Nernier (74), 12.VI.2022, leg. & coll. Blanc M.; 1 ex., Nernier (74), 18.VI.2022, leg. & coll. Blanc M.; 1 ex., Versoix (GE), 15.VI.2023, leg. & coll. Chittaro Y.

Données publiées. Chittaro and Blanc (2012); Breitenmoser (2017, 2022).

Commentaire. Espèce autrefois rarissime dans le bassin genevois, elle semble étendre sa répartition depuis quelques années. Elle s'observe dans la carie rouge pulvérulente des cavités ou des troncs pourrissant au sol des vieux chênes, de préférence en lisière bien exposée au soleil. Considérés comme crépusculaires par Leseigneur et al. (2015), les adultes sont également actifs de jour sur les troncs.

*6 *Ampedus elegantulus* (Schöherr, 1817)
Fig. 2F

Matériel examiné. 2 ex., Etrembières (74), 24.IV.2012, leg. & coll. Blanc M.; 1 ex., Veyrier (GE), 11.III.2014, leg. & coll. Blanc M.; 3 ex., Versoix (GE), 31.III.2023, leg. & coll. Chittaro Y., Cosandey V. & Breitenmoser S.

Données publiées. Blanc (2014a); Leseigneur et al. (2015).

Commentaire. Espèce colonisant les troncs morts et vermoulus des chênes, saules, hêtres, aulnes et peupliers, de préférence dans des habitats humides, à proximité d'un ruisseau, d'une rivière ou d'un étang. L'ensemble des observations faites dans le bassin genevois correspond à ces types de milieux. Probablement plus répandu qu'il n'y paraît dans la région, mais localisé et sporadique.

*7 *Ampedus nigroflavus* (Goeze, 1777)
Fig. 2G

Matériel examiné. 1 ex., Étrembières (74), 24.VI.2012, leg. & coll. Blanc M.

Données publiées. Blanc (2014a); Leseigneur et al. (2015).

Commentaire. Espèce rare et sporadique, connue d'une seule donnée pour le bassin genevois (Blanc 2014a), où elle fût observée dans la carie rouge et humide d'un tronc pourri de merisier au sol, le long d'une lisière forestière proche d'une rivière.

*8 *Ampedus sinuatus* Germar, 1844
Fig. 2H

Matériel examiné. 1 ex., Chéserex (VD), 10.V.2014, leg. & coll. Breitenmoser S.; 1 ex., Gingins (VD), 20.V.2014, leg. & coll. Breitenmoser S.; 1 ex., Gingins (VD), 11–26.IV.2015, leg. & coll. Breitenmoser S.; 1 ex., Trélex (VD), 26.IV-12.V.2015, leg. & coll. Breitenmoser S.; 1 ex., Trélex (VD), 12–29.V.2015, leg. & coll. Breitenmoser S.; 1 ex., Gingins (VD), 6.IV.-1.V.2018, leg. & coll. Breitenmoser S.

Données publiées. Leseigneur et al. (2015).

Commentaire. Largement répandue en Suisse sur le Plateau et en Valais, elle semble en expansion depuis le début des années 2000. En France, cette espèce est rare et localisée (Leseigneur et al. 2015). Elle est connue de longue date de la région de Léaz (01), à quelques kilomètres du bassin genevois et il est probable qu'elle soit présente en Haute-Savoie. Dans le bassin genevois, elle a été capturée par battage ou au piège d'interception en lisière de chênaies et de pinèdes. L'espèce paraît inféodée au bois sec en décomposition de feuillus et de pins, en situation thermophile sur versant sec et orienté au sud de préférence (Dodelin B. comm. pers.).

*9 *Brachygonus campadellii* Platia & Gudenzi, 2000

Fig. 2I

Matériel examiné. 1 ex., Prévessin-Moëns (01), 16.IV.2018, leg. & coll. Blanc M.; 2 ex., Cologny (GE), 27.VI.2018, leg. & coll. Blanc M.

Commentaire. Espèce récemment décrite par Platia and Gudenzi (2000) dont la répartition reste à préciser. Citée du sapin, du chêne, du frêne et du châtaignier par Delnatte et al. (2011), l'espèce a été capturée au piège d'interception dans un alignement de vieux chênes sénescents, ainsi que dans un vieux saule mort carié abattu.

*10 *Podeonius acuticornis* (Germar, 1824)

Fig. 2J

Matériel examiné. 1 ex., Versoix (GE), 08.I.1989, leg. Vit S., coll. MHNG; 2 ex., Cologny (GE), 18.X.2007, leg. & coll. Blanc M.; 1 ex., Cologny (GE), 17.IX.2008, leg. & coll. Morin C.; 1 ex., Pregny-Chambésy (GE), 15.IV.2009, leg. & coll. Blanc M.; 1 ex., Vandœuvres (GE), 28.IV.2011, leg. & coll. Blanc M.; 1 ex., Veyrier (GE), 27.III.2015, leg. & coll. Blanc M.; 2 ex., Sciez (74), IV.2016, leg. & coll. Blanc, M.; 3 ex., Versoix (GE), 14.III.2018, leg. & coll. Blanc M.; 1 ex., Chêne-Bougerie (GE), 07.IV.2018, leg. & coll. Blanc M.; 6 ex., Versoix (GE), 07.IV.2018, leg. & coll. Blanc M.; 2 ex., Anthy-sur-Léman (74), 21.IV.2018, leg. & coll. Blanc M.; 1 ex., Versoix (GE), 23.IV.2018, leg. & coll. Blanc M.; 1 ex., Savigny (74), 24.IV.2018, leg. & coll. Blanc M.; 3 ex., Versoix (GE), 29.IV.2018, leg. & coll. Blanc M.; 2 ex., Chêne-Bougerie (GE), 14.V.2018, leg. & coll. Blanc M.; 2 ex., Vandœuvres (GE), 14.V.2018, leg. & coll. Blanc M.; 1 ex., Versoix (GE), 15.V.2018, leg. & coll. Blanc M.; 1 ex., Vandœuvres (GE), 11.VI.2018, leg. & coll. Blanc M.; 3 ex., Chêne-Bougerie (GE), 19.XII.2018, leg. & coll. Blanc M.; 1 ex., Versoix (GE), 26.V-17.VI.2023, leg. & coll. Breitenmoser S.

Commentaire. *Podeonius acuticornis* s'observe plus facilement en hiver et au printemps, en colonies denses, dans la carie rouge cubique des chênes. Espèce pouvant aussi s'observer dans la carie blanche des vieilles racines de chênes, mais par individu isolé. Elle peut être trouvée par battage des branches de chênes et des arbustes alentours. Espèce discrète considérée comme très rare en France et en Suisse, elle n'était que rarement citée du bassin genevois avant 2011.

*11 *Nematodes filum* (Fabricius, 1801)

Fig. 2K

Matériel examiné. 1 ex., Etrembières (74), bois de Vernaz, 02.VI.2013, leg. & coll. Blanc M.

Commentaire. L'espèce a été observée en loge dans la carie humide d'un vieux peuplier creux rongé par les Coléoptères Curculionidae Cossoninae. À l'état adulte, il est possible d'observer *N. filum* dans les cavités, sous les écorces, sur le feuillage des arbres ou déambulant sur les troncs, surtout les peupliers, les saules, les charmes et les hêtres.

*12 *Microrhagus pyrenaeus* Bonvouloir, 1872

Fig. 2L

Matériel examiné. 1 ex., Vandœuvres (GE), VIII.1990, leg. Besuchet C., coll. MHNG; 1 ex., Signy-Avenex (VD), 2–13.VII.2018, leg. & coll. Breitenmoser S.; 2 ex., Veigy-Foncenex (74), 02.VIII.2021, leg. & coll. Blanc M.

Données publiées. Breitenmoser (2022).

Commentaire. Cette espèce se développe dans le bois mort carié (carie blanche) à un stade de décomposition avancé de vieux feuillus, préférentiellement le chêne. À Signy-Avenex, l'adulte a été capturé au piège d'interception situé dans une allée de chênes centenaires sénescents, tandis qu'à Veigy-Foncenex, un couple a émergé d'un élevage de petites branches mortes de chêne. Considéré comme l'un des *Eucnemidae* les plus rares d'Europe (Brustel and Van Meer 2008 ; Chittaro and Blanc 2012 ; Breitenmoser S. *in* Blanc and Rochet 2024), sa répartition a toutefois été précisée en France ces dernières années grâce, notamment, à l'utilisation de pièges d'interception. L'utilisation plus systématique de ce type de piégeage devrait sans nul doute mettre en lumière de nouvelles localités prochainement. À rechercher également sur les charmes (Saurat R., pers. comm).

Commentaires sur les espèces non retenues

Les 13 espèces suivantes ne doivent pas être considérées comme appartenant à la faune du bassin genevois, tout du moins jusqu'à ce que de nouvelles données viennent contredire notre position. Il s'agit soit d'espèces citées uniquement de la littérature sans exemplaires vérifiables, soit d'espèces connues seulement de spécimens étiquetés très imprécisément ou dont la localité est à mettre en doute. Dès 1993, Claude Besuchet a signalé l'inexactitude des captures de Henri Tournier, Max Täschler et Charles Maerky (Sanchez et al. 2016). Les exemplaires des collections Georges Toumayeff, Jean Simonet et Jean Steffen portant uniquement mention du jour et/ou du mois de collecte (sans année) sont issus originellement de la collection de Charles Maerky, mais réétalés et réétiquetés, et ne doivent pas non plus être considérés. En outre, certaines localités annoncées sur les forums entomologiques et malheureusement reprises comme telles dans les bases de données françaises sont pour certaines fausses ou imprécises. Par conséquent, ces données ont été systématiquement considérées comme douteuses.

Agriotes litigiosus (Rossi, 1792)

Commentaire. Espèce des prairies sèches et des champs cultivés, elle est peu commune et localisée en Suisse,

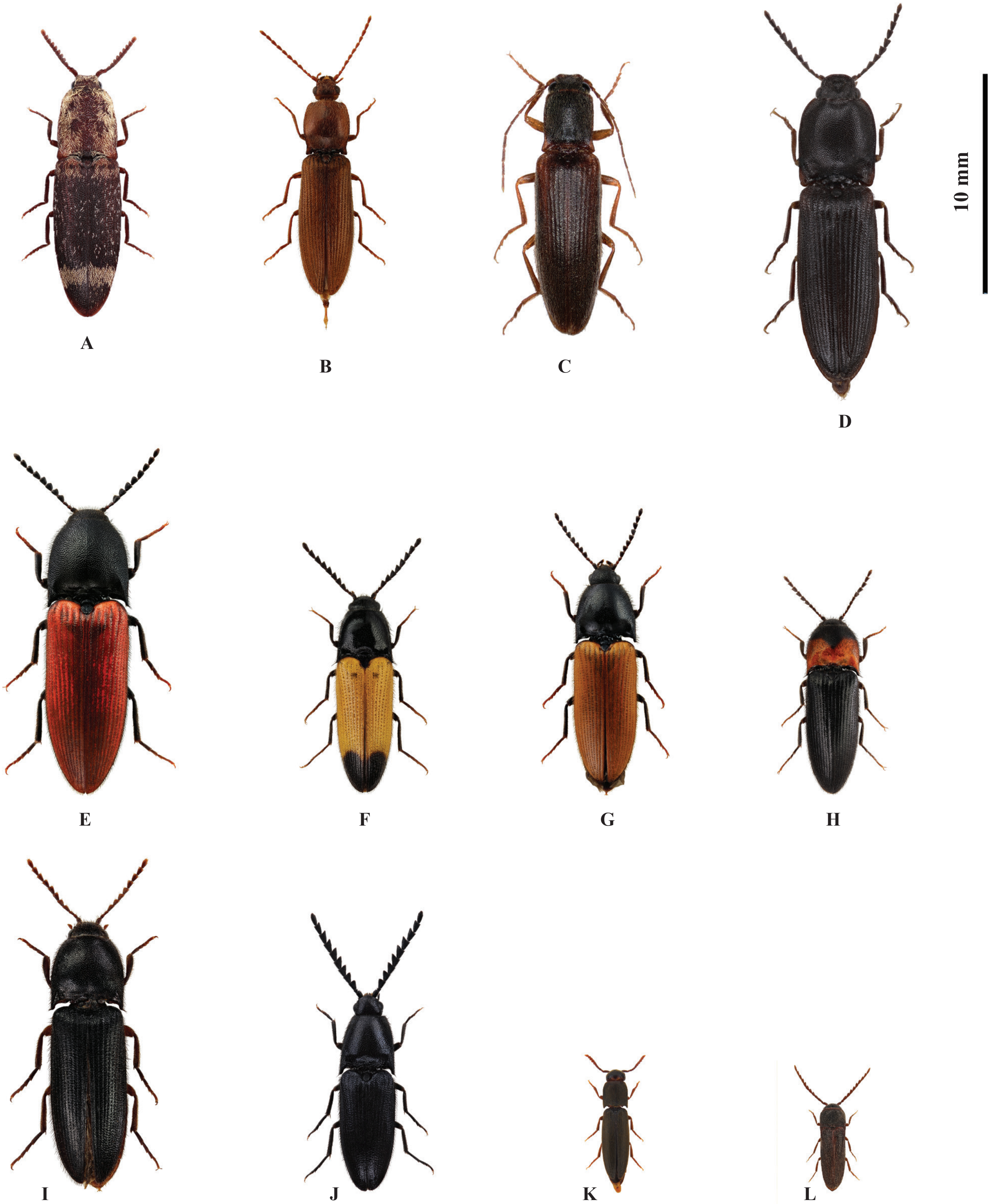

Figure 2. Habitus de spécimens capturés dans le bassin genevois de **A.** *Lacon querceus*; **B.** *Athous emaciatus*; **C.** *Athous tomentosus*; **D.** *Crepidophorus mutilatus*; **E.** *Ampedus cardinalis*; **F.** *Ampedus elegantulus*; **G.** *Ampedus nigroflavus*; **H.** *Ampedus sinuatus*; **I.** *Brachygonus campadellii*; **J.** *Podeonius acuticornis*; **K.** *Nematodes filum*; **L.** *Microrhagus pyrenaeus*. Photos: Christina Lehmann-Graber, sauf C: Stève Breitenmoser et Christina Lehmann-Graber

tout comme dans la région Auvergne-Rhône-Alpes (Leseigneur et al. 2015). Il existe certes des spécimens en collection, mais tous appartiennent à des collections problématiques et ne sont donc pas pris en considération. N’ayant pas fait l’objet d’observation tangible dans le bassin genevois ou à proximité, *A. litigiosus* a été écarté jusqu’à ce que de nouvelles données viennent confirmer sa présence dans la région.

Lacon punctatus **(Herbst, 1779)**

Données publiées. Annemasse (74), Cruseilles (74), Crevin (GE) (Leseigneur et al. 2015).

Commentaire. Espèce très thermophile dont les données fiables les plus proches du bassin genevois se situent dans la Drôme en France. Nous considérons la donnée de Cruseilles comme douteuse et à mettre sur le compte d'une capture accidentelle ou d'une erreur d'étiquetage. Les autres données reprises dans la littérature (Leseigneur et al. 2015) sont issues de la collection Maerky.

Cardiophorus asellus **Erichson, 1840**

Données publiées. Thoiry (01) (Leseigneur et al. 2015).

Commentaire. L'unique mention de *C. asellus* dans le bassin genevois provient de la collection Maerky (MHNG), considérée comme douteuse. L'espèce n'est connue que du Valais en Suisse et près d'Annecy en Haute-Savoie.

Cardiophorus biguttatus **(Olivier, 1790)**

Données publiées. Grand Salève (74) (Leseigneur et al. 2015).

Commentaire. Donnée issue d'un spécimen de la collection Maerky, réétiqueté par Simonet. Elle se situe très loin de sa distribution méridionale (Leseigneur 1972).

Stenagostus rufus **(De Geer, 1774)**

Données publiées. Petit Salève (74) (Leseigneur et al. 2015).

Commentaire. Donnée issue de la collection Maerky (MHNG). Espèce très thermophile liée au pin, peu probable dans la région.

Anostirus sulphuripennis **(Germar, 1843)**

Données publiées. Salève (74) (Leseigneur et al. 2015).

Commentaire. Un spécimen étiqueté " Salève " dans la collection Zehr (MHNG). Nous considérons cette donnée comme douteuse dans l'attente d'une confirmation ultérieure.

Liotrichus affinis **(Paykull, 1800)**

Données publiées. Genève (GE) (Stierlin 1898); Gaillard (74) (Leseigneur et al. 2015).

Commentaire. La donnée de Gaillard est issue de la collection Maerky (MHNG). La citation de Stierlin, dans le canton de Genève, nous parait douteuse pour cette espèce boréo-alpine.

Selatosomus confluens **(Gebler, 1830) ssp.** ***rugosus*** **(Germar, 1836)**

Données publiées. Etrembières (74) (Leseigneur et al. 2015).

Commentaire. Les deux données de Etrembières sont issues de la collection Maerky. Espèce de l'étage alpin, rarement présente en dessous de 2000 m, donc peu probable dans le périmètre du bassin genevois.

Selatosomus cruciatus **(Linnaeus, 1758)**

Données publiées. Genève (GE) (Stierlin and Gautard 1867); Etrembières (74), Thoiry (01) (Leseigneur et al. 2015).

Commentaire Données issues des collections Tournier et Maerky (MHNG) ou dont la donnée de littérature n'est pas attestée de spécimens de référence. Espèce rare et localisée, liée aux terrains sablonneux et humides, surtout dans les vieilles futaies. Peu probable dans le périmètre du bassin genevois.

Selatosomus melancholicus **(Fabricius, 1798)**

Données publiées. Reculet (01), Thoiry (74) (Leseigneur et al. 2015).

Commentaire. Données issues de la collection Maerky (MHNG). Espèce de l'étage alpin, peu probable dans le périmètre du bassin genevois.

Ampedus nemoralis **Bouwer, 1980**

Commentaire. Bien que réhabilitée par Leseigneur et al. (2015), les derniers travaux génétiques sur le genre *Ampedus* (Rougerie et al. 2015; Vuataz et al. 2019) n'ont pas démontré la validité de cette espèce. Nous considérons donc qu'il s'agit d'une simple variété d'*A. pomorum*.

Melanotus crassicollis **(Erichson, 1841)**

Données publiées. Crevin (GE) (Leseigneur et al. 2015).

Commentaire. Donnée issue de la collection Maerky (MHNG), et spécimen réétiqueté par Simonet. Espèce des régions chaudes – présente notamment en Valais (CH) – peu probable dans le bassin genevois.

Melanotus tenebrosus **(Erichson, 1841)**

Données publiées. Salève (74) (Leseigneur et al. 2015).

Commentaire. Connu d'un spécimen du Salève dans la collection Milliat déposé au Muséum d'histoire naturelle de Lille (MHNL). Au regard de la répartition plutôt méridionale de cette espèce, qui préfère les milieux secs et bien ensoleillés (Leseigneur 1972; Leseigneur et al. 2015), nous considérons cette donnée comme douteuse dans l'attente d'une éventuelle confirmation future.

Commentaires sur les espèces potentiellement présentes

Les 9 espèces suivantes n'ont pas encore été observées dans le bassin genevois, mais leur présence attestée à proximité ou leurs préférences en matière d'habitats, nous laisse entrevoir leur potentielle découverte dans un futur proche.

1) Anostirus castaneus (Linnaeus, 1758)

Données publiées. Thoiry (01) (Leseigneur et al. 2015).

Commentaire. La seule donnée connue est issue de la collection Maerky (MHNG), mais *A. castaneus* est bien répandu sur le plateau suisse, de Lausanne à Schaffhouse. Sa présence est donc tout à fait envisageable dans des biotopes sablonneux à l'extrême sud du canton de Vaud.

2) Aplotarsus angustulus (Kiesenwetter, 1858)

Données publiées. Salève (74) (Leseigneur et al. 2015).

Commentaire. La donnée reprise par Leseigneur et al. (2015) correspond à un exemplaire de la collection Maerky, réétiqueté et repréparé par Simonet. L'espèce est très rare en Suisse comme en France, avec toutefois des données fiables sur le Salève mais en limite du périmètre du bassin genevois. Sa présence est donc très probable dans les massifs montagneux de la région.

3) Agriotes sordidus (Illiger, 1807)

Commentaire. *A. sordidus* est connu en Europe centrale et réparti sur quasiment l'ensemble du territoire métropolitain français (Furlan 2004; Thibord et al. 2017; GBIF.org 2023). L'espèce est mentionnée sur la liste suisse des Elateridae (Chittaro and Blanc 2012) mais basée sur une unique et ancienne mention au centre du canton de Vaud qui peut paraître quelque peu douteuse. Sur la base de sa distribution en France, l'espèce est toutefois potentielle pour le bassin genevois. Elle peut engendrer des dégâts aux cultures de pommes de terre en particulier, ceux-ci sont occasionnés par les larves (vers fil de fer). Elle a un cycle larvaire plus court que les espèces connues causant les mêmes problèmes agronomiques telles que *A. lineatus*, *A. obscurus* et *A. sputator* (Jossi et al. 2008).

4) Ampedus balteatus (Linnaeus, 1758)

Commentaire. Annoncé du col de Saxel (74) par Morin C. (comm. pers.), le spécimen n'a pu être vérifié. Nous considérons également les spécimens genevois de la collection Tournier (MHNG) comme douteux. La présence de l'espèce est toutefois possible dans les grandes forêts de montagne du bassin genevois. Elle est notamment présente dans l'ouest du Jura vaudois.

5) Ampedus melanurus Mulsant & Guillebeau, 1855

Commentaire. Cette espèce forestière n'est actuellement pas recensée dans la région, mais de nombreuses données attestent sa présence à proximité, dans la chaîne jurassienne (Leseigneur et al. 2015). Sa découverte reste possible dans les vieilles pinèdes situées au sud du massif jurassien. Elle est à rechercher sur les troncs, sous les écorces ou dans la carie rouge et humide des résineux au sol.

6) Ampedus nigrinus (Herbst, 1784)

Données publiées. Leseigneur et al. (2015).

Commentaire. La donnée de Maerky (MHNG) citée par Leseigneur et al. (2015) est à exclure. Récemment observée en limite du périmètre régional (plusieurs exemplaires capturés dans les hêtraies-sapinières du Jura vaudois en 2020, leg. Breitenmoser S.), cette espèce rare et localisée est très certainement présente dans les forêts de conifères de montagne du bassin genevois.

7) Hypnoidus riparius (Fabricius, 1792)

Données publiées. Leseigneur (1972).

Commentaire. Bien qu'un exemplaire de la collection Tournier (sans date) soit conservé au Muséum de Paris, cette donnée est sujette à caution. Connue du col du Crozet, du côté de la commune de Lelex (01) et anciennement dans l'est du Jura vaudois, l'espèce est certainement présente du côté du bassin genevois, le long des cours d'eau de la chaîne jurassienne.

8) Zorochros pumilio (Kiesenwetter, 1858)

Données publiées. Leseigneur et al. (2015).

Commentaire. *Zorochros pumilio* est cité par Leseigneur et al. (2015) sur une capture unique et ancienne de Jacques Bitsch à Thonon-les-Bains (74), dont nous n'avons pu voir le spécimen. *Z. pumilio* n'est pas connue de Suisse, ni d'aucune autre station du bassin genevois ou à proximité. En l'absence de donnée récente, nous considérons cette espèce comme potentielle pour la région, jusqu'à ce que de nouvelles observations viennent confirmer sa présence.

9) Trixagus exul (Bonvouloir, 1859)

Commentaire. Famille souvent délaissée par les entomologistes, la répartition générale des *Throscidae* demeure très lacunaire. *Trixagus exul* est connu en Isère et en région Lyonnaise, mais son identification est délicate et il peut être confondu avec d'autres espèces du genre.

Discussion

Après révision, 126 espèces (1 Cerophytidae, 102 Elateridae, 14 Eucnemidae et 9 Throscidae) sont considérées comme faisant partie de la faune du bassin genevois. En comparant ces résultats avec ceux de Suisse (Table 2), il ressort que la diversité des espèces du bassin genevois est particulièrement élevée avec près de 70% de la faune helvétique. Le résultat est de 45% par rapport à la diversité des espèces de France continentale, mais reste tout de même élevé sachant qu'il y a un pourcentage non négligeable d'espèces se limitant à la partie méridionale

Table 2. Nombre d'espèces connues dans le bassin genevois, en France, en Suisse et dans les différents départements et cantons du bassin genevois pour les quatre familles traitées, selon l'INPN (consulté le 25/08/2023), info fauna (consulté le 25/08/2023) et le présent travail. À noter que *Ampedus nemoralis* Bouwer, 1980 est ici considéré comme une simple variété d'*A. pomorum* (Herbst, 1784), contrairement aux autres synthèses.

Pays / Zone géographique	Cerophytidae	Elateridae	Eucnemidae	Throscidae	Total
France	1	237	23	15	276
Suisse	1	154	17	9	181
Ain	1	116	12	6	135
Haute-Savoie	1	122	14	7	144
Canton de Genève	1	90	13	8	112
Canton de Vaud	1	121	12	8	142
Bassin genevois	**1**	**102**	**14**	**9**	**126**

du pays. On remarque que plus de 86% des espèces connues de Haute-Savoie, 92% de l'Ain et 88% du canton de Vaud sont présentes dans le périmètre d'étude, alors que celui-ci ne s'étend que sur une petite partie de chacun de ces territoires.

La grande richesse de ces quatre familles au sein du bassin genevois peut s'expliquer notamment par le contexte biogéographique. En effet, le bassin genevois est une porte d'entrée vers le sud de la vallée du Rhône et se situe à la croisée des différentes zones biogéographiques que sont le Plateau, les Alpes et le Jura, et présente une grande amplitude altitudinale allant de 372 à 1720 m. La grande diversité des milieux ouverts (cours d'eau et étangs, prairies, cultures annuelles ou pérennes) et forestiers (chênaies à charmes, ripisylves, hêtraies, hêtraies-sapinières, pessières, pinèdes [Pasche et al. 2016; Brändli et al. 2020]), en ajoutant encore les nombreux arbres isolés (près de 250 000 répertoriés juste pour le canton de Genève [Guinaudeau 2016]) contribue également à expliquer la diversité des espèces recensées. Cette richesse élevée en flore ou en faune pour une petite surface territoriale que représente le bassin genevois est également rapporté dans la littérature (e.g. von Arx 1985; Pétremand et al. 2022; Blanc and Rochet 2024).

Plusieurs espèces sont ici citées pour la première fois de cantons suisses ou de départements français du bassin genevois :

- nouveaux pour la Haute-Savoie : *Microrhagus pyrenaeus*, *Ampedus brunnicornis*, *Ampedus cardinalis*, *Ischnodes sanguinicollis*, *Cardiophorus gramineus*;
- nouveau pour le bassin genevois : *Ampedus sinuatus*;
- nouveau pour le canton de Genève et le bassin genevois : *Hylis simonae*;
- nouveau pour le canton de Genève et la Suisse: *Brachygonus campadellii*.

Des espèces rares, discrètes et/ou d'identification mal aisée, viendront sans doute compléter la liste dans un futur proche (cf. Commentaires sur les espèces potentiellement présentes). Plusieurs espèces et/ou observations reportées dans les catalogues régionaux et dans les bases de données ont été écartées, la plupart du temps en raison d'informations erronées, douteuses ou par simple erreur d'identification. Comme souvent, la répartition des espèces considérées comme communes reste à préciser.

D'après le relief du bassin genevois, les espèces de plaine demeurent logiquement majoritaires. Celles des étages montagnard et subalpin (ce dernier étant tout juste atteint dans les versants nord du jura) sont bien moins connues et inventoriées, mais notons toutefois la présence de quelques espèces d'intérêt patrimonial (Table 1) telles que *Ampedus erythrogonus*, *Ampedus scrofa*, *Danosoma fasciata* et *Denticollis rubens*. Ajoutons également *Athous zebei* et *A. emaciatus*, liés aux conifères d'altitude et présents dans la partie haut-savoyarde du bassin genevois. D'autre part, les espèces potentielles suivantes sont à rechercher ou à confirmer ces prochaines années : *Aplotarsus angustulus*, *Ampedus balteatus et A. nigrinus*, toutes trois se trouvant proches de la dition. Malgré ces quelques exemples, un important effort d'échantillonnage doit être entrepris dans tous les milieux (incluant les prairies et pâturages secs, les marais, les tourbières et les plages de torrents et de rivières), de manière à mettre en évidence les relations entre espèces et milieux d'intérêts, et d'agir de concert avec les autorités pour limiter leur érosion. En effet, par le passé certains massifs forestiers ont subi un vaste remaniement de leur végétation par des coupes rases et par la plantation d'essences exogènes, telle que le sapin de Douglas, en lieu et place des essences indigènes (e.g. Tschopp et al. 2015). En outre, certaines hêtraies pures ont été remplacées par des monocultures de résineux (Auge 2003; IGN 2012). Dans certaines zones, l'abandon progressif du sylvopastoralisme traditionnel a également eu un impact sur le cortège de plantes sauvages des prairies, et donc aussi sur celui des espèces phytophages et rhizophages associées. Par ailleurs, avec les changements climatiques, notamment les températures plus élevées et l'intensification des sécheresses estivales, les massifs forestiers vont évoluer (e.g. DGE-FORET 2022), ce qui impliquera également une adaptation de la faune y compris pour ces quatre familles de coléoptères.

Si les Elateridae, appelés aussi taupins, sont davantage connus ou médiatisés pour leur problématique phytosanitaire, qui rappelons-le concerne moins de dix espèces principalement du genre *Agriotes* (Jossi et al. 2008; Thibord et al. 2017; Naqqash 2023), un nombre bien plus important d'espèces sont de haute valeur patrimoniale. Celles-ci sont rares, exigeantes envers la qualité de leur habitat et/ou inscrites sur liste rouge et sont donc importantes du point de vue conservatoire.

Conclusion et perspectives

Ce travail dresse une première synthèse de l'état actuel de nos connaissances pour ces quatre familles dans le bassin genevois. Elles feront l'objet de recherches supplémentaires et spécifiques ces prochaines années, notamment dans le cadre de la publication future d'un atlas et d'une liste rouge régionale. Les résultats reflètent la grande richesse de ce petit territoire pour les familles étudiées et l'importance de conserver des habitats diversifiés de qualité pour préserver cette biodiversité locale.

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PENSOFT.

Alpine Entomology

A new osmiine bee with a spectacular geographic disjunction: *Hoplitis* (*Hoplitis*) *onosmaevae* sp. nov. (Hymenoptera, Anthophila, Megachilidae)

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Abstract

A new osmiine bee species, *Hoplitis* (*Hoplitis*) *onosmaevae* **sp. nov.** (Megachilidae), is described. So far, this species is exclusively known from the Mercantour National Park in the southwestern French Alps and from mountainous ranges in Turkey and northern Iraq, two areas separated by at least 2000 km. Phylogenetic analyses based on mitochondrial and nuclear genes revealed that *H. onosmaevae* is closely related to *H. adunca* (Panzer, 1798), *H. benoisti* (Alfken, 1935) and *H. manicata* (Morice, 1901). *Hoplitis onosmaevae* is presumably narrowly oligolectic and harvests pollen only on flowers of *Onosma* L. (Boraginaceae). It has a particularly long proboscis, which is probably an adaptation to collect nectar from the long-tubed flowers of this plant genus. The females collect pollen by buzzing the *Onosma* flowers, a rare behavior in megachilid bees. The species nests in insect burrows in dead wood, similar to *H. adunca* and *H. manicata* but unlike other closely related representatives of the subgenus *Hoplitis*, suggesting a single origin of nesting in dead wood and hollow stems in this lineage. In France, *H. onosmaevae* inhabits alpine steppe-like habitats close to forests and appears to be extremely local, since only two populations are currently known. The conservation status of this extremely rare bee species in Europe is discussed.

Résumé

Une nouvelle espèce d'abeille appartenant à la tribu des Osmiini, *Hoplitis onosmaevae* **sp. nov.** (Megachilidae), est décrite. Elle est à ce jour connue du Parc national du Mercantour dans le Sud des Alpes françaises et de zones montagneuses de Turquie et du Nord de l'Irak, deux aires distantes de plus de 2000 km. Des analyses phylogénétiques de gènes mitochondriaux et nucléaires indiquent que cette nouvelle espèce est apparentée à *H. adunca* (Panzer, 1798), *H. benoisti* (Alfken, 1935) et *H. manicata* (Morice, 1901). *Hoplitis onosmaevae* est certainement oligolectique, spécialisée pour la récolte du pollen sur les fleurs d'*Onosma* L (Boraginaceae). Elle est caractérisée notamment par un proboscis très allongé, qui est probablement une adaptation à la collecte du nectar dans les fleurs de ce genre botanique. Les femelles en exploitent le pollen en les faisant vibrer («buzzing»), comportement rare au sein de la famille des Megachilidae. Il a été observé que cette nouvelle espèce nidifie dans des galeries existantes dans le bois mort, à l'instar de *H. adunca* et de *H. manicata*, mais contrairement à d'autres représentants du sous-genre *Hoplitis*, ce qui suggère une origine unique de l'emploi du bois mort et des tiges creuses en tant que substrat de nidification au sein de ce groupe. En France, *H. onosmaevae* semble extrêmement localisée : elle n'a été trouvée que sur deux stations, correspondant à des habitats d'altitude d'affinité steppique, non loin de boisements. Son statut de conservation en Europe est discuté.

Key Words

Anthophila, Apiformes, *Hoplitis*, *Onosma*, osmiine bees, buzzing, conservation, France, Iraq, Turkey

Introduction

Hoplitis Klug, 1807 is the most diverse genus of the bee tribe Osmiini (Megachilidae) with 389 described species, about 80% of which occur in the Palaearctic (Müller 2023a). Fourteen subgenera of *Hoplitis* are currently recognized (Praz et al. 2008; Sedivy et al. 2013c; Müller 2023a) and nearly 60% of the described species belong to *Hoplitis* (*Alcidamea*) Cresson, 1864, *Hoplitis* (*Anthocopa*) Lepeletier & Serville, 1825 and *Hoplitis* (*Hoplitis*) Klug, 1807. The nominal subgenus, which is restricted to the Palaearctic and whose type species is the widespread and common *H. adunca* (Panzer, 1798), is the largest, with 93 described species. The representatives of the subgenus *Hoplitis* can be classified into six species groups, of which four correspond to former subgenera (Michener 2007): the *adunca* (*Hoplitis* s. str.), the *annulata* (*Annosmia* Warncke, 1991), the *erythrogastra* (*Bytinskia* Mavromoustakis, 1954) and the *persica* (*Coloplitis* Griswold, 1998) groups. The two additional species groups are the *bassana* and the *monstrabilis* groups (Sedivy et al. 2013c). While several new *Hoplitis* (*Hoplitis*) species have recently been described from Europe and Morocco (Müller 2012, 2016, 2022), more than 50 species belonging to this subgenus, mainly from Turkey, the Levant and Central Asia, remain undescribed (Müller 2023b).

Species of the subgenus *Hoplitis* are mostly oligolectic or mesolectic and collect the pollen either only on Boraginaceae or Fabaceae or on both of them. The pattern of frequent transitions between the exploitation of these two plant families among related species and the frequent exploitation of both families by the same species has been referred to as the "Boraginaceae-Fabaceae paradox" (Sedivy et al. 2013a). Within the Boraginaceae, the genus *Echium* L. is exploited by many species, but some species also collect the pollen from other genera, such as *Onosma* L., *Lithodora* Grisebach or *Heliotropium* L. Numerous species have particular morphological adaptations for pollen collection, such as hooked bristles on the proboscis or on the fore legs (Müller 2012; Sedivy et al. 2013a). Regarding nesting biology, different behaviours are found within this subgenus. Probably all species of the *annulata* and *monstrabilis* groups nest in the ground in self-excavated burrows (Rozen et al. 2009; Sedivy et al. 2013b; Le Goff 2017; Fateryga et al. 2023; Müller 2023b). Most species of the *adunca* group build their nests exposed in shallow depressions of rocks and stones or hidden within rock cavities and use sand as nesting material, often combined with small pebbles and hardened with salivary secretions, e.g. *Hoplitis anthocopoides* (Schenck, 1853) or *H. loti* (Morawitz, 1867) (Sedivy et al. 2013b). Two species of the *adunca* group nest in insect borings in dead wood or in hollow stems, in addition to other preexisting cavities, and use sand to separate their brood cells: *H. adunca* and *H. manicata* (Morice, 1901) (Müller 2023b; Sedivy et al. 2013b).

We describe here a new *Hoplitis* species of the *adunca* group. This new species was detected during faunistic inventories of the Mercantour National Park in the Alps in southern France. Upon morphological comparison, the French specimens were found to exactly correspond to specimens of an undescribed species from southern Turkey. In the present publication, this new species is morphologically diagnosed, its phylogenetic position within the subgenus *Hoplitis* is explored using genetic analyses, and its nesting biology and floral association are described based on field observations in southern France and microscopical analysis of pollen contained in the female scopae.

Material and methods

Abbreviations and symbols

FL1, FL2,...	flagellar segment 1, flagellar segment 2… (following scape and pedicel);
T1, T2,...	first metasomal tergum, second metasomal tergum...;
S1, S2,...	first metasomal sternum, second metasomal sternum…;
ETHZ	Eidgenössische Technische Hochschule Zürich, Entomological collection, Switzerland;
MAC	Private collection of Matthieu Aubert, Pégairolles-de-Buèges, France;
MNHN	Muséum national d'Histoire naturelle, Paris, France;
NMPC	National Museum (Natural History), Prague, Czech Republic;
OLML	Oberösterreichisches Landesmuseum, Linz, Austria.

Material studied

The following material was examined for this study: 1. males and females of the undescribed species from Mercantour National Park, France, from southern and eastern Turkey and northern Iraq; 2. males and females of *Hoplitis holmboei* (Mavromoustakis, 1948), *H. homalocera* Zanden, 1991, and *H. linguaria* (Morawitz, 1875), which are Boraginaceae specialists and also possess a very long proboscis (Sedivy et al. 2013a), that served for comparison. As no specimens of a fourth *Hoplitis* species with an extraordinarily long proboscis, *H. semilinguaria* Tkalců, 1992 (known only in the female sex), could be located neither in NMPC nor in OLML (Tkalců collection), where the types should be deposited according to the original description, the comparison was performed based on the original description.

Terminology

Morphological and anatomical terminology is based on Michener (2007).

Equipment

Morphological examination of specimens was done with a Perfex Sc 6.38 binocular (7× to 45× magnification). Measurements were realized with a micrometric eyepiece. All pictures of collected and prepared specimens were taken with a Keyence VHX 1000 digital microscope. A reflex body Nikon D7200 combined with a macro lens Nikkor 60 mm were used for field photographs.

Geographical informations

French collecting sites were georeferenced using a field GPS. Turkish and Iraqi specimens were collected by different entomologists between 1968 and 2022 (see list of paratypes below and Suppl. material 1 for details) and the label information regarding the collecting sites is heterogenous. In case the coordinates were not indicated on the label, they were extrapolated from the locality data. All coordinates are given in WGS 84. The distribution map was generated using QGIS Desktop 3.28.3 and AutoNavi Satellite layer.

Microscopical pollen analysis

Pollen was removed from the metasomal scopa of five females from France (one specimen) and three localities in Turkey (four specimens) as well as from two brood cells of a nest discovered in France, embedded in glycerol gelatine on a slide and compared with reference slides containing pollen of different Boraginaceae species and genera under a microscope at 400× magnification.

Genetic analyses

For two individuals of the new species collected in Saint-Dalmas-le-Selvage, France, in 2020 (see list of paratypes below), we sequenced four gene fragments included in the phylogenetic study of Sedivy et al. (2013c): the mitochondrial gene *cytochrome oxidase I* (COI) and three nuclear genes *conserved ATPase domain* (CAD), *elongation factor 1-alpha* (EF) and *long-wavelength rhodopsin* (Opsin), using standard DNA sequencing protocols and primers developed for bees or for Megachilidae (Praz et al. 2008; Litman et al. 2011; Sedivy et al. 2013c). Genetic distances were computed using the Kimura 2-parameter (K2P) distance model in a test version of Paup 4.0 (Swofford 2002) kindly provided by D. Swofford. The new sequences have been deposited on Genbank (accession numbers PP389027–PP389032) and BOLD (accession numbers HYMAA896-24 and HYMAA897-24). Single gene analyses were performed using maximum Likelihood in RAxML 8.2 (Stamatakis 2014), using a single partition and a GTR + G model; the four genes were then concatenated and analysed using RAxML. We implemented two distinct partitioning schemes: first, with four partitions, one per gene; and second, with seven partitions, three for the three nucleotide positions of COI, three for the three nucleotide positions of the nuclear genes, and one partition for the introns; in both cases, a GTR + G model was fitted to each partition.

Results

Field work during summer 2018 in the Mercantour National Park on flowers of *Onosma tricerosperma* subsp. *fastigiata* (Braun-Blanq.) G. López, 1994 (Boraginaceae) by the first author led to the capture of several *Hoplitis* specimens of the *adunca* species group, which were characterized by an extraordinarily long proboscis, a feature not known from other French or Central European species. Upon closer examination, these specimens were found to belong to an undescribed species, which was already known from southern Turkey. Other *Hoplitis* species with a very long proboscis, such as *H. holmboei* from Cyprus, *H. homalocera* from the Levant and *H. linguaria* from eastern Turkey and the Caucasus, differed morphologically, as did *H. semilinguaria* from Iran based on the original description.

Genetic analyses

The two COI sequences obtained for the two French individuals of the new species were identical to each other. Queries carried out with the identification tool of the BOLD systems (www.boldsystems.org) suggested that the closest relatives are *Hoplitis adunca* (89.86–90.48% identity), *H. benoisti* (Alfken, 1935) (89.35–89.71%) and *H. manicata* (85.68–86.42%). Based on COI, the genetic distances between the new species and *H. adunca*, *H. benoisti* and *H. manicata* were 10.98%, 11.05% and 14.9%, respectively.

Phylogenetic analyses of the concatenated, four-genes dataset placed the new species in a strongly supported clade (Bootstrap support, hereafter BS, 100%) that also included *H. adunca*, *H. benoisti* and *H. manicata* (Fig. 1).

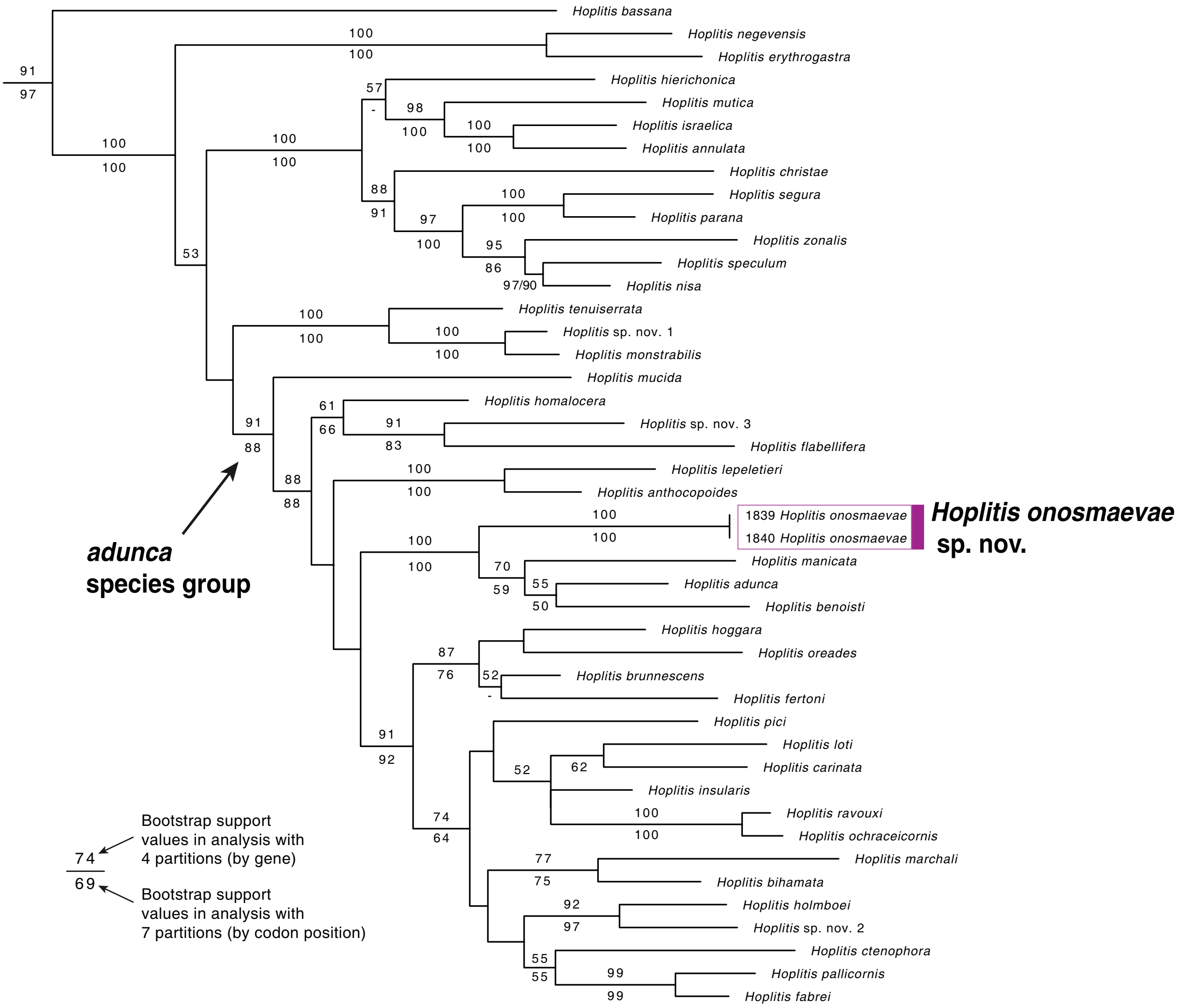


Figure 1. Phylogenetic tree based on maximum likelihood analyses of sequence data of the mitochondrial gene COI and of the three nuclear genes conserved ATPase domain (CAD), elongation factor 1-alpha (EF) and long-wavelength rhodopsin (Opsin). Numbers above branches: statistical support based on 1000 bootstrap replicates (values below 50 are omitted) in the analysis with 4 partitions (by gene); number below branches: support in analysis with 7 partitions (by codon position; a hyphen under a node indicates that this node was not recovered in the analysis); the topology is from the analysis with 4 partitions.

Within this clade, the new species was sister to these three species, although this relationship was only very weakly supported (BS 59–70%). The new species, which is characterized by a particularly long proboscis (see below), was not closely related to two other long-tongued species, *H. holmboei* and *H. homalocera*; there was no genetic data available for *H. linguaria* and *H. semilinguaria*.

Taxonomy

Hoplitis (*Hoplitis*) *onosmaevae* Aubert, sp. nov.

https://zoobank.org/9DAA5D35-8EC4-441F-8180-0A063BFBD30F

Figs 3–14, 16–21, 24

Type material. ***Holotype.*** France • ♀; Alpes-Maritimes, Tinée Valley, Saint-Etienne-de-Tinée, across from Bousiéyas, southern slopes of L'Alpe Mountain (type locality part of Mercantour National Park); 44.315°N, 6.859°E; 1985 m; 13.7.2018; Matthieu Aubert leg.; *Onosma* stand; MNHN (inventory number: EY35781).

Paratypes. France (2♀, 3♂) • 1♀, 1♂; same data as for holotype; ETHZ (♀) and MNHN (♂) coll. (MNHN inventory number: EY35831) • 1♂; Alpes-Maritimes, Tinée Valley, Saint-Etienne-de-Tinée, across from Bousiéyas, southern slopes of L'Alpe Mountain; 44.319°N, 6.858°E; 1920 m; 13.7.2018; Matthieu Aubert leg.; *Onosma* stand; ETHZ. • 1♀, 1♂; Alpes-Maritimes, Tinée Valley, Saint-Dalmas-le-Selvage, vallon du torrent de Jalorgues, Bouden/Bouding; 44.272°N, 6.843°E; 1705 m; 23.6.2020; Matthieu Aubert leg.; MAC. Iraq (1♂) • 1♂; Dahuk governorate, Mt. Gara; 37.015833°N, 43.350556°E; 1912 m, 11.5.2023, D. Baiocchi leg.; D. Baiocchi coll. Turkey (4♀, 6♂) • 1♂; Bolu province, Bolu lake env.; 21.6.1993;

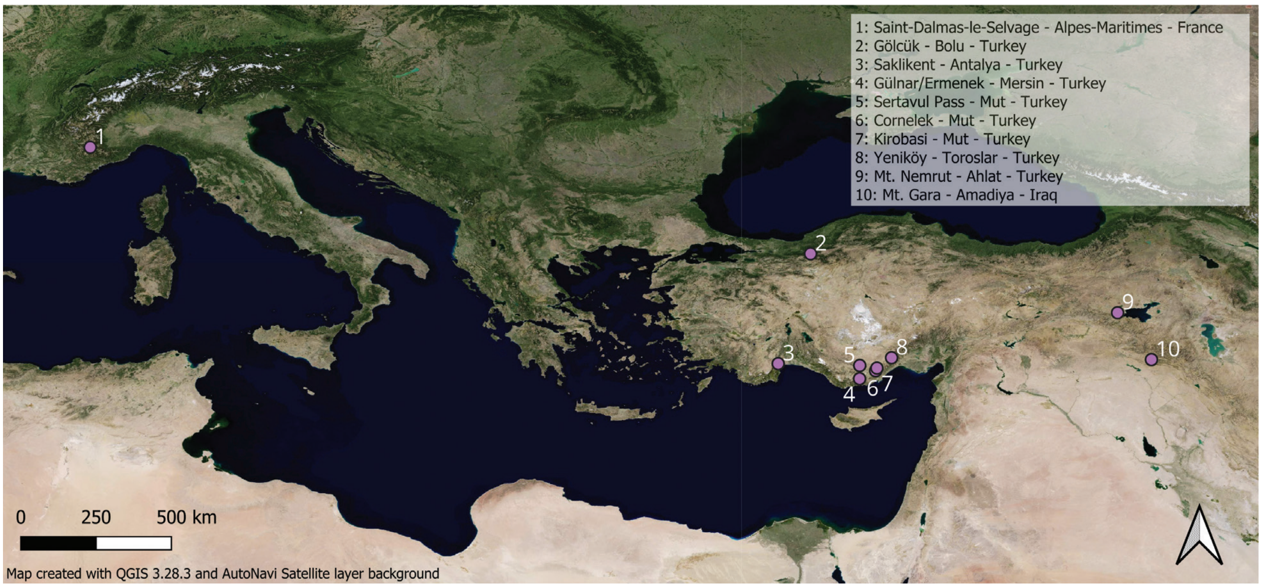


Figure 2. Distribution map of *Hoplitis onosmaevae* sp. nov.

M. Halada leg.; ETHZ. • 2♂; Antalya province, 4 km east of Saklikent; 36°52.51'N, 30°30.954'E; approx. 1600 m; 30.5.2009; John S. Ascher, Jerome G. Rozen, Hikmet Özbek leg.; ETHZ. • 1♀; Mersin province, Mersin district, between Gülnar and Ermenek; 36°21.380'N, 33°18.841'E; 1075 m; 24.5.2006; Erwin Scheuchl leg.; ETHZ. • 1♀; Mersin province, Mut district, Sertavul Pass; 36.812°N, 33.32°E; 1300 m; 7.6.1968; Josef Gusenleitner leg.; ETHZ. • 1♀; Mersin province, Mut district, Kirobasi; approx. 36.723°N, 33.900°E; 1450 m; 19.6.1997; Marek Halada leg.; ETHZ. • 1♀; Mersin province, Mut district, 40 km east of Cornelek; approx. 36.630°N, 33.866°E; 1700 m; 29.5.1996; Mi. Halada leg.; ETHZ. • 1♂; Mersin province, Toroslar district, Yeniköy; 37.08°N, 34.41°E; 1200 m; 29.5.1993; Stephan Risch leg.; ETHZ. • 2♂; Bitlis province, Mount Nemrut, 36.626°N, 42.186°E; 2350 m; 25.5.1989; Klaus Warncke leg.; ETHZ.

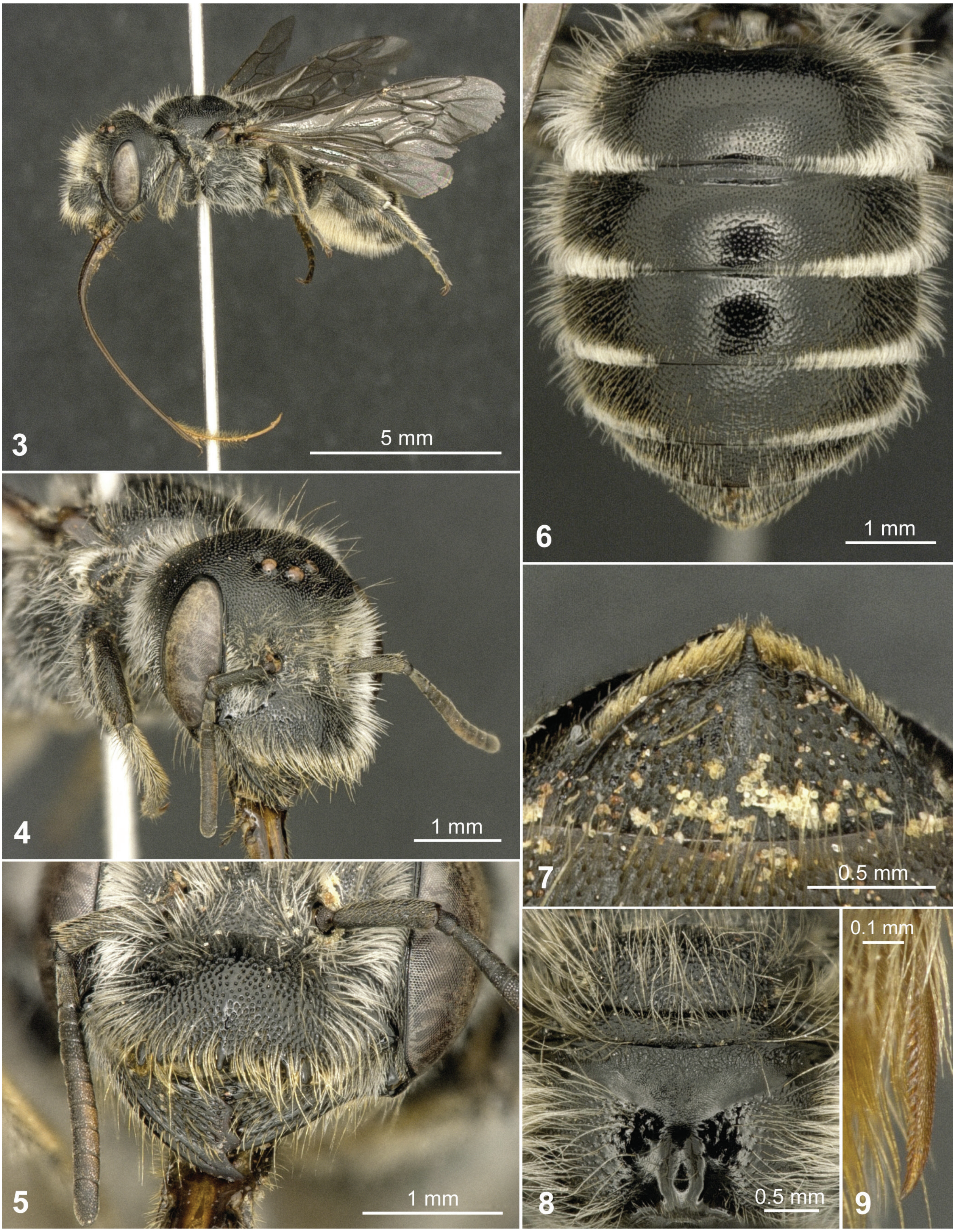
See Suppl. material 1 for a complete list of records as well as Fig. 2 for a distribution map.

Diagnosis. In most species of *Hoplitis* (*Hoplitis*), the length of the proboscis is at most one-third as long as the body. Only *H. linguaria*, *H. holmboei*, *H. homalocera* and *H. semilinguaria* have a longer proboscis, which reaches about half of the body length. *Hoplitis onosmaevae* possesses an even longer proboscis, which is approximately as long as the body (Fig. 3). In both sexes of *H. holmboei* and *H. homalocera*, the vertex is comparatively short (ocelloccipital distance less than two ocellar diameters) and, when seen in front view, not elevated behind ocelli, but regularly rounded across its width; in *H. onosmaevae* the vertex is longer (ocelloccipital distance about three ocellar diameters) and is strongly elevated behind ocelli (Figs 3, 4). *Hoplitis onosmaevae* differs from *H. linguaria* in both sexes by the color of the tegulae, which are reddish-orange in *H. linguaria* and brown (although often reddish brown along the external margin) in *H. onosmaevae*. In the female, *H. onosmaevae* can be distinguished from *H. linguaria* by the lateral margins of S6, which have a thickened rim, and by the apical margin of S6, which ends medially in a sharp spine as in *H. adunca* (Fig. 7); in *H. linguaria*, S6 lacks thickened rims or a medioapical spine. Moreover, the punctation of the supraclypeal area in *H. onosmaevae* is comparatively fine and dense with only small interspaces especially in the middle, whereas it is sparse in *H. linguaria* in the middle. In the male, *H. onosmaevae* can be distinguished from *H. linguaria* by the shape of the membranous appendage at the apical margin of S6 and the form of the gonostylus. In *H. onosmaevae*, the appendage of S6 is longitudinally raised medially, wider at the base than at the apex, tapers into a narrowed tip and is covered with short light orange hairs in the middle (Figs 12, 14). The gonostylus is threadlike and slightly clubbed at the apex. In *H. linguaria*, the membraneous appendage of S6 is flat, short and distinctly bilobed and the gonostylus is much thicker and narrowed at the apex. Compared to *H. semilinguaria*, which is known only in the female, the inner margins of the compound eyes are diverging towards the clypeus in *H. onosmaevae*, whereas they are parallel in *H. semilinguaria*. In addition, S6 of *H. linguaria* lacks thickened marginal rims as is probably also the case in *H. semilinguaria*. Tkalců (1992) compared these two species and did not provide any information on the structure of S6.

Hoplitis onosmaevae can be separated from the common species *H. adunca*, which is similar in size and also has thickened marginal rims and a medioapical spine on female S6, by the yellowish-brown hind tibial spurs (Fig. 9) (tibial spur black in *H. adunca*), in addition to the longer proboscis.

Description. Female (habitus: Figs 3, 18–20, 24). Body length 9–10 mm.

Integument color. Cuticula generally black, except where indicated hereafter. Proboscis brown, glossa or-



Figures 3–9. *Hoplitis onosmaevae* sp. nov., female (holotype). **3.** Lateral view; **4.** Head; **5.** Clypeus and mandibles; **6.** Metasoma, dorsal view; **7.** Last sternum, ventral view; **8.** Propodeum; **9.** Inner spur of hind tibia, posterior view.

ange. Cuticula reddish-brown laterally along apical margin of clypeus and more or less along margin of sternites and tergites, on internal surface of femora, apical part of leg segments, especially last tarsi and claws. All tibial spurs yellowish-brown to orange. Tegulae dark brown, external margin often reddish brown. Wing venation dark brown. Eyes grey-brown in the field. ***Vestiture color.*** Generally white, including scopa, except where indicated hereafter. Hairs slightly darker, greyish brown, on scutum. Some hairs along apical margin of clypeus and on tergal discs yellowish white. Hairs on internal surface of tibiae and tarsi, on basal part of femora and apical half of trochanters yellowish-orange.

Head. Vertex strongly elevated and tilted forward when seen in front or 3/4 view. Ocelloccipital distance approximately equal to three ocellar diameters (Fig. 4). Inner margin of compound eyes slightly diverging below (ratio between upper and lower interocular distance approximately 0,92). Clypeus strongly convex, protruding, apical margin with approximately nine teeth, lateral teeth triangular, median teeth nearly cylindrical (Figs 4, 5). Mandibles tridentate, apical tooth elongate, acute (Fig. 5). Proboscis equal to body length when fully extended, galea half as long as body, with short bristles basally. Labrum longer that wide. Head overall shiny, shagreened only on parts of clypeus (see below), densely punctate; interspaces absent or narrow, except on vertex and genae where interspaces can be as wide as one puncture diameter, on frons laterally and close to ocellar area where the interspaces can reach two puncture diameters. Frons along frontal line and supraclypeal area more densely and finely punctate (supraclypeal area sometimes comprises some narrow interspaces centrally). Clypeus more strongly punctate than elsewhere on head, interspaces up to 1 or 2 puncture diameters, punctation becoming denser and finer apically; clypeus in basal half with median impunctate longitudinal line (Fig. 5), line sometimes reaching apical margin. Labrum unpunctured and shiny in basal third, mat and shagreened apically, here more or less punctate. Proboscis surface unpunctured, smooth and shiny on the front, mat and shagreened laterally and dorsally. ***Antennae.*** FL2 slightly longer than FL3 and FL4 together; FL (5–6–)7–10 brown-orange below (Fig. 5).

Mesosoma. Pronotum weakly shagreened with shallow punctation, but shiny. Mesepisternum (except ventral part), scutum and scutellum shiny, densely and relatively strongly punctate, interspaces well visible, up to 2 to 3 punctures diameters on central part of scutum. Mesepisternal concavity shiny with sparse punctation. Axillae shagreened, densely and finely punctate. Metanotum shiny with distinct punctation. Metepisternum weakly shagreened but shiny. Propodeal triangle nearly entirely shagreened, shiny in its lower part; propodeal posteriorly nearly impunctate around propodeal pit, more densely punctate laterally; sides of propodeum densely and finely punctate (Fig. 8). Mesepisternum ventrally impressed along longitudinal axis, this concavity open posteriorly between mid-legs insertions, here shiny and sparsely punctate. Mesosoma entirely hairy except on propodeal triangle and propodeal pit (Fig. 8). Hairs on scutellum, lateral part of mesepisternum and on propodeum as long as on vertex, shorter on scutum and even more so on ventral parts of mesepisternum. ***Legs.*** External extensions on apex of first and mid tibiae relatively thin, elongated and curved. Spur of front tibiae modified, internal margin lamellar, external margin thick and curved, apex of spur pointed, internally with a minute fringe of hairs. Front metatarsi basally with an internal notch. Inner spurs of hind tibiae straight and regularly tapering, only slightly curved apically (Fig. 9).

Metasoma. T1 smooth and shiny, unpunctured on vertical part, disk with regular, sparse punctation (interspaces up to 4 puncture diameters), punctation denser and finer toward the margin. T2–3 similar to T1, but impressed basally, punctation sparser on T2 than on T1, becoming even sparser on T3. T4 similar to T3, slightly more shagreened, punctation rugose. T5–6 shagreened, punctation denser and more rugose than on T4. All terga with a thin impunctate margin, impunctate margin larger on T6. In fresh specimens, T1–4 laterally with long erect white hairs, hairs on T1 as long as those on scutellum; T1–4 with white, interrupted apical fasciae, T5 with continuous apical fasciae, T6 with decumbent, light hairs. S1–6 shiny but slightly shagreened with moderately dense (2 to 3 puncture diameters), rugose punctation, their margin impunctate. S6 laterally with a thickened rim, rim interrupted before apex; apex pointed (Fig. 7).

Male (habitus: Figs 16, 17). Body length 10–12 mm.

Integument color. As in ♀ except when mentioned below. Eyes grey-green in the field. ***Vestiture color.*** Predominantly brown-orange in fresh specimens, fading to yellowish to greyish white.

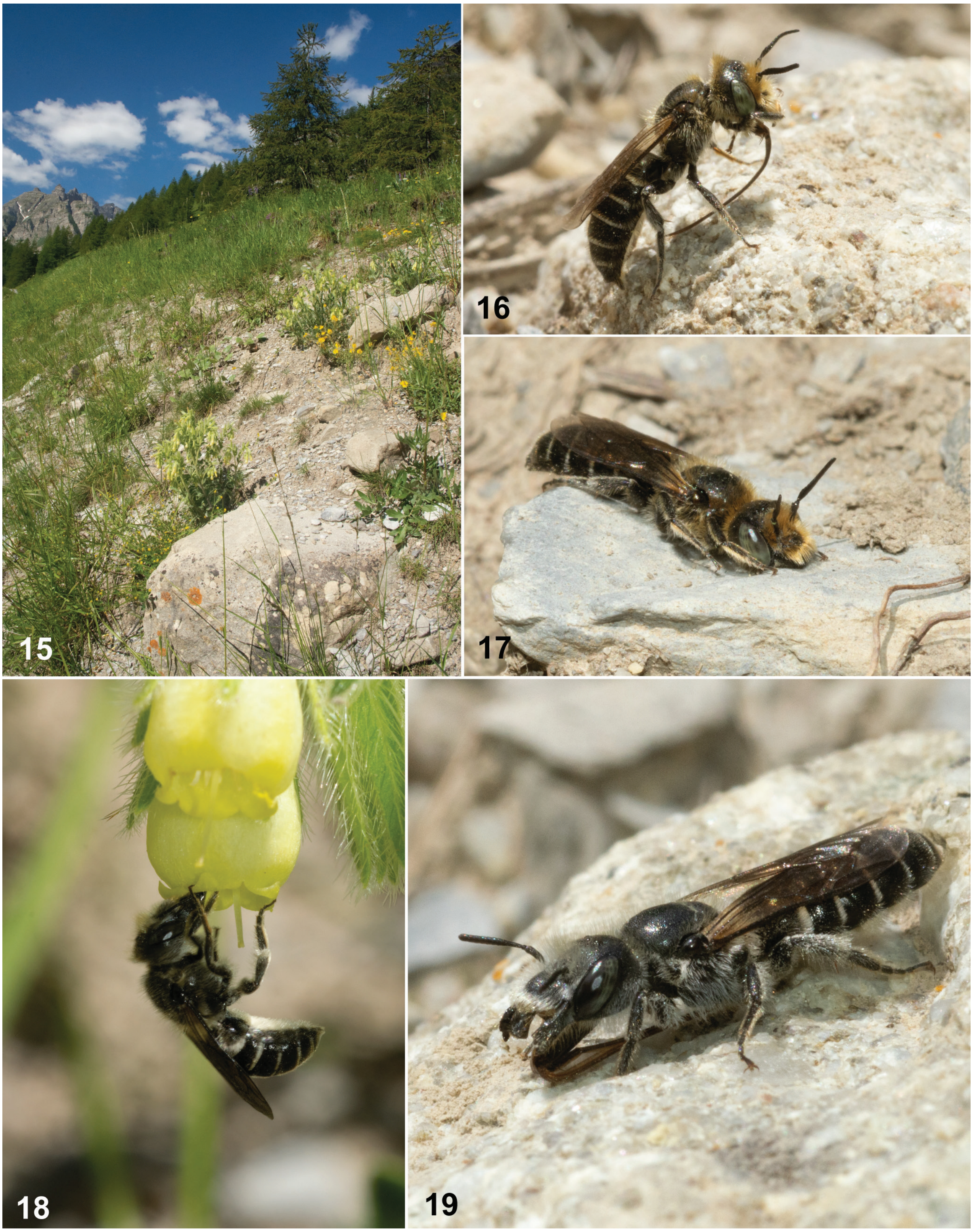
Head. Vertex as in ♀. Inner orbital edges slightly diverging below (less so than in ♀). Clypeus protruding, apical margin denticulate, but less regularly and strongly than in ♀; teeth partly hidden by dense apical fringe of hairs. Mandibles bidentate, upper tooth short, apical tooth sharp. Proboscis, galea and labrum proportions as in ♀. Vestiture very dense on frons, paraocular and supraclypeal areas and clypeus. Punctation overall more homogeneous than in ♀, finer and denser on average; clypeus entirely punctate except a narrow impunctate area along lateral margins, punctation fine and dense, difficult to see due to dense vestiture. Labrum medially shiny, unpunctured or with sparse punctation, shagreened and more densely punctate laterally. ***Antennae.*** Scape densely punctate and hairy, 3 times as long as wide at apex; width at apex twice basal width. FL2 triangular, at most 1,5 as long as wide at apex, as long as FL3 and FL4 together. FL3 and FL4 twice as wide as long. FL8–10 nearly square, FL11 approximately 1,5 times as long as wide. Flagella flattened dorso-ventrally; only internal surface of FL2 (distinctly) and FL3 (slightly) convex. FL5– or FL6–11 orange ventrally (Figs 10, 11).

Mesosoma and legs. As in ♀ except where indicated hereafter. Punctation denser and finer on scutum and lateral parts of mesepisternum, and denser on area around propodeal pit.

Metasoma. Tergal punctation generally as in ♀ but punctures less impressed and area with fine punctation on tergal margins wider. T7 finely punctate and shagreened basally, smooth and shiny medially, punctation becoming rugose and sparse apically. T2–3 depressed basally. T6 with a strong tooth laterally, apical margin irregular, slightly sinuate medially. In dorsal view, lateral margin of

Figures 10–14. *Hoplitis onosmaevae* sp. nov., male. **10.** Left antenna, dorsal view; **11.** Left antenna, front view; **12.** Sterna 3–6 (the metasoma was slightly extended to expose S6); **13.** Terga 5–7, dorsal view; **14.** Membraneous appendage of sternum 6, lateral view.

T7 slightly concave medially, apical margin rounded (Fig. 13). Metasomal vestiture as in ♀ except where indicated hereafter. Lateral fasciae of T1 less pronounced and more elongated, T2–5 with shorter hairs, T6 with continuous fasciae on apical margin, fasciae narrower in the middle but not interrupted, T7 with long hairs laterally but fewer hairs medially. S1 thicker than S2–4, with lamellar margin. S2–5 with a transverse premarginal gibbosity (inconspicuous on S5), S5 with longitudinal central groove. Margins of S1–4 slightly sinuate, S5 straight medially, rounded laterally. S6 basally with short and wide translucent lamella, median extension trapezoidal, with sinuate margins (Figs 12, 14; see also Diagnosis). S1 with strong and dense punctation on thickened part. S2–4 with dense punctation, shagreened and with fine punctation basally and premarginally, transverse gibbosities smooth and shiny, with sparse punctation medially. Median extension of S6 mostly shagreened (Fig. 14). Apical margin of S1–3 with sparse fringe of relatively long hairs, apical fringe shorter on S4, almost absent on S5. S6 baso-laterally with dense and long fringe of hairs, hairs emerging behind translucent lamella; surface of median extension of S6 with short yellowish-orange hairs. Gonostyli thread-like, slightly clubbed apically.



Figures 15–19. *Hoplitis onosmaevae* sp. nov., foraging habitat and behaviour (France, Saint-Dalmas-le-Selvage, 23.6.2020). **15.** Foraging habitat with patch of the host plant, *Onosma tricerosperma* subsp. *fastigiata*; **16.** Male resting on stone between two patrolling flights, with unfolded proboscis; **17.** Male resting on stone between two patrolling flights; **18.** Female on a flower of *Onosma tricerosperma* subsp. *fastigiata*; **19.** Female concentrating nectar with widely open mandibles.

Etymology. The species epithet *onosmaevae* refers to the assumed close association with plants of the genus *Onosma* (see section on pollen hosts below) and to Maëva Gardenat, to whom the first author wishes to dedicate this species.

Distribution. Known so far from the Mount Gara in northern Iraq (Dahuk Governorate), from the Nemrut Dağ in Eastern Turkey (Bitlis province), from the western and central Taurus Mountains in southern Turkey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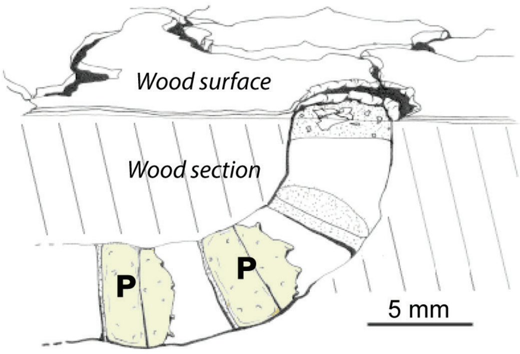

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Figures 20–25. *Hoplitis onosmaevae* sp. nov., nesting habitat and behaviour (France, Saint-Dalmas-le-Selvage, 23.6.2020, for photographs). **20.** Female in buzzing position on a flower of *Onosma tricerosperma* subsp. *fastigiata*; **21.** Female leaving a flower of *Onosma tricerosperma* subsp. *fastigiata*; **22.** Nesting habitat with dead trunks of larch; **23.** Nest entrance plugged with sand and pebbles; **24.** Female near the nest entrance, which is visible at the bottom left; **25.** Cross-section of nest (P = pollen provisions).

(Antalya and Mersin province), from the western Pontic Mountains in northwestern Turkey (Bolu Province) and from the Tinée Valley in the French southern Alps (Provence-Alpes-Côte-d'Azur region) (Fig. 2). In France, the species appears to be extremely rare and localized. So far it has only been found at two sites separated by less than 5 km; at each site, only few individuals were observed (the estimated number of individuals was 3 and 10–20, respectively). The search for the species was unsuccessful in several other localities in the French southern Alps with populations of *Onosma tricerosperma* subsp. *fastigiata*. These localities were situated 10 km to 18 km to the east, the north and the southwest of the two known sites of *H. onosmaevae*. Localities surveyed were the Bachelard valley above Fours-Saint-Laurent (Alpes-de-Haute-Provence, Uvernet-Fours, 44.32°N, 6.69°E) between 1750 m and 1900 m on 11.7.2019 and 27.6.2020, the Ubaye upper-valley, around la Barge and Maljasset (Alpes-de-Hautes-Provence, Saint-Paul-sur-Ubaye, 44.59°N, 6.83°E) between 1700 m and 2150 m on 11.7.2019 and 25.6.2020, the Ubayette valley, around Larche (Alpes-de-Haute-Provence, Larche, 44.45°N, 6.45°E) between 1650 m and 2000 m on 13.7.2019, above Saint-Ours (Alpes-de-Haute-Provence, Val d'Oronaye, 44.48°N, 6.81°E) between 1800 m and 1950 m on 26.6.2020, and the Barlatte upper-valley (Alpes-Maritimes, Châteauneuf-d'Entraunes, 44.18°N, 6.83°E) between 1700 m and 1850 m (MNP core area) on 25.6.2022. However, some of these unsuccessful visits were not performed under ideal conditions (e.g. end of blooming time or low abundance of blooming host plants), so that the occurrence of *H. onosmaevae* at all these sites cannot be excluded with certainty.

Field observations. Field observations were conducted at the "Vallon du torrent de Jalorgues" (Figs 15, 22) on 23.6.2020, when *Hoplitis onosmaevae* was found for the first time, and on 28.6.2020. The first visit took place in good weather conditions and lasted from 10:00 to 15:30. Several females and males were seen, most observations and pictures were realized on that day and a nesting site was found. During the second visit, fewer individuals were observed, possibly due to the less favorable weather conditions and we focused on a closed nest found five days before, around which a single female was seen.

Behaviour at *Onosma* stands. Several females were observed collecting pollen and nectar on flowers of *Onosma tricerosperma* subsp. *fastigiata* (Figs 18, 20, 21). After landing on the corolla, they entered the flower headfirst, clung to the style and then vibrated the flower by buzzing to extract the pollen. This behavior was observed several times. Each visited flower was sonicated usually twice during a few seconds. The females then collected nectar on the same flower and repeated the same sequence on the next flower. The bees landed frequently on the ground or on a stone between two flower visits to concentrate the nectar by widely spreading the mandibles and the labrum and slightly unfolding the proboscis (Fig. 19). Males were observed patrolling *Onosma* patches in their search for females, resting frequently nearby on the ground or on a stone (Figs 16, 17). They sometimes interrupted their patrolling flights to ingest nectar from *Onosma* flowers.

Pollen hosts. The pollen contained in the female scopae and the brood cells was morphologically identical to reference pollen samples of *Onosma*; while the French samples certainly belong to *Onosma*, the unambiguous identification of *Onosma* pollen was not possible for the Turkish samples, as several closely related Boraginaceae genera with similar pollen morphology occur in Turkey.

Nesting biology. A nesting site was found on 23.6.2020 in the "Vallon du torrent de Jalorgues" by observing the flight direction of a female leaving the main patch of host plants. The nesting site was situated at a distance of approximately 35–40 m from the *Onosma* patch, where three dead trunks of larch (*Larix decidua* Miller, 1768) were present, one lying and two still standing (Fig. 22). Two nests in preexisting insect burrows were discovered, one in the lying trunk and the other in a standing trunk. One nest was left untouched, while the second was partially opened five days later. This nest consisted of an unknown number of brood cells, of which the two outermost were excavated. These cells were in line and parallel to the external surface of the tree trunk. The following nest architecture was observed (Fig. 25): 1. a nest plug composed of small pebbles glued together with fine sand, which was probably mixed with secretions (Fig. 23); 2. an empty chamber; 3. a partition constructed with sand, but without pebbles; 4. the outermost cell containing a solid provision mass (egg or larva not visible); 5. a partition built with sand; 6. the penultimate cell containing a solid provision mass (egg or larva not visible); 7. another partition built with sand.

Discussion

Biogeography

In the past twelve years, numerous new bee species have been discovered in mainland France. These new discoveries mainly concern species known from adjacent or other European countries (Vereecken and Barbier 2009; Aubert et al. 2010; Dufrêne et al. 2014; Aubert 2016; Genoud and Dufrêne 2016; Gabiot and Dufrêne 2018; Le Divelec 2020; Le Divelec and Aubert 2020). Alternatively, some of the newly discovered taxa are cryptic species that were previously confused with closely related taxa (Ghisbain et al. 2018; Praz et al. 2019, 2022; Kasparek 2020; Litman et al. 2021). The discovery of overlooked, newly immigrated or cryptic species may continue or even accelerate in the future as interest in bees increases and identifications and species delimitation are more and more complemented by DNA analyses. Much rarer, however, is the discovery of morphologically well characterized bee species that are new to science, such as *H. onosmaevae*.

This discovery is particularly remarkable as this species shows a highly disjunct distribution, occurring in southern France and at least 2000 km away in Turkey and Iraq. The morphology of both females and males of the European and the Asian populations is completely identical including the shape of the male antenna and the form of the membraneous appendage of male sternum 6, which are highly diagnostic characters in the subgenus *Hoplitis*.

Thus, these disjunct populations are treated here as conspecific despite the lack of genetic data for the eastern populations. The bumblebee *Bombus brodmannicus* Vogt, 1909 shows an even more disjunct distribution occurring in the southern Alps and the eastern Pontic Mountains, the Armenian highlands and the Caucasus (Rasmont and Iserbyt 2014). Another putative *Onosma* specialist was discovered in France just a few years ago, *Eucera breviceps* (Friese, 1911), which was previously known only from Turkey and Syria (Aubert et al. 2024). It recently turned out, however, that this species is also present in Greece, Bulgaria and Italy. It cannot be excluded that *H. onosmaevae* also occurs in mountainous areas between France and Turkey, e.g. in Italy or the Balkans, where the bee fauna has not yet been thoroughly studied. In fact, the occurrence of *H. onosmaevae* in Bolu province close to the European part of Turkey renders the new species' occurrence in Greek mountain ranges quite probable.

Host plants

Hoplitis species of the subgenus *Hoplitis* show a tight association with two plant families, the Boraginaceae and the Fabacaeae (Sedivy et al. 2013a). Although our results are based on few samples only, analyses of pollen contained in the female scopae and the brood cells as well as field observations strongly suggest that *H. onosmaevae* sp. nov. is narrowly oligolectic on *Onosma*. The long mouthparts and the ability to buzz the flowers are clearly adaptations for the collection of nectar and pollen from *Onosma*. Pollen collection on Boraginaceae genera with narrow-tubed flowers requires morphological or behavioral adaptations known to occur in numerous species of diverse bee groups including *Hoplitis* species of the subgenus *Hoplitis* (Müller 1995). Among the *Hoplitis* species of the *adunca* group, *H. flabellifera* (Morice, 1901) possesses curved bristles on the front tarsi used to extract pollen from flowers of the genus *Anchusa* L. (Sedivy et al. 2013a). The recently discovered *H. lithodorae* Müller, 2012 has specialized hooked bristles on the galeae of the proboscis, which serve to scratch pollen out of the narrow corolla of the flowers of *Lithodora*, its exclusive pollen host (Müller 2012; Aubert 2016). Among the *Hoplitis* species of the *annulata* group, *H. aqabaensis* (Warncke, 1991), oligolectic on *Echiochilon* Desfontaine, has long and stiff pollen-collecting bristles on the ventral side of the first segment of the labial palpi and the base of the second segment (Sedivy et al. 2013a). In the *persica* species group, *Hoplitis persica* (Warncke, 1991), which is presumably oligolectic on *Heliotropium*, has apically curved and capitate bristles on the second segment of the labial palpi most probably used to extract pollen from the narrow-tubed *Heliotropium* flowers (Sedivy et al. 2013a).

In contrast to the Boraginaceae genera mentioned above, pollen collection on flowers of *Onosma* does not require morphological specializations on proboscis or front legs. In this genus, the pollen is shed into a cone that is formed by the five adjacent anthers and can be extracted either by buzzing or with mandibles and fore legs (Teppner 1995, 2011; Trunz et al. 2020). Beside *H. onosmaevae*, four additional species of the subgenus *Hoplitis* are known to apply buzzing to extract pollen from cone-shaped flowers of the Boraginaceae (Sedivy et al. 2013a): *Hoplitis holmboei*, which is oligolectic on several genera of the Boraginaceae, such as *Onosma*, *Echium* and *Lithodora*, *H. homalocera*, which exclusively collects pollen on *Podonosma* Boiss., a close relative of *Onosma*, and two undescribed species of *Hoplitis* (*Hoplitis* sp. nov. 2 and *H.* sp. nov. 3 in Sedivy et al. 2013a), which buzz the flowers of *Onosma* and *Trichodesma* R. Brown, respectively. At least two species that belong to other families than Megachilidae are also known to buzz the flowers of *Onosma*: *Eucera breviceps*, oligolectic on *Onosma* (Aubert et al. 2024), and the short-tongued bee *Andrena symphyti* Schmiedeknecht, 1883, oligolectic on Boraginaceae and known to collect pollen also on *Symphytum* L. and *Cerinthe* L. (Teppner 2011). The females of *Osmia apicata* Smith, 1853, a Boraginaceae oligolege with a strong preference for *Onosma* (Haider et al. 2013), do not buzz the *Onosma* flowers but scrape the pollen out of the cone with their fore legs after intruding their head into the corolla (Gogala and Surina 2011). The front legs of *H. onosmaevae* are probably not involved in pollen collection, although the females insert the head and the front part of the mesosoma into the corolla. Instead, by placing the ventral side of the mesosoma against the style (Fig. 20), the vibration of the thorax is transmitted to the cone through the style during buzzing (Buchmann 1983; Teppner 2018). The extraordinarily elongated proboscis of *H. onosmaevae*, which is probably not used for pollen extraction, allows males and females to access the nectar, which accumulates at the base of the *Onosma* corolla tube.

The phylogenetic position of *H. onosmaevae* strongly suggests that specialization on *Onosma* has occurred at least twice among species of the *adunca* group, once in *H. onosmaevae* and once in the clade containing *H. holmboei* and *Hoplitis* sp. nov. 2, whereas *H. holmboei*, and possibly *Hoplitis* sp. nov. 2, also collect pollen from other genera of Boraginaceae. The phylogenetic position of *H. linguaria*, which is most probably oligolectic on *Onosma* (Müller 2023b), and of *H. semilinguaria*, which might also be an *Onosma* oligolege due to its long proboscis, is unknown. However, morphology suggests that they are not closely related to *H. onosmaevae*, which differs from these two species by the presence of a marginal rim and a medioapical spine on S6, two characters that *H. onosmaevae* shares with its closest relatives *H. adunca*, *H. benoisti* and *H. manicata*. Whether *H. linguaria* and *H. semilinguaria* are closely related to each other or to *H. holmboei* will require further investigation; depending on their phylogenetic position, specialization on *Onosma* may have indepently evolved two, three or even four times in the subgenus *Hoplitis*.

Nesting biology

The nesting biology is unknown for more than two thirds of the *Hoplitis* species of the *adunca* group (Müller 2023b). Most species for which the nesting habits are known build their nests exposed in depressions of rocks or hidden within rock cavities and all use sand as nesting material, often combined with small pebbles (Sedivy et al. 2013b). Exceptions are *H. fertoni* (Pérez, 1890), which uses snail shells as nesting site, as well as *H. adunca* and *H. manicata*, which nest in insect burrows in dead wood and hollow stems beside other types of preexisting cavities. Interestingly, *Hoplitis onosmaevae*, which is closely related to the latter two species based on our phylogenetic analysis, was found to build its nests also in insect burrows in dead wood, suggesting that nesting in existing cavities in wood or stems has probably evolved only once in the subgenus *Hoplitis*. Whether *Hoplitis benoisti*, which builds its nests in depressions and cavities in rocks or in insect burrows in the soil (Sedivy et al. 2013b), has reverted to the ancestral nesting behaviour of the *adunca* group or whether it is sister to the other three species suggesting the origin of nesting in wood and stems in the ancestor of *H. adunca*, *H. manicata* and *H. onosmaevae* is unclear, since the phylogenetic relationships of these four species are not resolved.

Conservation

The extreme rarity of *Hoplitis onosmaevae* in France, where it is currently known only from two restricted and little distant localities, does not seem to be fully accounted for by the rarity of its host plant, since large *Onosma tricerosperma* subsp. *fastigiata* populations are known outside the known range of *H. onosmaevae*, for example in the southern part of the Massif Central and at lower altitudes in the southern Alps. *Hoplitis onosmaevae* was only found at elevations between 1900 m and 2000 m in France and between 1075 m and 2350 m in Turkey and Iraq. This suggests that *H. onosmaevae* may have a particularly narrow climatic niche in France and does not find suitable climatic conditions at lower elevations, despite the presence of the host plant. This situation is reminiscent of that of *Bombus brodmannicus*, which is also much more narrowly distributed in the Alps than its host plant, *Cerinthe* (Boraginaceae). Possibly, these two bee species are associated with climatic conditions that are only found at certain elevations in restricted areas of the southern Alps, for example humid and cold winters and particularly hot and dry summers. Other factors may also limit the distribution of *H. onosmaevae*, particularly the presence of dead wood as nesting substrate, which represents a scarce resource in the steppe-like grasslands, where *Onosma* plants preferentially grow. The local history of forest use by humans may also partly explain the rarity of *H. onosmaevae*; massive deforestation in the southern Alps from approximately 2000 BC (Beaulieu 1977) may have reduced the area of habitat suitable for the species by reducing the number of its potential nidification sites.

The strongly disjunct distribution of *H. onosmaevae* and the bee's extremely local occurrence in limited areas of the southern French Alps have important implications for conservation. The species has most probably a very narrow ecological niche, making it highly susceptible to future changes in its habitats, for example due to changes in agricultural practices or to climate change. Even if the two known sites of *H. onosmaevae* are located in the core area of the Mercantour National Park, human activities can threaten its populations. Pastoralism, for example, is a significant economic activity in the Park and considered as an important heritage, playing a role in maintaining open habitats (Parcs nationaux de France 2012). However, excessive pastoral pressure or overgrazing can easily impact the populations of the host plants, either by direct consumption of the plants or by repeated trampling. The negative impact of excessive grazing could even be aggravated by unfavorable climatic conditions, such as prolonged droughts, which are expected to reduce the availability of flowers and further increase pressure on the vegetation. The presence of dead wood in close neighbourhood to the *Onosma* stands is a further essential prerequisite for the occurrence of *H. onosmaevae*, rendering the preservation and promotion of a sufficient supply of dead wood at the French sites occupied by *H. onosmaevae* essential.

Conclusions

Given the extreme rarity of *Hoplitis onosmaevae* in France and the species' high vulnerability to habitat changes due to its strong dependence on *Onosma* and dead wood, a detailed conservation plan should be worked out in the southwestern Alps, including the following measures: 1. additional fieldwork to identify further populations and to determine the current distribution of *H. onosmaevae*, including in the Italian Alps, where the species could also be present; 2. the active conservation of the known populations of *H. onosmaevae*, for example by adopting an appropriate management plan, ensuring that the habitat characteristics do not change and providing an adequate supply of plant and nesting ressources for the bee, with the aim of increasing the overall size of the population; 3. adaptation of the eco-pastoral management plans in the regions of the Mercantour National Park where the species occurs, to preserve and increase the abundance of the *Onosma* stands.

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Supplementary material 1

Database for all specimens examined in this study

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Alpine Entomology

The enigmatic robber fly *Choerades mouchai* Hradský, 1985 redescribed and recorded from the Alps (Diptera, Asilidae)

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Abstract

Records of *Choerades mouchai* Hradský, 1985, are reported from Switzerland. These are the first records of the species published since its description and extend its known range to include the Alps. Previously, it was known only from parts of the Carpathian Mountain chain in Slovakia and Romania. A redescription of the male is provided, accompanied by photographs of diagnostic features, including the terminalia, and images of the entire insect. A table listing morphological differences between the males of *Ch. mouchai*, *Ch. femorata* and *Ch. marginata* is presented. The *Choerades* fauna of Switzerland is discussed, as is the information available about the ecology of *Ch. mouchai*.

Key Words

Robberfly, Faunistics, Switzerland, Europe

Introduction

The robber flies (Diptera, Asilidae) comprise about 600 species in Europe. Recent works on the central and northern European asilid fauna have significantly improved species identification and promoted faunistic studies (Goot 1985; Weinberg and Bächli 1995; Geller-Grimm 2003; Van den Broek and Schulten 2017; Wolff et al. 2018; Haarto et al. 2022). Despite these advances, there is no key which provides for the identification of all the *Choerades* species known from Europe. One reason for this is the unclear taxonomic status of some of them, such as *Ch. fulva* (Meigen, 1804), *Ch. podagrica* (Meigen, 1820) and *Ch. dioctriaeformis* (Meigen, 1820). Further, the females of two species, *Ch. castellanii* (Hradský, 1962) and *Ch. mouchai* Hradský, 1985 remain unknown. Apart from the work of Weinberg and Bächli (1995), the *Choerades* fauna of the Swiss Alps remains poorly studied.

The genus *Choerades*, which is part of the sub-family Laphriinae, is represented by at least ten species in central Europe. Adults are formidable predators and their larvae develop in the wood of old trees, where they predate the larvae of saproxylic insects. From the studies of Krivosheina and Mamayev (1975), larvae of some *Choerades* species are known to develop in deciduous trees, including *Ulmus*, *Fagus* and *Quercus.* Others, like *Ch. marginata*, *Ch. gilva* and *Ch. ignea* develop in conifers, such as *Pinus* or *Picea*.

The description of *Choerades mouchai* was based on males from Slovakia, in the north-western part of the Carpathians, and from Romania, in the south-eastern Carpathians, all collected more than 60 years ago (Hradský 1985). Since then, there appear to have been no published records of the species. The lack of clarity in the description of the species and its accompanying figures, plus the fact that *Ch. mouchai* has not been included in any key dealing with the European fauna, must have contributed to this lack of records. With that in mind, the new records of *Ch. mouchai* from the Swiss Alps, presented here, are accompanied by an illustrated redescription of *Ch. mouchai*, together with notes on its separation from the morphologically similar species *Ch. femorata* (Meigen, 1804) and *Ch. marginata* (Linnaeus, 1758). Ecological observations on *Ch. mouchai*, gathered from two of the three Swiss localities are also discussed.

Materials and methods

During surveys of selected families of Diptera in the Swiss central Alps, the male of an unfamiliar *Choerades* species was collected by one of us (GP) in a dry *Pinus sylvestris/Quercus pubescens* forest. First identified as *Ch. femorata*, its very particular terminalia led to further research in the literature and specialist expertise was also sought. This resulted in the discovery (by JB) of a second Swiss specimen of the same species. Collected in 2011, in the eastern Swiss Alps by M. Kadlecová, it was obtained from an insect exchange in Prague. A third male was then found by Christian Monnerat (info fauna, Neuchâtel) in his private collection, among material collected by an interception trap set up for saproxylic Coleoptera, in the central Swiss Alps, within an old *Fagus* slope forest.

Literature research brought to light Milan Hradský's description of *Ch. mouchai* (Hradský 1985) from the Carpathian Mountains. This description only partially matched the Swiss males. As the description and the illustrations provided in Hradský (1985) were insufficient to confirm the identity of these males, a comparison between them and the holotype and paratypes of *Ch. mouchai* in Hradský's collection was made (by JB). Photographs of one of the paratypes were also taken by Michal Tkoč at the Museum in Prague.

Results

Records of *Choerades mouchai* from the Alps

Material examined. 1♂, Switzerland, Graubünden, Rätische Alp Nord, 3 km E of Susch, 46°46'N, 10°06'E, 1410 m a.s.l., 12 Aug. 2011, M. Kadlecová leg., J. Bosák det. & coll. ; 1♂, Switzerland,Wallis, Fully, Planuit, 46°09'18"N, 7°06'34"E, 1193 m a.s.l., 9 July 2019, Y. Chittaro leg, G. Pétremand det., C. Monnerat coll., interception trap installed on old *Fagus* tree, MONNECH01005228 ; 1♂, Switzerland, Wallis, Sierre, Bois de Finges, 46°17'45"N, 7°34'38"E, 605m a.s.l., 17 May 2020, G. Pétremand leg., det. & coll., hand net, sitting on a *Quercus* log within Ononido-pinion forest, GBIFCH01022956.

Redescription of *Choerades mouchai* Hradský, 1985. To consolidate Hradský's (1985) description of *Ch. mouchai* we provide a new diagnosis based on Hradský's first description, augmented by data from the Swiss specimens, and accompanied by photos of one of the Swiss specimens (Figs 1–8) and photos of a paratype (from the Carpathian Mountains) (Figs 9, 10).

Diagnosis. *Ch. mouchai* is a black, white and golden haired Laphriinae species. Body length 12–14 mm (Figs 1–4, 9). ***Head.*** Antennae black, with black hairs on the first two segments. First antennal segment about three times longer than second (Fig. 5). Third antennal segment longer than the first and second combined. The cusps, to which the antennae are attached, are covered with black hairs. Mystax with long black hairs, mixed with shorter white bristles (Fig. 1, 4). Face with long silverish hairs on sides (Fig. 4), dense dusting along the eye margins and black bristles medially. Ventral part of the head with very long whitish hairs (Fig. 4). Proboscis black, with white hairs at tip (Fig. 4). Palpi with black hairs. Back of the head (posterior to ocellar triangle) with yellow hairs. Occipital hairs black on upper half and yellowish on lower half. Frons with mainly yellow hairs (Fig. 2). Ocellar triangle with two very long, glassy white/yellow hairs (sometimes absent). ***Thorax.*** Mesoscutum black, with three longitudinal stripes of dusting which are connected at its posterior margin (Fig. 2, 3). Lateral margins of mesoscutum dusted; shiny parts with blue reflections. Mesoscutum with long black hairs and shorter yellow hairs, but posterior margin with only long yellow hairs (Fig. 2). Hairs and bristles on scutellum yellow, bristles on its posterior margin about two times longer than the maximum length of the scutellum. Pleurae dusted. Posterior anepisternum mostly covered with yellow hairs, black hairs present on upper and posterior margins (Fig. 2). Wing membrane slightly darkened except at the wing base, with areas bare of microtrichia. Wing veins dark brown. Dorsal surface of the base of the costa with black and sometimes yellow hairs (Fig. 4). Legs black, with brownish-yellow short hairs and longer black hairs and bristles. Hind femur with yellow and black hairs, some of them on the ventral and dorsal faces about as long as its maximum depth. ***Abdomen.*** Sternites and tergites all shiny black. Tergites black with blue reflections and covered with dense golden hairs. Posterior margins of tergites with denser hair covering, hiding the basic colouration of the abdomen, which is visible on the anterior parts of tergites 1–5. Sternites with long yellow hairs. ***Terminalia*** (Figs 6–8, 10). Gonopod black at the base, brown to yellow towards the tip, with black hairs. Epandrium almost entirely black, ending with two or three prominent black hairs which are curved at the tip. Black pointed projection terminating the hypopygium covered in yellowish-white hairs only.

Distinctions between *Choerades mouchai* males and similar species in Europe. The male of *Ch. mouchai* is very similar to the males of *Ch. marginata*, and *Ch. femorata* and could easily be confused with either of them. As an aid to their identification, we list in Table 1 morphological differences between the males of these three species, which can be used to separate them. The male of *Choerades castellani* is also very similar but shows a unique character, its last tergite being bifid posteriorly (see Geller-Grimm, 2003). It has therefore not been included in Table 1.

Figures 1–5. *Choerades mouchai* male found in Bois de Finges (Switzerland) on 17th of May 2020. **1.** Habitus, lateral view; **2.** Habitus, oblique view; **3.** Habitus, dorsal view; **4.** Habitus, frontal view; **5.** Head in dorsal view.

Figures 6–8. Terminalia of *Choerades mouchai* male found in Bois de Finges (Switzerland) on 17th of May 2020. **6.** Hypopygium, lateral view; **7.** Hypopygium, dorsal view; **8.** Hypopygium, ventral view.

Figures 9, 10. *Choerades mouchai*, male paratype from Carpathian moutains. **9.** Habitus, lateral view; **10.** Hypopygium, lateral view.

Table 1. Characters allowing the distinction between *Ch. marginata*, *Ch. femorata* and *Ch. mouchai*.

Character	***Choerades marginata* ♂ Fig. 11**	***Choerades femorata* ♂ Fig. 12**	***Choerades mouchai* ♂ Figs 1–10**
coarse hair coloring on face [between antenna and facial gibbosity]	yellow	white to yellow	white (only present along eye margin, centrally absent, see Fig. 4)
mesoscutum	uniformly bright	uniformly bright	bright with three longitudinal pollinose stripes (sometimes not visible, especially in specimens passed in alcohol)
terminalia	uniformly black	uniformly black	gonopod black and bright yellow at tip
length of the 1st segment of antenna [in dorsal view]	1.8–2.5 times longer than 2nd segment	at 3–4 times longer than the 2nd segment	2.7–3.2 times longer than 2nd segment
hair color on tergites	yellow, brown-black hair on disc and white hair on the rear margin of tergites	yellowish-brown hair	golden-yellowish hair, very dense on rear margin
pilosity length on ventral and dorsal surface of hind femur	at most as long as half the depth of hind femur	at most as long as half the depth of hind femur	some hairs almost as long as maximum depth of hind femur
hair color on posterior anepisternum	mainly black (except for a few yellow hairs on lower third)	mainly black (except for a few yellow hairs on lower third)	mainly yellow except black hair in upper and posterior parts
Ecological demands	colder locations of mixed and coniferous forests	xerotherm localities of forest steppe character with deciduous trees	xerotherm localities of *Pinus* or *Fagus* forest

Figure 11. *Choerades marginata* male, habitus in lateral view (Switzerland).

Discussion

Weinberg and Bächli (1995) list eight species of *Choerades* for Switzerland and by extension for the Alps, including the problematic *Ch. dioctriaeformis* and *Ch. fulva*. Commentary on the latter two species is beyond the scope of the present text. *Choerades femorata* should be added to this list, a species omitted by Weinberg and Bächli (1995) but which is frequent in Switzerland. In the past, this species has long been confused with *Ch. marginata*. The addition of *Ch. mouchai* thus brings the *Choerades* fauna of the Alps to ten species. Two other *Choerades* species recently found in Germany (Geller-Grimm et al. 2003; Wolff et al. 2021) can also reasonably be expected to occur in the Alps: *Ch. castellanii* and *Ch. amurensis* (Hermann, 1914).

At present is seems that *Ch. mouchai* is poorly represented in public or private collections, only nine specimens being known - Romania, Slovakia (Carpathians - Hradský 1985) and Switzerland (Alps – this study). With the presence of *Ch. mouchai* in the Alps highlighted by the present text, it is to be hoped that re-examination of material in collections might reveal further records. It is interesting that for the time being there is no evidence of the occurrence of this species in the territory between the Carpathian and the Alps such as in the Czech Republic and Austria, two countries where the asilid fauna has been intensively studied.

In the Carpathians, *Ch. mouchai* has been found in *Pinus mugo* forest (M. Hradský, pers. com.). The records from the central Alps allow us to extend the habitat range of *Ch. mouchai* to dry *Pinus sylvestris* forest mixed with *Quercus pubescens* (Ononido-pinion) and to old and dry *Fagus* slope forest. The male collected by the first author in 2020 was sitting on a dead *Quercus* log fallen on the forest floor. It remains unknown if the larva of

Figure 12. *Choerades femorata* male, habitus in lateral view (Switzerland).

Ch. mouchai is associated with conifers (*Pinus*) or deciduous trees (*Quercus/Fagus*). Nevertheless, it seems to develop in thermophilic forest situations where both coniferous and deciduous trees are present, within old forests.

Conclusions

Discovery of *Choerades mouchai* in the Alps has enabled us to clarify the diagnostic features of the male, hopefully facilitating acquisition of further information about the distribution, biology and ecology of the species, and bringing us one step closer to the development of a key to the *Choerades* species of central Europe.

The detailed diagnosis provided should also improve the possibility of recognising the female of *Ch. mouchai*, leading potentially to its description in the years to come.

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Alpine Entomology

An updated checklist of the Hydradephaga of Switzerland (Coleoptera)

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Abstract

An updated checklist of the Swiss species of Hydradephaga (Dytiscidae, Gyrinidae, Haliplidae, Hygrobiidae, Noteridae) is presented and briefly discussed. A total of 139 species is retained as part of the Swiss fauna, while 53 species, which have been recorded in Switzerland in the past, are excluded from this list, either due to insufficient documentation or because their records were based on misidentified material. In contrast to previous works, the present study also provides, for the first time, distribution maps through an online map server for all Hydradephaga species in Switzerland, based on over 43,000 occurrences obtained from specimens held in museums and private collections, as well as literature data. The occurrences of the rarest species of Switzerland, as well as data on species erroneously cited in Switzerland, are presented and discussed.

Key Words

Insecta, diving beetles, Burrowing Water Beetles, Whirligig Beetles, Crawling Water Beetles, species list, new country records, faunistics, distribution

Introduction

The order Coleoptera is divided into five suborders: Protocoleoptera (extinct), Adephaga, Polyphaga, Myxophaga, and Archostemata (Bouchard et al. 2011). A large proportion of aquatic beetles belong to Adephaga and are often referred to as Hydradephaga in opposition to Geadephaga. The monophyly of Hydradephaga has been debated for long; some authors found it to be a monophyletic group (Ribera et al. 2002; McKenna et al. 2015; López-López and Vogler 2017), while others found it to be a paraphyletic group with Geadephaga nested inside (Maddison et al. 2009; McKenna et al. 2019) or with Gyrinidae as basal lineage and the rest of Hydradephaga monophyletic (Beutel et al. 2008; Baca et al. 2017). Recent studies based on morphology as well as genomic data support this last hypothesis (Vasilikopoulos et al. 2021). For practical reasons, Hydradephaga is still used in the present work even if it does not concern a natural group. Worldwide, ca. 6,000 species have been described in eight families and it represents a taxonomically diverse groups with one of the most well-known evolutionary history (Short 2018). The taxonomy of this group has always been of great interest to professional and amateur entomologists (Short 2018), and it is estimated that 70% of aquatic beetles (including non-Adephagous) have been described (Jäch and Balke 2008), while 80% of Dytiscidae are already named (Nilsson 2016).

Although there are rare terrestrial species (notably a few species of Dytiscidae in the tropics, see Brancucci 1979b; Balke and Hendrich 1996), all Hydradephaga in Switzerland are aquatic, occurring in various types of standing and flowing water. Most Hydradephaga are predaceous and occasionally necrophorous, both as larvae and adults. Haliplidae are a notable exception with herbivorous larvae and carnivorous, ominivorous, or exclusively phytophagous adults (van Vondel 1997). Most species are fully winged and capable of flight (Jackson 1952; Kehl and Dettner

2007). Adults of some species can live for several years (Cerrato and Meregalli 2020) and usually overwinter buried in the ground, out of water (Hájek 2009).

In Switzerland, Hydradephaga are represented by five families: Dytiscidae, Gyrinidae, Haliplidae, Hygrobiidae, and Noteridae. Faunistic knowledge about Hydradephaga has been summarized by Carron (2005, 2008), who published two checklists: the first concerning Dytiscidae and Noteridae (Carron 2005), and the second Gyrinidae, Haliplidae, and Hygrobiidae (Carron 2008). These checklists were critical of dubious records such as specimens from Charles Maerky's collection (see below and Monnerat et al. 2015), rightly excluding many taxa from the Swiss list. However, Carron (2005, 2008) did not base his works on the acquisition of an extensive dataset, and thus he could only give general distribution information for some very rare species and did not present distribution maps. Facing the need for quality datasets permitting extrapolation of ecological information and visualization of the distributions of species, particularly for good bioindicators (Bilton et al. 2019) such as Hydradephaga, we compiled all the occurrences available in all Swiss museums and private collections, as well as the literature and data gathered by naturalists. We also present an updated and annotated checklist of the Hydradephaga species present in Switzerland. Resident species are thus distinguished from species mistakenly mentioned for Switzerland or insufficiently documented.

Material and methods

To present a comprehensive list of the Swiss Hydradephaga and distribution maps based on all existing information, we performed an exhaustive revision and examination of the relevant material housed in all Swiss natural history museum collections following the same methodology used for other beetle groups (e.g., Chittaro et al. 2021; Sanchez and Chittaro 2022). The collections in the following museums were studied (the contact person is reported in parentheses after each institution):

AGRO	Agroscope-Changins, Nyon (Stève Breitenmoser)
BNM	Bündner Natur-Museum, Chur (Stephan Liersch)
ETH	Eidgenössische-Technische Hochschule, Zürich (Michael Greeff)
HGSB	Musée de l'Hospice du Grand-Saint-Bernard (Jean-Pierre Voutaz)
KMLI	Archäologie und Museum Baselland, Liestal (Marc Limat)
LEBA	Laboratoire d'écologie et de biologie aquatique, Université de Genève (Emmanuel Castella)
MHNF	Musée d'histoire naturelle de Fribourg (Sophie Giriens)
MHNG	Muséum d'histoire naturelle, Genève (Giulio Cuccodoro)
MHNN	Musée d'histoire naturelle de Neuchâtel (Jessica Litman)
MHNS	Musée de la nature du Valais, Sion (Sonja Gerber)
MSNL	Museo cantonale di storia naturale, Lugano (Bärbel Koch)
MZL	Naturéum (formerly: Musée cantonal de zoologie), Département de zoologie, Lausanne (Anne Freitag)
MZA	Museum zu Allerheiligen, Schaffhausen (Urs Weibel)
NMAA	Naturama, Aarau (Christian Sprecher)
NMB	Naturhistorisches Museum Basel (Matthias Borer)
NMBE	Naturhistorisches Museum Bern (Hannes Baur)
NMLU	Natur-Museum, Luzern (Marco Bernasconi)
NMO	Naturmuseum Olten (Pia Geiger)
NMSG	Naturmuseum St. Gallen (Karin Urfer)
NMTG	Naturmuseum Thurgau, Frauenfeld (Barbara Richner)
NMSO	Naturmuseum, Solothurn (Marc Neumann)
NMWI	Naturhistorisches Museum, Winterthur (Sabrina Schnurrenberger)

We also cited data gathered from four museums outside Switzerland:

MCB	Museo civico di Bolzano, Italy
MHNL	Musée Guimet d'histoire naturelle, Lyon
MHNP	Musée national d'Histoire naturelle, Paris
SMNS	Staatlichen Museum für Naturkunde Stuttgart, Germany

Moreover, we included data from the private collections of the authors, as well as those of the following professional and amateur entomologists: Emil Birnstiel (Zurich ZH), Mickaël Blanc (Sciez France), Hansjörg Brägger (Bischofszell TG), Berndt Eismann (Kreuzlingen TG), Christian Monnerat (Neuchâtel NE), Arnaud Vallat (La Chaux-de-Fonds NE), and André Wagner (Le Sentier VD). Data from the following institutions were also considered: Association de la Grande-Cariçaie AGC (Sophie Marti, Gaël Pétremand, Antoine Gander), Haute école du paysage, d'ingénierie et d'architecture de Genève HEPIA (Beat Oertli, Eliane Demierre) and of the Office cantonal de l'eau, Genève OCEau (Arielle Cordonier).

All available data from the literature relevant for Switzerland were also considered. The references from these publications are included in the bibliography if they are specifically cited in the text. Publications consulted but not cited in the text are not mentioned.

We followed the nomenclature and systematics of the "Catalogue of Palaearctic Coleoptera" (Hájek 2017a, b, c; Hájek and Fery 2017; van Vondel 2017). The list of the main synonyms of each taxon is provided in the references and is therefore not reported here.

The specimens were identified using the following publications: Holmen (1987), Foster and Friday (2011), Freude (2011), and Nilsson and Holmen (1995). An illustration of each species is provided in Hájek's iconographies (2007, 2009).

When not otherwise specified, general information on species' distributions is taken from the "Catalogue of Palaearctic Coleoptera" (Löbl and Löbl 2017). We have also used the relevant literature concerning the countries and regions adjacent to Switzerland, such as Franciscolo (1979) for Italy and the regional treatment of Kahlen and Hellrigl (1996) for South Tyrol/Alto Adige; Guignot (1947) and Bameul and Queney (2014) for France and regionally Callot (1990, 2018) for Alsace; Köhler and Klausnitzer (1998), Köhler (2000, 2011), and Bleich et al. (2016) for Germany; as well as Brandstetter and Kapp (1995) for Vorarlberg (Austria) and Liechtenstein.

Once an exhaustive list of species was compiled, we followed the procedure proposed by Monnerat et al. (2015) in order to assess which of these species should be considered as belonging to the Swiss fauna. We only retained species whose relative data were deemed sufficient (unambiguous labeling, reliable collections, etc.) for inclusion on the national checklist.

Those species whose presence in Switzerland is substantiated by less than 30 valid observations are subject to an additional comment. In these cases, species names in the table are followed by a letter and a number in bold ("**C1**" for example) and all the examined specimens and published observations are mentioned in order to document and justify the presence of these species in the checklist. Unless otherwise specified, all examined material was identified or reviewed by the first author.

Reliable identification is based on characters of the male genitalia for some of *Haliplus* spp. and to distinguish some highly similar species groups found in *Agabus* spp. For those species, only dissected males were counted as "verified" records, while records based exclusively on female specimens were omitted as unverifiable.

The specimens and literature-based records presented here are listed in chronological order of discovery (or publication date) and then in alphabetical order by locality, depending on available information. All occurrences are cited according to the following scheme: number of specimens, locality (pre-2000 data) or municipality and abbreviated canton (post-2000 data), date, collector, determinator (in the case that the determinator was not one of the authors), collection and official acronym of the institution where the specimen is deposited.

Information about localities and dates are reported as found on the labels. Interpretations of alphabetical abbreviations are placed within square brackets ("[ ]"). In old collections, the collector (leg.) is not always explicitly labelled. In such cases, we favored the « coll. » tag. In some cases, the original collection holder was not labelled but we were nonetheless able to identify the source of the collection based on type labels and/or handwriting.

The collection of Charles Maerky, deposited in the MHNG, has long been considered problematic (Monnerat et al. 2015). In addition to specimens coming from his personal collection ("coll. Maerky C."), it also contains insects from other sources (labelled, for instance, as "ex coll. Melly A.") but lacking any original labels. In such cases, we maintained the "coll. Maerky C." mention for his whole collection to ensure the association of these samples with the Maerky C. collection.

For literature-based data, detailed under "Published data", we retained the locality as it appeared in the original citation. We consider the "source" of the records to be the author of the publication, for example: "Ormontsthal by Venetz I. (Stierlin and Gautard 1867)". If the same records have been published more than once, then only the oldest publication is retained, given that localities in later publications are often altered and sometimes truncated.

Among the data cited in this paper under "Examined material" or "Published data", we inserted a superscript number code before those entries we considered insufficiently documented to be retained, using the following code to describe error type (following Monnerat et al. 2015). Thus, if one of the following eight criteria is fulfilled, a record is considered as doubtful:

1. data source cannot be verified
2. incorrect identification
3. specimen from problematic collection
4. specimen of unknown origin but attributed to a Swiss locality
5. double labelling, original locality misinterpreted or incorrectly copied
6. confusion between localities: original finding, breeding or hatching place and collection storage site
7. non-Swiss localities or potentially Swiss localities that share their names with foreign place names (and thus of dubious Swiss origin)
8. chorological or ecological inconsistencies

Abbreviations used: **coll.** = collection, **det.** = determinator, **ex.** = specimen, **leg.** = collector. Abbreviated Swiss cantons (only cantons cited in the text): **AG** = Aargau, **BE** = Bern, **BL** = Basel-Landschaft, **FR** = Fribourg, **GE** = Geneva, **GR** = Grisons, **JU** = Jura, **NE** = Neuchâtel, **OW** = Obwald, **SG** = St. Gallen, **SH** = Schaffhausen, **SO** = Solothurn, **TI** = Ticino, **TG** = Thurgau, **UR** = Uri, **VD** = Vaud, **VS** = Valais, **ZH** = Zurich.

Results

Swiss Hydradephaga list

For the basis of this work, we compiled 43,770 Swiss occurrences of Hydradephaga. In total, 72% of them concern specimens deposited in museums, 8% come from the literature, and 20% from other sources (private collectors, volunteer observers, research institutes, or ecology offices).

The 139 species of Hydradephaga listed in bold and without square brackets "[ ]" currently do or formerly did form populations in Switzerland, even if only scant information is available for many of them. The most species-rich family is Dytiscidae (113 species), followed by Haliplidae (16 species), Gyrinidae (7 species), Noteridae (2 species), and Hygrobiidae (1 species).

On the other hand, the 53 species listed in square brackets "[ ]" should not be considered as belonging to the Swiss fauna until new data show otherwise. In this category, we placed species whose individuals come from problematic collections, such as Charles Maerky's or Max Täschler's (Monnerat et al. 2015), and those that were erroneously mentioned for Switzerland due to incorrect identifications and those cited in old publications, like Stierlin and Gautard (1867), without reference to specific individuals and consequently considered doubtful. Other species may eventually be found in the Swiss territory but currently available data are not sufficient to confirm their establishment in Switzerland.

To facilitate searching for species in this document, taxa appear in alphabetical order for families, subfamilies, tribes, subtribes, genera, subgenera, species, and subspecies.

Updated distribution maps of these species are available on the info fauna cartographic server (https://lepus.infofauna.ch/carto/). All the valid data are also available on http://www.GBIF.org (https://doi.org/10.15468/dl.env254).

Checklist of the Swiss species

DYTISCIDAE Leach, 1815
AGABINAE C.G. Thomson, 1867
Agabini C.G. Thomson, 1867
[*Agabus* (*Acatodes*) *arcticus arcticus* (Paykull, 1798)] **C1**
***Agabus* (*Acatodes*) *congener* (Thunberg, 1794)**
***Agabus* (*Acatodes*) *lapponicus* (C.G. Thomson, 1867)**
***Agabus* (*Acatodes*) *sturmii* (Gyllenhal, 1808)**
[*Agabus* (*Acatodes*) *thomsoni* (J.R. Sahlberg, 1871)] **C2**
***Agabus* (*Agabus*) *labiatus* (Brahm, 1790)**
***Agabus* (*Agabus*) *uliginosus* (Linnaeus, 1760)**
***Agabus* (*Agabus*) *undulatus* (Schrank, 1776)**
***Agabus* (*Gaurodytes*) *affinis* (Paykull, 1798)**
***Agabus* (*Gaurodytes*) *biguttatus* (Olivier, 1795)**
***Agabus* (*Gaurodytes*) *bipustulatus* (Linnaeus, 1767)**
***Agabus* (*Gaurodytes*) *brunneus* (Fabricius, 1798) C3**
***Agabus* (*Gaurodytes*) *didymus* (Olivier, 1795)**
***Agabus* (*Gaurodytes*) *guttatus guttatus* (Paykull, 1798)**
***Agabus* (*Gaurodytes*) *melanarius* Aubé, 1837**
***Agabus* (*Gaurodytes*) *nebulosus* (Forster, 1771)**
***Agabus* (*Gaurodytes*) *paludosus* (Fabricius, 1801)**
[*Agabus* (*Gaurodytes*) *striolatus* (Gyllenhal, 1808)] **C4**
***Ilybius aenescens* C.G. Thomson, 1870**
***Ilybius ater* (De Geer, 1774)**
***Ilybius chalconatus* (Panzer, 1796)**
***Ilybius crassus* C.G. Thomson, 1856 C5**
***Ilybius erichsoni* (Gemminger & Harold, 1868) C6**
***Ilybius fenestratus* (Fabricius, 1781)**
***Ilybius fuliginosus fuliginosus* (Fabricius, 1792)**
***Ilybius guttiger* (Gyllenhal, 1808)**
[*Ilybius meridionalis* Aubé, 1837] **C7**
[*Ilybius montanus* (Stephens, 1828)] **C8**
***Ilybius neglectus* (Erichson, 1837) C9**
***Ilybius quadriguttatus* (Lacordaire, 1835)**
[*Ilybius similis* C.G. Thomson, 1856] **C10**
***Ilybius subaeneus* Erichson, 1837 C11**
[*Ilybius subtilis* Erichson, 1837] **C12**
***Platambus maculatus* (Linnaeus, 1758)**

COLYMBETINAE Erichson, 1837
Colymbetini Erichson, 1837
***Colymbetes fuscus* (Linnaeus, 1758)**
[*Colymbetes striatus* (Linnaeus, 1758)] **C13**
[*Meladema coriacea* Laporte, 1835] **C14**
***Rhantus* (*Nartus*) *grapii* (Gyllenhal, 1808)**
***Rhantus* (*Rhantus*) *bistriatus* (Bergsträsser, 1777) C15**
[*Rhantus* (*Rhantus*) *consputus* (Sturm, 1834)] **C16**
***Rhantus* (*Rhantus*) *exsoletus* (Forster, 1771)**
***Rhantus* (*Rhantus*) *frontalis* (Marsham, 1802) C17**
***Rhantus* (*Rhantus*) *latitans* Sharp, 1882**
***Rhantus* (*Rhantus*) *notaticollis* (Aubé, 1837) C18**
***Rhantus* (*Rhantus*) *suturalis* (W.S. Macleay, 1825)**
***Rhantus* (*Rhantus*) *suturellus* (Harris, 1828) C19**

COPELATINAE Branden, 1885
Copelatini Branden, 1885
***Liopterus haemorrhoidalis* (Fabricius, 1787)**

CYBISTRINAE Sharp, 1880
Cybistrini Sharp, 1880
***Cybister* (*Cybister*) *lateralimarginalis lateralimarginalis* (De Geer, 1774)**

DYTISCINAE Leach, 1815
Aciliini C.G. Thomson, 1867
***Acilius* (*Acilius*) *canaliculatus* (Nicolai, 1822)**
***Acilius* (*Acilius*) *sulcatus* (Linnaeus, 1758)**
***Graphoderus austriacus* (Sturm, 1834) C20**
***Graphoderus bilineatus* (De Geer, 1774)**
***Graphoderus cinereus* (Linnaeus, 1758)**
***Graphoderus zonatus zonatus* (Hoppe, 1795) C21**

Dytiscini Leach, 1815
***Dytiscus circumcinctus* Ahrens, 1811 C22**
***Dytiscus circumflexus* Fabricius, 1801 C23**
***Dytiscus dimidiatus* Bergsträsser, 1777 C24**
[*Dytiscus lapponicus* Gyllenhal, 1808] **C25**
***Dytiscus latissimus* Linnaeus, 1758 C26**
***Dytiscus marginalis marginalis* Linnaeus, 1758**
***Dytiscus semisulcatus* O.F. Müller, 1776**

Eretini Crotch, 1873
[*Eretes sticticus* (Linnaeus, 1767)] **C27**

Hydaticini Sharp, 1882
[*Hydaticus* (*Hydaticus*) *aruspex* Clark, 1864] **C28**
[*Hydaticus* (*Hydaticus*) *continentalis* J. Balfour-Browne, 1944] **C29**

Hydaticus (_Hydaticus_) _seminiger_ (De Geer, 1774)
Hydaticus (_Hydaticus_) _transversalis transversalis_ (Pontoppidan, 1763) C30
Hydaticus (_Prodaticus_) _grammicus_ (Germar, 1827) C31
[*Hydaticus* (*Prodaticus*) *leander* (P. Rossi, 1790)] **C32**

Hydroporinae Aubé, 1836
Bidessini Sharp, 1882
[*Bidessus coxalis* Sharp, 1882] **C33**
Bidessus delicatulus (Schaum, 1844) C34
Bidessus grossepunctatus Vorbringer, 1907
Bidessus minutissimus (Germar, 1823) C35
[*Bidessus pumilus* (Aubé, 1838)] **C36**
[*Bidessus saucius* (Desbrochers des Loges, 1871)] **C37**
Bidessus unistriatus (Goeze, 1777)
Hydroglyphus geminus (Fabricius, 1792)
Yola bicarinata bicarinata (Latreille, 1804)

Hydroporini Aubé, 1836
Deronectina Galewski, 1994
Boreonectes alpestris Dutton & Angus, 2007 C38
[*Boreonectes inexpectatus* Dutton & Angus, 2007] **C38**
Boreonectes griseostriatus griseostriatus (De Geer, 1774) C38
Deronectes aubei aubei (Mulsant, 1843)
[*Deronectes faimairei* (Leprieur, 1876)] **C39**
Deronectes latus (Stephens, 1829)
Deronectes moestus inconspectus (Leprieur, 1876) C40
[*Deronectes opatrinus* (Germar, 1823)] **C41**
[*Deronectes platynotus platynotus* (Germar, 1834)] **C42**
[*Deronectes semirufus* (Germar, 1844)] **C43**
Nebrioporus assimilis (Paykull, 1798) C44
Nebrioporus canaliculatus (Lacordaire, 1835) C45
[*Nebrioporus depressus* (Fabricius, 1775)] **C46**
Nebrioporus elegans (Panzer, 1794)
[*Oreodytes alpinus* (Paykull, 1798)] **C47**
Oreodytes davisii davisii (Curtis, 1831)
Oreodytes sanmarkii sanmarkii (C.R. Sahlberg, 1826)
Oreodytes septentrionalis (Gyllenhal, 1826)
Scarodytes halensis (Fabricius, 1787)
Stictotarsus duodecimpustulatus (Fabricius, 1792)

Hydroporina Aubé, 1836
Hydroporus angustatus Sturm, 1835
Hydroporus discretus discretus Fairmaire & Brisout, 1859
[*Hydroporus dorsalis* (Fabricius, 1787)] **C48**
[*Hydroporus elongatulus* Sturm, 1835] **C49**
Hydroporus erythrocephalus (Linnaeus, 1758)
Hydroporus ferrugineus Stephens, 1829
Hydroporus figuratus (Gyllenhal, 1826) C50
Hydroporus foveolatus Heer, 1840
[*Hydroporus geniculatus* C.G. Thomson, 1856] **C51**
[*Hydroporus gyllenhalii* Schiødte, 1841] **C52**
Hydroporus incognitus Sharp, 1869
Hydroporus kraatzii Schaum, 1867 C53
Hydroporus longicornis Sharp, 1871 C54
Hydroporus longulus Mulsant & Rey, 1861
Hydroporus marginatus (Duftschmid, 1805)
Hydroporus melanarius Sturm, 1835
Hydroporus memnonius Nicolai, 1822
[*Hydroporus morio* Aubé, 1838] **C55**
Hydroporus neglectus Schaum, 1845
Hydroporus nigellus Mannerheim, 1853
Hydroporus nigrita (Fabricius, 1792)
[*Hydroporus notatus* Sturm, 1835] **C56**
Hydroporus obscurus Sturm, 1835
[*Hydroporus obsoletus* Aubé, 1838] **C57**
Hydroporus palustris (Linnaeus, 1760)
Hydroporus planus (Fabricius, 1782)
Hydroporus pubescens (Gyllenhal, 1808)
Hydroporus rufifrons (O.F. Müller, 1776)
Hydroporus sabaudus sabaudus Fauvel, 1865
Hydroporus scalesianus Stephens, 1828 C58
[*Hydroporus striola* (Gyllenhal, 1826)] **C59**
[*Hydroporus tessellatus* (Drapiez, 1819)] **C60**
Hydroporus tristis (Paykull, 1798)
Hydroporus umbrosus (Gyllenhal, 1808)

Siettitiina Smrž, 1982
Graptodytes bilineatus (Sturm, 1835)
[*Graptodytes flavipes* (Olivier, 1795)] **C61**
Graptodytes granularis (Linnaeus, 1767)
[*Graptodytes ignotus* (Mulsant & Rey, 1861)] **C62**
Graptodytes pictus (Fabricius, 1787)
[*Graptodytes varius* (Aubé, 1838)] **C63**
[*Metaporus meridionalis* (Aubé, 1838)] **C64**
Porhydrus lineatus (Fabricius, 1775)
Rhithrodytes crux (Fabricius, 1792) C65
[*Stictonectes lepidus* (Olivier, 1795)] **C66**

Hydrovatini Sharp, 1880
[*Hydrovatus clypealis* Sharp, 1876] **C67**
Hydrovatus cuspidatus (Kunze, 1818)

Hygrotini Portevin, 1929
Hygrotus (_Coelambus_) _confluens_ (Fabricius, 1787) C68
Hygrotus (_Coelambus_) _impressopunctatus_ (Schaller, 1783)
[*Hygrotus* (*Coelambus*) *parallelogrammus* (Ahrens, 1812)] **C69**
Hygrotus (_Hygrotus_) _decoratus_ (Gyllenhal, 1810)
Hygrotus (_Hygrotus_) _inaequalis_ (Fabricius, 1777)
Hygrotus (_Hygrotus_) _quinquelineatus_ (Zetterstedt, 1828) C70
Hygrotus (_Hygrotus_) _versicolor_ (Schaller, 1783)

Hyphydrini Gistel, 1848
[*Hyphydrus aubei* Ganglbauer, 1891] **C71**
Hyphydrus ovatus (Linnaeus, 1760)

Laccophilinae Gistel, 1848
Laccophilini Gistel, 1848
Laccophilus hyalinus (De Geer, 1774)
Laccophilus minutus (Linnaeus, 1758)
Laccophilus poecilus Klug, 1834

GYRINIDAE Latreille, 1810
GYRININAE Latreille, 1810
Gyrinini Latreille, 1810
[*Aulonogyrus* (*Aulonogyrus*) *striatus* (Fabricius, 1792)] **C72**
Gyrinus (_Gyrinulus_) _minutus_ Fabricius, 1798
[*Gyrinus* (*Gyrinus*) *aeratus* Stephens, 1835] **C73**
[*Gyrinus* (*Gyrinus*) *caspius* Ménétriés, 1832] **C74**
[*Gyrinus* (*Gyrinus*) *colymbus* Erichson, 1837] **C75**
[*Gyrinus* (*Gyrinus*) *dejeani* Brullé, 1832] **C76**
Gyrinus (_Gyrinus_) _distinctus_ Aubé, 1838
Gyrinus (_Gyrinus_) _marinus_ Gyllenhal, 1808
[*Gyrinus* (*Gyrinus*) *natator* (Linnaeus, 1758)] **C77**
[*Gyrinus* (*Gyrinus*) *opacus* C.R. Sahlberg, 1819] **C78**
Gyrinus (_Gyrinus_) _paykulli_ G. Ochs, 1927
Gyrinus (_Gyrinus_) _substriatus_ Stephens, 1828
Gyrinus (_Gyrinus_) _suffriani_ W. Scriba, 1855
[*Gyrinus* (*Gyrinus*) *urinator* Illiger, 1807] **C79**

Orectochilini Régimbart, 1882
Orectochilus villosus villosus (O.F. Müller, 1776)

HALIPLIDAE Aubé, 1836
Brychius elevatus (Panzer, 1793)
[*Brychius glabratus* (A. Villa & G.B. Villa, 1835)] **C80**
Haliplus (_Haliplidius_) _confinis_ Stephens, 1828
Haliplus (_Haliplidius_) _obliquus_ (Fabricius, 1787)
[*Haliplus* (*Haliplus*) *apicalis* C.G. Thomson, 1868] **C81**
Haliplus (_Haliplus_) _fluviatilis_ Aubé, 1836
[*Haliplus* (*Haliplus*) *fulvicollis* Erichson, 1837] **C82**
Haliplus (_Haliplus_) _heydeni_ Wehncke, 1875
Haliplus (_Haliplus_) _immaculatus_ Gerhardt, 1877 C83
[*Haliplus* (*Haliplus*) *lineolatus* Mannerheim, 1844] **C84**
Haliplus (_Haliplus_) _ruficollis_ (De Geer, 1774)
Haliplus (_Haliplus_) _sibiricus_ Motschulsky, 1860
Haliplus (_Liaphlus_) _flavicollis_ Sturm, 1834
Haliplus (_Liaphlus_) _fulvus_ (Fabricius, 1801) C85
Haliplus (_Liaphlus_) _laminatus_ (Schaller, 1783)
Haliplus (_Liaphlus_) _mucronatus_ Stephens, 1828 C86
Haliplus (_Liaphlus_) _variegatus_ Sturm, 1834
Haliplus (_Neohaliplus_) _lineatocollis_ (Marsham, 1802)
Peltodytes caesus (Duftschmid, 1805)
Peltodytes rotundatus (Aubé, 1836) C87

HYGROBIIDAE Régimbart, 1879
Hygrobia hermanni (Fabricius, 1775) C88

NOTERIDAE C.G. Thomson, 1860
Noterinae C.G. Thomson, 1860
Noterini C.G. Thomson, 1860
Noterus clavicornis (De Geer, 1774)
Noterus crassicornis (O. F. Müller, 1776)

Commented species

C1) [*Agabus* (*Acatodes*) *arcticus arcticus* (Paykull, 1798)]

Examined material. [4,6,8]1 ex., Luzern, Birregg, XI.1927, leg. Huber A., NMLU.

Comment. Of the three subspecies of *Agabus arcticus*, the nominal subspecies is distributed in the northern Palaearctic (Hájek 2017a). Its presence in Switzerland seems unlikely since its European distribution is limited to Finland, Great Britain, Ireland, Norway, Russia (North European Territory), and Sweden. The single specimen found in the collections consulted was probably mislabeled.

C2) [*Agabus* (*Acatodes*) *thomsoni* (J.R. Sahlberg, 1871)]

Published data. [1,8]Am Roseg im Engadin by von Heyden L. (Stierlin 1883).

Comment. The only occurrence of this species in Switzerland is a very old and unverifiable literature mention. The presence of this species in Switzerland is highly unlikely, as it is only known in Europe from Finland, Norway, Russia (North European Territory), and Sweden. All citations of *A. thomsoni* in the Alps must be regarded as doubtful (Nilsson 1987).

C3) *Agabus* (*Gaurodytes*) *brunneus* (Fabricius, 1798)

Examined material. [3,4,6,8]1 ex., Alpes, Grisons, leg. and coll. Maerky C., MHNG; [3,4,6]1 ex., Suisse, leg. Sechehaye A., coll. Maerky C., MHNG; [3,4,6,8]1 ex., Alpes, Gemmi, 24.VII, leg. and coll. Maerky C., MHNG; [3,4,6,8]1 ex., Genève, VI., leg. Toumayeff G., MHNG; [3]1 ex., Pfeffers, 30.VII.1903, leg. and coll. Gaud A., MZL; 1 ex., Chiasso, Faloppia, 2.VI.1915, leg. and coll. Fontana P., MSNL; 7 ex., Mendrisio TI, 21.X.2021, leg. and coll. Cosandey V.; 4 ex., Coldrerio TI, 22.V.2023, leg. and coll. Chittaro Y. and Sanchez A.

Published data. [1]Pfeffers by von Heyden L. (Stierlin and Gautard 1867).

Comment. Considered potentially extinct by Carron (2005), this species was recently rediscovered in the extreme south of the canton of Ticino, in the continuity of its distribution in Italy (Franciscolo 1979). Contrary to the information given by Brancucci (1994), *A. brunneus* is present only south of the Alps, and absent from the north. In France, it is common in the south but rarer in the north (Guignot 1947).

C4) [*Agabus* (*Gaurodytes*) *striolatus* (Gyllenhal, 1808)]

Published data. [4,6,8]3 ex., Suisse, coll. Falcoz, MHNL, det. Carron G. (Carron 2005).

Comment. *Agabus striolatus* is mentioned from Switzerland on the basis of three specimens with imprecise labeling, deposited in the Falcoz collection in Lyon, France (Carron 2005). These data are insufficient to include the species in the Swiss fauna, as already suggested by Carron (2005). It is widely distributed in Europe, from northern France (Guignot 1947; Bameul and Queney 2014) and Great Britain to Scandinavia and western Russia (Nilsson and Holmen 1995; Hájek 2017a). *Agabus striolatus* is mentioned by dubious sources in Alsace and is therefore not retained by Callot (2018). The nearest population of this species is located more than 150 km from the Swiss border, in southern Germany (Bleich et al. 2016).

C5) *Ilybius crassus* C.G. Thomson, 1856

Examined material. $^{3,4,6)}$1 ex., Alpes, Savièse, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Schweiz, coll. Staehlin-Bischoff H., NMB; $^{3,4,6)}$2 ex., Suisse, leg. Turretini, coll. Maerky, MHNG; 1 ex., Kt. Bern, Gr. Scheidegg, VIII.1941, leg. and coll. Linder A., ETH; 1 ex., Le Sentier, marais, 7.V.1959, leg. Rehfous M., MHNG; 8 ex., Veveyse, F. David [Fontannaz-David], 20.VII.1959, leg. and coll. Scherler P., NMBE; 2 ex., Kt. Bern, Habkern, VII.1972, leg. and coll. Linder A., ETH; 1 ex., BE, Grindelwald, 16.VII.1979, leg. Anonymous, NMBE; 2 ex., Pontins, st. 15, 1995, leg. Carron G., ETH; 1 ex., Val-de-Ruz NE, 18.VIII.2023, leg. Chittaro Y.; 9 ex., Grindelwald BE, 21.VIII.2023, leg. and coll. Chittaro Y. and Sanchez A.

Published data. 1 ex., in einem kleinen Tümpel auf der grossen Scheidegg, VIII.1941, by Linder A. (Linder 1946).

Comment. This species is mainly found in central and northern Europe, from Switzerland and southern Germany (Köhler and Klausnitzer 1998; Bleich et al. 2016) to Scandinvia. It was not cited from France by Bameul and Queney (2014), nor from Italy by Franciscolo (1979). In Switzerland, *I. crassus* occurs in a few peat bogs in the Jura mountains, as well as in a few high elevation peat bogs in the northern Alps (BE) (Fig. 2).

C6) *Ilybius erichsoni* (Gemminger & Harold, 1868)

Examined material. 2 ex., Aletsch, leg. and coll. Bugnion E., MZL; $^{3,4,6)}$2 ex., Savièse, 5.VIII., leg. and coll. Maerky C., MHNG; 1 ex., GR, Celerina, VIII.1955, leg. Toumayeff G., MHNG; 8 ex., Graubünden, Alp Grüm, 3.VII.1961, leg. and coll. Wolf J.-P., ETH; 3 ex., GR, A. Grüm, VI.1962, leg. Toumayeff G., MHNG; 4 ex., Valais, Lac Ar-Pitetta s/Zinal, 25.VIII.1963, leg. Toumayeff G., MHNG; 2 ex., Moosalp sur Bürchen, 11.VII.1974, leg. and coll. Scherler P., NMBE; 1 ex., Bonigersee, 17.IX.1993, leg. Rotzer A., MZL; 2 ex., Moosalp, Postautohalt, 31.V.1994, leg. Rotzer A., MZL; 1 ex., [Seelein, Bettmeralp], 2.VIII.1996, leg. Carron G., LEBA; 3 ex., Anniviers VS, 30.VI.2001, leg. Carron G., ETH; 1 ex., Törbel VS, 1.VII.2001, leg. Carron G., ETH; 12 ex., Bürchen VS, 13.VII.2004, leg. Carron G., ETH; 45 ex., Bürchen VS, 12.VI.2005, 16.VI.2005, leg. Carron G., ETH; 4 ex., Bürchen VS, 2.VII.2021, leg. and coll. Chittaro Y. and Cosandey V.; 3 ex., 2.VII.2021, Törbel VS, leg. and coll. Cosandey V.; 7 ex., Anniviers VS, 19.VIII.2021, leg. and coll. Cosandey V.; 3 ex., Törbel VS, 8.IX.2023, leg. and coll. Chittaro Y. and Sanchez A.

Published data. 1 ♀, Toerbel, Breitmattsee, 2047m by Rotzer A. (recorded as *Agabus nigroaeneus*) (Rotzer 1989); Wallis, Goppisberg, Scheene Bodu, 20.VII.1987 and Wallis, Törbel, Breitmattsee, 7.VII.1987 by Rotzer A. (Brancucci and Rotzer 1989).

Comment. In Switzerland, this species is present only in the Alps, where it is extremely localized (Fig. 2). Targeted surveys of Alpine ponds have found it in abundance at historic sites, but no new sites could be found. Potentially, *I. erichsoni* may be outcompeted by *A. bipustulatus*, as these two species have never been found together in Switzerland. *Ilybius erichsoni* has a Holarctic distribution, being present in the Palaearctic region from Scandinavia to Japan, but also in central Europe, Italy, and Switzerland (Nilsson and Holmen 1995). Although it has never been reported in France (Bameul and Queney 2014), it could be present there.

C7) [*Ilybius meridionalis* Aubé, 1837]

Examined material. $^{3,4,6,8)}$2 ex., Tessin, leg. Frey-Gessner E., coll. Maerky C., MHNG.

Published data. $^{3,4,6,8)}$2 ex., Tessin by Frey-Gessner E., MHNG (Carron 2005).

Comment. In Europe, this species occurs in France (Guignot 1947; Bameul and Queney 2014) and Italy (Franciscolo 1979) in the western Mediterranean region (Guignot 1947). As already announced by Carron (2005), *I. meridionalis* is absent from Switzerland; the only Swiss occurrence comes from the problematic collection of C. Maerky (Monnerat et al. 2015) and should not be considered.

C8) [*Ilybius montanus* (Stephens, 1828)]

Examined material. $^{3,4,6)}$1 ex., Alpes, Louèche, 2.VII., leg. and coll. Maerky C., MHNG.

Comment. Although this species is widely distributed in Europe and North Africa, it is not considered part of the Swiss fauna. Indeed, the only Swiss occurrence comes from the problematic collection of C. Maerky (Monnerat et al. 2015). This species remains potential for Switzerland as it has been found in the neighboring regions of Alsace and Bas-Rhin (Callot 1990, 2018) as well as in Baden in southern Germany (Köhler 2011).

C9) *Ilybius neglectus* (Erichson, 1837)

Examined material. 1 ex., Schaffhausen, Schaaren, leg. Böschenstein A., NMSH; 1 ex., Stein a. Rhein, leg. Böschenstein A., NMSH; 1 ex., Nürensdorf, 28.VI.1855, coll. Dietrich K., ETH; 1 ex., Suisse, Vaud, Boussens, 1956, leg. Barbey, MZL; 1 ex., Mollens VD, 2.VII.2016, leg. and coll. Chittaro Y.; 1 ex., Mollens VD, 8.IV.2017, leg. and coll. Cosandey V.; 1 ex., Mollens VD, 31.V.2018, leg. and coll. Chittaro Y.; 2 ex., Ballens VD, 3.VIII.2021, leg. and coll. Chittaro Y.; 2 ex., Rümlang ZH, 23.V.2022, leg. and coll. Birnstiel E.; 4 ex., Rümlang ZH, 1.VI.2022, leg. and coll. Birnstiel E.; 1 ex., Mollens VD, 18.IV.2023, 27.V.2023, leg. and coll. Chittaro Y.; 2 ex., Thal SG, 1.V.2023, leg. and coll. Sanchez A.; 1 ex., Schaffhausen SH, 3.V.2023, leg. and coll. Sanchez A.

Published data. Marais de Kloten, 13.IX.1967, 20.IX.1967, 29.VII.1970 by Gassmann M., det. Schaeflein H. (Gassmann 1974).

Comment. This species has a northern distribution and reaches Switzerland at its extreme southern limit, as already indicated by Carron (2005). It is now known from a few localities in northeastern Switzerland and two isolated localities in the canton of Vaud. Sporadically present in the northern half of France (Bameul and Queney 2004), it is known from Alsace (Callot 1990, 2018), Vorarlberg (Brandstetter and Kapp 1995), and southern Germany (Köhler and Klausnitzer 1998; Köhler 2000; Bleich et al. 2016). Additional populations are likely to be found in northern Switzerland.

C10) [*Ilybius similis* C.G. Thomson, 1856]

Published data. [1,8]CH [Switzerland] (Brancucci 1994).

Comment. This species is mainly found in northern Europe and is not known from regions neighbouring Switzerland; in France, it is only mentioned in Finistère, Vienne, and Haute-Vienne (Bameul and Queney 2014) and only a few old records (before 1950) indicate it occurs in southern Germany, in the Land Bayern (Köhler and Klausnitzer 1998). *Ilybius similis* does not occur in Switzerland; it is only mentioned in the Swiss red list (Brancucci 1994) and no specimen deposited in Swiss natural history collections support its presence in the country.

C11) *Ilybius subaeneus* Erichson, 1837

Examined material. 1 ex., Batiaz, coll. Cerutti N., MHNF; 1 ex., Bern, leg. and coll. Burghold W., NMBE; [3,4,6]1 ex., Suisse, Bienne, leg. Fries A., coll. Maerky C., MHNG; 1 ex., Martig. [Martigny], leg. Favre E., coll. Moritz P., MHNS ; [3,4,6]1 ex., Kt. Wallis, leg. Täschler M., coll. Linder A., ETH; 1 ex., S. Léon. [St-Léonard], leg. and coll. Berhaut J., MHNS; 1 ex., Wallis, leg. Anonymous, ETH; 1 ex., Kt. Wallis, Siders, VI.1939, leg. and coll. Linder A., ETH ; 1 ex., Pte à la Bise, 20.IX.1946, leg. Simonet J., MHNG ; 1 ex., Suisse, Vaud, La Chaux, 27.V.1951, leg. Besuchet C., MZL; 1 ex., Hermance, Lac Léman, 25.V.1958, leg. Rehfous M., MHNG.

Published data. [1]Katzensee (Heer 1841) ; [1]Schaffhausen by Stierlin G. (Stierlin and Gautard 1867) ; [1]Lugano by Forel A.-H. (Stierlin 1883) ; [1]Châtelard and [2]Trient by Favre E. (Favre 1890) ; [1]St. Gallen by Müller-Rutz J. (Müller 1904); [2]Thal, b. Fuchsloch, VII.1957 by Hugentobler H. (Hugentobler 1966) ; [1]Grangettes, 1996, 1997 (Naceur 1997).

Comment. A few sparse occurrences of *I. subaeneus* exist in Switzerland, mainly in the canton of Valais and in the Lake Geneva region. The specimen cited from Trient by Favre (1890) was in fact an *I. fenestratus*, while the one from Thal cited by Hugentobler (1966) was an *I. ater*. *Ilybius subaeneus* is a Holarctic species known from southern Germany (Köhler and Klausnitzer 1998), near Basel (Bleich et al. 2016), and from northern France (Guignot 1947; Bameul and Queney 2014). Given these distribution data, observations in northern Switzerland cannot be ruled out.

C12) [*Ilybius subtilis* Erichson, 1837]

Published data. [1]Aigle (Heer 1841); [1]au-dessus du glacier d'Aletsch by Martin C. (Favre 1890).

Comment. In Switzerland, only two occurrences in the older literature exist, which is insufficient to include this species in the Swiss fauna. As Carron (2005) already pointed out, depending on the localities, it is very likely that the specimen cited by Favre (1890) was *Ilybius erichsoni* and that cited by Heer (1841) was *Agabus melanarius*. *Ilybius subtilis* is known from Alsace (Callot 1990, 2018), where it colonises ponds in dark forests, and from southern Germany (Köhler and Klausnitzer 1998), where the nearest localities are more than 150 km from the Swiss border (Bleich et al. 2016). The presence of this northern European and Siberian species in Switzerland is possible but needs to be confirmed.

C13) [*Colymbetes striatus* (Linnaeus, 1758)]

Comment. As Carron (2005) mentioned, there was one misidentified specimen of *Colymbetes striatus* (Peney GE, 1895, leg. Tournier H.) in the collections of the MHNG, which was in fact a *C. fuscus*. Without any concrete evidence, this species is therefore not considered indigenous in Switzerland, although it is widespread throughout the Palaearctic region.

C14) [*Meladema coriacea* Laporte, 1835]

Examined material. [3,4,6,8]1 ex., Sierne, 18.V., leg. Anonymous, coll. Maerky C., MHNG.

Comment. The only specimen of *M. coriacea* labelled as Swiss comes from the problematic collection of Charles Maerky and must be regarded as a doubtful record. Consequently, this species is not included in the Swiss list. According to Guignot (1947), it occurs in the Mediterranean area, including its islands, Portugal, and North Africa. In France, this species is present in the Mediterranean area and in Corsica (Bameul and Queney 2014). In Italy, its nearest populations are located more than 200 km from the Swiss border (Franciscolo 1979).

C15) *Rhantus* (*Rhantus*) *bistriatus* (Bergsträsser, 1777)

Examined material. [3,4,6]2 ex., Bern, leg. and coll. Burghold W., NMBE; [3,4,6]1 ex., Schaffh., coll. Stierlin G., ETH; [3,4,6]1 ex., Schweiz, leg. Staehlin-Bischoff, NMB; 1 ex., Valais, leg. Favre E., MHNG; [3,4,6]1 ex., Suisse, Bienne, 11.VI., leg. and coll. Maerky C., MHNG; 1 ex., Genève, Veyrier, 25.VII., leg. Huber A., NMLU; 1 ex., Martigny, 7.VI.1886, leg. Gaud A., MZL; 1 ex., Lac Léman, 1.VII.1925, leg. Huber A., NMLU; 1 ex., Petite Grave, 4.V.1957, leg. Rehfous M., MHNG.

Published data. [1]Bern by Heer O. (Stierlin and Gautard 1867) ; [1]mares entre le Guercet et le pont vers l'Eglise de Fully and [1]Praz-Pourris, près Vétroz by Favre E. (Favre 1890) ; [3,4,6]Schaffhausen by Stierlin G., Martigny VS by Gaud A. (MZL) and Region Genf (Carron 2005).

Comment. As already mentioned by Carron (2005), this species is only represented in collections by historical specimens, the last record dating from 1957. Although considered highly threatened by Brancucci (1994), it is more likely that this species is now extinct in Switzerland. *Rhantus bistriatus* is widely distributed in the Palaearctic region; it is present in the northern half and central France (Bameul and Queney 2014) but absent from Alsace (Callot 2018), and uncommon in southern Germany (Köhler and Klausnitzer 1998; Bleich et al. 2016).

C16) [*Rhantus* (*Rhantus*) *consputus* (Sturm, 1834)]

Examined material. [3,4,6)]2 ex., Schaffh., coll. Stierlin G., ETH; [3,4,6)]1 ex., Suisse, Argovie, leg. and coll. Maerky C., MHNG.

Published data. [1)]Bern by Perty M. (Heer 1837); [3,4,6)] Schaffhausen by Stierlin G. (Stierlin and Gautard 1867); [1)]Valais by Fauvel C.A.A. (Guignot 1931–1933); [1)]CH [Switzerland] (Brancucci 1994).

Comment. This species has a west-palaearctic distribution. It is not considered part of the Swiss fauna because the only existing specimen comes from the problematic collection of C. Maerky, while the literature occurrences cannot be verified. It is mentioned in Alsace (Callot 1990, 2018) in France, in Vorarlberg near Bregenz (Brandstetter and Kapp 1995) in Austria, and in southern Germany (Köhler and Klausnitzer 1998). Its presence in Switzerland is therefore potential but needs to be confirmed.

C17) *Rhantus* (*Rhantus*) *frontalis* (Marsham, 1802)

Examined material. 1 ex., Genève, Versoix, 10.VI.1924, leg. Huber A., NMLU; 1 ex., Genève, Veyrier, 25.VII.1924, leg. Huber A., NMLU; 2 ex., Lac Léman, 1.VII.1925, leg. Huber A., NMLU; 1 ex., Kt. Bern, Hindelbank, VIII.1969, leg. and coll. Linder A., ETH; 1 ex., CH, BE, Ins, Landw. Schule, 12.VII.1977, leg. Reser-Rezbanyai L., NMLU.

Published data. [1)]Bern by Ougspurger F. P. von and Perty M., [1)]Genf by Chevrier F. and Lasserre H., [1)]im Jura by Mellet L., [1)]Malans by Amstein J. G., [1)]Zürich by Heer O. (Heer 1837); [1)]Pomy (Heer 1841); [1)]Engadin by Meyer-Dür R. L., [1)]Saas by de Bonvouloir H. A. (Stierlin and Gautard 1867); [1)]St. Gallen by Täschler M. (Täschler 1872); [1)]Schaffhausen (Stierlin 1900).

Comment. Although this species is widely distributed in the Palaearctic region, its presence is attested by only a few occurrences in Switzerland, the last record dating from 1977. It has been collected in Liechtenstein near Ruggell (Brandstetter and Kapp 1995) and in southern Germany near Lake Constance (Bleich et al. 2016), so rediscoveries in northern Switzerland are still possible.

C18) *Rhantus* (*Rhantus*) *notaticollis* (Aubé, 1837)

Examined material. 3 ex., Filisur, leg. Wolf E., coll. Wolf J.-P., ETH; 1 ex., Gampel, 24.VI.1926, leg. Bucher P., NMBE; 8 ex., Mittelwallis, 24.VI.1926, leg. Bucher P., NMBE; 2 ex., Domleschg, Cazis, 7.VII.1937, leg. Wolf J.-P., ETH; 1 ex., Domleschg, Rodels, 28.VIII.1938, leg. Wolf J.-P., ETH; 11 ex., Domleschg, Rothenbr., 31.VII.1938, leg. Wolf J.-P., ETH; 7 ex., Domleschg, Roth. [Rothenbrunnen], 3.IX.1938, leg. Wolf J.-P., ETH; 5 ex., Kt. Wallis, Gampel, VI.1942, leg. and coll. Linder A., ETH; 11 ex., Kt. Wallis, Leuk, VI.1942, leg. and coll. Linder A., ETH; 1 ex., Martigny, VI.1945, leg. Linsenmaier W., NMLU; [4,6)]1 ex., Wülflingen, VI.1959, leg. Huber H., NMWI; 1 ex., Bevers, 19.VII.1971, leg. and coll. Scherler P., NMBE.

Published data. Sitten by Isenschmid M. (Stierlin 1883); Saxon, coll. Cerutti N. (Linder 1941); Tümpeln längs der Rhone bei Leuk und Gampel, VI.1942, by Kalt, Pochon H. and Linder A. (Linder 1946).

Comment. This Palaearctic species occurs from central and northern Europe to Japan (Nilsson and Holmen 1995). In Switzerland it has been caught numerous times in Valais and Grisons until 1971. These populations are now extinct, but it is interesting to note that they were the most southernly known. Indeed, *R. notaticollis* is sparsely distributed in France in the Vosges and Isère, where targeted prospections should be carried out (Guignot 1947; Bameul and Queney 2014), and in south Tyrol in Italy (Campo Tures) by old and doubtful occurrences (Franciscolo 1979; Kahlen and Hellrigl 1996). In southern Germany, it is known from the Land of Bayern (Köhler and Klausnitzer 1998) but its nearest populations are located at more than 150 km from the Swiss border (Bleich et al. 2016).

C19) *Rhantus* (*Rhantus*) *suturellus* (Harris, 1828)

Examined material. 3 ex., Einsiedeln, VI., coll. Bugnion E., MZL ; 1 ♂, 24.IV.2020, Les Ponts-de-Martel NE, leg. and coll. Chittaro Y.

Published data. [1)]1 ex., Genève by Tournier (Carron 2005).

Comment. The capture of a male specimen of *Rhantus suturellus* in a peat bog in the canton of Neuchâtel confirms that this species belongs to the Swiss fauna, which was not clear for Carron (2005). This circumboreal species also occurs in Alsace (Callot 1990, 2018) and in southern Germany (Köhler and Klausnitzer 1998; Köhler 2000; Bleich et al. 2016). Carron (2005) also mentions a specimen from Geneva collected by Tournier. However, it could not be found in the MHNG collection, where it should have been deposited.

C20) *Graphoderus austriacus* (Sturm, 1834)

Examined material. 2 ex., Katzensee, leg. Keller, coll. Allenspach V., NMB; 1 ex., Martigny, coll. Cerutti N., MHNF; 8 ex., Martigny, coll. Favre E., HGSB; [3,4,6)]1 ex., Genève, Peney, leg. and coll. Maerky C., MHNG; [3,4,6)]1 ex., Suisse, Bienne, 16.VI., leg. and coll. Maerky C., MHNG; 2 ex., Kt. Wallis, Martigny, V.1890, leg. Anonymous, coll. Linder A., ETH; 3 ex., Ch. Fully [Champagne de Fully], 19.V.1890, 20.V.1890, leg. [Favre E.], MHNG; 14 ex., Ch. Fully [Champagne de Fully], 10.VI.1890, leg. Favre E., coll. Cerutti N., Rätzer A., Mathey A., MHNF, MHNG and NMBE; 1 ex., Fully, 19.IV.1901, leg. and coll. Gaud A., MZL; 1 ex., Martigny, 25.IV.1902, leg. and coll. Gaud A., MZL; 1 ex., Basel, VII.1941, leg. and coll. Pochon H., MHNF.

Published data. $^{1)}$Basel by Knecht, $^{1)}$Bern by Meyer-Dür R. L. (Stierlin 1883); Mares entre le Guercet et Fully by Favre E. (Favre 1890); 3 ex., TI, Bolle di Magadino, 1999 by Focarile A. V. (Carron 2005).

Comment. This species is widely distributed in the Palaearctic region. Its range extends from France (mainly in the east and north of the country (Bameul and Queney 2014), but also in Provence according to Guignot (1947)) and northern Italy (Franciscolo 1979) to Sweden and Siberia (Nilsson and Holmen 1995). Although *G. austriacus* was known from a few scattered specimens in Switzerland, it may now be extinct in the country; the last occurrence was in southern Ticino in 1999, and targeted surveys in recent years have failed to find it again. *Graphoderus austriacus* is present in Alsace (Callot 1990, 2018) in France and in southern Germany (Köhler and Klausnitzer 1998).

C21) *Graphoderus zonatus zonatus* (Hoppe, 1795)

Examined material. $^{3,4,6)}$1 ex., Genève, Anc. Fossés, leg. Anonymous, coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Basel, leg. and coll. Täschler M., MHNG; $^{3,4,5,6)}$1 ex., Basel, leg. Anonymous, NMB; 7 ex., Finge, leg. Bugnion E., MZL; $^{3,4,6)}$1 ex., Genève, Lancy, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Suisse, Valais, leg. and coll. Maerky C., MHNG; 2 ex., Ch. Fully [Champagne de Fully], 20.V.1890, leg. Favre E., coll. Cerutti N., MHNF; 1 ex., Aïre, 6.V.1924, leg. Simonet J., MHNG; 6 ex., Kt. Bern, Uettligen, V.1932, V.1933, IV.1934, leg. and coll. Linder A., ETH; 4 ex., Domleschg, Roth., 31.VII.1938, leg. Wolf J.-P., ETH; 1 ex., Domleschg, Roth., 31.IX.1938, leg. Wolf J.-P., ETH; 1 ex., BE, Uttligen, IV.1942, leg. Linder A., coll. Toumayeff G., MHNG; 1 ex., VS, Sierre, VI.1942, leg. Linder A., coll. Allenspach V., NMB; 3 ex., Valais, Gampel, 8.VII.1942, leg. and coll. Pochon H., MHNF; 2 ex., ZH, Niederglatt, VI.1952, leg. Toumayeff G., NMB; 1 ex., VS, Pfynwald, 11.VII.1971, leg. Anonymous, NMBE; 1 ex., VD, Bavois, V.1972, leg. Toumayeff G., MHNG; 1 ex., Finge, Etang entonnoir [Scharzegilu], 1986, leg. Bille R.-P., MHNS; 2 ex., Gouille Salgesch, VIII.1987, leg. Bille R.-P., MHNS; 2 ex., Bonigersee, 29.IV.1993, 17.IX.1993, leg. Rotzer A., MZL; 1 ex., Valais, Moosalp, Breimattsee, 17.VII.1999, leg. Carron G., ETH; 3 ex., Törbel VS, 1.VII.2001, leg. Carron G., ETH; 1 ♂, Cudrefin VD, 16.VI.2014, leg. Vallat A.; 6 ♂, 2 ♀, Törbel VS, 2.VII.2021, leg. and coll. Chittaro Y. and Cosandey V.; 3 ex., Törbel VS, 8.IX.2023, leg. and coll. Chittaro Y. and Sanchez A.; 2 ex., Zeneggen VS, 8.IX.2023, leg. and coll. Chittaro Y. and Sanchez A.

Published data. Schweiz by Fauvel C. A. A. (Stierlin and Gautard 1867); 1 ex., Graubünden, Nähe Ofenpass, Alp da Munt, 2210 m, 27.VI.1984 by Schaeflein H. (Schaeflein 1989).

Comment. This species is widely distributed in the Palaearctic region. In neighboring countries, it is mentioned in southeast Germany (Köhler and Klaunsnitzer 1998; Bleich et al. 2016) and in northern and eastern France, where it reaches Lyon and Evreux (Guignot 1947; Bameul and Queney 2016). In Italy, it is known from a few localities (Franciscolo 1979). While the species was once known from several widely distributed stations in Switzerland, in recent years it has only been found in the canton of Valais and on the shores of Lake Neuchâtel. Targeted surveys of previously known sites have failed to find it, indicating that this species is certainly in danger of extinction in Switzerland.

C22) *Dytiscus circumcinctus* Ahrens, 1811

Examined material. $^{3,4,6)}$1 ex., Aarau, leg. Täschler M., coll. Spälti A., MHNG; 1 ex., Bern, leg. and coll. Burghold W., NMBE; $^{3,4,6)}$1 ex., Genève, Pl. les Ouates, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Schaffhausen, leg. Täschler M., coll. Spälti A., MHNG; $^{3,4,6)}$1 ex., Bienne, 6.VI., leg. Anonymous, coll. Maerky C., MHNG; $^{3,4,6)}$2 ex., Colombier, 2.IX., leg. Anonymous, coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Bienne, 6.VI., leg. Anonymous, coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Rouelbeau, 7.X., leg. Anonymous, coll. Maerky C., MHNG; 1 ex., [Dörflingen, Afling], 1848, leg. and coll. Brunner J., NMSH; 1 ex., Pt. Saconnex, IV.1892, leg. Poncy E., MHNG; 1 ex., Pt. Saconnex, V.1892, leg. Anonymous, MHNG; 1 ex., Fribourg, III.1935, leg. Rappo J., MHNG; 2 ex., Prosito, X.1948, leg. Anonymous, MHNS; 1 ex., Stadlersee, 29.IV.1956, leg. and coll. Linsenmaier W., NMLU; 1 ex., ZH, Regensberg, 28.VIII.1957, leg. and coll. Allenspach V., NMB; 4 ex., Les Grangettes, 27.X.1957, leg. and coll. Scherler P., NMBE; 1 ex., Les Grangettes, 24.VIII.1958, leg. and coll. Scherler P., NMBE; 2 ex., Les Grangettes, 5.X.1958, leg. and coll. Scherler P., NMBE; 2 ex., Kt. Waadt, Villeneuve, X.1959, leg. and coll. Linder A., ETH; 2 ex., Les Grangettes, 22.X.1959, leg. and coll. Scherler P., NMBE; 1 ex., VD, Villeneuve, Grangettes, X.1960, leg. Scherler P., MHNG; 2 ex., Les Grangettes, 25.X.1960, leg. and coll. Scherler P., NMBE; 2 ex., Les Grangettes, 25.X.1961, leg. Scherler P., MHNG; 1 ex., Rümlang ZH, 17.V.2022, leg. and coll. Birnstiel E.; 1 ex., Rümlang ZH, 14.VII.2023, leg. and coll. Cosandey V.

Published data. $^{1)}$Colombier im Waadtlande by Bugnion E. and $^{1)}$Katzensee by Heer O. (Heer 1837); $^{1)}$Schaffhausen by Stierlin G. (Stierlin and Gautard 1867).

Comment. This Holarctic species is distributed from northern and central Europe to western Russia. In Switzerland, *D. circumcinctus* is very rare, with only scattered records. After more than 50 years without data, it was found again in 2022 and 2023. It is present in southern Germany (Köhler and Klausnitzer 1998). In France, it is recorded from the northern and central regions and in the Alps, but is considered rare and sporadic (Bameul and Queney 2014), as in Italy (Franciscolo 1979).

C23) *Dytiscus circumflexus* Fabricius, 1801

Examined material. $^{3,4,6)}$1 ex., Aarau, leg. Täschler M., coll. Spälti A., MHNG; $^{3,4,6)}$1 ex., Suisse, Bex, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Suisse, Bienne, leg.

and coll. Maerky C., MHNG; [3,4,6)]2 ex., Genève, leg. Sechehaye A., coll. Maerky C., MHNG; [3,4,6)]1 ex., Schaffhausen, leg. Täschler M., coll. Spälti A., MHNG; 1 ex., Helv., BL, Oberwil, Ziegelei, 13.III.1954, leg. [Allenspach V.], coll. Allenspach V., MHNG.

Published data. [1)]Lausanne by Mellet L. (Heer 1837); [1)]Buchser-See [Buchs SG] by Rietmann O. (Täschler 1872); [1)]Basel (Stierlin 1900).

Comment. Although this species is widely distributed in Europe, such as in Italy (Franciscolo 1979), France (Bameul and Queney 2014), and Germany (Köhler and Klausnitzer 1998), it appears to be marginal in Switzerland, where it is known only from a single specimen caught in the Basel region in the far north of the country. All other records are linked to problematic collections and should be disregarded. As the species has not been found in Switzerland for 70 years, it is very probably extinct.

C24) *Dytiscus dimidiatus* Bergsträsser, 1777

Examined material. [3,4,6)]2 ex., Suisse, Colombier, leg. and coll. Maerky C., MHNG; 2 ex., Lausanne, leg. and coll. Gaud A., MZL; [3,4,6)]1 ex., Vevey, leg. Täschler M., coll. Spälti A., MHNG; 1 ex., Kt. Waadt, Yverdon, VIII.1939, leg. and coll. Linder A., ETH; [3,4,5,6)]1 ex., Basel, 20.V.1942, leg. Anonymous, NMB; 1 ex., Yverdon, VII.1952, leg. and coll. Sermet A., MZL; 1 ex., Kt., Waadt, Yvonand, IV.1957, leg. and coll. Linder A., ETH; 1 ex., Yvonand, IX.1958, leg. and coll. Sermet A., MZL; 7 ex., Yvonand, 28.IX.1958, leg. and coll. Scherler P., NMBE; 1 ex., Yvonand, 12.X.1958, leg. and coll. Scherler P., NMBE; 1 ex., Vaud, Chabrey, 26.VIII.1962, leg. Aellen V., MHNG; 1 ex., Vaud, Cudrefin, 30.IV.1973, leg. Brancucci M., NMB; 79 ex., Champmartin, 1974, leg. Brancucci M.; 1 ex., Font, 28.IX.1988, leg. Mulhauser B.; 1 ex., Chabrey, 16.VIII.1994, leg. and coll. Scherler P., NMBE; 1 ex., Estavayer, 8.VI.1995, leg. Calame F.; 1 ex., Font, 8.VI.1995, leg. Calame F.; 4 ex., Yvonand VD, 13.VIII.2021, 9.IX.2021, leg. and coll. Chittaro Y. and Cosandey V.

Published data. [1)]Concise am Neuchateller See by Heer O., [1)]Lausanne by Heer O. and [1)]Vevey by de Gautard V. (Stierlin and Gautard 1867); [1)]Buchser-See [Buchs SG] by Rietmann O. (Täschler 1872); [1)]Basel (Stierlin 1900); [Grève de Cudrefin] (Brancucci 1979, 1980); Portalban-Cudrefin, 16.VII.1994 by Scherler P. (Scherler 1995); Grande Cariçaie, 1958–1995 (Mulhauser 1997).

Comment. This Western Palaearctic species is distributed from North Africa to Scandinavia and east to the Caucasus. *Dytiscus dimidiatus* is very rare and localized in Switzerland; almost all the occurrences are concentrated exclusively on the southern shore of Lake Neuchâtel. It appears to be in steep decline there.

C25) [*Dytiscus lapponicus* Gyllenhal, 1808]

Published data. [1)]Simplon ! Par Rausis [« Douteux en Valais » selon Favre E.] (Favre 1890).

Comment. As already mentioned by Carron (2005), *D. lapponicus* is not native to Switzerland and should not have been evaluated in the red list (Brancucci 1994). Two specimens are deposited in the Favre collection (HGSB), which holds almost exclusively insects collected around Martigny and the Grand-Saint-Bernard pass in the canton of Valais. However, the two specimens do not carry a locality label and moreover concern the nominal subspecies, which does not occur in the Alps (see also comment in Carron 2005). The subspecies *disjunctus* Camerano, 1880 is recorded from the Italian and French Alps (Haute-Provence and Hautes-Alpes [Guignot 1947]), the nearest population being 100 km south of the Swiss border. In Italy, it was last collected in 1923 in the Colle della Magdalena Lake before the introduction of trout for sport fishing (Franciscolo 1979). Curiously, Bameul and Queney (2014) list the nominal subspecies for France whereas the southwestern limit of the distribution of *D. lapponicus lapponicus* appears to be in Westfalen, Germany (Köhler and Klausnitzer 1998).

C26) *Dytiscus latissimus* Linnaeus, 1758

Examined material. [3,4,6)]2 ex., Bodensee, leg. Anonymous, coll. Maerky C., MHNG; [3,4,6)]1 ex., Suisse, Bodensee, leg. and coll. Maerky C., MHNG; [3,4,6)]2 ex., Bern, leg. and coll. Burghold W., NMBE; 1 ex., Katzensee, leg. Keller, coll. Nägeli A., NMSO; 1 ex., Katzensee, leg. Schindler, ETH; 1 ex., Katzensee, leg Anonymous, NMAA; [3,4,6)]1 ex., Kt. Genf, leg. Täschler M., coll. Spälti A., MHNG; 2 ex., Zürich, leg. and coll. Linsenmaier W., NMLU; 4 ex., Katzensee, 18.IV.1883, 19.IV.1883, 22.IV.1883, leg. Anonymous, ETH; 1 ex., Katzensee, VIII.1885, leg. and coll. Nägeli A., NMSO; 1 ex., Katzensee, 3.IV.1887, leg. and coll. Nägeli A., NMSO; 1 ex., Zch., Katzensee, 18.VI.1895, leg. Anonymous, ETH; 1 ex., Katzensee, 1902, leg. Keller, coll. Nägeli A., NMSO; 1 ex., Katzensee, VI.1902, leg. De Brenzinger, NMB; 2 ex., Zür., Katz. See, 1910, leg. Keller, coll. Allenspach V., NMB; 2 ex., ZH, Katzensee, 15.V.1910, leg. and coll. Spälti A., MHNG; 2 ex., Kt. Zürich, Zürich, VIII.1928, leg. and coll. Linder A., ETH; 2 ex., Zch., Affoltern, Hänsiried, 19.VIII.1928, leg. and coll. Allenspach V., MHNG and NMB; 1 ex., Zch., Affoltern, Hänsiried, 26.VII.1931, leg. and coll. Allenspach V., MHNG; 1 ex., Zürich, Katzensee, VII.1942, leg. Wolf J.-P., ETH; 1 ex., Zürich, Katzensee, 28.VIII.1942, leg. Wolf J.-P., ETH; 1 ex., Zch., Katzensee, 3.IX.1942, leg. Wolf J.-P., ETH; 2 ex., Katzensee, 20.IX.1942, leg. Wolf J.-P., ETH; 3 ex., Zürich, Affoltern, Hänsiried, Seerosenteich Rosenberger, 7.V.1943, 20.V.1943, leg. and coll. Allenspach V., NMB; 2 ex., vorderer Katzensee, 19.VII.1945, leg. Wolf J.-P., ETH; 1 ex., Hettlingen, 1948, leg. Götz W., NMWI.

Published data. Katzensee (Fuessly 1775); Basel by Frey-Gessner E. and Bodensee by Fuessly J. C. (Heer 1837); Pfäffikersee, in einer Torfgrube, 15.VII.1864 by Dietrich K. (Dietrich 1865); Schaffhausen by Heer O. (Stierlin and Gautard 1867).

Comment. This species is distributed in central and northern Europe and Siberia. It is in steep decline in Europe and has disappeared from entire regions probably due, in part, to its specialized feeding habits, with the larvae relying on a high density of Limnephilidae (Trichoptera) (Scholten et al. 2018). In France, Bameul and Queney (2014) consider it as probably extinct as it has not been caught since the early twentieth century. In Italy, there is only one occurrence dating from the mid-nineteenth century (Lago di Fimon) (Franciscolo 1979). In Switzerland, the few occurrences are all situated around Zürich. The species has not been caught since 1948, although targeted surveys have been carried out (Döös et al. 2017). It is almost certain that this species has become extinct in Switzerland.

C27) [*Eretes sticticus* (Linnaeus, 1767)]

Published data. $^{1,8)}$[Schweiz ?] by Heer O. (Bremi-Wolf 1856).

Comment. There is only one literature reference citing this species in Switzerland. However, since this occurrence is not supported by any specimen in the examined collections, the species is not considered indigenous. In France, it is very rare and occurs in the Mediterranean area and on the Atlantic coast (Guignot 1947; Bameul and Queney 1947). In Italy, the nearest populations are located more than 100 km from the Swiss border (Franciscolo 1979).

C28) [*Hydaticus* (*Hydaticus*) *aruspex* Clark, 1864]

Comment. As Carron (2005) indicated, there was an old record of *H. aruspex* in the national database, relating to a specimen conserved at the MZL. However, after checking this collection, no specimen of this species was found, but instead one of *H. continentalis* bearing the same provenance indications (see C29). This record is therefore certainly the result of a previous misidentification. This species is distributed in the north of the Holarctic region. In Germany, *H. aruspex* is absent from the southern half of the country (Bleich et al. 2016). In France, it only occurs in the north (Somme) and west (Girondes, Landes) of the country and is considered a rare post-glacial relict species (Bameul and Queney 2014). In view of these distribution data, the presence of *H. aruspex* in Switzerland is very unlikely.

C29) [*Hydaticus* (*Hydaticus*) *continentalis* J. Balfour-Browne, 1944]

Examined material. $^{3,4,6,8)}$1 ex., Schaffhouse, 1908, leg. Gaud A., MZL.

Published data. $^{1,8)}$[Schweiz] by Heer O. (Bremi-Wolf 1856); $^{1,8)}$Schaffhausen by Stierlin G. (Stierlin and Gautard 1867); $^{1,8)}$1 ex., Genève and 3 ex., $^{1,8)}$Ch. Des Bois (Chavannes des Bois VD) by Tournier H. (Carron 2005).

Comment. While Carron (2005) retained this species for Switzerland based on a specimen kept at the MZL, we do not consider it to be indigenous here, as the sole specimen belongs to a collection that is not completely reliable. Although widely distributed in the Palaearctic region, *H. continentalis* is not known from areas adjacent to Switzerland; it is absent from the southern half of Germany (Bleich et al. 2016) and is not retained as part of the French Fauna (Bameul and Queney 2014), while a single occurrence is considered reliable in Italy (Franciscolo 1979).

C30) *Hydaticus* (*Hydaticus*) *transversalis transversalis* (Pontoppidan, 1763)

Examined material. $^{3,4,6)}$2 ex., Aarau, leg. Anonymous, NMSH ; $^{3,4,6)}$1 ex., Aarau, leg. Täschler M., coll. Spälti A., MHNG ; 2 ex., Basel, coll. Rätzer A., NMSO; $^{3,4,6)}$1 ex., Bern, leg. and coll. Burghold W., NMBE; $^{3,4,6)}$1 ex., Genf, leg. and coll. Lasserre H., ETH; $^{3,4,6)}$1 ex., Suisse, Louèche, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Genève, Pl. les Ouates, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Genève, Sionnet, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Suisse, leg. Poncy E., coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Wallis, coll. Stierlin G., MHNG; $^{3,4,6)}$1 ex., Rouelbeau, 22.IV, leg. Anonymous, coll. Maerky C. MHNG; $^{3,4,6)}$1 ex., Genève, Sionnet, 16.V, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Peney, 11.V.1886, leg. Anonymous, MHNG; 1 ex., Kt. St.Gallen, Thal, VII.1957, [leg. Hugentobler H.] and coll. Linder A., ETH; 1 ex., Staad, 6.VII.1957, leg. and coll. Spälti A., MHNG; 1 ex., Altenrhein, 11.IV.1966, leg. and coll. Spälti A., MHNG; 12 ex., Kt. St.Gallen, Altenrhein, IV.1969, leg. and coll. Linder A., ETH; 1 ex., Jura, Bonfol, Champ de Manche 1, 4.IX.1998, leg. Carron G., ETH; 6 ex., Thal SG, 1.V.2023, 11.IX.2023, leg. and coll. Chittaro Y., Cosandey V. and Sanchez A.

Comment. This Western Palaearctic species is only known from a few stations in northern Switzerland. In France, recent captures have been limited to Alsace along the Rhine (Callot 1990). This species is known from Vorarlberg in Austria (Brandstetter and Kapp 1995) and from southern Germany (Bleich et al. 2016), close to Switzerland. In Italy, populations are located near the Swiss border (Franciscolo 1979), which means this species could also be present in Ticino.

C31) *Hydaticus* (*Prodaticus*) *grammicus* (Germar, 1827)

Examined material. $^{3,4,6)}$1 ex., Bâle, leg. Anonymous, coll. Jörger J. B., NMB; $^{3,4,6)}$1 ex., Genève, Peney, leg. and coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Suisse, leg. Poncy E., coll. Maerky C., MHNG; $^{3,4,6)}$1 ex., Schaffh., leg. Anonymous, ETH; 1 ex., Fully, 16.V.1890, leg. Favre E., HGSB; 4 ex., Ch. Fully [Champagne de Fully], 19.V.1890, 20.V.1890, leg. Favre E., coll. Cerutti N., HGSB and MHNF; 1 ex., Fully, 20.V.1890, coll. Cerutti N., MHNF; 6 ex., Ch. Fully [Champagne de Fully], 24.V.1890, leg. Favre E., coll. Cerutti N., Mathey A. and Rätzer A., HGSB, MHNF and NMBE; 5 ex., Ch. Fully [Champagne de Fully], 10.VI.1890, leg. Favre E., coll. Cerutti N. and Rätzer A., MHNF and NMBE; 2 ex., Ch.

Fully [Champagne de Fully], 10.VI.1896, leg. Anonymous, MHNG; 2 ex., Fully, 10.IV.1901, coll. Gaud A., MZL; 11 ex., Kt. Wallis, Martigny, VI.1939, leg. and coll. Linder A., ETH; 6 ex., Valais, Martigny, 9.VI.1939, leg. and coll. Pochon H., MHNF; 2 ex., Valais, Gampel, 8.VI.1940, leg. and coll. Pochon H., MHNF; 10 ex., VS, Turtmann, 6.IV.1942, leg. and coll. Allenspach V., NMB; 6 ex., Gampel, VI.1942, leg. Linder A., coll. Linder A. and Steiner H., ETH and NMSO.

Published data. 1)Schaffhausen by Stierlin G. (Stierlin and Gautard 1867); 1)Aigle by Jaccard H. and Champagnes de Fully, V.1890 by Favre E. (Favre 1890); 1)Basel (Stierlin 1900); env. De Martigny, coll. Cerutti N. (Linder 1941).

Comment. This species is widespread in the Palaearctic region. In the countries surrounding Switzerland, its presence is only attested by old and sparse occurrences. In France, a single capture in Bas-Rhin in 1951 was recorded (Callot 1990, 2018; Bameul and Queney 2014), in Germany only two old occurrences (before 1950) are considered reliable (Köhler and Klausnitzer 1998), but the species is not established there and not assessed in the latest red list (Spitzenberg et al. 2016), while a single old record attests of the presence of *H. continentalis* in Bregenz, in Austrian Vorarlberg (Schaeflein 1983; Brandstetter and Kapp 1995). In Switzerland, its former presence is attested by numerous specimens collected in several localities in the canton of Valais. The last specimen was caught in 1942 and the species is now probably extinct in Switzerland. Populations in Italy near the canton of Ticino are known (Franciscolo 1979) and a (former) presence of *H. grammicus* in this canton is possible.

C32) [*Hydaticus* (*Prodaticus*) *leander* (P. Rossi, 1790)]

Examined material. 3,4,6,8)1 ex., Genève, Lancy, 1.V, leg. and coll. Maerky C., MHNG.

Comment. The "Swiss" specimen of *H. leander* comes from the problematic collection of C. Maerky and must be regarded as dubiously labeled. This species does not exist in Switzerland, as already indicated by Carron (2005). This species is present on the Mediterranean coast in France (Bameul and Queney 2014) and in Italy (Franciscolo 1979), where its nearest populations are located more than 200 km from the Swiss border. According to Guignot (1947), this species is distributed in the extreme south of Europe and North, West, and central Africa.

C33) [*Bidessus coxalis* Sharp, 1882]

Published data. 1,3,4,6,8)2 ex., GE, Meinier, Rouelbeau, coll. Maerky C., MHNG (Carron 2005).

Comment. Carron (2005) mentions two specimens kept at the MHNG, but searches in its collections have failed to find them. In any case, these specimens belonged to the dubious collection of C. Maerky and cannot be considered. This species does not belong to the Swiss fauna. It occurs in North Africa, on the Iberian Peninsula, and in France, where it is found in the southern half and along the coast as far as Brittany and Normandy (Bameul and Queney 2014).

C34) *Bidessus delicatulus* (Schaum, 1844)

Examined material. 1 ex., Genève, leg. Anonymous, MHNG; 1 ex., Peney, leg. Tournier H., ETH; 1 ex., Diepoldsau, 21.VII.1965, leg. Hugentobler H., NMSG; 5 ex., Genève, Chancy, La Laire, 25.VII.1984, 14.VIII.1985, leg. Besuchet C., MHNG; 1 ex., Genève, Verbois, étang, 27.IX.1990, leg. Besuchet C., MHNG; 1 ex., Buchrain LU, 24.IV.2004, leg. Lubini V., coll Birnstiel E.; 6 ex., Chancy GE, 31.V.2021, leg. and coll. Chittaro Y. and Cosandey V.; 2 ex., Chancy GE, 6.V.2022, leg. and coll. Cosandey V.

Published data. 1)Vevey (Stierlin and Gautard 1867); Diepoldsau, Altenrheinbett b. Kieswerk Sieber, VIII.1965 by Hugentobler H. (Hugentobler 1966); La Laire by Cosandey V. (Cosandey 2023).

Comment. In Switzerland, this species is only known from a few localities scattered at low elevation. Recent targeted surveys in the canton of Geneva found it in a single restricted station, where it was nevertheless abundant (Cosandey 2023). *Bidessus delicatulus* is known in Vorarlberg in Austria (Brandstetter and Kapp 1995) and in southern Germany (Köhler and Klausnitzer 1998; Köhler 2011; Bleich et al. 2016). In France, *B. delicatulus* is rare and localized (Guignot 1947).

C35) *Bidessus minutissimus* (Germar, 1823)

Examined material. 3,4,6)1 ex., Genève, leg. and coll. Maerky C., MHNG; 2 ex., Genf, leg. Chevrier F., ETH; 3,4,6)1 ex., ZH, coll. Bugnion E., ETH; 2 ex., Zürichhorn, leg. and coll. Forel A.-H., ETH; 1 ex., Genthod, VI., leg. Anonymous, NMBE; 5 ex., Zürich, 23.V.1868, coll. Bugnion E., MZL; 2 ex., Riva S. V., riva del lago [Riva San Vitale], 8.V.1914, leg. and coll. Fontana P., MSNL; 2 ex., Zürich Umg., Limmat, 23.V.1941, leg. Wolf J.-P., ETH; 1 ex., Moulin de Vert, 3.VIII.1984, leg. and coll. Scherler P., NMBE; 1 ex., Verbois, 14.VIII.1986, leg. and coll. Scherler P., NMBE; 5 ex., Genève, Verbois, 27.IX.1990, leg. Besuchet C., MHNG; 9 ex., Genève, Moulin de Vert, 30.V.1991, leg. Besuchet C., MHNG; 1 ex., XI.2002, Chancy GE, leg. Lavigne S., det. Carron G., MHNG; 7 ex., Arbon TG, 10.VIII.2004, leg. HYDRA-Institut für angewandte Hydrobiologie; 5 ex., Gordola TI, 19.V.2007, leg. and coll. Geiser M., NMBE; 1 ex., Chancy GE, 19.IV.2019, leg. and coll. Cosandey V.; 6 ex., Chancy GE, 31.V.2021, leg. and coll. Chittaro Y.; 8 ex., Chancy GE, 6.V.2022, leg. and coll. Cosandey V.

Published data. Genf (Heer 1841); Zürich am Horn by Kubli H. (Stierlin and Gautard 1867); Riva S. Vitale, V.1914 by Fontana P. (Fontana 1922); La Laire by Cosandey V. (Cosandey 2023).

Comment. This rare species has been caught mainly around Geneva but also in the canton of Ticino and in northern Switzerland. The ecological requirements of

Bidessus minutissimus could explain its rarity; it could be linked to underground flows of well-oxygenated water (Carron and Castella 2007).

C36) [*Bidessus pumilus* (Aubé, 1838)]

Published data. [2,8]2 ex., Locarno, IV.1934 by Toumayeff G. (Linder 1953).

Comment. This species colonizes the western part of the Mediterranean region, reaching Portugal and North Africa (Guignot 1947). In France, it is known only from Languedoc, Roussillon, Provence, and Corsica (Bameul and Queney 2014). In Italy, it is almost totally absent from the northern third of the country (Franciscolo 1979). This species does not exist in Switzerland; the two specimens cited in the literature were in fact a *Bidessus unistriatus* and a *Hydroglyphus geminus*, as mentioned by Carron (2005).

C37) [*Bidessus saucius* (Desbrochers des Loges, 1871)]

Examined material. [3,4,6,8]2 ex., Genève, Rouelbeau, 22.IV., leg. and coll. Maerky C., MHNG.

Published data. [3,4,6,8]2 ex., Rouelbeau, Meinier GE, coll. Maerky C., MHNG (Carron 2005).

Comment. The specimens examined belong to the problematic collection of C. Maerky, which cannot be considered reliable. *Bidessus saucius* does not exist in Switzerland. This species is known only from Corsica in France (Bameul and Queney 2014) and from Italy, where it is absent from the northern third of the country, the nearest occurrences being near Genoa (Franciscolo 1979).

C38) *Boreonectes alpestris* Dutton & Angus, 2007, [*Boreonectes inexpectatus* Dutton & Angus, 2007], and *Boreonectes griseostriatus* (DeGeer, 1774)

Published data. *B. alpestris* – 3 ♂, 2 ♀, Switzerland, Ticino, Above Medeglia, VIII.1994 by Focarile A. (Dutton and Angus 2007); *B. inexpectatus* – [1,4,5,6,7,8]Suisse (Bameul and Queney 2014); *B. griseostriatus* – 1 ♂, Switzerland, Valais, Lake by the Illsee (Angus 2010).

Comment. The very heterogenous genus *Stictotarsus* Zimmermann, 1919 has been shown to be polyphyletic (Ribera 2003) and was problematic for coleopterists (Angus 2010). To solve part of this problem, *Boreonectes* Angus, 2010 was established (Angus 2010), making it possible to exclude certain species from the genus *Stictotarsus*. Dutton and Angus (2007) showed that multiple karyotypic lineages were included under the nomen *griseostriatus*. They described these lineages as new species. Thus, the presence of two species of *Boreonectes* is attested for Switzerland: *B. alpestris* (Ticino) and *B. griseostriatus* (Valais) (Angus 2010), whereas the citation of *B. inexpectatus* in Switzerland (Bameul and Queney 2014) is most probably erroneous, the latter being known only from its type locality in France (Dutton and Angus 2007; Angus 2010). However, as the authors pointed out, most *Boreonectes* are visually impossible to identify without examining karyotypes, so we have decided, from a practical point of view, to assign all the Swiss data to a "*griseostriatus* aggregate".

C39) [*Deronectes fairmairei* (Leprieur, 1876)]

Published data. [3,4,6,7,8]7 ex., Chanzy [W of Lake Geneva, Switzerland], 1890 by de Vauloger, ex coll. R. R. Oberthür, ex Wehncke" (MNHN – Muséum National d'Histoire Naturelle, Paris, France) and [3,4,6,7,8]1 ex., Suisse, Dôle, VII.55 (IRSN – Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium) (Fery and Brancucci 1997).

Comment. This species has a western Mediterranean distribution. It is found in North Africa and along coastal regions from Portugal to western Italy (Liguria – Franciscolo 1979). In France, *D. fairmairei* is only known from the south of the country (Bameul and Queney 2014). The specimens bearing a "Swiss" label have already been considered doubtful by Fery and Brancucci (1997).

C40) *Deronectes moestus inconspectus* (Leprieur, 1876)

Examined material. 2 ex., Mulini di Morbio inferiore, roggia del Breggia, Castello, IV.1911, leg. and coll. Fontana P., MSNL; 1 ex., Chiasso, laghetto [Brogeda], 1914, leg. and coll. Fontana P., MSNL; 2 ex., Genève, Certoux, III.1949, leg. Toumayeff G., MHNG; 5 ex., Russin, Allondon, 6.VIII.1955, 13.VIII.1955, 27.V.1956, leg. Rehfous M., MHNG; 2 ex., Malval, Allondon, 27.VIII.1955, 19.VIII.1956, leg. Rehfous M., MHNG; 1 ex., Suisse, Tessin, s/Sagno, ruisseau, 18.IX.1955, leg. Besuchet C., MZL; 25 ex., Chancy, La Laire, 1.VIII.1956, 5.VIII.1956, 8.VIII.1956, 12.VIII.1956, 6.IX.1956, 27.VII.1957, 3.V.1958, 19.III.1960, leg. Rehfous M., MHNG; 3 ex., Chancy, La Laire, 12.VIII.1956, leg. Rehfous M., coll. Allenspach V., NMB; 2 ex., Genève, Chancy, V.1956, leg. Toumayeff G., MHNG; 3 ex., Genève, Chancy, La Laire, 14.VIII.1985, leg. Besuchet C., MHNG; 1 ex., Veyron VD, [II.2004], leg. Carron G., ETH; 2 ex., Dardagny GE, VIII.2005, leg. Anonymous, ETH; 6 ex., Dardagny GE, 24.VIII.2021, 9.IX.2021, leg. and coll. Cosandey V.; 5 ex., Dardagny GE, 10.IX.2021, leg. and coll. Chittaro Y.; 2 ♂, 21.X.2021, Mendrisio TI, leg. and coll. Cosandey V.

Published data. Breggia nel canale pei mulini [Morbio Inferiore], IV.1911 by Fontana P. (Fontana 1922); Genève by Sharp D. (Guignot 1931–1933); 1 ex., Genf, coll. Müller Cl., Zoologische Staatsmuseum München (Fery and Brancucci 1997); 1 ex., VD, Veyron bei Montricher, II.2004 by Carron G. (Carron 2005).

Comment. The nominal subspecies is a Corso-Sardinian endemic, while the *inconspectus* subspecies is present in continental Europe from Spain to Greece and Morocco (Fery and Brancucci 1997). It is present in a large part of France, mainly in southern regions (Bameul and Queney 2014). Following the Rhône valley, it reaches the Bugey and, in Switzerland, the Geneva region (Guignot 1947), where it is known from a few stations. It also exists in southern Ticino, where it is present in continuity with the Italian populations.

C41) [*Deronectes opatrinus* (Germar, 1823)]

Published data. 1,8)Genève (Guignot 1931–1933); 3,4,6,7,8)2 ex., Chanzy [Chancy – W of Lake Geneva, Switzerland], 1890 by de Vauloger (MNHN – Muséum national d'Histoire naturelle, Paris, France) (Fery and Brancucci 1997); 1)4 ex., Genève by Tournier H. (Carron 2005).

Comment. This meridional species is reported from Spain, Portugal, and southwestern France (Fery and Brancucci 1997). In the latter country, *D. opatrinus* reaches as far north as the Haute-Vienne region (Fery and Brancucci 1997; Bameul and Queney 2014). The specimens from the Vauloger collection are labeled with the same locality as *D. fairmairei*. They were examined by Fery and Brancucci (1997), who questioned the validity of these records. The four specimens mentioned by Carron (2005) could not be found in the MHNG collections where they were supposed to be, nor in the MHNP where most of the Tournier collection is deposited. Based on all these elements, *D. opatrinus* is not considered to be part of the Swiss fauna.

C42) [*Deronectes platynotus platynotus* (Germar, 1834)]

Published data. 2)Dussnang by Eugster A. (Hugentobler 1966).

Comment. Revision of the Hugentobler collection has revealed that the published Swiss occurrence (Hugentobler 1966) relates to a misidentified specimen of *D. aubei* (see also comment C43 for *D. semirufus*). According to Fery and Brancucci (1997), this species has a distribution restricted to central Europe; its range extends from the Netherlands and Belgium to Poland, Serbia, Romania, Bosnia, and Albania. It is not present in France according to Guignot (1947), but Bameul and Queney (2014) mention it from the Ardennes in the northwest of the country. *Deronectes platynotus* is known from Vorarlberg in the Pfänderstock (Brandtstetter and Kapp 1998), some 15 km from Switzerland, and from southern Germany (Köhler and Klaunitzer 1998), near Schaffhausen (Bleich et al. 2016). This species is potentially present in Switzerland, but this needs to be confirmed.

C43) [*Deronectes semirufus* (Germar, 1844)]

Published data. 2)Dusnang by Eugster A. (Stierlin 1883); 1)Schwarzwald (? Suisse) (Stierlin 1900); 2)1 ex., in der Breggia bei Chiasso, V.1943 by Pochon H. and 2)1 ex., Clarens bei Montreux, V.1944 by v. Peez (Linder 1946).

Comment. *Deronectes semirufus* has recently been rehabilitated as a distinct species from *D. aubei* (Fery and Brancucci 1997). It is known only from Italy, south from the Pô plain, and from France (Fery and Brancucci 1997), where it reaches the Alpes-Maritimes and the Alps of Haute-Provence (Bameul and Queney 2014). Some literature citations of *D. semirufus* from Switzerland refer to *D. aubei* (Stierlin 1883; Linder 1946), as already assumed by Carron (2005). Curiously, the specimen cited from Dusnang (or Dussnang) was published under two nomina, *D. platynotus* and *D. semirufus* (see also comment C42 for *D. platynotus*).

C44) *Nebrioporus assimilis* (Paykull, 1798)

Examined material. 3,4,6)1 ex., Kt. Basel, leg. Täschler M., coll. Linder A., ETH; 3,4,6)1 ex., Suisse, leg. Anonymous, coll. Maerky C., MHNG; 3,4,6)2 ex., Suisse, Vaud, leg. Sechehaye A., coll. Maerky C., MHNG; 3,4,6)2 ex., Genève, Veyrier, leg. Sechehaye A., coll. Maerky C., MHNG; 3,4,6)7 ex., Alpes, Chanrion, 2.VIII, leg. and coll. Maerky C., MHNG; 2 ex., Kt. Bern, Brienz, VI.1909, coll. Linder A., ETH; 12 ex., [Filzbach Talsee] PLOCH GL18, 26.VIII.1998, leg. Carron G. and Oertli B., LEBA and ETH; 10 ex., Glarus Nord GL, 20.VI.2023, leg. and coll. Chittaro Y.

Published data. 1)Matt,Wiedersteinerloch by Heer O. (Heer 1837); 1)Ct. Glarus, auf der Mühlebachalp (Heer 1841); 1)Niederschwerzenbach, 28.VIII.1864 by Frei (Dietrich 1865); 1)Aarau by Frey-Gessner E., 1)Basel by Imhoff L., 1)Engadin by Stierlin G., 1)Kt. Zürich by Dietrich K., 1)Lausanne by Bugnion E. and de Gautard V. and 1)Visp by Venetz I. (Stierlin and Gautard 1867); 1)Flimser See by Killias E. and 1)St. Moritzer See by Pfeil (Caflisch 1894).

Comment. This species is distributed in central and northern Europe, as well as in Siberia. In Switzerland, its presence is only attested by a few records in the Alps, in the cantons of Glarus and Bern, where this species reaches the southern limit of its distribution (Nilsson and Holmen 1995). *Nebrioporus assimilis* also occurs in southern Germany (Köhler and Klausnitzer 1998; Bleich et al. 2016), in Alsace (Callot 1990, 2018), in the French Hautes-Vosges (Guignot 1947), and has been cited twice in Vorarlberg in Austria, near the Rhine (Brandstetter and Kapp 1995). Supplementary populations may therefore be found in northern Switzerland.

C45) *Nebrioporus canaliculatus* (Lacordaire, 1835)

Examined material. 1 ex., Genève, Laconnex, VIII.1983, leg. Agroscope - RAC, Changins, MHNG; 1 ex., Genève, Les Baillets, Allondon, 27.IX.1990, leg. Besuchet C., MHNG.

Published data. CH (Carron 2005).

Comment. This species occurs mainly in western and central Europe, from Portugal to Greece, and along the coast as far as the Netherlands and southern Sweden (Nilsson and Holmen 1995). In Switzerland, only two occurrences in the canton of Geneva attest of the marginal presence of this species in the country. In France, it occurs mainly in the southern half of the country (Bameul and Queney 2014) but is also present in Alsace, where it can be abundant in gravel and sand quarries without vegetation (Callot 1990, 2018). It is also present in southern Germany (Köhler and Klausnitzer 1998), and along the Rhine (Bleich et al. 2016), which means that this species could also be present in northern Switzerland.

C46) [*Nebrioporus depressus* (Fabricius, 1775)]

Published data. [1)]Lac de Joux by Mellet L. (Heer 1837); [1)]Kt. Zürich by Dietrich K., [1)]Luzerner See by Pfeil, [1)]Schaffhausen, in Quellwasser by Stierlin G. and [1)]Wallis by Venetz I. (Stierlin and Gautard 1867); [1)]Dättlikon and Glatthal by Dietrich K. (Stierlin 1883); [2)]Pont de Dorénaz, 29.IV.1890 by Favre E. (Favre 1890); [1)]Caumasee by Jörger J.B. (Linder 1967); [1)]Aare bei Villnachern, 1985 by Sauter W. (Meier et al. 1989); [1)]UR, Seedorf, Ufer des Urner Sees, 11.IX.1990 by Uhlig M. (Uhlig and Uhlig 2006).

Comment. Mainly distributed in northern and eastern Europe, *N. depressus* does not belong to the Swiss fauna (see Caron (2005)); there are only a few citations in the literature, without reference specimens, or they were misidentified specimens, as in the case of the record of Favre (1890), which turned out to be a *N. elegans*.

C47) [*Oreodytes alpinus* (Paykull, 1798)]

Examined material. [3,4,6,8)]2 ex., Suisse, leg. Anonymous, coll. Maerky C., MHNG.

Published data. [1)]in der Töss am Fuss der Straleck by Heer O. (Dietrich 1865); [1)]Engadin by Heer O., [1)]Genf by Heer O., [1)]La London by de Bonvouloir H. A., [1)]Lausanne am Seeufer by Bugnion E., [1)]Rheinwald by Heer O., [1)]Schaffhausen by Heer O. and [1)]Schwarzsee bei Zermatt by de Gautard V. (Stierlin and Gautard 1867); [1)]1 ex., Saint-Bernard and [1)]2 ex., Suisse, coll. Maerky C., MHNG (Carron 2005).

Comment. *Oreodytes alpinus* is distributed in the northern Palaearctic (in Scotland, Fennoscandia, and northwest Siberia (Nilsson and Holmen 1995)) but is not present in the Alps. A few specimens are labeled as Swiss but, as they originate from the collection of C. Maerky, they must be regarded as doubtful. The occurrences in the literature probably concern *O. davisii*.

C48) [*Hydroporus dorsalis* (Fabricius, 1787)]

Published data. [2)]Basel by Bischoff-Ehinger A. and [1)] Vevey by de Gautard V. (Stierlin and Gautard 1867); [2)] Frauenfeld, Osterhalden [Osterhalde], VIII.1954 by Hugentobler H. (Hugentobler 1966); [1)]Grangettes, 1900 (Naceur 1997).

Comment. Recently, Bergsten et al. (2012) rehabilitated *Hydroporus figuratus*, a former synonym of *H. dorsalis*. Examination of all the "*Hydroporus dorsalis*" contained in Swiss collections revealed that all were in fact *H. figuratus*. Further, all the data in the literature probably also refer to *H. figuratus* (see also comment C50 for *H. figuratus*). As far as we know, *H. dorsalis* does not occur in Switzerland. However, its range is vast and could include Switzerland; *H. dorsalis* is potentially a resident.

C49) [*Hydroporus elongatulus* Sturm, 1835]

Examined material. [3,4,6)]1 ex., Genève, Bellerive, 3.VI., leg. and coll. Maerky C., MHNG.

Published data. [1)][Schweiz] by Stierlin G. (Bremi-Wolf 1856); [1)]Schaffhausen by Stierlin G. (Stierlin and Gautard 1867).

Comment. This species is distributed from central and northern Europe to Siberia (Guignot 1947). It is rare throughout its range (Guignot 1947; Nilsson and Holmen 1995; Bameul and Queney 2014). *Hydroporus elongatulus* is not included in the Swiss list because all the specimens labelled as Swiss come from Charles Maerky's problematic collection. However, its presence in Switzerland remains possible as it occurs in southern Germany in Bavaria and Württemberg (Köhler and Klausnitzer 1998), with its nearest populations located at about 20 km from Lake Constance (Bleich et al. 2016).

C50) *Hydroporus figuratus* (Gyllenhal, 1826)

Examined material. [3,4,6)]2 ex., Basel, leg. Anonymous, NMB; [3,4,6)]4 ex., Peney, 16.VI., leg. Anonymous, coll. Maerky C., MHNG; [3,4,6)]1 ex., Schweiz, leg. and coll. Staehlin-Bischoff, NMB; [3,4,6)]2 ex., Suisse, leg. Anonymous, coll. Maerky C., MHNG; [3,4,6)]1 ex., Villeneuve, 20.VI., leg. Anonymous, coll. Maerky C., MHNG; 2 ex., Stein a. Rhein [Stein am Rhein], Staffel, 19.III.1879, 24.IV.1884, leg. Böschenstein A., NMSH; [3,4,6)]1 ex., Wallis, 1903, leg. de Brenzinger, MHNG; 1 ex., Vevey, 10.V.1904, leg. and coll. Gaud A., MZL; 1 ex., Frauenfeld, Osterhalden, Winkel (Riet), 27.VIII.1954, leg. and coll. Hugentobler H., NMTG; 12 ex., Kt. Thurgau, Frauenfeld, VIII.1954, VII.1955, VIII.1955, leg. and coll. Linder A., ETH; 7 ex., TG, Frauenfeld, IX.1956, leg. and coll. Linder A., ETH, MHNG and NMB; 1 ex., Frauenfeld, Osterhalden, 17.IX.1956, leg. and coll. Hugentobler H., NMTG; 11 ex., Kt. Thurgau, Frauenfeld, VI.1967, leg. Linder A., coll. Allenspach V., Linder A., coll. Scherler P., MHNG, NMB and NMBE; 3 ex., Frauenfeld, leg. Linder A., NMBE; 5 ex., Frauenfeld, 15.IV.1969, leg. Linder A., coll. Kiener S. and Spälti A., MHNG; 5 ex., Kt. Thurgau, Frauenfeld, VIII.1970, leg. Linder A., coll. Ochs W. and coll. Kiener S., MHNG and NMBE; 5 ex., Schaffhausen SH, 3.V.2023, 12.IX.2023, leg. and coll. Chittaro Y., Cosandey V. and Sanchez A.

Comment. Recently, Bergsten et al. (2012) removed *Hydroporus figuratus* from the list of synonyms of *H. dorsalis*, considering both species valid. This species is widely distributed in the Western Palearctic but is absent from the Balcanic, Iberic, and Italian peninsulas (Bergsten et al. 2012). In Switzerland, the species is very rare and almost all records are from the northeast of the country. After more than 50 years without any occurrence, it was rediscovered in 2023 in a small forest marsh in the canton of Schaffhausen.

C51) [*Hydroporus geniculatus* C.G. Thomson, 1856]

Published data. [1)]Forêt d'Aletsch by Bugnion E. (Favre 1890).

Comment. *Hydroporus geniculatus* is a Holarctic species reaching Denmark in the south of its distribution (Nilsson and Holmen 1995). Carron (2005) indicated that the specimens cited by Favre (1890) were misidentified *H. nigellus*; unfortunately, these specimens were not found in the MZL collection where they are supposed to be deposited.

C52) [*Hydroporus gyllenhalii* Schiødte, 1841]

Examined material. [3,4,6)]1 ex., Basel, leg. Anonymous, coll. Linder A., ETH.

Published data. [1)]Engadin by von Heyden L. (Stierlin and Gautard 1867); [1)]Basel by Knecht (Stierlin 1883); [3,4,6)]2 ex., Basel by Linder, ETH (Carron 2005).

Comment. Only one specimen with imprecise labeling (no date and imprecise locality) is known from Switzerland. This specimen is deposited in the Linder collection but was not collected by him. The other citations in the literature are very old and unverifiable. Like Carron (2005), we consider this information as insufficient to include *H. gyllenhalii* in the Swiss fauna. This species is distributed in central and northern Europe. It is locally abundant in Alsace (Callot 1990, 2018) and is known a few kilometers from the Swiss border in the Vorarlberg in Austria (Brandstetter and Kapp 1995). It is also present in southern Germany (Köhler and Klausnitzer 1998), close to the Swiss border (Bleich et al. 2016). The presence of this species in Switzerland remains therefore possible but needs to be confirmed.

C53) *Hydroporus kraatzii* Schaum, 1867

Examined material. 3 ex., Scarl, 6.VIII.1918, leg. and coll. Handschin E., BNM; 2 ex., Suisse, Valais, Praz de Fort, 9.VI.1976, 26.VII.1989, leg. Besuchet C., MHNG; 1 ex., Le Mazé, Les Mouilles, 29.V.1977, leg. Matthey W., MHNN; 1 ex., Helv., Kt. Bern, Napf, 9.V.1979, leg. Kiener S., MHNG; 1 ex., Bedretto TI, 4.VIII.2004, leg. Carron G., ETH; 14 ex., Bedretto TI, 16.VII.2005, leg. Carron G., ETH; 1 ex., Saanen BE, 29.VII.2017, leg. and coll. Cosandey V.; 1 ♀, 2 ♂, Diemtigen BE, 1.VII.2021, 9.IX.2021, leg. Wüthrich R.; 5 ex., Trient VS, 29.VI.2022, leg. and coll. Cosandey V.

Published data. [1)]Engadine, Pontresina, dans l'Inn, [1)]Alpes bernoises, Petite Scheidegg and [1)]Alpes bernoises, Wengernalp (Guignot 1931–1933); [2)]1 ex., GR, Col de la Flüela, 2400 m, 16.VII.1976 by Scherler P. and [2)]1 ex., VS, Val Ferret, Lacs de Fenêtre, 5.VIII.1957 by Scherler P. (Brancucci 1979b); 1 ex., Buffalora Alm (Graubünden), Nähe Ofenpass, 1983, by Schaeflein H. (Schaeflein 1989).

Comment. This species occurs very locally in the mountainous regions of Europe, from the French Alps (Haute-Savoie and Isère according to Guignot (1947) and Bameul and Queney (2014)) to Bulgaria and Poland. In Switzerland, it is known from a dozen localities scattered throughout the Alps. As mentioned by Carron (2005), the individuals cited by Brancucci (1979c) are misidentified *H. longulus*. *Hydroporus kraatzi* has a semi-subterranean ecology, which probably explains, at least partially, the rarity of its observations (Fery 2009).

C54) *Hydroporus longicornis* Sharp, 1871

Examined material. 2 ex., VD, Pramagnon, V.1964, leg. Toumayeff G., MHNG; 1 ex., Kt. Bern, Reutigen, VII.1967, leg. and coll. Linder A., ETH; 1 ex., VD, Grangettes, V.1972, leg. Toumayeff G., MHNG; 2 ex., Vaud, Prévondavaux, 2.V.1974, leg. Comellini A., MHNG; 1 ex., Vaud, La Rippe, 4.IV.1976, leg. Comellini A., MHNG; 1 ex., Helvetia, VD, St. Tryphon, Les Iles, 5.X.1978, leg. Sekaly V., coll. Scherler P., NMBE; 1 ♂, Riggisberg BE, 12.VII.2021, leg. and coll. Cosandey V.; 1 ex., Trélex VD, 17.IV.2022, leg. and coll. Cosandey V.

Published data. Les Grangettes, leg. Tourmojew [Toumayeff G.] and 6 ex., St-Tryphon, Les Iles, 5.X.1978 by Sekaly V. (Brancucci 1979c); [1)]Umbrail-Pass in Graubünden, 2200 m, 13.VII.1978 by Rössler G., det. Schaeflein H. (Schaeflein 1983); 1 ex., Trélex VD, 2022, by Cosandey V. (Pétremand et al. 2023).

Comment. This semi-subterranean species is very discreet and colonizes springs and small water resurgences (Nilsson and Holmen 1995; Carron 2005). It is known from a very limited number of occurrences in Switzerland, mainly at the foot of the Jura (Pétremand et al. 2023). The alpine specimens cited by Schaeflein (1983) could refer to other species of black *Hydroporus* from high altitudes. This species is more widely distributed in the Palaearctic region than *H. kraatzi*, which has a similar ecology.

C55) [*Hydroporus morio* Aubé, 1838]

Published data. [1)]Bergliseeli by Heer O., [1)]Klausenpass by Heer O. and [1)]Prünellalp im Engadin [Piz Prünella] by Heer O. (Heer 1837); [1)]Bodensee by Täschler M. and [1)]St. Gallen by Täschler M. (Täschler 1872); [1)]Il Fuorn, 17.IX.1934 by Nadig A. (Handschin 1963); [1)]La Vraconnaz, 1985 by Mulhauser G. (Mulhauser et al. 1987).

Comment. This species is distributed in the north of the Holarctic region. No Swiss specimen has been found in the examined collections. The occurrences in the literature probably concern other *Hydroporus* species, in particular *H. melanarius* with which a taxonomic confusion has arisen (see Carron 2005). The presence of *H. morio* remains possible in Switzerland, however, as it is present in southern Germany in the Land Bayern (Köhler and Klausnitzer 1998) even though the nearest locality is more than 100 km from the Swiss border (Bleich et al. 2016).

C56) [*Hydroporus notatus* Sturm, 1835]

Published data. [1)]Tourbière du Cachot by Matthey W. (Matthey 1971); [1)]La Vraconnaz, 1985 by Mulhauser G. (Mulhauser et al. 1987).

Comment. This Euro-Siberian species colonizes northern Europe from France to Siberia (Guignot 1947; Nilsson and Holmen 1995). In France, it is cited in the north and east of the country (Guignot 1947; Bameul and Queney 2014) but is not known in Alsace (Callot 2018). In southern Germany, the nearest population is located in the Land Bayern (Köhler and Klausnitzer 1998), more than 200 km away from the Swiss border (Bleich et al. 2016). In Switzerland, no specimens attest its presence in the country. The literature occurrences could not be verified but certainly concern related species. Curiously, the species was not discussed by Carron (2005).

C57) [*Hydroporus obsoletus* Aubé, 1838]

Examined material. [3,4,6,8)]1 ex., Basel, leg. Anonymous, NMB.

Published data. [1)]Basel in einem kleinen Bach im Frühjahr by Bischoff-Ehinger A. (Stierlin and Gautard 1867); [1)]Bois de Chênes, Ferreyres-Moiry by Scherler P. (Scherler et al. 1989).

Comment. According to Guignot (1947), this species colonizes the sublittoral regions of Western Europe, from Norway to Spain and Portugal, via Italy and North Africa. In Germany, the nearest populations are located at more than 200 km from the Swiss border (Bleich et al. 2016). In France, it is only known from the south of the country and in Corsica (Bameul and Queney 2014). In Italy, it is also known from the southern part of the country (Franciscolo 1979). Only one specimen with imprecise labeling (no date and imprecise locality) is known from Switzerland. It should therefore be disregarded. The published occurrences probably concern other misidentified *Hydroporus* species (Carron 2005), as is the case for the Scherler et al. (1989) citation, which probably concerns a misidentified *H. discretus*. *Hydroporus obsoletus* does not belong to the Swiss fauna.

C58) *Hydroporus scalesianus* Stephens, 1828

Examined material. 3 ex., Pfäffikon ZH, 8.IX.2008, leg. Carron G., ETH; 10 ex., Zürich ZH, 7.V.2024, leg. and coll. Chittaro Y., Cosandey V. and Sanchez A.

Published data. Auslikerriet, Pfäffikon, 8.IX.2008 by Carron G. (Carron 2009).

Comment. This species is distributed from France (northern half, center, and southwest, according to Bameul and Queney [2014]) to Great Britain. It was also recorded in northern Italy (Franciscolo 1979), the Czech Republic, and Russia (Nilsson and Holmen 1995). In Switzerland, it has only been found twice in two marshes near Zurich. As this species is known from Vorarlberg in Austria, near the mouth of the Rhine in Lake Constance (Brandstetter and Kapp 1995), as well as in southern Germany (Köhler and Klausnitzer 1998; Bleich et al. 2016), it should be found in other localities of northeastern Switzerland.

C59) [*Hydroporus striola* (Gyllenhal, 1826)]

Published data. [1)]Econaz by Favre E. and [1)]Guercet près Martigny by Favre E. (Favre 1890); [2)]3 ex., bei Leuk, VI.1942 by Linder A. (Linder 1946); [2)]Scuol, 1.VIII.1946 by Linder A. (Handschin 1963); [2)]Egnach, Schilfboden gegen Salmsach, X.1962 by Hugentobler H. and [1)]St. Gallen by Täschler M. (Hugentobler 1966).

Comment. This Holarctic species is distributed in northern and central Europe and reaches as far east as Sibiria. All specimens labeled as *H. striola* in Swiss collections were misidentified and referred to other species (Carron 2005). All the data in the literature probably also concern misidentified specimens, as in the case of the specimens from Leuk (Linder 1946) and Scuol (Handschin 1963), which are in fact *H. incognitus* and the one from Egnach (Hugentobler 1966), which was *H. palustris*. This species is not considered part of the Swiss fauna but could be present in the country, as indicated by localities in Alsace (Callot 1990, 2018), and in Vorarlberg a few kilometers from the border (Brandstetter and Kapp 1995), as well as in southern Germany (Köhler and Klausnitzer 1998; Bleich et al. 2016).

C60) [*Hydroporus tessellatus* (Drapiez, 1819)]

Published data. [2)]Laghetto Chiasso by Fontana P. (Fontana 1922).

Comment. The published occurrence concerned a misidentified *H. marginatus* (Carron 2005). This species occurs throughout France but is more common in the Mediterranean region (Guignot 1947; Bameul and Queney 2014). As it is widely distributed in Italy (Franciscolo 1979), its presence in southern Ticino cannot be ruled out but needs to be confirmed.

C61) [*Graptodytes flavipes* (Olivier, 1795)]

Examined material. [3,4,6,8)]1 ex., Aarau, leg. Anonymous, NMAA; [3,4,6,8)]3 ex., Suisse, Argovie, leg. Anonymous, coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Bern, leg. Anonymous, ETH; [3,4,6,8)]3 ex., Genf, leg. and coll. Lasserre H., ETH; [3,4,6,8)]2 ex., Kt. Wallis, leg. Täschler M., coll. Linder A., ETH; [3,4,6,8)]2 ex., Martigny, leg. Favre E., HGSB; [3,4,6,8)]2 ex., Suisse, Valais, leg. Anonymous, coll. Maerky C., MHNG; [3,4,6,8)]6 ex., Valais, 7.IV.1904, leg. and coll. Gaud A., MZL.

Published data. [1)]Bern by von Ougspurger F. P., [1)]Genf by Lasserre H. and [1)]Zürich by Heer O. (Heer 1837); [1)]Wallis by Venetz I. (Stierlin and Gautard 1867); [3,4,6,8)]Martigny by Favre E. (Favre 1890); [1)]Yvonand-Estavayer-le-lac, Grande Cariçaie, 1995 by Badstuber A. (Mulhauser 1997); [1)]Grangettes,1992 (Naceur 1997).

Comment. This species is mainly distributed in the Mediterranean region. In France, it is present in coastal areas and is rarely found elsewhere (Bameul and Queney 2014). It reaches the Netherlands and Great Britain along the coast. Unlike Carron (2005), who considered this species indigenous (probably on the basis of the specimen from Martigny), we do not consider it to be Swiss on the basis of the information available; all the individuals examined come from problematic collections whereas the literature occurrences cannot be verified. In Germany, the species is also no longer considered indigenous; although there are some records from the nineteenth century, these have not since been confirmed, and the species is not included in the latest German red list (Spitzenberg et al. 2016).

C62) [*Graptodytes ignotus* (Mulsant & Rey, 1861)]

Examined material. [3,4,6,8)]2 ex., Kt. Bern, leg. Täschler M., coll. Linder A., ETH.

Published data. [3,4,6,8)]2 ex., Kt. Bern by Täschler M., ETH (Carron 2005).

Comment. This meridional species is distributed in the western Mediterranean region of Europe and North Africa (Guignot 1947). It reaches as far north the Lyon region in France (Bameul and Queney 2014) and Piedmont and Liguria in Italy (Franciscolo 1979). *Graptodytes ignotus* is not retained as part of the Swiss fauna because the specimens labeled as “Swiss” are associated with the problematic collector M. Täschler (see Monnerat et al. 2015).

C63) [*Graptodytes varius* (Aubé, 1838)]

Published data. [1)]Bern by von Ougspurger F. P. (Heer 1837); [1)]Bord du Rhône à Aigle by Jaccard H. (Favre 1890).

Comment. While distributed in southern Europe and North Africa, this species is absent from Germany (Köhler and Klausnitzer 1998). In France, it is restricted to the south of the country and Corsica (Guignot 1947; Bameul and Queney 2014), as it is in Italy (Franciscolo 1979). According to Carron (2005), the Jaccard collection has been lost, so citations in the literature remains unverifiable. This species does not belong to the Swiss fauna.

C64) [*Metaporus meridionalis* (Aubé, 1838)]

Published data. [1)]4 ex., Genf by Tournier H. (Carron 2005).

Comment. This species has a western mediterranean distribution (Toledo and Hosseinie 2003). It is known from North Africa, the Iberian Peninsula, southwestern France (Bameul and Queney 2014), and northeastern Italy (Franciscolo 1979), as well as Corsica, Sardinia, and Sicilia. The specimens cited by Carron (2005), which should be deposited in the MHNG collection, could not be found again. In any case, *Metaporus meridionalis* does not belong to the Swiss fauna.

C65) *Rhithrodytes crux* (Fabricius, 1792)

Examined material. 10 ex., TI, Indemini, Laveree, VII.1971, leg. Toumayeff G., MHNG; 6 ex., Indemini, 20.VIII.1971, leg. and coll. Scherler P., NMBE; 1 ex., Suisse, Vaud, Arzier, ruisseau, 28.VIII.1994, leg. Besuchet C., MHNG.

Published data. Indemini, VII.1971 by Toumayeff G. (Allenspach 1978); 1 ex., Arzier VD, 28.VIII.1994 by Besuchet C., MHNG (Carron 2005).

Comment. This rare species is only known from Italy, France, and Switzerland. In Switzerland, *R. crux* is known from two distant localities, one in Ticino and the other in the canton of Vaud. This species colonizes torrents and streams in limestone regions. In France, it is known from Haute-Savoie and the southeast of the country (Bameul and Queney 2014), while it is mentioned in northwest Italy (Franciscolo 1979).

C66) [*Stictonectes lepidus* (Olivier, 1795)]

Examined material. [3,4,6,8)]2 ex., Genève, leg. Anonymous, MHNG.

Published data. [3,4,6,8)]2 ex., Genève, [1,8)]2 ex., Genève by Tournier H., MHNG and [1,8)]1 ex., Yverdon VD, Moor am Seeufer, 1953 by Besuchet C., MZL (Carron 2005).

Comment. According to Guignot (1947), this is a western European species, distributed from Portugal to the British Isles and as far west as Germany. In France, Guignot (1947) and Bameul and Queney (2014) mention its presence over almost the entire country but indicate that it is absent from the Paris region and the northern and eastern regions. In Italy, it is not considered indigenous (Franciscolo 1979). In Germany, there are two reliable records of the species (Schlaeflein 1989; Bleich et al. 2016), but the species is not considered established and is therefore not assessed in the latest national red list (Spitzneberg et al. 2016). We also believe that the species is not established in Switzerland either. In Switzerland, Carron (2005) claims to have seen a specimen from Yverdon collected by C. Besuchet. However, this individual could not be found in the collections consulted. If this specimen shows up again, it would have to be regarded as erratic; this region was very well prospected in the last decades and the species was never found again.

C67) [*Hydrovatus clypealis* Sharp, 1876]

Published data. [1,8)]Basel and [1,8)]Katzensee (Stierlin 1900).

Comment. As already mentioned by Carron (2005), no specimen of *H. clypealis* was collected in Switzerland and the species can therefore not be considered indigenous. This species mainly colonizes the coastal areas of the British Isles, the Iberian Peninsula, Italy, the Balkans, and North Africa. In France, this sporadic species is known by sparse occurrences, mostly situated on the littoral and sublittoral areas (Guignot 1947; Bameul and Queney 2014), like in Italy, where its septentrional limit is situated at more than 100 km from the Swiss border (Franciscolo 1979).

C68) *Hygrotus* (*Coelambus*) *confluens* (Fabricius, 1787)

Examined material. [3,4,6]1 ex., Genève, Aïre, leg. and coll. Maerky C., MHNG; [3,4,6]2 ex., Genève, Cointrin, leg. Preudhomme de Borre C. F. P. A., coll. Maerky C., MHNG; [3]1 ex., Genève, leg. Anonymous, MHNG; [3,4,6]2 ex., Pomy, leg. Täschler M., coll. Spälti A., MHNG; [3,4,6]1 ex., Suisse, leg. Anonymous, MHNG; [3,4,6]1 ex., Suisse, leg. Anonymous, coll. Maerky C., MHNG; [3,4,6]3 ex., Suisse, Vaud, leg. Preudhomme de Borre C. F. P. A., coll. Maerky C., MHNG; [3,4,6]1 ex., Rouelbeau, 22.IV., leg. and coll. Maerky C., MHNG; [3,4,6]5 ex., Genève, Villette, 1.VI., 6.VI., 18.VI., leg. and coll. Maerky C., MHNG; [3,4,6]1 ex., Genève, Rouelbeau, 26.IV., leg. and coll. Maerky C., MHNG; [3,4,6]1 ex., Genève, Sionnet, 5.V., leg. and coll. Maerky C., MHNG; [3,4,6]1 ex., Genève, Sierne, 9.V., leg. and coll. Maerky C., MHNG; [3,4,6]4 ex., Villette, 1.VII., leg. and coll. Maerky C., MHNG; 1 ex., Lac de Joux, IX.1909, leg. and coll. Gaud A., MZL; 3 ex., Helvetia, BE, Liesberg, 6.VI.1976, leg. Brancucci M., NMB; 1 ex., Kt. Bern, Bern, IV.1977, leg. and coll. Linder A., ETH; 4 ex., Helv., Kt. Bern, Burgäschisee, 11.III.1978, leg. Kiener S., MHNG; 1 ex., Helv., Kt. Bern, Burgäschisee, 9.VIII.1979, leg. Kiener S., MHNG; 1 ex., VD, Bioley-Orjulaz, VII.1983, leg. Toumayeff G., MHNG; 5 ex., VD, Bioley O[rjulaz]., L. Coffy, VIII.1983, leg. Toumayeff G., MHNG; 1 ex., VD, Bavois, Bernoise, IX.1984, leg. Toumayeff G., MHNG; 1 ex., VD, Bavois, Bernoise, X.1984, leg. Toumayeff G., MHNG.

Published data. [1]Bern by von Ougspurger F. P., Lac de Joux by Mellet L. and [1]Pomy by Mellet L. (Heer 1837).

Comment. This species is widespread in the Palaearctic region but sporadic in Switzerland as well as in surrounding regions (Franciscolo 1979; Callot 1990; Brandstetter and Kapp 1995; Bameul and Queney 2014; Bleich et al. 2016). It was last found in Switzerland in 1984.

C69) [*Hygrotus* (*Coelambus*) *parallelogrammus* (Ahrens, 1812)]

Examined material. [3,4,6]1 ex., Suisse, Aarberg, leg. and coll. Maerky C., MHNG; [3,4,6]2 ex., Genf, leg. Täschler M., coll. Spälti A., MHNG; [3,4,6]2 ex., Suisse, Regensdorf, 14.VI, leg. and coll. Maerky C., MHNG; [3,4,6]1 ex., Genève, 24.XII.1904, leg. Gaud A., MZL.

Published data. [1]Genf (Heer 1841); Zürich by Isenschmid M. (Stierlin 1883); [1]Gegend von Schaffhausen by Stierlin G. (Stierlin 1900); [3,4,6]1 ex., Genf, 24.XII.1904 by Gaud A., MZL, [3,4,6]2 ex., Genf and [3,4,6]2 ex., Regensdorf ZH by Maerky C., MHNG (Carron 2005).

Comment. The few individuals labeled as "Swiss" all come from problematic collections and cannot therefore be considered reliable, while the data in the literature are impossible to verify. This species does not belong to the Swiss fauna, contrary to the opinion of Carron (2005). Although this species is widely distributed in the Palaearctic region (from Spain to eastern Siberia), it is absent from regions close to Switzerland. For example, it is not known in Alsace (Callot 2018), while the nearest populations in Germany are located at more than 150 km from the Swiss border (Bleich et al. 2016). Generally, in Italy as in France, this species is found mainly in coastal areas (Franciscolo 1979; Bameul and Queney 2014).

C70) *Hygrotus* (*Hygrotus*) *quinquelineatus* (Zetterstedt, 1828)

Examined material. 1 ex., SO, Seewen, VII.1956, leg. Toumayeff G., MHNG; 1 ex., Altenrhein, 21.V.1967, leg. Hugentobler H., NMSG; 1 ex., Suisse, St. Gall, Altenrhein, marais, 6.VI.1976, leg. Besuchet C., MHNG; 1 ex., Leuggern AG, 26.V.2004, leg. Lubini V., ETH; 1 ex., Stein am Rhein SH, 12.X.2004, leg. Lubini V., ETH.

Published data. 1 ex., Altenrhein, IV.1961 by Linder A. and 1 ex., Seewen SO, im Bassin des Elektrizitätswerkes, 12.VII.1957 by Toumayeff G. (Allenspach 1978).

Comment. This species is distributed throughout the northern Palaearctic region. It is considered part of the Swiss fauna based on only five captures, all made in the northeast of the country, mainly near Lake Constance. It could be present more widely in northern Switzerland as it is well distributed in Alsace (Callot 1990, 2018), in Vorarlberg near the mouth of the Rhine (Brandstetter and Kapp 1995), and in Baden north of Lake Constance as well as along the Rhine north of Basel (Köhler and Klausnitzer 1998; Bleich et al. 2016).

C71) [*Hyphydrus aubei* Ganglbauer, 1891]

Examined material. [3,4,6,8]1 ex., Genève, leg. Anonymous, MHNG; [3,4,6,8]1 ex., Schaff-hsn. [Schaffhausen], leg. and coll. Burghold W., NMBE.

Published data. [3,4,6,8]1 ex., Schaffhausen, 1978, coll. Burghold W., NMBE and [3,4,6,8]1 ex., Genf, MHNG (Carron 2005).

Comment. The two specimens examined are too incompletely labeled to allow this southern species to be considered part of the Swiss fauna. Moreover, these two localities are hardly credible if we consider that *H. aubei* is absent from adjacent regions. In France, it is only present in the west of the country and in the southern half (Bameul and Queney 2014) and is not recorded for Alsace (Callot 2018), the occurrences being based on a problematic collection. It is also absent from Germany (Bleich et al. 2016). In Italy, its nearest populations are located at more than 100 km from the Swiss border (Franciscolo 1979). Contrary to the opinion of Carron (2005), we do not include this species in the Swiss list.

C72) [*Aulonogyrus* (*Aulonogyrus*) *striatus* (Fabricius, 1792)]

Examined material. [3,4,6,8]1 ex., Crevin, coll. Maerky C., MHNG; [3,4,6,8]1 ex., Plan les Ouates, coll. Maerky C., MHNG; [3,4,6,8]1 ex., Sionnet, coll. Maerky C., MHNG; [3,4,6,8]2 ex., Pl. les-Ouates, Genève, 11.IV., coll. Maerky C., MHNG;

3,4,6,8)1 ex., Sionnet, 16.V., coll. Maerky C., MHNG; 3,4,6,8)1 ex., Jura, Gimel, 10.VI., coll. Maerky C., MHNG; 3,4,6,8)1 ex., Carouge, 11.VI., coll. Maerky C., MHNG; 3,4,6,8)1 ex., Alpes, Lavey, 12.VI., coll. Maerky C., MHNG; 3,4,6,8)1 ex., Jura, Gimel, 6.VII., leg. Maerky C., MHNG; 3,4,6,8)1 ex., Suisse, Regensdorf, 14.VII., coll. Maerky C., MHNG; 3,4,6,8)1 ex., Sionnet, 20.VII., coll. Maerky C., MHNG.

Published data. 1)CH [Switzerland] (Brancucci 1994).

Comment. This species is distributed in the Mediterranean region in Europe, North Africa, and Asia (Hájek and Fery 2017). In Italy, its nearest populations are located more than 200 km from the Swiss border (region of San Remo) (Fanciscolo 1979). All the specimens examined come from the problematic collection of C. Maerky, which should not be considered. Consequently, *Aulonogyrus striatus* does not belong to the Swiss fauna, as already pointed out by Carron (2008).

C73) [*Gyrinus* (*Gyrinus*) *aeratus* Stephens, 1835]

Examined material. 3)1 ex., Suisse, Zurich, leg. Preudhomme de Borre C.F.P.A., coll. Maerky C., MHNG.

Published data. 1)CH [Switzerland] (Brancucci 1994); 1)Grande Cariçaie, Portalban-Cudrefin, 30.X.1993, 16.VIII.1994 (Scherler 1995).

Comment. This species is widely distributed in northern and eastern Europe, Asia, and the Nearctic region (Hájek and Fery 2017). It is absent from Alsace (Callot 2018) and only mentioned in old records from southern Germany (Bleich et al. 2016). The specimen in the MHNG collection belongs to the problematic collection of C. Maerky and should therefore not be taken into account. Although P. Scherler's collection is credible, the specimens he cited (Scherler 1995) were not found in his collection and must therefore have considered misidentified material, as already assumed by Carron (2008). This species does not exist in Switzerland.

C74) [*Gyrinus* (*Gyrinus*) *caspius* Ménétriés, 1832]

Examined material. 3,4,6,8)1 ex., Genève, Rouelbeau, coll. Maerky C., MHNG; 3,4,6,8)1 ex., Suisse, leg. Anonymous, coll. Maerky C., MHNG; 3,4,6,8)1 ex., Genève, Vessy, coll. Maerky C., MHNG.

Published data. 1)CH [Switzerland] (Brancucci 1994); 1)? Grangettes (Naceur 1997).

Comment. The only three "Swiss" specimens examined are from Charles Maerky's collection and should not be considered, while the literature citations are not verifiable. In addition, and although widely distributed in the Palaearctic region (Hájek and Fery 2017), the species is not mentioned in regions neighboring Switzerland. Indeed, in Germany, the species only exists in the north (Köhler and Klausnitzer 1998; Bleich et al. 2016), whereas in France it colonizes the Mediterranean area and the coastal areas of the Atlantic Ocean and the English Channel (Guignot 1947). *Gyrinus caspius* is not part of the Swiss fauna, as already indicated by Carron (2008).

C75) [*Gyrinus* (*Gyrinus*) *colymbus* Erichson, 1837]

Published data. 1)Katzensee and 1)Zürich am Horn (Heer 1841); 1)Schaffhausen by Stierlin G. (Stierlin and Gautard 1867); 2)Champagnes de Fully by Favre E., 2)entre Guercet et pont de vers l'Eglise de Fully by Favre E. (Favre 1890).

Comment. There are no Swiss specimens of this species in the collections examined. The specimens cited by Favre (1890) were *Gyrinus substriatus*, and the other citations are not supported by any specimen, but probably refer to misidentified *G. distinctus* (Carron 2008). In addition, the species is not known from the regions surrounding Switzerland. It is not included in the list for Alsace (Callot 2018), nor in the German fauna (Köhler 2011; Bleich et al. 2016), while it is only known from a very old record in Vorarlberg, Austria (Brandstetter and Kapp 1995), which is probably doubtful. In Italy, the few records from the northern third of the country are unreliable (Franciscolo 1979). Despite its wide distribution in the Palaearctic region (Hájek and Fery 2017), particularly in the Mediterranean zone, this species is not included in the Swiss fauna.

C76) [*Gyrinus* (*Gyrinus*) *dejeani* Brullé, 1832]

Examined material. 3,4,6)1 ex., Suisse, coll. Maerky C., MHNG.

Comment. This species is mainly distributed in the Mediterranean region (Hájek and Fery 2017). In the north, it reaches central Italy (Franciscolo 1979), while in France it reaches the Lyon region (Guignot 1947). In Switzerland, only one specimen from the collection of C. Maerky is labeled as Swiss, without any further details. This collection being problematic, it should not be considered. As already pointed out by Carron (2008), this species does not belong to the Swiss fauna.

C77) [*Gyrinus* (*Gyrinus*) *natator* (Linnaeus, 1758)]

Published data. 1)Helvetia (Heer 1841); Zürich by Dietrich K. (Dietrich 1865); 1)Buchser-See [Buchs SG] by Rietmann O., 1)St. Gallen by Täschler M., 1)zwischen Rorschach und Horn am Bodensee by Täschler M. (Täschler 1872); 1)Rheintal bis Thusis and 1)Schiers by Wirz, 1) Kästris bei Killias E. (Caflisch 1894); 1)Gegend von Schaffhausen by Stierlin G. (Stierlin 1906); 1)Chiasso by Fontana P. (Fontana 1947); 1)Tourbière du Cachot by Matthey W. (Matthey 1971).

Comment. No Swiss specimens exist in the examined collections, as already mentioned by Carron (2008). Literature references to specimens that could be located in collections turned out to be misidentified *G. substriatus* or *G. suffriani*. Widely distributed in Europe (Hájek and Fery 2017), this Euro-Siberian species is known from Württemberg, near the Swiss border (Köhler and Klausnitzer 1998; Bleich et al. 2016). Its (past?) presence in the north of Switzerland therefore remains a possibility.

C78) [*Gyrinus* (*Gyrinus*) *opacus* C.R. Sahlberg, 1819]

Published data. [1,8)][Schweiz] ? (Bremi-Wolf 1856); [1,8)]Zürich by Heer O. (Stierlin and Gautard 1867).

Comment. This species is only cited from Switzerland by two old literature sources, without any reference specimen in the consulted collections. *Gyrinus opacus* is distributed in the north of the Holarctic region (Hájek and Fery 2017) and does not belong to the Swiss fauna.

C79) [*Gyrinus* (*Gyrinus*) *urinator* Illiger, 1807]

Examined material. [3,4,6,8)]1 ex., Basel, coll. Dietrich K., ETH; [3,4,6,8)]3 ex., Suisse, Bern, leg. Preudhomme de Borre C.F.P.A., coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Carouge, leg. and coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Katzensee, leg. Heer O., ETH; [3,4,6,8)]4 ex., Katzensee, leg. Täschler M., coll. Spälti, MHNG; [3,4,6,8)]1 ex., Suisse, Regensdorf, leg. Preudhomme de Borre C.F.P.A., coll. Maerky C., MHNG; [3,4,6,8)]3 ex., Suisse, leg. Anonymous, coll. Maerky C., MHNG; [3,4,6,8)]3 ex., Suisse, Tessin, leg. Preudhomme de Borre C.F.P.A., coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Vessy, leg. and coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Suisse, Zurich, leg. Preudhomme de Borre C.F.P.A., coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Genève, Carouge, 21.V., leg. and coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Jura, Thoiry, 21.VI., leg. and coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Suisse, Regensdorf, 11.VII., leg. and coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Jura, Burtigny, 15.VII., leg. and coll. Maerky C., MHNG; [3,4,6,8)]2 ex., Alpes, Orsières, 15.VII., leg. and coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Alpes, Bex, 22.VII., leg. and coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Jura, Bière, 22.VII., leg. and coll. Maerky C., MHNG; [3,4,6,8)]1 ex., Jura, Le Vaud, 11.VIII., leg. and coll. Maerky C., MHNG; [3,4,6,8)]2 ex., Alpes, Schuls, 16.VIII., leg. and coll. Maerky C., MHNG.

Published data. [1)]Dübendorf and [1)]Katzensee (Heer 1841); [1)]Bern by Isenschmid M. (Stierlin 1883).

Comment. Most specimens of *G. urinator* deposited in Swiss collections are related to the collection of C. Maerky and cannot be considered reliable (Carron 2008; Monnerat et al. 2015). Carron (2008) nevertheless considered this species indigenous based on specimens from Dübendorf, Katzensee, and Basel. However, as these collections are not entirely reliable and the labels incomplete, we consider that the information available is insufficient to retain this species for Switzerland. Furthermore, this species has a mainly southern distribution (Hájek and Fery 2017) and does not occur in regions adjacent to Switzerland.

C80) [*Brychius glabratus* (A. Villa & G.B. Villa, 1835)]

Published data. [1)][Schweiz] by Heer O. (Bremi-Wolf 1856); [1)]Tessin by Heer O. (Stierlin and Gautard 1867).

Comment. In Switzerland, there are only two imprecise references in the literature. They are not supported by specimens in Swiss collections and therefore cannot be considered valid, even if this species is easily identified. Currently endemic to Italy (van Vondel 2017), its presence in canton Ticino remains possible (Franciscolo 1979) but needs to be confirmed, as already mentioned by Carron (2008).

C81) [*Haliplus* (*Haliplus*) *apicalis* C.G. Thomson, 1868]

Published data. [1,8)]Yvonand-Estavayer-le-lac, Grande Cariçaie, 1995 (Mulhauser 1997).

Comment. In Switzerland, this species is only mentioned in Mulhauser's (1997) publication on the fauna of the Grande Cariçaie nature reserve, but no specimens have been deposited in any of the collections examined. This species is distributed in the northern part of the Holarctic region (van Vondel 2017) and does not exist in Switzerland or in neighboring regions.

C82) [*Haliplus* (*Haliplus*) *fulvicollis* Erichson, 1837]

Published data. [1)]Brütten, 25.VI.1854 and 15.IX.1854 by Dietrich K. (Dietrich 1865); [1)]Schaffhausen by Stierlin G. (Stierlin and Gautard 1867); [1)]La Rivaz in Tessin [Riva] by Frey-Gessner E. (Stierlin 1883); [1)]Sisselen (Stierlin 1900).

Comment. Only very old literature sources mention this species for Switzerland and no reference specimen has been found in the Swiss collections, as already noted by Carron (2008). It is possible that these occurrences are the result of confusions with the nomen of *H. flavicollis*. This species exists in Germany but is absent or dubiously present in the southern Länder close to Switzerland (Köhler and Klaunitzer 1998; Köhler 2011), while in France it is known only from the north of the country and from the Ardennes (Bameul and Queney 2014). Although widely distributed (van Vondel 2017), this Euro-Siberian species appears to be absent from Switzerland.

C83) *Haliplus* (*Haliplus*) *immaculatus* Gerhardt, 1877

Examined material. [3)]1 ex., Genf, leg. Täschler M., MHNG; 2 ex., Rheinau, IV.1913, leg. and coll. Jörger J. B., NMB; 1 ex., Zch, Dietikon, 19.III.1938, leg. and coll. Allenspach V., NMB; 2 ♂, SO, Seewen, VII.1956, leg. Toumayeff G., MHNG; 1 ex., Kt. St. Gallen, Altenrhein, VII.1968, leg. and coll. Linder A., ETH; 1 ex., Helvetia, NE, Entre deux Monts, mare, 13.VI.1976, leg. Brancucci M., NMB; 1 ♂, CH, FR, Kleinbösingen, Auried, 27.V.1991, leg. Hoess R., NMBE; 4 ex., Arlesheim, Wider, 7.V.1992, 15.V.1992, leg. Anonymous, NMB; 3 ♂, BL9999 [Anwil, Talweiher], 8.VII.1997, leg. Auderset Joye D., LEBA; 1 ♂, ZG0043, Plans d'eau CH [Risch, Binzmühleweiher], 6.VIII.1997, leg. Oertli B., LEBA; 1 ♂, BS0010 [Riehen, Autal], 9.VII.1998, leg. Oertli B., LEBA; 1 ex., Jussy GE, 22.VII.2002, leg. Oertli B., LEBA; 1 ♂, Le Chenit VD, 9.VII.2005, leg. Carron G., ETH; 2 ex., Seltisberg BL, 27.IV.2010, leg. Brancucci M., coll. Geiser M., NMBE; 1 ♂, 1 ♀, Vandoeuvres GE, 2.IV.2012, leg. Anonymous; 1 ♂, Rottenschwil AG, 3.V.2021, leg. Birnstiel E., MZL; 1 ♂, Rottenschwil AG, 6.IX.2021, leg. and coll. Birnstiel E.; 1 ♂, Bettens VD, 13.VIII.2021, leg. and coll. Chittaro Y.; 1 ♂, Yvonand VD, 13.VIII.2021, leg. and coll. Chittaro Y.; 2 ♂, Yvonand VD, 9.IX.2021, leg. and coll. Cosandey V.; 2 ♂, Yvonand VD, 17.VI.2022, leg. and coll. Cosandey V.

Published data. 1)Hemberg, Bendelmoos, VI.1959 by Hugentobler H. (Hugentobler 1966); 1)Untervaz by Jörger J. (Linder 1967); 1)Marais de Kloten, 3.IX.1969 by Gassmann M. (Gassmann 1974).

Comment. The dissection of most males of *Haliplus* (*Haliplus*) spp. deposited in Swiss natural history collections has enabled clarification of the distribution of *H. immaculatus*, which is rare in Switzerland. It is mainly present on the Plateau and in the Jura but seems absent from the Alpine valleys and Ticino. It occurs in northern and central Europe (van Vondel 2017).

C84) [*Haliplus* (*Haliplus*) *lineolatus* Mannerheim, 1844]

Published data. 1)Untervaz by Jörger J. B. (Linder 1967).

Comment. As mentioned by Carron (2008), no specimen originating from Switzerland is deposited in a Swiss museum and no literature citations exist. The citation from Linder (1967) concerns *Haliplus wehnckei* Gerhardt, 1877, falsely considered a synonym of *H. lineolatus* (whereas it is a synonym of *H. sibiricus*). This species appears to be erroneously cited for Switzerland in the Palaearctic catalogue by van Vondel (2017). Known in Germany in the Württemberg region (Köhler and Klausnitzer 1998) and recently in Bavaria (Bleich et al. 2016), this Euro-Siberian species remains a possibility in Switzerland. According to Bameul and Queney (2014), the citations from France (Guignot 1947) are erroneous and refer to *H. sibiricus*. This species is also absent from Italy (Franciscolo 1979).

C85) *Haliplus* (*Liaphlus*) *fulvus* (Fabricius, 1801)

Examined material. 3,4,6)1 ex., Aarau, leg. Blösch C., NMAA; 3,4,5,6)2 ex., Basel, leg. Anonymous, NMB; 3,4,6)2 ex., Katzensee, leg. Täschler M., MHNG; 1 ex., Schaffhausen, leg. Anonymous, ETH; 1 ex., Schaffh., leg. Böschenstein A., NMSH; 2 ex., Wiedl. See [Widlersee], 14.IV.1880, leg. Böschenstein A., NMSH; 1 ex., Vaux [Vaux-sur-Morges], 10.VI.1901, leg. and coll. Gaud A., MZL; 1 ex., Wallis, 1908, leg. de Brenzinger, ETH; 1 ex., Nidau, IX.1910, leg. Mathey A., NMBE; 1 ex., Rheinau, IV.1913, leg. and coll. Jörger J. B., NMB; 5 ex., BE, Nidau, 9.VIII.1921, leg. Mathey A., NMBE; 15 ex., Kt. Bern, Büren a. A., V.1938, IV.1939, X.1943, V.1946, V.1947, VI.1950, leg. and coll. Linder A., ETH; 1 ex., Katzensee, 6.III.1948, leg. and coll. Allenspach V., NMB; 1 ex., marnière, Hauterive, Neuchâtel, Suisse, 25.V.1951, leg. Aellen V., MHNG; 1 ex., OW 0167 [Sarnen, Sewensee,], 23.VIII.1996, leg. Oertli B., LEBA; 5 ex., Oberwil BL, 26.IV.2023, leg. and coll. Cosandey V.; 11 ex., Bonfol JU, 12.VI.2023, leg. and coll. Chittaro Y.; 1 ex., Flaach SH, 12.IX.2023, leg. and coll. Sanchez A.

Published data. 1)Bern by von Ougspurger F. P., 1)Genf by Chevrier F., 1)Jura by Mellet L., 1)Lac de Joux by Mellet L., 1)Neuchâtel by Mellet L., 1)Pomy by Mellet L. and 1)Vall-Orbes by Mellet L. (Heer 1837); 2)Guercet près Martigny by Favre E. and 1)Vaux , V., by Bugnion E. (Favre 1890); 2)nel Lago a Riva S. Vitale, VI.1914 by Fontana P. (Fontana 1922); 1)Frauenfeld, Ziegelweiher im Gill, VII.1953 by Hugentobler H. (Hugentobler 1966).

Comment. Among all European Haliplidae, *H. fulvus* has the widest distribution (van Vondel 1997); it is present in most of the Palaearctic region and in the north of the Nearctic, colonizing various sections of water (fresh and brackish) with rich Characeae vegetation (van Vondel 1997). Surprisingly, it has been recorded only sporadically in Switzerland. It was found again in 2023 in three localities in the north of the country. The specimens cited by Favre (1890) from Martigny were in fact *H. obliquus*, while those from Riva S. Vitale cited by Fontana (1922) were *H. flavicollis*.

C86) *Haliplus* (*Liaphlus*) *mucronatus* Stephens, 1828

Examined material. 3,4,5,6)1 ex., Basel, leg. Anonymous, NMB; 1 ex., Basel, coll. Stierlin G., MHNG; 2 ex., Burgdorf, coll. Rätzer A., NMBE and NMSO; 1 ex., Dübendorf, leg. Anonymous, ETH; 1 ex., Genève, leg. Böschenstein A., NMSH; 3,4,5,6)1 ex., Schaffhausen, leg. Täschler M., MHNG; 2 ex., Valais, leg. Favre E., HGSB; 3,4,5,6)1 ex., Suisse, leg. Anonymous, MHNG; 1 ex., Zch, Dietikon, leg. Keller, coll. Allenspach V., NMB; 2 ex., Genève, leg. and coll. Gaud A., MZL; 2 ex., Dh. [Diessenhofen TG], 1848, leg. and coll. Brunner J., NMSH; 1 ex., Wagner Riedt [Wangener Riedt], 28.VIII.1864, leg. and coll. Dietrich K., ETH; 1 ex., Peney, 20.III.1875, leg. Böschenstein A., NMSH; 1 ex., Aïre, 23.VII.1877, leg. Böschenstein A., NMSH;1 ex., Dörfl. [Dörflingen], 6.IX.1877, leg. and coll. Brunner J., NMSH; 1 ex., Vaux [Vaux-sur-Morges], 6.VI.1881, leg. and coll. Bugnion E., MZL; 1 ex., Kt. Bern, Aarwangen, IX.1929, leg. and coll. Linder A., ETH; 1 ex., CH, K. Zü, Oberengstringen, 25.III.1932, leg. and coll. Allenspach V., NMB; 1 ex., Aff., Zürich Umg., 10.VIII.1941, leg. and coll. Wolf J.-P., ETH; 1 ex., Hänsiried, Zürich Umg., 10.VIII.1941, leg. and coll. Wolf J.-P., ETH; 2 ex., Hänsiried, Zürich Umg., 17.IX.1941, leg. and coll. Wolf J.-P., ETH; 1 ex., Warth-Weiningen, Ochsenfurt, 30.VII.1952, leg. and coll. Hugentobler H., NMTG; 5 ex., Cartigny GE, 18.VIII.2021, leg. and coll. Cosandey V.; 1 ex., Avusy GE, 9.IX.2021, leg. and coll. Cosandey V.; 2 ex., Cartigny GE, 9.IX.2021, leg. and coll. Cosandey V.; 4 ex., Cartigny GE, 10.IX.2021, leg. and coll. Chittaro Y.

Published data. Dübendorf by Bremi-Wolf J. J. and 1) Wallis by Lasserre H. (Heer 1837); 1)Tös [Töss] ob Dättlikon in Lachen (Heer 1841); 1)Niederschwerzenbach, 28.VIII.1864 by Dietrich K. (Dietrich 1865); 1)Mühlenthal bei Schaffhausen by Stierlin G. (Stierlin and Gautard 1867); 1)Genf by Böschenstein A. (Stierlin 1883).

Comment. This species is distributed in central and southern Europe, in the coastal areas of Morocco and Libya, as well as in Turkey, Iraq, and along the Black Sea (van Vondel 1997). It is very sporadic north of the Loire River in France (Bameul and Queney 2014). In Switzerland, historical occurrences of *H. mucronatus* are sporadically distributed at low elevation on the Plateau and in Geneva (Carron 2008, Fig. 7A). Substantial survey efforts in the canton of Geneva have led to its rediscovery after more than 50 years without data (Cosandey 2023). This species is found in fresh and brackish waters, and often colonizes gravel or Characeae clay quarries (Foster and Friday 2011; van Vondel 1997).

C87) *Peltodytes rotundatus* (Aubé, 1836)

Examined material. 1 ex., Moulin de Vert, GE, .IV.1953, leg. Simonet J., coll. Toumayeff G., MHNG; 2 ex., M.lin de Vert, 24.IV.1953, leg. Simonet J., MHNG; 5 ex., Genève, Moulin de Vert, 3.VIII.1984, leg. Besuchet C. and Scherler P., MHNG, NMBE; 1 ex., Verbois, 14.VIII.1986, leg. and coll. Scherler P., NMBE; 1 ex., Versoix, Combe Chapuis, 10.IV.1995, leg. Anonymous, LEBA; 1 ex., PLOCH GE0010 [Bois des Mouilles], 4.VII.1996, leg. Anonymous, LEBA; 1 ex., Versoix GE, 7.VI.2003, leg. Carron G., ETH; 2 ex., Versoix GE, 22.V.2005, leg. Carron G., LEBA; 4 ex., Russin GE, 12.VII.2005, leg. Carron G., ETH; 1 ex., Pregny-Chambésy GE, 2.IV.2012, leg. Anonymous; 2 ex., Laconnex GE, 23.IV.2020, leg. and coll. Cosandey V.; 1 ex., Meyrin GE, 23.IV.2020, leg. and coll. Cosandey V.; 1 ex., 15.IX.2021, Versoix GE, leg. and coll. Cosandey V.; 2 ex., Laconnex GE, 24.VIII.2021, leg. and coll. Cosandey V.; 1 ex., 27.VIII.2021, Gy GE, leg. and coll. Cosandey V.; 1 ex., Jussy GE, 7.X.2021, leg. and coll. Cosandey V.; 6 ex., Meyrin GE, 7.X.2021, leg. and coll. Cosandey V.; 3 ex., Collex-Bossy GE, 28.IV.2022, leg. and coll. Cosandey V.; 4 ex., Mendrisio TI, 22.V.2023, leg. and coll. Chittaro Y. and Sanchez A.

Published data. 9 ex., Cartigny, Moulin-de-Vert, 1953, 1984 by Toumayeff, 1 ex., Veytay, Gouille Marion, 1990 by Besuchet, 1 ex., Versoix, étang de Combe-Chapuis, 2003, 1 ex., étang de Richelien, 2005 and 4 ex., Russin, Teppes, 2005 (Carron 2008).

Comment. *Peltodytes rotundatus* could be expanding in Switzerland; historical records of this species are very rare, whereas it has recently been found regularly in the canton of Geneva in the last 20 years (Carron 2008; Cosandey 2023) and was detected for the first time in Ticino in 2023. This species is distributed mainly in southern Europe and North Africa.

C88) *Hygrobia hermanni* (Fabricius, 1775)

Examined material. 1 ex., Aigle, leg. and coll. Favre E., HGSB; 3,4,6)1 ex., Bienne, leg. and coll. Maerky C., MHNG; 3,4,6)1 ex., Suisse, Bienne, leg. and coll. Maerky C., MHNG; 3,4,6)1 ex., Crevin, leg. and coll. Maerky C., MHNG; 3,4,6)1 ex., Genève, leg. and coll. Maerky C., MHNG; 3,4,6)2 ex., Genf, leg. and coll. Lasserre H., ETH; 3,4,6)1 ex., Genf, leg. and coll. Spälti A., MHNG; 3,4,6)1 ex., Genève, Plan les Ouates, leg. and coll. Maerky C., MHNG; 3,4,6)1 ex., Suisse, leg. Turretini, coll. Maerky C., MHNG; 3,4,6)1 ex., Suisse, Carouge, leg. Frey, coll. Maerky C., MHNG; 3,4,6)2 ex., Suisse, Meyrin, leg. Frey, coll. Maerky C., MHNG; 3,4,6)1 ex., Genève, Veyrier, leg. and coll. Maerky C., MHNG; 3,4,6)2 ex., Genève, Villette, leg. and coll. Maerky C., MHNG; 3,4,6)1 ex., Bienne, 18.V., leg. and coll. Maerky C., MHNG; 3,4,6)1 ex., Crevin, 25.VI., leg. and coll. Maerky C., MHNG; 4 ex., Aigle, 4.VI.1908, 14.VI.1912, leg. and coll. Gaud A., MZL; 3 ex., Bavois, VD, IV.1972, leg. Toumayeff G., coll. Linder A., ETH and MHNG; 22 ex., VD, Bavois, V. and VI.1972, leg. Toumayeff G., MHNG; 34 ex., Bavois, 13.V.1972, leg. and coll. Scherler P., NMBE; 1 ex., VD, Bavois, Bernoise, IX.1972, leg. Toumayeff G., MHNG; 1 ex., VD, Goumoens, Tuilerie, V.1974, leg. Toumayeff G., MHNG; 12 ex., VD, Bavois, VIII.1975, leg. Toumayeff G., MHNG; 29 ex., VD, Bavois, Bernoise, VI.1983, VIII.1984, IX.1984, leg. Toumayeff G., MHNG; 1 ex., VD, Bavois, Cristallin, VIII.1984, leg. Toumayeff G., MHNG; 10 ex., CH, FR, Kleinbösingen, Auried, 15.XI.1990, 21.III.1991, 19.IX.1991, leg. Hoess R., NMBE; ? ex., GE, Bardonnex, Evordes, Drize, III.1995, leg. Perfetta J.; 1 ex., Hochfelden, 26.IV.1996, leg. Ettmüller W.; 7 ex., Jura, Bonfol, Champ de manche, 4.IX.1998, leg. Carron G., ETH; 1 ex., Meyrin GE, 2005, leg. Sandoz F.-A.; 1 ex., Ballens VD, 9.V.2005, leg. and coll. Chittaro Y.; 5 ex., Meinier GE, 13.IX.2005, leg. Carron G., ETH and LEBA; 1 ex., Vandoeuvres GE, 2.IV.2012, leg. Anonymous; 1 ex., Jussy GE, 26.VI.2012, leg. Anonymous; 1 ex., La Chaux (Cossonay) VD, 30.VII.2016, leg. and coll. Chittaro Y.; 3 ex., Bougy-Villars VD, 3.IV.2017, leg. and coll. Cosandey V.; 4 ex., Gy GE, 14.IX.2020, leg. and coll. Cosandey V.; 1 ex., Jussy GE, 18.V.2022, leg. and coll. Cosandey V.

Published data. 1)Genf by Lasserre H. (Heer 1837); 1)Jorat by Heer O. (Stierlin and Gautard 1867); Aigle by Jaccard H. (Favre 1890); Champ de Manche, 1998 by Carron G. (Carron 1999).

Comment. Widespread in Western Europe, only sparse records exist in Switzerland, which could be explained by the difficulty of catching the specimens. The species is a bottom-dweller that lives in muddy, stagnant water and prefers small, silty ponds rich in detritus and dense vegetation (Dettner 1997). Moreover, they can burry themselves in the substrate of ponds and remain there up to 30 minutes, rising to the surface only briefly to breathe (Dettner 1997). They can also leave aquatic habitats for long periods (Kovac and Maschwitz 1990). Larvae hunt *Tubifex* worms in the mud (Dettner 1997).

Discussion

This study represents an update of the previously published lists of Carron (2005, 2008) dealing with the Hydradephaga of Switzerland. Based on a large and robust dataset, the faunal knowledge of this group in Switzerland can now be considered solid. Occurrence maps for the species retained as part of the Swiss fauna are available on the info fauna map server (www.infofauna.ch; https://lepus.infofauna.ch/carto). All the data have been transmitted to GBIF, making this work part of a global understanding of biodiversity. This study is part of a wider project to update our knowledge of the fauna of aquatic beetles in Switzerland, following on from the work on Hydrophiloidea by Cosandey et al. (2023), but is also a further step towards a complete comprehension of the beetle fauna of Switzerland (e.g., Chittaro et al. 2021; Sanchez and Chittaro 2022).

We can confirm the native status of most of the species retained by Carron (2005, 2008, 2009), with the exceptions of seven species (*Deronectes opatrinus*, *Graptodytes flavipes*, *Gyrinus urinator*, *Hydaticus continentalis*, *Hygrotus parallelogrammus*, *Hyphydrus aubei*, and *Stictonectes lepidus*), which we excluded for various reasons (see comments for each species). On the other hand, we can now confirm the presence in Switzerland of *Dytiscus circumflexus* and *Rhantus suturellus*, excluded by Carron, as well as the recently described *Boreonectes alpestris*. The Swiss list of Hydradephaga now contains a total of 139 species whose presence (past or present) can be considered certain. As observed worldwide, Dytiscidae is the most diverse family of Hydradephaga in Switzerland (113 species), followed by Haliplidae (16 species), Gyrinidae (7 species), Noteridae (2 species), and Hygrobiidae (1 species).

The distribution map of Hydradephaga species richness in Switzerland shows that most of the areas with high species diversities are located in lowlands and in thermophilous areas of Switzerland (Fig. 1A). However, several species (also) occur at high elevations (Fig. 1B), underlining the importance of Switzerland for the conservation of some localized and highly specialized alpine species. Certain species are restricted to peat bogs like *Hydroporus obscurus* and *Ilybius crassus* (Fig. 2, blue squares), or to high elevation alpine ponds like *Ilybius erichsoni* (Fig. 2, green squares), *Agabus congener* (Fig. 3, blue squares), and *A. lapponicus* (Fig. 3, green squares). These two last species are both present in the Alps, but do not appear to occur in the same ponds. According to Nilsson (1987) the temperature of the waterbody could be the limiting factor, with *A. lapponicus* restricted to cooler habitats. *Ilybius erichsoni* appears to be reaching the western limit of its distribution in the Swiss Alps. It is localized and only occurs in a few isolated alpine ponds (Fig. 2, green squares) where it can be abundant. Another rare alpine species is *Hydroporus kraatzi*, which was recently rediscovered in France by Queney (2006) and is sporadically present in Switzerland. It is widely distributed in the Alps, but its catches are exceptional (although it can be abundant). This semisubterranean species may be easier to catch after heavy rainfalls (V. Cosandey pers. obs.), perhaps displaced into the streams from its habitat situated not directly in the water (Fery 2009). It is interesting to note

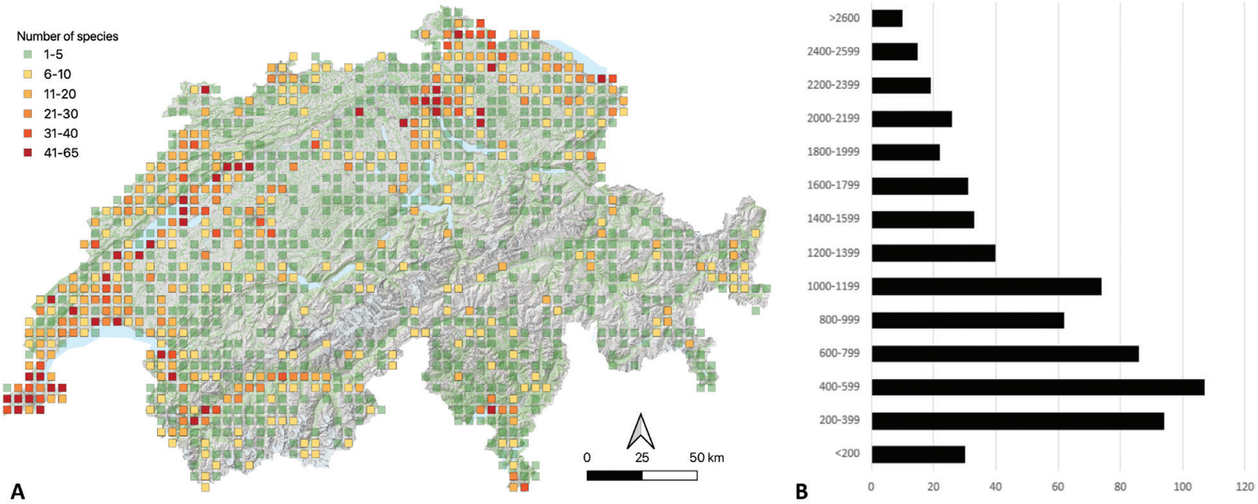

Figure 1. Distribution of species richness of Hydradephaga in Switzerland. **A.** Map with the total number of species recorded per 5×5 km grid, all data and all years combined. The lowland areas of Switzerland are generally those with the highest diversity of Hydradephaga, but some rich areas are also found on higher elevations; **B.** Altitudinal distribution of species richness. All altitudinal information (where provided) for each species was considered and aggregated by 200 m altitudinal class.

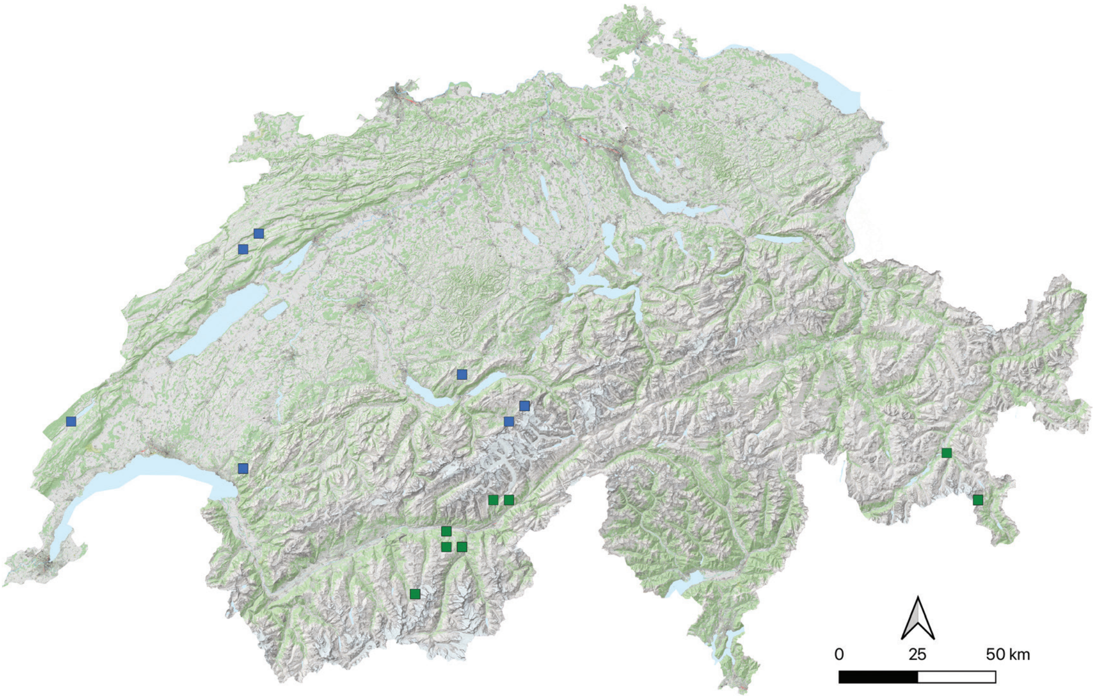

Figure 2. Occurrence maps of two alpine rare species with restricted distribution in Switzerland. *Ilybius crassus* (blue squares) is only found in a few peat bogs of the Jura mountains and in rare ponds of the Northern Alps, while *Ilybius erichsoni* (green squares) is restricted to some alpine ponds situated at high elevations, where it can be abundant.

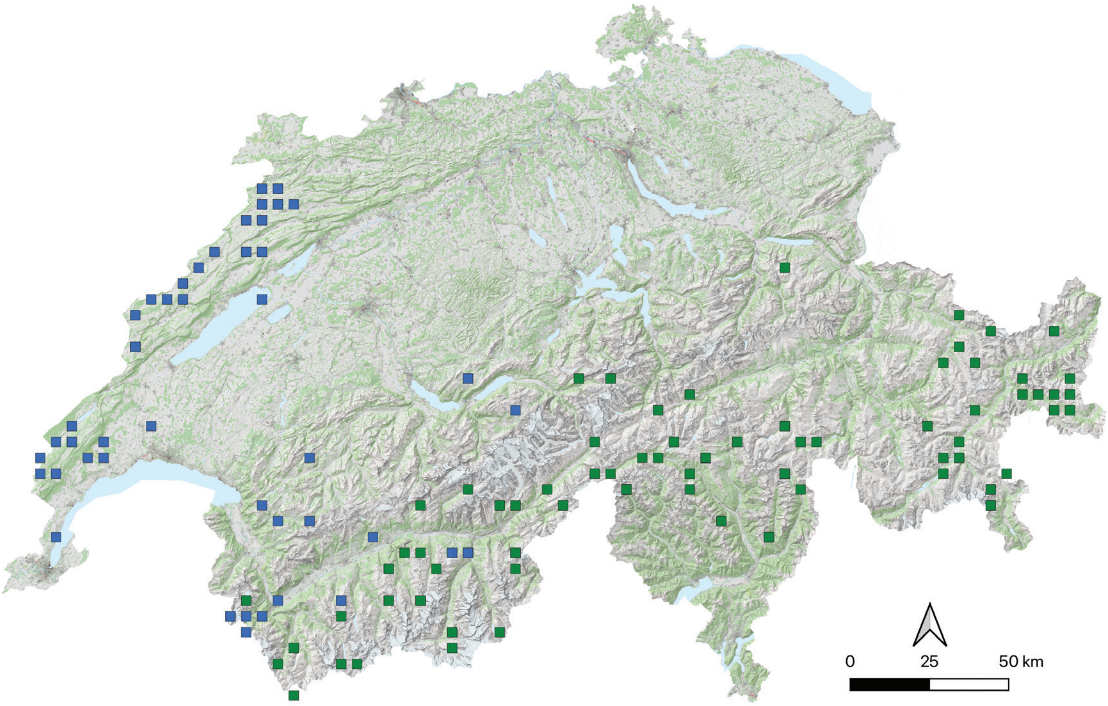

Figure 3. Occurrence maps of two common sister-species Dytiscidae from mountainous regions. *Agabus congener* (blue squares) and *Agabus lapponicus* (green squares). They do not seem to occur together in the same ponds even if their distributions overlap.

that Switzerland appears to be at the southern limit of the distributions for many northern species, which only reach the northern slopes of the Alps (*Ilybius crassus*, *Nebrioporus assimilis*) or the lowlands in the northeast of the country (*Agabus undulatus*, *Dytiscus circumflexus*, *Hydaticus transversalis*, *Hydroporus figuratus*, *Hydroporus scalesianus*, *Hygrotus quinquelineatus*, and *Ilybius guttiger*, for example).

In parallel to the work done in museums, our targeted field surveys (visiting 361 km^2, for a total of 4,327 occurrences) carried out during the last five years have provided new data for most of the Swiss species (n = 123), representing 88% of the Hydradephaga signaled in the country. This research led to some surprises, such as the rediscovery in Switzerland of *Agabus brunneus* (Fig. 4A), *Haliplus mucronatus* (Fig. 4B), *Ilybius crassus*, *Hydaticus transversalis*, *Hydroporus figuratus* (Fig. 4C), *Hydroporus longicornis*, and *Nebrioporus assimilis*, as well as the rediscovery of *Dytiscus circumcinctus* by our colleague Emil Birnstiel. All these species had not been reported in Switzerland for 25 years or more. However, our research did not uncover any new species for Switzerland, although several species are known from neighboring regions and remain potential. This is the case for example for *Ilybius montanus* (Stephens, 1828) cited from Alsace by Callot (2018), for *Agabus unguicularis* (C.G. Thomson, 1867) known from southern Germany (Köhler and Klausnitzer 1998; Köhler 2011), and especially for *Hydroporus striola*, *H. gyllenhalii*, and *Ilybius wasastjernae* (C.R. Sahlberg, 1824). Some of these species could effectively be present in Switzerland. However, the species accumulation curve (Fig. 5) clearly seems to plateau, indicating that our knowledge of this fauna is very good and probably not far from exhaustive.

The 16 Swiss species (= 12%) that we have not found in the last 5 years indicate the probable loss of a large proportion of them, such as *Hydaticus grammicus* (last Swiss observation in 1942), *Dytiscus latissimus* (1948), *Dytiscus circumflexus* (1954), *Rhantus bistriatus* (1957), *Ilybius subaeneus* (1958), *Rhantus notaticollis* (1971), *Rhantus frontalis* (1977), *Hygrotus confluens* (1984), *Nebrioporus canaliculatus* (1990), and *Rhitrodytes crux* (1994), which have not been reported in Switzerland for at least 25 years (minimum duration considered in the German Red List of Spitzenberg et al. (2016) for a species to be considered extinct). For others, there are more recent observations, but their disappearance is already to be expected, such as *Scarodytes halensis*, reported for the last time by Carron in the canton of Geneva in 2007 and which has not been found in the last five years despite intensive surveys in the canton (see Cosandey 2023). In general, a large number of Hydradephaga species have declined over time, and even if they still exist in our country, they have become extremely rare such as *Dytiscus semisulcatus* (see comparison with the congeneric and very similar *Dytiscus marginalis*, which remained stable over time Fig. 6), *Haliplus mucronatus* (see comparison with *Haliplus heydeni*, Fig. 7), or even probably have disappeared like *Gyrinus minutus* (see comparison with *Gyrinus substriatus*, the only common species of the genus in Switzerland:, Fig. 8A, B). A comparison of the relative proportions of localities (considered as 5 × 5 km areas) between two 30-year periods (1964–1993 versus 1994–2023, 1994 being the year of publication of Brancucci's red list for Switzerland) for each species known from more than five localities during the two periods shows that several species that are still widespread have nevertheless declined sharply in Switzerland. The steepest declines were seen among *Agabus paludosus* (-62%), *Agabus biguttatus* (-60%), *Hydroporus melanarius* (-44%), *Hydroporus nigellus* (-42%), *Agabus lapponicus* (-39%), *Bidessus grossepunctatus* (-35%),

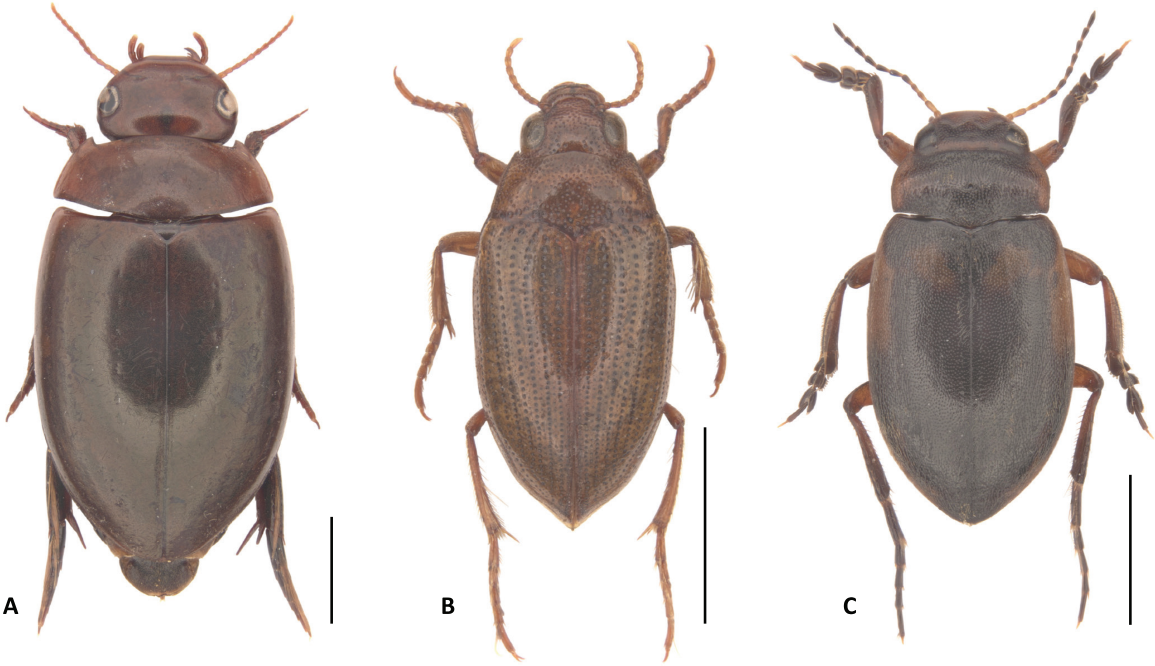

Figure 4. Examples of Hydradephaga species recently rediscovered in Switzerland. Habitus of **A.** *Agabus brunneus* (rediscovered in 2021, previous record in 1915); **B.** *Haliplus mucronatus* (rediscovered in 2021, previous record in 1952), and **C.** *Hydroporus figuratus* (rediscovered in 2023, previous record in 1970). Scale bars: 2 mm. (Photos V. Cosandey)

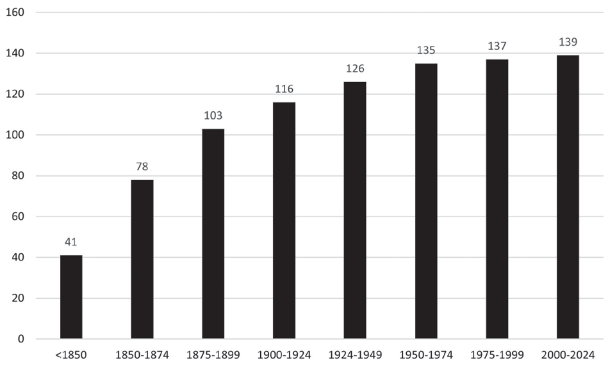

Figure 5. Accumulation of Hydradephaga species recorded in Switzerland through time. The year in which each species was first recorded in Switzerland was taken into account and grouped into 25-year periods. The curve clearly plateau since a few decades, indicating that this group is well-known in Switzerland.

Ilybius fuliginosus (-32%), *Deronectes aubei* (-28%), *Ilybius aenescens* (-28%), and *Rhantus latitans* (-28%).

This negative trend is easily explained; in Switzerland, 80–88% of wetlands have been destroyed (Küchler et al. 2018), most of them having been drained to gain arable land or for urban development. As a result, 90% of wetland types are on the national red list of habitat types (Delarze et al. 2016). The correction of watercourses and the poisoning of waters by industry and agriculture are also major factors (Brancucci 1994), like the ongoing eutrophication of suitable waters and the gradual decrease in rainfall in recent years in the planar and hilly regions (Spitzenberg et al. 2016).

However, some species may also expand, such as *Hydrovatus cuspidatus*, which has gained ground in recent decades (Carron and Merz 2012), but also apparently *Graptodytes bilineatus*, *Rhantus grapii*, and *Peltodytes rotundatus*. Colonization (or recolonization) capacity depends to a large extent on the flight capacity of the various species. Iversen et al. (2017) highlighted the large difference in flight capability between *Acilius* spp. and *Graphoderus* spp., which is directly visible in the colonization rates of newly created ponds. In Switzerland too, *Acilius* spp. are more common and widespread than *Graphoderus* spp., with *G. bilineatus* and *G. zonatus* declining for decades in Switzerland.

Now that all the historical data held in the collections of Swiss natural history museums have been databased, Hydradephaga need an urgent revision of their red list; our data shows that some statuses proposed by Brancucci (1994) are inadequate. For example, *Graphoderus cinereus* appears on the red list as being more threatened than *G. austriacus* or *G. bilineatus*, as already mentioned by Carron (2005). However, our results show that *G. austriacus* is potentially extinct in Switzerland, while *G. bilineatus* is in steep decline (Knoblauch and Gander 2019): only three populations are currently known in Switzerland, whereas *G. cinereus* is fairly common and widespread in Switzerland. It is likely that Brancucci

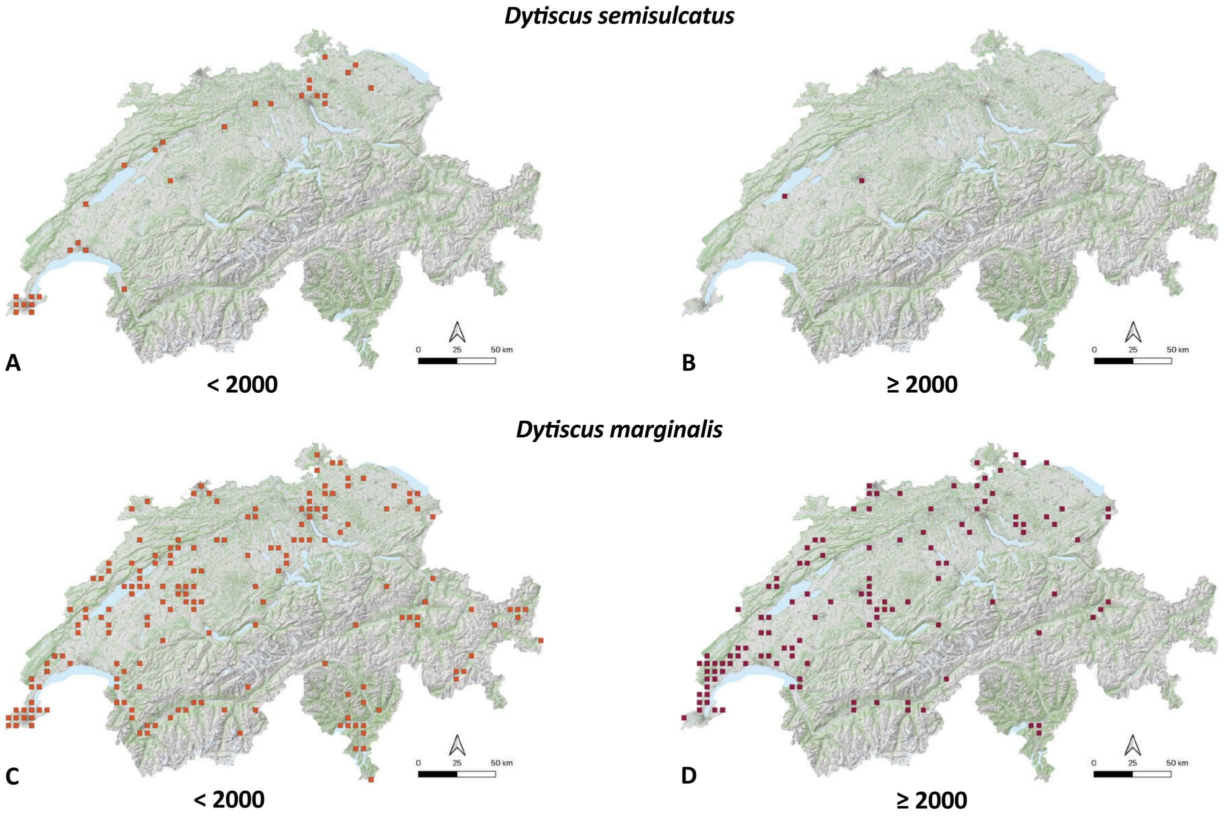

Figure 6. Changes in the distribution of two congener Dytiscidae over time. Occurrences of a species in steep decline, *Dytiscus semisulcatus* **A.** Before 2000 and **B.** After 2000. Occurrences of a morphologically similar species remaining common, *Dytiscus marginalis*; **C.** Before 2000 and **D.** After 2000.

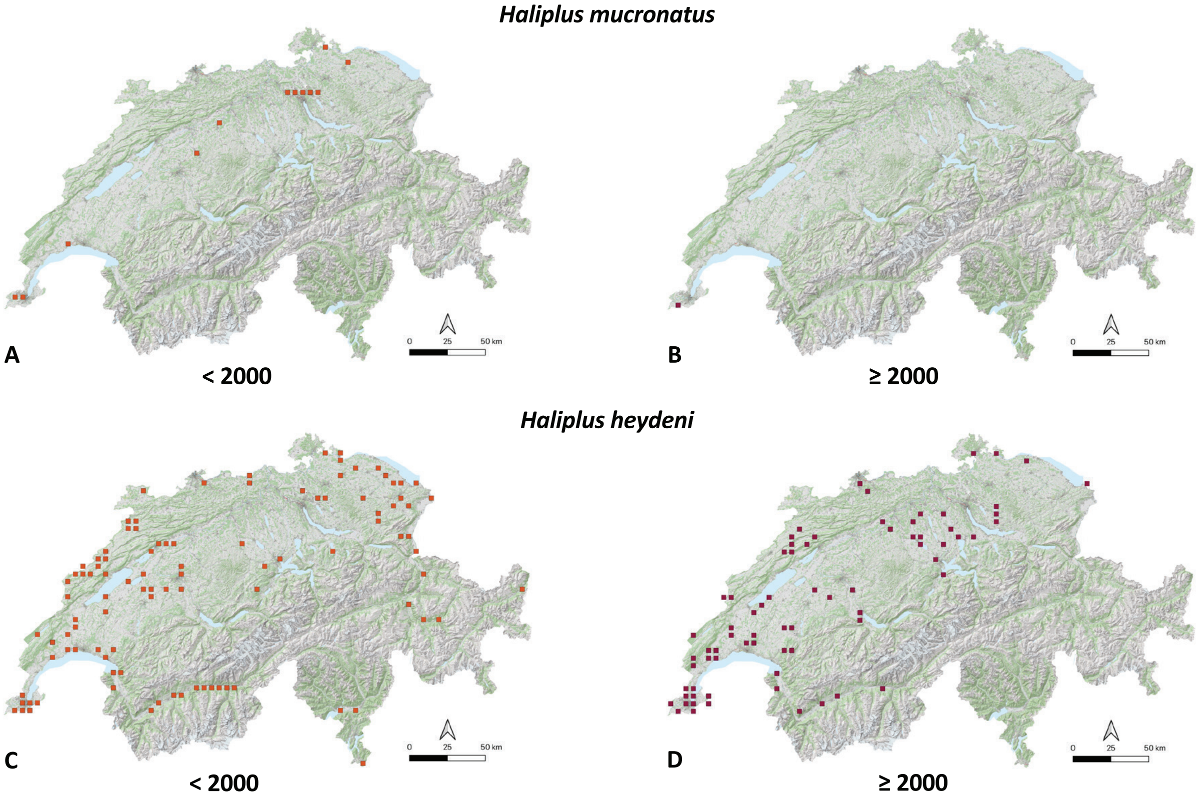

Figure 7. Changes in the distribution of two Haliplidae species over time. Occurrences of *Haliplus mucronatus*, a species recently rediscovered in Switzerland **A.** Before 2000 and **B.** After 2000. Occurrences of *Haliplus heydeni*, a common and widely distributed species in Switzerland **A.** Before 2000 and **B.** After 2000.

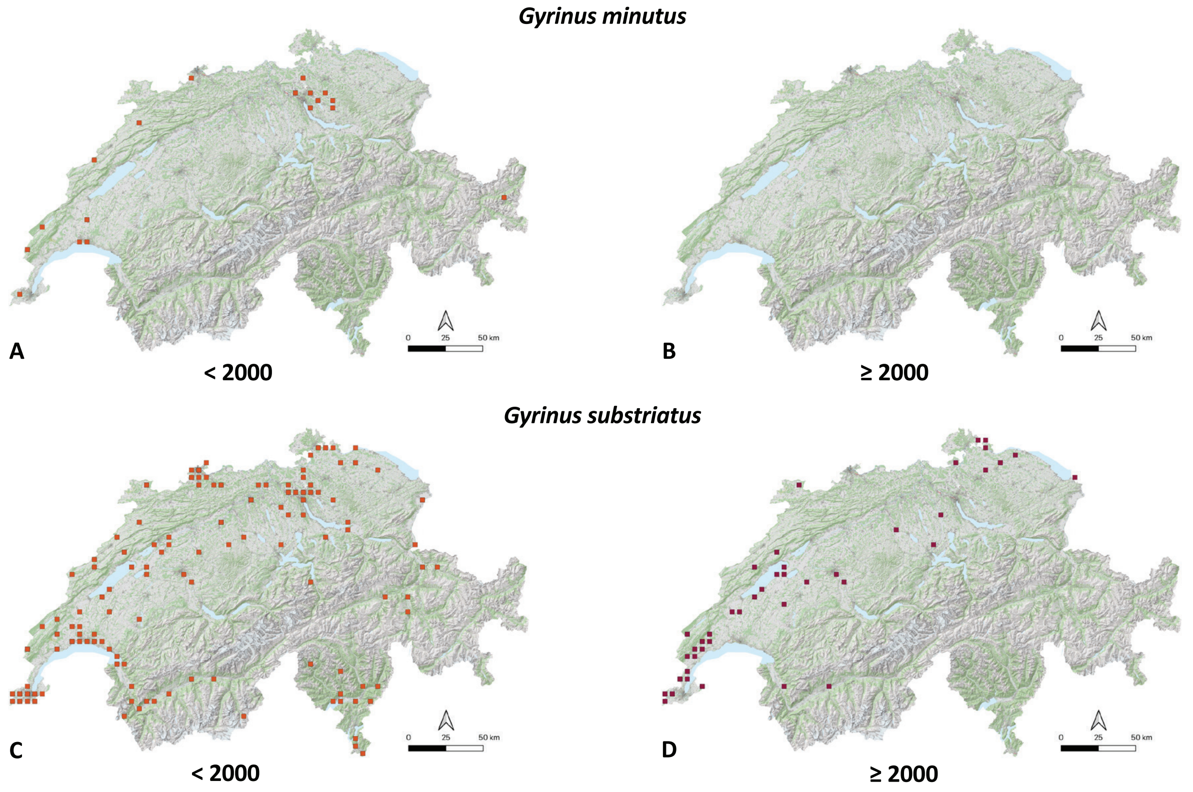

Figure 8. Changes in the distribution of two Gyrinidae species over time. Occurrences of a probably extinct species, *Gyrinus minutus* **A.** Before the years 2000 and **B.** After. Occurences of *Gyrinus substriatus*, the most common Gyrinidae in Switzerland **C.** Before the years 2000 and **D.** After 2000.

attributed these statuses in direct inspiration from his work on the ecology of Dytiscidae in the Grande-Cariçaie reserve (VD/FR/NE), where he found more *G. bilineatus* than *G. cinereus* (Brancucci 1980). In addition, Brancucci's (1994) red list includes many non-native species that have never been present in Switzerland, such as *Agabus subtilis*, *Ilybius similis*, *Dytiscus lapponicus*, *Hydroporus striola*, *Aulonogyrus striatus*, and *Gyrinius caspius*, as Carron (2005, 2008) already mentioned, and as our systematic data collection confirms. A revision of the Red List is therefore highly desirable.

Acknowledgments

We would like to acknowledge Claude Besuchet (1930–2020), who managed to get many Swiss specimens identified or verified by European specialists during the course of his work on the Catalogue of Swiss Coleoptera, which was unfortunately left unfinished. We also thank Georges Toumayeff (1901–1993), who assembled the Swiss collection of MHNG on request of C. Besuchet. Furthermore, we acknowledge Gilles Carron (1970–2009) for the quality of his works and for having already identified a large proportion of the Hydradephaga deposited in Swiss museums.

We are also thankful to all the Swiss museum curators and collection managers, who have welcomed us so often and so kindly within their institutions over the past few years, as well as all the active coleopterists whose expertise enriched our understanding of the distribution of these species in Switzerland.

Finally, we are grateful to Michael Balke and Emil Birnstiel for their meaningful comments on the manuscript.

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DNA barcoding reveals a new cryptic species of *Denisia* Hübner, 1825 (Lepidoptera, Oecophoridae) from the south-western Alps

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Abstract

A new species of concealer moths (Oecophoridae), *Denisia cryptica* **sp. nov.**, is described from specimens collected in the south-western Alps (Italy, France). It differs from similar congeneric taxa of the *Denisia stipella* species-group by a combined pattern of colour and markings of the forewing upperside, the colour of the head, particularly the yellow second segment of the labial palpi, and by highly divergent DNA barcode (cytochrome c-oxidase subunit 1) sequences. Male and female genitalia are like several other species, with only subtle diagnostic characters. Adult and partially genitalia of *D. cryptica* **sp. nov.** and the closest European species are shown for comparison. Finally, a complete checklist of European species of *Denisia* is added.

Key Words

Cottian Alps, cryptic morphology, endemism, France, Italy, Oecophorinae

Introduction

Denisia is one of the species-rich genera in Europe within the family Oecophoridae, which is represented here by 139 species (Lepiforum 2024). 23 species of *Denisia* have been recorded in Europe (Lepiforum 2024). Remarkably, four of these species were only discovered in the 21st century (Huemer 2001; Lvovsky 2007; Corley 2014; Nel and Varenne 2019), although one of them, *Denisia lutea* Varenne & Nel, 2019, has been incorrectly synonymized with the North African *Denisia curlettii* Lvovsky & Koster, 1996 (Leraut 2023; Nel and Varenne 2024). No additional congeneric species are currently known from Asia. However, two species are recorded from North America, viz. *Denisia yukonella* Lvovsky, 2007 and *Denisia haydenella* (Chambers, 1877), with the former now considered as junior synonym of *Brymblia quadrimaculella* (Chambers, 1975) (Pohl and Landry 2023). This synonymization reflects the general lack of a phylogenetic analysis of the subfamily Oecophorinae. Consequently, the generic delimitation of *Denisia* and other genera requires further investigation, particularly through extensive molecular analyses.

Only a few species like *Denisia stipella* (Linnaeus, 1758) and *Denisia similella* (Hübner, 1796) are widely distributed across the continent, especially in the temperate zones, while the vast majority have more localized ranges. Particularly, the various major mountain systems in Europe such as the Pyrenees, Alps, or Caucasus, as well as large Mediterranean islands, are partly inhabited by regional endemism. However, recently studied molecular data suggest a significantly underestimated species diversity, especially among species with allopatric distribution patterns (Huemer and Mutanen 2015; Zlatkov and Huemer 2017; Huemer 2022; Huemer and Wieser 2023).

The preimaginal life habits of *Denisia* species are insufficiently explored and often completely unknown. Tokár et al. (2005) mainly cite the bark of decaying or dead wood, rarely also lichens growing on trees, as larval substrates for the Central European fauna. However, there appear to be two trophic adaptation strategies: a large group of species, as far documented, lives on dead wood, while the other, as primarily demonstrated by Schmid (2019) for *D. rhaetica* (Frey, 1856), feeds on lichens growing on rocks. Typical megabiomes of *Denisia* species thus encompass both forest habitats and rocky environments, extending into the alpine zone.

In the course of a comprehensive survey of Lepidoptera in the nature parks of the Cottian Alps (northwestern Italy) (Huemer and Wieser 2023), a new and previously unknown species of the genus *Denisia* has now been discovered, thanks to rigorous molecular identification controls using DNA barcoding.

In addition, a comprehensive checklist of European *Denisia* is provided in this paper.

Materials and methods

A total of 224 specimens of phenotypically similar *Denisia* have been examined morphologically: 4 *D. cryptica* sp. nov., 22 *D. nubilosella*, 133 *D. stipella*, 37 *D. similella*, 23 *D. fuscicapitella* (all Central Europe), and 1 *D. subaquilea* (Spain), 2 *D. obscurella* (Finland), 2 *D. luticiliella* (Russia). External and internal morphology of North American *D. haydenella* is based on Hodges (1974) and BOLD, with supplementing comments and unpublished figures from Landry (in litt.). Further externally very distinct species were only considered for genetic analysis. The material is preserved in the Research Collection of Tiroler Landesmuseum Ferdinandeum (Austria). Species identification is based on the phenotypic characteristics of the adults and partly confirmed by dissections and DNA barcoding.

Tissue samples (a single hind leg) from three *D. cryptica* sp. nov. were prepared according to prescribed standards to obtain DNA barcode sequences of an optimally 658 bp segment of the mitochondrial COI gene (cytochrome c oxidase subunit 1). The material was successfully processed at the Canadian Centre for DNA Barcoding (CCDB, Biodiversity Institute of Ontario, University of Guelph) using the standard high-throughput protocol described in deWaard et al. (2008). In addition, 155 public and private barcode sequences of 19 species of *Denisia* in the Barcode of Life Data Systems (BOLD; Ratnasingham and Hebert 2007; Ratnasingham 2018) were used for analysis. All barcode sequences, except for two shorter sequences of *D. pyrenaica*, range between 560 and 658 bp. Further details including complete voucher data and images can be accessed in the public dataset DS-DENISIA1 "Denisia sp.n. - Alps" dx.doi.org/10.5883/DS-DENISIA1 in the Barcode of Life Data Systems BOLD (Ratnasingham and Hebert 2007).

All sequences were assigned to Barcode Index Numbers (BIN), algorithm-based operational taxonomic units that provide an accurate proxy for the true species. BINs were automatically calculated for records in BOLD that comply with the DNA Barcode standard (Ratnasingham and Hebert 2013).

Degrees of intra- and interspecific variation of DNA barcode fragments were calculated using the Kimura two-parameter model on the platform of BOLD systems v. 4.0. (https://boldsystems.org). A Neighbor-Joining tree was constructed using the Kimura two-parameter model in MEGA7 (Kumar et al. 2016).

Photographs of adults were taken with an Olympus OM-D Mark III camera and a 60 mm macro lens, genitalia photographs with a Zeiss Axiolab 5 microscope, mounted with an Olympus OM-D Mark III camera. 60 to 90 stacked photographs were edited using Helicon Focus 4.8 and Adobe Photoshop 6.0.

A linguistic review was conducted on ChatGPT.

Abbreviations. **TLMF** = Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria.

Results

Molecular analysis

Molecular analysis is based on 158 DNA barcodes sequences for 19 *Denisia* species including selected public sequences from BOLD. The interspecific distances to the nearest neighbor vary from 4.3% to 9.3% per species pair, except for a species pair with alleged barcode sharing. Intraspecific barcode variation is generally much lower, with a maximum of 1.5% in most species but exceeds 4% in three species (see discussion) (Table 1, Fig. 1). The sequences grouped into 23 distinct and strongly divergent clusters, each with different BINs (except for *Denisia pyrenaica* and *Denisia graslinella* which currently have no BINs attached).

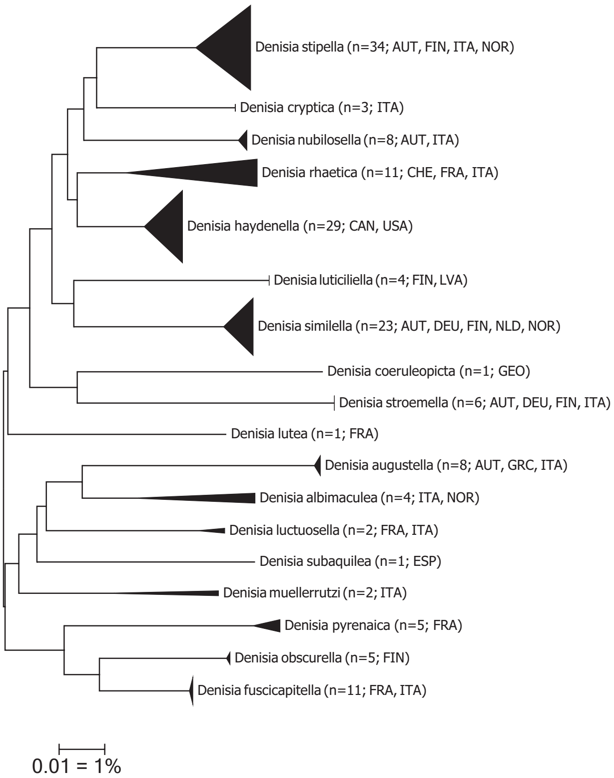


Figure 1. Neighbor-Joining tree of *Denisia* spp. (Kimura 2-parameter, built with MEGA7 (Kumar et al. 2016); Note: the scale bar only applies to internal branches between species. Width of triangles represent sample size, depth the genetic variation within the cluster. Source: DNA Barcode data from BOLD, DS-DENISIA1 (Barcode of Life Database; Ratnasingham 2018).

Table 1. Intraspecific mean K2P (Kimura 2 Parameter) divergences, maximum pairwise distances, Barcode Index Number (BIN), nearest species, distance to nearest neighbour (NN) (distances in %) of *Denisia* spp. Source: DNA Barcode data from BOLD, DS-DENISIA1 (Barcode of Life Database, cf. Ratnasingham 2018).

Species	Mean Intra-Sp	Max Intra-Sp	BIN	Nearest Species	Dist. NN
Denisia albimaculea	2.23	5.51	BOLD:ACW8519; BOLD:ACE2328	*Denisia augustella*	7.13
Denisia augustella	0.13	0.36	BOLD:ACW5127	*Denisia stipella*	5.72
Denisia coeruleopicta	N/A	0	BOLD:AEH2382	*Denisia haydenella*	8.34
Denisia cryptica	0	0	BOLD:AEF7084	*Denisia haydenella*	4.9
Denisia fuscicapitella	0.17	1.11	BOLD:AAU3742	*Denisia obscurella*	4.33
Denisia graslinella	N/A	0	-	*Denisia pyrenaica*	0.93
Denisia haydenella	0.63	2.5	BOLD:AAD4867	*Denisia cryptica*	4.9
Denisia luctuosella	1.08	1.08	BOLD:AFI9939	*Denisia muellerrutzi*	7.23
Denisia lutea	N/A	0	BOLD:AEG2567	*Denisia haydenella*	7.89
Denisia luticiliella	0	0	BOLD:AAQ3820	*Denisia stipella*	7.22
Denisia muellerrutzi	4.58	4.58	BOLD:ACE1985; BOLD:ACE1986	*Denisia luctuosella*	7.23
Denisia nubilosella	0.17	0.46	BOLD:AAP6545	*Denisia stipella*	5.73
Denisia obscurella	0.06	0.15	BOLD:AAI9703	*Denisia fuscicapitella*	4.33
Denisia pyrenaica	0.78	1.26	-	*Denisia graslinella*	0.93
Denisia rhaetica	4.22	6.29	BOLD:AAU0845; BOLD:AAU0846; BOLD:AAU0847	*Denisia haydenella*	5.38
Denisia similella	0.71	1.49	BOLD:AAE3459	*Denisia haydenella*	6.48
Denisia stipella	1.41	3.82	BOLD:AAD6108	*Denisia rhaetica*	5.31
Denisia stroemella	0	0	BOLD:AAL1494	*Denisia fuscicapitella*	9.35
Denisia subaquilea	N/A	0	BOLD:ACA9737	*Denisia luctuosella*	8.58

The three available *D. cryptica* sp. nov. sequences were assigned to one unique cluster. The mean intraspecific p-distance of *D. cryptica* sp. nov. is 0% (BIN:BOLD:AEF7084, n=3). The distance to the nearest neighbor *D. haydenella* from North America (BIN:BOLD:AAD4867) (n=92) is 4.9%.

Taxonomy

Denisia cryptica sp. nov.

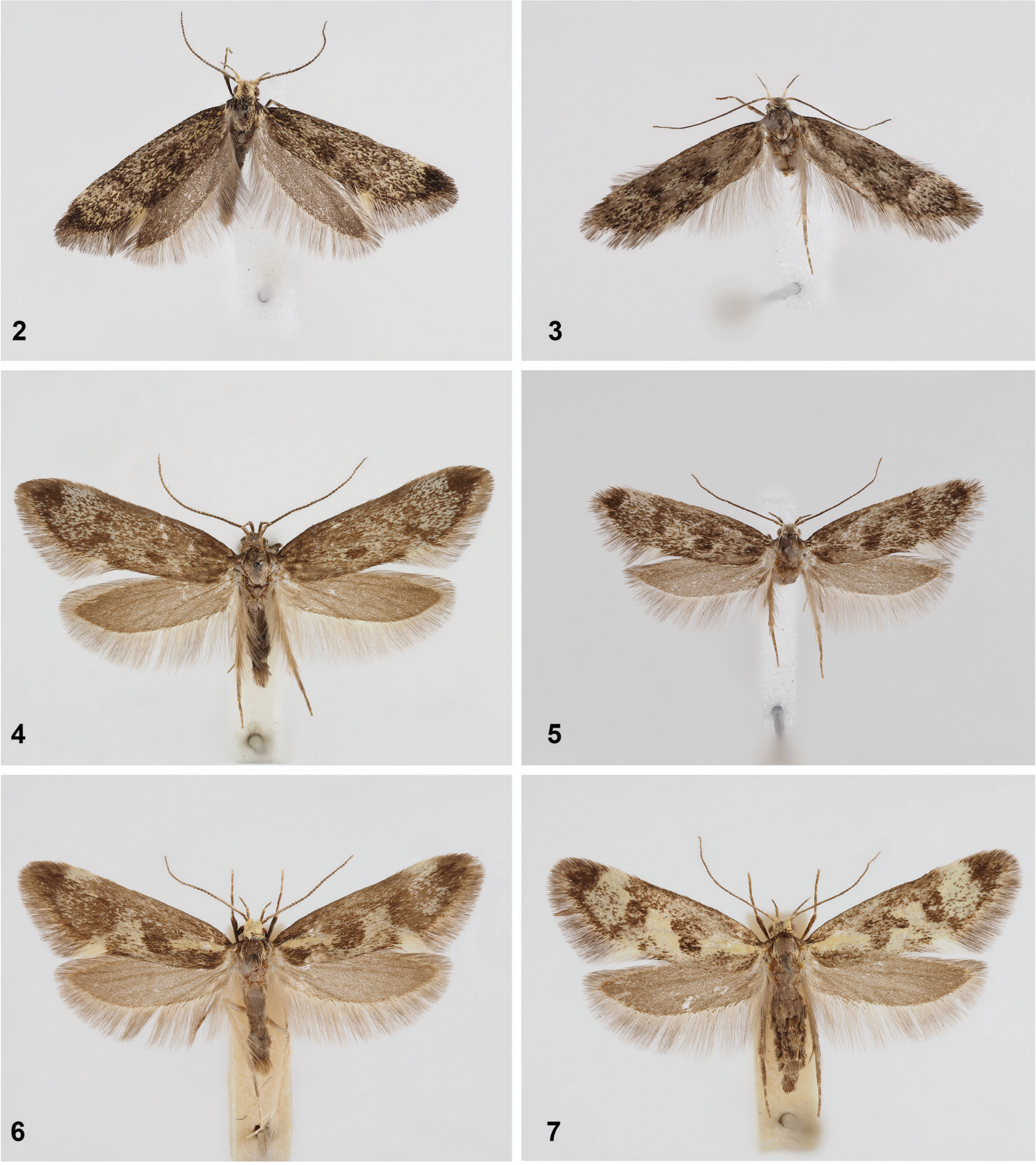
https://zoobank.org/9D72F563-4785-4CF8-8CF0-B9C718962909

Figs 2, 3, 8, 9, 14, 16, 18

Material examined. ***Holotype.*** Italy • ♂; Prov. Torino, Fenestrelle, Umg. Pracatinat, Forte delle Valli [type locality part of Orsiera-Rocciavrè Nature Park]; 1700–1720 m; 45°2'17"N, 7°4'14"E; 2 June 2022; leg. P. Huemer; DNA Barcode ID TLMF Lep 32850; TLMF.

Paratypes. Italy • 1 ♂; same collection data as holotype; • 1 ♂, 1 ♀; Prov. Torino, PN Orsiera - Rocciavré, Villaretto, Gran Faetto, Colletto; 1445 m; 45°00'28"N, 07°08'28"E; 19 June 2020; leg. P. Huemer; gen. slides GEL 1305♂, 1306♀ P. Huemer; DNA Barcode IDs TLMF Lep 29494, TLMF Lep 30299; TLMF. France • 1 ♂, Hautes-Alpes, Brunissard, Arvieux; 1900 m; 5 July 1995; leg. J. Nel; gen. slide 3197♂ J. Nel; TLMF • 1 ♂, Alpes-de-Haute-Provence, La Fayée de Lure; 1550 m; 4 July 1998; leg. J. Nel; gen. slide 7225♂ J. Nel; TLMF.

Diagnosis. *Denisia cryptica* sp. nov. differs from species with similar forewing patterns and coloration by the yellow-scaled head and the second segment of the labial palpus, which is at least partially yellow on the inner side. The overall similar species *D. nubilosella* (Figs 4, 5) and *D. haydenella* have a dark brownish-grey coloration of the head, which is sometimes mottled cream-white, particularly in females. However, the labial palps are grey-brown on the inner side with only few whitish scales on the second segment, lacking the extended yellow of the new species. Furthermore, the scapus is predominantly grey-brown and not cream-yellow in both relatives (Figs 10, 11). Additionally, the intense yellow speckling on the upper surface of the forewings of *D. cryptica* sp. nov. is absent in the mentioned species which at most exhibit some cream mottling, particularly in females. A dark head and labial palps are also typical for *D. fuscicapitella*, *D. obscurella* and *D. caucasiella* which in addition differ by pattern of the forewing upperside. *Denisia stipella* and *D. similella* (Figs 12, 13) also have a yellow head and extensive yellow coloration of the second segment of the labial palpus but both species differ immediately from *D. cryptica* sp. nov. by the striking yellow pattern of the upper surface of the forewings (Figs 6, 7). Significant differences in forewing patterns also apply to all other species of the genus. The male genitalia of *D. cryptica* sp. nov. are extremely like several species of *Denisia*, with at most subtle differences in the length and shape of the uncus and the valva (Figs 14, 15). Female genitalia are also very similar to other species, with potentially diagnostic features such as the shape of the signum (based on a single specimen) (Figs 16–19). However, except for one pair of species, all sequenced species (19 out of 24) exhibit significant divergences in DNA barcodes (Fig. 1).



Figures 2–7. Adults; **2.** *Denisia cryptica* sp. nov., holotype, male, Italy; **3.** *D. cryptica* sp. nov. paratype, female, Italy; **4.** *D. nubilosella*, male, Austria; **5.** *D. nubilosella*, female, Austria; **6.** *D. stipella*, male, Germany; **7.** *D. stipella*, female, Germany.

Description. Adult (Figs 2, 3, 8, 9). Head brush cream-yellow, particularly scales above compound eye, medially and on frons brownish-yellow; scapus cream-yellow, with pecten, flagellum grey-brown with few whitish scales, pectinate in male, filiform in female; labial palpus recurved, second segment cream-yellow on inner side, outer surface and third segment grey-brown mottled with some cream-yellow. Thorax and tegulae grey-brown, mottled with cream-yellow, particularly in posterior part. Forewing length 7.4–7.6 mm (male), 6.8 mm (female); forewing ground color grey-brown with extended cream-yellow mottling (cream-withe in the only available female) except for costal base, medial dot-like area and apex; fringes dark grey-brown, lighter in tornal area with small cream-yellow spot at tornus; hindwing light grey-brown with concolorous fringes;

Figures 8–13. Adults, head (dorsal and dorsolateral view); **8.** *Denisia cryptica* sp. nov., holotype, male, Italy; **9.** *D. cryptica* sp. nov. paratype, female, Italy; **10.** *D. nubilosella*, male, Austria; **11.** *D. nubilosella*, female, Austria; **12.** *D. stipella*, male, Germany; **13.** *D. stipella*, female, Germany.

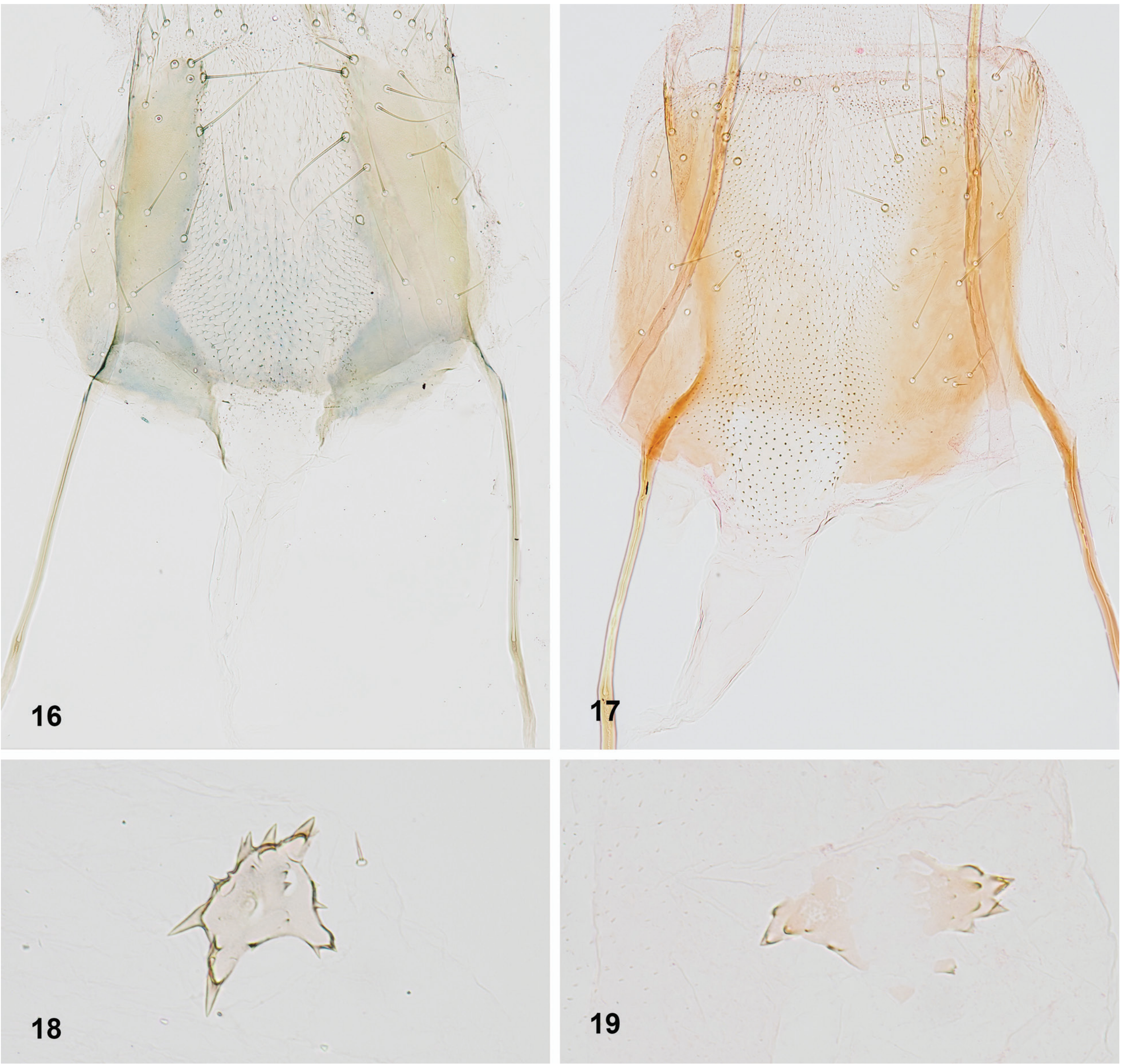
underside of wings unicolorous grey-brown. Legs grey-brown, mixed with cream at lower surface. Abdomen grey-brown.

Male genitalia (Fig. 14). Uncus broad and short, sub-triangular, apically pointed; gnathos massive, sub-triangular, distinctly longer than uncus, ventral part with pointed apex, dorsal part with dentate cushion like structure; valva broadly sub-oval, distal part rounded, sacculus broad but weakly demarcated, inner side largely covered with long setae; saccus broadly rounded; juxta lobe long and basally broad with recurved digitate distal part and upwards curved pointed apex, phallus short and slender, basally slightly inflated, without cornuti.


14


15

Figures 14, 15. Male genitalia; **14.** *D. cryptica* sp. nov. paratype, Italy, slide GEL 1305 P. Huemer; **15.** *D. stipella*, Italy, GEL 496 P. Huemer.



Figures 16–19. Female genitalia, **16–17.** Details of segment VIII; **18–19.** Signum enlarged **16, 18.** *D. cryptica* sp. nov. paratype, Italy, slide GEL 1306 P. Huemer; **17, 19.** *D. stipella*, Austria, GEL 932 P. Huemer.

Female genitalia (Figs 16, 18). Posterior apophyses approximately two times length of segment VIII; anterior apophyses approximately reaching the length of segment VIII. Segment VIII without special processes or indentations; lateroventral area conspicuously sclerotized with some strong setae in posterior part, posterior edge rounded, anterior edge with advanced acute sclerotization that border the indistinctly separated membranous antrum laterally; ventromedial area continuously covered with numerous tiny microtrichia. Signum very small, irregularly bounded plate with several thorns on outer edge.

Biology. Adults have been collected in June at light (Fig. 20). Host-plant and early stages are unknown. However, like related species it possibly feeds under the bark of decaying or dead trees. From the habitat, *Pinus sylvestris* is the most likely candidate as host plant. Contrariwise, *D. nubilosella* seems to be restricted to *Picea abies*.

Distribution. Currently only known from two localities in the Cottian Alps (northern part) (Italy) and furthermore from two isolated spots in the French Alps but likely more widely distributed.

Etymology. The species name refers to the cryptic appearance of the new species and is derived from the latin adjective *crypticus*.

Remarks. Examined specimens from France were misidentified as *D. nubilosella* and the occurrence of that species in the south-western Alps requires confirmation.

Figure 20. Type-locality of *Denisia cryptica* sp. nov. with light equipment used for collecting.

Checklist of European *Denisia*

Genus *Denisia* Hübner, 1825

Denisia Hübner, 1825. Type species: *Phalaena* (*Tinea*) *stipella* Linnaeus, 1758

Blepharocera Chambers, 1877 *nec* Agassiz, 1847 (homonym)

Chambersia Riley, 1891

***Denisia stroemella* (Fabricius, 1779) (*Tinea*)**

***Denisia obscurella* (Brandt, 1937) (*Borkhausenia*)**

***Denisia rhaetica* (Frey, 1856) (*Oecophora*)**

Lampros engadinella Herrich-Schäffer, 1856

***Denisia pyrenaica* Leraut, 1989**

***Denisia graslinella* (Staudinger, 1870) (*Oecophora*)**

***Denisia muellerrutzi* (Amsel, 1939) (*Borkhausenia*)**

***Denisia luctuosella* (Duponchel, 1840) (*Lita*)**

Lita funestella Duponchel, 1838

Borkhausenia luctuosella sardiniella Amsel, 1936

***Denisia ragonotella* (Constant, 1885) (*Oecophora*)**

Borkhausenia reducta Walsingham, 1901

Borkhausenia ragonotella f. bifasciella Amsel, 1939 (infrasubsp.)

***Denisia augustella* (Hübner, 1796) (*Tinea*)**

[*Tinea*] *moestella* Geyer, 1832

Oecophora augustella var. *latoniella* Millière, 1875

Lita tiliicolella Bruand, 1859

***Denisia piresi* Corley, 2014**

***Denisia albimaculea* (Haworth, 1828) (*Tinea*)**

Oecophora albilabris Zeller, 1850

Oecophora schmidii Saalmüller, 1881
Schiffermuelleria stauderella Mitterberger, 1914
Schiffermuelleria augustella var. *corsicella* Caradja, 1920
Borkhausenia albimaculea sardiniella Amsel, 1936

***Denisia lutea* Varenne & Nel, 2019**
***Denisia similella* (Hübner, 1796) (*Tinea*)**
***Denisia fuscicapitella* Huemer, 2001**
***Denisia luticiliella* (Erschoff, 1877) (*Oecophora*)**
Oecophora irroratella Staudinger, 1880

***Denisia caucasiella* Lvovsky, 2007**
***Denisia stipella* (Linnaeus, 1758) (*Phalaena* (*Tinea*))**
Phalaena (*Tinea*) *accessella* [Denis & Schiffermüller], 1775
Tinea sulphurella Hübner, 1796
Tinea tigrella Hübner, 1813
Lampros westermannella Zetterstedt, 1839

***Denisia cryptica* sp. nov.**
***Denisia nubilosella* (Herrich-Schäffer, 1854) (*Lampros*)**
***Denisia subaquilea* (Stainton, 1849) (*Oecophora*)**
brittanicella Herrich-Schäffer, 1854 [uninominal]

***Denisia fiduciella* (Rebel, 1935) (*Borkhausenia*)**
***Denisia aragonella* (Chrétien, 1903) (*Oecophora*)**
***Denisia coeruleopicta* (Christoph, 1888) (*Oecophora*)**

Remarks. Generic descriptions were published by Tokár et al. (2005) and are not repeated herein. The systematic arrangement of species follows Lepiforum (2024) and is mainly based on superficial morphological resemblance of wing pattern and genitalia structures. Original generic assignment in brackets.

Discussion

The discovery of a potentially local endemic species in the European Alps may come as a surprise at first glance. However, the Southern Alps exhibit a particularly high degree of endemism (Huemer 1998). The area of the Cottian Alps has long been recognized as a hotspot for endemic Lepidoptera, and even in the 21st century, several new species have been described from there (Baldizzone and Gaedike 2004; Gianti 2005; Huemer and Hebert 2011; Nel 2012; Huemer and Mutanen 2015; Huemer et al. 2020). The systematic application of molecular methods in identifying extensive newly collected material, however, suggests an astonishingly large number of additional, previously overlooked cryptic species (Huemer and Wieser 2023).

As a fundamental issue in the delineation of *Denisia* species, the widespread cryptic morphology of many representatives of the genus has proven to be a challenge. Similarities in external appearance occur in numerous species pairs or groups. However, even the delineation using genital morphological characteristics often reaches its limits in this genus, meaning that the specifically evaluated genital morphology is frequently based on subtle features. Here, a characterization of species using molecular data, especially DNA barcode sequences, appears to lead to more indisputable results. All analyzed species of *Denisia* exhibit significant interspecific divergences on the order of approximately 4–9%. This extent of genetic divergence appears to be highly representative for the genus due to the large number of sequenced taxa. Out of the globally described 24 species, barcode sequences are available for 19 species. Only the species pair *D. pyrenaica* and *D. graslinella* shows, based on the few known sequences, an overlap in the DNA barcode, which may, however, possibly be due to a previously overlooked synonymy of these two taxa. Conversely, striking intraspecific divergences have also been documented in the genus *Denisia*, exceeding 5% in *D. rhaetica* and *D. albimaculea*. However, initial analyses suggest further overlooked cryptic diversity, although taxonomic revisions in these species groups are still pending.

The newly described *D. cryptica* sp. nov. fits into the overall picture of a genetically strongly divergent species, which, however, is difficult to differentiate from other congeners both phenotypically and in genitalia structures. Most helpful and effective are especially complexes of features from color and pattern of the forewing upper surface combined with head coloration and colour of the labial palps and antennae.

Acknowledgments

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Alpine
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A threefold plant specialist – distribution, habitat requirements and nesting biology of the rare leafcutter bee *Megachile genalis* in the eastern Swiss Alps (Hymenoptera, Megachilidae)

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Abstract

The leafcutter bee *Megachile genalis* Morawitz, which nests in thick, erect and usually hollow plant stems, is rare and endangered throughout Europe. In Switzerland, it was recorded only six times in the Grisons between 1932 and 2019. In order to create the necessary basis for the conservation of this rare bee, its distribution, habitat requirements and nesting biology were investigated in the eastern Swiss Alps by systematically searching for its nests, by DNA metabarcoding of the cell-building material, by analysing the pollen contained in abandoned brood cells and larval faeces, and by deducing aspects of the species' nesting biology from collected old nests. A total of 141 new and 64 old nests were discovered at elevations between 600 m and 1270 m in – with decreasing frequency – the Albula Valley, the Lower Engadine, the Domleschg and the Ruinaulta. The nests were exclusively built in living stems of *Peucedanum verticillare* (Apiaceae), an up to 2–3 m tall umbellifer that grew on fallow land, road and railway embankments, scree slopes, ruderal areas and forest clearings. The leaf fragments used by the females of *M. genalis* to construct the brood cells in 20 selected nests were largely from shrubs and trees of the Rosaceae (e.g. *Rosa*, *Rubus*, *Prunus*, *Sorbus*), rarely also from *Corylus* (Betulaceae). The pollen in 65 brood cells was exclusively collected on thistles (e.g. *Arctium*, *Carduus*, *Cirsium*) and other Asteraceae. The nests were characterised by a surprisingly high variability in their architecture. They consisted of i) an approximately 6 mm x 9 mm large nest opening gnawed by the female bee at a height of 22–217 cm above ground with her mandibles, which are well adapted to penetrate the hard stem walls due to their enlarged base indicating strong adductor muscles and the short and chisel-like shape; ii) a 5–25 mm thick nest plug built 1.5–45 cm below the nest opening from pith particles, leaf fragments and/or grass fibers; iii) 1–14 brood cells usually arranged in one cigar-like series and lying 11–99 cm below the nest opening; and iv) a facultative 4–40 mm thick basal plug consisting of pith particles and/or leaf fragments. Brood mortality was high: at least 56% of 284 brood cells were unsuccessful due to parasites, mould or unknown reasons, and reproduction completely failed in almost half of 46 nests. The most harmful brood parasite was *Melittobia acasta* Walker (Hymenoptera, Eulophidae), which infested 19% of the brood cells and 28% of the nests. Measures to conserve the population of *M. genalis* in the eastern Swiss Alps should focus on the conservation and propagation of suitable habitats for *P. verticillare* in close vicinity to Asteraceae-rich areas and on the promotion of thistles.

Key Words

Anthophila, Apiformes, *Coelioxys inermis*, conservation, *Exeristes roborator*, *Lasiambia*, mandibular strength, metabarcoding, pollen analysis, *Trichodes apiarius*, *Xylophrurus augustus*

Introduction

Leafcutter bees of the genus *Megachile* (Megachilidae) use fragments of green leaves or, more rarely, flower petals to build their brood cells, which they either hide in preexisting cavities (insect borings in dead wood, hollow stems, rock and soil crevices, hollow spaces under stones) or in self-excavated burrows in dead wood, pithy stems or loose soil (Praz 2017; Westrich 2018). According to current knowledge, most Central European *Megachile* species appear to be rather flexible in the selection of their nesting sites. One exception is *M. genalis* Morawitz, which constructs its nests exclusively in erect stems of various thick-stalked plants (Ruhnke 1998, 2000; Westrich 2018).

Megachile genalis is very rare throughout Europe and red-listed in Belgium, the Czech Republique, Germany, Slowakia and Switzerland (Feráková et al. 2001; Westrich et al. 2011; Straka and Bogusch 2017; Drossart et al. 2018; Müller and Praz 2024). In Switzerland, it is one of the rarest bee species. It was recorded only six times in the Grisons before 2023, namely in the Lower Engadine in 1932, 2004 and 2013 and in the Albula Valley in 2016, 2017 and 2019. Despite a targeted search in 2018 in the frame of the elaboration of a red list of bees in Switzerland, *M. genalis* was not rediscovered in the Lower Engadine, rendering the Albula Valley the only region in Switzerland where the species was assumed to occur today.

The main objectives of the present study were to clarify the current distribution and abundance of *M. genalis* in the Grisons, to investigate the species' requirements for nesting site, nest-building material and host plants and to get some insights into its poorly known nest architecture. The results should create the necessary basis for the conservation and promotion of this rare bee species at its current sites of occurrence in the eastern Swiss Alps.

Methods

Bee species

Megachile genalis, which belongs to the subgenus *M.* (*Megachile*) (Praz 2017), is a 10–14 mm long bee species distributed from Western Europe via Turkey to easternmost Russia and Japan (Ascher and Pickering 2020; Fig. 1a). In Central Europe, it is a univoltine, late-flying species active from mid-June to early September (Westrich 2018), while in warmer parts of eastern Europe it may have two generations (Wiesbauer 2023). A typical character of the females are the basally strongly inflated mandibles not found in any other European *Megachile* species (Fig. 1b–d). The species builds its nests in erect, thick and usually hollow, rarely pithy stems of various plants (Dudich 1884; Henschel 1888; Buysson 1902; Friese 1923; Grandi 1954, 1957; Dorn and Weber 1988; Ruhnke 1998, 2000; Westrich 2018; Sobieraj-Betlińska 2021; Tischendorf 2021; Wiesbauer 2023). In contrast to all other stem-nesting bee species of Europe, living rather than dead stems are used as nesting sites (Ruhnke 1998, 2000; Westrich 2018; Wiesbauer 2023). Nests of *M. genalis* are easily recognized by the usually oblong-oval shape of the nest opening, which is gnawed by the females into the stem (Figs 1g, h, 5a–d). The nests contain several brood cells, which lie inside the stem in a linear series and are nested into each other forming a cigar-like structure (Fig. 6a, c, h, i). For the construction of the brood cells, the females use roundish to oval leaf pieces (Figs 1g, 6e), which are cut out on green leaves. The brood cells are supplied with a mixture of pollen and nectar supposed to be collected mainly on Asteraceae (Ruhnke 1998, 2000; Westrich 2018; Wiesbauer 2023; Fig. 1a, h). The winter is spent as a prepupa inside a self-spun cocoon within the brood cell (Fig. 6g).

Study area

The main study area was located in the Parc Ela (Grisons) in the eastern Swiss Alps and encompassed the Albula Valley between Alvaschein in the west and Davos Wiesen in the east (Fig. 2). Within the Albula Valley, 16 subplots ranging in area from 4 ha to 53 ha at altitudes between 900 m and 1400 m were selected to search for nests of *Megachile genalis*. These subplots were primarily chosen based on the frequency of sun-exposed fallow land expected to contain plant stems suitable for nesting by *M. genalis*, such as unmown edges along forests and hedges, uncultivated farmland, road and railway embankments or forest clearings. After the fieldwork had revealed that *M. genalis* nests in stems of *Peucedanum verticillare* (L.) Mert. & W. D. J. Koch (Apiaceae) in the Albula Valley (see Results), four additional study areas in the Grisons with known populations of *P. verticillare* were selected (Fig. 2), i.e. the Lower Engadine between Ardez and the border with Austria (one subplot of 465 ha at altitudes between 1000 m and 1400 m), the Domleschg (five subplots ranging from 29 ha to 119 ha at altitudes between 600 m and 1100 m), the Ruinaulta (two subplots of 47 ha and 88 ha at altitudes between 600 m and 850 m) and the surroundings of Chur (two subplots of 26 ha and 33 ha at altitudes between 550 m and 1000 m). The selection of the subplots in these four additional areas was based on data provided by the National Data and Information Center on the Swiss Flora (info flora) on the occurrence of *P. verticillare* in Switzerland after 1999.

Nesting biology

In the 26 subplots of the five study areas, nests of *Megachile genalis* were searched for during a total of 14 days and 105 hours from 23 July to 5 October 2023. Both living and dead and both hollow and pithy stems of all plant species and individuals with an outer stem diameter of at least 10 mm near their base were checked for the presence of the characteristic nest openings, which differ from those of other stem-nesting aculeate Hymenoptera, such as *Hoplitis tridentata* (Dufour & Perris) (Megachilidae), by their size and their oblong-oval shape (Fig. 5a–d). Due to the relatively large body size and the relatively thick cell walls consisting of several layers of leaf fragments, *M. genalis* is not expected to nest in stems with an outer diameter of less than 10 mm, which is confirmed by Ruhnke (1998, 2000), who recorded a minimum outer stem diameter of 13.5 mm in 36 nests.

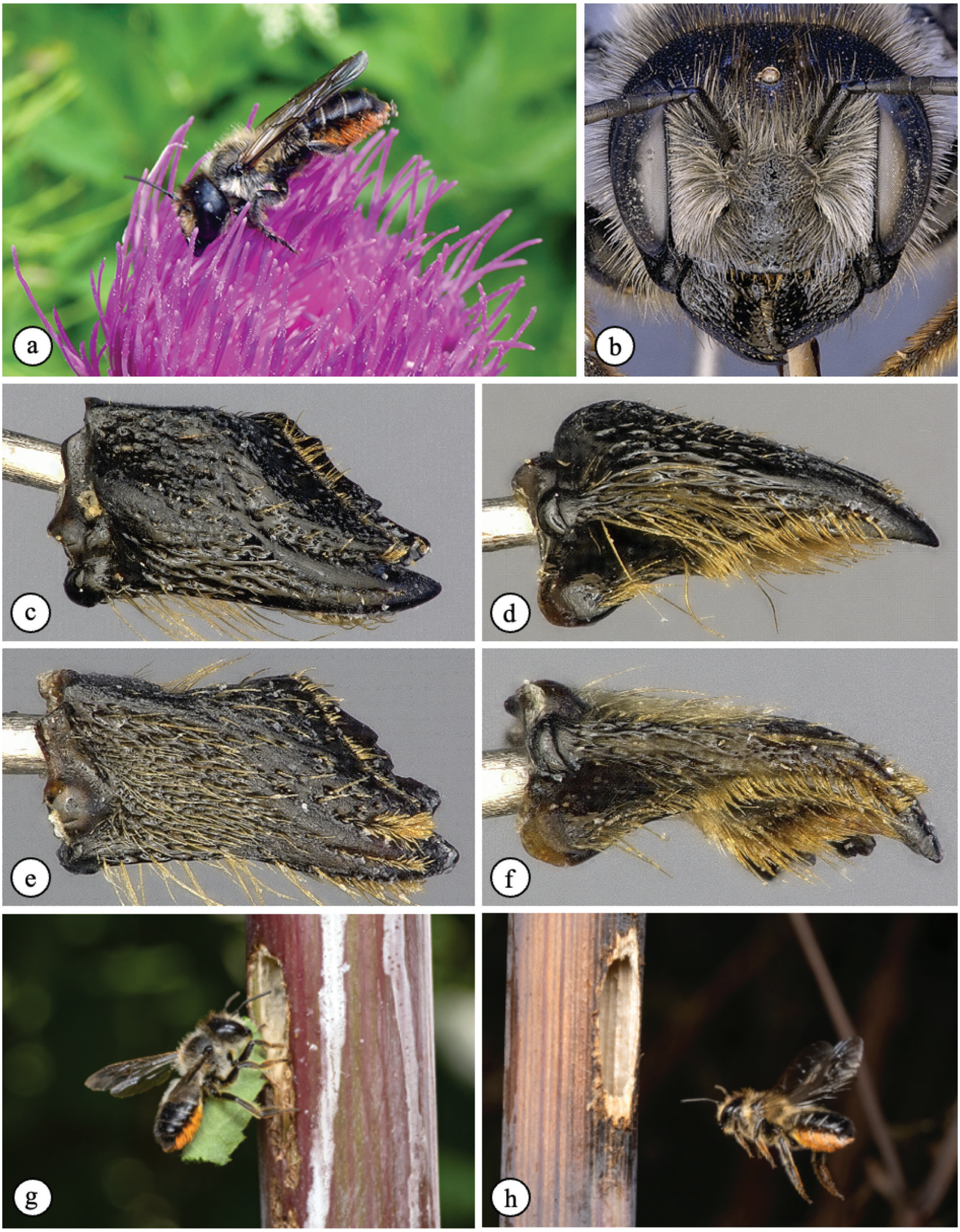

Figure 1. *Megachile genalis* and *M. centuncularis*. **a.** Female of *M. genalis* visiting *Cirsium palustre*; **b.** Head of *M. genalis* with basally inflated mandibles; **c, d.** Specialised mandible of *M. genalis* in **c.** Front view and **d.** Ventral view; **e, f.** Unspecialised mandible of *M. centuncularis* in **e.** Front view and **f.** Ventral view; **g, h.** Female of *M. genalis* entering her nest with: **g.** A rosaceous leaf fragment and **h.** Asteraceae pollen in the metasomal scopa.

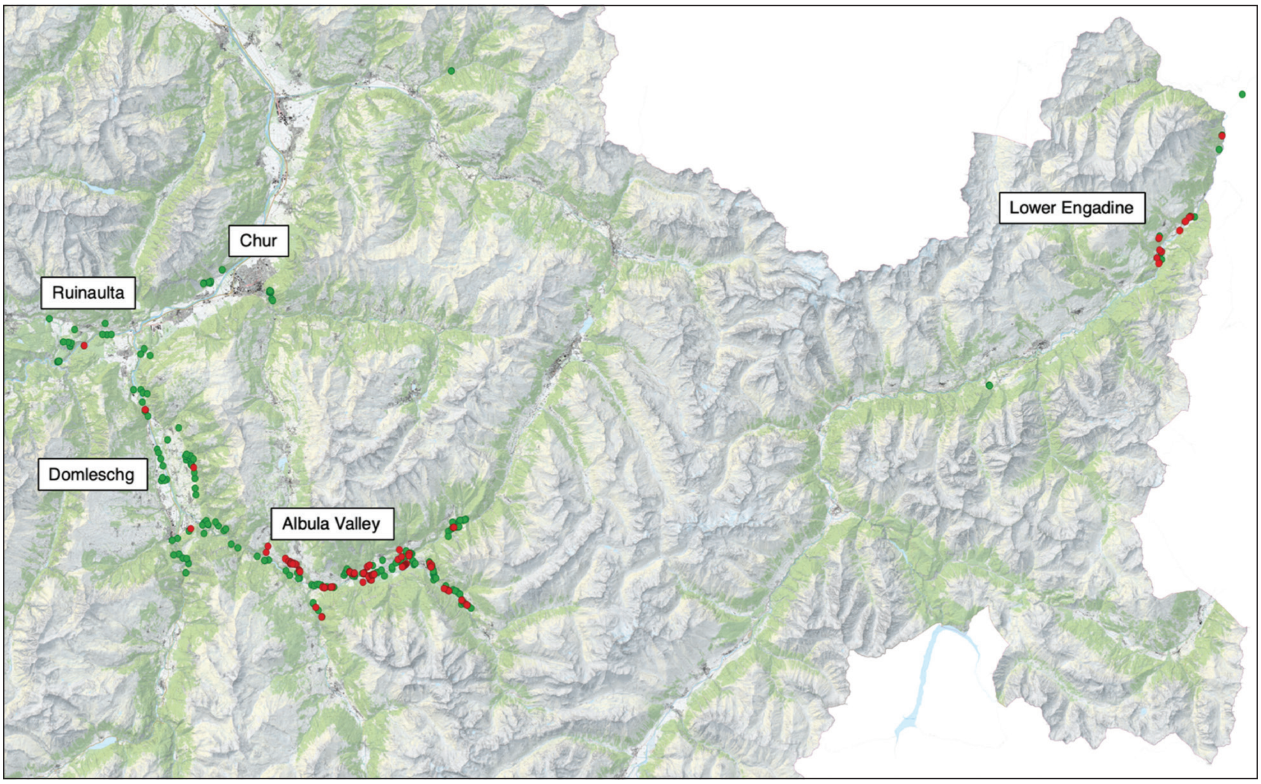

Figure 2. Distribution of *Megachile genalis* and *Peucedanum verticillare* in the eastern Swiss Alps. Red dots = nests of *M. genalis* discovered in 2023, green dots = records of *P. verticillare* after 1999.

For nests discovered in living plant stems, the following parameters were recorded in the field: i) plant species, ii) distance between ground and lower margin of nest opening, iii) longitudinal and transverse diameter of nest opening, iv) outer diameter of stem at level of nest opening, and v) compass direction of nest opening. In contrast to nests in living stems, which were left undisturbed in place with few exceptions, nests in dead and thus at least one year old stems were collected to record the following additional parameters in the laboratory: vi) inner diameter of stem at level of nest opening, vii) presence and composition of (traces of) nest plugs, viii) position and number of brood cells, ix) outer and inner diameter of stem at level of brood cells, and x) larval mortality and brood parasites. The identification of brood parasites was based on dead specimens found inside the brood cells. As all nests discovered in dead stems turned out be old nests from the last year or the year before the last year (see Results), the parameters vi)–x) could not be assessed for each old nest resulting in different parameter sample sizes.

To identify the plant sources of the leaf fragments used by the females of *M. genalis* to construct the brood cells, the outer leaf layers were removed from 157 cells of 20 nests collected in eight different subplots in the Albula Valley. The leaf fragments from all cells of a nest were pooled resulting in 20 leaf samples. These samples were analysed by AIM - Advanced Identification Methods GmbH (Leipzig, Germany) applying DNA metabarcoding. After homogenisation of the leaf fragments, DNA of 80 mg leaf material from each nest was extracted with the Qiagen DNeasy Plant Kit following the manufacturer's manual. From the extracted DNA, barcoding sequences of the nuclear marker ITS2 were PCR amplified using target specific next-generation sequencing primers and analysed by amplicon sequencing on the Illumina MiSeq platform. Amplified sequences with a minimum length of 100 base pairs were kept and clustered into a total of 192 operational taxonomic unit sequences (OTU). Given the many pitfalls of the metabarcoding approach (Förster et al. 2023), the automated identifications to genus and species level were manually checked by entering all OTU sequences represented by more than five reads (n = 62) into the BOLD identification system for ITS (https://boldsystems.org/index.php/IDS_OpenIdEngine; accessed January 2024). For each OTU sequence, the plant taxon with the highest score ("Best ID") was selected. If the Best ID referred to a species that is either not native to Central Europe or does not occur in the study area, the identification was left at genus level. Overall, the automated identifications of 53% of all OTU sequences had to be adjusted. The determination of the proportion of plant taxa used for brood cell construction was limited to OTU sequences with more than five reads, which accounted for 99.8% of the total number of reads.

To assess whether the unique shape of the female mandibles of *M. genalis* might be related to the species' habit to gnaw holes into the walls of plant stems, the mandibles of the following European *Megachile* species were compared with those of *M. genalis* based on photomicrographs of three amputated and unworn mandibles per species: *M. alpicola* Alfken, *M. centuncularis* (L.), *M. lapponica* Thomson, *M. ligniseca* (Kirby), *M. melanopyga* Costa, *M. octosignata* Nylander, *M. pyrenaea* Pérez, *M. pilicrus* Morawitz, and *M. versicolor* Smith. These species all belong to the same subgenus *M.* (*Megachile*) as *M. genalis* and usually nest in preexisting cavities above or more rarely below ground. In contrast to *M. genalis*, they need free access to the nest cavity and do not use their mandibles to gnaw the nest entrances into the plant substrate (Praz 2017; Westrich 2018). To determine the ratio of mandibular length to mandibular width, the maximum length of the mandible (from the condyle to the apex of the apicalmost tooth) and the maximum width of the mandible at its base (from the acetabulum to the condyle) was measured.

Pollen hosts

To investigate the pollen host preferences of *Megachile genalis*, pollen samples from 65 brood cells originating from 39 old nests, which were collected in eight subplots in the Albula Valley, were microscopically analysed. The pollen samples were taken either from pollen remains in cells with dead larvae (n = 22 cells) or from the faeces layer surrounding the cocoon wall (n = 43 cells; Fig. 6f). The digested pollen grains in the larval faeces could still be identified based on the characteristics of the exine, which remained intact during the passage through the larval gut. The pollen samples from the cells and the faeces were dissolved in a drop of distilled water and embedded in glycerine gelatine on a microscopic slide. For each sample, 300 pollen grains were identified under a light microscope at a magnification of 400 × along a randomly selected line across the coverslip (12 × 12 mm). If the sample contained several pollen types, the relative pollen volume of each pollen type was determined by correcting the number of counted grains with the volume of the pollen types contained in the sample.

Results

Distribution

Nests of *Megachile genalis* were found in four of the five study areas at elevations between 600 m and 1270 m (Fig. 2). With 176 nests discovered, the Albula Valley proved to be the stronghold of *M. genalis* in the eastern Swiss Alps, followed by the Lower Engadine (23 nests), the Domleschg (5 nests) and the Ruinaulta (1 nest). No nests were found in the surroundings of Chur, which is most probably explained by the very low number of erect plant stems suitable for nesting.

Nesting biology

Nesting site

In total, 205 nests of *Megachile genalis* were discovered. Of these nests, 141 were in living and 64 in dead stems. None of the nests found in dead stems was built in the year of discovery, indicating that the females of *M. genalis* selected only living stems for nesting.

Although all plant stems with a minimum outer diameter of 10 mm were examined for the presence of the typical oblong-oval nest openings, nests of *M. genalis* were exclusively found in stems of *Peucedanum verticillare* (Apiaceae), a monocarpic umbellifer up to 2–3 m tall that grows vegetatively for two to four years, produces a large inflorescence in the third to fifth year and then dies (Fig. 3a–c). The stems of *P. verticillare* are hollow and consist of several internodia separated by thin transverse partitions of pith at the nodi (Fig. 3d, e).

The nesting habitat of *M. genalis* coincides with the growth sites of *P. verticillare*, which – due to the plant's special life cycle – tolerates neither regular mowing nor grazing and thus occurs mainly on fallow land, along road and railway embankments, on scree slopes and ruderal areas as well as on forest clearings (Fig. 4a–h).

Nest architecture

The nests of *Megachile genalis* consisted of i) the nest opening gnawed by the female, ii) the nest closure built between the nest opening and the brood cells ("nest plug"), iii) the brood cells and iv) a facultative basal plug below the brood cells.

The *nest openings* (Fig. 5a–d) were situated at a height of 22–217 cm above ground (Table 1, Fig. 7a). They were on average 8.6 mm long and 5.9 mm wide (Table 1) and oriented in all directions, but predominantly in the sector from east to south (n = 92 of 138 nests; Fig. 7b). Almost two thirds of the nest openings were situated in the uppermost fifth of the internodium with the distance between the upper margin of the nest opening and the stem nodus above it averaging 5.1 cm or 23.2% of the total length of the internodium, which measured on average 22 cm (Table 1). The average diameter of the stem at the level of the nest opening was 14.4 mm on the outside and 10.5 mm on the inside (Table 1).

The *nest plugs* strongly varied in the material used, the thickness and the position within the stem. In 13 of 22 nests with a preserved closure, the plug was constructed from densely packed particles of pith only, which originated from the inner stem wall as was evident from the gnawing marks usually just above the plug (Fig. 5f); in one case, two layers of pith particles in a distance of 9.5 cm were present. In four nests, the plug consisted of 9–10 loosely to densely packed leaf fragments (Fig. 5g). In two nests, the plug was two-layered with an upper layer of densely packed pith particles immediately adjacent to a lower layer of 8–10 leaf fragments (Fig. 5h). And in one nest each, the plug consisted of 12 leaf fragments intermixed with pith particles (Fig. 5i), of densely packed grass fibres (Fig. 5j), and of three adjacent layers built from a mixture of pith particles and grass fibres above, followed by an empty space and densely packed pith particles in the middle and several leaf fragments below (Fig. 5k). The thickness of the one- and two-layered plugs ranged from 5–25 mm (Table 1), while the single three-layered plug was 59 mm thick including the 15 mm long empty space in between. The plugs of 31 nests were positioned 1.5–45.0 cm below the nest opening (Table 1), either

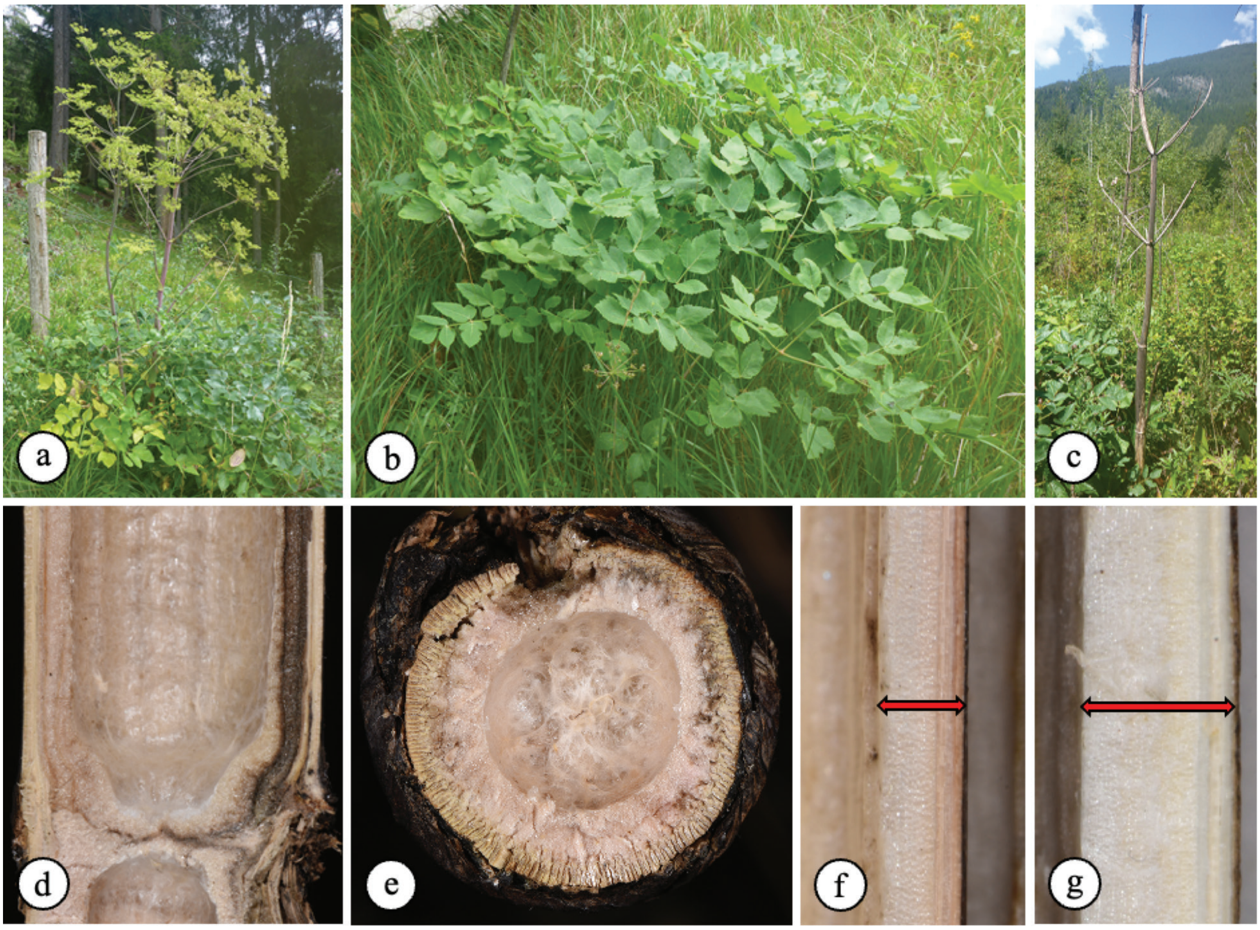

Figure 3. *Peucedanum verticillare*. **a.** Plant in flower; **b.** Leaf rosette; **c.** Dead plant; **d, e.** Transverse partition of pith between two internodia **d.** In lateral view and **e.** In top view; **f, g.** Thickness of stem wall at level of **f.** Nest opening (1.8 mm) and **g.** Brood cells (3.2 mm).

within the same internodium as the nest opening (n = 8), within the same internodium as the brood cells (n = 14), within the same internodium as both nest opening and brood cells (n = 6) or within an internodium between the nest opening and the brood cells (n = 3). They were built either in the central section of the internodium (n = 24) or directly above or below the nodus (n = 7).

The *brood cells* were mostly located far below the nest entrance; the distance between the bottom of the lowest brood cell and the nest opening was on average 49.9 cm (Table 1, Fig. 7d). In 9 (16.1%) of 56 nests, the brood cells were placed in the same internodium as the nest opening, in 17 nests (30.4%) one internodium below, in 20 (35.7%) two internodia below, in 9 (16.1%) three internodia below and in 1 nest (1.7%) four internodia below. As the internodia are separated from each other by 2–4 mm thick transverse partitions consisting of soft pith (Fig. 3d, e), female bees that did not construct the brood cells in the same internodium as the nest opening had to gnaw through one or more partitions (Fig. 5e). The average diameter of the stem at the level of the brood cells was 20.0 mm on the outside and 14.3 mm on the inside and thus about 5 mm wider than at the level of the nest opening (see above and Table 1).

The nests contained 1–14 brood cells (Fig. 7c). In 41 of 49 nests, the cells were in one contiguous, cigar-like series (Fig. 6a) either at the bottom of the internodium directly adjacent to the nodus (n = 28) or in the central section of the internodium (n = 13); in the other nests, the cells were divided into two (n = 6) or three series (n = 2; Fig. 6b) distributed in one (n = 2) or two internodia (n = 6). As an exception, two of 56 nests contained one and four downwards-facing brood cells in the internodium above the nest opening in addition to the brood cells below the nest opening, and one stem contained two nests, each with its own opening.

The walls of the brood cells consisted of several layers of loosely connected and easily detachable leaf fragments on the outside and a few layers of tightly connected leaf fragments on the inside (Fig. 6e, h, i). While the outer leaf layer varied in thickness and in the number of leaf fragments depending on the inner diameter of the stem, thus allowing the utilisation of stems ranging from 10–20 mm in inner diameter (see Table 1), the inner leaf layer was of more or less constant thickness. The width of the cells after detachment of the outer layer of leaf fragments averaged 7.9 mm, the length 13.5 mm (Table 1). By adding to the minimum inner cell width of 7 mm a few millimetres for a thin outer leaf layer, which was present in all cells, the minimum inner stem diameter required for nesting is about 10 mm. This estimate corresponds to the smallest recorded inner diameter of a stem occupied by *M. genalis* (see Table 1). By considering the thickness of the stem wall, which measured 2–4 mm at the level of the brood

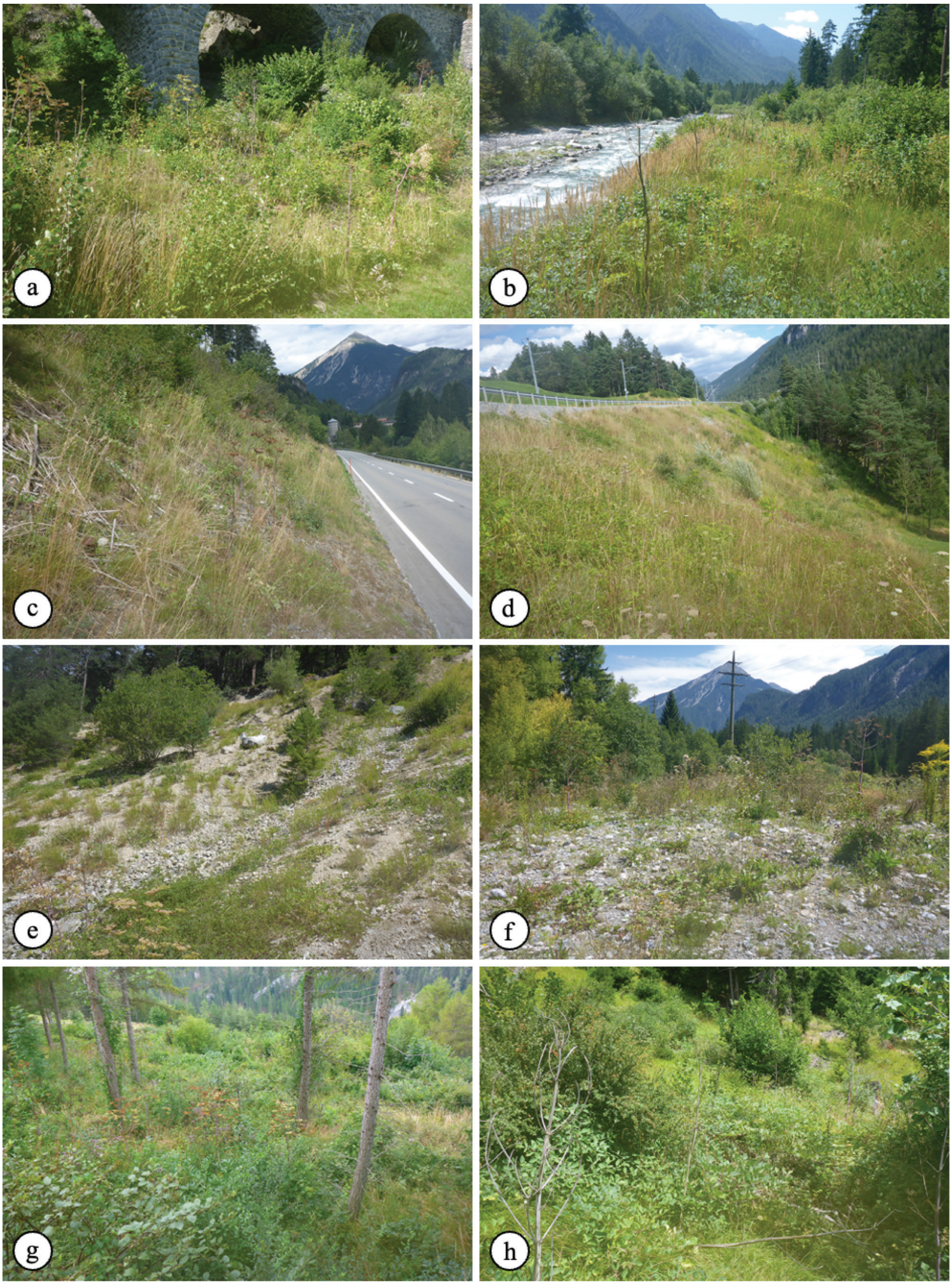

Figure 4. Nesting habitats of *Megachile genalis*. **a, b.** Fallow land; **c, d.** Road and railway embankment; **e, f.** Scree slope and ruderal site; **g, h.** Forest clearings.

cells, *M. genalis* is dependent on plant stems with an outer diameter of at least 14 mm for its reproduction, which corresponds well to the minimum outer stem diameter of 13.5 mm determined by Ruhnke (1998, 2000) for 36 nests and of 15 mm found in the present study for 53 nests (Table 1).

Basal plugs were found in 24 nests, whereas they were absent in 14 nests. The basal plug was always constructed within the same internodium as the brood cells, either directly at the nodus (n = 20) or at some distance above the nodus (n = 4). It consisted of a single layer of densely packed pith particles (n = 16; Fig. 5l), of an upper layer of leaf fragments immediately followed by a lower layer of densely packed pith particles (n = 4; Fig. 5m) or of 11–36 loosely to densely arranged leaf fragments (n = 4). The

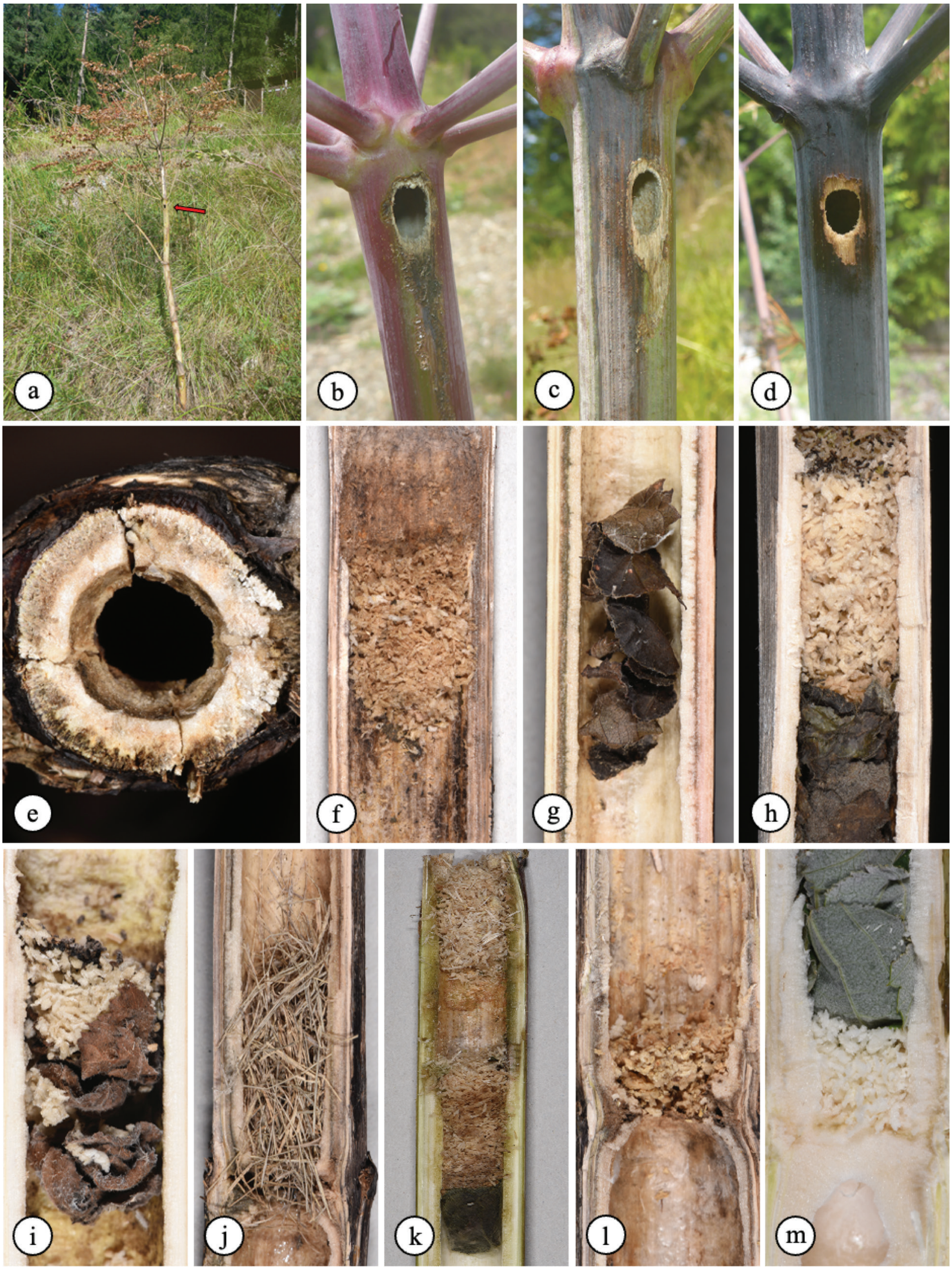

Figure 5. Nests of *Megachile genalis* in hollow stems of *Peucedanum verticillare*. **a–d.** Nest openings gnawed into the plant stem; **e.** Gnawed through transverse partition between two internodia; **f–k.** Nest plugs (for details see text); **l, m.** Basal plugs (for details see text).

thickness of the basal plugs ranged from 4–40 mm (Table 1). In the majority of nests, a basal plug was present although the transverse stem partition at the nodus was intact, suggesting that plug construction is independent of the integrity of the stem partition.

Cell-building material

The genetic analysis of the outer leaf layers of 157 brood cells from 20 nests showed that the females of *Megachile genalis* collected the leaf fragments for the construction

Figure 6. Nests of *Megachile genalis* in hollow stems of *Peucedanum verticillare*. **a.** Contiguous brood cell series; **b.** Interrupted brood cell series; **c.** Close-up of brood cells; **d.** Enigmatic marks on inside of stem wall; **e.** Brood cell with outer leaf layer removed; **f.** Layer of faeces surrounding cocoon wall; **g.** Overwintering prepupa; **h, i.** Brood cell series with outer leaf layer **h.** Present and **i.** Removed.

of the brood cells exclusively on representatives of the Rosaceae and the Betulaceae (Fig. 8). Among the Rosaceae, species of *Rosa* (e.g. *R. canina* L.) and *Rubus* (e.g. *R. caesius* L., *R. idaeus* L.) as well as *Prunus avium* L., *Fragaria vesca* L. and *Sorbus aucuparia* L. served as sources for the leaf fragments. Among the Betulaceae, *Corylus avellana* L. was used. All these species are shrubs or trees except for the herbaceous *F. vesca*. Although metabarcoding does not allow exact quantification, the percentages of OTU sequences obtained indicate that

Table 1. Parameters of nests of *Megachile genalis* constructed in hollow stems of *Peucedanum verticillare* (Apiaceae) in the eastern Swiss Alps.

Parameter	Mean ± SD	Range	n
Height of nest opening above ground	110 ± 37 cm	22–217 cm	191
Length of nest opening	8.6 ± 1.3 mm	5.5–12 mm	149
Width of nest opening	5.9 ± 0.6 mm	4.5–7.5 mm	149
Outer stem diameter at nest opening	14.4 ± 2.9 mm	9–28 mm	185
Inner stem diameter at nest opening	10.5 ± 2.7 mm	6.5–17 mm	63
Distance between upper margin of nest opening and stem nodus above it	5.1 ± 5.1 cm	0.1–17 cm	59
Distance between upper margin of nest opening and stem nodus above it relative to total length of internodium	23.2 ± 22.7%	0.4–87.9%	59
Thickness of nest plug	16.4 ± 6.7 mm	5–25 mm	17
Distance between centre of nest plug and nest opening	19.7 ± 11.5 cm	1.5–45 cm	31
Distance between bottom of lowest brood cell and nest opening	49.9 ± 21.7 cm	10.5–99 cm	56
Outer stem diameter at brood cell level	20.0 ± 3.2 mm	15–27 mm	53
Inner stem diameter at brood cell level	14.3 ± 2.5 mm	10–20 mm	51
Number of brood cells	6.1 ± 3.7	1–14	54
Length of brood cell after detachment of outer leaf fragment layer	13.5 ± 1.0 mm	11–16 mm	68
Width of brood cell after detachment of outer leaf fragment layer	7.9 ± 0.7 mm	7–9 mm	68
Thickness of basal plug	13 ± 12.0 mm	4–40 mm	10

R. canina, *R. idaeus* and *R. caesius* were the most important leaf fragment sources (85.2% of the total number of reads), but that other representatives of the Rosaceae as well as *C. avellana* were also occasionally exploited (all below 6.5% of reads). The great importance of the Rosaceae is also shown by the finding that their leaves were recorded in all 20 nests analysed (Table 2), whereas leaves of *C. avellana* were only found in six nests with more than 1% reads. However, with 97% reads, *C. avellana* was the predominant leaf fragment source in one nest (Fig. 8).

Brood mortality and parasites

In a total of 284 brood cells examined, *Megachile genalis* did not reach the imaginal stage in 159 cells (56%) due to parasitation, mould or unknown reasons. This figure is a minimum estimate as it was not possible to determine whether *M. genalis* or a similarly sized brood parasite had emerged from brood cells with normally sized eclosion holes. In 21 (46%) of 46 nests, reproduction completely failed, whereas the proportion of successful brood cells exceeded 50% in only 18 nests (Fig. 7e).

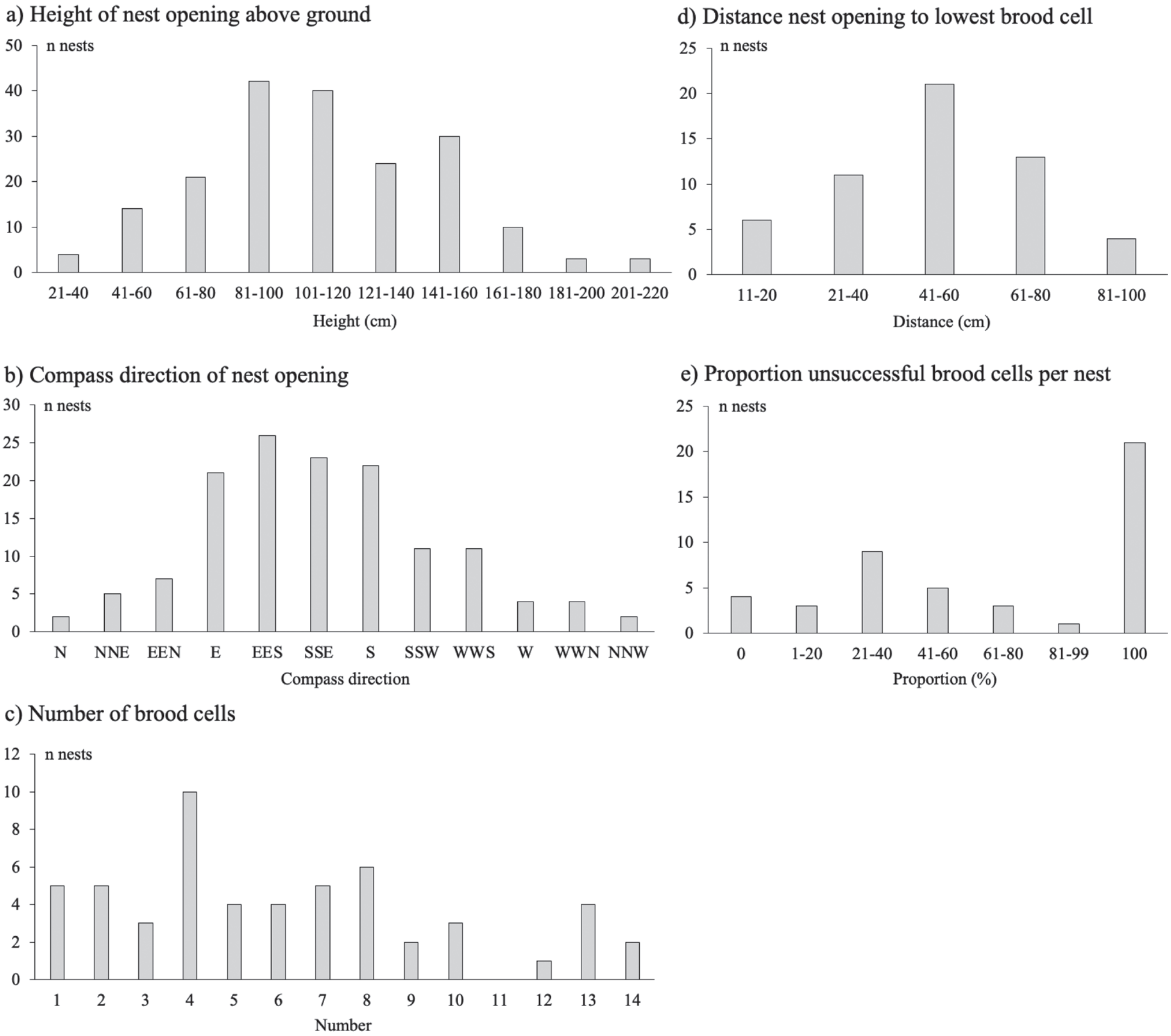

Figure 7. Nest parameters of *Megachile genalis*. **a.** Height of nest opening above ground (n = 191 nests); **b.** Compass direction of nest opening (n = 138 nests); **c.** Number of brood cells per nest (n = 54 nests); **d.** Distance between nest opening and bottom of the lowest brood cell (n = 55 nests); **e.** Proportion of unsuccessful brood cells per nest (n = 46 nests).

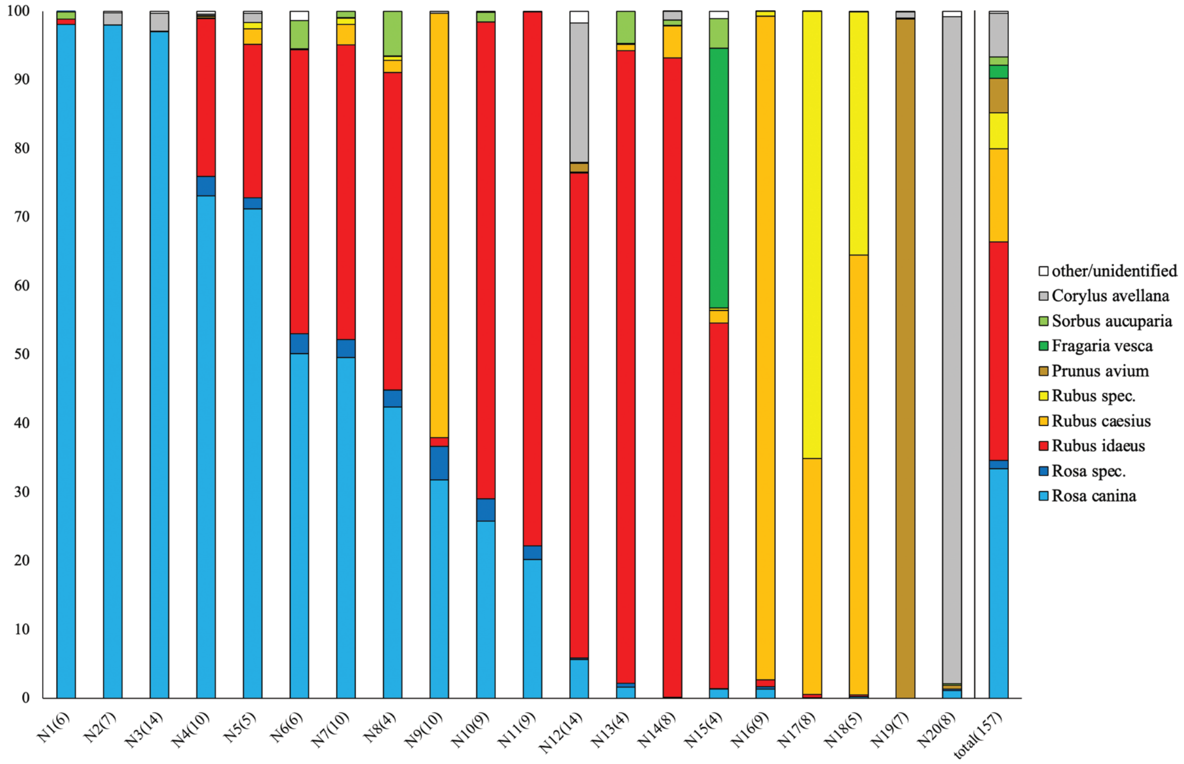

Figure 8. Origin of the leaf fragments used by *Megachile genalis* to build the brood cells in 20 nests collected in eight subplots in the Albula Valley (Grisons, Switzerland). For each nest, the percentage of ITS2 sequence reads for the identified plant taxa is given.

Table 2. Number and percentage of nests of *Megachile genalis* containing leaf fragments of the listed plant taxa based on DNA metabarcoding. Only plant taxa with more than 1% ITS2 sequence reads in a nest were considered. n = 20 nests collected in eight subplots in the Albula Valley (Grisons, Switzerland).

Plant taxon	**n**	**%**
Rosaceae	20	100
Rosa	16	80
Rosa canina	16	80
Rosa spec.	8	40
Rubus	15	75
Rubus idaeus	12	60
Rubus caesius	9	45
Rubus spec.	2	10
Sorbus aucuparia	6	30
Prunus avium	2	10
Fragaria vesca	1	5
Betulaceae	6	30
Corylus avellana	6	30

The most important brood parasite was *Melittobia acasta* (Walker) (Hymenoptera, Eulophidae), which had infested 53 (19%) of 284 brood cells and 13 (28%) of 46 nests, followed by *Exeristes roborator* (Fabricius) (Hymenoptera, Ichneumonidae; n = 4/2), *Xylophrurus augustus* (Dalman) (Hymenoptera, Ichneumonidae; n = 2/2), *Coelioxys inermis* (Kirby) (Hymenoptera, Megachilidae; n = 1/1), *Trichodes apiarius* L. (Coleoptera, Cleridae; n = 1/1) and an unidentified bombyliid fly (Diptera, Bombyliidae; n = 1/1). Furthermore, a female most probably of *Lasiambia* spec. (Diptera, Chloropidae) was observed entering a nest of *M. genalis*, adding a further species to the list of the bee's brood parasites in the study area. For the vast majority of the unsuccessful brood cells, the cause of mortality could not be determined.

Female mandibular shape

The comparison of the female mandible of *Megachile genalis* (Fig. 1c, d) with that of closely related *Megachile* species of the same subgenus, such as *M. centuncularis* (Fig. 1e, f), revealed three differences. First, the outer surface of the mandible of *M. genalis* is strongly inflated at its base, whereas the basal outer surface of the mandible of the other *M.* (*Megachile*) species is plane; second, the mandible of *M. genalis* is shorter relative to its basal width compared to the other species (about 1.8 × as long as wide in *M. genalis* compared to about 2.0 × as long as wide in e.g. *M. centuncularis*); and third, the mandible of *M. genalis* is apically barely curved inwards in contrast to the related species, which possess mandibles that are distinctly curved inwards.

Pollen hosts

The microscopic analysis of pollen remains and larval faeces from 65 brood cells and 39 nests revealed that more than 99% of all pollen collected by *Megachile genalis* originated from flowers of the Asteraceae (Table 3). Within the Asteraceae, representatives of all three subfamilies (Asteroideae, Carduoideae, Cichorioideae) were exploited. However, species of the Carduoideae were by far the most important pollen sources and their pollen was recorded in every brood cell, suggesting that *M. genalis* has a clear preference for this subfamily and particularly for thistles, whose pollen was represented by significantly higher proportions in the pollen samples than that of *Centaurea*.

Table 3. Pollen host spectrum of *Megachile genalis* in the eastern Swiss Alps. n = 65 brood cells from 39 nests collected in eight subplots in the Albula Valley (Grisons, Switzerland).

Pollen host	% pollen grain volume	Number of brood cells with pollen type (%)
Asteraceae	99.1	65 (100)
Carduoideae	84.4	65 (100)
Thistles (*Arctium, Carlina, Cirsium, Onopordum*)	72.2	62 (95.4)
Knapweeds (*Centaurea*)	12.2	40 (61.5)
Cichorioideae	13.4	45 (69.2)
Asteroideae	1.2	10 (15.4)
Other taxa	0.9	28 (43.1)

Discussion

The present study revealed that *Megachile genalis* is highly specialised in the eastern Swiss Alps with respect to nesting site, cell-building material and pollen hosts. The species nested exclusively in living stems of *Peucedanum verticillare* (Apiaceae) in the investigated plots, it used mainly leaf fragments from shrubs and trees of the Rosaceae for brood cell construction and it exploited only flowers of the Asteraceae for pollen.

Distribution

The occurrence of *Megachile genalis* in the eastern Swiss Alps is closely linked to larger stands of *Peucedanum verticillare*, and the distribution of the plant and the bee species largely coincides in the Grisons (Fig. 2). Since *P. verticillare* grows not only in man-made habitats such as fallow land or road and railway embankments, but typically also in disturbed natural habitats such as scree slopes, forest clearings or floodplains, the occurrence of *M. genalis* in the eastern Swiss Alps may have existed already before humans began to open up the forest-dominated landscape in the Neolithic period (ca. 5500-2200 years BC, Hitz et al. 2023).

Nesting biology

Nesting site

In the study area, nests of *Megachile genalis* were invariably discovered in living plant stems. This observation is in line with the findings of other authors (Ruhnke 1998, 2000; Westrich 2018; Wiesbauer 2023) and shows that *M. genalis* is an exception among the stem-nesting bees of Europe in that it builds its brood cells in living rather than dead stems. To the best of our knowledge, the only other bee species known to use living stems as nesting site is the Nearctic *Megachile montivaga* Cresson, which belongs to the same subgenus as *M. genalis* and was found to nest in green stems of thistles (Orr et al. 2015). However, in contrast to *M. genalis*, which appears to be strictly specialised to erect plant stems, *M. montivaga* has a wider nesting niche and also nests in the ground or in trap nests (Orr et al. 2015 and references therein). A possible advantage of colonising living rather than dead stems could be that living stems are more firmly anchored in the soil compared to dead stems and are therefore less likely to fall over, which would be associated with a high mortality of the progeny due to increased humidity and/or predation near the ground. Similarly, since the likelihood of being destroyed or becoming unsuitable for nesting due to bending or falling increases with the age of the stems, specialization to living stems may be advantageous in that it results in a larger number of potential nesting sites available to the bees.

Due to its body size and brood cell architecture, *M. genalis* requires thick nesting stems with an inner diameter of at least 10 mm and – depending on the thickness of the stem wall – an outer diameter of at least 13–14 mm. Apart from *Peucedanum verticillare*, there were only a few plant species in the study area that had stems with an outer diameter exceeding 12 mm. These species included *Dipsacus fullonum* L. (Caprifoliaceae), which, however, occurred only very rarely and locally in gardens, *Angelica sylvestris* L. (Apiaceae), which usually grew in (semi-) shaded and rather damp locations that were suboptimal for *M. genalis*, *Heracleum sphondylium* L. (Apiaceae), which – as a typical species of nutrient-rich meadows – was almost always mown before the flight period of *M. genalis* had started, as well as species of *Verbascum* (Scrophulariaceae), *Arctium*, *Carduus* and *Cirsium* (Asteraceae), all of which have pithy stems and are probably colonised only in the absence of hollow stems. The finding that *M. genalis* exclusively nested in stems of *P. verticillare* in the study area may therefore be explained less by a local specialisation than by the lack of alternatives. In fact, *M. genalis* appears to be rather flexible in the selection of the plant species used as nesting substrate: its nests were found in thick stems of Apiaceae (*Angelica*, *Conium*, *Heracleum*), *Dipsacus* (Caprifoliaceae), *Allium* (Amaryllidaceae), Asteraceae (*Carduus*, *Cichorium*, *Cirsium*, *Dahlia*, *Echinops*) and in an exceptional case in the leaf sheath of *Zea mays* (Poaceae) (Buysson 1902; Benoist 1940; Grandi 1954, 1957; Ruhnke 1998, 2000 and references therein; Hausl-Hofstätter 2007; Westrich 2018; Sobieraj-Betlińska 2021; Wiesbauer 2023). Interestingly, in eastern Austria where *M. genalis* has two generations per year due to the warm climate, the females of the first generation preferentially nest in soft and thin-walled stems of *Allium* (Amaryllidaceae), which are easy to penetrate, whereas those of the second generation colonise hard and thick-walled stems of *Cichorium intybus* (Asteraceae) and various species of Apiaceae, which are more likely to persist over the winter (Wiesbauer 2023).

Nest architecture

The examination of numerous, mainly one- to two-year-old nests of *Megachile genalis* in stems of *Peucedanum verticillare* revealed a striking variability with respect to the characteristics of the nest opening (size, height above ground, orientation, position within internodium), the nest plug (thickness, material, position both in stem and within internodium), the brood cells (number, linear or interrupted series, position both in stem and within internodium), and the basal plug (presence or absence, thickness, material, position within internodium). Particularly intriguing was the use of different materials either alone or in combination for constructing the nest plug, including particles of pith, leaf fragments and grass fibres. This high species-specific flexibility is also apparent in the population of *M. genalis* studied by Ruhnke (1998, 2000), where the females colonized (and hollowed out) pithy rather than hollow stems and where about two thirds of all nests contained brood cells above and below the nest opening, which was observed only in two nests in the present study.

Although this high variability makes it difficult to capture the nest architecture of *M. genalis* at a glance, the "average nest" in the eastern Swiss Alps can be described as consisting of i) a nest opening that is 9 mm long and 6 mm wide, is located one meter above the ground, is oriented towards southeast and is gnawed in the uppermost fourth of the internodium, ii) a nest plug that is 15 mm thick, consists of densely packed particles of pith and lies 20 cm below the nest opening in the central section of the same internodium as the brood cells, iii) six brood cells that are constructed in one contiguous series in the second internodium below the nest opening and are located at the bottom of the internodium in a distance of 50 cm from the nest entrance, and iv) a basal plug that is 13 mm thick, consists of densely packed pith particles and lies at the nodus of the same internodium as the brood cells.

One unexpected characteristic of the nests of *M. genalis* in the study area was the large distance between the nest opening and the bottom of the lowest brood cell, which measured on average about half a metre and maximally almost one metre. The reason for this large distance is possibly related to the thickness of the stem wall, which need to be gnawed through by the female bee to enter the stem. The stem wall thickness of *P. verticillare* increased from an average of 2 mm at the level of the nest opening to an average of 3 mm at the level of the brood cells and up to 5 mm near the stem base (Table 1, Fig. 3f, g). As the walls of living stems are very hard, the females might need less time and energy to gnaw the nest entrance in the upper thinner part of the stem, where the diameter is too small to place the brood cells, than to penetrate the lower thicker part, where the brood cells will later be placed, even if this means that one or more soft and thin transverse partitions of pith have to be gnawed through at the nodi.

In many nests, zigzag-shaped, narrow and longitudinal to transverse marks were visible in the pith of the inner walls of the internodium that contained the brood cells (Fig. 6d). These marks were most probably bitten by the females with their mandibles, but are most likely not related to the acquisition of nest-building material, e.g. for the construction of the basal plug, since the pith along these bite marks was not completely detached from the stem wall. It is equally unlikely that these marks served to roughen the walls for better attachment of the brood cells within the stem cavity, as they were also found outside the brood cell area. The function of these conspicuous bite marks therefore remains a mistery.

Cell-building material

In the study area, species of Rosaceae (*Rosa*, *Rubus*, *Prunus*, *Sorbus*, *Fragaria*) were by far the most important sources of the leaf fragments used by *Megachile genalis* to construct its brood cells. This finding is in agreement with observations made by Dudich (1884), Henschel (1888), Friese (1923) and Wiesbauer (2023), who recorded leaves of the rosaceous genera *Rosa*, *Rubus* and *Pyrus* as cell-building material of *M. genalis*. Six of the eight plant genera identified by Ruhnke (1998) as leaf sources for *M. genalis* also belonged to the Rosaceae including *Rosa*, *Rubus*, *Prunus*, *Fragaria*, *Crataegus* and *Agrimonia*. Thus, *M. genalis* seems to have a strong preference for leaves of Rosaceae to build its brood cells. However, the preference for Rosaceae leaves is not exclusive as leaves of other plant taxa, such as *Acer* (Sapindaceae), *Corylus* (Betulaceae) or *Robinia* (Fabaceae), are rarely also used (Ruhnke 1998; Schweighofer 2021; this study).

Several osmiine bee species of *Osmia* and *Hoplitis* (Megachilidae) were also found to preferentially use leaves of the Rosaceae as nest-building material (Müller 1994; Prosi et al. 2016; Müller and Richter 2018; Müller et al. 2019, 2020), suggesting that the selection of leaves for nest construction by *M. genalis* and the osmiine bees is far from accidental and that leaves of Rosaceae might possess particularly favourable properties. A special leaf consistency that might render rosaceous leaves especially suitable for cutting the fragments and manufacturing the brood cells by leafcutter bees hardly explains the high importance of this plant family for megachilid bees, since the *Osmia* and *Hoplitis* species mentioned above use to masticate the Rosaceae leaves to pulp, which does not seem to require a particular leaf consistency. One alternative, albeit very speculative explanation for the importance of Rosaceae as source for nest-building material may be that the defensive secondary compounds contained in Rosaceae leaves provide a particularly effective protection for bee larvae against mould, pathogenic bacteria or predators.

Brood mortality and parasites

The brood mortality of *Megachile genalis* in the study area amounted to 56% and in almost half of all nests reproduction completely failed. As the method applied in the present study, i.e. the examination of old nests, did not allow to determine whether *M. genalis* or a similarly sized brood parasite had emerged from brood cells with normally sized eclosion holes, both brood mortality and the proportion of unsuccessfull nests were certainly higher. Given the average number of six brood cells per nest and assuming that the females constructed only one to maximally two nests during their flight period, the reproductive output of *M. genalis* in the study area in 2023 was very low and did not exceed an average of two to five offspring per female. A slightly lower brood mortality with an average of 51% failed brood cells over a period of two years was recorded for *M. genalis* in eastern Germany (Ruhnke 1998). Compared to a recent metastudy that included publications on 147 solitary bee species and found an average brood mortality of 29% for all species and 37% for cavity-nesting species (Minckley and Danforth 2019), the proportion of unsuccessful brood cells in *M. genalis* as recorded by Ruhnke (1998) and in the present study was substantially higher. Similarly high or even higher mortality rates were found in other Palaearctic megachilid bees such as *Hoplitis princeps* (52% brood mortality), *Osmia uncinata* (77%) and *Osmia pilicornis* (83%) (Prosi et al. 2016; Ivanov and Fateryga 2018; Müller et al. 2020), suggesting that overall brood mortality in megachilid bees may be higher than in other bee lineages.

Melittobia acasta (Hymenoptera, Eulophidae), which had infested 19% of the brood cells and 28% of the nests, was the main brood parasite of *M. genalis* in the study area. The other five antagonists were of much less significance and had infested together a total of 3% of the brood cells and 15% of the nests (but see methodological limitation above). Similarly, *Lasiambia* spec. (Diptera, Chloropidae) was the main brood parasite in the population of *M. genalis* investigated by Ruhnke (1998) and responsible for an estimated mortality of 10–30% of all cells, whereas the other antagonists had parasitized together less than 6% of the cells. *Melittobia acasta*, *Exeristes roborator* (Hymenoptera, Ichneumonidae), *Coelioxys inermis* (Hymenoptera, Megachilidae) and *Lasiambia* spec., which were found to parasitize nests of *M. genalis* in the study area, were also recorded by Ruhnke (1998), who additionally identified *Aritranis explorator* (Tschek) and *Cratichneumon fugitivus* (Gravenhorst) (Hymenoptera, Ichneumonidae) as well as *Coelioxys mandibularis* Nylander as brood parasites.

The new finding by Ruhnke (1998) that *Coelioxys inermis* and *C. mandibularis* develop in the nests of *M. genalis* has been overlooked in the bee literature. Interestingly, *Coelioxys inermis* has been bred so far from nests of *Megachile alpicola*, *M. centuncularis*, *M. lapponica* and *M. versicolor* (Voith 1997; Amiet et al. 2004; Westrich 2018 and references therein), all of which belong to the subgenus *M.* (*Megachile*) as *M. genalis* does, suggesting that *C. inermis* may be specialized to *M.* (*Megachile*) species as hosts. In contrast, the host spectrum of *C. mandibularis* is taxonomically wider and encompasses *Megachile versicolor*, *Hoplitis* (*Anthocopa*) *villosa* (Schenck) and probably several further *Megachile* and *Hoplitis* species of the subgenera *M.* (*Eutricharaea*), *M.* (*Megachile*), *M.* (*Xanthosarus*) and *H.* (*Anthocopa*) (Voith 1997 and references therein).

Female mandibular shape

The female mandibles of *Megachile genalis* are unique among the European *M.* (*Megachile*) species with respect to three characters: i) they possess a strongly inflated base; ii) they are shorter and more compact; and iii) they are apically barely curved inwards. These three characters are probably related to the specialised habit of the females to gnaw through the hard walls of living plant stems. The inflated base likely contains strong adductor muscles, which are capable of exerting high pressure on the stem surface. And both the shorter length and the absence of an inward apical curvature gives the mandible a compact and chisel-like shape, which seems to be well suited to transmit mandibular power onto the plant substrate. Interestingly, the latter two characters were also found in females of *Osmia nigriventris* (Zetterstedt), a boreoalpine mason bee of the subgenus *O.* (*Melanosmia*) that uses its shortened and apically almost straight mandibles to gnaw nesting burrows into hard bark and wood (Müller et al. 2019); in contrast, the female mandibles of related *O.* (*Melanosmia*) species that colonise preexisting cavities for nesting are longer and apically distinctly curved inwards, which corresponds to the difference in mandibular shape between the stem-gnawing *M. genalis* and its cavity-nesting relatives. Therefore, the peculiar shape of the female mandible of *M. genalis* is interpreted here as an adaptation that has evolved for penetrating the hard walls of plant stems.

Pollen hosts

In the study area, *Megachile genalis* collected pollen exclusively on flowers of the Asteraceae and among the Asteraceae particularly on species of the Carduoideae. Pollen of thistles (*Arctium*, *Carduus*, *Cirsium*, *Onopordum*) accounted for almost 75% of the total pollen grain volume in the brood cells analysed, which is surprising as thistles occurred only locally and rarely on pastures and ruderal areas in the study area, whereas species of *Centaurea* or Cichorioideae grew abundantly almost everywhere on nutrient-poor meadows. This suggests that *M. genalis* has a distinct preference for the pollen of thistles in the eastern Swiss Alps. This preference, however, is unlikely a local phenomenon since thistle species of *Carduus* and *Cirsium* were also noted as the preferred host plants of *M. genalis* in eastern Germany and Poland (Dorn and Weber 1988; Ruhnke 1998; Celary and Wiśniowski 2002) and as flower-visiting females of *M. genalis* were repeatedly observed on flowers of *Carduus*, *Cirsium* and *Silybum* in different regions of Germany and Austria (Sieber 1933; Schweitzer 2002; Auer in Westrich 2018; Schweighofer 2021; Tischendorf 2021). In addition to thistles, *Centaurea* (Carduoideae), *Cichorium* and *Picris* (Cichorioideae) as well as *Buphthalmum* and *Inula* (Asteroideae) are other known Asteraceae pollen hosts of *M. genalis* (Ruhnke 1998; Schweighofer 2021; present study). The results of the present study in combination with anecdotal observations in the literature confirm the oligolecty of *M. genalis* on Asteraceae as was already suspected by various authors (Ruhnke 1998, Westrich 2018). *Megachile genalis* is thus best categorised as broadly oligolectic on Asteraceae with a strong preference for thistles.

Conclusions

In the eastern Swiss Alps, *Megachile genalis* relies on i) living stems of *Peucedanum verticillare* (Apiaceae) as nesting sites, ii) green leaves of mainly *Rosa* and *Rubus* (Rosaceae) as cell-building material and iii) flowers of thistles and other Asteraceae as pollen sources. While the required nest building material is ubiquitous throughout the study area, the supply of pollen hosts and particularly nesting sites is much more limited. Measures to conserve the population of *M. genalis* in the Grisons should therefore focus on the promotion of thistles and, above all, on the conservation and propagation of suitable habitats for *P. verticillare* in close vicinity to Asteraceae-rich areas. As *P. verticillare* does not tolerate regular mowing or grazing, many of its current stands are located on fallow land that is at risk of becoming completely overgrown in the near future, since its (sporadic) management is not rewarded by agroecological schemes. The more strongly advanced strict segregation between forest and cultivated land caused by the loss of such irregularly managed fallow land probably explains the rarity of *M. genalis* in the Domleschg compared to the Albula Valley and the Lower Engadine, where still many suitable transitional habitats between forest and open land exist. In the Grisons, the fate of *M. genalis* – a rare and endangered bee species throughout Europe – will depend on whether a balance can be found between the complete abandonment of use and the annual mowing or grazing of the (potential) habitats of *P. verticillare*.

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PENSOFT.

Alpine Entomology

Das Steppenelement *Adosomus roridus* (Pallas, 1781) in der Schweiz und erste Dokumentation der Entwicklung in *Artemisia absinthium* L. (Coleoptera, Curculionidae)

The steppe element *Adosomus roridus* (Pallas, 1781) in Switzerland and first documented development in *Artemisia absinthium* L. (Coleoptera, Curculionidae)

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Zusammenfassung

Überprüfte Sammlungsexemplare und aktuelle Funde des besonders selten gefundenen und nur äusserst lokal vorkommenden *Adosomus roridus* aus der Schweiz führten zur Entdeckung von Eiern, Larven und Puppen in einer neuen Wirtspflanze *Artemisia absinthium* L. in der subalpinen Felsensteppe in Zermatt. Fotos der Habitate, der Pflanze und der Präimaginalstadien werden gezeigt und die Funde werden vorgestellt und diskutiert.

Abstract

Revised collection specimens and recent finds of the exceptionally rare and locally occurring *Adosomus roridus* from Switzerland lead to the discovery of eggs, larvae and pupae in a new host plant *Artemisia absinthium* L. in subalpine rocky steppe habitats at Zermatt. Photos of the habitat, plant, and life stages are presented, and the records are given and discussed.

Key Words

ecology, faunistics, host plant, new records, rare species

Einleitung

Adosomus roridus (Pallas, 1781) ist die einzige europäische Art der Gattung und wird nach Stejskal and Trnka (2013) und Würmli (1976) als seltenes, äusserst lokal verbreitetes und gefährdetes Steppenelement (Kaspische Art oder Ponto-kaspische Art) angesehen (Koch 1992; Mazur 2002). Seine Verbreitung reicht von Südschweden durch Mitteleuropa bis nach Italien im Süden und über die Karpathen und den Kaukasus bis nach Kasachstan im Osten. In Mitteleuropa, überwiegend im östlichen Teil, gibt es nur wenige, sehr lokale Vorkommen. (Meregalli 2024).

Die Biologie von *Adosomus roridus* wurde von Trnka et al. (2015) erst kürzlich geklärt. Eine Oligophagie für Asteraceae wurde festgestellt. Die Zucht gelang in der Slovakei an *Tanacetum vulgare* L. Seltener wurde auch *Artemisia vulgaris* L. angenommen. Als Habitate wurden Rebberge und Ruderalstellen ausgemacht. Käfer wurden von April bis September gefunden, die neue Generation schlüpfte vom frühen Sommer bis in den Herbst. Überwinternd konnten sowohl Imagines als auch Larven gefunden werden.

Die Aufnahme von Funddaten im Rahmen von SwissCollNat Projekten und die daraus gewonnene Erkenntnis, dass *A. roridus* im Gebiet von Zermatt konstant nachgewiesen wurde, sowie die aktuellen Funde aus demselben Gebiet mit exakter Fundortangabe von Stefan Birrer, führten zu einer erfolgreichen Begehung des Gebietes im August 2024. Darüber wird im Folgenden berichtet.

Material und Methoden

Literaturangaben und folgende Sammlungen wurden überprüft:

NMB	Naturhistorisches Museum Basel
NMBE	Naturhistorisches Museum Bern
MHNF	Naturhistorisches Museum Fribourg
MHNG	Musée d'histoire naturelle de la ville de Genève
MAS	Museum zu Allerheiligen in Schaffhausen
cCG	collection Christoph Germann (Rubigen)
cHB	collection Hansjörg Brägger (Amriswil)
cWS	collection Wolfgang Schiller (Deutschland, Grenzach-Wyhlen)

Am 15. August 2024 wurde eine Exkursion nach Zermatt durchgeführt. Zwölf Imagines von *Adosomus roridus* wurden lebend mitgenommen. Belegtiere sind in den Sammlungen der Autoren und im NMB hinterlegt. Die Fotos wurden im Habitat mit einer Olympus tough T3 gemacht. Ein Teil der revidierten Exemplare wurde fotografiert und ist als Suppl. material 1 digital abgelegt.

Resultate

Historische Literaturnachweise

In der Schweiz ist *Adosomus roridus* sehr lokal und selten zu finden. Germann (2010) erwähnt pauschal Nachweise aus den biogeographischen Regionen Jura, westliche Zentralalpen und Alpensüdflanke mit Südbünden. Alte Meldungen stammen aus den Kantonen Wallis und Schaffhausen. Stierlin (1883) erwähnt Schaffhausen mit Verweis auf "Vogler". Das Belegtier wurde überprüft und befindet sich im MAS. Rätzer (1888) gibt "Zermatt" an und ergänzt "s." [= selten], ein Belegtier vom 8.1884 ist in der Sammlung August Rätzer im NMBE überprüft worden. Favre (1890) gibt an "rare. Zermatt (Rätz.); aussi à Schaffhouse". Stierlin (1898) listet Zermatt und Randen bei Schaffhausen auf, und erwähnt "sehr selten". Stierlin (1906) erwähnt *A. roridus* als "sehr selten" in seiner Fauna des Kantons Schaffhausen.

Historische und neuere Funde

Nebst den Literaturhinweisen seit 1883 und dem historischen Belegtier liegt nur ein neuer Nachweis aus dem Schaffhausischen vor, nämlich der Fund vom 20. Mai 1990 von Hansjörg Brägger (cHB). Nach Angaben von Brägger liegt der exakte Fundort bei an einem trockenen, sehr mageren, durch Verbuschung bedrohten Kalkstandort bei folgendem Punkt: 47°47'06.04"N, 8°36'44.05"E [Schweizer Koordinaten: 687'950, 293'375], südlich von Bargen oberhalb von Säige.

Konstant bestätigte Nachweise aus der Schweiz während 140 Jahren liegen ausschliesslich aus dem Gebiet Zermatt vor, angefangen mit einem Belegtier von Rätzer vom August 1884 im NMBE und Literaturnachweisen seit 1890 von Favre, und einem weiteren Belegtier vom 11.8.1916 von Erich Däniker (auch im NMBE). Weitere zwei Belege liegen von Victor Allenspach (27.6.1931, NMB) vor, weitere vier Belege aus den Sammlungen Franz Straub und H. Marchand mit der Angabe "Zermatt" (Juli [19]35, NMB), eines von Hans Pochon vom 8.1938 (MHNF), vier von Marcel Rehfous vom 3.7.1957 (MHNG), zwei Exemplare von Wolfgang Schiller vom 17.6.1982 (cWS) mit detaillierter Angabe "1670 m, prairie artemisia", nach Aufzeichnungen von Pierre Scherler und zuletzt ein aktuelles Exemplar von Stefan Birrer vom 20.7.2023 oberhalb des Bahnhofs von Zermatt, Balmen, 46°01'48.19″ N, 7°45'02.60"E [Schweizer Koordinaten: 624'165.22, 097'660.30], (NMB).

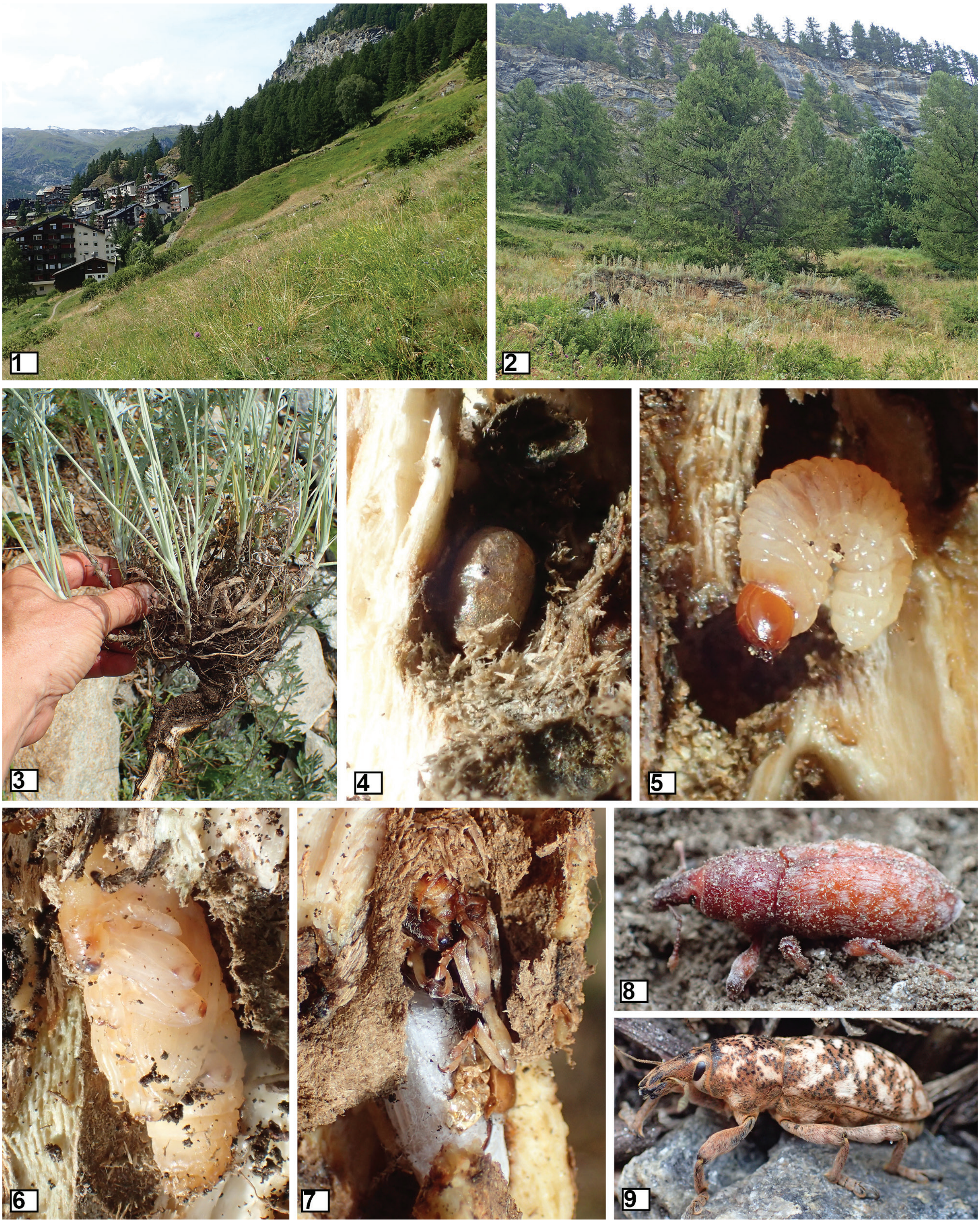
Weitere Fundorte

In den 70er Jahren wurde von Walter Ettmüller ein erster Fund im Tessin bei Mergoscia erbracht (1 ex. 13.7.1973; Aufzeichnungen Pierre Scherler). Dazu kommt der Nachweis in Würmli (1976) von der "Lötschbergsüdrampe" (nach A. Linder; es befinden sich jedoch keine Belegtiere dazu in der Sammlung an der ETHZ) und ein Fund von Peter Sonderegger bei Fully [Umgebung] aus dem Jahr "2005" (cCG).

Resultate der Begehung

Auf einer gezielten Exkursion nach Zermatt am 15. August 2024 wurden zwei nach Südosten gerichtete Abhänge aufgesucht. Einerseits der Abhang gleich oberhalb des Bahnhofs von Zermatt (Fig. 1) am Punkt 46°01'28.53"N, 7°44'47.74"E [Schweizer Koordinaten 623'848, 97'052], auf 1600 m ü. M., und andererseits das etwas höher gelegende Ze Bäche am Punkt 46°01'23.87"N, 7°44'34.70"E [Schweizer Koordinaten 623'568, 96'907] auf 1730 m ü. M. (Fig. 2). Beide Gebiete sind durch Hangneigung und Exposition sehr trocken und gut besonnt. Die Vegetation kann als Felsensteppe bezeichnet werden. An beiden Orten ist die Wirtspflanze *Artemisia absinthium* L. gut vertreten, vorallem auch in gestörten Bereichen (entlang der Wege, zerfallenden Trockenmauern oder Rutschungen). An diesen Stellen konnten auch die Käfer gefunden werden.

Die Wirtspflanze *Artemisia absinthium* L. wurde bereits von Smreczyński (1968) und Dieckmann (1983) als Frasspflanzen der Imagines festgestellt, eine Entwicklung darin wurde auch von Würmli (1976) bereits angenommen, konnte jedoch bis jetzt nicht gezeigt werden.



Figures 1–9. 1. Habitat an südexponiertem Hang auf 1600 m ü. M. oberhalb Zermatt, der von Gärten am Dorfrand bis hinauf zu Lawinenverbauungen unterhalb eines begrenzenden Steilhangs reicht. *Artemisia absinthium* wächst hier an steinigen Ruderalstellen; **2.** Zweites Gebiet "Ze Bäche" auf 1730 m ü. M., hier wächst *A. absinthium* gehäuft an Trockenmauern; **3.** Zur Prüfung auf Frass im Wurzelhals und den oberen Wurzelpartien wurden die Wirtspflanzen ausgegraben und aufgeschnitten; **4.** In eine ausgefressene Nische auf der Aussenseite der Hauptwurzel und unterhalb der Bodenoberfläche abgelegtes einzelnes Ei (3 mm Länge), die Frassspäne bedeckten das Ei komplett; **5.** Junglarve (ca. 7 mm Länge) in einem Frassgang; **6.** Puppe in einem Frassgang in der Hauptwurzel; **7.** Dito, jedoch parasitiert (Käfervorderteil mit 3 Beinpaaren und Hinterleib bestehend aus einem Larvenkokon des Parasitoiden); **8.** Frisch geschlüpfter Käfer; **9.** Ausgehärtetes Exemplar am Fundort (Fotos: C. Germann).

Bereits die ersten untersuchten Stauden von *Artemisia absinthium* – eher kräftige und grosse Pflanzen (Fig. 3) – enthielten Eiablage-Gruben (Fig. 4) am Wurzelhals unterhalb der Bodenoberfläche, sowie eine bis zwei Junglarven von 6–8 mm Länge pro Wurzelhals oder Hauptwurzel (Fig. 5). Bei weiteren untersuchten Pflanzen fanden wir im oberen Bereich der Hauptwurzel Puppen (Figs 6, 7). Eine der Puppen (Fig. 7) war parasitiert worden und die Larve des Parasitoiden (Hymenoptera: Braconidae oder Ichneumonidae) hatte sich aus dem bereits fertig entwickelten Käfer herausgefressen und sich ihrerseits auch verpuppt. Zudem konnten wir am Fundort total 12 Imagines finden. Die Tiere versteckten sich unter oder in den Pflanzen, wo sie beim Schütteln der Stauden, manchmal auch paarweise, herunterfielen und häufig in Schreckhaltung mit ausgestreckten Beinen auf dem Rücken lagen.

Die mitgenommene oben erwähnte Puppe des Käfers schlüpfte nur zwei Tage später. Der Jungkäfer war einige Stunden hell orangefarben (Fig. 8) bevor er die typische dunkle Färbung mit hellen Schuppenflecken zeigte (Fig. 9). Erst nach vier Tagen frass das Tier an angebotenen Blättern der Wirtspflanze. Bis Mitte September zeigten die lebend gehaltenen Tiere am Morgen und vormittags deutlich stärkere Aktivität, als am Nachmittag und abends oder nachts. Drei vermutlich ältere Tiere (sichtbar an der spärlichen Beschuppung und teilweise fehlenden Tarsengliedern) starben innert dieser Zeit. Vermutlich waren es letztjährige Exemplare. Die Übrigen zeigten regen Frass an den Blättern und Stängeln der *A. absinthium*-Pflanzen. Auch konnten mehrfach Kopulae beobachtet werden.

Diskussion

Mit der hiermit bestätigten Entwicklung von *Adosomus roridus* in *Artemisia absinthium* kann eine weitere sicher belegte Wirtspflanze vorgestellt werden. Die Walliser Felsensteppe, aber auch Trockenwiesen im Jura (Randen) sind Habitate von *A. roridus* in der Schweiz, wobei das in den Sammlungen dokumentierte stete Vorkommen über 140 Jahre bei Zermatt besonders hervorgehoben werden muss. Bei gezielter Suche konnten bei der Feldbegehung im August 2024 unerwartet viele Tiere gefunden werden. Da sich die Art in den dichten Stauden sehr gut verstecken kann, ist es leicht, Exemplare von *A. roridus* trotz ihrer beachtlichen Grösse von über 15 mm zu übersehen. Die hier vorgestellten Beobachtungen dürften beitragen, in günstigen Habitaten die Art wieder (oder überhaupt erst) nachzuweisen. Bei uns in der Schweiz wäre ein Wiedernachweis im Gebiet des Randen (Schaffhausen) zu erwarten, oder auch ein Erstnachweis in weiteren inneralpinen Trockentälern wie dem Unter- oder Oberengadin wäre möglich. Im Wallis wären zudem sicher weitere geeignete Habitate auf *A. roridus* zu überprüfen. Offensichtlich (wie hier auch gezeigt), sind höhere Lagen bis gegen 1700 m ü. M. bei guter Besonnung und Steillage kein Hindernis zur erfolgreichen Besiedlung und Entwicklung für *Adosomus roridus*. Da wir Ende Sommer in den subalpinen Felsensteppen von Zermatt Eier, Junglarven und frisch geschlüpfte Imagines antrafen, gehen wir davon aus, dass dort die Entwicklung mindestens zweijährig ist (vgl. dazu Trnka et al. 2015). Die gefundenen Eier (aus welchen übrigens keine Larven mehr ausschlüpften) zeigen sogar, dass fakultativ zweimal überwintert werden kann, einmal im Eistadium, und noch einmal als Imago nach Schlupf im Spätsommer. Auch die Eiablage dürfte sich über eine längere Zeit hinziehen von Herbst vermutlich bis in den Frühsommer, je nach Witterung. Dies ist bei Gebirgswetter auch wichtig, da der Winter sehr früh im Herbst bereits einbrechen kann, dasselbe mit späten Kälteeinbrüchen im Frühjahr.

Danksagung

Stefan Birrer (Reinach) und Hansjörg Brägger (Amriswil) danken wir herzlich für Belegtiere und/oder genaue Fundortangaben. Herzlichen Dank an Michael Greeff (ETHZ) für die Überprüfung der Arthur Linder-Sammlung. Dank für die Unterstützung im Rahmen der SwissCollNet Initiative der Schweizerischen Akademie der Naturwissenschaften, und speziell an Hannes Baur (NMBE) sowie Patrick Favre, Nina Perret-Gentil und Sophie Giriens (alle MHNF). Dank der beiden Projekte “Curculionoidea of the Natural History Museum Bern” und “Reconditioning and digitisation of Hans Pochon›s and Nestor Cerutti›s Coleoptera collections” am MHNF konnten vorliegende Funddaten erst erkannt, überprüft und erhoben werden. Den Reviewern danke wir herzlich für Ihre Bemerkungen zum Manuskript.

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Supplementary material 1

Fotos der revidierten Exemplare von *Adosomus roridus* (Pallas, 1781) und ihrer Etiketten in chronologischer Reihenfolge

Authors: Christoph Germann, Stefan Wartmann

Data type: pdf

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PENSOFT. Alpine Entomology

Discovery of *Anthophora onosmarum* Morawitz, 1876 in Europe (Hymenoptera, Apidae)

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https://zoobank.org/AA28E0FE-B483-46FE-A121-2E53259E4804

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Abstract

Anthophora onosmarum is a poorly known bee species described from the Caucasus (Georgia). New fieldwork has revealed that the species is present in Bulgaria and Greece, and is also widespread across Turkey, predominantly on the Anatolian plateau. New behavioural data shows that *A. onosmarum* is likely narrowly oligolectic on the plant genus *Onosma* (Boraginaceae), and is capable of buzzing flowers to release pollen. This finding illustrates the growing trend of overlooked bee species with more Caucasian, Anatolian, or even Middle Eastern distributions occurring in under-surveyed mountainous parts of the Southern Balkans.

Key Words

Balkans, oligolecty, *Onosma*, solitary bees

Introduction

Anthophora Latreille, 1803 is moderately large genus of bees, with around 430 species listed globally (Brooks 1988; Michener 2007; Ascher and Pickering 2024), and the genus is widely distributed in both the New (Nearctic and Neotropics) and Old Worlds (predominantly in the Palaearctic and Afrotropical regions, with marginal occurrence in the Oriental region). Although it has a long history of study, our understanding of individual species, their distributions, and indeed the taxonomic status of the available names is hugely incomplete (e.g. Rasmont and Wood 2024). Currently, 77 species are reported from Europe, making *Anthophora* the seventh largest genus of bees in this region (Ghisbain et al. 2023).

In this context, we take the opportunity to present new findings of the poorly studied species *Anthophora onosmarum* Morawitz, 1876 which was described from the Caucasus, from what is the modern day state of Georgia. To our knowledge, there has not been a single publication dealing with the ecology and distribution of this species since its description, with only minimal treatment as to its subgeneric position (Brooks 1988) or cataloguing of its type material or publication date (Marikovskaya 2000; Ebmer 2021). We present its ecology and newly report the species from Europe for the first time.

Methods

Fieldwork in Bulgaria and Greece in May–June 2024 led to the discovery of *Anthophora onosmarum* as new for Europe. After associating the bee with *Onosma* sp. (Boraginaceae) in Bulgaria, during an 8-day trip in northern Greece in June 2024 in Western and Central Macedonia, we targeted *Onosma*-rich sites to find additional records of the bee. We visited approximately 20 sites, of which 10 were in dry, steppe-like slopes between 600–1000 m. *Onosma* plants were abundant at nine of these 10 sites, suggesting that this plant genus is widely distributed in hilly regions in northern Greece. Since *Onosma*-associated bees were of interest to us, we systematically surveyed this plant genus whenever large stands were found. In agreement with Teppner (1995), *Osmia apicata* Smith, 1853 was the most common Boraginaceae-specialised bee during these searches; this species was present at a minimum of six of the 10 visited sites. Surprisingly, although we spent much time in sites with abundant *Onosma*, we observed *A. onosmarum* only at one site, where numerous specimens were present. Additionally, with the knowledge that *A. onosmarum* was present in Europe, searches of museum collections were able to uncover 23 additional previously unidentified specimens, clarifying the range of this species. All specimens were identified by TJW.

A DNA barcode was generated from a male specimen from Greece using the LepF/LepR primer, following standard protocols as mentioned in Praz et al. (2022). Field photographs were taken with a Canon EOS Rebel T6i with a Canon EF 100mm f/2.8L Macro IS USM lens. Specimen photographs were taken using an Olympus E-M1 Mark II with a 60 mm macro lens. Additional close-ups were taken with the addition of a Mitutoyo M Plan Apo 10X infinity corrected objective lens in combination with an Olympus M.Zuiko 2× teleconverter lens, a 10 mm Kenko DG extension tube, and a Meike MK-P-AF3B 10 mm extension tube. Photographs were stacked using Helicon Focus B (HeliconSoft, Ukraine) and plates were prepared in GNU Image Manipulation Program (GIMP) 2.10. Head length ratios were measured using photographs in GIMP, measuring from the top of the vertex to the anterior margin of the clypeus (head length) and between the outer margins of the compound eyes at their widest points (head width).

Abbreviations

IBER	Bulgarian Academy of Sciences, Institute of Biodiversity and Ecosystem Research, Sofia, Bulgaria
OÖLM	Oberösterreichisches Landesmuseum, Linz, Austria
PRUN	Research collection of Christophe Praz, University of Neuchatel, Switzerland
RMNH	Naturalis Biodiversity Center, Leiden, the Netherlands
TJWC	Personal collection of T.J. Wood, Leiden, the Netherlands
ZISP	Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia

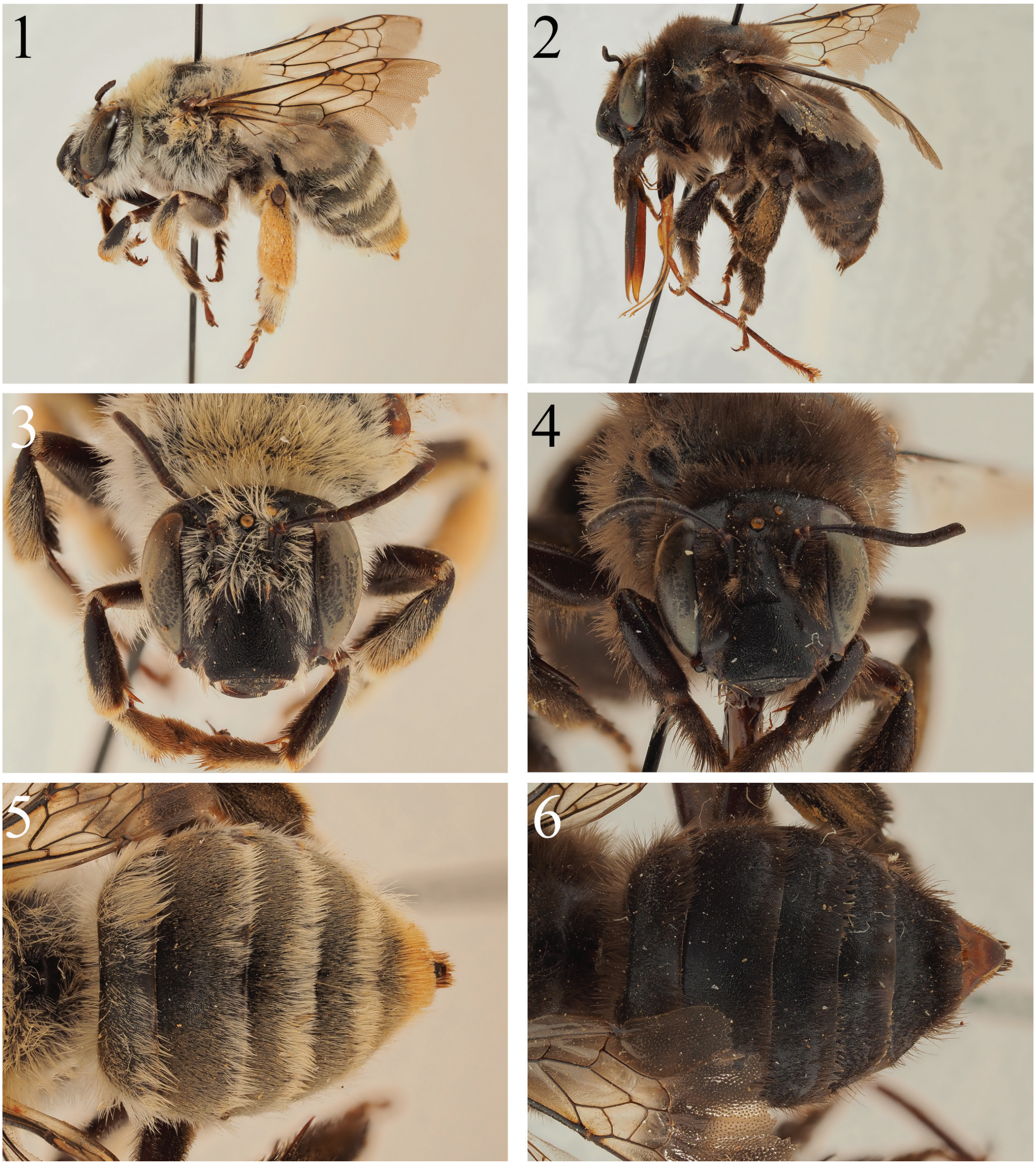
Results

Anthophora (*Paramegilla*) *onosmarum* Morawitz, 1876

Anthophora onosmarum Morawitz, 1876: 15, ♀♂ [Azchur (presumably Azkur/ Atskuri, Georgia), ZISP, examined by photograph]

Material examined. BULGARIA • 1♂; Blagoevgrad, Gorno Spanchevo, 1.5 km E; 420 m a.s.l.; 22 May 2024; T.J. Wood leg.; TJWC • 1♂; Stara Kresna; 20 Jun. 1987; Karas leg.; OÖLM (ex. collection B. Tkalců); **GREECE** • 1♂, 1♀; Western Macedonia, Kottas, 1.6 km E of Vatochori; 850 m a.s.l.; 13 Jun. 2024; T.J. Wood leg.; RMNH • 3♂, 1♀; Western Macedonia, Kottas, 1.6 km E of Vatochori; 850 m a.s.l.; 13 Jun. 2024; C. Praz leg.; PRUN; **IRAN** • 1♀; Zentralprovinz, 10 km nördlich Karadj [Karaj]; 1100 m a.s.l.; 23 May 1977; Holzschuh & Resel leg.; OÖLM; **TURKEY** • 1♂; 10 km W of Urgup [Ürgüp]; 15 Jun. 1998; Ma. Halada leg.; OÖLM • 2♂; 50 km S Kars, Pasli; 1 Jul. 1997; Ma. Halada leg.; OÖLM • 2♂; Bolu, S Karayokuş Gec Hocadag; 40.3503°N, 31.3003°E; 760 m a.s.l.; 19 Jun. 1986; E. Hüttinger leg.; OÖLM • 1♂, 1♀; Elazig [Elâzığ]: Hazar-See; 1 Jun. 1978; M. Schwarz leg.; OÖLM • 1♂; Konya, 10 km S Karaman; 1100 m a.s.l.; 19 Jun. 1985; M. Schwarz leg.; OÖLM • 1♂; Konya: Karaman; 11 Jun. 1978; M. Schwarz leg.; OÖLM • 2♀; Madenşehir [Madenşehri]/Konya; 6 Jun. 1971; K. Warncke leg.; OÖLM • 2♀; Madenşehir [Madenşehri]/ Konya; 22–23 Jun. 1984; K. Warncke leg.; OÖLM • 1♀; Malatya, 3 km SE of Kubbe Gecidi, st. 2641; 1700 m a.s.l.; 3 Jul. 2000; H. v. Oorschot, H. v. d. Brink, P. Oosterbroek leg.; RMNH; ZMA.INS.5144676 • 2♂; Maraş [Kahramanmaraş], Afsin [Afşin]; 8 Jun. 1985; OÖLM • 1♂; Meram, Konya; 14 Jun. 1968; K. Kudas leg.; OÖLM • 1♂; Nevsehir [Nevşehir], Urgup [Ürgüp]; 16 Jun. 1977; K. Warncke leg.; OÖLM • 1♂; Nevşehir, 10 km NE of Nevşehir; 1200 m a.s.l.; 5–7 Jul. 1982; H. v. Oorschot & H. v. d. Brink leg.; RMNH; ZMA.INS.5144674 • 1♂; Nordhand des östl. Hama dag, südl. Igdir (Kars); 1300–1600 m a.s.l.; 27 Jun. 1971; Reinig leg.; OÖLM; • 1♂; Prov. Ankara, Baglum [Bağlum Güzelyurt]; 1400 m a.s.l.; 13 Jul. 1961; J. Leinfest leg.; RMNH; ZMA.INS.5144675.

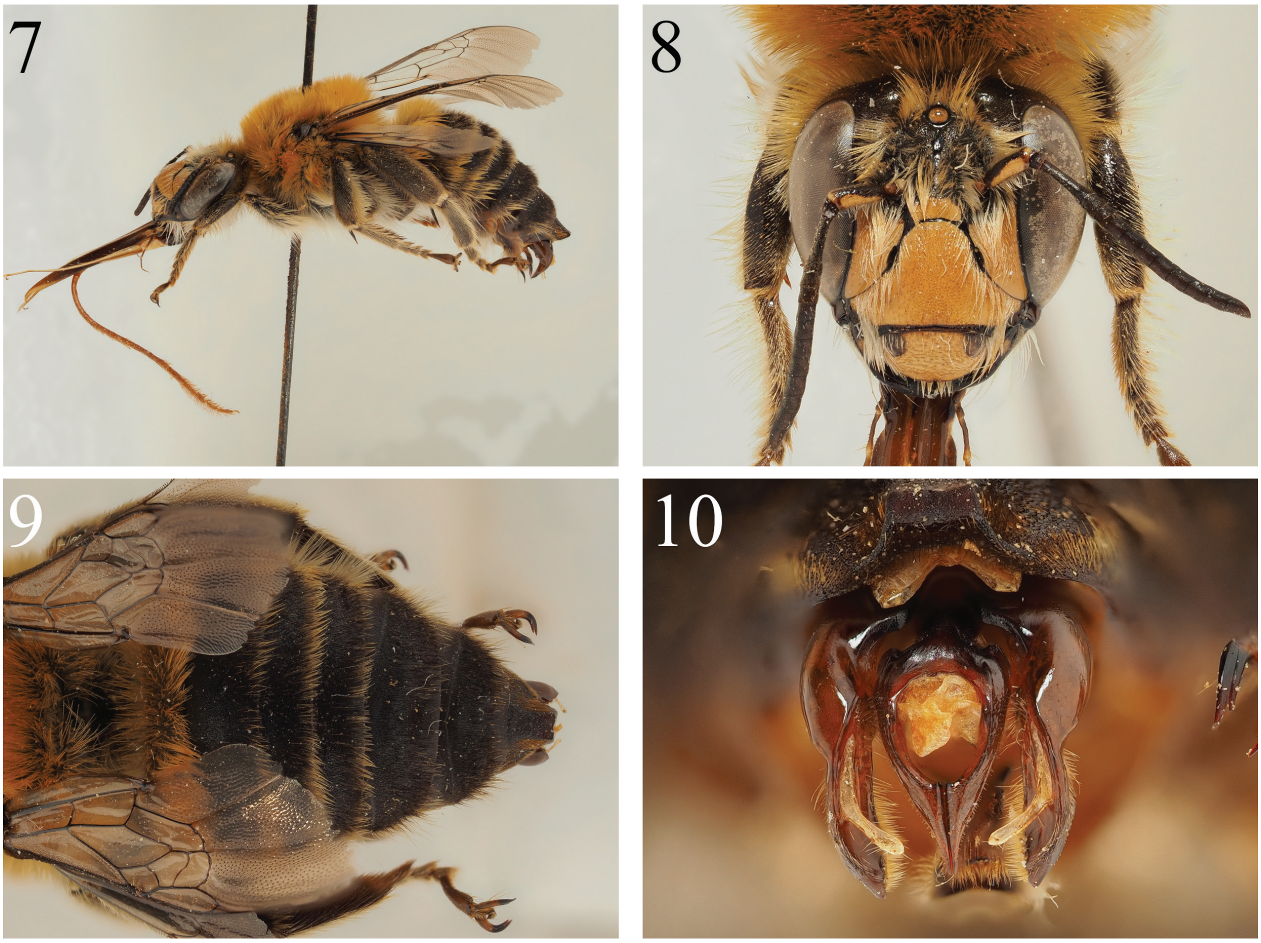
Diagnosis. There is currently no modern identification key for *Anthophora* that can be used in south-eastern Europe. The work of Friese (1897) is badly out of date due to the many taxonomic changes which have been made and must still be made in the Anthophorini. *Anthophora onosmarum* is included in this work (as *Podalirius* s. str.), but does not key out well as the mandibles can be partially yellow-marked, whereas Friese considered them to be entirely dark. Within the European fauna, *A. onosmarum* is best diagnosed due to the combination of its elongate head, in direct frontal view with the lower margin of the clypeus ventrally projecting below the lower margin of the compound eyes (Figs 3, 4), with the inner margins of the compound eyes slightly diverging ventrally (most strongly pronounced in the male sex, Fig. 8), head therefore relatively elongate, only 1.15–1.20 times wider than long (in comparison other *Anthophora* (*Paramegilla*) species with the head much wider than long, typically between 1.50–1.85 times wider than long), malar space slightly expanded but only subequal to length of antennal segment 4, clypeus bulging in profile view (extending as far in front of the compound eye as the diameter of the compound eye itself; Figs 1, 2), length of tongue very long, almost extending beyond tip of metasoma (Fig. 2), in female sex with metasoma covered with either adpressed pale yellow-orange



Figures 1–6. *Anthophora onosmarum* Morawitz, 1876 females, light (Turkey, Madenşehri; 23 Jun. 1984; K. Warncke leg.; OÖLM) and dark (Turkey, Madenşehri; 22 Jun. 1984; K. Warncke leg.; OÖLM) forms). **1.** Light form, profile; **2.** Dark form, profile; **3.** Light form, face, frontal view; **4.** Dark form, face, frontal view; **5.** Light form, metasoma, dorsal view; **6.** Dark form, metasoma, dorsal view.

pubescence (Fig. 5; intensity of colour depending on the age of the specimen) or adpressed black pubescence (Fig. 6), but if with black pubescence then without lateral white hairbands, male with extensive yellow markings on face, these covering the labrum, clypeus, lower paraocular areas to a level reaching the antennal insertions, ventral surface of antennal scape, and sometimes with a small dot on the mandibles (Fig. 8), mid legs without hair patches of fringes, hind basitarsi essentially unmodified (without the presence of teeth) only slightly thickened apically, and genital capsule with gonocoxae produced into long apical projections which come to a curved apical point, with long, thin, and hyaline finger-like gonostyli (Fig. 10). A revised key to European *Anthophora* will hopefully be produced in the near future (TJW, in prep.).

Colour variation. A total of nine female specimens were examined, these showing two distinct colour morphs – four specimens showed black pubescence (Greece,



Figures 7–10. *Anthophora onosmarum* Morawitz, 1876 male (Bulgaria, Stara Kresna; 20 Jun. 1987; Karas leg.; OÖLM). **7.** Profile; **8.** Face, frontal view; **9.** Metasoma, dorsal view; **10.** Genital capsule, dorsal view.

central Turkey; Figs 1, 3, 5), and five showed yellow pubescence (central and eastern Turkey, Iran; Figs 2, 4, 6). There was a weak geographic gradient with darker individuals in the west and lighter individuals in the east, but on two occasions (Madenşehri, 6th June 1971 and 22–23rd June 1984) Klaus Warncke collected one black and one yellow female at the same place. The specimens illustrated in Figs 1–6 are from Madenşehri from the 22–23rd June 1984. Very little is known about colour variation in Anthophorine bees, and we make no decisive comments here, other than to say that for at least *A. onosmarum* this seems to represent simple variation, as it is not accompanied with structural differences. Morawitz (1876) described the female as being of the yellow form: "*Das Weibchen ist schwarz, das Gesicht, die Schläfen und die Brust weiss, das Hinterhaupt, die obere Fläche des Thorax und das erste Abdominalsegment sehr dicht fuchsroth behaart*" [The female is black, the face, the gena and the mesosoma has white hairs, the dorsal part of the thorax and the first metasomal segment dense, bright orange-red hairs]. In some *Andrena* species (Andrenidae), specimens from the Balkans are darker, for example *Andrena* (*Hoplandrena*) *clusia* ssp. *prilepensis* Warncke, 1973 (described from North Macedonia) which is almost completely melanic relative to the nominate subspecies which was described from Azerbaijan. This can also be seen in *Eucera* (*Cubitalia*) *breviceps* (Friese, 1911) (Apidae) (Aubert et al. 2024a). In any case, male *A. onosmarum* appear to be much more consistent in terms of their colouration, with no melanic individuals observed so far. This would appear to fit the overall pattern of reduced colour variation in male anthophorines relative to females (e.g. Brooks 1983).

Genetics. We obtained a full-length (658 base pairs) DNA barcode from a male specimen (BOLD accession number HYMAA898-24; www.boldsystems.org); when submitted to the identification tool in the Bold Systems, the closest matches (87.4–89.5% similarity) were to *Anthophora* (*Paramegilla*) *balneorum* Lepeletier, 1841, *A.* (*Paramegilla*) *nigrovittata* Dours, 1872, and *A.* (*Dasymegilla*) *quadrimaculata* Panzer, 1798. The tree-based identification suggested that *A. onosmarum* was sister to a clade containing *A. balneorum* and *A. nigrovittata*. These results confirm that the obtained barcode is distinct from all other species represented on BOLD, and tentatively suggest phylogenetic affinities with *A. balneorum* and *A. nigrovittata*.

Behavioural observations and general remarks. A single male of *A. onosmarum* was captured in south-western Bulgaria (Blagoevgrad, Gorno Spanchevo) visiting *Onosma* sp. (given the challenging nature of *Onosma* identification, it was not possible to confidently determine to species level; Teppner 1991) growing on piles of discarded building materials mixed with soil on 22nd May 2024. The surrounding habitat was composed of a small area of dry exposed slopes adjacent to a mountain road surrounded by deciduous woodland; *Onosma* was observed only on the refuse piles. Despite remaining at the site for several hours, no further individuals of *A. onosmarum* were seen.

On 13 June 2024 several individuals (approximately 10 males and five females) of *A. onosmarum* were observed in northern Greece (1.6 km E of Vatochori) on dry slopes with abundant *Onosma* sp. (Figs 11, 12). The individual *Onosma* plants formed spaced clumps, and male *A. onosmarum* were patrolling between clumps (Fig. 13), stopping only occasionally for nectar (Figs 14–16). Males were extremely active and difficult to photograph. Some males stopped to rest by finding thin upstanding stems of dead or dry vegetation and gripping them with their jaws. Males were not observed landing on the ground; presumably this would require more energy to return to the air, or it would increase the time taken to become airborne and therefore reduce their ability to quickly react to a passing female.

Females showed a similar behaviour, rapidly moving between *Onosma* clumps, usually with their tongue extended (Fig. 17). Upon encountering a flower, the females hang upside down from the corolla, using their long tongue to access the nectaries (Fig. 18). Females were also observed tightly gripping the corolla (whilst also keeping their tongue inside, Fig. 19) and were heard

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Figures 11–12. 11. *Anthophora onosmarum* Morawitz, 1876 habitat in northern Greece on 13th June 2016; **12.** *Onosma* sp. (Boraginaceae).

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Figures 13–16. *Anthophora onosmarum* Morawitz, 1876 male behaviour visiting *Onosma* sp. (Boraginaceae) flowers.

Figures 17–20. *Anthophora onosmarum* Morawitz, 1876 female behaviour visiting *Onosma* sp. (Boraginaceae) flowers.

to emit a short high pitched buzz. This buzz released pollen which could be observed falling onto the underside of the metasoma as the bee released its grip on the corolla (Fig. 20). This pollen is presumably then groomed into the hind tibial scopa during flight.

Based on the long tongue (necessary to reach the deep nectaries of the *Onosma* flowers), the flower-buzzing behaviour, and the generally strong behavioural association with this plant genus (also mentioned in Morawitz 1876), we consider *A. onosmarum* likely to be narrowly oligolectic on this plant genus. It is not impossible that other genera of Boraginaceae are used; evidence from other bee groups is mixed. *Osmia* (*Osmia*) *apicata* Smith, 1853 (Megachilidae) is broadly oligolectic on Boraginaceae with a preference for *Onosma* (Haider et al. 2013), but this species does not buzz the flowers and scrapes out the pollen with its forelegs (Gogala and Surina 2011). *Hoplitis* (*Hoplitis*) *onosmaevae* Aubert, 2024 (Megachilidae) and *E. breviceps* however do buzz flowers of *Onosma* (Aubert et al. 2024a, 2024b), and seem to be narrow oligoleges of *Onosma*. In the new world, Boraginaceae-associated *Perdita* species (Andrenidae) also show variation within their use of this botanical family, from broad to very narrow specialisation (Portman et al. 2016). Ultimately, pollen analysis on collected specimens or more extensive behavioural observations would been needed to decisively conclude on this question.

Based on the examined specimens, collected males outnumber collected females by slightly more than 2:1 (21 examined males, nine examined females), and the flight period ranges from 22nd May to 13th July, with a median date of 16th June. This would fit with our observation on 13th June 2024 in northern Greece, where we observed a mixture of patrolling males showing signs of wear, combined with pollen collecting females, implying that nest provisioning was well underway.

Whilst *A. onosmarum* is here newly reported for Bulgaria, Greece, and Europe as a whole, inspection of specimens from the Borek Tkalců collection (OÖLM) revealed that an undetermined male was actually collected in Bulgaria as early as 1987. Searches in the IBER collection in Sofia in 2023 and 2024 (TJW) did not uncover any further specimens, but searches were not exhaustive.

Distribution. Greece*, Bulgaria*, Turkey*, Georgia, Iran (Rasmont 2014; Ascher and Pickering 2024) (Fig. 21).

Distributional notes. The *locus typicus* is “Azchur” which is probably the village of Atskuri in southern Georgia (41.73°N, 43.16°E) and which is alternatively spelt “Azkur” or “Ahiska”. This village is located at an altitude of 900 metres above sea level. Iran is listed based on a GBIF record from the Donald Baker collection from the Snow Entomological Collection at the University of Kansas. Its details are “Iran: centr. Alborz, Kandavan Pass,

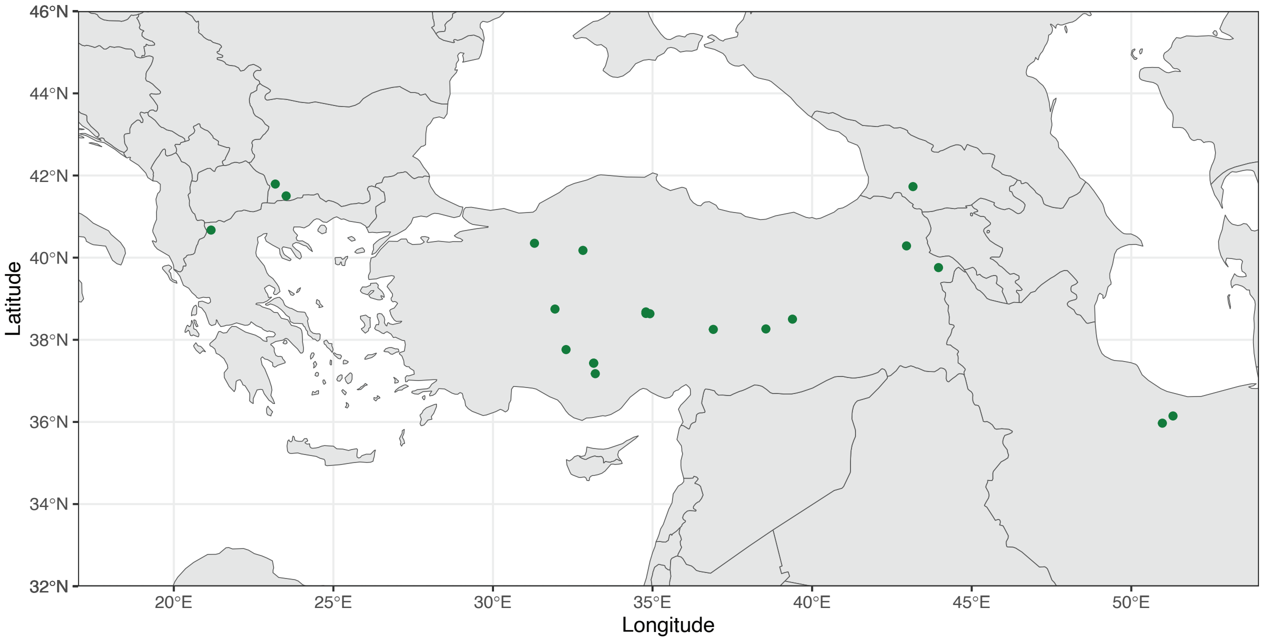

Figure 21. Distribution map for *Anthophora onosmarum* Morawitz, 1876 (green points) based on examined specimens and verified literature records.

nr. Pol-e-Zanguleh, 2200 m. 8 VII 1967. STA 8. Baker Exp.". This record comes from just 40 kilometres to the north-east of the specimen we report here from north of Karaj. Rasmont (2014) also lists southern Russia (North Caucasus) which is plausible (although the species is not listed from Russia by either Levchenko et al. 2017 or Proshchalykin et al. 2023), and Libya, this being not at all plausible clearly the result of an encoding or other type of data error. We therefore take a conservative approach in our distributional listing based on confirmed specimens. Given the collecting locality in north-western Greece, *A. onosmarum* is almost certainly present also in Albania and North Macedonia. Where altitude data are available, *A. onosmarum* is found between 420–2200 metres above sea level, with 7/10 records with altitude information reported above 1000 metres above sea level.

Concluding remarks

Although the attractiveness of the plant genus *Onosma* for bees has been known for some time (Dukas and Dafni 1990; Teppner 1995; see also Teppner 2011), the recent finding of a newly described species (*Hoplitis onosmaevae*) ranging from southern France to Turkey and northern Iraq (Aubert et al. 2024b) and a new eucerine bee reported for western Europe (*Eucera breviceps*; Aubert et al. 2024a), as well as our observations of *A. onosmarum*, suggest that bees associated with this plant are still poorly investigated. Our findings in Greece indicate very local or sporadic appearance, given the abundance of their host plants. Similarly, we observed *Eucera breviceps* at only a single site (2 km E of Komnina, 40.5882°N. 21.8007°E), where three females were spotted on the same patch of *Onosma*, even though *Onosma* was abundant at that site. Given the large body size of *A. onosmarum*, its overlooked presence in Europe is surprising, even with these stated caveats.

Overall, our limited observations correspond to those made by Teppner (1995), with *Osmia apicata* the dominant visitor to *Onosma* in the Balkans, with other species like *E. breviceps* only recorded once. Teppner (1995) also mentions an unidentified species of *Anthophora* collected on *Onosma* on the foothills of Mount Orvilos on the Greek/Bulgarian border (also known as Slavyanka), which could belong to *A. onosmarum* as it is less than 20 km from the known specimen collected from Gorno Spanchevo in Bulgaria. Taken together, these observations emphasise the rarity of both *A. onosmarum* and *E. breviceps* in the Balkans, in spite of the wide distribution and abundance of their host-plants. They also emphasise the growing trend of bee species with more Caucasian, Anatolian, or even Middle Eastern distributions occurring in under-surveyed mountainous parts of the Southern Balkans (Ghisbain et al. 2023; Aubert et al. 2024a, 2024b).

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PENSOFT.
Alpine Entomology

Jean Wüest, membre d'honneur de la Société entomologique suisse (SES)

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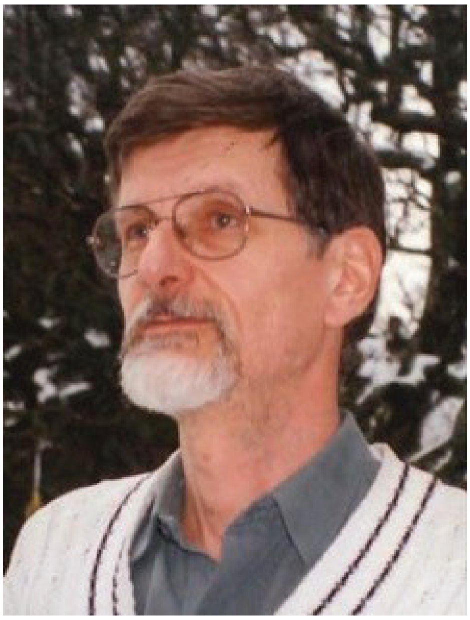

Jean Wüest, notre membre de longue date (depuis 1966), a été nommé membre d'honneur de la Société entomologique suisse le 9 mars 2024, lors de l'assemblée annuelle de la SES à Neuchâtel. Jean fait partie des visages bien connus de notre société : depuis 36 ans, il assiste assidument aux réunions de la société dont il a été membre du comité de 1978 à 2024 en tant que délégué de la Société entomologique de Genève (SEGe). De 1999 à 2002, il a été Président, puis, de 2002 à 2005, Vice-président de la SES. De nature discrète mais travailleur et rigoureux, il a su apporter son aide et son soutien à la société.

Né à Genève le 27 janvier 1943, Jean Wüest est profondément ancré dans l'entomologie genevoise : il est le petit-fils de John Jullien, membre fondateur de la Société lépidoptérologique de Genève en 1905, devenue la Société entomologique de Genève (SEGe) en 1958. Il est actif dès l'âge de 15 ans à la SEGe, présentant des photos d'insectes et montant des expositions. Il entre dans son comité en 1966, puis préside la SEGe de 1970 à 1980. En tant que rédacteur principal du « Bulletin romand d'Entomologie » (1981–2008), il apportera un soutien essentiel au développement de cette revue et à l'entomologie en Romandie. En 2008, la fusion du « Bulletin romand d'Entomologie » avec les « Mitteilungen der Entomologischen Gesellschaft Basel » (1951–2008) et les « Entomologische Berichte Luzern » (1979–2007) a donné naissance à la nouvelle revue d'entomo-faunistique suisse « Entomo Helvetica ».

Jean Wüest est titulaire d'un doctorat en biologie de l'Université de Genève, basé sur sa thèse de doctorat dans laquelle il a traité des aspects histologiques et cytologiques chez *Nauphoeta cinerea* (Olivier, 1789) (Blattodea, Blaberidae) (thèse n° 1707, Université de Genève). Il est titulaire de certificats de microscopie électronique (Université de Genève, 1969) et de radioisotope (Ecoles polytechniques fédérales de Zurich et Lausanne, 1971). Il sera recruté par le Muséum d'histoire naturelle de Genève (MHNG) en 1979 en tant que chargé de recherche responsable du microscope électronique à balayage après qu'il a copublié une image de spores du champignon *Tarichium gammae* J.Weiser (Entomophthorales, Entomophthoraceae), récoltés sur des larves d'*Ocnogyna parasita* (Hübner, 1790) (Lepidoptera, Erebidae, Arctiinae) au Laquintal, une première pour l'époque ! Il collaborera ainsi sur de très nombreux projets du MHNG, du Conservatoire et jardin botanique (CJB), du Musée d'Art et d'Histoire et de la Faculté des Sciences de l'Université. Ses images ont été utilisées dans plus de 300 publications scientifiques (dont les nôtres, ce dont nous lui sommes très reconnaissants !). Il a également rédigé les carnets du Muséum de 1998 à 2005. Parallèlement à son poste au MHNG, il effectua une carrière d'enseignant dans le département de Zoologie, à la Faculté de Sciences de l'Université de Genève. Il y a été maître assistant (1975–1980) avant de devenir chargé de cours (1980–2008). Il a dispensé des cours de systématique animale, d'entomologie, de microscopie et d'endocrinologie comparée et accompagna des stages de biologie marine. Enfin, il enseigna la parasitologie à la Haute école du paysage, d'ingénierie et d'architecture de Genève (HEPIA). Jean était très pince sans rire, tant qu'il était parfois difficile de savoir s'il blaguait ou non. Pendant son cours de systématique, il aimait traiter les Rhinogradentia (comme un vrai groupe) pour tester les étudiants. Il arrivait même que les étudiants ne s'étaient pas rendus compte qu'il s'agissait d'un canular à la fin du cours !

L'implication de Jean Wüest dans les sociétés savantes semble être une composante de son identité : il a été membre de pas moins de huit sociétés et associations. En outre, il a fait partie de la Commission fédérale d'experts CITES (2000–2008), du Conseil scientifique des Congrès internationaux francophones d'entomologie (1998–2006) et du Council for international entomology congresses (délégué de la Société entomologique suisse, 2000–2004).

En genevois impliqué, Jean intégra la Compagnie de 1602. Celle-ci organise chaque année le défilé commémoratif de la bataille de l'Escalade lorsque, le 12 décembre 1602, les Savoyards ont failli prendre Genève. Ces faits d'armes sont une des composantes importantes de l'identité genevoise dont le récit est relaté dans l'hymne genevois, le « Cé qu'è lainô », d'ailleurs récemment inscrit dans la Constitution cantonale. Enfin, nous aimerions également mentionner que Jean a joué du violon pendant plus de 70 ans et qu'il a fait partie de plusieurs orchestres amateurs, où il a pu interpréter des œuvres du 18^{e} au 20^{e} siècle, y compris des opéras (par exemple La Traviata).

Nous sommes heureux et fiers de compter Jean Wüest parmi nos membres d'honneur. Au nom de toute la SES, nous souhaitons lui adresser un immense merci pour toutes les années passées au service de la société !

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Alpine Entomology

Protokoll der Jahresversammlung der Schweizerischen Entomologischen Gesellschaft vom 8. und 9. März 2024 am Naturhistorischen Museum Neuchâtel

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In diesem Jahr fand die Jahresversammlung der SEG auf Einladung des Naturhistorischen Museums Neuchâtel am 8. und 9. März in Neuchâtel statt. Der Themenschwerpunkt am Freitag galt Insektenschädlingen auf Nutzpflanzen und den Interaktionen zwischen phytochemischen Stoffen und Herbivoren. Mit zwei Hauptvorträgen von Betty Benrey und Ted Turlings von der Universität Neuchâtel gab es einen umfassenden Einstieg in das Thema. Zunächst behandelte Betty Benrey das Thema der Pflanzenzucht und deren Auswirkung auf die chemischen Abwehrstoffe der Pflanzen. Die Selektion des Menschen führte bei vielen Nutzpflanzen zu grösseren Organen (z. B. Früchte, Wurzeln, Blätter) und geringerer Samenverteilung, aber auch zu einem geringeren Gehalt an toxischen Substanzen. Dies könnte dazu geführt haben, dass die natürliche Abwehr gegenüber Herbivoren ebenfalls reduziert wurde. In zahlreichen Studien mit mesoamerikanischen Nutzpflanzen, die eine lange Kultivierungsgeschichte haben, konnte gezeigt werden, dass bestimmte Pflanzenteile von Kultur- und Wildpflanzen unterschiedlich von Herbivorie betroffen waren. Zum Beispiel waren die Blätter von wilden und gezüchteten Limabohnen für die Entwicklung von Raupen gleich gut geeignet, hingegen entwickelten sich samenfressende Käfer aufgrund reduzierter Inhaltsstoffe auf den Kulturpflanzen besser. Eine Möglichkeit, diese negativen Effekte in Nutzpflanzen abzumildern, ist ein Anbausystem mit Mischpflanzung. Im Experiment war die Arthropodendiversität in Mehrkulturen aus Bohnen, Mais und Kürbis (Milpa-System) höher im Vergleich zu Monokulturen. Dies erhöhte die Stabilität des Systems, da z. B. Parasitoide durch extraflorale Nektarien der Bohnen angelockt wurden und länger überlebten, wodurch die Parasitierungsrate bei Larven auf benachbarten Maispflanzen anstieg.

Im zweiten Hauptvortrag gab Ted Turlings einen Überblick zum Thema frass-induzierte pflanzliche Signalstoffe. Dabei spannte er den Bogen von den Anfängen der Forschung bis zu modernen Anwendungsmöglichkeiten zur Schädlingsbekämpfung. Da die Frassaktivitäten eines Herbivoren die Pflanzen zur Produktion und Emittierung eines bestimmten Substanzgemischs anregt, lassen sich bereits verschiedene Schädlinge mit technischen Hilfsmitteln allein aufgrund dieser abgegebenen Stoffe identifizieren. Dies könnte in Zukunft für eine Echtzeitüberwachung von Feldern und einen gezielten Einsatz von biologischer Schädlingsbekämpfung (z. B. mit Nematoden) genutzt werden.

Folgende fünf Vorträge wurden am Freitag gehalten:

- Consequences of plant domestication for resistance against insect herbivores – case studies with Mesoamerican crops.
  Betty Benrey, Universität Neuchâtel

- Herbivore-induced plant volatiles and their possible use in crop protection.
  Ted Turlings, Universität Neuchâtel

- Erstnachweis von invasiven Douglasiengallmücken der Gattung *Contarinia* (Diptera: Cecidomyiidae) in der Schweiz – eine neue Bedrohung für die Zukunftsbaumart Douglasie?
  Simon Blaser, Eidg. Forschungsanstalt WSL, Birmensdorf

- Culture du colza et lutte contre ses insectes ravageurs: la durabilité est-elle possible?
  Ivan Hiltpold, Agroscope, Nyon-Changins

- Lutte biologique contre *Drosophila suzukii*: État des lieux sur les lâchers des parasitoïdes exotiques.
  Dominique Mazzi, Agroscope, Cadenazzo

Am Samstag wurde das Thema der chemischen Stoffe bei Pflanzen-Herbivoren-Interaktionen fortgeführt. Sergio Rasmann von der Universität Neuchâtel behandelte in seinem Hauptvortrag den Aspekt der möglichen Ko-Evolution von Herbivoren und Pflanzen, mit einem Schwerpunkt auf Käfer. Die hohe Diversität bei den Coleopteren könnte zum Teil eine Folge der Anpassung an die chemische Abwehr ihrer Nahrungspflanzen sein. Eine Hypothese dabei ist, dass die Pflanzenabwehr in Regionen mit höherer Pflanzen-Herbivoren-Interaktion stärker ausgeprägt sein sollte. Verschiedene Studien stützen diese Annahme: Die Arten der Gattung *Asclepias* (Seidenpflanzen) weisen weniger chemische Stoffe auf, je weiter entfernt vom Äquator sie vorkommen. Dies korreliert mit der allgemeinen Diversität von Pflanzen und Herbivoren. Analog zeigte sich, dass in der Schweiz die chemische Abwehr von Pflanzen mit zunehmender Höhenlage abnimmt, parallel zur Häufigkeit von Interaktionen zwischen Pflanzen und Herbivoren. Im Test waren Alpenpflanzen daher auch weniger resistent gegen einen Nahrungsgeneralisten (Afrikanischer Baumwollwurm, *Spodoptera littoralis*) als vergleichbare Arten aus dem Tiefland.

Am Nachmittag folgte eine Reihe von weiteren interessanten Vorträgen aus den verschiedensten Themengebieten.

Folgende sieben Vorträge wurden am Samstag gehalten:

- Chemically-mediated plant-insect interactions across space and time.
  Sergio Rasmann, Universität Neuchâtel

- Die Blattflohfauna der Schweiz (Hemiptera, Psylloidea).
  Daniel Burckhardt, Naturhistorisches Museum Basel

- Résultats préliminaires de l’inventaire national des collemboles et acariens.
  Sylvain Lanz & Loïc Bulliard, horizon a

- Reference genomes and entomology – insights from Lepidoptera.
  Kay Lucek, Universität Neuchâtel

- Situation du moustique tigre (*Aedes albopictus*) en Suisse romande.
  Daniel Cherix, Universität Lausanne

- Le frelon asiatique est arrivé ! Qui est-il et que peut-on faire?
  Carine Vogel, https://www.frelonasiatique.ch

- What drives host-switches and diversification in cuckoo-bees: chemical ecology, ecological niche, or phenology?
  Christophe Praz, Universität Neuchâtel / info fauna

Christophe Praz, Jessica Litman und dem Team des Naturhistorischen Museums Neuchâtel sei für die hervorragende Organisation und Verpflegung während der Jahresversammlung herzlich gedankt.

Generalversammlung

Begrüssung

Die Präsidentin Dominique Mazzi eröffnet die Generalversammlung um 9:35 Uhr und begrüsst die anwesenden 24 Mitglieder und einen Gast (total 25 Personen).

Protokoll der Generalversammlungen 2023 in Zürich und via Videokonferenz

Das Protokoll wird kommentarlos und unverändert genehmigt.

Bericht der Präsidentin, Dominique Mazzi

Administratives

Die SEG wurde im administrativen Bereich auch 2023 wieder von info fauna unterstützt. Die SEG ist Mitglied der Plattform Biologie der Akademie der Naturwissenschaften Schweiz (SCNAT) in Bern und wurde dort von der Leiterin der Plattform, Claudia Rutte, betreut.

Finanzielle Unterstützung

Die von der Präsidentin der SEG eingereichten Gesuche wurden von der Akademie der Naturwissenschaften Schweiz (SCNAT) in Bern und der Biedermann-Mantel-Stiftung in Zürich mit 9‘200 CHF bzw. 6‘000 CHF unterstützt. Wir sind diesen beiden Geldgebern für ihre wichtigen Beiträge sehr dankbar.

Jahresversammlung, Generalversammlung und Vorstandssitzungen

Die Jahrestagung der SEG (entomo.ch) fand am 3. und 4. März 2023 an der ETH Zürich statt. Die gut besuchte Veranstaltung bot den Teilnehmenden einen Einblick in verschiedene Aspekte der entomologischen Forschung in der Schweiz und Raum für den persönlichen Austausch. Insgesamt wurden 15 wissenschaftliche Vorträge gehalten.

Die Themenschwerpunkte lagen bei der Erforschung der Biodiversität der Schweizer Insektenfauna und beim Einsatz von Parasitoiden in der angewandten Schädlingsbekämpfung. Das vollständige Programm der entomo.ch 2023 ist unter diesem Link verfügbar: https://entomo.ch/de/news/uuid/i/5986701a-bdfa-5e9c-b3c5-c16810b9b647-entomo.ch_2023 Die Generalversammlung fand am 4. März 2023 an der ETH Zürich statt. Es fanden zwei Vorstandssitzungen statt: Freitag, 3. März an der ETH Zürich und Mittwoch, 1. November 2023 am Naturhistorischen Museum in Bern.

Website

Die SEG-Webseite auf dem Portal Naturwissenschaften Schweiz der SCNAT (https://entomo.ch/) dient als erste Anlaufstelle für alle möglichen Fragen zu Insekten. Als Kontaktperson auf der Webseite erhielt die Präsidentin der SEG im Jahr 2023 zahlreiche Anfragen zu verschiedenen Themen von der Öffentlichkeit und den Medien. Alle Anfragen wurden beantwortet oder zur Beantwortung an anderen Organisationen oder Expertengruppen weitergeleitet.

Forschungsunterstützende Informations- und Koordinationsaufgaben

In Partnerschaft mit dem DigiCenter der ETH-Bibliothek arbeitet die SEG seit einigen Jahren an verschiedenen Digitalisierungsprojekten. Sobald ein Projekt zu Ende geführt wird, sind alle Bände der vollständig digitalisierten Zeitschrift im pdf-Format online öffentlich zugänglich: https://www.e-periodica.ch/

Neulich wurden drei weitere Zeitschriftenreihen aufgeschaltet, alle aus dem Raum Basel: «Mitteilungen der Entomologischen Gesellschaft Basel» (1951–2007), «Mitteilungen des Entomologen-Vereins Basel und Umgebung» (1917–1922) und «Vereins-Nachrichten / Entomologen-Verein Basel und Umgebung» (1944–1950).

Eine Unterseite der SEG-Webpage liefert eine Übersicht aller Digitalisierungsprojekte mit Links zu den Seiten auf e-periodica: https://entomo.ch/de/publications/digitalisierungsprojekte Ausserdem wurde im Jahr 2023 wieder der prestigeträchtige Prix Moulines der SEG für eine herausragende entomologische Publikation verliehen. Der Prix Moulines ging an Christian Roesti für sein Buch «Die Steinfliegen der Schweiz» (2021, Haupt Verlag, Bern). Es handelt sich um ein Nachschlagewerk und Bestimmungsbuch, das alle Steinfliegenarten der Schweiz aufführt. Das mit zahlreichen wissenschaftlichen Zeichnungen und Farbfotos illustrierte Buch beinhaltet auch Verbreitungskarten und Sonogramme. Es bietet einen neu erarbeiteten Bestimmungsschlüssel und beschreibt umfassend die Morphologie, die Biologie und den Lebensraum der Arten. Diese Auszeichnung krönt die hervorragende Leistung des Autors und fördert die Verbreitung des Werks. Mehr Informationen unter: https://entomo.ch/de/uuid/i/eacf1031-2e15-5510-a0ad-a3bf066526a9-Prix_Moulines_geht_an_Christian_Roesti.

Insekt des Jahres

Wie jedes Jahr wurde in Zusammenarbeit mit den Schwestergesellschaften in Deutschland und Österreich das «Insekt des Jahres» gekürt. Ziel dieser Initiative ist es, ökologisch wichtige aber oft unterschätzte Insekten der Bevölkerung näher zu bringen. Das Insekt des Jahres 2024 ist der Stierkäfer, *Typhaeus typhoeus*, ein Vertreter der Familie der Mistkäfer und Botschafter einer Gruppe von «Nutztieren», die dafür sorgen, dass der Dung von Säugetieren zersetzt wird und die darin enthaltenen Nährstoffe wieder für die Pflanzen verfügbar sind. Wie üblich wurde ein Flyer dazu verfasst, der via SEG bezogen werden kann. Mehr Informationen unter: https://entomo.ch/de/portrait/insect_of_the_year/insect_of_the_year_2024.

Im Namen des Vorstandes und der SEG-Mitgliedschaft bedanke ich mich nochmals besonders herzlich bei allen genannten Institutionen, Gremien und Personen für ihre wertvolle Unterstützung und ihren Einsatz.

Bericht des Redaktors der Fauna Helvetica, Daniel Burckhardt

Im Berichtsjahr wurden die Bände 33 und 34 publiziert. Band 33 von H. Luka, L. Pfiffner, A. Luka-Stan und P. Nagel ist den Staphylinidae (ohne Pselaphinae und Scydmaeninae) gewidmet mit Angaben zur Ökologie und Verbreitung. Es ist dies der erste Band von Fauna Helvetica, der ausschliesslich digital publiziert wurde. Band 34 von H. Blöchlinger behandelt die Bombyliidae. Der reich bebilderte Band liegt in gedruckter Form vor und beinhaltet Bestimmungsschlüssel und Artporträts.

Die überarbeitete Version der Checkliste der Dipteren der Schweiz (Merz et al. 1998), die als zweiter Band der FH-Reihe nur in digitaler Form erscheinen wird, befindet sich derzeit in der Layout-Phase. Das Manuskript von T. Hertach über die Singzikaden ist jetzt weit fortgeschritten und weitere Arbeiten sind in Vorbereitung.

Für die gute Zusammenarbeit möchte ich meinem Redaktionskollegen Dr. Yves Gonseth und den Mitarbeiterinnen und Mitarbeitern von info fauna ganz herzlich danken.

Bericht der Chefredaktorin von Alpine Entomology, Jessica Litman

The seventh issue of Alpine Entomology was sent out to members in February 2024. This issue included twenty-two articles representing a total of 284 pages: 16 research articles, four short communications and one in memoriam, as well as the yearly report of the SES. Five new articles were added to the topical collection “Trends in arthropods of alpine aquatic ecosystems” and one new article to the topical collection “Impacts of alien insects in the Alpine ecosystem”. This issue saw several changes to the editorial board of Alpine Entomology. Jessica Litman (Muséum d’histoire naturelle de Neuchâtel) replaced Thibault Lachat as editor-in-chief; other members of the board now include Yves Basset (Smithsonian Tropical Research Institute), Hannes Baur (Naturhistorisches Museum Bern), Seraina Klopfstein (Naturhistorisches Museum Basel), Dominique Mazzi (Agroscope Cadenazzo), Lyubomir Penev (Pensoft) and Inon Scharf (Tel Aviv University).

Alpine Entomology has been indexed by Scopus since 2020. In June 2023, Alpine Entomology received its first impact factor in Clarivate's Journal Citation Reports, demonstrating its increasing visibility and importance in the field. Many thanks are due to subject editors, reviewers and to Pensoft, for ensuring the timely publication of submitted articles (average time from submission to publication in 2023 = 2.7 months). Ideas for new topical collections are welcome. In the future, Alpine Entomology will continue to strive to attract a steady flow of high-quality articles concerning alpine and montane entomology from regions around the world.

Bericht des Quästors, Yohan Collaud

Aus der Jahresrechnung 2023 von Herrn Collaud ist folgende Tabelle entnommen:

Positionen / Objets	**Ausgaben / Dépenses**	**Einnahmen / Revenus**
Publikationskosten / Charges de publications:		
Publikation AE - Druck / Impression	7’881.48	
Pensoft: Website, Open access	14‘814.75	
Publikation «Fauna Helvetica»	23‘510.85	
Honorare Hauptreferenten / Honoraires des conférenciers principaux	725.00	
ETH-Digitalisierungsprojekte / Projets de digitalisation ETH	1‘207.51	
Verwaltung / Administration	12‘141.37	
Beitrag sc|nat / Cotisation sc|nat	1‘463.00	
Arbeitsgruppenförderung / Groupes soutien de travail	1‘689.75	
Ausserordentliche Kosten / Charges extraordinaires	678.00	
Mitgliederbeiträge / Cotisations		14‘457.00
Verkäufe «Fauna Helvetica» / Ventes «Fauna Helvetica»		7‘328.60
Beiträge / Subventions:		
sc|nat		6‘914.75
Biedermann-Mantel-Stiftung		6‘000.00
Spenden und sonstige Einnahmen / Dons et autres produits		30.00
Zinsen / Intérêts:		
SEG-Konten / Comptes SEG		150.80
Wechselkursdifferenz / Différence de change	10.48	
«Fauna Helvetica»-Konto / Compte «Fauna Helvetica»	73.68	
Auflösung von Rücklagen / Dissolution de réserve («Fauna Helvetica»)		22‘265.00
Total / Totaux	**64‘195.87**	**57‘146.15**
Jahresverlust / Perte annuelle 2023	**-7‘049.72**	
	57‘146.15	57‘146.15

Die Erfolgsrechnung für das Jahr 2023 schloss mit einem Verlust von 7‘049.72 CHF und einem Vermögen von 100‘403.20 CHF.

Daniel Burckhardt und Yves-Gonseth merken an, dass die Beträge für Ausgaben bei Fauna Helvetica schwer zu budgetieren sind, da die Veröffentlichungen von neuen Bänden unregelmässig erfolgen. Ausserdem gab es im Jahr 2023 zum ersten Mal einen rein digitalen Band, bei dem natürlich Druck- und Versandkosten entfallen.

Bericht der Rechnungsrevisoren, Andreas Sanchez und Yannick Chittaro

Sehr geehrte Damen und Herren

Als Kontrollstelle der Schweizerischen Entomologischen Gesellschaft und der Entomo Helvetica haben wir die Jahresrechnung 2023 geprüft. Dabei stellten wir fest, dass:

- die Eröffnungsbilanz, der Jahresabschluss und die Betriebsrechnung der Rechnungserlegung entsprechen
- die Belege konform und genau sind und den gewöhnlichen Aktivitäten der SEG entsprechen
- das Vermögen der Gesellschaft dem Aktivkonto der Bilanz (Liquidität + Transitorische) entspricht.

Für ihren Teil gewährleistet die Kassiererin, dass die Buchführung, im Rahmen ihrer Befugnisse, korrekt und nach den Prinzipien der Formel des Obligationencodes (CO 959 t 662a/2) durchgeführt wurde.

Deshalb beantragen wir der Mitgliederversammlung, die vorliegende Jahresrechnung zu genehmigen und der Quästorin Entlastung zu erteilen.

Den Quästoren wird von den anwesenden Mitgliedern einstimmig Decharge erteilt.

Finanzielles und Mitgliederbeiträge

Finanzielle Situation der SEG

Die Präsidentin erläutert den Anwesenden die derzeitige finanzielle Situation der SEG. Aktuell wird ein jährlicher Verlust von 6‘000 bis 7‘000 CHF verzeichnet. Dies liegt zum Grossteil an gestiegenen Kosten bei unserer Zeitschrift «Alpine Entomology» (Druck, Versand). Der Vorstand hat daher beschlossen, eine Erhöhung der Mitgliederbeiträge vorzuschlagen: Mitglieder in Ausbildung zahlen weiterhin 30 CHF, Mitglieder, die auf ein gedrucktes Exemplar von «Alpine Entomology» verzichten, zahlen weiterhin 60 CHF und Mitglieder, die ein gedrucktes Heft erhalten wollen, zahlen nun 90 CHF. Es folgt eine allgemeine Diskussion zum Thema Finanzielles bei «Alpine Entomology». Hannes Baur, der einer der Mitinitianten bei der Umstellung auf unsere neue Zeitschrift war, erläutert: In der Anfangsphase von «Alpine Entomology» hat man bewusst niedrige Publikationskosten angesetzt, um die Zeitschrift attraktiver und bekannter zu machen. Die Publikationskosten könnten nun angehoben und flexibler gestaltet werden (Waiver-System). Christophe Praz merkt an, dass z. B. Publizierende mit einer Schweizer Institution im Rücken (Universität, Museum etc.) mehr bezahlen könnten, da die Kosten von den Institutionen übernommen werden.

Ein weiterer Einwand ist, dass gemäss Statuten alle Mitglieder der SEG ein Anrecht auf ein gedrucktes Exemplar unserer Zeitschrift haben, weshalb eine Erhöhung der Mitgliederbeiträge in Zusammenhang mit dem Erhalt der Zeitschrift ohne eine Statutenänderung nicht möglich wäre.

Die Präsidentin schlägt zum Schluss der Diskussion folgendes vor:

1. Das Preissystem der Publikationskosten von «Alpine Entomology» soll angepasst werden.
2. Alle Mitglieder der SEG sollen befragt werden, ob sie in Zukunft weiterhin ein gedrucktes Exemplar von «Alpine Entomology» erhalten möchten, oder freiwillig darauf verzichten. Dies soll die Druck- und Versandkosten senken.
3. Die Mitgliederbeiträge sollen nicht geändert werden.

Die Vorschläge werden einstimmig angenommen.

Mitgliederbeiträge 2024

Die Beiträge bleiben erneut gleich (siehe oben): Mitglieder in der Schweiz zahlen 60 CHF, Studierende oder sich anderweitig in Ausbildung befindende Mitglieder zahlen nur die Hälfte des ordentlichen Beitrags (30 CHF). Mitgliedern im Ausland, die die gedruckte Version von «Alpine Entomology» wünschen, werden zusätzlich 15 CHF Versandkosten verrechnet.

Personelles

Änderungen im Vorstand

- Unsere Medienverantwortliche Claudia Buser hat ihr Amt aus beruflichen Gründen niedergelegt. Oliver Martin und Dominique Mazzi werden das Amt *ad interim* weiterführen, bis eine Nachfolge gefunden wurde.
- Vivien Cosandey übernimmt die Vertretung der assoziierten Lokalgesellschaft aus Genf von Jean Wüest. Der Wechsel wird einstimmig bestätigt.

Ehrenmitglieder

Jean Wüest wird vom Vorstand als Ehrenmitglied vorgeschlagen. Herr Wüest war als wissenschaftlicher Mitarbeiter am Muséum d'Histoire Naturelle de Genève tätig, wo er das Elektronenmikroskop betreute. Gleichzeitig war er auch Lehrbeauftragter für Entomologie an der Universität Genf. Von 1978 bis 2024 war Herr Wüest Vorstandsmitglied der SEG als Vertreter der Société Entomologique de Genève. Von 1999 bis 2002 war er zudem Präsident und von 2002 bis 2005 Vizepräsident der SEG. Die Ernennung wird einstimmig angenommen.

Todesfälle

Unserem verstorbenen Mitglied Heidi Günthart-Butz (Expertin für Zikaden, Ehrenmitglied der SEG; 1919–2023) wird mit einer Schweigeminute gedacht.

Jahresversammlung 2025

Die nächste Jahresversammlung, die entomo.ch 2025, soll am 1. oder 2. Märzwochenende stattfinden. Ein definitiver Austragungsort steht noch nicht fest.

Ende der Generalversammlung um 11:03 Uhr.

Zuchwil im November 2024,
der Sekretär Marc Neumann.