



Alpine

Entomology

6 2022

Alpine Entomology

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Alpine Entomology

2022. Volume 6

ISSN: 2535-0889 (online)

Photo

The cover picture shows habitus of *Ikaros navarretei* sp. nov. See paper of **Reyes-Hernández JL, Hansen AK, Solodovnikov A** *Ikaros navarretei* (Coleoptera, Staphylinidae, Staphylininae), a new apterous rove beetle species from high elevations in Colombia.

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Lack of genetic structure suggests high connectivity of *Parnassius phoebus* between nearby valleys in the Alps

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Academic editor: Peter Huemer ♦ Received 11 January 2022 ♦ Accepted 13 March 2022 ♦ Published 24 March 2022

Abstract

The spatial scale of intraspecific genetic connectivity and population structure are important aspects of conservation genetics. However, for many species these properties are unknown. Here we used genomic data to assess the genetic structure of the small Apollo butterfly (*Parnassius phoebus* Fabricius, 1793; Lepidoptera: Papilionidae) across three nearby valleys in the Central Swiss Alps. One of the valleys is currently used for hydropower production with future plans to raise the existing dam wall further. We found no significant genetic structure, suggesting a currently high connectivity of this species in our studied region.

Key Words

Lepidoptera, conservation, gene flow, genomics, *Parnassius sacerdos*

Introduction

The maintenance of genetic diversity is a key target of current conservation efforts because such diversity is thought to enable species to cope with changing environments (DeWoody et al. 2021). Among the factors that can reduce genetic diversity are habitat fragmentation and global climate change (Pauls et al. 2013; Schlaepfer et al. 2018). Alpine environments may especially be threatened by climate change (Engler et al. 2011), the latter often promoting the subdivision of locally adapted species (Jordan et al. 2016). The scale at which intraspecific gene flow occurs is thus an important property of a species with significant implications for conservation and management. However, the spatial scale of genetic connectivity is often unknown as its assessment either requires large-scale mark-recapture studies or genomic data (Gagnaire et al. 2015).

Here, we assessed the potential for intraspecific gene flow in an alpine butterfly – the small Apollo (*Parnassius phoebus* Fabricius, 1793; Lepidoptera: Papilionidae).

The species occurs locally in alpine environments from Alaska over Russia to the Alps (Todisco et al. 2012). Many of its allopatric populations have been described as distinct subspecies whose taxonomic status has though remained elusive (Weiss and Rigout 2005). For example, there is an ongoing debate if *P. phoebus* from the Alps should be named *P. sacerdos* (International Commission on Zoological Nomenclature 2017) or not (Bálint 2021), where *P. sacerdos* and Eurasian *P. phoebus* are polyphyletic based on mitochondrial haplotypes (Todisco et al. 2012). Given the unresolved taxonomy, we use *P. phoebus* here, which is consistent with the current Swiss red list for butterflies (Wermeille et al. 2014). *P. phoebus* subspecies differ often phenotypically from each other but intraspecific phenotypic variation also occurs at smaller scales. Indeed, a former study on alpine melanism, highlighted the adaptive value of increased melanism with increased elevation and latitude in *P. phoebus* (Guppy 1986). Males that were darker on their hindwings spent a greater proportion of time in flight at low air temperatures and showed increased movement (Guppy

1986). Importantly, the global diversity within *P. phoebus* is young, *i.e.*, evolved over the last ~125'000 years, where geographically distant populations within a continent diverged as recently as 10'000–50'000 years ago (Todisco et al. 2012). Like for other species of this genus, *P. phoebus* is thought to have moderate dispersal capabilities, being able to fly from some hundred metres to few kilometres (Guppy 1986; Brommer and Fred 1999). However, natural barriers has been shown to limit intraspecific gene flow in other *Parnassius* species (Keyghobadi et al. 1999), but to which degree this is true for *P. phoebus* is not known.

Parnassius phoebus is a univoltine species and in the Alps can be found in humid, often flooded habitats with mostly extensive stands of *Saxifraga aizoides*, the primary larval food plant of this species (Lepidopterologen Arbeitsgruppe 1987). Habitats include relatively flat headwaters and riparian zones of small and large watercourses, often with alluvial plains in the subalpine and alpine and occasionally the montane zones. In the Bernese Alps, the species can be found from 1400 to 2300 m elevation, occurring both on limestone and silicate rock substrates. Imagoes feed on nectar from a range of plants, including thistles, *Origanum* and various cushion-forming plants, such as *Saxifraga*. Eggs are generally not directly laid on the host plant, but either on dried plants in its vicinity or directly on the soil substrate (Lepidopterologen Arbeitsgruppe 1987).

We used nuclear genomic data to assess the potential for gene flow among individuals collected from three nearby valleys in the Central Swiss Alps (Fig. 1). We focused on this region because the Trift valley experienced significant past and future anthropogenic alterations as a consequence of artificial damming for hydropower production (Haeberli et al. 2016; Guillén-Ludeña et al. 2018). This, together with the impact of climate change could thus render *P. phoebus* locally vulnerable, especially if current intraspecific gene flow would be limited (Condamine and Sperling 2018).

Methods

Sampling

We collected a total of 18 butterflies during summers 2015–2020. Sampling was conducted in three valleys in the Central Swiss Alps (Susten (N=6), Trift (N=8), Wenden (N=4), Fig. 1, Suppl. material 1: Table S1). We captured all individuals with hand nets and killed them with an overdose of ethyl acetate. Full bodies were dried for further genetic analyses.

Genetic data processing

We genotyped all individuals using single-end restriction-site associated DNA (RAD) sequencing with the restriction enzyme *PstI*. For all individuals

we extracted the DNA from thorax tissue using the Qiagen DNeasy Blood and Tissue kit (Qiagen, Zug, Switzerland) following the manufacturer's protocol. Library preparation and sequencing on one Illumina HiSeq 4000 lane was outsourced to Floragenex (Portland, OR, USA). All genomic data is archived on NCBI (BioProject ID: PRJNA814465).

We filtered all obtained genomic data following (Lucek et al. 2020), *i.e.*, we only retained reads with an intact *PstI* restriction site, followed by de-multiplexing and barcode-trimming with *process_radtags* from Stacks 1.48 (Catchen et al. 2013). Using the FASTX toolkit (http://hannonlab.cshl.edu/fastx_toolkit/), we then removed reads containing bases with a Phred quality score <10 or more than 5% of base pairs with quality <30. This approach yielded ~18.5 million high quality reads in total for our analysis. Given the lack of a *Phoebus* reference genome, we generated a *de novo* assembly of RAD-tags using all filtered reads for all individuals with *ustacks* 1.48 (Catchen et al. 2013) with the following settings: minimum stack size of 50 reads, a maximum of three base pairs of difference for stacks to be merged, excluding loci with unusually high coverage to avoid repetitive regions. The initial *de novo* assembly consisted of 11'004 contigs. To further identify and remove exogenous contigs from the assembly, we compared the assembly against the NCBI GenBank nucleotide collection with the *blastn* function from BLAST+ 2.7.1 (Camacho et al. 2009). A total of 40 or 0.4% of all contigs were of exogenous origin and we removed them from the initial assembly.

In a next step, we mapped the reads of each individual against our reference assembly with minimap2 2.2 (Li 2018) and genotyped all specimens with BCFtools 1.10.2 (Danecek and McCarthy 2017). We filtered the genotypes with VCFtools 0.1.16 (Danecek et al. 2011) to remove indels, to include only bi-allelic polymorphic sites with a minimal depth of six and a minimal genotype quality of 20, employing a minor allele frequency filter of 0.03 and allowing up to 50% of missing data per site. Due to high rates of missing data, two specimens were filtered out (Suppl. material 1: Table S1). The overall filtering resulted in 5157 SNP sites available for our downstream analyses.

Genetic analyses

To test for an individual based genetic structure, we first employed a phylogenomic analysis comprising all retained specimens. We used RAXML 8.2.11 (Stamatakis 2014) implementing a generalised time-reversible (GTR) model with optimised substitution rates and a gamma model of rate heterogeneity. We further applied an ascertainment bias correction to account for the fact that we only used polymorphic SNP positions with the *ASC_GTRGAMMA* function implemented in RAXML. Significance was assessed using 1000 bootstrap replicates followed by a thorough maximum likelihood search.

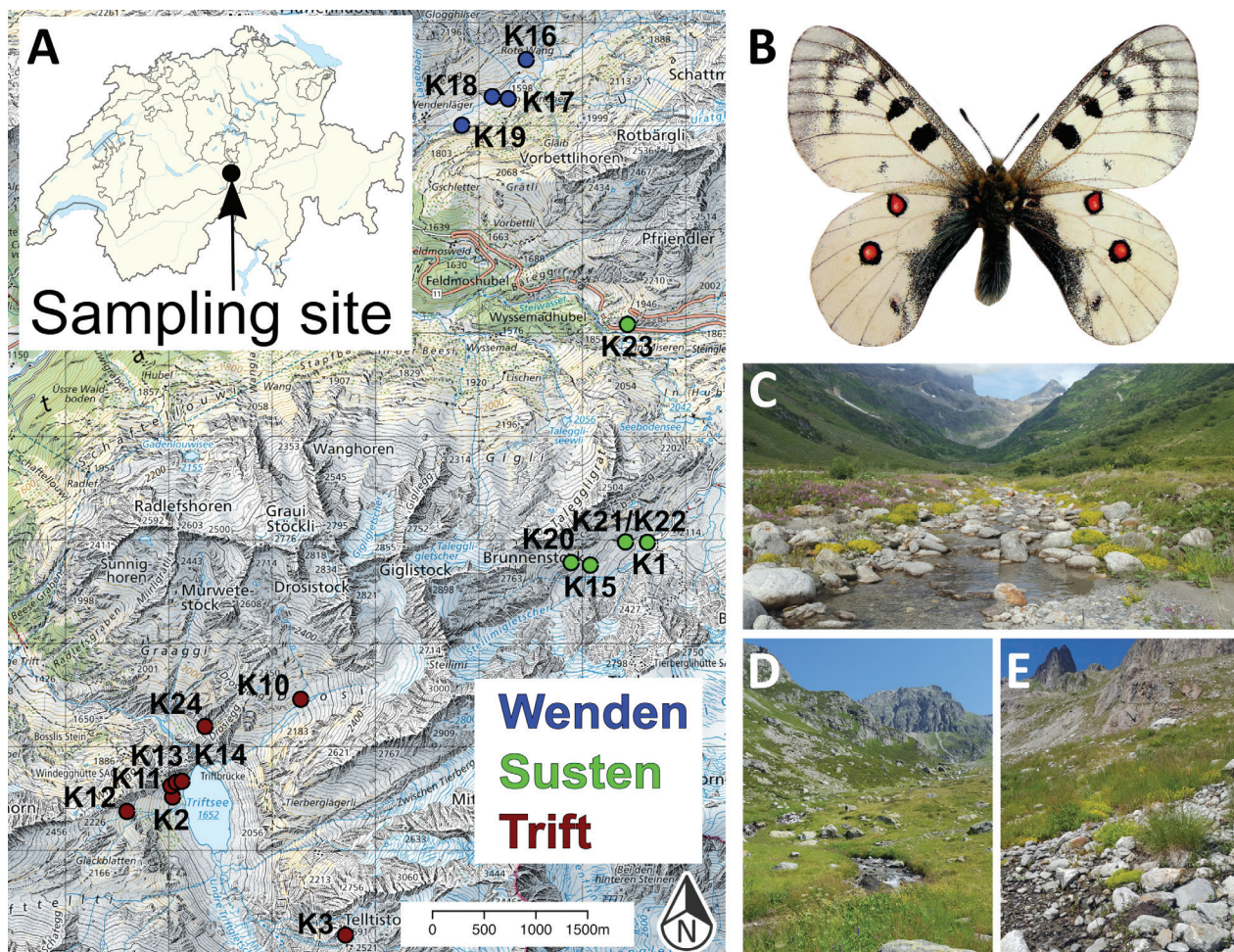


Figure 1. Overview of our sampled sites. **A.** Map depicting the sampling locations of all collected individuals from the central Swiss Alps with the inset depicting the sampling site in Switzerland (see Table S1 for details). Circle colour indicates the different valleys. For each individual the respective sample ID is given (see Table S1). Map source: Federal Office of Topography swisstopo; **B.** Example of *Parnassius phoebus* (individual K13); **C–E.** Habitat pictures for Wenden, Trift and Susten, respectively.

We next inferred population structure with Admixture 1.3.0, which implements a likelihood approach to estimate ancestry (Alexander et al. 2009). We ran ADMIXTURE by varying the number of assumed populations, *i.e.*, K , from 1 to 5 and performed a cross-validation test to determine the optimal value of K . In a second step we used a principal component (PC) analysis as implemented in GenoDive 3.0.5 (Meirmans 2020) to visualize the genetic relationship among individuals.

Finally, we estimated the overall level of pairwise genetic differentiation (F_{ST}) among individuals from the three valleys (Susten, Trift, Wenden; see Suppl. material 1: Table S1) using GenoDive, with 1000 bootstrap iterations to estimate significance. Because genetic differentiation would only occur at few loci that experience direct or indirect selection in the case of recent divergence (Seehausen et al. 2014), we also performed locus-by-locus F_{ST} in Genodive analyses between Trift individuals and individuals from Susten and Wenden combined.

Results

The bootstrap approach employed in our RAXML analysis found no significant node splits (*i.e.* >95% bootstrap support), suggesting the absence of a detectable differentiation among individuals. Similarly, no clustering occurred related to the three different valleys (Fig. 2a). The best number of genetic clusters as inferred by Admixture was likewise one ($K=1$), where the subsequent model assuming two genetic cluster showed no clustering by valleys (Fig. 2c). The two leading PC axes accounted for 9.3 and 8.4% of the total variation respectively and only here some individuals from the Trift valley seemed to be differentiated from the other individuals along PC1 (Fig. 2b).

The level of pairwise genetic differentiation among valleys was generally low and non-significant (Susten vs. Trift: $F_{ST} = 0.005$, $p = 0.195$; Susten vs. Wenden: $F_{ST} = 0.017$, $p = 0.143$; Trift vs. Wenden: $F_{ST} = 0.021$, $p = 0.177$). This was similarly true when individuals from Susten and Wenden were pooled ($F_{ST} = 0.006$, $p = 0.059$; Fig. 3). The locus-by-locus analysis for the

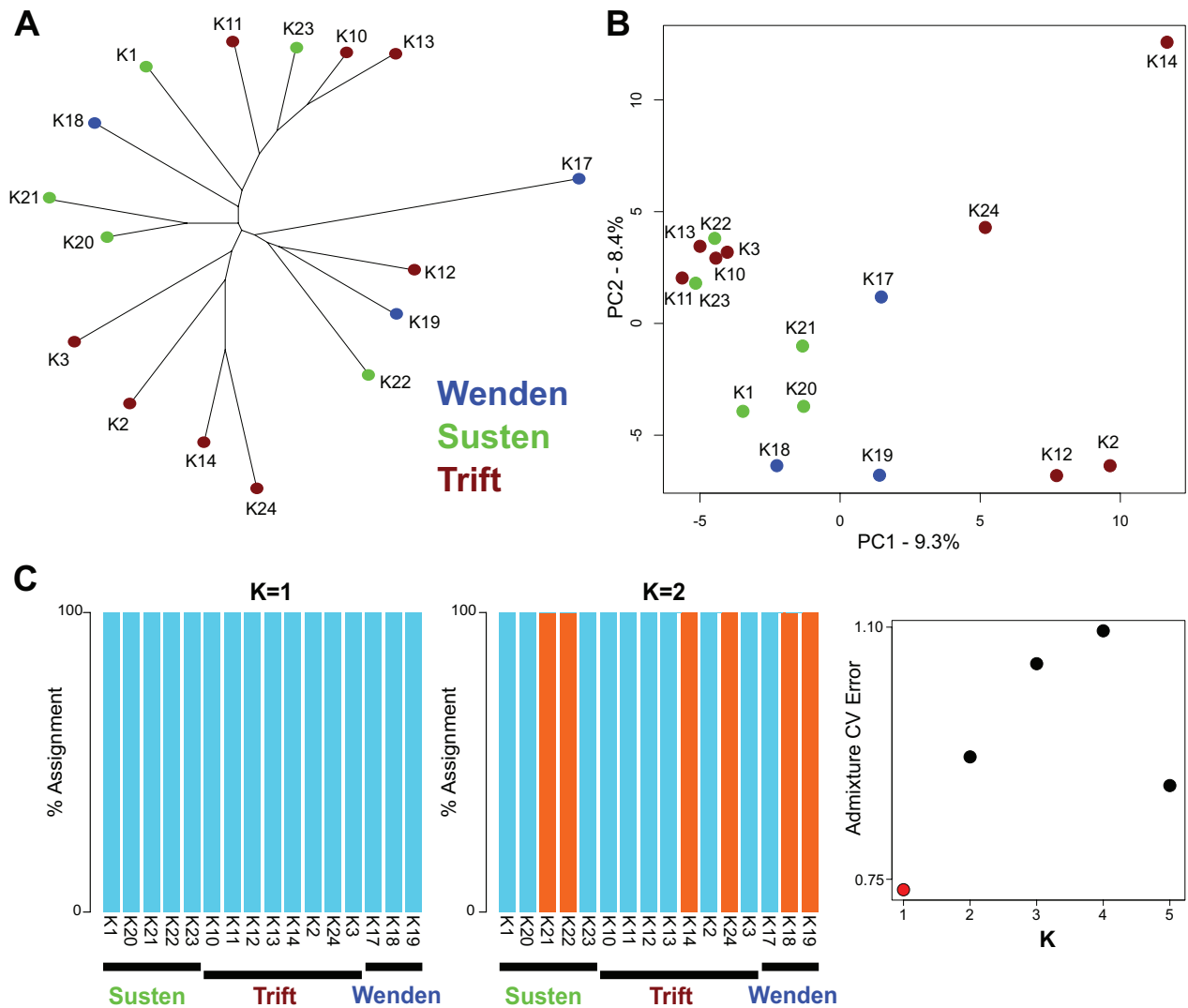


Figure 2. Summary of the individual based genetic analyses. **A.** Unrooted phylogram based on a RAxML analysis. None of the nodes were statistically significant (all with <95% bootstrap support); **B.** Scores of a principal component (PC) analysis for the two leading axes. **C** – Individual based assignments as inferred by Admixture. One genetic cluster ($K=1$) was the best supported number as inferred by the cross validation (CV) error. For **A**, **B** colours depict valleys. For each individual the respective sample ID is given (see Fig. 1, Suppl. material 1: Table S1).

same comparison identified only 11 SNPs with an $F_{ST} > 0.20$ (Fig. 3), however, none of the associated contigs could be mapped to a known gene by BLAST.

Discussion

Using genomic data, we found a lack of genetic structure among individuals of the small Apollo *Parnassius phoebus* that could be attributed to the three valleys in close proximity, *i.e.*, being 4–8 km apart, which we sampled in the central Swiss Alps (Figs 1, 2). Our results thus suggest a high connectivity of this species in our studied region. Consequently, the valleys, mountain ridges, glaciers or other potentially unsuitable habitat structures in our studied region (Fig. 1) do not present strong barriers to gene flow. This finding contrasts with

observations in other *Parnassius* species where such geographic structures resulted in fine-scale population structure (Brommer and Fred 1999; Keyghobadi et al. 1999). While the absence of significant genetic differentiation, as estimated by F_{ST} , may also highlight the statistical limitations given the sample size of our study, the individual-based analyses that we applied would allow to detect potential fine-scale structure (Rieder et al. 2019).

P. phoebus is an evolutionary young species that has moreover recolonized the studied area only after the last glaciation period (Todisco et al. 2012). Consequently, even if local adaptation would have occurred, the respective populations may not necessarily have had enough time to accumulate genetic differentiation beyond few genomic regions that experience selection (Nosil 2012; Seehausen et al. 2014). Indeed, our locus-based analysis identified

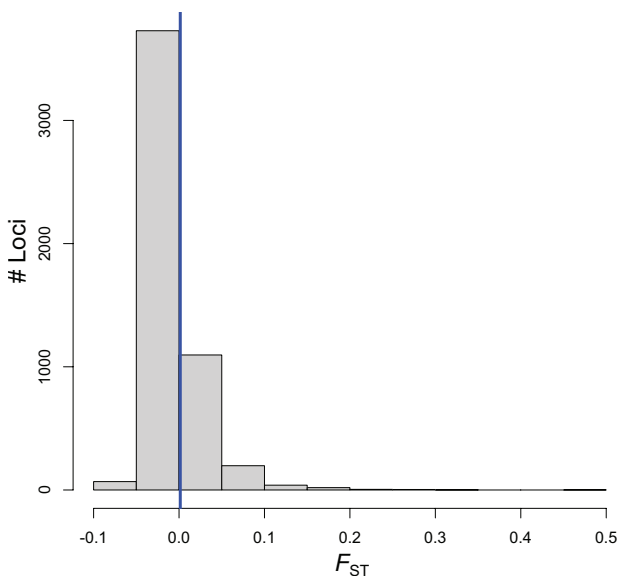


Figure 3. Histogram of the genetic differentiation (F_{ST}) between individuals from the Trift valley and the two other valleys combined, calculated for each locus separately. The blue line indicated the global $F_{ST} = 0.0057$.

very few sites of accentuated differentiation (Fig. 3). Such genomic differentiation at only few target loci may be consistent with a potential very early stage of divergence-with-gene-flow, where further differentiation depends on the evolution of barriers to gene flow (Nosil 2012). However, the interpretation of such genomic regions has to be done with care, as they can also emerge through non-adaptive processes including genetic drift (Ravinet et al. 2017). Lastly, both the lack of significant genomic differentiation and the limited number of loci that showed accentuated differentiation could reflect a limited resolution given the restricted number of polymorphic SNPs available for our analyses and the absence of a reference genome.

A high connectivity despite potential natural barriers may suggest that *P. phoebus* could be less affected by future anthropogenic modifications in the studied area (Haeberli et al. 2016; Guillén-Ludeña et al. 2018). However, such modifications will act combined with the effects of climate change, which is thought to be a main threat for species of the genus *Parnassius* (Condamine and Sperling 2018). Although *P. phoebus* can likely track its climatic niche by shifting its range up the mountains until they can go no higher, the species also depends on the availability of host plants, which can be equally affected by both factors (Condamine and Sperling 2018). Therefore, from a conservation perspective, it would be advisable to broaden the geographic scope of our study to identify the scale of potential population structure in *P. phoebus* across the Alps, ideally with denser genomic data. In addition, future anthropogenic habitat modifications, as it is planned for the Trift valley (Ehrbar et al. 2018), should be accompanied by a genetic monitoring for both *P. phoebus* and its host plant.

Acknowledgements

Fieldwork and sequencing were funded by the Kraftwerke Oberhasli (KWO) AG. We would especially thank Magdalena Rohrer from the KWO for her support throughout the project. We further thank Sebastian Wymann for his outstanding efforts during fieldwork. We thank Peter Huemer, Thomas Schmitt and two anonymous reviewers for their insightful comments that helped us improve the manuscript. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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Supplementary material 1

Table S1

Authors: Andreas Jaun, Hans-Peter Wymann, Kay Lucek
Data type: pdf

Explanation note: Summary of all individuals included in our study, including their sample ID, the collection date, the valley where they were collected with their respective coordinates. Individuals highlighted in bold were excluded from the genomic analyses due to their amount of missing data.

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Link: <https://doi.org/10.3897/alpento.6.80405.suppl1>

Two new high Andean species of *Liodessus* diving beetles from Venezuela (Coleoptera, Dytiscidae, Bidessini)

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<http://zoobank.org/75DB5DB6-C3E5-4B3C-9B5C-15722723ED3B>

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Academic editor: Andreas Sanchez ♦ Received 20 December 2021 ♦ Accepted 14 March 2022 ♦ Published 10 May 2022

Abstract

Two new species of the diving beetle genus *Liodessus* Guignot, 1939 are described from high mountain regions in Venezuela: *Liodessus meridensis* **sp. nov.** from Laguna de Mucabají, Mérida and *L. venezuelensis* **sp. nov.** from Laguna de Mucabají and below Pico Bolívar, Mérida. We delineate the species using morphological characters such as male genital structure and beetle size, shape and color. Mitochondrial *cox1* sequence data provided an additional character source. Both new species occur at altitudes above 3,500 m and were collected in shallow water at the edge of high-altitude ponds.

Key Words

Dytiscidae, *Liodessus*, new species, Venezuela, Mérida

Introduction

Liodessus Guignot, 1939 are small diving beetles, usually less than 3 mm long, and occur in the New World as well as the Afrotropical region (Biström 1988; Nilsson and Hájek 2021). In the high Andes, at altitudes from ca. 3,000 to nearly 5,000 meters, they are probably the most abundant aquatic beetles (Balke et al. 2020a; Balke et al. 2020b). However, diving beetles from such high altitudes of the Páramo and Puna regions remain poorly studied. Since 2019, eleven new species have been described from Peru (Balke et al. 2020a, b) and Colombia (Balke et al. 2020c; Balke et al. 2021;

Megna et al. 2019). Since then, it has become apparent that many more remain to be discovered, most of them likely microendemics. To address this in a combined evidence framework, we established a DNA sequence-supported project for the study of these beetles (Balke et al. 2020a, b), using the Barcode of Life Data System (BOLD) of the Canadian Centre for DNA Barcoding and the 5' mitochondrial *cox1* gene fragment (www.boldsystems.org) (Ratnasingham and Hebert 2007). Here, we continue our collaborative research project on the water beetle fauna of the higher mountain regions of South America by reporting the discovery of two new species of *Liodessus* from Venezuela.

Materials and methods

The following acronyms are used in the text: CBP (Collection D. T. Bilton, Plymouth, UK); MIZA (Museo del Instituto de Zoología Agrícola “Francisco Fernández Yépez”, Universidad Central de Venezuela, Maracay, Venezuela); SEMC (Natural History Museum and Biodiversity Research Center, University of Kansas) and ZSM (SNSB-Zoologische Staatssammlung, München, Germany, temporarily stored for further morphological work).

Morphological descriptions and photography. The description of morphological characters follows our previous work on *Liodessus* beetles, e.g. Balke et al. (2020b). Images were taken with a Canon EOS R camera. We used Mitutoyo 10× (habitus) or 20× (genital structures) ELWD Plan Apo objectives. These were attached to a Carl Zeiss Jena Sonnar 3.5/135 MC, used as a focus lens. Illumination was with three LED segments SN-1 from Stonemaster (<https://www.stonemaster-onlineshop.de>). Image stacks were generated with the Stackmaster macro rail (Stonemaster), and images were then assembled with the computer software Helicon Focus 4.77TM on an iMac with a Radeon Pro 5500 XT GPU.

DNA analysis. The DNA sequencing and data analysis protocols follow standard Canadian Centre

for DNA Barcoding (CCDB) barcoding procedures (www.ccdb.ca). We delivered tissue samples to CCDB, which were processed and the barcode data uploaded to BOLD systems. We used a simple approach to calculate a neighbour-joining tree (p-distances) in Geneious software (version 11.0.4.), in order to learn if newly added entries could be assigned to existing species groups or not. This approach has been proven helpful in guiding the morphological descriptive process, not the least by enabling us to unambiguously identify the new species presented here, even in the absence of male specimens.

Results

Liodessus meridensis sp. nov.

<http://zoobank.org/CB562F9F-95AD-4537-ACA5-305AA84CB53C>

Figs 1A, 2A, B, 3A, 4

Type locality. Laguna de Mucabají, Mérida, Venezuela.

Type material. *Holotype*: Male: Venezuela; Mérida, Laguna de Mucabají, 3,500 m, i.2004, 8.7964, -70.8255, García & Balke (MIZA). *Paratypes*: 13 exs same label data as holotype (MIZA, ZSM); 47 exs Venezuela: Mérida, ca. 5 km E Gavidia, 3,600 m, 23.I.2012, 8.6895,

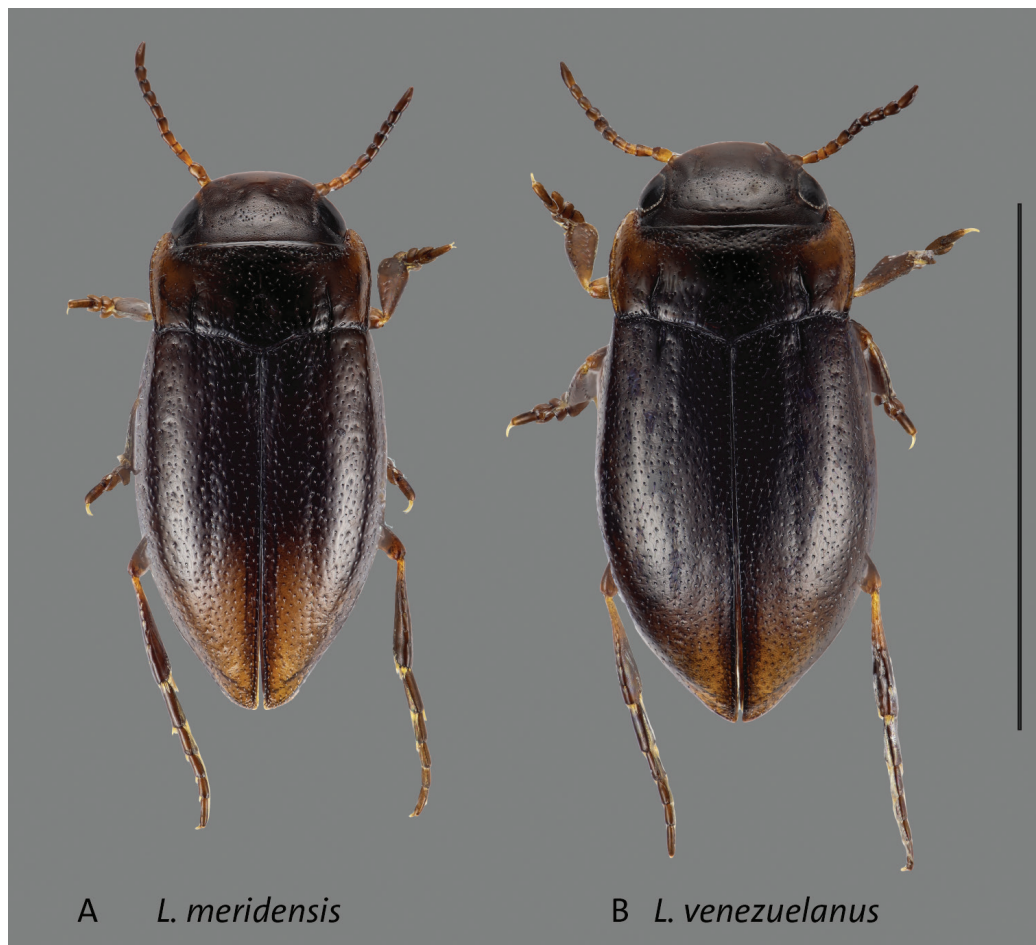


Figure 1. Dorsal habitus of *Liodessus* spp. nov. *L. meridensis* (A); *L. venezuelanus* (B). Scale bar: 2 mm.

-70.8817, Short, Arias & Gustafson, lagoon margin, VZ12-0123-03A (MIZA, SEMC).

Description. Habitus with only slight discontinuity between pronotum and elytron (Fig. 1A), pronotum widest before base and more parallel sided laterally (Fig. 1A). Total length (TL) 2.1 mm; length without head (TL-h) 1.9 mm; maximum width (MW) 0.9 mm.

Color. Very dark brown to blackish dorsally and ventrally, basal antennomeres, base of meso- and metatibia contrastingly of lighter color (Figs 1A, 2A, B).

Surface sculpture. Head with few larger and smaller setiferous punctures; with distinct microreticulation except on middle of head between the eyes (Figs 1A, 2A, B). Pronotum and elytron shiny; with moderately dense and coarse setiferous punctation (Fig. 1A).

Structures. Antenna stout. Head without occipital line; with rounded clypeus. Pronotum with distinct lateral beads; with distinct long and deep basal striae (Fig. 1A). Elytron with short basal stria; without sutural line; without basal epipleural transverse carina. Metathoracic wings not examined in holotype (in paratype: short, about half the length of elytron).

Genitalia. Median lobe of aedeagus of long, simple curvature in lateral view, more or less gradually narrowing towards tip; also gradually narrowing towards a narrow tip in ventral view; parameres of simple “Bidessini” type, two-segmented (Fig. 3A).

Female. Pronotum and elytra microreticulate, dull (specimens from Gavidia); shiny in the ones from Laguna de Mucabají.

Variation. Size variation of the paratypes is TL 2.1–2.3 mm; TL-h 1.8–2.0 mm; MW 0.9–1.1 mm. The elytral striae are hardly noticeable in a few paratypes.

Etymology. Named after the state of Mérida, in which the collecting localities are situated. The name is an adjective in the nominative singular.

Comparative notes. Distinguished from the other species of *Liodessus* by the diagnostic combination of the following features: Species from Venezuela; beetle smaller (TL 2.1–2.3 mm); very dark brown to blackish; head without occipital line; pronotal and elytral striae present; wings reduced considerably; shape of median lobe (narrow and “pointed” in lateral and ventral view, with its particular shape).



Figure 2. *Liodessus* spp. nov. Detail of head in dorsal view. *L. meridensis* (A, B); *L. venezuelanus* (C, D).

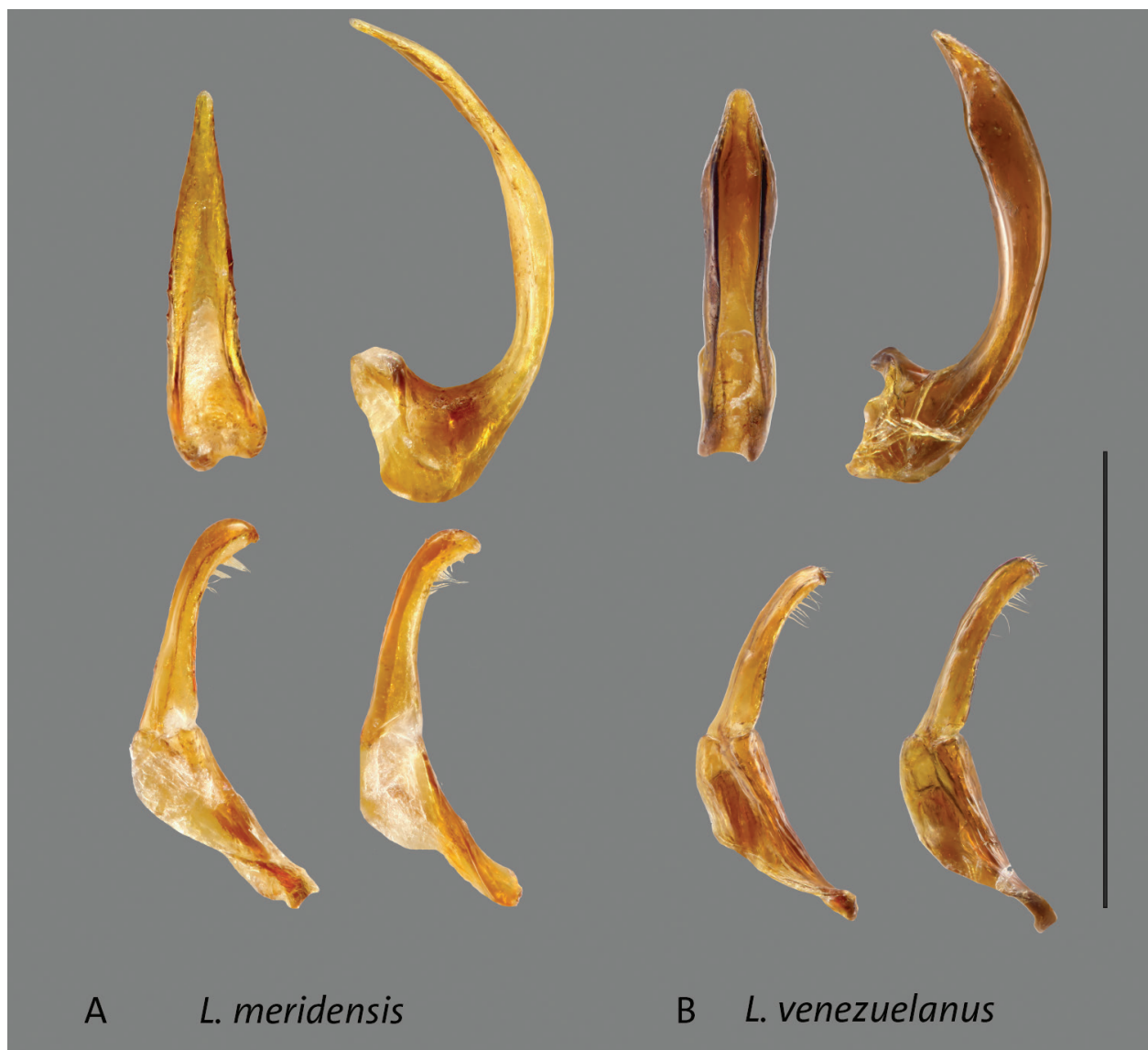


Figure 3. *Liodessus* spp. nov. Median lobe ventral and lateral views; parameres outer and inner surfaces, *L. meridensis* (A); *L. venezuelanus* (B). Scale bar: 0.5 mm.

BOLD platform. We provided 1 entry to our BOLD *Liodessus* project. The species is well delineated from all other *Liodessus*, with an uncorrected p-distance of around 9% or more.

Distribution. Known from around Mérida, Venezuela.

Habitat. Collected from shallow water at the edge of high-altitude ponds (Fig. 4).

***Liodessus venezuelanus* sp. nov.**

<http://zoobank.org/BD12A35E-2B7F-4D16-8BF5-B316DB57E2F6>

Figures 1B, 2C, D, 3B, 4

Type locality. Laguna de Mucubají, Mérida, Venezuela.

Type material. *Holotype*: Male: Venezuela; Mérida, Laguna de Mucubají, 3,500 m, i.2004, 8.7964, -70.8255, García & Balke” (MIZA). *Paratypes*: 1 ex. same label data as holotype (ZSM); 8 exs Venezuela: Mérida, Pico

Bolívar, Laguna de Gallo, 4,000 m, 6.XII.1998, 8.5269, -71.0722, Bilton (CBP, ZSM); 3 exs Venezuela: Mérida, ca. 5 km E Gavidia, 3,600 m, 23.I.2012, 8.6895, -70.8817, Short, Arias & Gustafson, lagoon margin, VZ12-0123-03A (MIZA, SEMC).

Description. Habitus with more evident discontinuity between pronotum and elytron (Fig. 1B), pronotum widest before base and more rounded laterally (Fig. 1B). Total length 2.2 mm; length without head 2.0 mm; maximum width 1.0 mm.

Color. Very dark brown to blackish dorsally and ventrally, basal antennomeres, base of meso- and metatibia contrastingly of lighter color (Figs 1B, 2C, D).

Surface sculpture. Head with few larger and smaller setiferous punctures (Figs 1B, 2C, D); with distinct microreticulation except on middle of head between the eyes. Pronotum and elytron shiny; with moderately dense and coarse setiferous punctation (Fig. 1B).

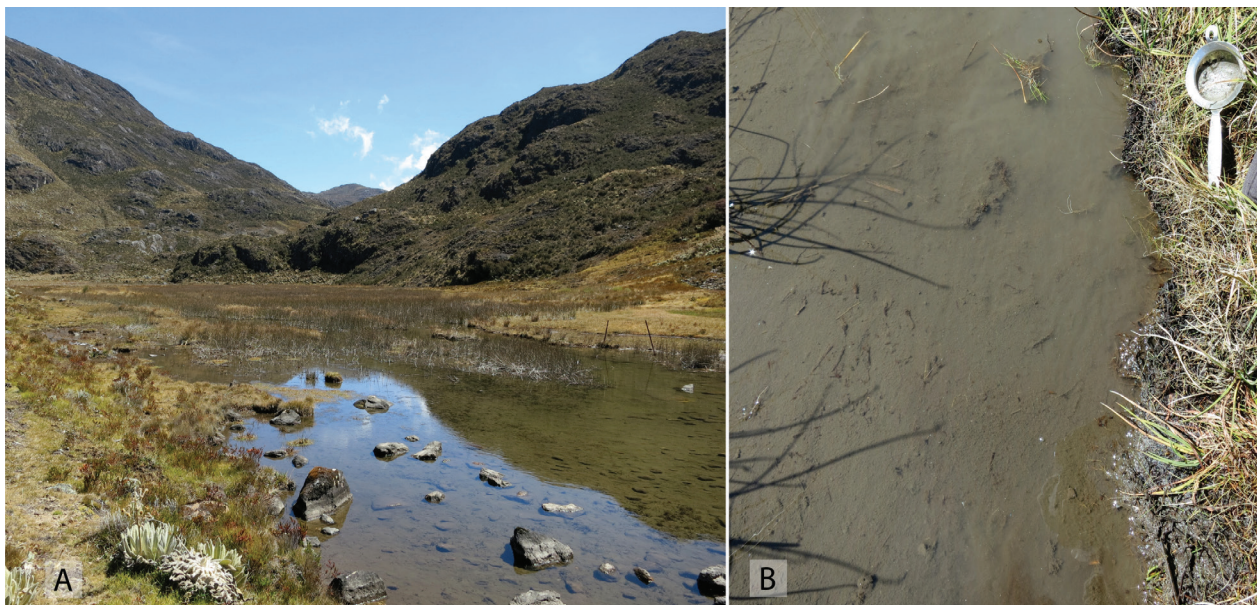


Figure 4. Habitat of *Liodessus* spp. nov. near Gavidia, Venezuela, where both new species were collected (collecting event VZ10-0123-03A). Overview (A); detail of shallow water at the edge (B).

Structures. Antenna stout. Head with occipital line; with rounded clypeus. Pronotum with distinct lateral beads; with distinct long and deep basal striae (Figs 1A, B). Elytron with short basal stria; without sutural line; without basal epipleural transverse carina. Metathoracic wings not examined in holotype (in paratype: short, about half the length of elytron).

Genitalia. Median lobe of aedeagus broadened towards apex, then narrowing in lateral view; also broadening towards tip in ventral view, tip broadly rounded; parameres of simple “Bidessini” type, two segmented (Fig. 3B).

Female. Pronotum and/or elytra microreticulate, dull (specimens from Laguna de Gallo); shiny in the single females from Laguna Mucabají and Gavidia.

Variation. Size variation of the paratypes is TL 2.0–2.3 mm; TL-h 1.8–2.0 mm; MW 0.9–1.1 mm. In few paratypes, the elytral basal stria is not very obvious.

Etymology. Named after the country of origin. The name is an adjective in the nominative singular.

Comparative notes. Distinguished from other species of *Liodessus* by the diagnostic combination of the following features: Species from Venezuela; beetle relatively small (TL 2.0–2.3 mm); very dark brown to blackish; head without occipital line; pronotal and elytral striae present; wings reduced considerably; shape of median lobe (broad in lateral and ventral view, with its particular shape).

BOLD platform. We provided 1 entry to our BOLD *Liodessus* project. The species is well delineated from all other *Liodessus*, with an uncorrected p-distance of around 8% or more.

Distribution. Known from around Mérida, Venezuela.

Habitat. Collected from shallow water at the edge of high-altitude ponds (Fig. 4).

Checklist of the High Andean species of *Liodessus* Guignot, 1953

1. *Liodessus acollensis* Guignot, 1955: Peru
2. *Liodessus alpinus* Balke et al., 2020a: Peru
3. *Liodessus altoperuensis* Balke et al., 2020b: Peru
4. *Liodessus andinus* Guignot, 1957: Bolivia
5. *Liodessus azufralis* Megna et al., 2019: Colombia
6. *Liodessus bogotensis* Guignot, 1953: Colombia
7. *Liodessus caxamarca* Balke et al., 2020b: Peru
8. *Liodessus hauthi* Balke et al., 2020a: Peru
9. *Liodessus lacunaviridis* Balke et al., 2020a: Colombia
10. *Liodessus picinus* Balke et al., 2021: Colombia
- 11a. *Liodessus quillacinga quillacinga* Megna et al., 2019: Colombia
- 11b. *Liodessus quillacinga cochaensis* Megna et al., 2019: Colombia
- 11c. *Liodessus quillacinga cumbalis* Megna et al., 2019: Colombia
12. *Liodessus quimbaya* Megna et al., 2019: Colombia
13. *Liodessus rhigos* Balke et al., 2020a: Peru
14. *Liodessus thespesios* Balke et al., 2020a: Peru
15. *Liodessus meridensis* sp. nov.: Venezuela
16. *Liodessus venezuelanus* sp. nov.: Venezuela

Discussion

The two new species described here are the first high-altitude species of *Liodessus* reported from Venezuela, and we expect to discover additional species in the vast, unsampled Venezuelan mountain regions. Their phylogenetic position remains to be established based on a multigene dataset. Based on the single DNA fragment we utilized here, the two

species are genetically well delineated from all other known high-altitude *Liodessus*. It is well understood that one genetic marker alone cannot be the ultimate tool for taxonomy (Dietz et al. 2021), in particular markers such as *coxI*, which are not involved in speciation per se (Kwong et al. 2012). Rather, such DNA sequence data can be used to guide the sorting of specimens to operational units and support the taxonomic decision-making process. This approach has been utilized successfully to study very diverse beetle taxa (Riedel et al. 2013a; Riedel et al. 2013b; Tänzler et al. 2012), including our own previous work on *Liodessus*. The approach can be technically scaled up massively, using next-generation sequencing technology, which also reduces analytical costs (Srivathsan et al. 2021; Wang et al. 2018). Such data do not, however, replace taxonomic expertise and the evaluation of morphological structure (Riedel et al. 2013a).

Acknowledgements

We are grateful for the generous support from the SNSB-Innovative scheme, funded by the Bayerisches Staatsministerium für Wissenschaft und Kunst (Project: 2018 „Geographische Isolation, Endemismus und Artbildungsprozesse bei Insekten in der hochmontanen Páramo Kolumbiens (und darüber hinaus)“ as well as 2021 „The origin of the world’s widest altitudinal gradient“), and Bayerischer Pakt für Innovation (BayPFI) for digitizing equipment. Michael Balke acknowledges support from the EU SYNTHESYS program, projects FR-TAF 6972 and GB-TAF-6776, which helped preparing this research during type study visits to NHM and MNHN in 2017. We thank Andrew E.Z. Short for kindly providing specimens and advice for this study; he acknowledges support from the US National Science Foundation grant #DEB-0816904. Michael Balke acknowledges support from the Deutsche Forschungsgemeinschaft (BA2152/27-1). Adrián Villastrigo is a fellow of the Alexander von Humboldt Foundation, which enabled his participation in this research. Thanks to our colleagues at MIZA for hosting us in 2004.

Consortium of European Taxonomic Facilities (CETAF) data use statement: “Data on genetic material contained in this taxonomic article are published for non-commercial use only. Utilization by third parties for purposes other than non-commercial scientific research may infringe the conditions under which the genetic resources were originally accessed, and should not be undertaken without obtaining consent from the original provider of the genetic material.”

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Ikaros navarretei (Coleoptera, Staphylinidae, Staphylininae), a new apterous rove beetle species from high elevations in Colombia

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<http://zoobank.org/CAAB885C-7DB8-4C4B-9D01-53B07656840B>

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Academic editor: Christoph Germann ♦ Received 10 January 2022 ♦ Accepted 6 April 2022 ♦ Published 11 May 2022

Abstract

A new species of the xanthopygine genus *Ikaros* Chatzimanolis & Brunke, 2021 is described from Colombia: *Ikaros navarretei* sp. nov. Illustrations and a key are provided to identify the four known species of *Ikaros*.

Key Words

Northern Andean páramo, Cauca, Staphylinini, Xanthopygina, new species, taxonomy

Introduction

The Staphylinini rove beetle genus *Ikaros* was established by Chatzimanolis and Brunke (2021) for three species and placed in the subtribe Xanthopygina. *Ikaros* may be distinguished from other genera of this subtribe by the reduction of elytra exposing tergum II, absence of hind wings and by the abdomen constricted anteriorly and expanded posteriorly (Chatzimanolis and Brunke 2021). The apterous condition in rove beetles can occur in different environments, e.g. isolated islands (Jenkins Shaw and Solodovnikov 2016; Jensen et al. 2020), hypogean in caves or crevices of talus (Solodovnikov and Hansen 2016; Hu et al. 2020), or at high elevations like that of *Ikaros* (Chatzimanolis and Brunke 2021). A significant portion of alpine insect communities, especially Coleoptera, show various degrees of wing reduction (Mani 1968). Given that loss of wings lowers dispersal capacity and as a consequence leads to higher level of endemism, combined with high specialization to adapt to harsh environmental conditions of high mountains (Mani 1968), discovery of new species for an apterous genus from the Andes mountains with little known rove beetle biodiversity (Méndez-Rojas et al. 2012) was anticipated. One new species was found in the institutional collection and is described here with an update to the identification

key for all four currently known species of *Ikaros*. Interestingly, despite the comprehensive phylogenetic analysis in Chatzimanolis and Brunke (2021), the sister group relationships of this genus are still unclear. Presumably, a better understanding of the diversity of this peculiar xanthopygine genus will facilitate our understanding of its affinities and diversification process related to wing loss in rove beetles at high elevations.

Materials and methods

Depositories

CNC Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Ontario, Canada (A. J. Brunke)

The specimen was examined using a Leica M125 dissecting microscope (Leica Microsystems, Switzerland). Photos were taken using a Canon 5D Mark III fitted with the Canon MP-E 65mm f/2.8 1-5x Macro lens (Canon, Japan). To obtain high-resolution photos a stacking system (StackShot 3x, Cognisys, USA) was utilized taking 25 images then combined in Zerene Stacker (Zerene Systems, USA) using the PMax function.

Photos were further processed in Adobe Lightroom 2022 (Adobe, USA) and Adobe Photoshop 2022 to adjust colors and remove minor dust specks. Line drawings were made by digitally inking a photo using Adobe Illustrator 2022 adding details by careful examination in the microscope.

Label data are provided verbatim and square brackets ([]) enclose our comments. A slash (/) is used to divide separate labels. Georeferencing and obtaining the elevation were done with Google Earth Pro 7.3. The map was made with QGIS 3.22.1 (QGIS Development Team 2021) and edited with Adobe Photoshop 2022. The spatial information was obtained from the following resources: Bioclimatic variables 1 (annual mean temperature), 12 (annual precipitation) and elevation with a resolution of 30 s (Fick and Hijmans 2017), bodies of water (Lehner and Döll 2004), and ecoregions (Dinerstein et al. 2017). To extract the attributes of the spatial layers for the localities, the QGIS plugin “point sampling tool” was used.

A single dry specimen was first relaxed in warm soapy water, and then the aedeagus was removed from the inside of the abdomen for study. The aedeagus was cleared and stripped of excessive muscle layers by being placed in a 10% KOH solution, then rinsed with water, and finally placed in glycerin for preservation and later observation. Total body length was measured from the anterior margin of frons (thus excluding mouthparts) to the posterior margin of segment VIII; width: length ratio measurements were made on the widest and longest parts of each structure. Measurements were made with an ocular micrometer. All measurements were taken in millimeters. The terminology used for characters is the same as Chatzimanolis and Brunke (2021); that said, the original description of the genus and species (Chatzimanolis and Brunke 2021) used some ambiguous terms. Therefore, we here present our interpretation of these:

1. “...the shape of the abdomen: constricted anteriorly and expanded posteriorly”. We interpreted this as the abdomen not being parallel-sided or evenly constricting posteriorly, but instead expanding until the posterior part of tergite V, where it is widest, then constricting towards the terminalia.
2. “Pronotum ... with stark polygon-shaped microsculpture”. We interpreted this as having clear isodiametric microsculpture.

Results

Ikaros navarretei sp. nov.

<http://zoobank.org/2C1E9003-82DD-4CF6-900D-16451E23B9E4>

Type locality. Colombia, Cauca, Silvia, 2.5889, -76.24886, 3400 m a.s.l.

Generic placement. Our specimen fully agrees with the generic diagnosis and description provided by Chatzimanolis and Brunke (2021).

Diagnosis. *Ikaros navarretei* sp. nov. can be distinguished from all other species in this genus by the combination of the presence of an arch-like carina on terga III–V; the meshed to isodiametric microsculpture on the dorsal surface of the head, thorax, and mesoscutellum; antennomeres with crown-like macrosetae shorter than the length of antennomere.

Etymology. The species epithet is in recognition (patronymic) of José Luis Navarrete Heredia for his contribution to the knowledge of the family Staphylinidae and training of many coleopterologists in Latin America.

Type material. Holotype. Male, point mounted, with genitalia in a separate microvial, with labels as follows: “COLOMB. [COLOMBIA], 20 km E Silvia, Cauca, [~ 2.5889, -76.24886, 3400 m a.s.l.] VII.16.1970 [16 June 1970], II, 000' J.M. Campbell / Xantopygina sic? gen. det. Newton 1998 / HOLOTYPE *Ikaros navarretei* Reyes-Hernández, Hansen and Solodovnikov, des. Reyes-Hernández, Hansen and Solodovnikov 2022” CNC.

Description. Habitus as in Fig. 1A. Total body length 10.06 mm. Forebody length 5.25 mm long.

Coloration of body reddish-brown, with abdomen having undertones of metallic green-brown.

Head subrectangular, slightly wider than long, HW/HL ratio = 1.1. Epicranium with numerous large punctures, except impunctate center; punctures not contiguous, the distance between punctures typically equals the width of 1–2 punctures; with transversely meshed to isodiametric microsculpture (Fig. 1B). Labial palpus with palpomere 3 (apical) widest before the apex. Antennomeres with crown-like macrosetae shorter than length of antennomere.

Pronotum longer than wide, PW/PL ratio = 0.9; surface of pronotum with a median impunctate area as wide as 3–5 punctures; with multiple rows of irregular punctures in addition to rows flanking impunctate center; with meshed to isodiametric microsculpture (Fig. 1C).

Elytra shorter than pronotum, EL/PL ratio = 0.83. Elytra with large, deep punctures, the distance between punctures equals to width of 0.5–2 punctures; only with isodiametric microsculpture at mesoscutellum, disc of elytra with micropunctuation (Fig. 1D).

Abdominal terga III–V with arch-like carina (Fig. 1E), arch-like carina on terga IV and V nearly straight. Male secondary sexual structures with very shallow emargination on sternum VII; with deep, broad V-shaped emargination on sternum VIII; borders of emargination on sternum VII and VIII appearing ‘shaved’ (with no setae); lateral tergal sclerites IX subcylindrical and the same length as sternum IX; tergum X subtruncate medio-apically; sternum IX with basal portion symmetrical, about 0.57× as long as distal portion and subtruncate apically.

Aedeagus as in Fig. 2; in parameral view apex of paramere nearly reaching apex of median lobe (Fig. 2A); paramere broadest at the middle of its length, converging to rounded tip (violin-like shape), characteristic arrangement of peg setae in two sublateral rows containing 4–5 setae with an additional single setae closer to apex (Fig. 2B); in lateral view paramere narrower apically; median lobe in dorsal view narrowing to small, rounded apex; in

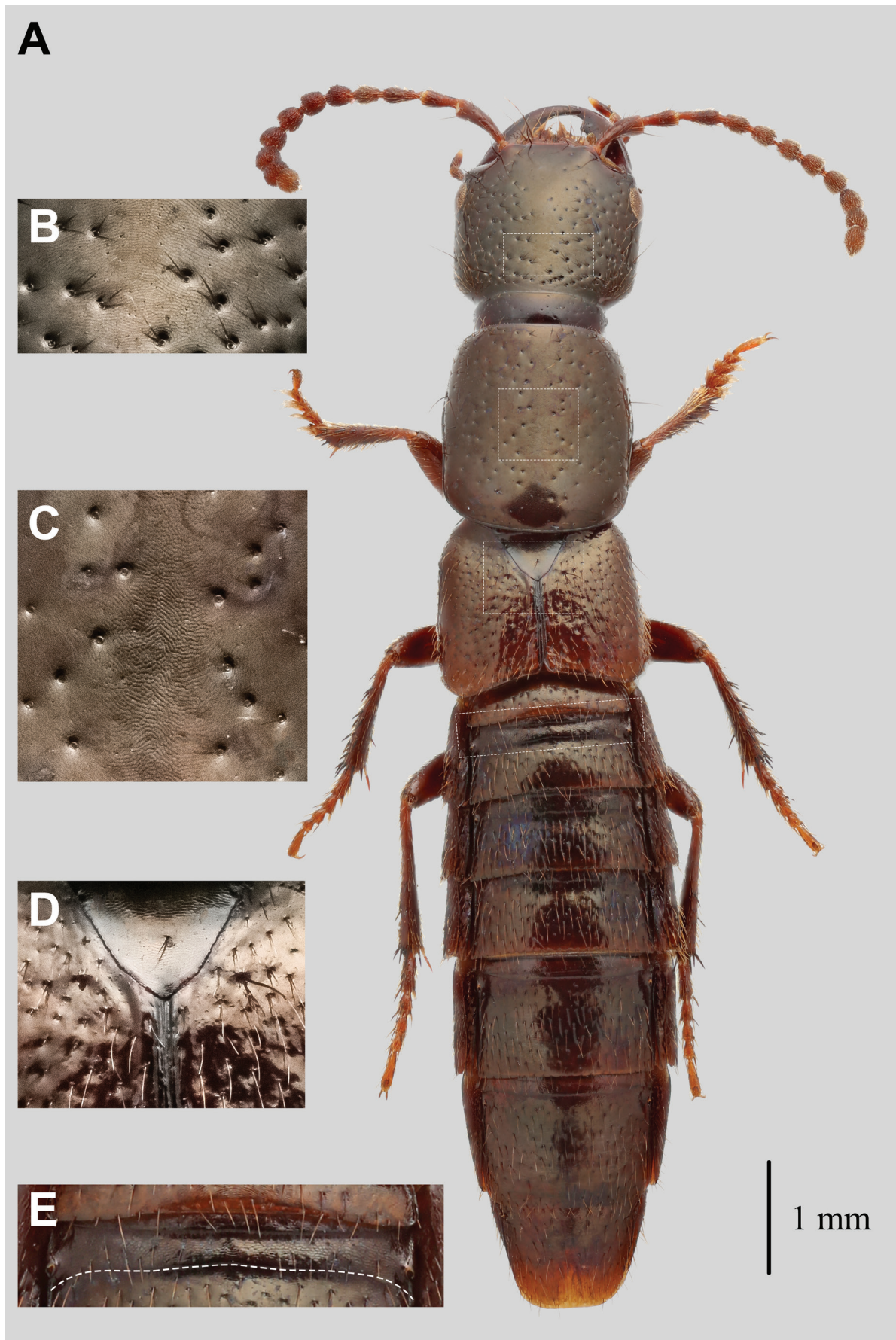


Figure 1. Dorsal view of *Ikaros navarretei* sp. nov. **A.** Habitus; **B.** Close up of head punctation and meshed to isodiametric microsculpture; **C.** Close up of pronotum punctation and meshed to isodiametric microsculpture; **D.** Close up of mesoscutellum and elytra punctation and microsculpture; **E.** Close up of abdominal tergite III with arch-like carina highlighted by white dashed line.

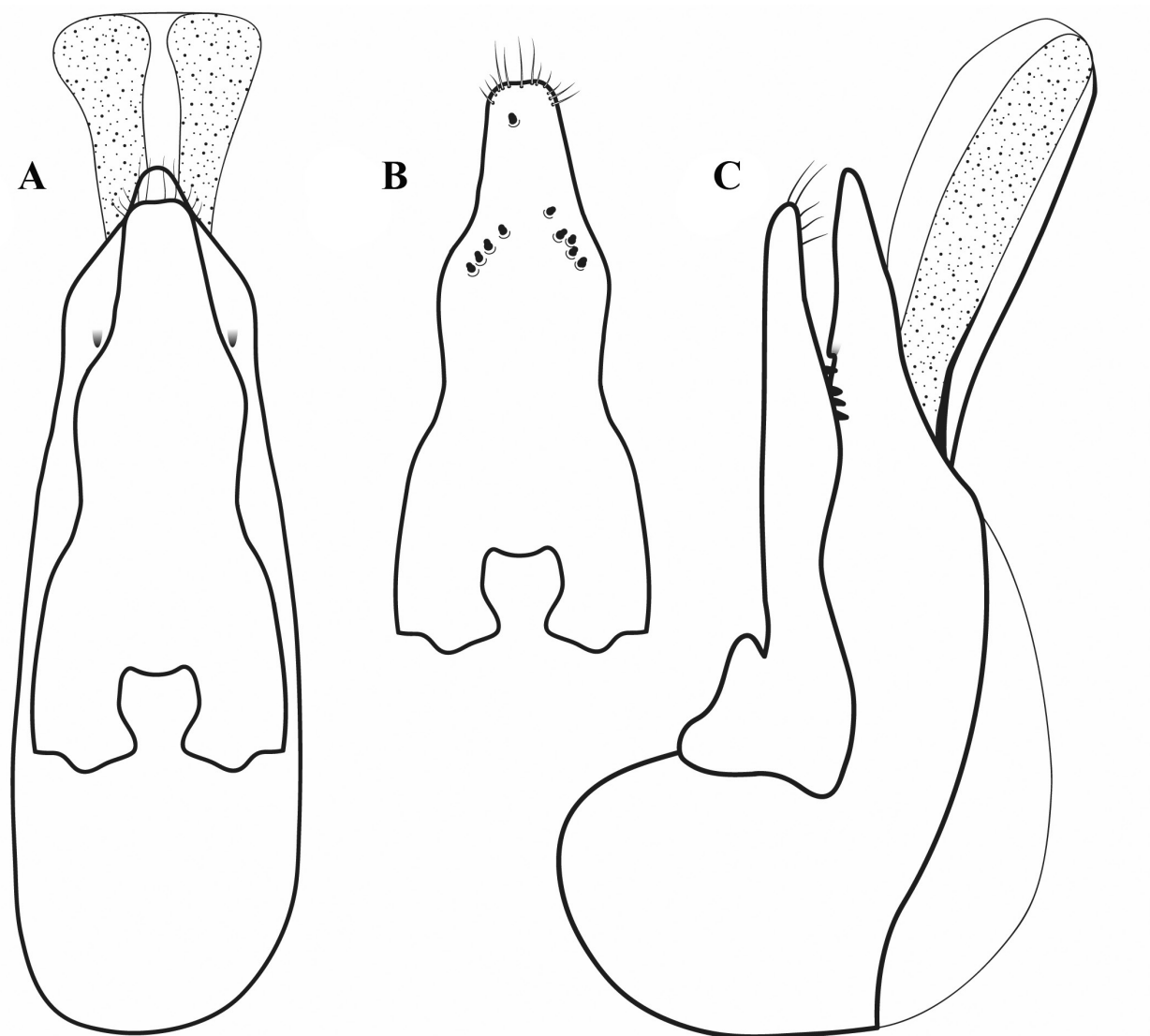


Figure 2. Aedeagus of *Ikaros navarretei* sp. nov. **A.** Aedeagus in parameral view; **B.** Paramere in antiparameral view with peg setae; **C.** Aedeagus in lateral view. Scale bar: 1 mm.

lateral view, median lobe becoming narrower near apex, with one subapical tooth (Fig. 2C).

Distribution and habitat. Known only from the type locality near Silvia in the Cauca Department, Colombia (Fig. 3).

Note. In *Ikaros navarretei* sp. nov. a structure which we call the arch-like carina on the abdominal terga for the sake

of compatibility with other literature on Xanthopygina, appears to be somewhat similar to a structure usually called in the Staphylinini literature as the posterior basal tergal carina (PBTC). This is a very different condition from other species of *Ikaros* and, as far as we are aware, all other Xanthopygina where the arch-like carina is more of a curved fragment that does not reach the spiracles as in the PBTC.

Key to the species of *Ikaros* after Chatzimanolis and Brunke (2021)

- 1 Abdominal terga III–V with arch-like carina 2
- Abdominal terga III–V without arch-like carina..... 3
- 2 Crown-like macrosetae of antennae long (as least twice as long as antennomeres). Arch-like carina on terga IV and V distinctly curved. Paramere almost parallel side converging to broad rounded tip; median lobe in lateral view without subapical tooth (see Fig. 5 in Chatzimanolis and Brunke 2021)..... *I. polygonus*
- Crown-like macrosetae of antennae short (not even as long as antennomeres). Arch-like carina on terga IV and V nearly straight. Paramere with violin-like shape; median lobe in lateral view with subapical tooth (Fig. 2) *I. navarretei* sp. nov.
- 3 Disc of pronotum with only a short dorsal row of a few punctures *I. apteros*
- Disc of pronotum with multiple long rows of punctures *I. paramo*

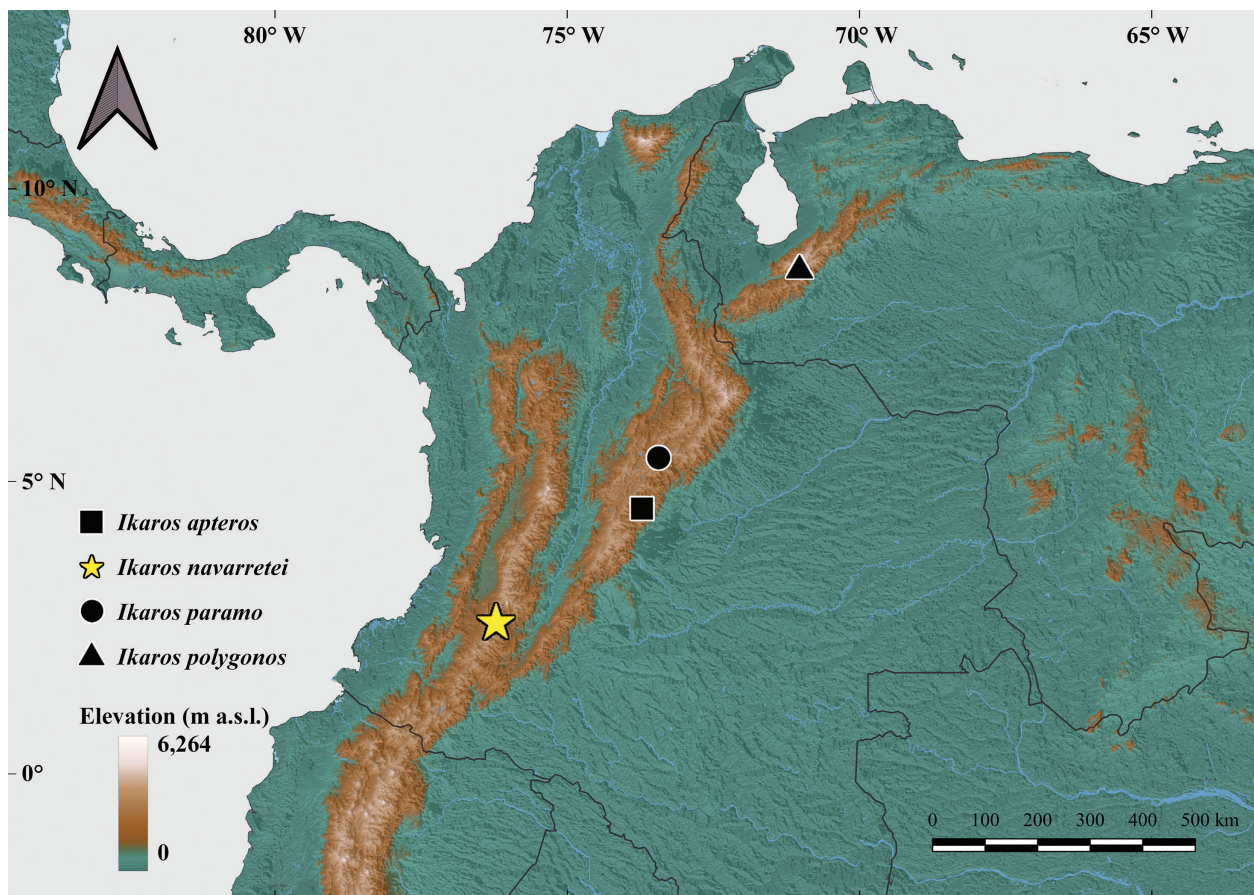


Figure 3. Distribution of *Ikaros*. Elevation colored from green (low) across brown (middle) to white (high). Black square (■) *Ikaros apterus*. Yellow star (★) *Ikaros navarretei* sp. nov.. Black circle (●) *Ikaros paramo*. Black triangle (▲) *Ikaros polygonos*.

Table 1. *Ikaros* genus species’ habitat, geographical and environmental characteristics.

Species	Coordinates (Latitude, Longitude)	Elevation (m a.s.l.)	Annual mean temperature (°C)	Annual precipitation (mm)	Ecoregion	Biome
<i>Ikaros apteros</i>	4.5166, -73.7501	3230	9.2	1543	Northern Andean páramo	Montane Grasslands & Shrublands
<i>Ikaros navarretei</i> sp. nov.	2.5889, -76.2488	3400	8.3	1623	Northern Andean páramo	Montane Grasslands & Shrublands
<i>Ikaros paramo</i>	5.7040, -73.4380	3500	8.4	971	Northern Andean páramo	Montane Grasslands & Shrublands
<i>Ikaros polygonos</i>	8.6277, -71.0085	3400	9.4	921	Cordillera de Merida páramo	Montane Grasslands & Shrublands

Discussion

According to the georeferencing that was carried out from the collection data of all the *Ikaros* species, the altitude range where they are found is from 3000 to 3600 m a.s.l. The genus is found in ecoregions characterized by shrubby páramo in the Montane Grasslands and Shrublands biome (Dinerstein et al. 2017; Chatzimanolis and Brunke 2021). Information on the environmental conditions in which the *Ikaros* species is found is provided in Table 1.

As species of this genus are rarely collected and poorly represented in collections, much is still

unknown about their biology, systematic position, and conservation status. As the Andes are one of the most important conservation hotspots due to their high species richness and endemism (Myers et al. 2000; Larsen et al. 2011), efforts to discover new endemic apterous species in sites such as these are of high priority. In the case of the rather enigmatic genus *Ikaros*, a complete species inventory is also an opportunity to resolve its phylogenetic position and study the evolution of morphological characters in Xanthopygina associated with adaptations to alpine habitats.

Acknowledgements

Stylianos Chatzimanolis is thanked for providing high-resolution images of the already described *Ikaros* species, that we used for comparison to our specimen. Furthermore, we thank the curators and collections managers of the CNC for always being helpful with loans from their collection. An unexpected specimen turned up amongst a larger loan from CNC for another project. We thank A. J. Brunke and S. Chatzimanolis for their review comments. PhD scholarship funding for JLRH at the Natural History Museum of Denmark comes from the PHYLORAMA grant from the University of Copenhagen.

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Zoophthora giardii Balazy and *Conidiobolus gustafssonii* Balazy (Fungi, Entomophthorales), two entomopathogens new for Switzerland

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<https://zoobank.org/2762DD92-F5D7-4DBE-B809-0F9ACACE9F30>

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Academic editor: Oliver Martin ♦ Received 6 March 2022 ♦ Accepted 2 June 2022 ♦ Published 6 July 2022

Abstract

Meconema meridionale Costa (Orthoptera, Tettigoniidae) infected with *Zoophthora giardii* Balazy (Entomophthorales, Entomophthoraceae) were collected at five localities in the northern half of Switzerland. At one of these sites, the fungus caused epizootics in two subsequent years. Symptoms and morphological data coincide with those given by Balazy who found the fungus on *Meconema thalassinum* De Geer. *Conidiobolus gustafssonii* Balazy (Entomophthorales, Ancylistaceae) was found on a single *Ectobius vittiventris* Costa (Blattodea, Ectobiidae). Symptoms and dimensions of the primary conidia correspond with the original description given by Balazy who found the fungus on *Ectobius lapponicus* L. The two fungi are new for Switzerland and *Meconema meridionale* and *E. vittiventris* represent new hosts for these pathogens.

Key Words

Insect pathogenic fungi, morphology, distribution

Introduction

The Neozygites and the Entomophthorales belong to the phylum Entomophthoromycota of the fungal kingdom. They comprise mainly arthropod-pathogenic species but also members with a saprobiontic life style (Humber 2012).

Recently, two insect species, the southern oak bush-cricket *Meconema meridionale* and the amber wood cockroach *Ectobius vittiventris* were found infected by entomophthoralean fungi in Switzerland. Both insects originate from the mediterranean region but are spreading northwards (T. Haye, pers. comm.). *Ectobius vittiventris* has colonized Germany up to Nordrhein-Westfalen (Schäfer et al. 2016) and is recorded from the Alps up to an altitude of 1400 m (Baur et al. 2004). *Meconema meridionale* has colonized the whole of western Europe up to the North Sea but seems to avoid higher altitudes (<https://www.gbif.org/species/1690429>).

Subsequent microscopic examination of the fungi revealed that they represented members of the genera

Zoophthora and *Conidiobolus* that have not been recorded before in Switzerland. In the present paper, the fungi are described and discussed in detail.

Materials and methods

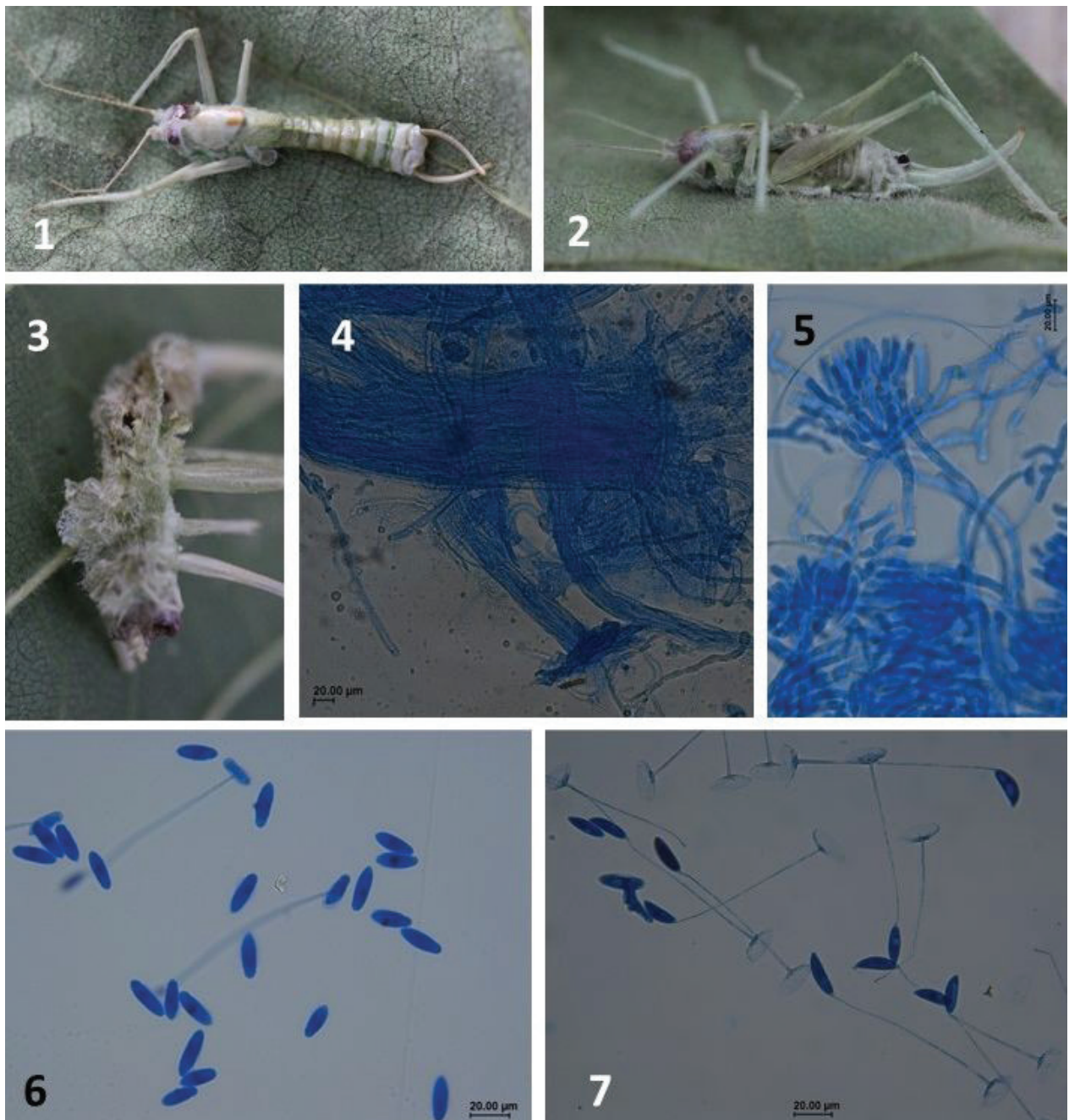
An overview of the collected material is given in Table 1. At Bümpliz BE a striking high number of infected bush crickets were found in a cemetery. Two samples of the material collected on August 2021 were sent to the author. The first one collected on August 12 contained five females and three fragments, the second one collected on August 25 contained three males (Fig. 1), seven females (Fig. 2) and two fragments. All cadavers were found on the underside of leaves of deciduous trees and bushes except those collected at Regensdorf.

A selection of infected *M. meridionale* and the dead *E. vittiventris* were placed individually in small Petri dishes with water. A microscopic slide was placed above the cadavers to collect the projected primary

conidia. Secondary conidia were picked up from the water surface as described by Papierok (2007). Fourteen cadavers of *M. meridionale* and the only cadaver of *E. vittiventris* were carefully dissected into tiny pieces. The fungal material was mounted in lactophenol-cotton blue (LPCB) or in lactophenol-aceto-orcein (LPAO) as described by Keller (1987). Only primary conidia with the axis parallel to the slide and with the whole spore outline in focus, were measured. Primary conidia originating from *E. vittiventris* were obtained by three

methods: 1) by picking up from the leaf; 2) by projection from the cadaver on a slide and 3) by preparation of fungal material from the host tissue.

All measurements were based, if not otherwise stated, on 25 structures per individual host, except cystidia, designated as one series. Usually more than one series was studied from each structure, to assess variation. The number of series is given after the range of the mean values, the range of the extreme values (in brackets) and the ratio length/diameter (L/D).



Figures 1–7. *Zoophthora giardii*. **1.** Infected male fixed with rhizoids on a leaf. **2.** Infected female. Rhizoids between insect body and leaf are visible. **3.** Cadaver from the ventral side showing the layer of rhizoids. **4.** Compound rhizoids (LPCB). **5.** Branched conidiophores (LPCB). **6.** Primary conidia, two with capillary tube (LPCB). **7.** Type II secondary conidia or capilliconidia with capillary tubes and remnants of primary conidia (LPCB).

Table 1. Collection data of infected *Meconema meridionale* and *Ectobius vittiventris*. The coordinates were taken from www.map.swisstopo.admin.ch. The collection sites are followed by the official abbreviation of the corresponding Swiss canton.

Host	Collection site with coordinates	Host plant	Collector	Date of collection
Meconema meridionale	Bümpliz BE, 46.94187/7.38426	Catalpa bignonioides	T. Haye	Sept. 17, 2020; Aug. 12, 2021; Aug. 25, 2021
	Muttenz BL 47.53299/7.63401	Catalpa bignonioides	T. Haye	Aug. 18, 2021
	Duggingen BL 47.53207/7.63426	Fagus sylvatica	T. Haye	Aug. 18, 2021
	Eschenz TG 47.65028/8.85586 47.65228/8.87800	Corylus avellana and Prunus sp.	S. Keller	Aug. 27, 2021; Sept. 02, 2021
	Regensdorf ZH (47.43588/8.4619	Ceiling of a house entry	G. Grabenweger	Sept. 09, 2021
Ectobius vittiventris	Bern BE 46.934176/7.431215	Hedera helix	N. Häner	Aug. 25, 2021

Results

The microscopic examination of the *M. meridionale* material revealed the following: The host body was completely filled with hyphae like hyphal bodies. The rhizoids, which fixed the host tightly to the surface consisted of compound hyphae (Fig. 4). The conidiophores were branched (Fig. 5). The endings of the conidiophores, the so-called terminal portions, from which the primary conidia developed, segregated from the conidiophores, before the conidia were formed. The terminal portions were irregularly subcylindrical and measured on average $25.1 \times 5.8 \mu\text{m}$ (Table 2). The primary conidia were subcylindrical and had the widest diameter in the central portion (Fig. 6). The outer wall partly separated from the conidial body. They measured on average $20.0\text{--}21.6 \times 6.8\text{--}7.2 \mu\text{m}$ and had a length/diameter ratio of 2.86–3.08 (Table 2). The indistinct papilla was rounded. The primary conidia germinated either with a capillary germ tube to develop a type II secondary conidium (capilliconidium) or with a short thick germ tube to develop a type I secondary conidium, which resembles the primary conidium. Fully developed type I secondary conidia were too rare to be measured. The capilliconidia were fusiform and slightly bent (Fig. 7). They measured on average $20.1\text{--}20.8 \times 5.7\text{--}6.0 \mu\text{m}$ with a length/diameter ratio of 3.36–3.55 (Table 2). They were formed at the end of a narrow capillary tube which had an average length of $75.1\text{--}92.4 \mu\text{m}$. Usually, a primary conidium formed a single capillary tube but sometimes two or even three capillary tubes were noticed but only one ended with a conidium. Resting spores were not present.

The diseased *Ectobius* was tightly fixed with compound rhizoids on a leaf of *Hedera helix* with the wings slightly opened. The cadaver was surrounded by a white halo of projected conidia (Fig. 8). The mounted material showed different fungal structures. The hyphal bodies, which filled the body cavity, were usually irregularly rounded (Fig. 9), sometimes composed of two, rarely more rounded structures, or irregularly short hyphae-like structures. The conidiophores were unbranched with slightly increased diameter at the end from which a single conidium developed (Fig. 10). The primary conidia were round to slightly pyriform,

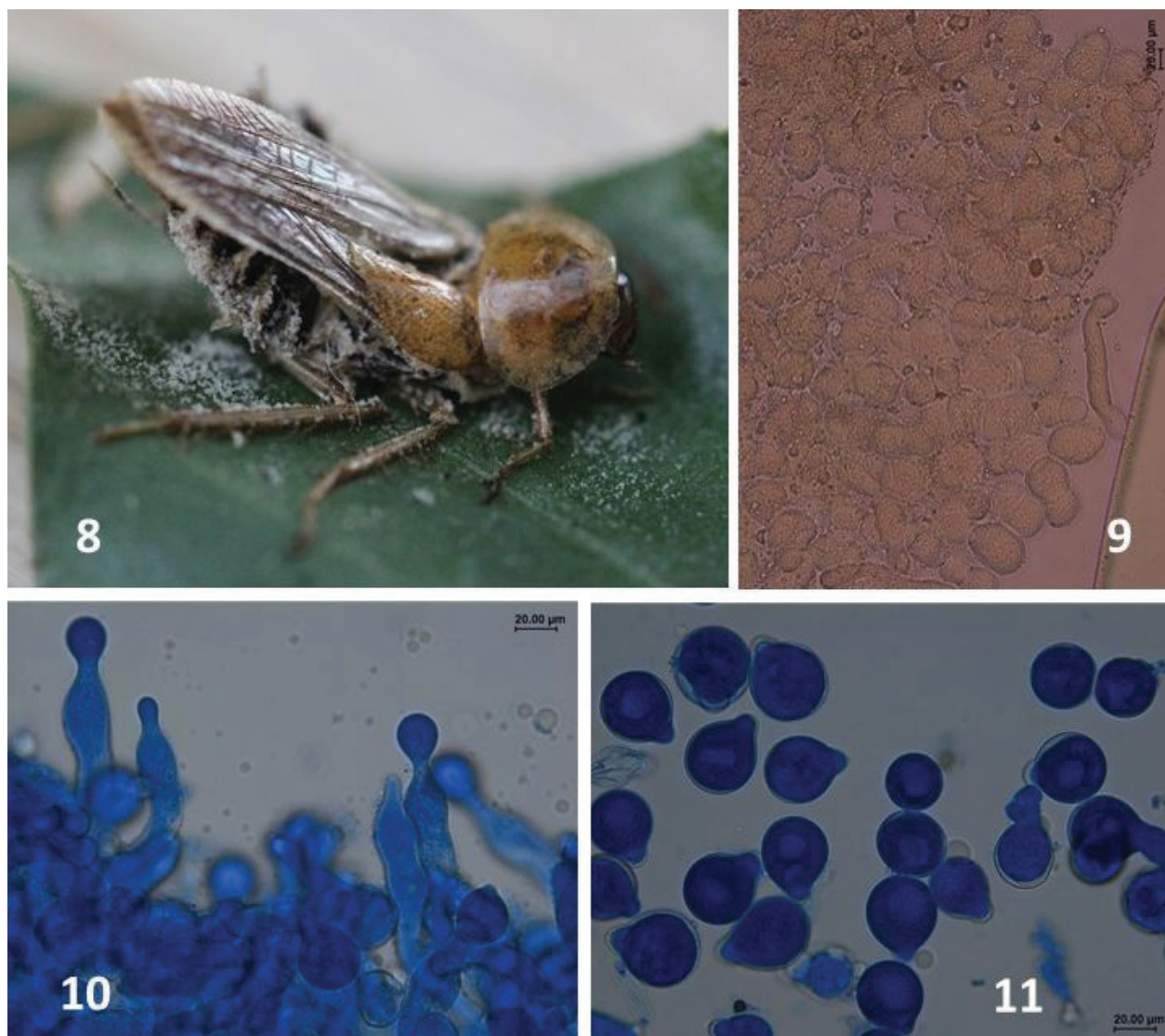
the conidial body smoothly joined the rounded papilla (Fig. 11). Projected conidia measured $43.2 (39\text{--}50) \times 35.6 (31\text{--}40) \mu\text{m}$ with a length/diameter ratio (L/D) of 1.21, conidia taken from the leaf measured $40.6 (37\text{--}46) \times 31.5 (28\text{--}34) \mu\text{m}$, L/D = 1.29, and those from host tissue were $39.9 (37\text{--}44) \times 31.4 (28\text{--}35) \mu\text{m}$, L/D = 1.27. The projected conidia were slightly larger which is probably due to the compression, the other two slides contained either non-fungal material or parts of the host which prevented compression of the conidia. The primary conidia germinate with a single short tube to form a secondary conidium which resembles the primary one. No fully developed secondary conidia were observed. Resting spores were absent.

Meconema meridionale and *E. vittiventris* represent new hosts for the corresponding fungus. Fungal material was deposited at the United Herbaria Zurich under the numbers ZT Myc 66704 and 66705 (*Z. giardii*) and ZT Myc 66706 (*C. gustafssonii*).

Discussion

The description of the fungus attacking *Meconema meridionale* fits quite well the description of *Z. giardii* given by Bałazy (1993). Therefore, we consider the two fungi as identical, although there are minor differences in the length of the capilliconidia. According to the original description, the primary and the capillary conidia measure $19.5\text{--}23.5 \times 6\text{--}7 \mu\text{m}$ and $21\text{--}25 \times 5.5\text{--}6.5 \mu\text{m}$, L/D=3.8 respectively. These small differences could also be the result of different preparation and staining methods.

The finding of *Zoophtora giardii* in Switzerland is not surprising since the species was previously recorded from France, Germany, and Poland (Bałazy 1993) who considered the species as “rather rare”. This is in contrast to the findings in Switzerland, where *Z. giardii* was found at several localities occasionally at an epizootic level. This might be due to another host. Bałazy found the fungus on *Meconema thalassinum* while we found the fungus on *M. meridionale* which represents a new host for *Z. giardii*. It is possible that this species was never in contact with this fungus in the original



Figures 8–11. *Conidiobolus gustafssonii*. **8.** Infected host. Note the white conidia beside the host. **9.** Hyphal bodies (LPAO). **10.** Unbranched conidiophores with developing conidia (LPCB). **11.** Primary conidia (LPCB).

distribution sites, and is therefore more sensitive to fungal infections.

According to the original description (Bałazy 1993) the primary conidia of *C. gustafssonii* measure on average $41\text{--}47 \times 30\text{--}40 \mu\text{m}$. We measured conidia obtained by three different methods. Those of projected conidia were the largest. However, this may be an artefact, since the conidia become compressed between slide and cover glass during preparation. More accurate data result from measurements of conidia taken from the leaf or host tissue. These preparations contain material which is larger than the conidia and prevent conidia from being compressed. Therefore, we consider $40\text{--}41 (37\text{--}46) \times 31.5 (28\text{--}35) \mu\text{m}$ as the accurate size of the conidia of our material which matches the original description. Bałazy found the fungus on *Ectobius lapponicus*. Our finding on *E. vittiventris* represents a new host of this fungus.

With these findings, the number of entomophthorean fungi in Switzerland increases to 90 species (Keller 2008). There is no other country with such

Table 2. *Zoophthora giardii*. Dimensions of the fungal structures in μm (PC = primary conidia, SC type II = secondary conidia of the capillary type, Cap. tube = capillary tube, CP = conidiophore, s.d. = standard deviation), based on 25 measurements each.

Structure and slide number	Length (L) (s.d.) min-max	Diameter (D), (s.d.), min-max	Ratio L/D	Stain
PC 20	21.5 (1.14) 20–24	7.2 (0.67) 6–8	3.00	LPCB
PC 24	21.6 (1.31) 19–24	7.0 (0.80) 6–8	3.08	LPCB
PC 29	20.0 (0.87) 19–21	7.0 (0.47) 6–8	2.86	LPCB
PC 30	20.4 (1.31) 19–24	6.8 (0.51) 6–7	3.01	LPCB
PC 34	21.2 (1.25) 19–24	7.2 (0.76) 6–8	2.96	LPCB
SC type II 17	20.1 (0.87) 19–21	5.7 (0.59) 5–7	3.55	LPCB
SC type II 21	20.3 (1.13) 19–22	6.0 (0.39) 6–7	3.36	LPCB
SC type II 24	20.8 (0.96) 19–22	6.0 (0.47) 5–7	3.48	LPCB
Cap. tube 17	76.5 (5.61) 66–85			LPCB
Cap. tube 20	92.4 (8.08) 80–112			LPCB
Cap. tube 24	75.1 (8.00) 61–94			LPCB
CP terminal portion	25.1 (2.22) 21–30	5.8 (0.79) 5–7	4.36	LPAO

a high diversity of classified arthropod-pathogenic Entomophthoromycota. Especially pre-alpine valleys showed a high species richness. More than a third of the species recorded in Switzerland originate from the headwaters of the two rivers Murg (canton Thurgau) and Töss (canton Zurich) (Keller 2008, 2012). These rather undisturbed riverine forests harboured a rich entomofauna which obviously served as hosts of entomophthorean fungi. The same effect can be expected in alpine ecosystems which are still unexplored regarding insect pathogenic fungi. There will be certainly more species of Entomophthoromycota, not only in Switzerland but worldwide, since this group of fungi has never been subject of specific research, although they play an important role in the regulation of arthropod populations and bear a large potential in pest control.

Acknowledgements

The author thanks Tim Haye and Nina Häner, CABI Delémont, who provided fungus material, Giseller Grabenweger and Carmen Naef of Agroscope Reckenholz, who provided the infrastructure of their laboratory and helped with the microphotography, Tim Haye for critically reviewing the manuscript and for providing additional information, and Mark Goettel, formerly at Lethbridge Research Center, Canada, for reviewing the manuscript and helping with the English phraseology.

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Modeling the distribution of coprophagous beetle species in the Western Swiss Alps

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Academic editor: Marco Moretti ♦ Received 13 March 2022 ♦ Accepted 2 June 2022 ♦ Published 6 July 2022

Abstract

Coprophagous beetles are essential for fecal matter removal and are thus considered key ecosystem services providers. Yet, our knowledge of these beetles' distribution and ecology remains very limited. Here, we used Species Distribution Models (SDM) to investigate the species-environment relationships (i.e. their niche) and predict the geographic distribution of coprophagous beetles in the Western Swiss Alps. We used our own sampled data and existing national data from the Swiss faunal database to calibrate, for each species, a regional and a national SDM respectively. In both models, the best predictors were temperature and rock cover proportion, while a soil characteristic ($\delta^{13}\text{C}$) indicating its organic content and texture was important in the regional models and precipitations in the Swiss models. The model performed better for species specialized on low or high altitudes than for generalist species occurring in a large altitudinal range. The model performances were neither influenced by the size, nor by the nesting behavior (laying eggs inside or below the excrements) of the species. We also showed that species richness decreased with altitude. This study opens new perspective for a better knowledge of coprophagous beetle's ecology and a useful tool for their conservation in mountain regions.

Key Words

Dung beetles, Species distribution modeling (SDM), Ensemble of Small Models (ESMs), Hydrophilidae, Geotrupidae, Scarabaeidae

Introduction

Coprophagous beetles are part of a specialized entomofauna feeding on the droppings of mammals (Hanski 2016). Some taxa have coprophagous adults and predaceous larvae, which are chasing fly larvae from dung patches (Hydrophilidae, Sphaeridiinae), while other have coprophagous adults and larvae. In the latter case, some species lay their eggs directly in the dung (non-nesters: Scarabaeidae, Aphodiinae) and other dig simple wells or sophisticated network of tunnels and rooms where they stock dung and lay their eggs (paracoprids: Geotrupidae and Scarabaeidae, Scarabeinae) as a strategy to avoid the harsh intra- and inter-specific competition to exploit dung patches before they dry (Hanski 2016). By feeding on excrements and burying it, coprophagous beetles are essential for dung decomposition (Gittings et al. 1994).

They avoid the accumulation of excrements, preventing pasture surface loss (Beynon et al. 2012b) and supplementary expenses for dung removal (Fincher 1981; Losey and Vaughan 2006; Beynon et al. 2015) and are therefore considered as key “Ecosystem Service Providers” (Nichols et al. 2008). In addition, coprophagous beetles represent a part of the food for some insectivorous animals such as birds (in particular corvids) (Lumaret and Stienet 1990) or mammals (e.g. greater horseshoe bat (*Rhinolophus ferrumequinum*)) (Beynon et al. 2015). The economic and ecological importance of coprophagous beetles coupled with the possibility to characterize the whole species assemblages found at a given location (dung patch) in a given time point (Finn and Giller 2000; Hanski 2016) make them an adequate group to study biogeography (Lumaret 1979) and animal communities (Hanski and Koskela 1977). In Europe, the species

assemblages of coprophagous beetles and their relative abundance have already been investigated (Lumaret and Stiernet 1984; Lumaret and Stiernet 1989; Errouissi et al. 2004; Negro et al. 2011) and the importance of climatic and edaphic factors have been shown at a coarse level (Hortal et al. 2001; Lobo and Martin-Piera 2002; Lumaret and Jay-Robert 2002). However, ecological needs and fine geographic distribution of single coprophagous beetle species remains an understudied topic.

The study of the realized environmental niche of species, adaptation to local conditions and interspecific interactions (Hutchinson 1957) allows a better understanding of the distribution of species (see Niche-Geography duality: Colwell and Rangel 2009), which is crucial to overcome Wallacean (knowledge about the geographical distribution of species) and Hutchinsonian (knowledge about the tolerance of species to abiotic factors) shortfalls concerning biodiversity (Hortal et al. 2015). The development of statistical species distribution models (SDM; also called 'habitat suitability' or 'ecological niche' models; see Franklin 2010; Peterson et al. 2011; Guisan et al. 2017) to quantify the niche and derive geographic predictions have brought powerful perspectives to better understand, compare and quantify the relationship between organism and their environment (i.e. their environmental niche), but also to predict their distribution in space and time (Guisan and Zimmermann 2000; Guisan and Thuiller 2005). These tools can therefore bring essential knowledge about the ecology of understudied taxonomical groups like most arthropods (Hochkirch et al. 2021). SDMs have been used to study various groups of insects (Pellissier et al. 2012; Pradervand et al. 2014; D'Amen et al. 2015; Descombes et al. 2016; Mata et al. 2017) but there are only few examples of single modeled coprophagous beetles (e.g. Chefaoui et al. 2005; Lobo et al. 2010).

The aim of this study was to bring a better understanding of the factors influencing the distribution of coprophagous beetle species in temperate mountain environments using a SDM approach. In order to obtain a sufficient number of accurate species data to quantify species-environment relationships, we sampled coprophagous beetles throughout the Western Swiss Alps in a random stratified manner. We additionally obtained all the occurrences available in Switzerland for the beetles of interest (Hydrophilidae, Geotrupidae and Scarabaeidae) from the Swiss national database (www.cscf.ch). This allowed us to compare fine-scale models calibrated in the study area using our precisely sampled data (regional model) and large-scale models calibrated at the Swiss level using national occurrences and our data (Swiss model). We expected the latter to reduce the risk, while calibrating the SDMs, of truncating the species' environmental niche, which can happen when the complete extent of the species' geographic distributions and environmental requirements are not covered in an analysis (Pearson et al. 2004; Thuiller et al. 2004; Hannemann et al. 2016; Guisan et al. 2017; El-Gabbas and Dormann 2018; G. Mateo et

al. 2019; Chevalier et al. 2021). Here, we particularly focused on the climatic, land-use and edaphic factors as environmental predictors of the species' presence. In addition, we investigated the effects of species characteristics such as the altitudinal amplitude where they occur, their nesting behavior and their body size on the SDMs performances. Finally, we assessed whether the stacking of all species predictions produced meaningful richness maps of coprophagous beetles in the study area.

Materials and methods

Study area

The study was conducted in Western Switzerland, in the alpine region of the Canton of Vaud, which goes from Vevey to Bex and to Rougemont (Fig. 1). It spans a wide altitudinal gradient, from 372 to 3051 meters above sea level. Since the lower part of the region is dedicated to crop fields and its slopes are covered by forests, we only considered the upper part of the area, starting from an altitude of 1000 meters above sea level (Fig. 1), where pastures grazed by domestic livestock (principally cows and sheep) and alpine grasslands inhabited by big wild herbivores, like Alpine chamois (*Rupicapra rupicapra*), Alpine ibex (*Capra ibex*) and Red deer (*Cervus elaphus*) occur. The study region is of particular interest for interdisciplinary research as it constitutes a priority region for research (<http://rechalp.unil.ch>; Reynard et al. 2020; von Däniken et al. 2014) and is also a priority region for biodiversity conservation (Lassen and Savoia 2005).

Sampling

From the 31 of May to the 12 September 2020, we collected beetles in 132 sampling plots (Fig. 1) of 20 meters radius located in a random stratified manner (Guisan and Hirzel 2002) in open habitats (excluding the forests and built areas). We stratified the study region in 10 strata according to altitude (every 300 meters, from 1000 to 2500 meters) and the yearly sum of solar radiations (two levels: lower and higher than the mean radiation observed in the study area). In order to perform a sampling representative of the environment variability of the study area, we sampled a number of random points in each stratum proportional to its size. This could ensure optimizing the number of species to be found (according to the species-area relationship; Lomolino 2001) while still allowing good species-environment relationships to be fitted (Hirzel and Guisan 2002). To avoid bias due to the phenology of the beetles, we sampled the whole altitudinal gradient regularly through time.

We choose to perform active sampling over trapping in order to minimize the logistics and maximize the number of sampling stations. Each plot was sampled once. There, 20 minutes were dedicated to the manual search of beetles

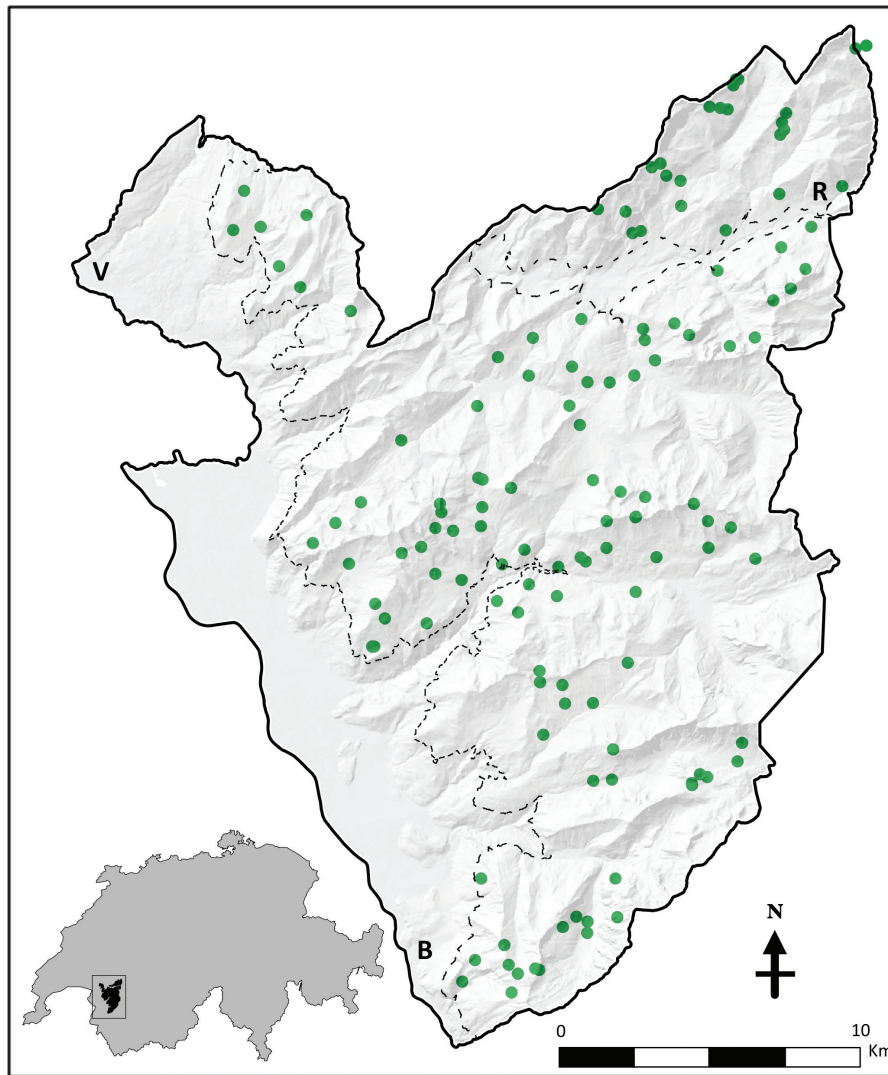


Figure 1. Map of the study area situated in the alpine region of the Canton of Vaud above 1000 meters above sea level (dashed line) with three of its the major localities: Bex (B), Rougemont (R) and Vevey (V). The 132 plots where coprophagous beetles were sampled in 2020 are represented by the green circles.

inside of the dung using a little shovel with the goal to catch the maximum number of species. We identified the collected beetles with the help of a binocular and based on identification keys found in the specialized literature (Baraud 1992; Fikáček 2006; Vorst 2009; Klausnitzer 2011). For the statistical analyses, *Amidorus immaturus* and *A. obscurus* were pooled together since these two species were erroneously not distinguished at the Swiss scale (Cosandey et al. 2017). The species were recorded as present or absent in each sampling plot. We classified the Scarabaeidae and Geotrupidae species according to their nesting behavior in ‘non-nesters’ (laying eggs in the dung), ‘paracoprids’ (laying eggs in dung buried under the excrement) with the help of the specialized literature (Klemperer 1980; Rojewski 1983; Zunino and Barbero 1990; Hanski 2016) and the revisions proposed by Tonelli (2021). All the data were transmitted to the Swiss database (info fauna-CSCF; distributional maps available here: <https://lepus.unine.ch/carto/>).

Swiss beetle data

In addition to our sampling dataset, we received all the Swiss data (26'602 occurrences from museums and private collections) from the Swiss database (info fauna-CSCF; www.cscf.ch) for the species of coprophagous beetles we found during our sampling. For the statistical analyses, we discarded the duplicated occurrences and the imprecise old museum data (geographic accuracy of less than 250 meters) ending with a 5359 occurrences dataset (20.15% of all occurrences).

Environmental data

To depict the species' niche and to fit our models, we used 13 predictors (Table 1): (i) land-use variables originating either from the Swiss Federal Office of Statistics (2004) - alpine pastures, lowland pastures, cultivations, human

Table 1. The 13 predictors used in our models. For each of the variables, we provide its category, name, a short description and the model in which it was used: Swiss and/or regional.

Category	Name	Description
Swiss models		
Bioclim	Bio10	Mean temperature of the warmest year quarter in a 250 meter focal window
Bioclim	Bio16	Mean precipitation in the wettest year quarter in a 250 meter focal window
Bioclim	Bio17	Mean precipitation of the driest quarter of the year in a 250 meter focal window
Land use	Alpine pastures	Proportion of alpine pastures (situated above the permanent habitation area) area in a 250 meter focal window
Land use	Cultivations	Proportion of cultivated area in a 250 meter focal window
Land use	Forest edges	Proportion of forest edges area in a 250 meter focal window
Land use	Human infrastructures	Proportion of human infrastructures cover in a 250 meter focal window
Land use	Humid habitats	Proportion of humid habitats area in a 250 meter focal window
Land use	Lowland pastures	Proportion of lowland pastures (situated in the permanent habitation area) area in a 250 meter focal window
Land use	Rock	Proportion of rocks and bare soils area in a 250 meter focal window
Regional models		
Bioclim	Solar radiation	Sum of the total radiation over one year
Soil	C13	Predicted carbon isotope composition $\delta^{13}\text{C}$ of the soil in the study region
Soil	pH	Predicted soil pH in the study region

infrastructures (at a 50 meters resolution) - or from the Swiss Federal Office of Topography (Topographic Landscape Model 3D catalogue, 2012); - humid habitats, forest edges, rock and bare soil covers (25 meters resolution); and ii) climatic variables (at a 25 meters resolution) calculated from the bioclimatic data of Switzerland (Hijmans et al. 2005; Broennimann 2018) - mean temperature of the warmest quarter of the year (Bio10), precipitation in the wettest year quarter (Bio16), and precipitation in the driest year quarter (Bio17). Elevation was not included as predictor, as it is not a causal variable for species (Guisan et al. 2017) and is driving many other variables already included as predictors (e.g. temperature). To take into account the precision of the data at the Swiss level, we ran, for each variable focal window (Bellamy et al. 2013; Scherrer et al. 2019), which summarized the proportion of each land-use variables (i) and the mean climatic condition (ii) in a 250 meters radius around every pixel of 25 meters. These predictors were used to calibrate the Swiss models.

For all species recorded at least 15 times in our sampling (Table 2), we calibrated regional models with the land-use, bioclimatic variables and fine scale predictors with a 25 meters resolution (Table 1) such as the yearly sum of solar radiation (Zimmermann and Kienast 1999) and edaphic factors; soil pH (Buri et al. 2017) and the carbon isotope composition $\delta^{13}\text{C}$, which is an indirect measure of soil texture and organic matter content (Bird et al. 2003; Buri et al. 2020). We verified that the correlations between the variables were not too high (<0.7) as proposed by Dorman et al. (2013).

Statistical analyses

All the statistical analyses were performed with R Studio version 1.0.153. (R core team, 2017). The models were built using the biomod2 (Thuiller et al. 2009) and eco-spat package (Di Cola et al. 2017). Among the techniques

available to fit Species Distribution Model (SDM) (Elith et al. 2006; Guisan et al. 2017), we choose to use Ensemble of Small Models (ESMs; Lomba et al. 2010; Breiner et al. 2015, 2018). In this approach many small (here bivariate) models are fitted and averaged in a weighted way within a single Ensemble model in order to avoid overfitting of the models and is thus very useful in the case of species with few occurrences in a dataset (Lomba et al. 2010; Breiner et al. 2015), like ours.

For each species found at least 15 times (Scherrer et al. 2019) during our sampling, we calibrated a 'Regional' model with our presence-absence occurrences and all predictors (climatic, land use, edaphic and radiance; see Table 1). In parallel, we calibrated a 'Swiss' model for all species found in the study area and known from at least 15 accurate occurrences in Switzerland (originating from info fauna-CSCF and our sampled data) and background points, also called 'pseudo-absences' (or 'background points'; same number as the number of presences) with climatic and land-use variables as predictors (see Table 1). As the region of interest is not an outlier compared to the main topo-climatic conditions in Switzerland, we are confident that the response curves of the Swiss models are not truncated and that the predictions in the regions of interest are not biased.

We calibrated all our models using two techniques (Breiner et al. 2015). More precisely, we choose to use Generalized Linear Models (GLM) and Generalized Additive Models (GAM), to represent both parametric (GLM) and semi-parametric (i.e. more data-driven; GAM) modeling approaches. Both models are calibrated using a binomial distribution with logit link function to accommodate the binary nature of the response (Warton and Hui 2011). Hundred runs were conducted with 70% of the dataset used for model calibration and 30% for model validation. The GLM and GAM models were separately merged in two Ensemble models (ESM-GLM and ESM-GAM) with the single bivariate runs weighted according

Table 2. Species of coprophagous beetles found in the study area. For the 47 species, we report the family, the subfamily, the number of occurrences in the study area (in brackets for species with less than 15 occurrences, for which no regional models were run) and the number of all existing precise occurrences in Switzerland (in brackets for species, with less than 15 occurrences), the nesting behavior (N – Non-nesters, P – Paracoprids, H – Hydrophilidae [predatory larvae, no nesting]) and the mean size in mm. The species are depicted in Suppl. material 3: Fig. S3.

Family	Subfamily	Species	Occurrences in the study area	Occurrences in Switzerland	Nesting behavior	Size [mm]
Geotrupidae	Geotrupinae	Anoplotrupes stercorosus (Scriba, 1791)	26	326	P	15.5
Geotrupidae	Geotrupinae	Geotrupes spiniger (Marsham, 1802)	(9)	77	P	22
Geotrupidae	Geotrupinae	Geotrupes stercorarius (Linnaeus, 1758)	17	76	P	20.5
Geotrupidae	Geotrupinae	Trypocopris vernalis (Linnaeus, 1758)	(2)	67	P	11
Hydrophilidae	Sphaeridiinae	Cercyon haemorrhoidalis (Fabricius, 1775)	(8)	90	H	2.8
Hydrophilidae	Sphaeridiinae	Cercyon impressus (Sturm, 1807)	88	206	H	3.15
Hydrophilidae	Sphaeridiinae	Cercyon lateralis (Marsham, 1802)	70	140	H	2.75
Hydrophilidae	Sphaeridiinae	Cercyon melanocephalus (Linnaeus, 1758)	23	81	H	2.6
Hydrophilidae	Sphaeridiinae	Cercyon obsoletus (Gyllenhal, 1808)	(4)	15	H	3.6
Hydrophilidae	Sphaeridiinae	Cercyon pygmaeus (Illiger, 1801)	46	110	H	1.45
Hydrophilidae	Sphaeridiinae	Cercyon quisquilius (Linnaeus, 1761)	(7)	6	H	2.25
Hydrophilidae	Sphaeridiinae	Cryptopleurum crenatum (Kugelann, 1794)	(8)	16	H	2
Hydrophilidae	Sphaeridiinae	Cryptopleurum minutum (Fabricius, 1775)	17	73	H	2
Hydrophilidae	Sphaeridiinae	Megasternum concinnum (Marsham, 1802)	(1)	55	H	1.95
Hydrophilidae	Sphaeridiinae	Sphaeridium bipustulatum Fabricius, 1781	17	97	H	4.35
Hydrophilidae	Sphaeridiinae	Sphaeridium lunatum Fabricius, 1792	78	188	H	5.65
Hydrophilidae	Sphaeridiinae	Sphaeridium marginatum Fabricius, 1787	(5)	24	H	4.55
Hydrophilidae	Sphaeridiinae	Sphaeridium scarabaeoides (Linnaeus, 1758)	80	228	H	5.75
Scarabaeidae	Aphodiinae	Acrossus depressus (Kugelann, 1792)	76	268	N	7.5
Scarabaeidae	Aphodiinae	Acrossus rufipes (Linnaeus, 1758)	62	242	P	12
Scarabaeidae	Aphodiinae	Agoliinus satyrus (Reitter, 1892)	(2)	24	N	6
Scarabaeidae	Aphodiinae	Agrilinus convexus (Erichson, 1848)	(12)	77	N	5
Scarabaeidae	Aphodiinae	Amidorus obscurus s.l. (Fabricius, 1792)	42	129	N	7
Scarabaeidae	Aphodiinae	Ammoecius brevis (Erichson, 1848)	(1)	18	N	4
Scarabaeidae	Aphodiinae	Aphodius fimetarius aggr. (Linnaeus, 1758)	16	231	N	6.5
Scarabaeidae	Aphodiinae	Bodilopsis rufa (Moll, 1782)	59	217	P	6
Scarabaeidae	Aphodiinae	Calamosternus granarius (Linnaeus, 1767)	(8)	249	N	4
Scarabaeidae	Aphodiinae	Colobopterus erraticus (Linnaeus, 1758)	82	207	P	6
Scarabaeidae	Aphodiinae	Esymus pusillus (Herbst, 1789)	20	130	N	4
Scarabaeidae	Aphodiinae	Euheptaulacus carinatus (Germar, 1824)	(10)	25	N	5
Scarabaeidae	Aphodiinae	Nimbus contaminatus (Herbst, 1783)	(3)	61	N	6
Scarabaeidae	Aphodiinae	Oromus alpinus (Scopoli, 1763)	27	133	N	5.5
Scarabaeidae	Aphodiinae	Otophorus haemorrhoidalis (Linnaeus, 1758)	47	156	N	4.5
Scarabaeidae	Aphodiinae	Parammoecius gibbus (Germar, 1816)	21	50	N	3.75
Scarabaeidae	Aphodiinae	Planolinoides borealis (Gyllenhal, 1827)	(4)	(9)	N	4.5
Scarabaeidae	Aphodiinae	Planolinus fasciatus (A. G. Olivier, 1789)	(4)	21	N	4.5
Scarabaeidae	Aphodiinae	Rhodaphodius foetens (Fabricius, 1787)	(4)	21	N	7.5
Scarabaeidae	Aphodiinae	Teuchestes fossor (Linnaeus, 1758)	64	203	P	10.5
Scarabaeidae	Aphodiinae	Volinus sticticus (Panzer, 1798)	(5)	141	N	4.5
Scarabaeidae	Scarabaeinae	Copris lunaris (Linnaeus, 1758)	(1)	72	P	17.5
Scarabaeidae	Scarabaeinae	Euoniticellus fulvus (Goeze, 1777)	(5)	55	P	9
Scarabaeidae	Scarabaeinae	Onthophagus baraudi Nicolas, 1964	16	27	P	5.5
Scarabaeidae	Scarabaeinae	Onthophagus coenobita (Herbst, 1783)	(3)	123	P	8
Scarabaeidae	Scarabaeinae	Onthophagus fracticornis (Preyssler, 1790)	58	315	P	8.5
Scarabaeidae	Scarabaeinae	Onthophagus illyricus (Scopoli, 1763)	(6)	64	P	8.75
Scarabaeidae	Scarabaeinae	Onthophagus joannae Goljan, 1953	(10)	128	P	5
Scarabaeidae	Scarabaeinae	Onthophagus verticornis (Laicharting, 1781)	(1)	19	P	8

to their AUC scores. Finally, these two single-technique ESMs were included in a final Ensemble model (final ESM), weighted by their respective SomersD score. All the final models were projected over the study region. We evaluated the quality of our models, with a maximization of their True Skill Statistic score (TSS; Allouche

et al. 2006; maxTSS; Jimenez-Valverde 2014; Guisan et al. 2017). The relative importance's of each variable in the models were also extracted using the ecospat.ESM VarContrib function of the ecospat package, which sums separately the weights of the bivariate models including each variable and compares them to the sum of all the

bivariate models. Finally, we used the probability value (or suitability value in the case of the Swiss presence/background model) providing the maxTSS as a cutoff to binarize species predictions into presence/absence maps.

Swiss model performances in relation with species' biological traits

We tried to explain the performance differences between single species models with species characteristics such as the standard deviation of the altitudinal amplitude (i.e. difference between highest and lowest altitude where the species were recorded in Switzerland), the influence of the three different nesting behavior (species with coprophagous larvae: non-nesters and paracoprids; species with predaceous larvae: Hydrophilidae) and the body size of the beetles (according to the specialized literature; Baraud 1992; Allemand and Leblanc 2004; Vorst 2009; Klausnitzer 2011) on the quality of the Swiss models (max TSS). Using the package lme4 (Bates et al. 2015), we ran a Generalized Linear Model (GLM) with these three species characteristics as explanatory variables and the median maxTSS of the final models of each species as response variable.

Species richness of coprophagous beetle communities

We summed all species' maps of environmental suitability (as proposed by Dubuis et al. (2011)) resulting of our Swiss models ESMs to get a map of the index of cumulated suitability reflecting the species richness in each pixel (25 meters resolution) of the study area. Because these models were based on presence-pseudoabsence, the predictions are not true probabilities (Guillera-Arroita et al. 2015) and accordingly their sum is not a true estimate of species richness but rather an index of cumulated suitability of coprophagous beetles that can reflect on the variations of species richness. We also summed the environmental suitability of the species with the same nesting behavior (non-nesters, paracoprids or non-nesting Hydrophilidae) to obtain predictions of the cumulative index per group.

Results

Coprophagous beetles inventory

During our sampling, we recorded 1120 occurrences of coprophagous beetles belonging to 48 species. We pooled the data of *A. immaturus* (20 occurrences) and *A. obscurus* (38 occurrences) together (see remark in the material and methods section) and considered for the statistical analyses 47 species (Table 2, Suppl. material 3: Fig. S3) belonging respectively to Scarabaeidae (21 Aphodiinae and 8 Scarabaeinae), Geotrupidae (4 species) and Hydrophilidae (14 species).

Swiss models

Only one of the 47 species that we recorded in the study region had less than 15 occurrences at the Swiss level (*Planolinoides borealis*; Table 2) and was therefore not used to build ESMs. For the 46 other species, the models calibrated at the Swiss level ranged from a median maxTSS going from 0.27 (*Anoplotrupes stercorosus*) to 0.93 (*Ammoecius brevis*) (Fig. 2A). All specific maps are provided in the supplementary material (Suppl. material 1: Fig. S1). At the Swiss level the variables had not high differences in their contribution but it is still possible to observe that the most important were the mean temperature of the warmest quarter of year (Bio10), the proportion of rock and bare soils (Rock) the precipitation during the driest quarter of the year (Bio17) (Fig. 3A) and the forest edges proportion. The proportion of human infrastructure, wet habitats and cultivation had the lowest contribution (Fig. 3A).

Regional models

On the 47 species recorded in the study area, 23 had enough occurrences (at least 15) to build ESMs. The regional models showed a high heterogeneity in their performances going from a median maxTSS of 0.40 (*Acrossus rufipes*) and 0.85 (*Parammoecius gibbus*) (Fig. 2B). All the maps are presented in the supplementary material (Suppl. material 2: Fig. S2). In the regional models, the variable with the highest contribution were the proportion of rock and bare soil cover (Rock), the carbon isotope composition of the soil ($\delta^{13}C$), the mean temperature of the warmest quarter of year (Bio10) and the forest edges proportion (Fig. 3B), while the cultivation proportion and the human infrastructure had the lowest contribution (Fig. 3B).

Swiss model performances in relation with species' biological traits

We tested the influence of species' biological traits on the performances of the Swiss models. The altitudinal range of the species had a significant influence on the median maxTSS in the models (GLM result: p-value = 1.78×10^{-10} , t-value = -8.42; Fig. 4A). Neither the nesting strategies (GLM result: p-values = 0.94 and 0.25, t-values = 0.08 and -1.16; Fig. 4B), nor the mean size of the species had an influence on the performance of the models (GLM result: p-value = 0.81, t-value = 0.24; Fig. 4C). There was no significant interaction between variables.

Species richness of coprophagous beetle communities

The sum of the environmental suitability resulting of our Swiss models predicted a global decrease in species richness from the low to the high altitudes (min = 11.45,

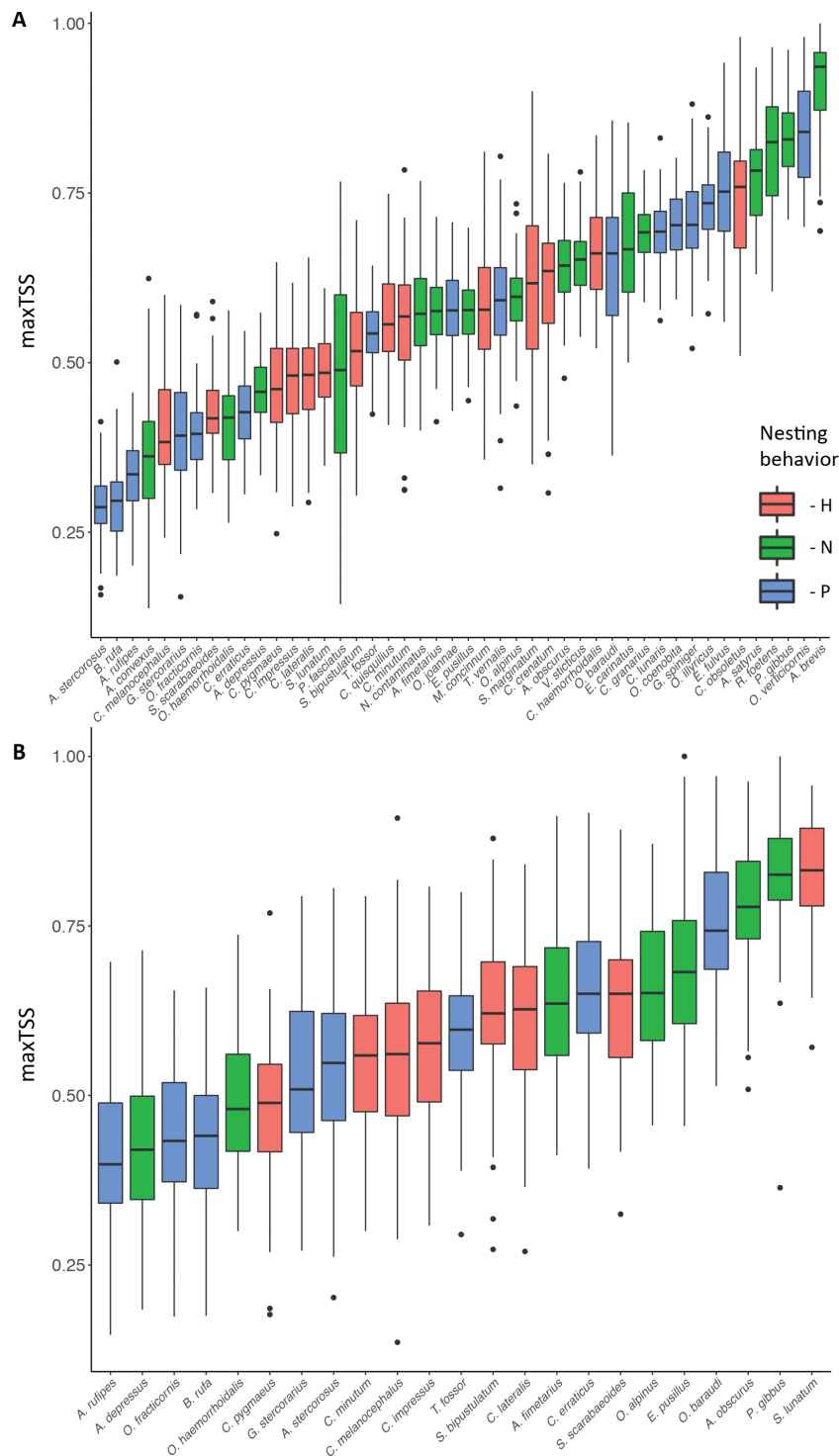


Figure 2. Results of the Ensemble of Small Models (ESMs) ordered by increasing median of max True Skills Statistics (maxTSS), calibrated (A) at the Swiss scale (46 species treated) and (B) at the Regional scale (23 species treated). The boxplots are colored according to the nesting behavior of the species (N – Non-nesters, P – Paracoprids, H – Hydrophilidae [predatory larvae, no nesting]). All the model projections are presented in Suppl. material 1: Fig. S1 and all the species are illustrated in Suppl. material 3: Fig. S3.

max = 24.59 species) (Fig. 5A). This trend was particularly sharp for the paracoprids (min = 3.07, max = 9.28) (Fig. 5B) but much less for the non-nesters (min = 4.62, max = 7.18) (Fig. 5C). Hydrophilidae also showed a strong loss of species diversity with the increasing altitude (min = 2.51, max = 8.52 species). (Fig. 5D).

Discussion

We investigated the influence of various factors on the distributions of single coprophagous beetle species in the Western Swiss Alps using correlative species distribution modeling (SDM) approaches based on quantifying

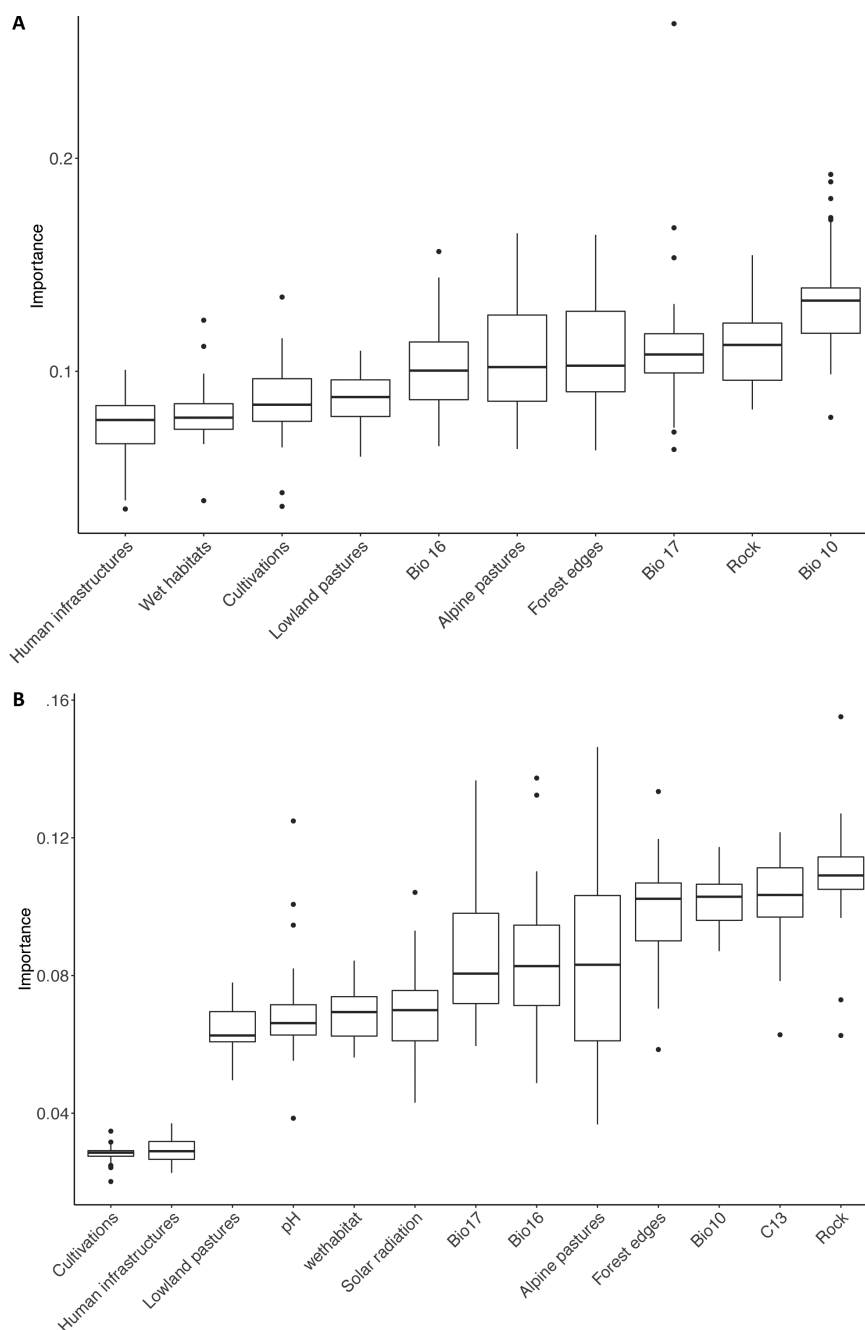


Figure 3. Relative importance of the variables used as predictors in the Ensemble of Small Models (ESMs) presented in increasing order of importance, for (A) the 46 models calibrated at the Swiss scale and (B) the 23 models calibrated at the Regional scale. For the full descriptions of the predictors, see Table 1.

habitat suitability (Guisan et al. 2017). Given the high number of species with small number of occurrences, we used a particular approach recently developed for small sample sizes: ensemble of small models (ESMs; Lomba et al. 2010; Breiner et al. 2015, 2018). In all our models, the predictors with the greatest importance included climatic variables (Fig. 3), like in many SDM studies (Austin and Van Niel 2011; Pradervand et al. 2013; Mod et al. 2016; Scherrer et al. 2019). Interestingly, in both models (i.e. Swiss, Fig. 3A and Regional, Fig. 3B) the proportion of rock and bare soil cover (Rock) was an important predictor. In the study region as in the rest of

the Alps, the altitude is correlated with the proportion of rocky surfaces, which could act as a confounding factor. As specialized species are better modeled than the widespread species covering a large elevation range (Guisan and Hofer 2003), the importance of the rocky surface variable in the models might be artificially high. It is also possible that more species are present in pastures of high ecological value (i.e. with a high overall biodiversity) including grasslands with discontinuous vegetation cover (Delarze et al. 2015). Furthermore, the superficial rock cover proportion could be an indirect way of quantifying the heterogeneity of the landscape, such as the proportion

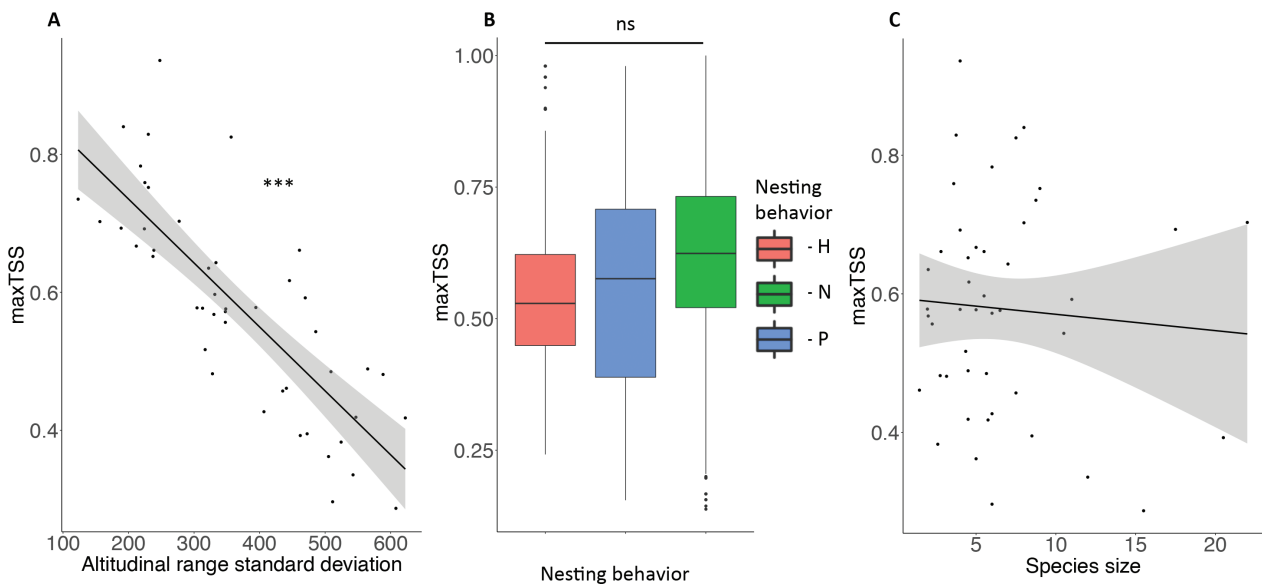


Figure 4. Model performances in relation to species characteristics. The median max True Skills Statistics (maxTSS) of each species are plotted (A) against the altitudinal amplitude standard deviation of the species in Switzerland; (B) according to the nesting behavior of the species (N – Non-nesters, P – Paracoprids, H – Hydrophilidae [predatory larvae, no nesting]); (C) against the species size. The grey area represents the confidence interval 95%.

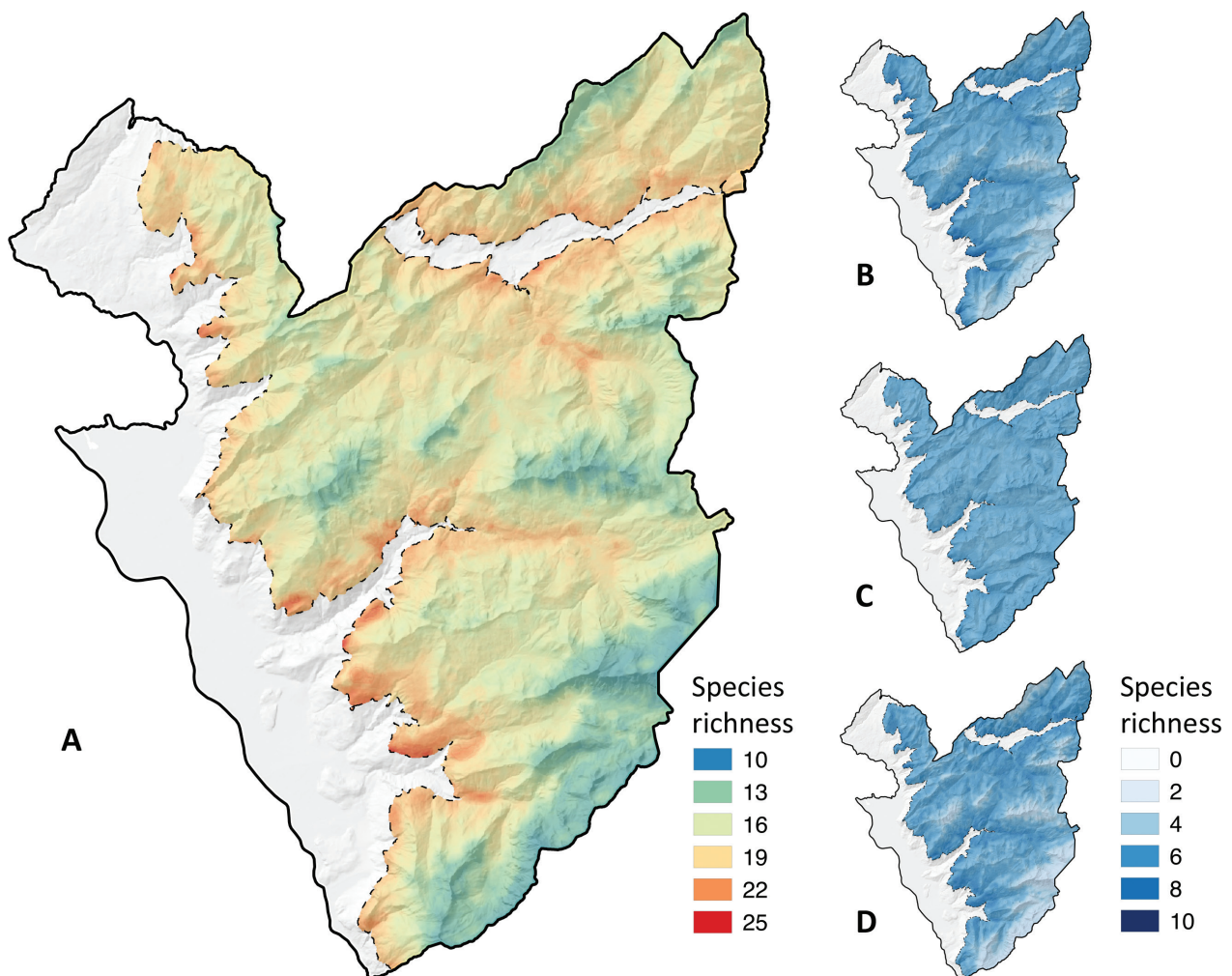


Figure 5. Expected species richness, based on the index of cumulated species suitability, in the Swiss Western Alps study area starting at 1000 meters above sea level according to the stacking of regional models considering (A) all species, (B) the Paracoprids, (C) the Non-nesters and (D) the Hydrophilidae.

of forest edges, which was also an important predictor (Fig. 3) in our model. Indeed, Negro et al. (2011) suggested that habitat heterogeneity, especially the presence of natural forested areas next to pastures, plays an important role in increasing coprophagous beetle species richness. In contrast, some variables had little influence in our models. These were often land cover or land use variables spatially restricted in Switzerland (e.g. wet habitats) or in the study area (e.g. cultivations) but it is difficult to know if it is the low frequency of these variables over the landscape that induces their smaller influence in the models or if they really do not have an influence on species distributions.

Our ESMs had very variable predictive performances as measured by the maximized TSS (see Jimenez-Valverde 2014; Guisan et al. 2017), with values ranging from 0.27 to 0.93 for the Swiss models (Fig. 2A) and from 0.40 to 0.85 for the regional models (Fig. 2B). Note that the use of threshold independent discrimination metrics, such as the maxTSS (or the classical AUC) for the evaluation of presence/absence models (i.e. our Regional models) may be problematic because of a non-linear asymptotic relationship between discrimination metrics and true model accuracy, and that it might be accordingly difficult to distinguish between models with high AUC value (Jimenez-Valverde 2014). Nonetheless, maxTSS from models calibrated in the same area can still correctly inform on the ranking of accuracy between models (e.g. between poor, useful or good models), except among very high TSS values (i.e. calling for caution in the ranking among good models). We found that ubiquitous species present over a wide altitudinal range had weaker models compared with specialized species occurring in narrower altitudinal amplitude (Fig. 4A). Our results are in line with those of Guisan and Hofer (2003) and Grenouillet et al. (2011), who showed that the distributions of generalist reptile and fish species, respectively, are more difficult to predict, and with those of Tessarolo et al. (2021), who found that niche marginality has a major influence on the models' quality for dung beetles in Spain. On the other hand, we found no influence of the nesting behavior (Fig. 4B) nor the size of the species (Fig. 4C) on the maxTSS of the models, meaning that these biological traits seem not relevant to explain models' quality.

When looking at the expected species richness of the coprophagous beetle communities based on the stacking of single species environmental suitability values over the study region, the global trend shows a diminution of the number of species with increasing altitude (Fig. 5). This result was also observed in other taxa in the same region (Dubuis et al. 2011 for plants; Pradervand et al. 2013 for orthopterans; Reymond et al. 2013 for ants; Pellissier et al. 2013 for butterflies; Scherrer et al. 2019 for bats; Seppely et al. 2020 for protists), for which the climatic predictors, especially temperature, were also of great importance. However, it is important to notice that for coprophagous beetles, the decrease in species richness depends on the nesting behavior: the paracoprids (Fig. 5B) and the Hydro-

philidae (Fig. 5D) show a steep decrease with increasing elevations, while the non-nesters (Fig. 5C) show a gentler one. This latter group forms the biggest part of the coprophagous beetle diversity at high altitude where almost no paracoprids and Hydrophilidae are found (Fig. 5B, C). This result, consistent with those of Lobo et al. (2007) is explained by the ecology of non-nester beetles, which are more tolerant to cold and are outcompeted by paracoprids in thermophilous places (Hanski 2016).

Many of the studies focusing on the coprophagous fauna use dung-baited trap to get an exhaustive species list in addition to data on the phenology and abundance (see for example Lumaret 1978). No large-scale trapping campaign was performed in Switzerland where the ecology of coprophagous beetles is still poorly studied. As a first step in a better knowledge of these taxa and since we were not interested in phenological or abundance data, we made the choice to perform an active sampling, less constraining logistically (transport of traps and dung), more efficient to visit a large number of sites (what we needed to build models) and allowing to select the individuals to collect sparing identification time. Moreover, the active search has been shown to be a very efficient way to get species inventories for beetles traditionally caught with traps (Chittaro and Marggi 2016). Our active field sampling designed in a random stratified manner permitted to be representative of the various environment of the study area and likely allowed us to find most of the coprophagous beetle species known from the study area (*Agolius abdominalis* and *Neagolius montanus* only were missing). Nevertheless, it is possible that we missed the occurrence of some species with low detectability in some plots. Future studies aim to correct for this bias, for example by implementing methods to estimate the completeness of plot inventory, or combining models of α - and β -diversity to predict the spatial community composition in a region, and areas of incompleteness within it (Mokany et al. 2011).

From a faunistic point of view, our study brings valuable new records for beetles, an under-sampled taxon in comparison to other insect groups such as orthopterans, butterflies, and even more vertebrates (Troudet et al. 2017), with the perspective to improve predictions of global change impact on biodiversity in mountain areas (Guisan et al. 2019) and better support conservation decisions (Guisan et al. 2013). Indeed, the data sampled in our study represents now 17.9% (N=1120, Swiss database info fauna-CSCF) of all precise occurrences existing for these 47 coprophagous beetle species in Switzerland (N=6258). An important part (42%) of all the coprophagous beetle species of Switzerland is found in the Vaud Alps (info fauna-CSCF), reinforcing the status of biodiversity hotspot of this study region in the European Alps (Lassen and Savoia 2005). Future studies should investigate more of such under-sampled taxa, like other invertebrate groups, to allow more robust comparative studies and produce better global biodiversity assessments within a same study area (Mod et al. 2020).

Acknowledgements

We particularly thank: Yannick Chittaro and Andreas Sanchez for their advises in entomology, for providing us the Swiss occurrences dataset and for their comments on the manuscript; Tatiana Zingre for her help during the field sampling; Paul Béziers, Robin Séchaud and the reviewers for their constructive remarks on the manuscript, which permitted to improve it substantially. Finally, we thank the researchers/curators of the Natural History Museum of Geneva, Giulio Cuccodoro, Bernard Landry and Emmanuel Toussaint for providing the photographic material. AG received support from the Federal Office of the Environment through the ValPar. CH project.

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Supplementary material 1

Figure S1

Authors: Vivien Cosandey, Olivier Broennimann, Antoine Guisan

Data type: pdf file

Explanation note: Map of all the 46 species for which a model was run at the Swiss scale. The environmental suitability of each species is projected in the study area above 1000 meters above sea level (represented by a dashed line).

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Link: <https://doi.org/10.3897/alpento.6.83730.suppl1>

Supplementary material 2

Figure S2

Authors: Vivien Cosandey, Olivier Broennimann, Antoine Guisan

Data type: pdf file

Explanation note: Map of the 23 species for which a model was run at the Regional scale. The environmental suitability of each species is projected in the study area above 1000 meters above sea level (represented by a dashed line).

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Link: <https://doi.org/10.3897/alpento.6.83730.suppl2>

Supplementary material 3

Figure S3

Authors: Vivien Cosandey, Olivier Broennimann, Antoine Guisan

Data type: pdf file

Explanation note: Illustration of all the coprophagous beetle species found in the study region. Illustration: Vivien Cosandey.

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Link: <https://doi.org/10.3897/alpento.6.83730.suppl3>

Periscelis (Myodris) haennii sp. nov., a new species of Periscelididae (Diptera) from Ticino, Switzerland, with a new key to European species of the subgenus

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Academic editor: Patrick Rohner ♦ Received 15 April 2022 ♦ Accepted 15 July 2022 ♦ Published 25 August 2022

Abstract

A new Periscelididae species, *Periscelis (Myodris) haennii* sp. nov., is described from Losone near Locarno, Canton Ticino (Southern Switzerland). It has been found during a biodiversity survey using attractant traps in a Quercus-Castagnetum forest. This new species is closely related and very similar to *P. (M.) annulata* (Fallén, 1813) occurring syntopically in the same traps. Interestingly, also *P. (M.) piricercus* Carles-Tolrá & Verdugo Pérez, 2009 co-occurred with these species; consequently, all European species of the subgenus *Myodris* Lioy, 1864 were found in this locality. A new illustrated key to males of these species is presented. The DNA sequences of the barcoding region of COI for all these species are given.

Key Words

new species, Quercus-Castagnetum forest, Ticino, systematics, relationships, molecular barcoding

Introduction

In an effort to increase the knowledge on forest insect diversity of Canton Ticino, the recent entomological research program carried out by the Natural history museum of Canton Ticino (Museo cantonale di storia naturale, MCSN) in Lugano (Switzerland) has been focusing on the natural areas around the city of Locarno. During the sampling plan, aimed at testing different sampling methods, a large amount of specimens of Periscelididae was captured (Pollini Paltrinieri et al., unpublished data) in which many individuals appearing as *Periscelis (Myodris) annulata* (Fallén, 1813) when using available identification keys (most recent in Papp and Withers 2011), actually had different morphological characters of genitalia to the diagnostic ones, suggesting that it could be a new species of the subgenus *Myodris* Lioy, 1864. This incongruence of morphological features prompted taxonomic verification with international

expertise (by the late László Papp, Budapest and Miguel Carles-Tolrá, Barcelona) that lead to the present study.

To verify validity of the new species the male terminalia of both other European species of the subgenus, viz. *P. (M.) annulata* and *P. (M.) piricercus* Carles-Tolrá & Verdugo Pérez, 2009 have been examined in detail and those of *P. (M.) annulata* (the closest relative of the new species) were redescribed and illustrated. Moreover, DNA sequences of the barcoding region of COI of all these species have been obtained and their genetic distances tested.

The new species is treated within the subgenus *Myodris* of the genus *Periscelis* Loew, 1858 following the classification adopted by Mathis and Rung (2011) and supported by Roháček and Andrade (2017). Consequently, the elevation of *Myodris* to generic rank proposed by Papp and Withers (2011) is not here accepted. The taxonomic concept of *P. (M.) annulata* follows the redescription of this species by Papp and Withers (2011).

Materials and methods

Material

Three stations were surveyed in a Quercus-castanetum forest (Fig. 3) during a full year (July 2015–July 2016) using different kinds of traps; the 99.4% of Periscelididae have been caught with three slightly different attractant traps (transparent with wine – Fig. 1, transparent with beer, and yellow with wine – Fig. 2). A total of 305 males of the new species have been trapped. The material was preserved in ethanol but 53 specimens (type) have subsequently been dried and mounted on pins. The specimens are deposited in MCSN – Museo cantonale di storia naturale, Lugano (Switzerland) and SMOC – Silesian Museum, Opava (Czech Republic).

Drawing techniques and photography

Details of the male and female terminalia were drawn using Abbe's drawing apparatus on a compound microscope (JENVAL). Whole adult (dry-mounted) specimens were photographed by means of a digital camera Canon EOS 5D Mark III with a Nikon CFI Plan 4× /0.10NA 30 mm WD objective attached to Canon EF 70–200mm f/4L USM zoom lens. The specimen photographed by means of the latter equipment was repositioned upwards between each exposure using a Cognisys StackShot Macro Rail and the final photograph was compiled from multiple layers (35) using Helicon Focus Pro 7.0.2. The final images were edited in Adobe Photoshop CS6. Wings were photographed on a compound microscope Olympus BX51 with an attached digital camera (Canon EOS 1200D). Photographs of male terminalia in



Figures 1–3. Attractant traps and habitat of *Periscelis (M.) haennii* sp. nov. **1.** Transparent trap with wine, hanging on tree branch; **2.** Same, yellow trap; **3.** Habitat of the species (where wine traps were installed), a Quercus-castanetum forest at Losone near Locarno. Photos by L. Pollini Patrineri.

ethanol were taken with an Olympus UC50 camera mounted on a microscope Olympus SZX12, processed with Stream Essentials Olympus and by Auto Montage Software.

Barcoding

To demonstrate molecular differences between European *Myodris* species the barcoding region of COI was amplified (see below). One specimen of all three species and also that of *Periscelis* (s. str.) *winnertzii* Egger, 1862 (all from Switzerland, Canton of Ticino: Losone), preserved in 80% ethanol, were used for analysis. The DNA was extracted using NucleoSpin Tissue Kit (Macherey-Nagel, Düren, Germany) following manufacturer's protocols. Individual flies were rinsed in PBS buffer, placed in sterile Eppendorf tubes and incubated overnight at 56 °C with proteinase K. PCRs (total volume=20 µL) were performed using primers for barcoding region of COI gene LCO1490 LCO1490 (5'-GGTCAACAAATCATAAAGATATTGG-3') and HC02198 (5'-TAAACTTCAGGGTGACCAAAAAATCA-3') (Folmer et al. 1994). Amplified products were purified using the Gel/PCR DNA Fragments Extraction Kit (Geneaid, New Taipei City, Taiwan), following manufacturer's protocol. PCR products were sequenced by Eurofins genomics (Germany). Sequences of COI gene were assembled in SeqTrace 0.9.0 (Stucky 2012). GenBank accession numbers are as follows: *Periscelis* (*M.*) *haennii* sp. nov. – OM314931, *P. (M.) annulata* – OM314930, *P. (M.) piricercus* – OM314932, *P. (s. str.) winnertzii* – OM314933. Genetic distances of these species were calculated in MEGA version 11 (Tamura et al. 2021) using Kimura 2-parameter model (K2P) and they are presented in Table 1.

Table 1. Genetic distances for COI (Kimura 2-parameter) among *Periscelis* species. The barcoding region of COI has been 658 pb long.

Species	1	2	3	4
1 <i>P. (Myodris) annulata</i>				
2 <i>P. (Myodris) piricercus</i>	6.88%			
3 <i>P. (Myodris) haennii</i> sp. nov.	7.58%	9.12%		
4 <i>P. (Periscelis) winnertzii</i>	13.88%	14.23%	15.77%	

Morphological terminology follows that used for *Periscelis* spp. by Roháček and Andrade (2017). Morphological terms of the male genitalia are depicted in Figs 11–22.

Abbreviations of morphological terms used in text and illustrations

ac	acrostichal (setae)
c	costal cells
ce	cercus
dc	dorsocentral setae
dp	distiphallus
dm-cu	discal medial-cubital (= posterior, tp) cross-vein

ea	ejacapodeme
ed	ejaculatory duct
ep	epandrium
hu	humeral (seta)
hy	hypandrium
M	media
ma	medandrium
npl	notopleural (setae)
oc	ocellar (setae)
ors	fronto-orbital (setae)
pa	postalar (seta)
pg	postgonite
pha	phallapodeme
pvt	postvertical (seta)
r₁	1 st radial cell
r₂₊₃	2 nd radial cell
r-m	radial-medial (= anterior, ta) cross-vein
S6	sternite 6
sa	supra-alar (seta)
sc	scutellar (seta)
ss	surstylus
stpl	sternopleural (= katapisternal) (seta)
vte	external vertical (seta)
vti	internal vertical (seta)

Results

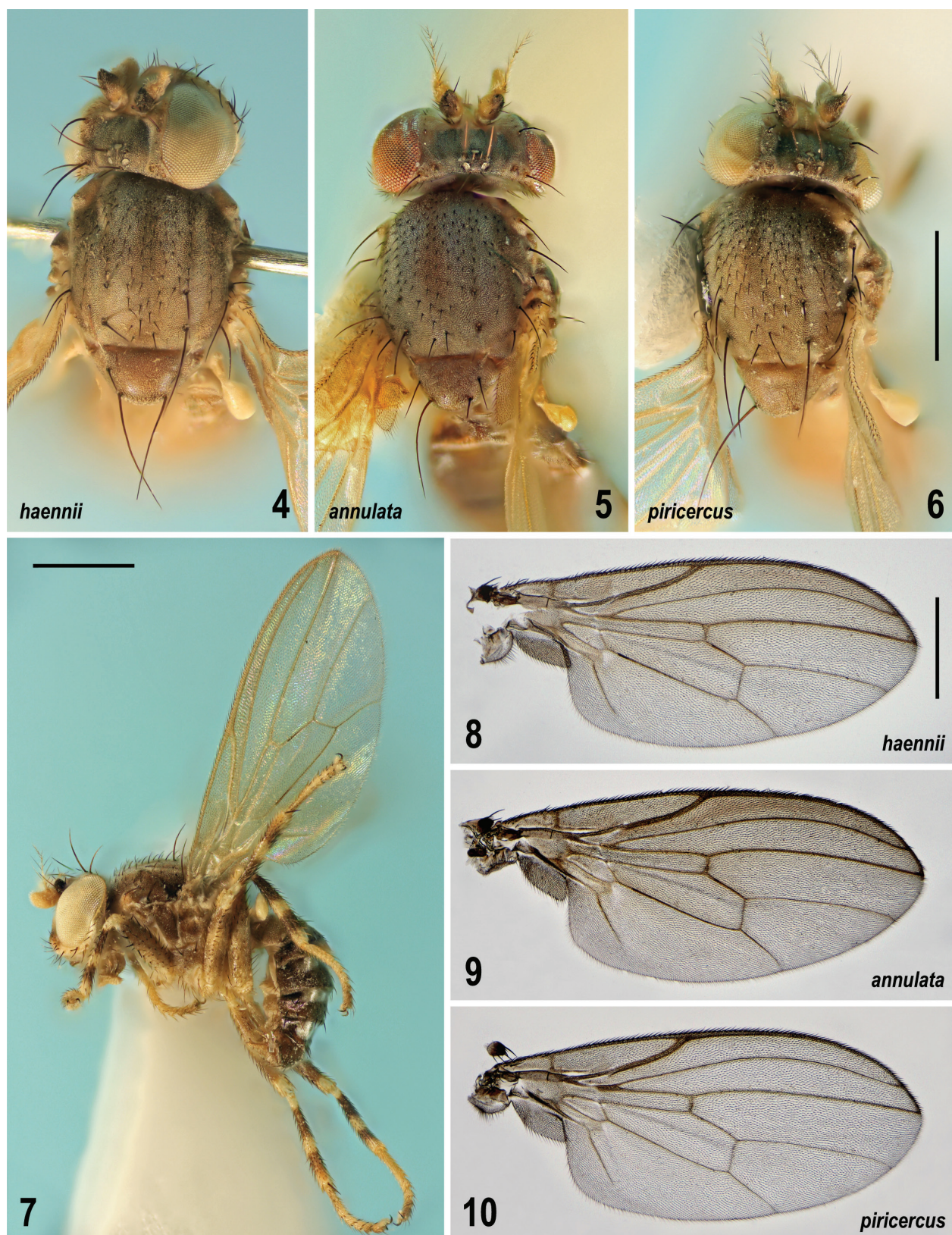
Periscelis (Myodris) haennii Pollini Paltrinieri & Roháček, sp. nov.

<https://zoobank.org/55CCD6F7-85F3-4301-ACA5-3414E8CB2F00>
Figs 4, 7, 8, 11–16, 23–26, 35

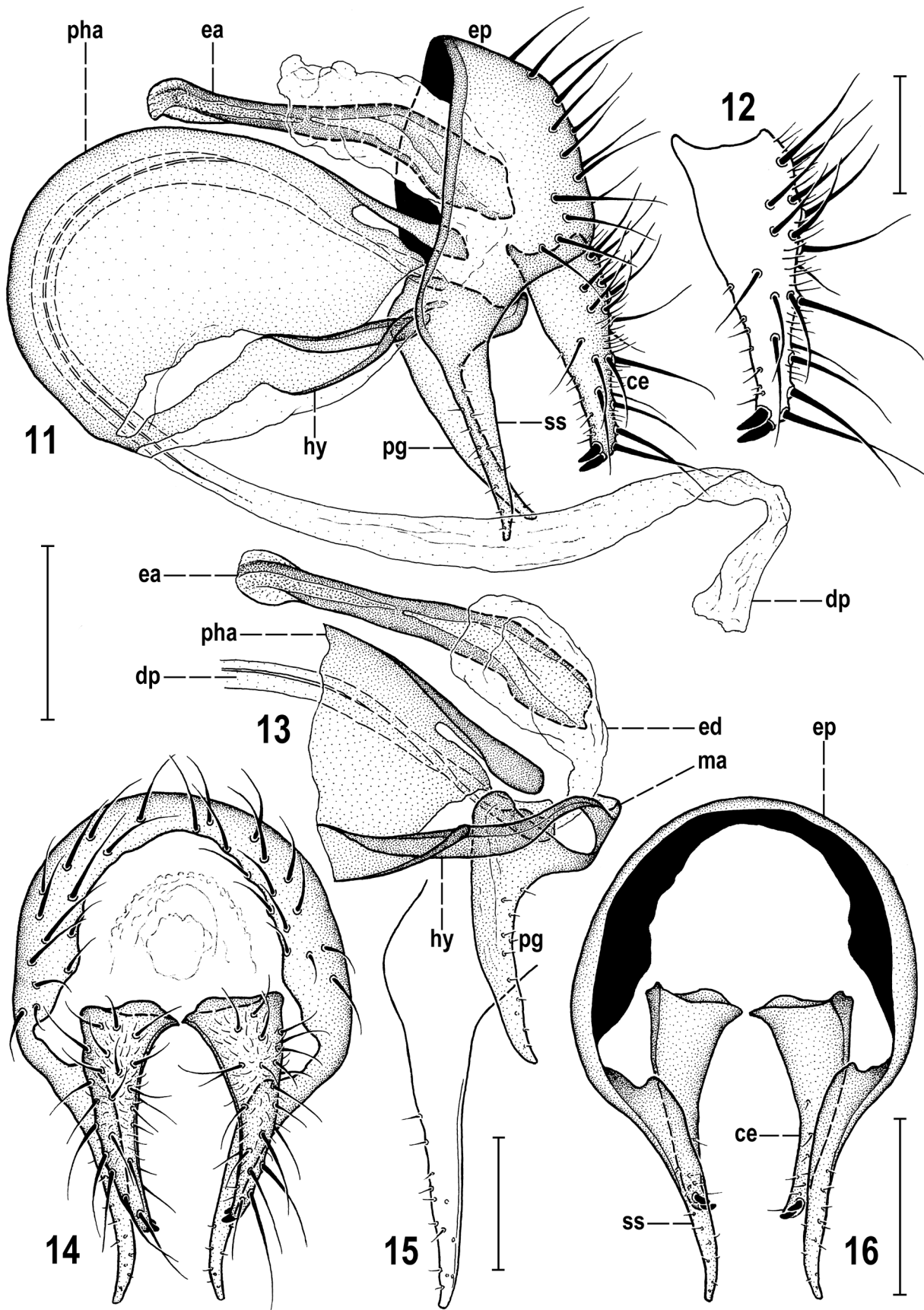
Type locality. Switzerland, Canton of Ticino, Municipality of Losone, Forest reserve of “Parco Collina di Maia”, 46°09'53"N, 8°44'54"E, 419 m.

Holotype. • ♂, pinned, labelled “SVIZZERA – TI; 701.168/113.372; Losone, Arcegno, Collina di Maia; Castagneto con querce; 419 m; 21–28.07.2015, prd. 1; VINO Bianca; ARC 2; Leg: L. Pollini P.& M. Abderhalden; DIPT04008, GBIFCH00559684. [Switzerland, Ticino; Losone, Arcegno, Collina di Maia; chestnut and oak forest; 419 m; 46°09'53"N, 8°44'54"E Wine trap White] (deposited in MCSN).

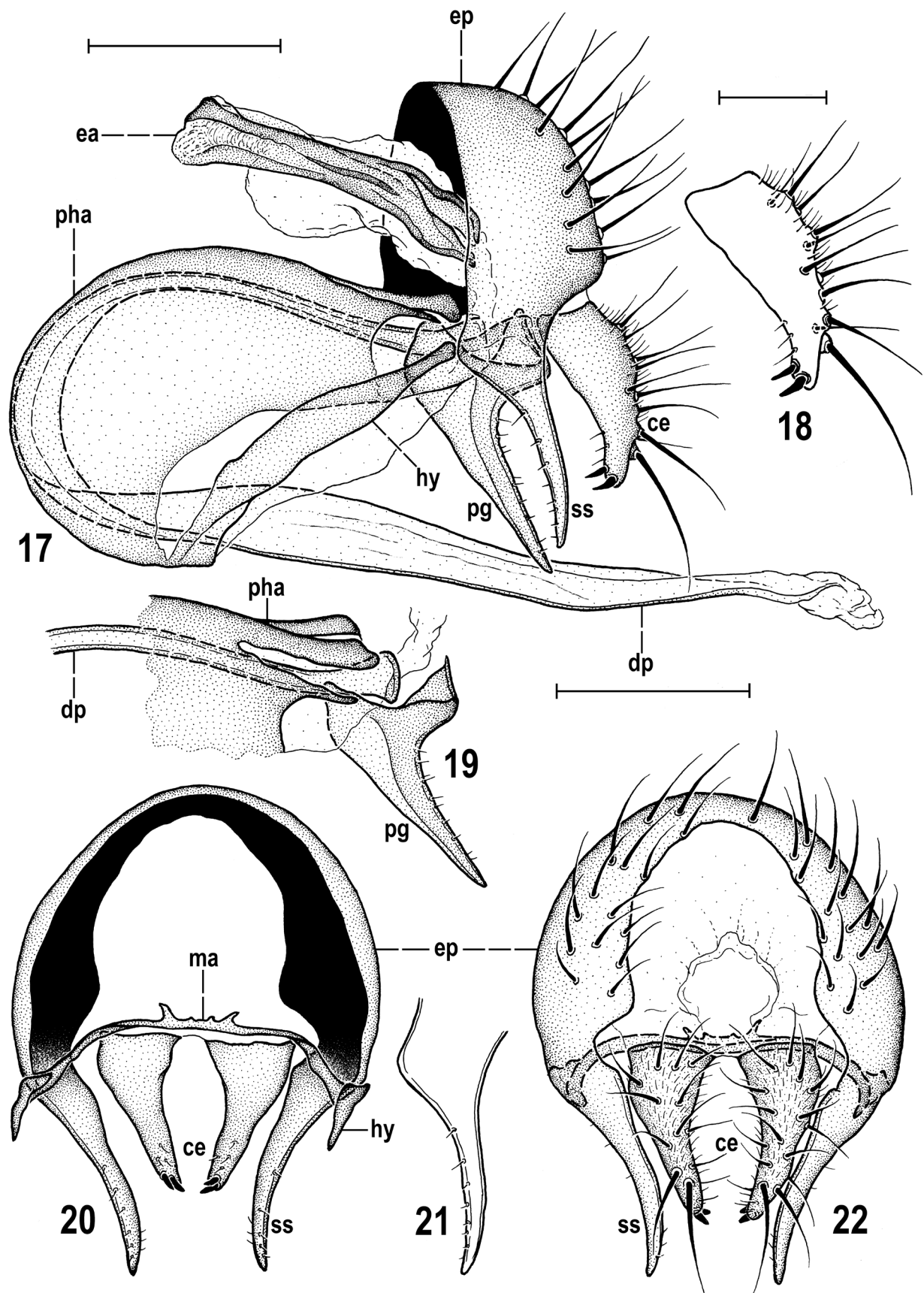
Paratypes. • 2♂♂; SVIZZERA – TI; Losone, Arcegno, Collina di Maia; Castagneto con querce; 420 m; 701.151/113.376 [46°09'51.337"N, 8°44'53.687"E]; ARC1; 20.05–06.06.2016; VINO Bianca. • 1♂; same, but 23.06–07.07.2016. • 1♂; same, but 701.013/113.741 [46°10'03.240"N, 8°44'47.535"E]; 411 m; ARC2; 20.05–06.06.2016. • 2♂♂ same but 06–23.06.2016; VINO gialla. • 2♂♂ same but, 701.307/113.196 [46°09'45.434"N, 8°45'00.812"E]; 366 m; ARC3; 21–28.07.2015. • 5♂♂ same but 20.05–06.06.2016; VINO Bianca. All L. Pollini & M. Abderhalden leg., all dried from ethanol and pinned (MCSN). • 15♂♂ Losone, Arcegno, Collina di Maia; Castagneto con querce; 411 m; 701.013/113.741 [46°10'03.240"N, 8°44'47.535"E]; ARC2; 06–20.05.2016. • 4♂♂; same but



Figures 4–10. *Periscelis (Myodris)* species, adults. **4.** *P. (M.) haennii* sp. nov., male paratype (dried from ethanol), thorax dorsally; **5.** *P. (M.) annulata* (Fallén), male (dry mounted), thorax dorsally; **6.** *P. (M.) pirircercus* Carles-Tolrá & Verdugo Páez, male (dried from ethanol), thorax dorsally; **7.** *P. (M.) haennii* sp. nov., male paratype (dried from ethanol), laterally; **8.** *P. (M.) haennii* sp. nov., male paratype, right wing; **9.** *P. (M.) annulata* (Fallén), male, right wing; **10.** *P. (M.) pirircercus* Carles-Tolrá & Verdugo Páez, male, right wing. Only Fig. 5 is based on specimen from Slovakia, others are from specimens from Losone (Switzerland). All scales: 0.5 mm. Photos by J. Roháček.



Figures 11–16. *Periscelis (Myodris) haennii* sp. nov., paratype, male genitalia. **11.** Entire genitalia, laterally; **12.** Cercus, laterally; **13.** Aedeagal complex, laterally (only basal parts of distiphallus, phallapodeme and hypandrium depicted); **14.** External genitalia caudally; **15.** Surstylus, laterally; **16.** External genitalia cranially (setosity of epandrium and cerci largely omitted). For abbreviations see p. 41. Scales: 0.05 mm (**12**, **15**); 0.1 mm (**11**, **13**, **14**, **16**).



Figures 17–22. *Periscelis (Myodris) annulata* (Fallén), male genitalia (Slovakia). **17.** Entire genitalia, laterally; **18.** Cercus, laterally; **19.** Aedeagal complex, laterally (only basal parts of distiphallus, phallapodeme and hypandrium depicted); **20.** External genitalia cranially (setosity of epandrium and cerci largely omitted); **21.** Surstylus, laterally; **22.** External genitalia caudally. For abbreviations see p. 41. Scales: 0.05 mm (**18**); 0.1 mm (**17, 19–22**).

701.307/113.196 [46°09'45.434"N, 8°45'00.812"E]; 366 m; ARC3; 23.06-07.07.2016.; all L. Pollini & M. Abderhalden leg.; all preserved in ethanol (MCSN). • 18♂ (3♂ with genit. prep., 1 intact ♂ photographed) 701.168/113.372; 419 m; ARC2; 13-27.07.2017, prd. 25; Vino bianca. • 2♂ same data but 10-23.08.2017, prd. 27; all L. Pollini & M. Abderhalden leg., all dried from ethanol and 16 mounted on pinned triangular cards, 4 double-pinned (on minutia pin in pinned plastic bracket) (SMOC).

Not included in type series. all other specimens from the same locality preserved in ethanol (deposited in MCSN). Same locality, 701.168/113.372, 419 m, ARC2, 13–27.07.2017, 13–27.07.2017, prd. 25, vino bianca, 1♂, L. Pollini & M. Abderhalden leg., but with blue label “JR32, OM314931” (handwritten) in addition; specimen used for molecular study, with body (after DNA extraction) preserved in glycerine in pinned plastic vial (SMOC).

Diagnosis. A small species (1.3 mm) (Fig. 7) closely resembling *Periscelis (Myodris) annulata* but with microtomentum of scutum and scutellum (Fig. 4) darker and more brownish, consequently, acrostichal and dorsocentral brown stripes are less contrasting (somewhat resembling mesonotal pattern in *P. (M.) piricercus*, cf. Fig. 6). Cerci longer and more slender (Figs 11, 12, 14, 24, 35) than those of *P. (M.) annulata* (Figs 17, 18, 22, 28, 36), with 2 short anteroapical black spines which are short and emerge close to each other; subapical posterior setae hardly longer than other posterior setae (Figs 12, 24). Surstylus more gradually tapering and rather straight distally (Figs 15, 25). Postgonite more elongate, with slender distal part longer and slightly bent (Figs 13, 26).

Description. Male (Fig. 7). Total body length (holotype) 1.31 mm, wing length 1.01 mm. General colour mainly brown and grey, microtomentose and dull; some parts of head and legs yellow and abdomen with small silvery white microtomentose spots in lateral margin of tergites. Head: face microtomentose, protruding in front of anteroventral eye margin; mainly brown but yellow ochreous on the concavities below the antennae and on carina. Darkened on the protrusion above mouth edge. Frons large, brown, ocellar triangle small, situated at posterior margin of frons; ocelli arranged in equilateral triangle. Gena relatively low, postgena expanded posteriorly, brown and becoming darker posteriorly, towards concave occiput. Eye margin with a thin yellow ochreous stripe. Clypeus brown, palpi yellow. Antennae divergent and largely yellow, only pedicel with dull black dorsal spot covering completely the outer lateral side and one third of the inner side; pedicel with a row of short setae. Pedicel cap-shaped, relatively large, larger than the first flagellomere; the latter with apex slightly curved upwards, yellow, covered with light short pilosity. Arista yellow, long-pectinate, dorsally with 7 rays (3 longer and 4 shorter), ventrally with 4–5 rays (2 longer and 2–3 shorter). Mouthparts and palpi yellow ochreous, clypeus brown. Cephalic chaetotaxy: all setae blackish brown; pvt well developed, divergent, situated at dorsal margin of occiput behind the inner margin of ocelli; 1 longer convergent and inclinate vti; 1 slightly divergent

and latero-clinate vte; 1 reclinate ors, 1 proclinate oc; 3–4 microsetulae in front of ors. No vibrissae or pseudovibrissae but with 3–4 short ventro-reclinate setae on ventral side of vibrissal angle and anterior part of gena; a row of 4–5 pairs of inclinate setae on lateroventral margin of face; gena posteriorly to vibrissal part with a series of 5–6 thicker and longer ventro-clinate peristomal setae, becoming shorter posteriorly; expanded part of postgena and occiput behind eye with numerous short setae being stronger near posteroventral eye margin.

Thorax: dull, brown with a grey microtomentose pattern; mesoscutum grey with brown acrostichal and dorsocentral brown stripes little contrasting compared to the background colouring; pleural part of thorax brown, with an apical paler stripe on the anepisternum; scutellum distinctly (basally) wider than long, rounded trapezoidal.

Thoracic chaetotaxy: all setae and setulae blackish brown; ac setulae numerous and in 8 irregular rows, more numerous in the anterior half of scutum, 2 postsutural strong dc setae, the posterior one longer; 8–10 setulae in front of dc but no setulae between dc setae; 1 prescutellar ac; 1 strong hu (= postpronotal) seta plus 2 small setulae on humeral callus; 2 strong npl setae; 1 sa and 1 pa; 2 sc setae, the apical one very long; 2 stpl (= katapisternal) setae, the anterior one shorter, and numerous short setulae on sternopleuron (katapisternum).

Wing (Fig. 8) closely resembling that of *P. annulata*, pale brownish, cross-vein r-m and section between r-m and dm-cu cross-veins on M somewhat brown darkened; cells c, r₁, r₂₊₃ light brown shadowed. Haltere light brown.

Legs yellow and brown variegated. Base of fore coxa brown, ventrally apically yellow, coxae 2 and 3 brown. Fore femur dark brown with base yellow. Femora 2 and 3 yellow with two not well bounded brown rings; tibiae with two dark brown rings, the distal one longer than the proximal; tarsi yellow with two last segments brown. Femur 1 with a series of 7–8 long and thicker distal posteroventral setae and other finer upright posterodorsal setae; femur 2 posteroventrally with a row of short and thicker setae; tibia 2 with 1 distinct and thicker ventroapical seta.

Abdomen brown, sternites lighter; tergites 3–6 with a pair of anterolateral small silvery spots. Postabdomen: pregenital sternite (sternite 6) simply transversely suboblong but posteromedially with small and shallow emargination (Fig. 23), generally pale brown but medially narrowly lighter, with setae restricted to posterior half of sclerite. Sternite 6 most resembling that of *P. annulata* except for all setae generally shorter, including longest lateral setae.

Male genitalia (Figs 11–16) most resembling those of *P. (M.) annulata*. Epandrium (Figs 11, 14, 16) relatively small, formed as a short arch-shaped sclerite, thus distinctly higher than long (Fig. 11) and about as high as broad (cf. Fig. 14), with large anal opening (fissure). Setosity of epandrium relatively uniform, restricted to its posterior marginal area but (in contrast to that of *P. annulata*) with some setae also posteroventrolaterally. Anteroventral projection of epandrium (= surstylus) long, proximally broad but distally gradually tapered (not angulate basally anteriorly)

and very slender, in distal half with fine setulae at anterior margin (Fig. 15), and with apex somewhat blunt. Cerci relatively free, situated below anal opening as in all other *Periscelis* species but slender and elongate (longer than in any other known species of the subgenus *Myodris*), longer than height of anal opening (see Fig. 14). Each cercus (Fig. 12) tapering towards apex, the latter armed by a pair of closely arising robust, short and anteriorly directed spines; posterior and (partly) lateral sides of cercus with long setae and some micropubescence; posterior apical and subapical setae hardly longer than those situated more proximally (see Fig. 12). True gonostylus (as defined by Roháček and Andrade 2017) entirely absent (as in all *Myodris* species) and medandrium very reduced, forming a poorly visible strip-like sclerite situated posterior to hind part of hypandrium. Hypandrium (Fig. 11) frame-shaped but in contrast to that of *Periscelis* s. str. species more distinctly separated from phallapodeme (both sclerites only partly fused anteriorly and laterally). No appendages (= pregonites) of hypandrium. Aedeagal complex very large (compared to epandrium) and symmetrical, formed by voluminous phallapodeme, very long aedeagus and paired postgonites. Phallapodeme (Fig. 11) very similar to that of *P. (M.) annulata*, large, forming a single pocket-shaped (hood-like) capsule, thus with short and forked basal part completely fused to distal capsuliform part (in contrast to construction in *Periscelis* s. str. species, where these parts are separate, cf. Roháček and Andrade 2017, fig. 6). Aedeagus (Fig. 11) simple (without separate basal part = phalophore, thus formed only by distiphallus), weakly sclerotized to submembranous, forming slender and very long arched ribbon, partly hidden in capsule of phallapodeme; apex of distiphallus slightly widened, terminally blunt, unarmed, membranous. Postgonite (Fig. 13, pg) long and slender, about as long as surstylus (cf. Fig. 11), with short broad basal part and long, slender, slightly bent (often subterminally very slightly sinuate) distal part having subacute apex and series of setulae laterally and at posterior margin. Ejacapodeme (Figs 11, 13, ea) large and robust, relatively simple, basally somewhat wider than distally, longer and more elongate (about 5.5 times as long as its maximum width) than that of *P. (M.) annulata*.

Taxonomic remarks and relationships. Based on structures of male genitalia, *Periscelis (M.) haennii* sp. nov. is clearly different from all known Palearctic relatives of the subgenus *Myodris* (cf. diagnosis above and Papp and Withers 2011). Although externally very similar to *P. (M.) annulata* (and most resembling the latter species also in genital characters) it proved to be distinctly different from both other European (and syntopically occurring) *Myodris* species in the DNA sequences of the barcoding gene COI (genetic distances are 7.58% from *P. (M.) annulata* and 9.12% from *P. (M.) piricercus*, respectively), see Table 1. Thus, not only the morphological characters of the male genitalia but also molecular features demonstrate the validity of this formerly cryptic species; as only one specimen has been barcoded for each species, in this context it is not possible to detect intraspecific variation.

The study of long series of all three European *Periscelis (Myodris)* species obtained from the same area and habitat revealed the formerly unknown external variability both in thoracic micropubescence and colour pattern, and, particularly, in clouding of wing membrane and veins. The latter was particularly variable in *P. (M.) annulata*. Based on these findings we found that these three species cannot be safely recognized from only external features and their identification should always be verified by study of male genitalia. Consequently, females of these species cannot be unambiguously recognized at present from morphology. However, they can now be identified by means of the molecular barcoding.

The new species seems to be the closest relative of *P. (M.) annulata*. The most obvious putative synapomorphy of these two species is the markedly elongated and slender male cercus (being distinctly shorter and basally more dilated in all other species of *Myodris*, including *P. (M.) piricercus* and *P. (M.) kabuli* L. Papp, 1988, see Papp and Withers 2011). However, it is to remark that *P. (M.) haennii* shares with *P. (M.) piricercus* similarly closely positioned anteroapical spines on male cercus (cf. Fig. 24 and Fig. 32) but this “feature” also occurs in more distant relatives, viz. in *P. (M.) kabuli* and even in the Nearctic *P. (M.) flinti* (Malloch, 1915), cf. Papp and Withers (2011, figs 27, 35). The close relationship of *P. (M.) haennii* and *P. (M.) annulata* is also indicated by the elongate (with long slender distal part) postgonite which can be another putative synapomorphy of this species-pair.

Biology. Unknown but probably similar to that of *P. (M.) annulata* which is associated with sap runs on wounded trees, particularly oaks and elms (most often in their crowns) having larvae developing in fermenting tree sap (cf. Papp 1998). The 305 specimens of *P. (M.) haennii* sp. nov. were collected by means of attractant traps (wine and beer, see Figs 1, 2) in a lowland forest of oaks and chestnuts (Fig. 3). Actually, in these traps also both other *Periscelis (Myodris)* and two *Periscelis* (s. str.) species were captured (Pollini Paltrinieri et al., unpublished data).

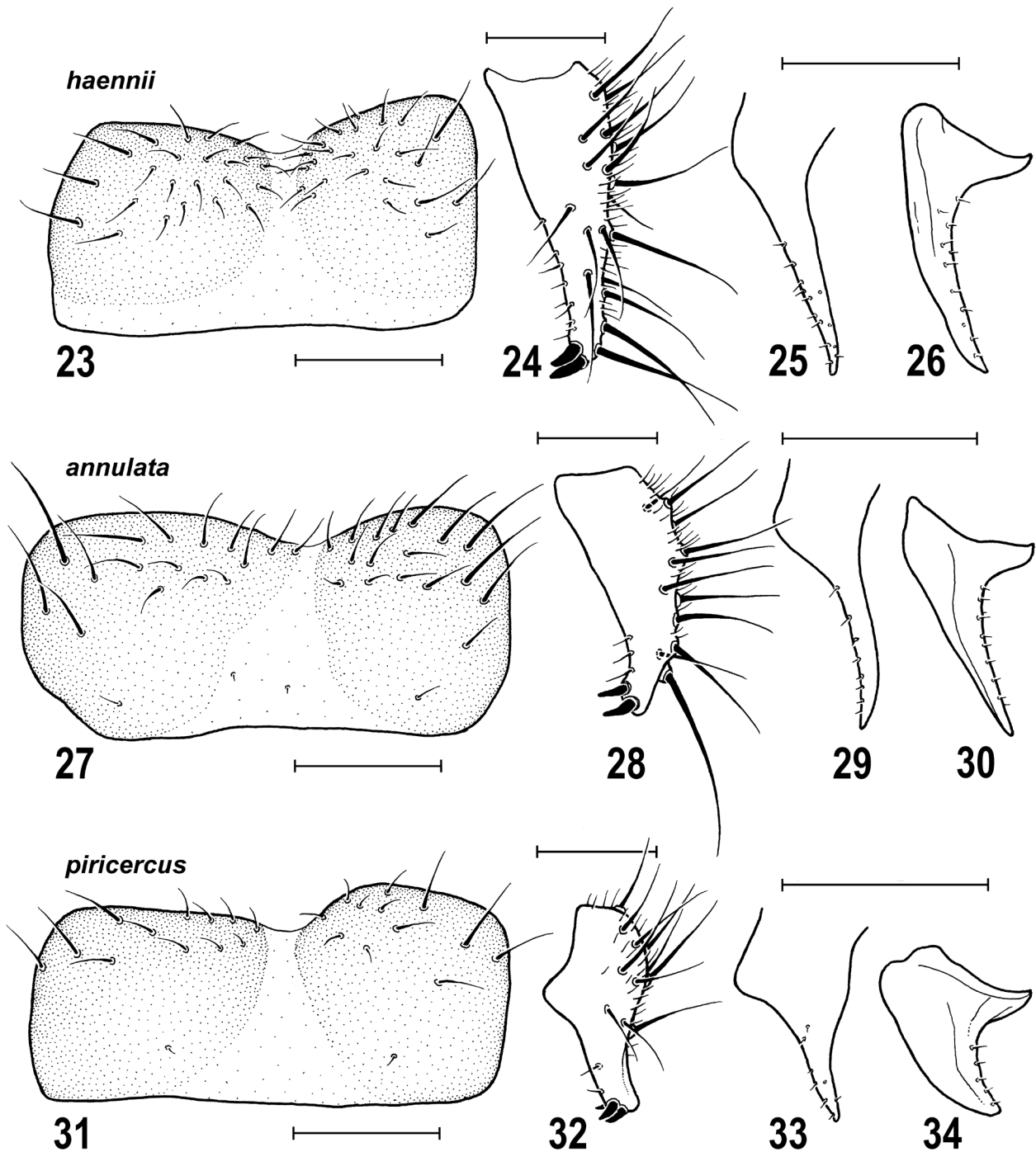
Distribution. Hitherto only known from southern Switzerland. However, it can be presupposed that *P. (M.) haennii* will also be found elsewhere in Europe, particularly in more southern areas simply because it has not been formerly distinguished from *P. (M.) annulata*.

Etymology. The specific name is dedicated to the eminent Swiss dipterist and our friend Jean-Paul Haenni.

Periscelis (Myodris) annulata (Fallén, 1813)

Figs 5, 9, 17–22, 27–30, 36

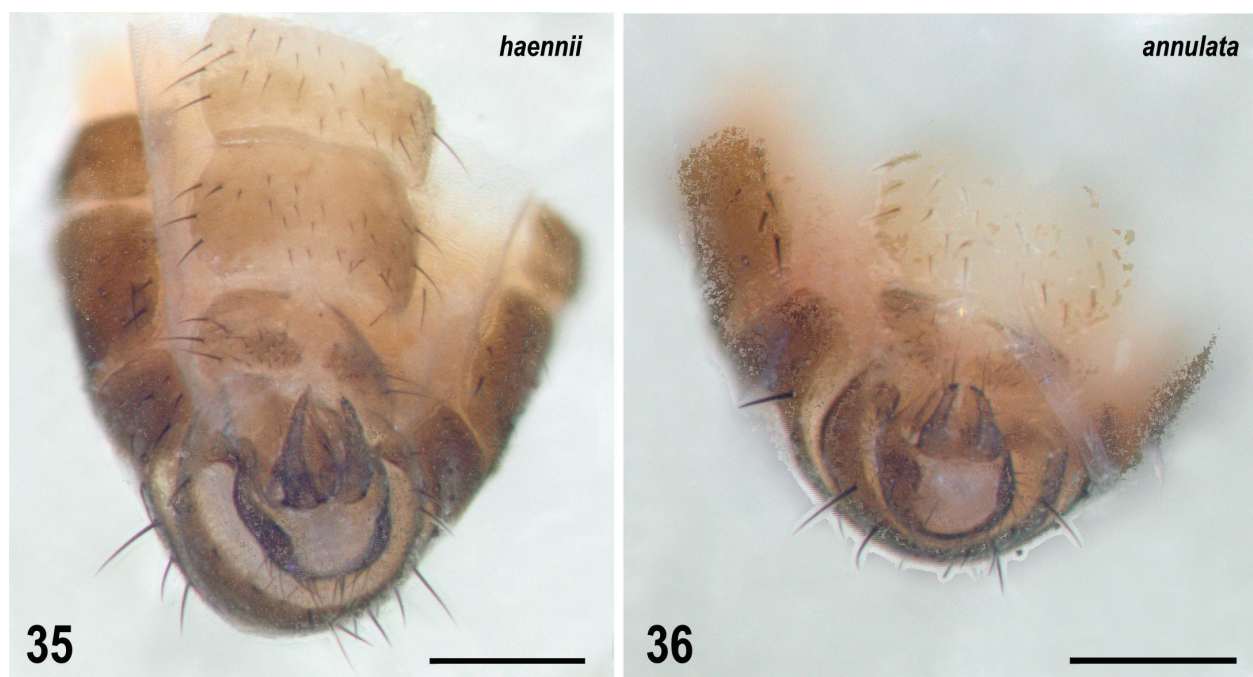
Redescription of male genitalia. Epandrium (Figs 17, 20, 22) small, shortly arch-shaped, distinctly higher than long (Fig. 17) but almost as broad as high (Fig. 22), with large (although slightly narrower than that of *P. (M.) haennii*) anal opening. Setae on epandrium relatively long but subequal in length and distributed only in posterior marginal area surrounding anal opening. Surstylus (Fig. 21) long, proximally



Figures 23–34. Male S6 and structures of genitalia of European *Periscelis* (*Myodris*) species. 23–26. *P. (M.) haennii* sp. nov., paratype: 23. S6; 24. Cercus laterally; 25. Surstylus laterally; 26. Postgonite laterally; 27–30. *P. (M.) annulata* (Fallén), Slovakia: 27. S6; 28. Cercus laterally; 29. Surstylus laterally; 30. Postgonite laterally; 31–34. *P. (M.) piricercus* Carles-Tolrà & Verdugo Páez, Switzerland: 31. S6; 32. Cercus laterally; 33. Surstylus laterally; 34. Postgonite laterally. Scales: 0.05 mm (24, 28, 32); 0.1 mm (23, 25–27, 29–31, 33, 34).

broad but relatively suddenly (see somewhat angular anteroapical part) distally tapered. This slender distal part of surstylus slightly bent, provided with a row of fine setulae at anterior margin (Fig. 21) and with relatively acute apex. Cerci free and inserted below anal opening as in relatives. Each cercus slender and elongate but shorter than height of anal opening (see Figs 20, 22), tapered distally, with apex slightly bent anteriorly (Fig. 18) and provided with a pair of

distinctly separate short anteroapical spines; posterior and posterolateral sides of cercus with some micropubescence and a row of long setae, the apical and (often) also subapical which are longer than others (see Fig. 18). True gonostylus lost; medandrium (see Fig. 20, ma) extremely reduced, forming a small transverse sclerite attached to posterior part of hypandrium. Hypandrium (Fig. 17) frame-shaped and relatively well separated from (dorsally attached) phal-



Figures 35–36. Distal part of male abdomen of two *Periscelis (Myodris)* species (photographed in situ in ethanol). **35.** *P. (M.) haennii* sp. nov., paratype; **36.** *P. (M.) annulata* (Fallén), Switzerland. Scales: 0.1 mm. Photos by L. Pollini Patrineri.

lapodeme as characteristic for all *Myodris* species, without any trace of pregonites. Aedeagal complex very large, composed of large pocket-shaped phallapodeme, very long and slender submembranous aedeagus and distinctly sclerotized paired postgonites. Phallapodeme (Fig. 17) formed as in *P. (M.) haennii*, thus pocket-shaped and compact (= without separate basal part). Aedeagus (Fig. 17) also very similar (both in form and length, and formed only by distiphallus) to that of the latter species but its membranous

apex rather spindle-shaped. Postgonite (Fig. 19) relatively large and distally slender, slightly longer than surstylus (cf. Fig. 17), with basal part short and broad, with distal slender part gradually tapered, straight and somewhat shorter than that of *P. (M.) haennii* having acute apex and a row of setulae at posterior margin. Ejacapodeme (Fig. 17) robust but relatively simple, basally hardly wider than distally, shorter and less elongate (about 4.5 times as long as its maximum width) than that of *P. (M.) haennii*.

Key to males of European *Periscelis (Myodris)* species

- 1 Pregenital sternum sparsely setose (Fig. 31). Cercus short, pyriform due to dilated proximal half (Fig. 32). Surstylus short, basally broad, distally shortly projecting (Fig. 33). Postgonite short and broad, with robust apex (Fig. 34).....
..... *P. (M.) piricercus* Carles-Tolrá & Verdugo Páez, 2009
- Pregenital sternum more densely setose (Figs 23, 27). Cercus slender and elongate, never pyriform (Figs 24, 28). Surstylus long, basally narrower, distally very slender and long projecting (Figs 25, 29). Postgonite long and distally slender (Figs 26, 30)..... 2
- 2 Cercus longer (longer than anal opening of epandrium, cf. Figs 14, 35), with 2 short robust anteroapical spines closely attached and subapical posterior setae hardly longer than other posterior setae (Fig. 24). Surstylus more gradually tapering and rather straight distally (Fig. 25). Postgonite more elongate, with slender distal part longer and slightly bent (Fig. 26)..... *P. (M.) haennii* sp. nov.
- Cercus shorter (shorter than anal opening of epandrium, cf. Figs 22, 36), with 2 short robust anteroapical spines distinctly separated and 1 or (more often) 2 subapical posterior setae distinctly longer than other posterior setae (Fig. 28). Surstylus more abruptly tapered and slightly bent distally (Fig. 29). Postgonite more robust, with slender distal part shorter and straight (Fig. 30) *P. (M.) annulata* (Fallén, 1813)

Discussion and conclusions

Periscelis (Myodris) haennii sp. nov. is a further cryptic species of Periscelididae in Europe. Similarly as

Periscelis (M.) piricercus (cf. Carles-Tolrá & Verdugo Páez, 2009) and *P. (P.) fugax* (cf. Roháček and Andrade 2017), also this species has been unknown up to the present because it was hidden among externally very similar

relatives, differing only by detail in structures of the male terminalia. Considering these findings the Periscelididae can be more diverse in Europe; further unnamed species can particularly be expected in little explored eastern and southeastern parts of the continent.

The discovery of this new species highlights how natural environments in Switzerland can offer new discoveries and how important it is that basic biodiversity studies are funded. Other dipteran species, belonging to small families of Acalyptratae or to nematoceran families, probably remain to be discovered, but at present the main limiting factors are the lack of expert taxonomists and the material possibility of carrying out field studies involving different methodologies over relatively long periods of time.

Acknowledgements

We are much obliged to the late László Papp (1946–2021) (Budapest, Hungary) who studied some material of *Periscelis (M.) haennii* sp.n. in 2018, kindly confirmed it is a new species and initiated preparation of this study but could not participate in it due to his illness. Nikola Burdíkóvá and Jan Ševčík from the Ostrava University (Czech Republic) are thanked for the molecular barcoding of adults of *Periscelis* species and for calculation of their COI genetic distances and P. J. Chandler (Melksham, England, U.K.) for thorough revision of the manuscript. Our deepest thanks go to Michele Abderhalden, unfortunately no longer with us, for developing this research together and spending some unforgettable moments in the field. We would also like to thank the many interns who helped us sort through the large amount of material collected and finally Filippo Rampazzi, director of MCSN, for initiating and coordinating this extensive data collection campaign. The research of JR was supported by the Ministry of Culture of the Czech Republic by institutional financing of long term conceptual development of the research institution (the Silesian Museum, MK000100595).

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NextRAD phylogenomics, sanger sequencing and morphological data to establish three new species of New Guinea stream beetles

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<https://zoobank.org/E3397603-2FCC-4BCA-8352-8C9B229BC493>

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Academic editor: Christoph Germann ♦ Received 17 May 2022 ♦ Accepted 13 July 2022 ♦ Published 25 August 2022

Abstract

We use molecular phylogenomic as well as morphological data to provide a taxonomic update on New Guinea endemic *Philaccolilus* diving beetles. In these lotic beetles, we find cryptic diversity that highlights the need for geographically denser sampling combined with the use of an integrative taxonomic approach to unravel the true diversity and biogeography of these beetles. We describe three new species: *P. intania* **sp. nov.** from the northern Bird's Head Peninsula, *P. kirana* **sp. nov.** from the southern Bird's Head as well as *P. febrina* **sp. nov.** which is more widespread on the Bird's Head. *Philaccolilus ameliae weylandensis* is elevated to species rank, as *Philaccolilus weylandensis* **stat. nov.**

Key Words

Dytiscidae, *Philaccolilus*, new species, New Guinea mountain ranges, population genomics, morphology

Introduction

The diving beetle genus *Philaccolilus* Guignot, 1937 is endemic to the island of New Guinea. To date, thirteen species and one subspecies were recognized (Balke et al. 2018; Nilsson and Hájek 2022). These beetles are among the few New Guinea diving beetles with strict lotic habitat preference. They inhabit, specialized on the species level, lower order forest streams, a variety of different size mountain creeks and streams, and some even

lowland rivers. In larger streams and rivers, their typical habitat is fast streaming water at the edge, on sandy bottom and with presence of plants and / or roots in the water. In lower order streams, the beetles can be observed swimming on the sandy / gravelly bottom of small pools underneath cascades. Most of these habitats do experience very heavy flooding during rainfalls, which leads to some degree of downstream drift, as inferred from finding single specimens of forest species along the margin of large rivers after flooding.

The beetles usually show a characteristic and strongly contrasting yellow / orange and black dorsal color pattern (Figs 1–3), also seen in other stream inhabiting diving beetles (e.g. species in the genera *Platynectes* Régimbart, 1879, *Neptosternus* Sharp, 1882, *Philaccolus* Guignot, 1937, *Laccodytes* Régimbart, 1895, *Laccophilus* Leach, 1815) (see Balke et al. 2000).

To study the population structure and biogeography of *Philaccolilus* species, we have previously presented

data from nextRAD sequencing. This is an approach to perform genotyping by sequencing and collect genomic data e.g. for population genomic questions (Lam et al. 2018). We discovered hidden diversity in the clades studied, with larger scale geographic structuring. At the same time, we find idiosyncratic patterns of population connectivity. On one hand, populations separated geographically by significant mountain and lowland regions show low degrees of genetic divergence. On the other

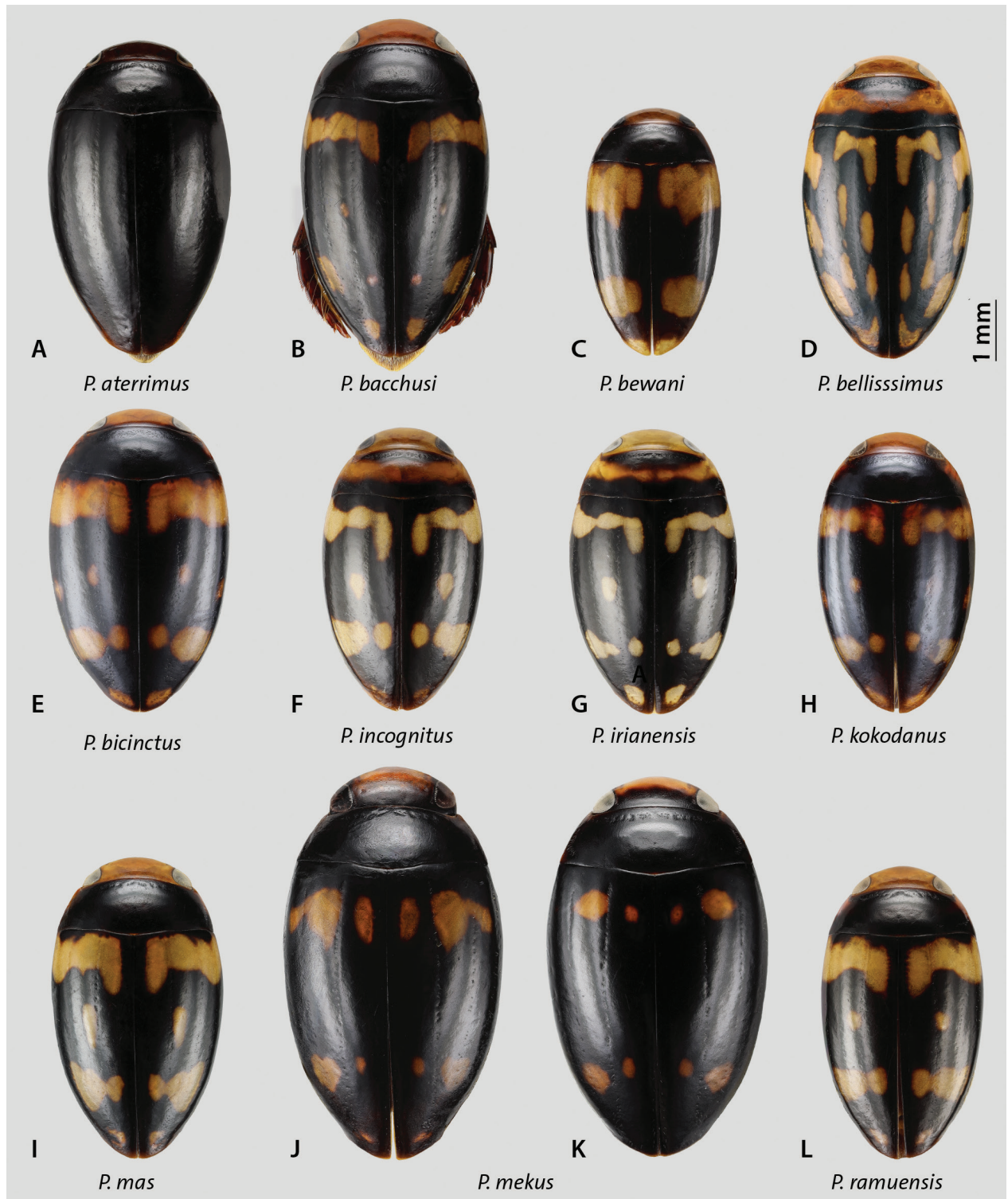


Figure 1. A–L. Dorsal habitus of *Philaccolilus* species, appendages mostly removed; brightness of paler spots digitally slightly enhanced for clarity, without altering the basic color tone.

hand, geographically closer populations of the same putative “morphological” species were genetically comparably divergent (Lam et al. 2018). Here, we provide a morphological evaluation of newly discovered lineages, also adding data from PCR based Sanger sequencing. We suggest three new species, and raise one previously suggested subspecies to species status.

This work is the continuation of our long-term engagement with the State University of Papua (UNIPA) and the Department of Biology, Universitas Cenderawasih, Waena, Papua, Indonesia (UNCEN) facilitate by reciprocal visit of staff and joint lectures and field training (see e.g. Balke et al. 2018; Cancian de Araujo et al. 2018).

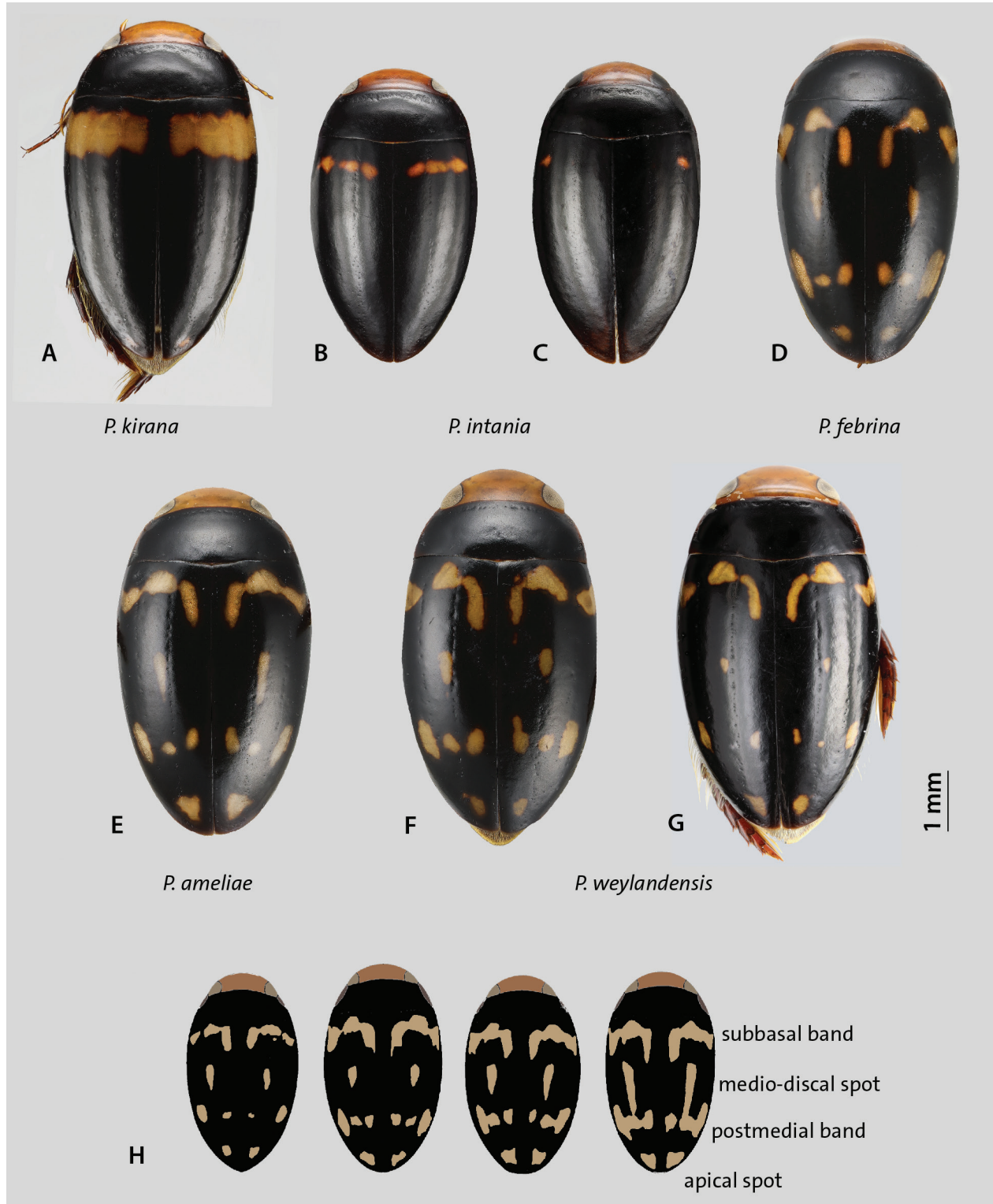


Figure 2. A–G. Dorsal habitus of *Philaccolilus* species in the *P. ameliae* complex, as well as *P. kirana* and *P. intania*, appendages mostly removed; brightness of some paler spots digitally slightly enhanced for clarity, without altering the basic color tone; **H.** schematic drawings of color pattern variation in *P. ameliae* species complex, with explanation of elytral pattern positions (modified from Balke et al. 2000).

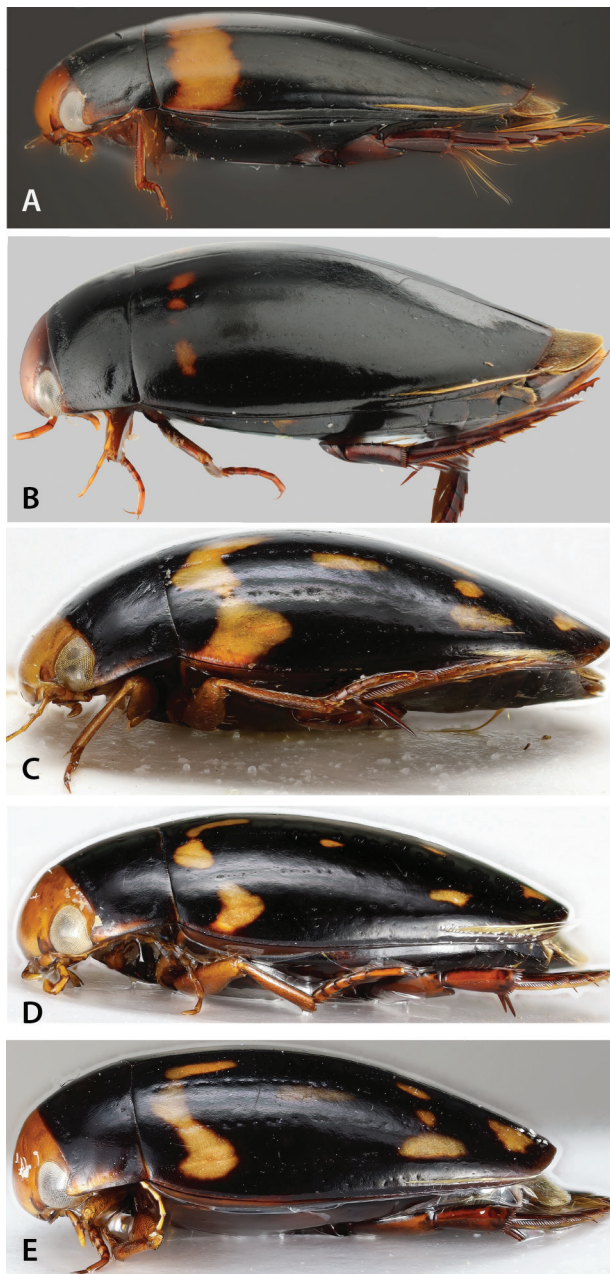


Figure 3. Lateral habitus of *Philaccolilus* species; brightness of some paler spots digitally slightly enhanced for clarity, without altering the basic color tone. **A.** *P. kirana*; **B.** *P. intania*; **C.** *P. weylandensis* (Weyland Mts., basal lateral spot clearly reaching elytral margin); **D.** *P. weylandensis* (Digul River, basal lateral spot vaguely reaching elytral margin); **E.** *P. ameliae* (Waaf, basal lateral spot clearly isolated from elytral margin).

Materials and methods

The following acronyms are used in the text: NARI (Papua New Guinea National Insect Collection, Port Moresby, PNG); MZB (Museum Zoologicum Bogoriense, Cibinong, West Java, Indonesia), KSP (Koleksi Serangga Papua, at the Biology Department of Universitas Cenderawasih (UNCEN), Waena, Papua, Indonesia) and ZSM (SNSB-Zoologische Staatssammlung, München, Germany, temporarily stored for further morphological work). TL – total length of beetle, TW – total width of beetle.

Morphological descriptions and photography

The description of morphological characters using an abbreviated written format supported by digital photographs of diagnostic structures as established in previous recent studies on similar taxa (Balke et al. 2020). Generic characters are not repeated in the species descriptions.

Images were taken with a Canon EOS R camera. We used Mitutoyo 20x ELWD Plan Apo objective for genital structures and a Canon MPE65 macro lens for the habitus photographs. The Mitutoyo lens was attached to a Carl Zeiss Jena Sonnar 3.5/135 MC, used as a focus lens. Illumination was with three LED segments SN-1 from Stonemaster (<https://www.stonemaster-online-shop.de>). Image stacks were generated with the Stackmaster macro rail (Stonemaster), and images were then assembled with the computer software Helicon Focus 4.77TM on a Mac Pro workstation using a Radeon Pro W6800X MPX module.

DNA analysis

nextRAD procedures were explained in detail in our previous publication, which was focused on biogeographic patterns of *Philaccolilus* across New Guinea (Lam et al. 2018). We also used traditional Sanger sequencing (SGS), where we sequenced the 3' fragment from the mitochondrial cytochrome c oxidase subunit 1 (CO1) gene, explained in (Lam 2017). Here, we used the sequence analysis program Geneious version R11 to assess the divergence between the different groups of sequences as uncorrected p-distances.

To examine the distribution of mtDNA sequence diversity within and between taxa, haplotype networks were constructed using the TCS algorithm (Clement et al. 2002) implemented in the PopART software (Leigh and Bryant 2015). In the networks below, each colored circle represents a mitochondrial haplotype. The color represents geographic locality. The size of the circle is proportional to the number of individuals with the haplotype (i.e. the larger the circle, the more specimens show exactly the same DNA sequence). Multiple specimens from the same locality usually show some degree of intraspecific difference (this is often cited as low genetic divergence, e.g. less than 1 or 2%). That means, that the sequence of the targeted gene fragment can be slightly different, with few nucleotide substitutions. The networks show this by connecting haplotypes with lines. Hashmarks represent a single nucleotide polymorphism (SNP). If there is only one hashmark on a connector, that means the two connected sequence types only differ by one nucleotide substitution. The more hashmarks, the more divergent are two connected haplotypes. A black dot on a connector indicates a hypothetical haplotype that should exist to explain the nucleotide diversity in a specific sequence position.

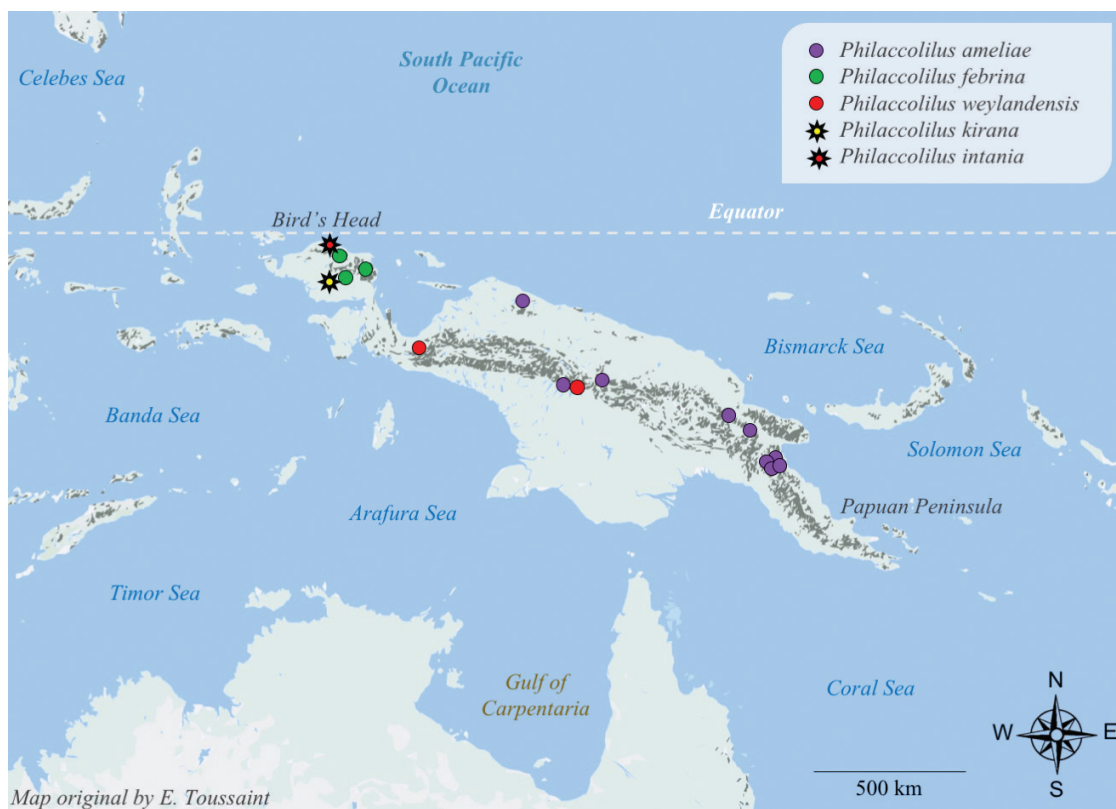


Figure 4. Distribution of *Philaccolilus* species in New Guinea. Dots – *P. ameliae* complex, stars – *P. kirana* and *P. intania* here described from the Bird’s Head Peninsula.

To assess population structuring, we used a Bayesian clustering approach implemented in the program STRUCTURE 2.3.4 (Pritchard et al. 2000). We ran 10 replicates, each using a burn-in length of 100,000 and a run length of 1,000,000 steps, with the admixture and the correlated allele frequencies models without using prior population information (geographic sampling location). We tested number of clusters (K) from 1 to 18. The optimal number of distinct clades was determined by examining both the posterior probabilities of the data for each K and the ΔK estimator described by Evanno et al. (2005) as calculated in Structure Harvester (Earl and VonHoldt 2012). Results for the identified optimal values of K were summarized using CLUMPP ver. 1.1 (Jakobsson and Rosenberg 2007) using 1000 permutations and the LargeKGreedy algorithm; the result is then plotted using DISTRUCT ver. 1.1 (Rosenberg 2004).

In the STRUCTURE plots, each bar represents an individual and each block represents a geographic population. The colors of each bar represent their genetic population. An individual bar that contains multiple colors represents a sample with mixed ancestral population.

Results

Molecular phylogenetic evidence

Using nextRAD sequencing, we generated data from 1,726 genomic loci, from which we extracted 5,609 SNPs (single nucleotide polymorphisms) for population

genomic analyses. For specimens tentatively identified as *P. ameliae* Balke et al. 2000, we recovered three well-delineated clades: one that contained 7 specimens from Sandaun Province and Waaf; one with 17 specimens from the Weyland Mts. and Brazza River, as well as one clade that contains 34 specimens from across the Bird’s Head Peninsula (Fig. 5A, B). We concluded that what was referred to as one species, *P. ameliae* (with one subspecies, *P. ameliae weylandensis* Balke et al. 2000), should indeed be considered as three genetically well differentiated species. Specimens of *P. ameliae weylandensis* from the Weyland Mts. and Digul River formed one cluster, however with some degree of substructuring (Fig. 5B) (Lam et al. 2018). This indicates more hidden, genetic diversity. Specimens of *P. ameliae* from Waaf at the north coast and Sandaun (Mianmin) in the central highlands show a high degree of admixture, i.e. populations from these two far apart localities are not isolated genetically. We did not obtain nextRAD data for the population from Brazza River (Fig. 5B). The specimens from the Bird’s Head Peninsula show a moderate degree of admixture (Fig. 5A), however with evident sign of substructuring between localities from the Arfak Mts. (Arfak, Testega) and the Tamrau Mts.

We also included 4 specimens of two populations of morphologically different putative species from the Bird’s Head Peninsula for nextRAD sequencing (Lam 2017, as “P. band” and “P. black”). Population genomic results regarding species status were ambiguous, likely due to limited sampling (Figs 4, 5C). These could not be assigned to other known species from the main body of New Guinea island.

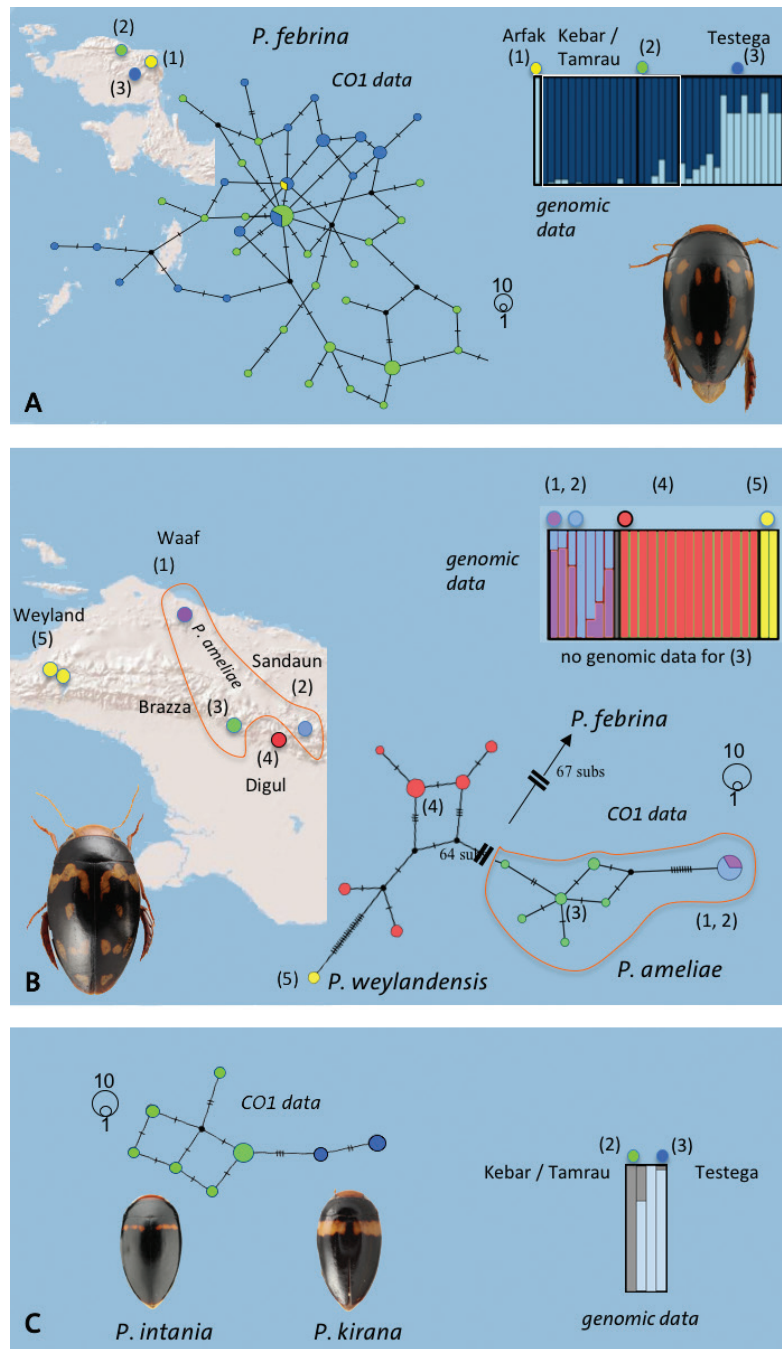


Figure 5. Results of the genomic nextRAD as well as mitochondrial DNA CO1 data sequencing of *Philaccolilus* species in New Guinea. **A.** *P. febrina* in the Bird's Head Peninsula; **B.** *P. ameliae* and *P. weylandensis* in New Guinea main body; **C.** *P. kirana* and *P. intania* from the Bird's Head Peninsula (localities see **A**). Results of the structuring analysis of nextRAD data depicted as barplots, the CO1 data as haplotype network, subs.= substitutions.

All related statistical data were provided by Lam 2017 and Lam et al. 2018.

Sanger sequencing produced an alignment of 738 base pairs, for 98 specimens of *P. ameliae* as previously defined. We recover the same major clades as in the genome wide nextRAD data analysis. The CO1 divergence between these clades is comparably high, above 8% (Fig. 5B), with 64 substitutions between *P. ameliae weylandensis* and *P. ameliae* as well as 67 substitutions between these and the Bird's

Head specimens. In *P. ameliae*, we find some degree of differentiation between the populations north of the central New Guinea watershed (Waaf, Sandaun) and the one from the south (Brazza River). The population of *P. ameliae weylandensis* from the Weyland Mts. and Digul River to the east are also moderately differentiated. These two are also from different sides of the central New Guinea watershed, north and south, respectively. In the CO1 haplotype network, the specimens from the Bird's Head Peninsula also show a moderate degree

of admixture (Fig. 5A), however with evident sign of substructuring between localities from the Arfak Mountains (Arfak, Testega) and the Tamrau Mts., as inferred from the nextRAD genomic data.

We also obtained data for 12 specimens of two populations of the above mentioned morphologically different putative species from the Bird's Head Peninsula (Fig. 5C), and find two clusters according to geographic locality (Testega in southern Arfak Mts. and the Tamrau Mts. to the north). The CO1 divergence between these is however very low, c. 0.4%, shown in the haplotype network in Fig. 5C.

Taxonomic implications based on these data are discussed and illustrated below.

Taxonomy

Genus *Philaccolilus* Guignot, 1937

Diagnosis. Laccophilinae with simple (pointed) metatibial spurs, simple lanceolate prosternal process (not trifid) (Fig. 8E), posteromedial pronotal margin more or less straight, elytral microreticulation with small transverse cells, metacoxal lines slightly diverging anteriorly (Fig. 8E), metatarsal lobes relatively long (hind tarsi therefore appearing broad, oar like) (Fig. 8E), without metacoxal/metafemoral stridulation device (Miller and Bergsten 2016) (Fig. 8E). Dorsal surface dark, with contrasting yellow / orange pattern, or completely black. The dorsal color pattern is usually delineating species (except for *P. irianensis* and *P. incognitus*, Fig. 1F, G). The extend of the paler markings can vary within species (e.g. Fig. 1J, K) and even left/right side in an individual, but not so the principal position and overall shape of the pattern. Therefore, the examination of multiple specimens is recommended. Penultimate ventrite with tuft of long golden setae medially. The median lobe of aedeagus is of, generally speaking, simple structure, i.e. simply curved sclerotized structure (e.g. Figs 6, 7).

Taxonomic decisions based on multiple data sources. The two lineages from different parts of the Bird's Head, "P. band" and "P. black" (Lam 2017) are genetically very similar. Based on CO1 data, the Arfak and Tamrau Mts. populations (Figs 4, 5C) are geographically structured, but only based on a low CO1 divergence. Based on that, their geographic distribution, clearly different body size and elytral color pattern, we suggest that they represent two species that evolved only recently in the two different mountain areas of the Bird's Head, after their ancestral species colonized that area out of the main body of New Guinea island.

What was so far referred to as *Philaccolilus ameliae* is a complex of at least three species. While morphological differences are subtle, both nextRAD and CO1 data clearly delineate three clades that we here assign species status. *Philaccolilus ameliae* is known

from eastern and central New Guinea. *Philaccolilus febrina* is described from the Bird's Head (Fig. 5A). *Philaccolilus weylandensis* (new status) was described as a subspecies of *P. ameliae* from the west of New Guinea (Weyland Mts.) and was later also found in the Digul River on the southern slopes of the central range, more in the center of New Guinea (Fig. 4). Populations from these two localities are genetically differentiated and might in fact represent two species. We leave them assigned to *Philaccolilus weylandensis*, expecting additional samples from along the southern slopes of the central range. It is interesting to note that the only locality between Digul River and Weyland Mts. revealed a population of *Philaccolilus ameliae* (Fig. 5B). This hints to more complex diversification and biogeographic patterns in this complex, that requires additional fieldwork.

Philaccolilus intania sp. nov.

<https://zoobank.org/4909B236-E61D-477A-8B74-A7A4A2352E41>

Figs 2B, C, 3B, 4, 5C, 6C, D, 8A, B, 10F

Type locality. Tamrau Mts., Kebar, Bird's Head Peninsula, West Papua.

Holotype. Male. Indonesia, West Papua, above Kebar, forest creek, 720 m, 7.v.2015, -0,7831, 133,0721, UNIPA team (BH060) (MZB).

Paratypes. (MZB, KSP, ZSM) 25 exs, same label data as holotype; 5 exs, Indonesia, West Papua, Tamrau Mts N of Kebar, forest stream, 750 m, 7.xi.2013, -0,7831, 133,0721, UNIPA team (BH033). Note. BH033 and BH060 are the same creek, sampled in different years and slightly different stream section (+/- 50 meters).

Description of holotype. Medium sized member of the genus. TL 4.8 mm; TW 2.7 mm.

Color. Body surface black except for orange head as well as narrow, dark orange subbasal elytral band that not reaching lateral margin (Figs 2B, C, 3B).

Structures. Hind margin of last ventrite emarginate in the middle (Fig. 8A).

Genitalia. Median lobe of aedeagus as in Fig. 6C, D.

Female. Hind margin of last ventrite in the middle projected ("dwarf hat shape") (Fig. 8B).

Variation. Size variation of the paratypes is (N=12) TL 4.7–5.1 mm (av. 4.9 mm); TW 2.6–2.9 mm (av. 2.8 mm). Orange subbasal elytral band is dissolved into isolated dots in some specimens.

Etymology. Named after Sophia Intania Balke, daughter of first author. The species name is a noun in the nominative singular standing in apposition.

Comparative notes. Distinguished from the other *Philaccolilus* species based on the following combination of features: body size; pronotum black; whole head orange; elytron only with a narrow, dark orange subbasal band not reaching the lateral margin (or only isolated spots in the position of the band); shape of median lobe (except for *P. kirana*, Fig. 6A, B).



Figure 6. Median lobe of aedeagus of *Philaccolilus* species **A, B.** *P. kirana*; **C, D.** *P. intania*.

Distribution. So far only known from the Tamrau Mts. in the north of the Bird's Head Peninsula of New Guinea (Fig. 4).

Habitat. Collected from a shaded forest stream, seen swimming on the sandy and gravelly bottom, in the current where pools form behind large rocks or underneath shallow cascades (Fig. 10F). After about 50 meters, that stream fed into a larger river which is depicted in Fig. 9C. In that larger, more exposed river, we only found *P. febrina*.

***Philaccolilus kirana* sp. nov.**

<https://zoobank.org/44488B73-3D65-43A6-948C-E868191EA71F>
Figs 2A, 3A, 4, 5C, 6A, B, 8A, B, 10A–D

Type locality. Arfak Mts., Testega, Bird's Head Peninsula, West Papua.

Holotype. Male. Indonesia, West Papua, Testega, 1,210 m, 3.v.2015, -1,3686, 133,5908, UNIPA team (BH054) (MZB).

Paratypes. (MZB, KSP, ZSM) 38 exs, same label data as holotype; 8 exs, Indonesia, West Papua, Testega, 1,100 m, 1.v.2015, -1,3827, 133,5967, UNIPA team (BH052).

Description of holotype. Larger member of the genus. TL 5.6 mm; TW 3.1 mm.

Color. Body surface black except for orange head; anterior angle of pronotum very dark orange; elytron with broad, dark yellow subbasal band that reaching lateral margin; with small apical spot (Figs 2A, 3A).

Structures. Hind margin of last ventrite emarginate in the middle (Fig. 8A).

Genitalia. Median lobe of aedeagus as in Fig. 6A, B.

Female. Hind margin of last ventrite in the middle projected (“dwarf hat shape”) (Fig. 8B).

Variation. Size variation of the paratypes is (N=27) TL 5.0–5.6 mm (av. 5.3 mm); TW 2.9–3.2 mm (av. 3.0 mm). The subbasal elytral band is more or less constantly developed; apical spot is not evident in some specimens. One specimen has the apical portion of the right elytron paler, orange, and there are two small orange postmedial spots on the left elytron.

Etymology. Named after Maruscha Kirana Balke, daughter of first author. The species name is a noun in the nominative singular standing in apposition.

Comparative notes. Distinguished from the other *Philaccolilus* species based on the following combination of features: body size; pronotum black; whole head orange; elytron usually with only a broad, dark yellow subbasal band reaching the lateral margin and usually small apical spot; shape of median lobe (except for *P. intania* Fig. 6C, D).

Distribution. So far only known from the type locality and nearby, situated in the southern Arfak Mts. of the Bird's Head Peninsula of New Guinea (Fig. 4).

Habitat. Collected from a small lower order stream hidden in dense montane forest (Fig. 10D). Few specimens collected from a more or less sun exposed stream (Fig. 10A–C), together with *P. febrina*.



Figure 7. Median lobe of aedeagus of *Philaccolilus* species (left, lateral, right, ventral view) **A, B.** *P. ameliae* (from Brazza River); **C, D.** *P. ameliae* (paratype from Wau); **E, F.** *P. febrina* (from Tamrau Mts.); **G, H.** *P. weylandensis* (from Weyland Mts.); **I, J.** *P. weylandensis* (from Digul River).

Definition of the *Philaccolilus ameliae* complex

Philaccolilus ameliae Balke et al. (2000) was described from Morobe and Madang provinces in the eastern part of Papua New Guinea (Fig. 4), while the subspecies *Philaccolilus ameliae weylandensis* Balke et al. (2000)

from much further west on the island, in the Weyland Mts. of Papua (Fig. 4). The subspecies was suggested based on the slightly narrower curvature of the median lobe in ventral view in *Philaccolilus a. weylandensis* (Balke et al. 2000). We find that the shape of the median lobe shows slight variation among specimens and possibly populations

(Fig. 7A–D, G–J), and differences are indeed subtle. The discovery of *Philaccolilus ameliae*-like specimens on the Bird's Head Peninsula and different areas in central New Guinea prompted an integrative taxonomic investigation of what we refer to as the *Philaccolilus ameliae* complex. We diagnose the complex as follows: moderately to larger sized beetles in the genus; pronotum black; whole head orange; elytral pattern dark yellow: narrow subbasal band with characteristic shape as depicted in Fig. 2D–H (basically three spots that can be isolated or more or less fused); a medio-discal dot or extended into longitudinal spot (in few specimens of *P. ameliae* extended posteriorly and reaching the postmedial band); postmedial band (of three isolated spots, rarely fused); an apical spot. The elytral color pattern is therefore variable, but constantly of the same general pattern and configuration (Fig. 2G). The outer spot of subbasal band can reach the lateral elytral margin (Fig. 3C), or hardly so (Fig. 3D) or not at all (Fig. 3E). Hind margin of male last ventrite truncate (Fig. 8C), in the female (“dwarf hat shape”) (Fig. 8D).

***Philaccolilus ameliae* Balke, Larson, Hendrich & Konyorah, 2000**

Figs 2E, 4, 5B, 7A–D, 8C, D

Philaccolilus ameliae Balke, Larson, Hendrich & Konyorah, 2000: 35.

Type locality. Gusap, Markham Valley, Morobe Province, Papua New Guinea.

New material studied. (KSP, MZB, NARI, ZSM). 7 exs, PNG, Morobe, Herzog Mts., Patep, 700 m, 20.xi.2006, -6.9711, 146.6315, Balke & Kinibel (PNG 105); 14 exs, PNG, Sandaun, Mianmin, 1,000 m, 20.x.2008, -4.8881, 141.5686, Ibalim (PNG191); 2 exs, PNG, Sandaun, Mianmin (river), 700 m, 21.x.2008, -4.8809, 141.5284, Ibalim (PNG197); 14 exs, PNG, Sandaun, Mianmin area, 800 m, 6.i.2010, -4.9092, 141.6159, Ibalim & Pius (PNG239); Papua, Sarmi, Waaf, N Foja Mts, riverbank, 120 m, 23.ix.2014, -2,3445, 138,7395, Balke & Menufandu (Pap030); 9 exs, Papua, Dekai, upper Brazza, 273 m, 2./3.vi.2015, -4,7410, 139.6542, Sumoked (Pap044).

Note. All of these specimens from central New Guinea were assigned to *P. ameliae* based on matching them with a short CO1 sequence with four individuals from Morobe: Herzog Mts., Patep, which is part of the type area of *P. ameliae*. For the 300 basepair fragment obtained, the identity with Sandaun and Waaf specimens matched 99%. The short fragment for the Patep specimens was not used for the haplotype network in Fig. 5.

Description. Same as for the species complex. Moderately to larger sized member of the genus: the specimens from the Waaf population are on average (5.1 mm) smaller than from PNG localities (5.5 mm). The lateral spot of subbasal band not or at most hardly so in contact with lateral margin. The extend of the elytral spots is variable (Fig. 2H), the most extended configuration of the paler spots is only observed in few specimens and sometimes

even only on one elytron. The outer spot of the subbasal band does not reach the elytral margin, or at most, in few specimens, vaguely so (as in Fig. 3D, E) (Table 1).

The medio-discal spot is typically narrow and longish, sometimes connected to the postmedial band.

Size. Paratypes from PNG: Wau TL (N=15) 5.3–5.7 mm (av. 5.5 mm), TW 2.9–3.1 mm; specimens from PNG: Mianmin (N=15) 5.3–5.9 mm (av. 5.5 mm), TW 2.9–3.1 mm; specimens from Papua: Waaf (N=9) 4.9–5.3 mm (av. 5.1 mm), TW 2.9–3.0 mm.

Genitalia. Median lobe of aedeagus as in Fig. 7A–D.

Distribution. Widespread from central to east New Guinea (Fig. 4).

Habitat. Collected from different stream types, but usually more sun exposed.

***Philaccolilus weylandensis* Balke, Larson, Hendrich & Konyorah, 2000, stat. nov.**

Figs 2F, G, 3C, D, 4, 5B, 7G–J, 8C, D

Philaccolilus ameliae weylandensis Balke, Larson, Hendrich & Konyorah, 2000: 35.

Type locality. Weyland Mts., southern Nabire, Papua.

New material studied. (KSP, MZB, ZSM) 49 exs, S Ok Sibil, tributary of Digul Riv, 292 m, 7./9.vi.2015, -5.0917, 140.7087, Sumoked (Pap046); 7 exs, Papua, N Waaf vill, pondok, 150m, 4.–7.vi.2016, -2.4061, 138.7439, Sumoked (Pap061).

Description. Same as for the species complex. Larger sized member of the genus. The lateral spot of subbasal band is broadly in contact with lateral margin in all specimens from the Weyland Mts. and in some from the Digul River. Habitus and color pattern are as in Fig. 2F, G. The outer spot of the subbasal band of Weyland Mts. specimens does reach the elytral margin, or, in few specimens, vaguely so (as in Fig. 3C, D) (Table 1). In the Digul River specimens (Fig. 3D), in most specimens the subbasal band only vaguely reaches the elytral margin (the outer dot is rarely isolated and rarely fully in touch with margin (Table 1)). As such, generally speaking, *Philaccolilus weylandensis* is characterized by a trend to possess this out spot being more or less in contact with the elytral margin.

Table 1. Color variation on elytra in *P. ameliae* species complex.

	Outer basal lateral spot reaching elytral margin?		
	no	vaguely	yes
<i>P. ameliae</i>			
Wau	x	(x)	
Sandaun	x		
Foja	x		
Brazza	x	(x)	
Patep	x		
<i>P. weylandensis</i>			
Weyland Mts.		(x)	x
Digul River	(x)	x	(x)
<i>P. febrina</i>	x		



Figure 8. Last male and female ventrite of *Philaccolilus* **A, B.** As in *P. kirana* and *P. intania*; **C, D.** As in *P. ameliae*, *P. febrina* and *P. weylandensis*. Not to scale. In **C.** with last and penultimate ventrites to illustrate the tuft of long golden setae on penultimate ventrite; **E.** *P. febrina* male in ventral view, not to scale.

The medio-discal spot is typically shorter and somewhat broader, or even only a dot (Figs 2F, G) and never fused with postmedial band.

Size. Paratypes from the Weyland Mts. TL (N=6) 5.5–5.7 mm (av. 5.6 mm), TW 3.0–3.1 mm; specimens from Ok Sibil (N=12) 5.3–5.6 mm (av. 5.4 mm), TW 3.0–3.1 mm.

Genitalia. Median lobe of aedeagus as in Fig. 7I, J.

Distribution. Weyland Mts., localities north of the central watershed; as well as Digul River south of Ok Sibil, which is south of the central watershed (Fig. 4).

Habitat. Collected from different stream types, but usually more sun exposed.

***Philaccolilus febrina* sp. nov.**

<https://zoobank.org/C1C8B146-9242-4CB6-AAEC-15ED651AC272>
Figs 2D, as in G in part; 4, 5A, 7E, F, 8C, D, 9A–D, 10A–C, E–F

Type locality. Tamrau Mts., Kebar, Bird's Head Peninsula, West Papua.

Holotype. Male. Indonesia, West Papua, Tamrau Mts. N of Kebar, forest stream, 750 m, 7.xi.2013, -0.7831, 133.0721, UNIPA team (BH033) (MZB).

Paratypes. (MZB, KSP, ZSM) 4 exs, same label data as holotype; 26 exs, Indonesia, West Papua, Road Manokwari – Mokwam, 320 m, 25./27.i.2006, 01 00.596S 133 53.921E,



Figure 9. A–D. Habitats of *Philaccolilus febrina*. A Stream more or less on level of valley floor, locality BH62; B–D. Locality BH61, open stream flowing out of Tamrau Mts. and feeding into the stream shown in Fig. 9A.

Tindige, Prativi & Balke (BH01); 5 exs, West Papua, Indabre River, 1,300 m, 8.iv.2007, -1.1122, 133.8745, Sites & Supuma; 1 ex., Testega, ca. 1,100 m, 1.v.2015, -1.3829, 133.5992, UNIPA team; 36 exs, West Papua, Testega, 1,100 m, 1.v.2015, -1.3827, 133.5967, UNIPA team (BH052); 36 exs, West Papua, above Kebar, forest creek, 720 m, 7.v.2015, -0.7831, 133.0721, UNIPA team (BH060); 112 exs, West Papua, above Kebar, open forest stream, 720 m, 7.v.2015, -0.7856, 133.0712, UNIPA team (BH061); 93 exs, West Papua, above Kebar, open river, 600 m, 7.v.2015, -0.8009, 133.0578, UNIPA team (BH062) (note: mislabelled as BH061); 63 exs, West Papua, Kebar Valley, 600 m, 8.v.2015, -0.8348, 133.1839, UNIPA team (BH063).

Description of holotype. Moderately to larger sized member of the genus. Total length of beetle: 5.0 mm; maximum width: 2.7 mm.

Color. Body surface black except for dark yellow head; anterior half of pronotum lateral margins dark orange; elytron with dark yellow subbasal “band” composed of three spots, hardly fused, not reaching the lateral margin (as in Fig. 3E); with medio-discal spot; with postmedial “band” composed of three spots; with small apical spot (Fig. 2D).

Structures. Hind margin of last ventrite truncate (Fig. 8C).

Genitalia. Median lobe of aedeagus as in Fig. 5E, F.

Female. Hind margin of last ventrite in the middle projected (“dwarf hat shape”) (Fig. 8D).

Variation. Size variation of the paratypes is (N=25) TL 4.7–5.3 mm (av. 5.0 mm); TW 2.5–2.8 mm (av. 2.7 mm). The elytral spots can be more or less elongated, rarely some of them fused; medio-discal spot and postmedial “band” are not in touch (only in one specimen and only on one elytron almost as in Fig. 2H, right) in any of the studied specimens of *Philaccolilus febrina*.

Etymology. Named after Ditta Febrina Amran Balke, wife of first author and ZSM Coleoptera collection and project manager. The species name is a noun in the nominative singular standing in apposition.

Comparative notes. Distinguished from the other *Philaccolilus* species based on the following combination of features: body size; pronotum black; whole head orange; characteristic general dark yellow pattern on elytron (Fig. 2D, G); shape of median lobe (Fig. 7E, F). Very similar to *P. ameliae* and *P. weylandensis*. Morphologically, *Philaccolilus febrina* differs from the previous species of the *P. ameliae* complex by slightly smaller average size and the slightly broader median lobe in ventral view (Fig. 7F).

Distribution. Widespread in the Tamrau and Arfak mountains (Fig. 4).

Habitat. Collected from different stream types, but usually more sun exposed (Figs 9A–D, 10A–C, E). Also found in a forest stream, seen swimming at the sandy and gravelly bottom, of a larger pool behind large rocks (Fig. 10F).



Figure 10. Habitats of *Philaccolilus* species A–C. *P. kirana* and *P. febrina* locality BH052; D. *P. kirana* BH54; E. *P. febrina* BH63; F. *P. intania* and *P. febrina* BH60.

Conclusions

Combining morphological examination, traditional single-gene fragment sequencing and population genomic analyses, we improve our understanding of New Guinea stream beetles in the genus *Philaccolilus*. We previously uncovered cryptic diversity among populations in the *P. ameliae* complex, with complex patterns of genetic connectivity (Lam et al. 2018), where for example remote populations of *P. ameliae* from Sandaun and

Waaf (Fig. 5B) share the same mitochondrial haplotype, while closer Sandaun and Brazza populations are well differentiated, but divided by the central watershed. We suggest that much more comprehensive field sampling will be required to untangle the biotic and abiotic factors leading to such patterns. Large scale biogeographic investigations of the New Guinea biota are currently becoming more abundant, and it is desirable to design population genomic studies to provide more data on the speciation processes behind them.

Acknowledgements

We thank Jiří Hájek and Günther Wewalka for reviewing the manuscript of this paper and their kind comments. This research is regulated with MoUs and MTAs between SNSB-ZSM and UNIPA/UNCEN as well as the former Indonesian institute of science (LIPI). Financial support came from Deutsche Forschungsgemeinschaft grants BA2152/11-1, 11-2, 17-1, 19-1 and 19-2. The visit and project work of Suriani Surbakti and Rawati Panjaitan to and at ZSM was supported by DFG BA2152/17-1, also supporting workshops and training at their respective home institutions. Athena Lam was a NSF Graduate Research Fellow and received additional support from the Department of Environmental Science Policy and Management, UC Berkeley. Matt Van Dam was supported by NSF DBI #1402102.

Also, training courses conducted at UNIPA in Manokwari were funded by the Deutscher Akademischer Austauschdienst (DAAD) as part of the Indonesian-German Network for Teaching, Training and Research Collaborations (IGN-TTRC), initiated by W. Nellen (Malang, Indonesia) through the University of Kassel, Germany. Special thanks to Dr. Augustinus Kilmaskossu (UNIPA) for his support organizing training classes at UNIPA. We are grateful for support from the SNSB-Innovative scheme, funded by the Bayerisches Staatsministerium für Wissenschaft und Kunst.

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Description of the female of *Platycheirus altomontis* Merlin & Nielsen in Nielsen, 2004 (Diptera, Syrphidae) with notes on the occurrence and hilltopping behaviour of rare French montane and Alpine Syrphidae

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Academic editor: Claudia Buser ♦ Received 3 February 2022 ♦ Accepted 8 August 2022 ♦ Published 19 September 2022

Abstract

A focused search in very high (2500–3200 m asl) Alpine mountain tops in France resulted in the discovery of the very rare Alpine-endemic syrphid *Platycheirus altomontis* Merlin & Nielsen in Nielsen, 2004, including its hitherto unknown female. A description of the female is given and further complemented with behavioural observations of this species with special reference to hilltopping. Additional records and behavioural observations are provided for rare and new species for the French fauna from the montane and Alpine habitat with focus on species of high altitude (>2750 m) and hilltopping behaviour. The species *Rohdendorfia alpina* Sack 1938 is new to France and was observed in large numbers at scree slopes above 2750 m and males were found sitting at hilltops up to 3200 m. Hilltopping behaviour of Syrphidae was observed over the whole altitudinal range visited, and multiple species engaged in this behaviour even at above 3000 m. Hilltopping appears to be more common in some genera (e.g. *Parasyrphus* and *Pipizella*) than in others and may be linked to specific phenotypes in some species. The latter was observed for the species *Cheilosia melanura* (Becker, 1894) of which at high hilltops much smaller males were found than at lower altitudes.

Key Words

hilltopping, *Rohdendorfia*, France, Alps, mate finding strategy

Introduction

France has the largest expanse of territory of any state currently within the European Union, and also has the longest list of Syrphidae, with 555 species (Speight et al. 2018) and several new species added since. Within such a vast expanse (549.000 km²) it is not surprising that large differences exist in the sampling effort among different areas, and many areas remain undersampled. Especially from the less investigated areas, new species for France are still reported regularly (Lair 2018a, 2018b). Undersampling not only refers to the number of samples in an area but also to sampling over its entire altitudinal gradient and over the season. The French Alps have been thoroughly investigated over many years for Syrphidae (Verlinden 2020) but less so during summer

and probably never before at high altitudes. With the high mountain habitat and its communities increasingly under threat (Beniston 2005), increasing our knowledge on the contemporary high mountain fauna not only would improve our general knowledge on the national fauna of France, but also may provide a unique time document and provide a baseline to help to understand how these communities may be affected by ongoing threats in the future.

Hilltopping is a mate-finding strategy encountered in many insect families (Skevington 2008). This interesting behaviour is very common in Syrphidae but has received little attention so far in literature (Waldbauer 1990; Schmid 1999; Alcock 2011). In the Alpine environment with many pronounced hilltops, hilltopping is probably a common phenomenon, and it can be expected that some

rare species may be more easily found this way, as they concentrate around hilltops (Skevington 2008). Apart from knowing which species engage in this behaviour, an interesting question is whether in summer hilltopping by Syrphidae also occurs at very high hilltops (>3000 m asl) far above the tree line and whether specific species of the high mountain habitat are involved.

The main objectives of this study are to answer the above questions: provide an overview of the hover fly community of the Alpine habitat with special focus on very high mountains (>2800 m), and determine which species use hilltopping behaviour and to what height this behaviour occurs. Several expeditions to high mountain areas in France (mainly the Alps and the Pyrenees) were conducted with special focus on high mountain hover fly communities and on their hilltopping behaviour. The presence and behaviour of rare species will be discussed and an overview generated of the species that showed hilltopping behaviour. Lastly, a description of the hitherto undescribed female of *Platycheirus altomontis* Merlin & Nielsen in Nielsen, 2004 is provided.

Materials and methods

Between 2019 and 2021, several excursions were undertaken by the author to the French Alps, the French Pyrenees and the Ardèche. An overview of the reported excursions, their duration and the altitudinal range covered can be found in Table 1. Both the excursions to the Alps were focused on hilltops and high landmarks in the landscape, but especially in July the highest accessible points in the area were targeted. On all days the weather was favourable with long sunny spells and wind speed never exceeding 4 Bf. Hilltops were searched on eye sight and token specimens collected with a hand net. All collected syrphids are preserved in the personal collection of the author (Tessenderlo, Belgium). Identification of the hoverflies was achieved by a combination of different sources: Barkalov and Ståhls (1997), Nielsen (2004, 2014), van Veen (2004), Šašić et al. (2016), Ståhls and Barkalov (2017) and Speight and Sarthou (2015). Names of Syrphidae follow those in the Syrph the Net volumes (Speight, 2020).

Table 1. Overview of the visited mountain regions in France with indication of the visited localities, the dates, and the investigated altitudinal range.

Region: localities	Period	Year	Altitudinal range (m asl)
French Alps: Vars, Villar-d'Arène, Freissinières	19–26 June	2020	770–2430 (mainly 1700–2300)
French Alps: Vars, Villar-d'Arène, Molines-en-Queyras	25–28 July	2020	1160–3140 (mainly >2500)
French Pyrenees: Bagnères-de-Bigorre, Bordes-Uchentein.	14–19 July	2020	930–1950 (mainly 930–1350)
Ardèche: Lafarre, St.-Jeure-d'Andaure	4–9 August	2021	550–1250

Hoverflies were studied under a WILD M5a stereomicroscope (magnification 6–50x). The terminology used to describe the female of *P. altomontis* followed Cumming and Wood (2017). Body length was measured from the top of the antenna to the tip of the abdomen. Photographs were taken to illustrate some rare species and to support the description of the female of *P. altomontis*. All photographs except of *Rohdendorfia alpina* Sack 1938 were taken by Sander Bot with a Canon EOS 6D camera Body and a Mejiro Genossen FL0530 4.0/110 Float Lens (habitus photos) or Leitz-Wetzlar Photar 1:2/25 macro lens (remainder of photos). Before stacking in Helicon Focus 7.7.5 (Kharkiv, Ukraine), exposure and sharpening of the photos was adjusted in Adobe Lightroom Classic (version 10.4).

No strict criteria exist for recognizing an insect present at a hilltop as a hilltopper. Skevington (2008) explains that true hilltopping is a mate finding strategy whereby males await (often virgin) females, which implies that the population of a hilltopping species should be strongly male-biased. Also males should execute some sort of mate finding behaviour, but this behaviour can be very different among species and is therefore difficult to define. For this study, a species was considered as doing hilltopping when the species was present at or near a hilltop, when a clear male bias was seen and/or when males displayed some behaviour that could be recognized as mate finding behaviour (hovering, patrolling or sitting on stones, trees or other landmarks, chasing other insects). Searching for hilltopping insects anticipated on the known partitioning of the hilltop by different species (Skevington, 2008). We therefore investigated different niches at the hilltop (bare stones, small trees, tree trunks, sheltered versus exposed side of the hilltop, etc...), at different distances from the summit.

Results

Platycheirus altomontis Merlin & Nielsen in Nielsen, 2004

Examined material. FRANCE • 1 female, 05-Hautes-Alpes, Molines-en-Queyras, near Pain de Sucre, 44.698°N, 6.991°E, 2780 m, 26 Jul. 2020; 3 males, 2 females, 05-Hautes-Alpes, Vars, La Mortrice, 44.574°N, 6.769°E, 3142 m, 27 Jul. 2020.

Two high mountain tops were searched and both produced *P. altomontis*. A female was found feeding on small white flowers near the top of the Pain de Sucre, and 3 males and 2 females were found on the top of La Mortrice. The females were visiting small flowers, the males were feeding or sitting on the stones, from which they made short flights, suggestive of hilltopping behaviour. The female of *P. altomontis* is unknown so far and is described below. Females of *P. altomontis* were identified as such because they occurred together with the males, and because they shared some typical characters also found in the males including the very dark legs, the very broad

head, and the very long hairs on the head and thorax. A male *P. altomontis* is shown in Fig. 1, the female is shown in Figs 2–4.

Description of the female of *P. altomontis*. The following description is based on the three collected females.

Head (Figs 2, 3): Eyes bare, frons at the height of the antenna distinctly broader than an eye. Third antennal segment (flagellum) 1.2 to 1.6 times longer than wide, dark grey-brown but narrowly orange below at base, scape and pedicel black, arista relatively short and thick, slightly longer than flagellum. Face below the antennae with very long, white pilosity, mainly at the sides, as long or longer as the distance between the posterior ocelli. Face completely covered with thin grey pollinosity, frons and vertex undusted except narrow triangular paired dust spots that each reach one third of the width of the frons. Frons with long white to dark grey pilosity, about as long as the 3rd antennal segment. Facial tubercle and mouth edge distinctly protruding, occiput completely pollinose but denser pollinose on ventral side.

Thorax (Fig. 3): Scutum and scutellum shining metallic blue-black with long white pilosity, as long or longer as flagellum. Pleurae and humerus with thin grey pollinosity and rather long white pilosity.

Wing: Stigma light yellow. Wing covered with microtrichia, except cell bm, br and cua microtrichose apically, otherwise bare. Calypter yellow-white, haltere yellow-brown.

Legs: All legs completely dark with thin grey pollinosity, but tibiae narrowly yellow at base and femora yellow

at their distal end. Legs entirely pale-haired. Coxae and trochanters of usual shape.

Abdomen (Fig. 4): Relatively short and broad, tergites 2 and 3 more than 2 times broader than long. Abdomen dark grey-black, largely matt except large shining areas in the frontal corners at the sides of all tergites. Tergites 3 and 4 on these shining areas with large semi-rectangular spots of white-grey pollinosity with rounded inner corners, covering somewhat more than half the length of the median axis of the tergite. Pilosity on abdomen pale; sparse, short and adpressed centrally, long and erect laterally. Pilosity on sternites pale. Pilosity on s1-2 very long and erect, on 3–5 short and adpressed.

Body length: 6–7 mm.

Of the 23 species in the *Platycheirus ambiguus* group, the females are as yet unknown for 8 species. In the key for females of Nielsen (2014) the female of *P. altomontis* would run to *P. lundbecki* (Collin, 1931). No material of *P. lundbecki* females was available to me to compare with, therefore no differential diagnosis relative to that species is provided. Based on current knowledge of the distribution of the species, the area of origin may be decisive for deciding which species is involved (Nordic countries: *P. lundbecki*, high Alpine mountain tops: *P. altomontis*). From all other known species of the *P. ambiguus* group the female of *P. altomontis* differs by the rather small, compact build with short and broad, black abdomen with grey dust spots and very dark legs.

The female resembles the male of *P. altomontis* apart from the usual sexual dimorphism found within this genus.



Figure 1. Habitus dorsal view of a male *Platycheirus altomontis*, 27.Vii.2020, Vars, la Mortrice (photo by Sander Bot).



Figure 2. Frontal view of the head of a female *P. altomontis*, 27.Vii.2020, Vars, la Mortrice (photo by Sander Bot).



Figure 3. Side view of the head and thorax of a female *P. altomontis*, 27.Vii.2020, Vars, la Mortrice (photo by Sander Bot).



Figure 4. Dorsal view of the abdomen of a female *P. altomontis*, 27.Vii.2020, Vars, la Mortrice (photo by Sander Bot).

Additional records and observations of rare and new syrphids from the French mountains

All expeditions combined, a total of 205 species of Syrphidae have been observed in mountains in France by the author (see Suppl. material 1). Of these, two species are new to France and 26 species occur in 5 or less French departments based on Speight et al. (2018) and may be considered rare in the French context. Below an alphabetically ordered account of these rare and new species recorded in France is given. If applicable, details on ecological observations are provided. All records are leg. and coll. F. Van de Meuter and are from France, unless otherwise stated. For each location, the department with its number (if in France), the height above sea level in meters, and decimal coordinates (WGS84) are provided. Observations are annotated with behavioural observations mainly regarding hilltopping.

- *Cheilosia crassiseta* Loew, 1859

Examined material. FRANCE • 1 male, 05-Hautes-Alpes, Villar-d'Arène, Col du Lautaret, 45.029°N, 6.401°E, 2075

m, 21 Jun.2020; 2 males, 05-Hautes-Alpes, Molines-en-Queyras, near Pain de Sucre, 44.698°N, 6.991°E, 2780 m, 26 Jul. 2020; 2 males, 5 females, 05-Hautes-Alpes, Vars, near La Mortrice, 44.574°N, 6.760°E, 2844 m, 27 Jul. 2020.

- *Cheilosia marginata* (Becker, 1894)

Examined material. FRANCE • 2 males, 05-Hautes-Alpes, Villar-d'Arène, Col du Lautaret, 45.029°N, 6.401°E, 2075 m, 21 Jun. 2020.

- *Cheilosia pascuorum* Becker, 1894

Examined material. FRANCE • 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 1780 m, 44.623°N, 6.716°E, 20 Jun. 2020.

- *Dasysyrphus postclaviger* (Stys & Moucha, 1962)

Examined material. FRANCE • 2 females, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.623°N, 6.716°E, 1780 m, 20 Jun. 2020; 1 male, 05-Hautes-Alpes, Vars, Val

d'Escreins, 44.613°N, 6.743°E, 2010 m, 24 Jun. 2020; 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.621°N, 6.721°E, 1792 m, 24 Jun. 2020.

• *Eristalis alpina* (Panzer, 1798)

Examined material. FRANCE • 1 male, 07-Ardèche, Lafarre, 45.058°N, 4.496°E, 550 m, 4 Aug. 2021; 1 male, 1 female, ibidem, 6 Aug. 2021.

Notes. Previously only known from one department in the Alps. On observation.org, however, a female *E. alpina* has been reported from Central France by Menno Reemer at Valcivières, indicating more populations or a metapopulation may be present in the mountainous of the south-central part of France.

• *Melangyna barbifrons* (Fallén, 1817)

Examined material. FRANCE • 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.611°N, 6.743°E, 2140 m, 20 Jun. 2020; 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.605°N, 6.766°E, 2280 m, 22 Jun. 2020.

Both specimens were caught on flowering *Salix* sp..

• *Melangyna quadrimaculata* (Verrall, 1873)

Examined material. FRANCE • 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.605°N, 6.766°E, 2280 m, 22 Jun. 2020.

On flowering *Salix* sp..

• *Melangyna ericarum* (Collin, 1946)

Examined material. FRANCE • 1 male, 05-Hautes-Alpes, la Danchère, path to Lac Lauvitel, 1180 m, 44.982°N, 6.072°E, 25 Jul. 2019; 2 males, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.614°N, 6.746°E, 1950 m, 20 Jun. 2020; 1 male, 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.611°N, 6.743°E, 2140 m, 20 Jun. 2020; 1 female, 05-Hautes-Alpes, Freissinières, 44.712°N, 6.447°E, 2050 m, 23 Jun. 2020; 1 female, 05-Hautes-Alpes, Cervières, Le Laus, 44.849°N, 6.735°E, 1805 m, 25 Jun. 2020.

Notes. This species is poorly described in current literature but can be identified with Speight and Sarthou (2015). Possibly overlooked to some extent. Males were observed hovering above forest tracks in pine wood.

• *Merodon atratus* (Oldenberg, 1919)

Examined material. FRANCE • 3 females, 05-Hautes-Alpes, la Bérarde, parc des Ecrins, 44.905°N, 6.316°E, 1910 m, 23 Jul. 2019; 3 males, 1 female, 05-Hautes-Alpes, la Grave, Le Chazelet, plateau des Emparis, 44.905°N, 6.332°E, 1800 m, 23 Jul. 2019; 1 male, 05-Hautes-Alpes, Molines-en-Queyras, vers col d'Agnel, 44.713°N, 6.919°E, 2090 m, 26 Jul. 2020; 2 males, 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.608°N, 6.731°E, 2345 m, 27 Jul. 2020; 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.616°N, 6.723°E, 1825 m, 27 Jul. 2020.

• *Merodon cinereus* (Fabricius, 1794)

Examined material. FRANCE • 2 females, 05-Hautes-Alpes, la Bérarde, parc des Ecrins, 44.905°N, 6.316°E, 1910 m, 8 Jul. 2005; 1 female, 05-Hautes-Alpes, Molines-en-Queyras, vers col d'Agnel, 44.713°N, 6.919°E, 2090 m, 26 Jul. 2020; 1 male, 05-Hautes-Alpes, Molines-en-Queyras, vers col d'Agnel, 44.700°N, 6.946°E, 2290 m, 26 Jul. 2020; 3 males, 4 females, 05-Hautes-Alpes, Molines-en-Queyras, vers col d'Agnel, 44.692°N, 6.971°E, 2576 m, 26 Jul. 2020; 1 male, 05-Hautes-Alpes, Villar d'Arène, Col du Lautaret, 45.033°N, 6.403°E, 2050 m, 28 Jul. 2020; 1 male, 2 females, 07-Ardèche, Saint-Martial, Gerbier de Jonc, 44.843°N, 4.195°E, 1430 m, 6 Aug. 2021; 1 male, 1 female, 07-Ardèche Saint-Martial, 44.866°N, 4.195°E, 1400 m, 6 Aug. 2021.

• *Merodon parietum* Wiedemann in Meigen, 1822

Examined material. FRANCE • 1 male, 2 females, 09-Ariege, Bordes-Uchentein, Maison du Valier, 42.808°N, 1.049°E, 1380 m, 14 Jul. 2020.

• *Paragus absidatus* Goeldlin, 1971

Examined material. FRANCE • 2 males, 1 female, 05-Hautes-Alpes, la Grave, Le Chazelet, plateau des Emparis, 44.905°N, 6.332°E, 1800 m, 24 Jul. 2019.

• *Parasyrphus kirgizorum* (Peck, 1969) / *P. tarsatus* (Zetterstedt, 1836)

Examined material. FRANCE • 5 males, 10 females, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.611°N, 6.743°E, 2140 m, 20 Jun. 2020; 5 males, 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.603°N, 6.759°E, 2320 m, 22 Jun. 2020; 1 male, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.613°N, 6.743°E, 2010 m, 24 Jun. 2020.

Notes. In the Alps a long series of *Parasyrphus* was collected (Figs 5, 6), which clearly belong to the same species, but which cannot unambiguously be identified with current literature, displaying features of *P. kirgizorum* and *P. tarsatus*. The specimens are large (11–14 mm), have a clear orange underside of the third antennal segment, and large, black triangular marks on the sternites (Fig. 6). For now, they are left unidentified but for future reference, pictures are provided which may allow for identification once stable characters and species delimitations are reformulated (see Figs 5, 6). Found on flowering *Salix* sp. at the edges of remnant snow patches. On 22.Vi.2020, a group of hilltopping males (>25) was found at the last larch *Larix* sp. above the treeline at 2320 m. They were sitting on the tree or were hovering close to it.

• *Pipizella bispina* Šimić 1987

Examined material. FRANCE • 1 male, 1 female, 05-Hautes-Alpes, la Danchère, path to Lac Lauvitel, 44.982°N, 6.072°E, 1180 m, 25 Jul. 2019.

Found sunning on tree leaves in a small clearing within broad-leaved forest.

• *Pipizella elegantissima* Lucas, 1976

Examined material. FRANCE • 1 male, 1 female, 38-Isere, Mont-de-Lans, 770 m, 45.009°N, 6.068°E, 19 Jun. 2019. ITALY • 2 male, 1 female, Oulx, Amazes Torino, 45.009°N, 6.826°E, 1160 m, 25 Jul. 2020.

Notes. *Pipizella elegantissima* was seen at the edge and along paths of broad-leaved forests on the lower, warmer slopes of the Alps, usually flying low through forest margin vegetation. Though it occurs at rather low elevation, it appears to be mountain species that is so far only known from the French and Italian Alps and the Italian Apennines (Speight, 2020).

• *Pipizella speighti* Verlinden, 1999

Examined material. FRANCE • 1 male, 09-Ariege, Bordes-Uchentein, Maison du Valier, 42.802°N, 1.056°E, 1760 m, 14 Jul. 2020.

• *Platycheirus brunnifrons* Nielsen, 2004

Examined material. FRANCE • 5 females, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.611°N, 6.743°E, 2140 m, 20 Jun. 2020; 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.614°N, 6.746°E, 1950 m,

20 Jun. 2020; 3 females, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.605°N, 6.766°E, 2280 m, 22 Jun. 2020; 7 females, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.613°N, 6.743°E, 2010 m, 24 Jun. 2020; 1 female, 05-Hautes-Alpes, Cervières, Col d'Izoard, 44.820°N, 6.737°E, 2400 m, 25 Jun. 2020; 1 female, 05-Hautes-Alpes, Molines-en-Queyras, Fontgillarde, 44.718°N, 6.908°E, 2040 m, 26 Jul. 2020.

Notes. *Platycheirus brunnifrons* were always caught on late flowering *Salix* sp. at the edge of remaining snow patches except for the individual in July that was feeding on a yellow crucifer. The identification of the female *P. brunnifrons* was based on Nielsen (2014) and corroborated by comparison with a long series of male and female *P. brunnifrons* from the Caucasus.

• *Platycheirus clauseni* Nielsen, 2004

Examined material. FRANCE • 1 male, 65-Hautes-Pyrénées, Bagnères-de-Bigorre, Tourmalet, 42.901°N, 0.158°E, 2010 m, 17 Jul. 2020.

Notes. Feeding on a low yellow crucifer on a dry scree slope.

• *Platycheirus complicatus* (Becker, 1889)

Examined material. FRANCE • 1 male, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.605°N, 6.766°E, 2280 m, 22 Jun. 2020.



Figure 5. Male *Parasyrphus kirgizorum* or *P. tarsatus*, 20.Vi.2020, Vars, Val d'Escreins. Habitus dorsal view with detail of the head (photos by Sander Bot).



Figure 6. Male *Parasyrphus kirgizorum* or *P. tarsatus*, 20.Vi.2020, Vars, Val d'Escreins. Ventral view of abdomen. Note the dark triangular markings on the sternites (photo by Sander Bot).

• *Platycheirus discimanus* (Loew 1871)

Examined material. FRANCE • 1 male, 2 females, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.611°N, 6.743°E, 2140 m, 20 Jun. 2020; 2 males, 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.605°N, 6.766°E, 2280 m, 22 Jun. 2020; 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.603°N, 6.759°E, 2320 m, 22 Jun. 2020; 2 males, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.613°N, 6.743°E, 2010 m, 24 Jun. 2020.

• *Platycheirus fasciculatus* Loew, 1856

Examined material. FRANCE • 3 males, 1 female, 65-Hautes-Pyrénées, Bagnères-de-Bigorre, Tourmalet, 42.808°N, 0.159°E, 2090 m, 17 Jul. 2020; 1 female, 05-Hautes-Alpes, Molines-en-Queyras, top Pain de Sucre, 44.691°N, 6.999°E, 3140 m, 28 Jul. 2020.

Notes. Both in the Alps and the Pyrenees found on scree slopes with sparse vegetation. A male is shown in Fig. 7.

• *Platycheirus sticticus* (Meigen, 1822)

Examined material. FRANCE • 1 female, 31-Haute-Garonne, Portet-d'Aspet, 42.941°N, 0.858°E, 1025 m, 11 Jul. 2020.

• *Platycheirus tatricus* Dušek & Láška, 1982

Examined material. FRANCE • 1 female, 05-Hautes-Alpes, La Bérarde, parc des Ecrins, 44.905°N, 6.316°E, 1910 m, 7 Jul. 2005; 1 female, 05-Hautes-Alpes, La Bérarde, parc des Ecrins, 44.905°N, 6.316°E, 1910 m, 23 Jul. 2019; 1 male, 2 females, 05-Hautes-Alpes, Villar d'Arène, Col du Lautaret, 45.026°N, 6.406°E, 2220 m, 21 Jun. 2020; 9 males, 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.603°N, 6.759°E, 2320 m, 22 Jun. 2020; 1 male, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.605°N, 6.766°E, 2280 m, 22 Jun. 2020; 1 female, 05-Hautes-Alpes, Freissinières, 44.712°N, 6.447°E, 2050 m, 23 Jun. 2020; 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.613°N, 6.743°E, 2010 m, 24 Jun. 2020; 1 female, 09-Ariege, Bordes-Uchentein, Maison du Valier, 42.802°N, 1.056°E, 1760 m, 14 Jul. 2020; 2 females, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.608°N, 6.731°E, 2345 m, 27 Jul. 2020.

Notes. On 22.Vi.2020, a group of hilltopping males (>25) was found at the last larch *Larix* sp. above the treeline at 2320 m.

• *Rohdendorfia alpina* Sack 1938 NEW TO FRANCE

Examined material. FRANCE • 17 males, 11 females, 05-Hautes-Alpes, Molines-en-Queyras, near Pain de Sucre, 44.698°N, 6.991°E, 2780 m, 26 Jul. 2020; 7 females, 05-Hautes-Alpes, Vars, near La Mortrice, 44.574°N, 6.760°E, 2844 m, 27 Jul. 2020; 3 males, 1 female, 05-Hautes-Alpes, Vars, top La Mortrice, 44.574°N, 6.769°E, 3142 m, 27 Jul. 2020.

Notes. A species of bare scree slopes at high altitude. Though this species was never seen before in France, it is very common locally. The numbers listed above are only a fraction of the numbers seen in the field. *Rohdendorfia alpina* was found at both of the two high mountain tops visited in July 2020 and probably is present at many other mountain tops in the French Alps. At La Mortrice, male *R. alpina* seemed to perform hilltopping behaviour. A male and a female are shown in Figs 8, 9.

• *Spazigaster ambulans* (Fabricius, 1798)

Examined material. FRANCE • 1 male, 1 female, 05-Hautes-Alpes, Molines-en-Queyras, vers col d'Agnel, 44.700°N, 6.946°E, 2290 m, 26 Jul. 2020; 1 male, 1 female, 05-Hautes-Alpes, Molines-en-Queyras, vers col d'Agnel, 44.713°N, 6.919°E, 2090 m, 26 Jul. 2020.

• *Sphaerophoria estebani* Goeldlin, 1991

Examined material. FRANCE • 3 males, 05-Hautes-Alpes, La Bérarde, parc des Ecrins, 44.904°N, 6.332°E, 2400 m, 23 Jul. 2019.

Notes. All individuals were caught on a patch of disturbed and slightly fertilized patch of ground next to a refuge building with sparse pioneer vegetation of yellow crucifers. In the nearby more pristine habitat other *Sphaerophoria* species were found. It is the experience of the author, that many of the species of the *Sphaerophoria rueppellii*-group are linked to disturbed situations with pioneer vegetation: *S. rueppellii* in open lowland situations (ground works, riparian zone of streams,...) *S. shirchan* in recent forest clearings, and *S. estebani* in high mountain areas (scree slopes, human disturbances,...).

• *Syrphocheilosia claviventris* (Strobl, 1910)

Examined material. FRANCE • 2 males, 1 female, 05-Hautes-Alpes, Villar-d'Arène, Col du Lautaret, 45.029°N, 6.401°E, 2075 m, 21 Jun. 2020; 1 female, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.605°N, 6.766°E, 2280 m, 22 Jun. 2020; 1 female, 05-Hautes-Alpes, Freissinières, 44.704°N, 6.435°E, 2240 m, 23 Jun. 2020; 2 females, 05-Hautes-Alpes, Molines-en-Queyras, vers col d'Agnel, 44.692°N, 6.971°E, 2576 m, 26 Jul. 2020.

• *Xylota triangularis* Zetterstedt, 1838

Examined material. FRANCE • 1 male, 05-Hautes-Alpes, Vars, Val d'Escreins, 44.614°N, 6.746°E, 1950 m, 20 Jun. 2020.

Hilltopping at montane and Alpine hilltops

During the above-mentioned visits to the French Alps, 13 species were observed hilltopping. Raw estimates of numbers and altitude at which the behaviour was performed are indicated in Table 2.

Discussion

With a rather limited but focused search effort, several new species for the French fauna were discovered (see also Ricarte et al. 2021). This may seem surprising as the visited mountain areas belong to the best investigated departments and areas in France (Speight et al. 2018; Verlinden 2020). However, within these areas, apparently not the full altitudinal gradient has been investigated. The altitudinal window at very high altitudes near and above 3000 m asl yielded a large number of some very rare and two new species for France. Of *Rohdendorfia alpina*, a species new to France, many tens were seen at several places with a limited search effort. Also *P. altomontis* was present in numbers. In the lower montane and alpine meadows between 1200–2400 m that abound in Syrphidae,



Figure 7. Habitus dorsal view of male *Platycheirus fasciculatus*, 17.Vii.2020, Bagnères-de-Bigorre, Tourmalet (photo by Sander Bot).



Figure 8. Habitus dorsal view of male *Rohdendorfia alpina*, 26.Vii.2020, Molines-en-Queyras, near Pain de Sucre (photo by Martin Speight).

mainly with *Cheilosia* (>40 species on a few days in one area), *Platycheirus*, *Pipizella* and *Sphaerophoria*, no new species were found and all these species have been seen repeatedly at multiple locations in France and elsewhere. Indeed, this is the main altitudinal niche explored by entomologists in mountain areas (see e.g. Verlinden 2020).

The high mountain habitat above 2800 m is probably undersampled for Syrphidae over much of Europe. *Platycheirus altomontis* was only recently described (Nielsen 2004) from specimens caught in the Italian Alps near the summit

of Mount Scorluzzo (height: 3094 m) in 1998 and was recently added to the Swiss fauna based on old collection material from 1932 (Fisler and Speight 2020), but those are the only published records of this species so far. This species is now found at a first focused search at both French mountain tops investigated in July 2020. Just as with the sightings reported here for France, the other two locations where *P. altomontis* has been seen (Italy, Switzerland) are close to or above 3000 m. Though syrphids may be difficult to locate in the vast hostile and often inaccessible rocky environment



Figure 9. Habitus dorsal view of female *Rohdendorfia alpina*, 26.Vii.2020, Molines-en-Queyras, near Pain de Sucre (photo by Martin Speight).

Table 2. Overview of the species observed hilltopping in the French Alps in June and July 2020. The estimated number of individuals and the elevation(s) (in m asl) of the hilltop(s) are indicated.

Species	Nr. (males)	Elevation (m asl)	Month
<i>Cheilosia canicularis</i> (Panzer, 1801)	15	2345	July
<i>Cheilosia melanura</i> (Becker, 1894)	25	2320	June
<i>Didea alneti</i> (Fallen, 1817)	2	2320	June
<i>Epistrophe leiophthalma</i> (Schiner & Egger, 1853)	1	3142	July
<i>Eristalis tenax</i> Linnaeus, 1758	3	3142	July
<i>Eupeodes flaviceps</i> (Rondani, 1857)	2	3142	July
<i>Parasyrphus kirgizorum</i> (Peck, 1969) / <i>tarsatus</i> (Zetterstedt, 1838)	25	2320	June
<i>Pipizella calabra</i> (Goeldlin, 1974)	25	2320	June
<i>Pipizella nigriana</i> (Séguy, 1961)	30	2320	July
<i>Pipizella pennina</i> (Goeldlin de Tiefenau, 1974)	2	2320	June
<i>Platycheirus altomontis</i> Merlin & Nielsen in Nielsen, 2004	3	3142	July
<i>Platycheirus tatricus</i> Dušek & Láška, 1982	25	2320	June
<i>Rohdendorfia alpina</i> Sack, 1938	25	2780/3142	July

of high mountains, it is clear that males of this species aggregate at hilltops at or above 3000 m, as evidenced by this study and by the more than 100 males seen at mount Scorzuzo in Italy. This knowledge of its behaviour and the fact that now also the female can be recognized, may considerably increase the success rate of finding this species of the high mountain habitat in other areas.

Platycheirus is mainly a northern genus, with nearly $\frac{3}{4}$ of all 63 European species occurring in Scandinavia, although many species also have isolated populations much further

south in mountains (Speight 2020). The *P. ambiguus* group to which *P. altomontis* belongs, however, deviates from the general pattern with 12 of the 13 European species occurring in mountains of Central and Southern Europe and 7 species having a southern alpine distribution (Nielsen 2004; Speight 2020). As a rule, the southern alpine species are all very rarely seen and occur on rather dry, rocky, sparsely vegetated mountains at high elevation (2000–3200 m). Though it is never explicitly mentioned, several of these species were found at mountain tops where series of males were collected, suggesting they were hilltopping (Nielsen 2004, this study). Such insight into the ecology of these rare species could help to get a better view on their distribution.

Even at hilltops above 3000 m, *P. altomontis* was not the only syrphid species hilltopping: at La Mortrice also hilltopping males of *Rohdendorfia alpina*, *Epistrophe leiophthalma* (Schiner & Egger, 1853), *Eupeodes flaviceps* Rondani (1857) and *Eristalis tenax* Linnaeus 1758 were present. Earlier in spring, when high hilltops are too cold and covered with snow, lower hilltops and clear landmarks on the slopes, such as large boulders or the last trees above the tree line are locations where hilltopping takes place. On 22 June 2020 together with *Parasyrphus kirgizorum/tarsatus* and *Platycheirus tatricus* also *Cheilosia melanura*, *Didea alneti*, *Pipizella calabra*, *P. nigriana* and *P. pennina* were present. Some of these species were hardly found elsewhere during the period of investigation. Hilltopping males formed loose swarms (*C. melanura*, *P. tatricus*) next to the landmarks, or sat on the landmarks (other species). Hilltopping is a mate finding strategy that is believed to be especially prevalent (and rewarding) in rare species (Skevington 2008), however, very often also more common species engaged in hilltopping. Males of the very common *Cheilosia melanura* were seen hilltopping, but intriguingly they were all small individuals

compared to the larger males of the same species that were found hovering in forest clearings at lower altitudes. Assuming no cryptic speciation is involved, this suggests hilltopping can simply be part of the portfolio of mate finding strategies found within a species, both common and rare, but in this case also that it may be an alternative mating strategy related to specific phenotypes (Hutchings and Myers 1994). There may also be some phylogenetic dependence in hilltopping behaviour: in some genera this behaviour is very common (e.g. many species of *Parasyrphus* and *Pipizella*) whereas it is never seen in other (e.g. *Sphaerophoria* and *Paragus*). More research however is needed, in the first place to establish in which species this behaviour occurs and next into how it evolved and why it occurs.

Acknowledgements

I would like to thank Lisa Fisler for some valuable comments on a previous version of the text. I am indebted to Martin Speight and especially Sander Bot for making the high-quality photographs.

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Supplementary material 1

Table S1

Authors: Frank Van de Meutter

Data type: excel file

Explanation note: **Table S1**. 205 species of Syrphidae, that have been observed in mountains in France.

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Link: <https://doi.org/10.3897/alpento.6.81676>

Sudden collapse of xylophilous bee populations in the mountains of northern Utah (USA): An historical illustration

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<https://zoobank.org/523CA3B4-4A0D-4AA8-91F7-009A12C920FD>

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Academic editor: Jessica Litman ♦ Received 18 August 2022 ♦ Accepted 28 October 2022 ♦ Published 18 November 2022

Abstract

A scarcity of studies of the dynamics of wild bee populations hampers conservation efforts by bee ecologists and conservationists. Present limited information suggests that bee populations are highly unpredictable from year-to-year. Here we present an historical data set from nine sites replicated in 1984 and 1985 that demonstrates extreme between-year variability in numbers for 19 xylophilous bee species. Sixteen of those species produced far fewer nests in 1985, and 13 species in 1985 produced less than a third the number of nests produced in 1984. We argue that the 1985 collapse was not due to semivoltinism, i.e., the absence of morphs that require two years to mature, or to excessive sampling in 1984, but to a record cold period from January to March 1985 which likely killed most diapausing bees. Such events illustrate the dynamism of wild bee populations and thereby the large number of years needed to establish statistically significant population trends. We suggest that the current emphasis by bee conservationists to promote widespread surveillance monitoring programs is misguided and that funds are more effectively spent on hypothesis-driven targeted monitoring and on actions to actually reclaim degraded wild bee habitat.

Key Words

Anthophila, Megachilidae, weather, parsivoltinism

Introduction

Insect population numbers, including those of wild, native bees, are notoriously variable from year-to-year (Hanski 1991). In early reviews, Roubik (2001) and Williams et al. (2001) found that bee populations were highly dynamic and subsequent studies have generally confirmed that finding. For example, Roubik and Villanueva-Guttierrez (2009) reported great variation in nesting by bees utilizing trap-nests over a 17-year period. Franzen and Nilsson (2013) followed twelve populations of a rare bee in Sweden over nine years and found that only one population persisted through the entire period. Ogilvie et al. (2017) found that numbers of three species of bumblebees visiting flowers in subalpine Colorado meadows varied greatly over eight years. Graham et al. (2021) reported significant declines and recoveries

of several blueberry-visiting native bee species over a fifteen-year period. A recent study of common orchid bees in Panama by Roubik et al. (2021) reported much inter-annual variation in population numbers of common species but detected no significant trend over the entire 40-year period. Other studies of differing durations have all reported great year-to-year changes in species composition and abundance, and in host-plant associations in bee communities (Tepedino and Stanton 1981; Alarcon et al. 2008; Herrera 2019).

Despite the cautions of Roubik (2001) and Williams et al. (2001) that detecting significant trends in bee species population size over time may be a formidable task, and findings of wide swings in bee population numbers over periods of time longer than a few years, calls persist for an intensive continent-wide program in North America to monitor native bee species population sizes, and bee

species richness and diversity (e.g., LeBuhn et al. 2013; Woodard et al. 2020). This is, in part, due to the importance of bees to crop and wild plant pollination (Klein et al. 2007; Ollerton et al. 2011) and to the burgeoning number of reports of bee declines (e.g., Powney et al. 2019; Duchenne et al. 2020; Zattara and Aizen 2021). Concern over bee declines has also sparked calls for publication of older, standardized, data sets which might expand our understanding of the behavior of bee populations (Wagner et al. 2021).

In that spirit, we present an older, brief data set, an extension of a previous paper in which we described cohort-splitting and parsivoltinism in several xylophilous species of *Osmia* bees (Tepedino et al. 2022). Progeny of parsivoltine species develop to the adult stage in either one or two years and sibs of both year-morphs are commonly found in the same nest (Torchio and Tepedino 1982). Relevant to interpreting our present report is the earlier finding that the incidence of two-year morphs increases with altitude and lower average temperatures (Tepedino et al. 2022).

We first provide an example of extreme temporal and spatial dynamism in northern Utah populations of several solitary bee species and then speculate on the possible causes of such a phenomenon and what it signals for surveillance monitoring efforts for species of wild bees.

Methods

Our study was conducted in Logan Canyon, in northern Utah (Cache, Rich Cos., Wasatch-Cache National Forest), United States of America in 1984 and 1985. Logan Canyon rises from about 1300 m to 2500 m in a northeasterly direction through the Bear River Range of the Wasatch Mountains. Site elevations and geographic locations are shown in Table 3; a map can be found in Tepedino et al. (2022).

Females of target species readily nest in tunnels drilled in artificial wooden domiciles (pine trap-blocks). Sampling with trap-blocks avoids the need for precise synchronization with bee flight seasons so important when other methods (e.g., bowl-traps) are used because blocks are in place for the entire season. Populations were sampled at nine sites, beginning in April 1984 and again in 1985. Sites were selected along an elevation gradient in the mountain brush zone (Banner 1992) of open shrub (e.g., *Artemisia*, *Quercus*, *Cercocarpus*, *Acer*)/grassland habitats with diverse, mostly perennial, wildflowers in the Asteraceae, Plantaginaceae, Fabaceae and other families. Block placement closely followed snow melt; thus, blocks at lower southwestern sites were positioned earlier than blocks at higher northeastern sites.

Sites and methods in the two years were identical. At each site, ten nest blocks were placed 4–8 m apart in unshaded spots. Blocks were attached with screws and bolts to the top of meter-high posts and faced east to capture the morning sun. Each block contained 50 drilled holes arranged in five columns and ten repeating rows. Each

row contained an unvarying sequence of drilled hole sizes: 2, 4, 6, 8, 10 mm.

Blocks were collected after several mid-October frosts when bee activity and flowering had ceased, and stored in an unheated garage in Logan, Utah. Nest dissection, description and preliminary identification commenced immediately and proceeded for several weeks. The contents of each nest cell were recorded and placed in gelatin capsules which were attached to two-sided adhesive paper on thick cardboard (sticky boards) and returned to the garage. After all nests were dissected, all sticky boards were moved to a temperature-controlled room at 3–5 °C for the normal winter dormancy period.

In April of the year following collection, sticky boards were removed from the temperature room, held for a few days at room temperature (~18–20 °C) and then placed in incubators at 29° C to accelerate emergence. Boards were checked for emergence of adult bees twice daily. Upon emergence, adults were frozen, pinned, labelled, identified and associated with their natal nests. Identifications were made by the junior author by comparison with specimens in the National Bee Collection at the United States Department of Agriculture, Agricultural Research Service Pollinating Insect Research Unit in Logan Utah and confirmed or corrected by Terry L. Griswold, Curator of the collection where voucher specimens are deposited.

Nests from all sites were combined within years for each species and comparisons of numbers of nests were made between years with the Wilcoxon Signed Rank Test, a non-parametric version of the paired t-test (Zar 1999). Temperature records, mean monthly minimums and daily minimums, were retrieved from pertinent National Oceanic and Atmospheric Administration weather stations in the Bear River drainage (www.ncdc.noaa.gov) Table 3.

Results

We recorded 19 species of bees that produced at least 10 nests in our trap-nests in either 1984 or 1985 (Table 1). No species was recorded only in 1985.

Of the 19 species that produced at least 10 nests in either 1984 or 1985 (Table 1), 16 produced fewer nests in 1985. Of those, 15 species at least halved their 1984 output in 1985; in 1985, 13 species produced less than a third the number of nests produced in 1984 (Table 1). A comparison, between years, of nests produced by species was highly significant (Wilcoxon Signed Rank Test, $P < 0.001$).

Based on our earlier finding of significant differences in voltinism between high and low elevation populations (Tepedino et al. 2022), we grouped sites by elevation (below or above 1850 m) and compared the number of nests constructed by species between years (Table 2). Again, we found highly significant differences with approximately six times as many nests being produced in 1984 as in 1985 for both elevation groups (both < 0.01).

Table 1. The number of nests made by 19 species of xylophilous bees at each of nine sites in 1984/1985. Only species with >10 total nests shown. ¹ = Low elevation sites. All Latitudes are decimal 41, all Longitudes are decimal -111; ² = parsivoltine species. Emboldened species (3) built more nests in 1985 than in 1984.

Sites	LC3 ¹	LC4 ¹	LC5 ¹	LC6	LC7	LC8	LC9	LC10	BL ¹	TOT
El (m)	1605	1553	1848	2074	2134	2280	2378	2436	1794	
Lat	.7475	.7608	.8335	.9387	.9628	.9593	.9413	.9255	.8781	
Long	.7436	.7075	.5955	.5558	.5306	.5079	.4812	.4713	.3660	
Species										
Ashmeadiella bucconis (Say, 1837)	12/10	0/3	0/1	0/0	0/0	0/0	0/0	0/0	0/0	12/14
<i>Chelostoma minutum</i> Crawford, 1916	4/2	23/14	0/0	0/0	0/1	0/1	0/0	0/0	0/0	27/18
Dianthidium ulkei (Cresson, 1878)	10/23	0/5	0/0	0/0	0/0	0/0	0/0	0/0	0/0	10/28
<i>Heriades carinata</i> Cresson, 1864	29/0	31/4	1/0	4/1	0/2	0/0	0/0	0/0	0/0	65/7
<i>Hoplitis albifrons</i> (Kirby, 1837)	0/0	0/0	0/0	1/0	0/1	26/3	0/0	3/0	0/0	30/4
<i>Hoplitis fulgida</i> (Cresson, 1864)	0/0	0/0	15/0	20/3	0/0	18/1	4/0	6/0	0/0	63/4
<i>Megachile pugnata</i> Say, 1837	0/0	20/0	35/8	4/3	4/0	0/0	0/0	0/0	0/0	63/11
<i>Megachile relativa</i> Cresson, 1878	1/2	2/1	3/3	18/1	4/6	15/4	4/2	6/1	0/0	53/20
<i>Megachile rotundata</i> (Fabricius, 1787)	38/0	22/9	3/0	0/0	0/0	0/0	0/0	0/0	0/0	63/9
<i>Osmia atrocyanea</i> Cockerell, 1897	0/0	8/0	11/0	0/0	0/0	0/0	0/0	0/0	0/0	19/0
<i>Osmia bruneri</i> Cockerell, 1897	25/9	82/36	242/0	0/0	0/0	17/0	0/1	0/0	238/29	604/75
<i>Osmia californica</i> ² Cresson, 1864	9/0	6/3	3/0	26/0	0/0	0/0	0/0	0/0	0/0	44/3
<i>Osmia coloradensis</i> ² Cresson, 1878	20/0	10/0	46/1	40/0	17/3	99/18	26/0	59/0	81/0	398/22
<i>Osmia iridis</i> Cockerell & Titus, 1902	0/0	0/0	13/0	0/1	0/0	0/0	0/0	0/0	0/0	13/1
<i>Osmia kinkaidii</i> Cockerell, 1897	0/0	19/1	4/0	7/5	0/0	20/4	0/0	0/4	25/8	75/22
<i>Osmia lignaria</i> Say, 1837	0/1	1/34	0/0	1/0	0/0	0/0	0/0	0/0	7/0	9/35
<i>Osmia melanopleura</i> Cockerell, 1916	0/0	8/0	5/0	0/0	0/0	6/5	0/0	0/4	0/0	19/9
<i>Osmia montana</i> ² Cresson, 1864	21/0	4/0	9/0	7/0	0/0	10/2	0/0	9/0	5/0	65/2
<i>Osmia texana</i> ² Cresson, 1872	42/0	67/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	109/1

Discussion

Our results illustrate how dynamic populations of native bee species can be from year-to-year and site-to-site and are consistent with other reports of inter-annual variation in bee numbers (e.g., Roubik 2001; Williams et al. 2001; Franzen and Nilsson 2013; Graham et al. 2021; Roubik et al. 2021). For example, we found the number of *O. bruneri* nests to vary eightfold across two years and tenfold among sites that differed in 300 m elevation (Table 1); and, that in 1985, the several parsivoltine *Osmia* species recurred at only 27.3% of 1984 sites. Unfortunately, we have no subsequent data to describe how rapidly these populations might have recovered. Data from an earlier unpublished study of several species of xylophilous bees and wasps over seven years in Logan Canyon (1973–1979) also show great inter-annual variation in number of nests though not as exaggerated as that reported here (there were no sudden disappearances of abundant species between years; F.D. Parker, V.J. Tepedino and S. Droege, unpublished). Those data suggest recovery within 5–7 years of species whose populations had greatly diminished in one year. However, those recoveries occurred in the absence of an extreme winter such as was experienced in January-to-March, 1985 (see below).

There are at least three explanations for the observed decline in population numbers in 1985: parsivoltinism, excessive trapping of bees in 1984, and weather. The prevalence of two-year forms in nests from 1984, particularly at elevations above 1850 m, might explain the

virtual absence of those parsivoltine *Osmia* species in 1985. However, the decline in numbers of nests occurred not only at upper elevation sites where two-year morphs were predominant but also at lower elevation sites where there were far fewer two-year individuals in 1984 (Tepedino et al. 2022). Indeed, there was no difference between upper and lower sites in the rate of decline in numbers of nests in 1985, suggesting that the decrease in nest numbers was due to something other than parsivoltinism.

A second explanation is that the trapping program of 1984 removed almost all xylophilous bees and greatly depressed reproduction in 1985. What little information is available on the effect of bee removal on subsequent population size does not support this explanation. Only Gezon et al. (2015) have directly tested the effect of removing bees on population numbers in subsequent years. Sampling over four years with pan-traps and by netting they found no change in bee abundance or

Table 2. Mean and median number of nests made by N number of bee species at nine study sites in Logan Canyon in 1984 and 1985. Totals combines data for all sites (19 species) in each respective year. See Table 1 for site designation as lower elevation (LE) or upper elevation (UE).

	Totals		Lower Elevation		Upper Elevation	
	1984	1985	1984	1985	1984	1985
N	19		18		14	
Mean	91.6	15.0	66.3	10.9	25.3	4.1
Median	53.0	9.0	19.0	4.0	6.0	2.0

diversity despite removing over 2800 bees per year. The unpublished study cited above of nine xylophilous bee species in northern Utah over seven years (1973–1979) by Parker, Tepedino and Droege found a significant increase in the nests of one species, a significant decrease in nesting of another species, and no discernable change in seven species. Torchio and Tepedino (1982), also sampling for two years with trap nests in northern Utah mountains, found an increase in nests in the second year for one species (*O. californica*) and a decrease in nests in the other (*O. montana*). We tentatively conclude that sampling such as employed here does not usually depress bee population numbers in the short term though the effect of persistent long-term sampling is unclear.

A more likely cause of the 1985 decline is extreme cold weather which has long been implicated in sudden declines of insect populations (e.g., Ehrlich et al. 1972; Solbreck 1991; Stahl et al. 2006; Graham et al. 2021). The January-to-March period of 1985 had many days of record-breaking cold temperatures at several available weather stations in and near Logan Canyon (Table 3). For example, at each of six weather stations in northern Utah, in the first three months of 1985 there were an average of 50 days that were > 10 degrees colder than the 30-year (1981–2010) minimum average for each of those sites. Indeed, on Feb. 1, 1985, the second coldest temperature ever recorded in the contiguous 48 states, - 56.3°C, was recorded at Peter Sinks, a natural limestone sinkhole in Logan Canyon (weather.gladstonefamily.net/site/PSINK; elev. 2488 m; Lat 41.9130, Lon -111.5142). Peter Sinks is < 6 km distant from LC6 through LC10 (calculations using Google Earth). Such temperature extremes can have profound demographic and genetic effects on native insect populations (see Filazzola et al. 2021 for a recent review) particularly those that nest aboveground and are unprotected by deep snow. Thus, it is more likely that the much lower temperatures of early 1985 sustained for extended periods decimated overwintering populations of xylophilous bees.

Although our data set spans but two years, and documents an extreme event, the large between-year differences in population numbers warn of the difficulty of uncovering significant population trends for bees by using surveillance monitoring even when several decades of data are available (Tepedino and Portman 2021). In

general, the usefulness of surveillance monitoring studies for determining population trends in a timely manner has also been recently questioned by others (Fox et al. 2019; White 2019). Fox et al. (2019), for example, analyzed long-term surveillance data for butterflies and moths of the United Kingdom and concluded that the 10-year trend rule advocated by the International Union for the Conservation of Nature (IUCN) was unreliable because it was “unacceptably biased by the start year.” Thomson (2019) reported that a trend of significant declines in pollination services to *Erythronium grandiflorum* over a 17-year period disappeared when nine additional years of data was gathered. Thus, very long monitoring periods are necessary to uncover trends, though whether they yield any actionable information is debatable (Roubik et al. 2021). Others (Powney et al. 2019; LeCroy et al. 2020) used long periods (15 and 33 years, respectively) to report significant declines of bee populations without suggesting actionable remedies to address those declines. When remedies to long-term declines are suggested, e.g., Duchenne et al. 2020, they are non-specific to species and are of a sort that would be recommended without any monitoring at all, e.g., restore degraded habitat.

Bee conservationists are presently caught between the undeniable need for some long-term monitoring studies to learn of the state of pollinator populations, particularly in more pristine locations, and the urgency to restore, at least partially, habitats that have already been degraded. Because funds for conservation of wild bees are limited (Tepedino and Portman 2021), a compromise between short- and long-term efforts should be sought. Rather than the current emphasis on a plethora of scattershot, easily implemented, “monitoring” efforts (Portman et al. 2020), a limited number of well-chosen pristine sites should be selected to serve as long-term monitoring sites (Tepedino and Portman 2021). Concurrently, because bee declines are known to be occurring (Powney et al. 2019; Duchenne et al. 2020; Zattara and Aizen 2021), there is much we can and should do to ease the present plight of wild bee populations (e.g., Potts et al. 2016; Kremen and Merenlander 2018; Forister et al. 2019). The emphasis on surveillance monitoring should give way to targeted-monitoring studies (Nichols and Williams 2006) whose primary objective is testing hypotheses that will lead to management-oriented conservation (Tepedino and Portman 2021).

Table 3. Weather data from 6 NOAA stations (USC# = identification number) in or adjacent to Logan Canyon. Coldest is the coldest day in the month; Mm is the mean minimum temperature for the month (NOAA average 1981–2010); # below >10 Mm is the number of days the minimum temperature was colder than 10 degrees below Mm; the total number of days for the period was 90 (31 for each of January and March, 28 for February). *= Lon -112.

Site	NOAA ID USC#	Lat	Lon (-111)	El (m)	Coldest (°C) /# below >10 Mm			Tot # days below	
					Jan	Feb	Mar	Mm	>10 Mm
Cutler	00421918	41.8331	0579*	1308	-15/17	-22/16	6/17	77	50
Hardware	00423671	41.6000	5667	1695	-34.4/15	-36.1/16	-23.9/12	70	43
Laketown	00424856	41.8250	3208	1823	-32.8/18	-36.7/18	-23.3/18	77	54
Lifton	00105275	42.1230	3133	1809	-38.3/19	-40.6/19	-26.7/22	80	60
Richmond	00427271	41.9063	8100	1426	-29.4/19	-32.8/16	-15.6/16	78	51
USU	00425186	41.7460	8030	1460	-22.8/17	-28.3/12	-14.4/12	79	41

Acknowledgements

Thanks to Don Viers for nest preparation, Rhonda Griswold for laboratory monitoring, and Zach Portman and Jim Cane for suggestions on improving our presentation.

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Der Fremdling im Therapiegarten – *Cis chinensis* (Coleoptera, Ciidae) und sein Umfeld

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Academic editor: Beat Wermelinger ♦ Received 12 May 2022 ♦ Accepted 26 October 2022 ♦ Published 18 November 2022

Zusammenfassung

Im Sommer 2021 konnten im Therapiegarten auf dem UPK-Campus (Universitäre Psychiatrische Kliniken) in Basel Proben des Baumpilzes *Antrodia xantha* an *Pinus strobus* gesammelt werden. Sie enthielten eine für die Schweiz neue, gebietsfremde Ciidae-Art: *Cis chinensis* Lawrence, 1991, eine Art die sonst als Vorratsschädling an Trockenpilzen bekannt ist. Es werden die Imagines und Larven der Basler Population beschrieben und abgebildet. Beim Grössenvergleich der Imagines der beiden im Abstand von zwei Wochen gesammelten Proben-Serien zeigten sich statistisch signifikante Unterschiede. Anscheinend konnte vorzugsweise die späte Gruppe während ihrer Entwicklung von den überdurchschnittlich hohen Juni-Temperaturen 2021 profitieren. Für die Larvalentwicklung wird eine Anzahl von (4–)5 Larvenstadien postuliert. Als Endoparasitoid der Eier von *C. chinensis* konnte eine unbekannte Mymaridae der Gattung *Cleruchus* festgestellt werden. Bemerkenswert war zudem ein ungewöhnlich starker Befall der Ciidae durch phoretische Milben (Histiostomatidae). Bei Nachuntersuchungen Anfang 2022 konnten in der unmittelbaren Umgebung der Population an *A. xantha* auch an Fruchtkörpern anderer Pilze Nachweise von *C. chinensis* erbracht werden. Eine Artenliste aller festgestellten Ciidae des UPK-Campus ist beigelegt, und das Brutpilz-Spektrum von *C. chinensis* wird diskutiert.

Abstract

Samples of the tree fungus *Antrodia xantha* were collected on *Pinus strobus* in the therapy garden of the UPK campus (University Psychiatric Clinics) in Basel in summer 2021. The samples contained an alien Ciidae species new to Switzerland: *Cis chinensis* Lawrence, 1991, a species otherwise mainly known as a storage pest of commercially dried fungi. The adults and larvae of the Basel population are described and illustrated. When comparing the size of the adults of the two sample series collected two weeks apart, statistically significant differences were found. It appears that the above-average temperatures in June 2021 favoured the size of the second group. A number of (4–)5 larval stages are postulated for larval development. As an endoparasitoid of the eggs of *C. chinensis*, an unknown Mymaridae of the genus *Cleruchus* was found. Noteworthy was an unusually heavy infestation of Ciidae by phoretic mites (Histiostomatidae). During follow-up surveys in early 2022, additional individuals of *C. chinensis* were also found on the fruitbodies of other fungi growing in the immediate vicinity of the site where the population of the species was initially observed on *A. xantha*. A list of all Ciidae detected on the UPK campus is provided, and the spectrum of host-fungi of *C. chinensis* is discussed.

Key Words

Ciidae, Mymaridae, Histiostomatidae, faunistics, urban ecology, host fungi, ontogenesis, phoresy

Einleitung

Gärten und alte Park-Landschaften liefern immer wieder Überraschungen und sind nicht selten wichtige Biodiversitäts-Inseln. Zu den interessantesten Standorten im Stadtgebiet von Basel zählt der Campus der Universitären Psychiatrischen Kliniken. Die psychiatrische Klinik Friedmatt, nicht weit von der französischen Grenze, wurde zwischen 1884–1886 ursprünglich als symmetrisch geordnete Pavillonanlage, umgeben von einem Park nach englischem Vorbild angelegt. War die Anlage in der 1. Hälfte des 20. Jh. noch weitgehend isoliert auf freiem Feld, so ist sie inzwischen von der Stadt eingeholt worden. Das Areal besitzt heute eine Grösse von 12,23 Hektaren. Es hat viele ältere, auch fremdländische Baumbestände, die z. T. bis ins späte 19. Jh. zurückreichen. Bemerkenswert ist das Areal gerade auch aus mykologischer Sicht, denn im Gegensatz zu anderen Parks und zur Umgebung allgemein werden seine Grünflächen extensiv gepflegt und deutlich weniger genutzt, weshalb man auch reichhaltige Pilzvorkommen finden kann. Dadurch bieten sich auch vielfältige Lebensräume für mycetobionte und mycetophile Arten sowie deren Begleiter.

Keine andere Käferfamilie ist besser an das Leben in Pilzen und speziell an dasjenige in Fruchtkörpern von Baumpilzen angepasst als die Ciidae Leach in Samouelle, 1819, von denen weltweit annähernd 650 beschriebene Arten in 42 Gattungen bekannt sind (Lawrence and Lopes-Andrade 2010). Die Gattung *Cis* Latreille, 1796, stellt mit etwa 400 Arten, die mit Abstand artenreichste Gattung der Familie. Für die Schweiz konnten bis 2012 41 Ciidae-Arten registriert werden (Reibnitz et al. 2013).

Individuenreiche Ciidae-Populationen ziehen immer auch diverse Parasitoide an, darunter insbesondere auch Hymenoptera wie z. B. Zwergwespen (Mymaridae). Es sind dies solitäre oder gesellige Endparasitoide von Insekteneiern, die als ursprünglichste Vertreter der Überfamilie Chalcidoidea (Erzwespen) gelten. Weltweit sind sie durch über 1400 Arten in mehr als 100 Gattungen ver-

treten (Goulet and Huber 1993). Für die Schweiz sind sie ziemlich schlecht bearbeitet, man kennt lediglich etwa 35 Arten dieser unscheinbaren Hautflügler (Noyes 2019).

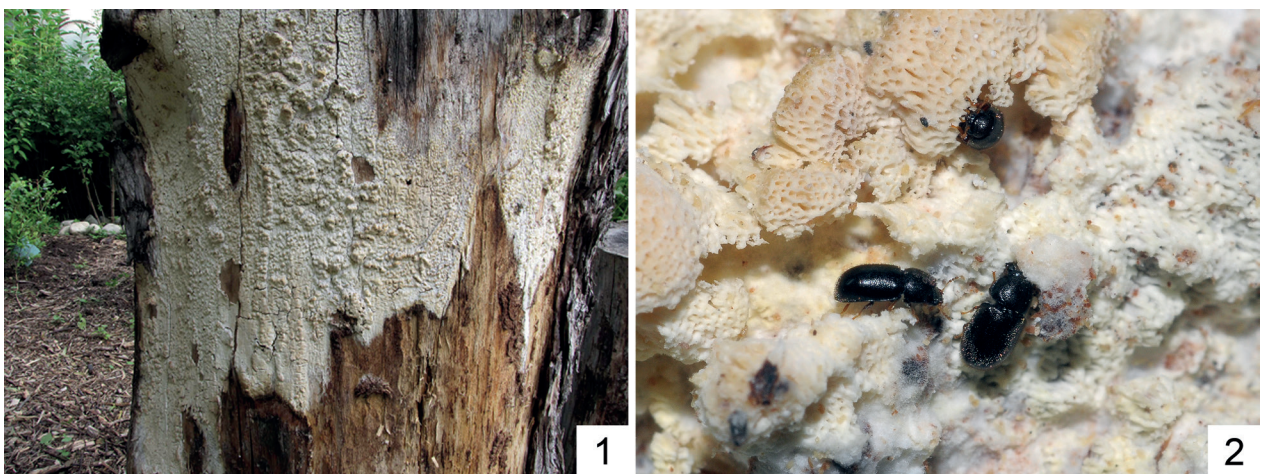
Als weitere Profiteure sind phoretische Milben zu nennen, deren Wandernymphen Käfer als Tragwirte nutzen. Dazu zählen etwa die Vertreter der Familie Histiostomatiidae, von denen weltweit in 58 Gattungen über 500 rezente Arten bekannt sind (Krantz and Walter 2009).

Im Rahmen eines «Pilz-Projekts» (A. Coray), das seit 2009 die Wirbellosen-Fauna (speziell diejenigen der Insekten) in ausdauernden Baumpilzen der Regio Basiliensis erforscht, wurden Pilz-Proben vom UPK-Campus untersucht. Diese zeigten die ungewöhnliche Konstellation einer für die Schweiz neuen, fremdländischen Ciidae-Art, parasitiert durch eine unbekannte Mymaridae und betroffen von einem unerwartet starken Milbenbesatz und bildeten den Auslöser für diverse weiterführende Untersuchungen an *Cis chinensis* und seinem Umfeld.

Material und Methoden

Am 27. und 28. Juni 2021 wurden im «Therapiegarten» des UPK-Campus zwei Pilzproben (leg. P. Vlček) der Gelben Tramete, *Antrodia xantha* (Fr.) Ryv. an einem stehenden Föhren-Stammstück (*Pinus strobus*) gesammelt (Figs 1–2). Eine weitere Probe vom gleichen Standort kam am 11. Juli hinzu (leg. A. Coray).

Beim erwähnten «Pilz-Projekt» werden vielversprechende Fruchtkörper gesammelt und im Labor des Naturhistorischen Museums Basel ausgewertet. Vor der Entnahme wird in den meisten Fällen noch die Situation vor Ort fotografisch festgehalten, als zusätzliche Hilfe der Pilzbestimmung, die vorzugsweise nach makroskopischen Merkmalen erfolgt. Die gesammelten Pilzproben werden in Quickbeuteln aufbewahrt und je nach Zustand und Bedarf von Zeit zu Zeit kontrolliert. Aussortierte Tiere werden entweder in Ethylacetat oder Ethanol (75–90%) abgetötet. Entsprechende Präparate sind im Naturhistorischen Museum Basel deponiert.



Figures 1–2. *Antrodia xantha* mit Befall durch *Cis chinensis*. **1.** Föhren-Stammstück (*Pinus strobus*) mit Bewuchs durch die Gelbe Tramete (*Antrodia xantha*) am Tag der ersten Probenentnahme, 27.VI.2021. Basel, UPK-Campus, Therapiegarten. – Foto: P. Vlček. **2.** Gruppe von *Cis chinensis* an *Antrodia xantha*. Laboraufnahme der zweiten Probe vom 28.VI.2021. – Foto: A. Coray, 30.VI.2021.

Die im Resultatteil publizierten Makroaufnahmen wurden mit Hilfe eines Keyence VHX-S650E hergestellt und mittels Adobe Photoshop CS5.1 nachbearbeitet. Die Originalzeichnungen entstanden mit Hilfe eines Stereomikroskops Leica MZ 12.5 unter Verwendung eines Zeichentubus. Dies gilt auch für die Darstellung einer Alt-Larve, deren Vorzeichnungen in Ethanol erfolgten in dem die Tiere mittels Glasperlen (\varnothing 0,3 mm) fixiert waren. Die Körpergrösse der Imagines wurde bei 50-facher Vergrößerung vom Kopfvorderrand bis zum Abdomenapex gemessen, die bei der korrekten Einstellung gleichzeitig scharf zu sehen waren. Die Messungen an den Larven (Kopfkapsellänge und Gesamtlänge) erfolgten nach Exemplaren in Ethanol bei Vergrößerungen zwischen 25–80 \times . Für die Auswertung der Messdaten der Imagines haben wir ein lineares Modell benutzt um den Effekt des Sammeldatums und des Geschlechts auf die Grösse zu untersuchen, wobei beide Variablen als zweistufige Faktoren betrachtet wurden (Sammeldatum: 27./28. Juni oder 11. Juli). Statistische Analysen und Diagramme wurden in R Version 4.1.2 ausgeführt (R Core Team 2021).

Die verwendete Nomenklatur der Ciidae folgt im Wesentlichen Jelínek in Löbl and Smetana (2008), zu Abweichungen siehe jedoch Reibnitz et al. (2013). Bei der Namensgebung der Pilze orientieren wir uns an Swiss-Fungi (<https://swissfungi.wsl.ch>) und am Index Fungorum (<http://www.indexfungorum.org>).

Die drei im Juni/Juli 2021 gesammelten Pilzproben von *Antrodia xantha* tragen, nach ihrem jeweiligen Sammeldatum die Laufnummern 914, 915 und 916, die jedoch nicht Teil der Etikettierung sind. Das gesamte Material ist wie folgt etikettiert:

CH-Basel / BS, Friedmattviertel, UPK-Campus, Therapiegarten W-Ecke, 266 m. K.: 609.430 / 268.975. Ni.: *Antrodia xantha* an hüfthohem Föhrenklotz. 27.VI.2021. P. Vlček [= 914]. | 28.VI.2021. P. Vlček [= 915]. | 11.VII.2021. A. Coray. [= 916]. [Die angegebenen Schweizer Koordinaten entsprechen den geographischen Koordinaten 47°34'16.75"N, 7°33'50.15"E].

Resultate

Belegmaterial

An den Proben von *Antrodia xantha* fanden sich zahlreiche Individuen eines mycetophagen Käfers, der sich bei genauerer Untersuchung als *Cis chinensis* Lawrence, 1991 bestimmen liess. *Cis chinensis* war, abgesehen von einer Staphylinidae-Larve, die einzige Käferart in den Proben 914–916. Bei der Auswertung ergaben sich folgende Individuenzahlen:

Probe 914 – Erstausswertung 28.VI.2021: 15♂♂ + 9♀♀; Folgeserie 8.VII.2021: 1 ♀; Folgeserie 18.VII.2021: 10♂ + 8♀ + 7 Larven und 2 Puppen; Folgeserie 9.VIII.2021: 26♂♂ + 24♀♀ (davon 14♂♂ + 10♀♀ in Ethanol) + 3

Larven; Folgeserie 29.VIII.2021: 17♂♂ + 20♀♀; Folgeserie 23.X.2021: 6♂♂ + 9♀♀; Folgeserie 16.XII.2021: 2♂♂ + 7♀♀; Folgeserie 18.II.2022: 2♀♀ + 1 Larve.

Probe 915 – Erstausswertung 30.VI.2021: 14♂♂ + 14♀♀ + 1 Larve; Folgeserie 6.VII.2021: 1♂ + 1♀ + 16 Larven; Folgeserie 18.VII.2021: 2♀♀ + 2 Larven; Folgeserie 29.VII.2021: 9♂♂ + 14♀♀; Folgeserie 9.VIII.2021: 20♂♂ + 14♀♀; Folgeserie 29.VIII.2021: 19♂♂ + 16♀♀ + 2 Larven; Folgeserie 23.X.2021: 7♂♂ + 10♀♀; Folgeserie 16.XII.2021: 4♂♂ + 5♀♀; Folgeserie 18.II.2022: 2♂♂ + 1♀ + 1 Larve.

Probe 916 – Erstausswertung 11.VII.2021: 14♂♂ + 2♀♀ + 14 Larven; Folgeserie 14.VII.2021: 2♂♂ + 3♀♀; Folgeserie 16.VII.2021: 8 Larven und 1 Puppe; Folgeserie 18.VII.2021: 6 Larven; Folgeserie 29.VII.2021: 14♂♂ + 15♀♀ + 3 Laven und 3 Puppen; Folgeserie 9.VIII.2021: 33♂♂ + 41♀♀ (davon 20♂♂ + 23♀♀ in Ethanol) + 4 Larven und 1 Puppe; Folgeserie 29.VIII.2021: 29♂♂ + 18♀♀ + 1 Larve; Folgeserie 23.X.2021: 10♂♂ + 13♀♀; Folgeserie 16. XII.2021: 3♂♂ + 7♀♀; Folgeserie 18.II.2022: 2♂♂ + 3♀♀.

Bis Mitte Februar 2022 waren dies beachtliche 518 Exemplare an adulten Tieren, die aussortiert wurden (259♂♂ + 259♀♀). Verteilt auf die einzelnen Proben sind dies für Nr. 914 156 Ex. (76♂♂ + 80♀♀), für Nr. 915 153 Ex. (76♂♂ + 77♀♀) und für Nr. 916 209 Ex. (107♂♂ + 102♀♀). Anfang September 2022 fanden sich aber immer noch lebende Tiere (Imagines und Larven) in allen Proben, obwohl die Substrate bereits völlig aufgebraucht schienen.

In der Probe des 27. Juni machten sich am 8. Juli 2021 erstmals Ei-Parasitoiden der Hymenopteren-Familie Mymaridae bemerkbar, die zweifelsohne die Eier von *Cis chinensis* parasitiert hatten. Von dieser Mymaridae der Gattung *Cleruchus* Enock, 1909 ist folgendes Material erhalten:

Probe 914 – Folgeserie 8.VII.2021: 8♂♂ geflügelt + 1♀ geflügelt † in Ethanol < 90% + 5♀♀ geflügelt † als Trockenpräparate; 9.VII.2021: 3♂♂ geflügelt und 1♂ apter + 17♀♀ geflügelt und 1♀ apter in Ethanol 75%; Folgeserie 18.VII.2021: 2♀♀ geflügelt (1 Ex. †) in Ethanol 75%; Folgeserie 26.VII.2021: 2♀♀ geflügelt † als Einschlusspräparate.

Probe 915 – Folgeserie 26.VII.2021: 1♀ geflügelt † als Einschlusspräparat.

Für die Einschlusspräparate verwendeten wir das Einbettungsmittel nach Lompe (1986).

Weitere Belege betreffen Hornmilben (Histiostomatidae), die sich als Wandernymphen (Deutonymphen) an Ciidae angeheftet hatten und den entsprechenden Individuen separiert beigelebt wurden. Ansonsten fanden sich nur in Probe 916 ganz vereinzelt noch andere Arthropoden.

Neben *Antrodia xantha* wurden noch eine Reihe weiterer Pilz-Fruchtkörper gesammelt. Näheres zu deren Auswertung im Abschnitt «Ciidae auf dem UPK-Campus und ihre Brutpilze».

Antrodia xantha als Brutpilz

Die Ende Juni und Mitte Juli 2021 im Therapiegarten des UPK-Campus vorgefundenen Fruchtkörper (Basidiocarpien) von *Antrodia xantha* (Fries 1815) Ryvarden 1973 überdeckten zusammenhängend eine Fläche von mehreren Quadratdezimetern unter der abgefallenen Rinde eines hüfthohen Föhren-Stammstücks (Fig. 1). Bei der Baumart handelt es sich um eine nordamerikanische Weymouths-Kiefer (*Pinus strobus*), die ehemals auf dem UPK-Campus wuchs und 2019 gefällt wurde (Auskünfte Thierry Muller, UPK).

Der lignicole, an Totholz lebende Pilz, wächst fast ausschliesslich auf Nadelhölzern, vorzugsweise auf *Pinus* und gehört zu den Braunfäuleerregern. An senkrechtem Substrat, an Stirnholz oder bei abgefallener Rinde bildet *Antrodia xantha* oft kleine, hufförmige, miteinander verwachsene Hütchen (forma *pachymeres*). Beim Wachstum der Fruchtkörper können offenbar auch Teile der Bast-schicht mitgeschleppt und umwachsen werden – besonders auffällig (in allen unseren Proben) waren 1½–2 mm lange, beidseits zugespitzte, normalerweise senkrecht ausgerich-tete Holzfasern, die wir zunächst nicht deuten konnten.

Beheimatet ist *Antrodia xantha* insbesondere in der Holarktis (meridional bis temperat), mit montaner Verbreitungstendenz (Krieglsteiner 2000). Bei Breitenbach and Kränzlin (1986) wird sie auch für die Schweiz aufgeführt und nach neueren Erhebungen als «nicht selten» eingestuft (SwissFungi – WSL), auch aus unserer Region war sie bereits vorher bekannt (P. Vlček).

Im Gegensatz zur häufigen Reihigen Tramete, *Antrodia serialis* (Fr.) Donk, ist *Antrodia xantha* eigentlich kein «Käferpilz». Bei der Auswertung von Untersuchungsergebnissen aus Finnland, wo die Art recht häufig vorkommt, konnte Schigel (2011) in ihr keine Käfer-Larven nachweisen. *Cis chinensis* hat sich bei uns jedoch problemlos in den Fruchtkörpern dieses Pilzes entwickeln können.

Cis chinensis und seine Entwicklung

Cis chinensis wurde von Lawrence 1991 nach Exemplaren, die 1988 mit Trockenpilzen («*Ganoderma lucidum*») aus China in die USA gelangten, beschrieben. Souza-Goncalves and Lopes-Andrade (2018) vermuten allerdings, dass es sich dabei um ein jüngeres Synonym von *Cis mikagensis* Nobuchi & Wada, 1955, handeln könnte. Da unseres Wissens bislang jedoch ein Typenvergleich unterblieben ist, behalten wir hier den für kosmopolitische Funde gebräuchlichen Namen *Cis chinensis* bei, immer jedoch mit einem Seitenblick auf *Cis mikagensis*.

Die Exemplare der Basler Population von *Cis chinensis* (Fig. 3 ♂, Fig. 4 ♀) sind von kräftiger Gestalt und zeigen mit Werten zwischen 1,6–2,4 mm eine ziemlich grosse Spannweite hinsichtlich ihrer Körpergrösse. Ihre dunkelbraune bis fast schwarze Körperfärbung scheint typisch für Freilandtiere und wurde bereits von Reibnitz anhand italienischer Exemplare aus dem Trentino festgestellt (Lohse and Reibnitz 1991). Der Vorderrand von Kopf

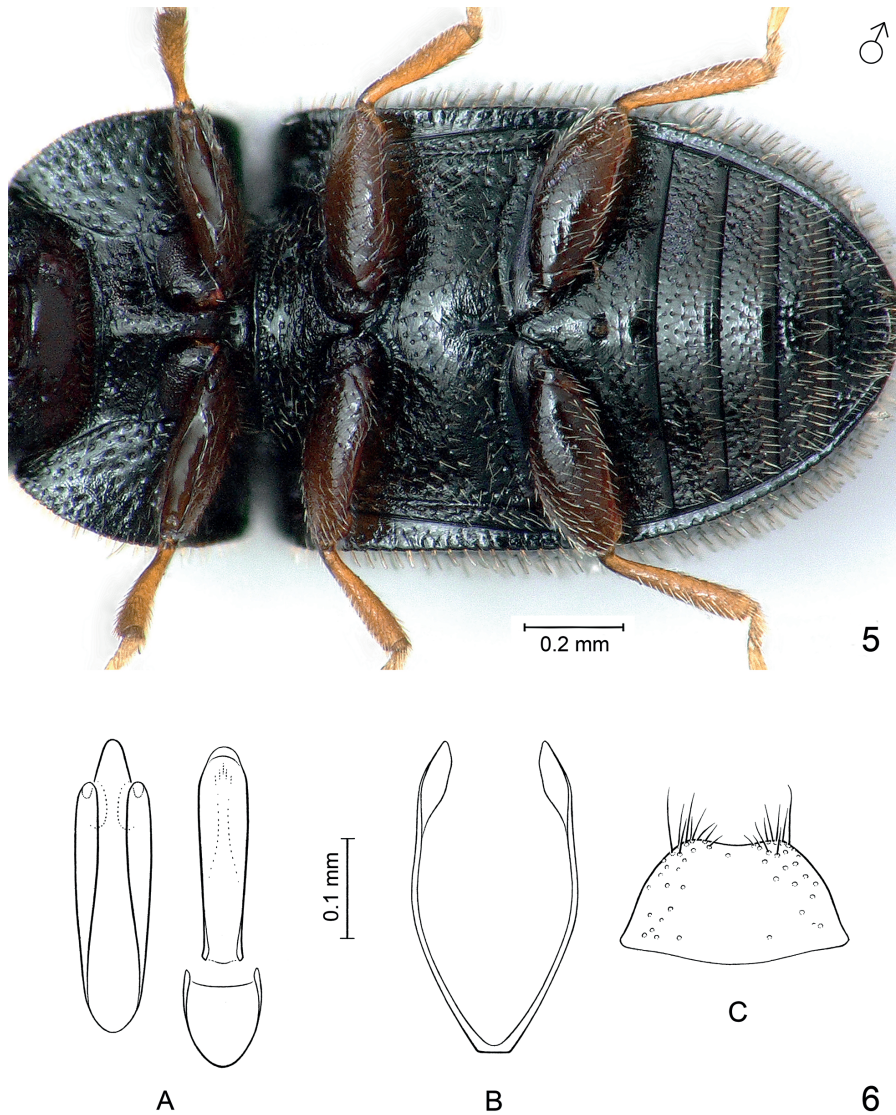


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Figures 3–4. Habitus von *Cis chinensis*. Grosse ♂ und ♀ aus Probe 915, Folgeserie vom 6.VII.2021. – Fotos: D. Burckhardt, 12.VII.2021, Nachbearbeitung: A. Coray.



Figures 5–6. ♂ von *Cis chinensis*. **5.** Ventralansicht mit nabelartiger Auszeichnung auf dem ersten Abdominalsternit. Foto: D. Burckhardt, 12.VII.2021, Nachbearbeitung: A. Coray. **6. A)** Genital in Dorsalansicht, separiert in Paramerenplatte, Penis und Basalplatte; **B)** spangenförmiges 9. Sternit; **C)** 8. Sternit. – Zeichnungen: A. Coray.

und Halsschild sind etwas aufgehellt rötlichbraun, auch die Flügeldecken zuweilen ein klein wenig heller als der Halsschild. Die Mundteile, die Beine und die 10-gliedrige Fühler sind gelblich- bis rötlichbraun gefärbt, die 3-gliedrige Fühlerkeule, oft etwas angedunkelt, besitzt die üblichen Sensillen zur Geruchswahrnehmung. Die Körperoberfläche ist fettglänzend und dicht mit etwas unregelmässig angeordneten Porenpunkten und gelbweissen Borstenhaaren besetzt. Der Abstand der Poren entspricht auf dem Halsschild \pm deren Durchmesser, während sie auf den Flügeldecken im Allgemeinen etwas weiter auseinander stehen, jedoch im Bereich um das Schildchen oft grösser sind und enger zusammenstehen, was dort auch zu einer leicht runzligen Oberfläche führen kann. Der Halsschild besitzt beidseits einen mässig breiten nach vorne verengten Rand, der von oben \pm auf ganzer Länge sichtbar bleibt und aussen ziemlich dicht mit langen Wimpernhaaren besetzt ist. Als einziger Unterschied zu *Cis mikagensis* wird von Lawrence (1991) angegeben, dass bei jener die Seitenränder des Pronotums von oben kaum sichtbar seien

(«only barely visible for their entire lengths from above»), bei Nobuchi (1955) heisst es dazu: «lateral margins not so hardly visible from above». Beim ♂ wird der Vorderrand des Pronotums von zwei kräftigen, winklig vorgezogenen, etwas hochgewölbten Fortsätzen gebildet. Bei besonders kleinen Exemplaren ist dieses Kennzeichen allerdings eher schwach ausgebildet. Beim ♀ ist der Vorderrand ebenfalls etwas hochwölbt aber in der Mitte höchstens unmerklich eingedellt. Besonders auffällig ist beim Männchen der 4-zackige Kopfvorderrand, der auch bei kleineren Exemplaren noch gut erkennbar ist. Beim ♀ ist dieses Kennzeichen hingegen nur schwach ausgebildet. Die Ventralseite ist bei beiden Geschlechtern deutlich weitläufiger mit Porenpunkten besetzt und behaart als die Dorsalseite. Das ♂ besitzt hier in der Mitte des 1. Sternits eine runde nabelförmige Auszeichnung («pubescent fovea») mit Pinselhaaren, die etwa das 2½-fache ihres Durchmessers von dessen hinterem Rand entfernt liegt (Fig. 5). Das männliche Genital ist dreiteilig (Fig. 6A). Es besteht aus einer länglichen, an den Längsseiten umgebogenen Parameren-

platte (Tegmen), in deren Längsrinne sich der eigentliche Penis (Median-Lobus) befindet und einem Sklerit an der Basis der Paramerenplatte (Basalplatte). Für genauere Untersuchungen muss der Penis herauspräpariert werden. Unsere schematisierende Darstellung entstand nach eingebetteten Genital-Präparaten und unter Zuhilfenahme einer mikroskopischen Aufnahme. Sie bewahrt dabei die natürliche Form der Paramerenplatte mit den umgebogenen Seitenlappen und ist deshalb nicht unbedingt mit den Abbildungen mikroskopischer Präparate in anderen Publikationen, welche die Seitenlappen seitlich ausgebreitet zeigen, vergleichbar. Das 9. Sternit ist bei den Ciidae zu einer schmalen Spange reduziert (Fig. 6B), während das 8. Sternit wieder ein gewohntes Aussehen aufweist (Fig. 6C).

Um eine Vorstellung von der Variation der Körpergrösse innerhalb der Basler Population zu erhalten, haben wir 121 Imagines aus einem Zeitraum von maximal drei Wochen nach der jeweiligen Proben-Entnahme gemessen. Wir erhielten danach folgende Ergebnisse (R = Spannweite (range), \bar{x} = arithmetisches Mittel, \tilde{x} = Median):

- ♂♂+♀♀ (n = 121): $R = 1,55\text{--}2,39$ mm ($\bar{x} = 2,12$ mm, $\tilde{x} = 2,15$ mm).
- ♂♂ (n = 67): $R = 1,76\text{--}2,33$ mm ($\bar{x} = 2,105$ mm, $\tilde{x} = 2,113$ mm).
- ♀♀ (n = 54): $R = 1,55\text{--}2,39$ mm ($\bar{x} = 2,135$ mm, $\tilde{x} = 2,183$ mm).
- ♂♂+♀♀ Proben 914+915 (n = 73): $R = 1,62\text{--}2,39$ mm ($\bar{x} = 2,094$ mm, $\tilde{x} = 2,113$ mm).
- ♂♂+♀♀ Proben 916 (n = 48): $R = 1,55\text{--}2,36$ mm ($\bar{x} = 2,156$ mm, $\tilde{x} = 2,213$ mm).

Lawrence (1991) gibt für seine Serie aus Trockenpilzen (n = 26) Werte von 1,68–2.17 mm an ($\bar{x} = 2.01$), Nobuchi (1955) für die Freilandfunde von *Cis mikagensis* an *Lenzites* sp. Werte von 1,7–2,5 mm.

Die Messwerte aller berücksichtigten *Cis chinensis* zeigen eine gegen höhere Werte leicht geneigte Normalverteilung. Nur 3.5% der Variabilität in der Körpergrösse konnte durch Sammeldatum und Geschlecht erklärt werden (Lineares Modell, $\beta_{\text{Sammeldatum}} = 0.065$, $\beta_{\text{Geschlecht}} = -0.036$, $F_{2,118} = 3.2$, P-Wert = 0.0446, $r^2 = 0.035$). Neben der Tatsache, dass die ♀♀ im Durchschnitt ein klein wenig grösser waren als die ♂♂, was sich jedoch als nicht signifikant erwies (post-hoc test P-Wert = 0.2008), fielen v. a. die doch deutlichen Unterschiede zwischen den Proben 914+915 – die an zwei aufeinanderfolgenden Tagen gesammelt und deshalb bei unserer Auswertung zusammengezogen wurden – und der zwei Wochen später gesammelten Probe 916 auf (Fig. 7). Dieser Befund erwies sich tatsächlich als signifikant (post-hoc test P-Wert = 0.0248).

Die Konservierung von Larven erlaubt uns eine knappe Beschreibung und Abbildung einer Alt-Larve von *Cis chinensis* (Fig. 8). Sie unterscheidet sich nicht gross von gewissen einheimischen Arten der Gattung *Cis* (siehe Rühm and Milewski 1996; Holter et al. 1999). Der Körper ist langgestreckt zylindrisch, von milchig-weisser Färbung. Die rundliche Kopfkapsel, das 9. und (etwas weniger aus-

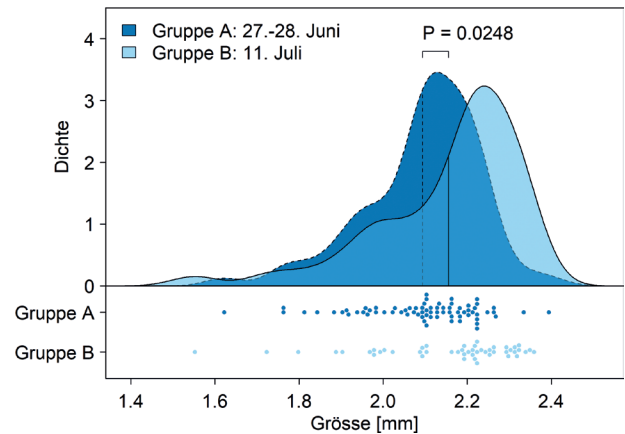
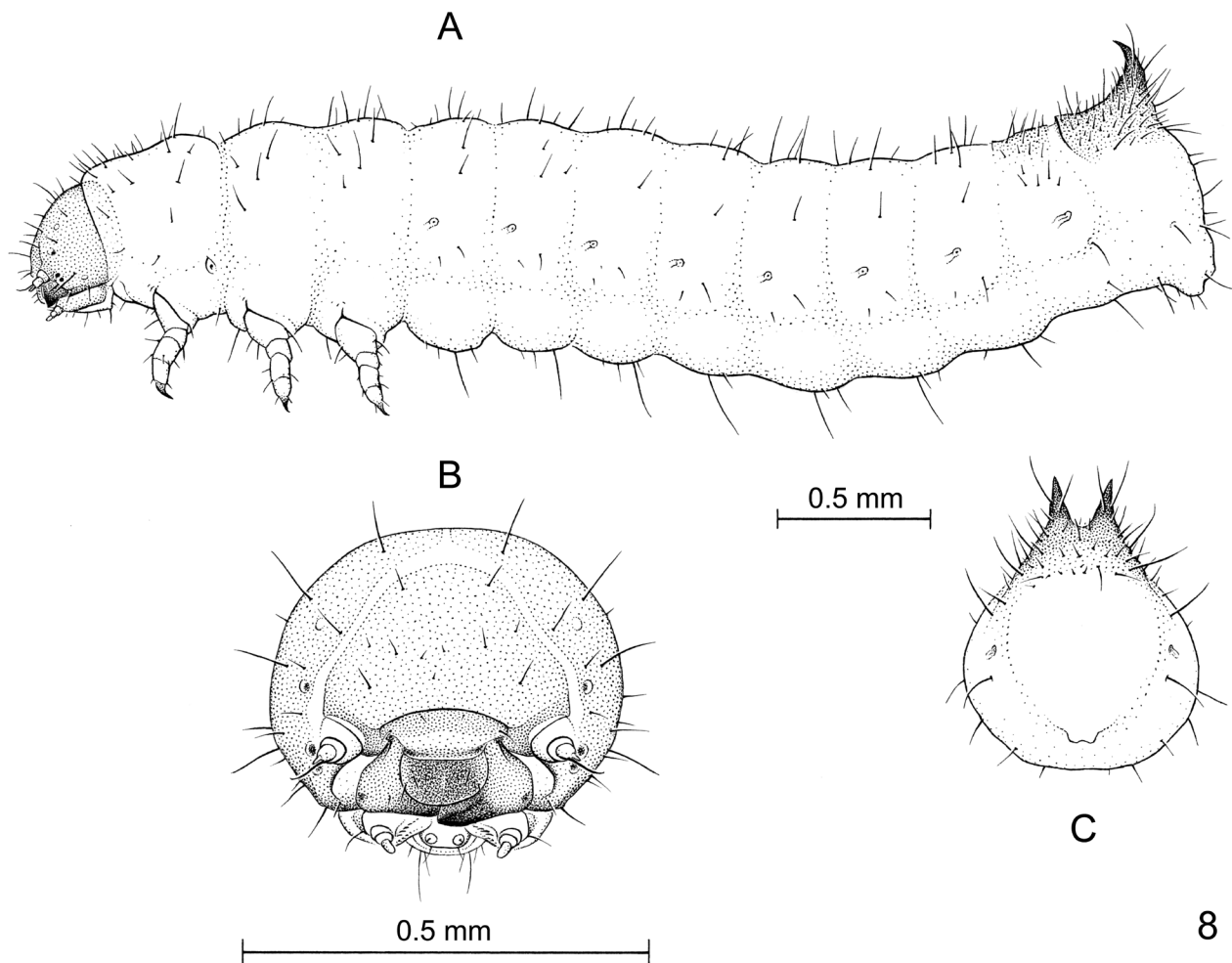


Figure 7. Dichtediagramm und Rohdaten als Punktwolken zur Verteilung der Körpergrössen der Imagines aus den drei Pilzproben, getrennt nach den Gruppen A (27. + 28. Juni) und B (11. Juli) – Grafik: D.A. Marques.

geprägt) das 8. Abdominaltergit sind stärker sklerotisiert, ± ockergelb; die derb dreieckigen Mandibeln sowie die beiden Urogomphi des 9. Tergits sind von dunkelbrauner bis schwarzbrauner Färbung. Stigmen finden sich beidseits lateral auf den Abdominalsegmenten 1–8, ein weiteres Stigmenpaar, etwas ventralwärts versetzt, zwischen dem 1. und 2. Thorakalsegment. Der ganze Körper ist unterschiedlich stark behaart. Einzelne der Haare sind recht lang, und es lassen sich gewisse Reihungen ausmachen. Die kurzen Beine sind gut entwickelt und ebenfalls spärlich behaart. Beidseits der Kopfkapsel befinden sich je 5 annähernd gleichgrosse Stemmata (Augenpunkte), von denen jedoch nur 3 pigmentiert sind: zwei eng beieinander nahe der Antennenbasis und das unmittelbar darüber liegende (Fig. 8A, B). Von den beiden unpigmentierten Stemmata liegt das eine direkt oberhalb der pigmentierten, das andere recht tief hinten platziert. Ihre Positionen heben sich als rundlichmilchig-weiße Flecken von der hell-ockergelben Grundfärbung ab. Besonders die Position des hinteren Stemmas ist nur sehr schwer zu eruieren. Die kurzen Antennen sind zweigliedrig. Das zweite Antennenglied erscheint gegabelt, trägt auf der Innenseite ein langes, haarförmiges Sensorium trichodeum und ist auf der Aussenseite in einen stumpfen dornförmigen Fortsatz verlängert (Fig. 8B). Wichtige diagnostische Merkmale liefern speziell die Gestalt und Lage der Urogomphi. Diese sind kräftig, leicht nach vorne gekrümmt und stehen an der Basis um etwa die Basisbreite eines Urogomphus auseinander. Von hinten gesehen ist der Einschnitt ± V-förmig (Fig. 8C), d. h. die Urogomphi divergieren, zusammen mit dem 9. Tergit sind sie bei *Cis chinensis* recht stark behaart. Im Vergleich mit einheimischen Arten (siehe Holter et al. 1999) ergeben sich summarisch die grössten Ähnlichkeiten mit der Gruppe um *Cis boleti*, wobei *Cis chinensis* im Gegensatz zu diesen lediglich 3 pigmentierte Stemmata aufweist, auch sind die Urogomphi nur etwa 2× so lang wie an der Basis breit (nicht 2,5×).

Um die Anzahl der Stadien festzustellen haben wir an aussortierten Larven von *Cis chinensis* in Ethanol Messungen der Kopfkapsellänge und der Gesamtlänge durchgeführt. Die überwiegende Zahl derselben stammt vom Juli 2021.



8

Figure 8. Altlarve von *Cis chinensis*. **A)** Gesamtansicht lateral; **B)** Kopf frontal; **C)** Urogomphi apikal. Zeichnungen: A. Coray.

Die Anzahl gemessener Larven ($n = 37$, bzw. $n = 16$ bei den Proben 914+915 und $n = 21$ bei Probe 916) war allerdings nicht wirklich ausreichend, um zu einem eindeutigen Resultat zu gelangen. Sicher identifizieren liessen sich das erste und die beiden letzten Stadien, das zweitletzte anhand eines Exemplars kurz vor der letzten Larvalhäutung, die sich im Körper bereits abzeichnete. Trotz gewisser Vorbehalte geben wir nachfolgend eine Table unserer Messwerte unter der Prämisse von fünf Larvenstadien, wobei wir problematische Zuordnungen in Klammern setzen (Table 1).

Table 1. Messwerte der Larvenstadien von *Cis chinensis*.

Stadium	Anzahl Messungen	Kopfkapsellänge	Gesamtlänge
L1	$n = 2$ (3)	0,14–0,16 (–0,19) mm	1,11–1,32 (–1,78) mm
L2	$n = 7$ (6)	(0,19) 0,21–0,24 mm	1,55–2,25 mm
L3	$n = 6$	0,26–0,30 mm	1,77–3,07 mm
L4	$n = 15$	(0,31) 0,33–0,38 mm	2,49–4,06 mm
L5	$n = 7$	0,39–0,43 mm	3,22–4,64 mm

Eine *Cleruchus*-Art als Gegenspieler

Die überwiegende Zahl der aus den Eiern von *Cis chinensis* geschlüpften Zwergwespen (Mymaridae) war geflügelt (Fig. 9), jedoch fanden sich auch je 1♂ und 1♀ einer ungeflügelten Morphe der mutmasslich gleichen Art. Mit

dem Bestimmungsschlüssel von Samková et al. (2020) liessen sich unsere Exemplare bis zur Gattung *Cleruchus* determinieren. Für die Art-Bestimmung verwendeten wir danach den Schlüssel für die paläarktischen *Cleruchus*-Arten von Triapitsyn (2014), wobei es aber nicht gelang unsere Exemplare einer bestimmten Art zuzuordnen. Uns fiel auf, dass die ♀♀, verglichen mit ähnlichen Arten, verhältnismässig kurze Fühlerkeulen besitzen. Wir schickten deshalb unser Ethanol-Material zur Bearbeitung an Serguei V. Triapitsyn von der University of California, Riverside, und es hat sich nun herausgestellt, dass wir mit einer neuen Art konfrontiert wurden, siehe die nachfolgende Arbeit von Triapitsyn et al. (2022).

Die neue Art kommt auch im Gebirge vor. Während eines Besuchs in Basel (27. Mai 2022) konnte Serguei V. Triapitsyn bei der Überprüfung von Teilen des Ethanol-Materials aus dem «Pilz-Projekt» weitere Exemplare an *Stereum*-Arten aus dem Süd-Schwarzwald (Deutschland) und dem Zentralen Kettenjura (Schweiz) identifizieren:

(Probe 517) Deutschland, Baden-Württemberg, Zell im Wiesental, Pfaffenberg, Käserner Tannen, 860 m. Koord.: 47°43'58.6"N, 7°51'34.4"E. Nische: *Stereum sanguinolentum* (Alb. & Schw.) Fr. an *Abies alba*. 21.V.2014. – 1♀ vom 6.VII.2014.

(Probe 661) Schweiz, Kanton Basel-Landschaft, Nenzlingen, Uff Egg, 654 m. Koord.: 47°27'23.2"N,

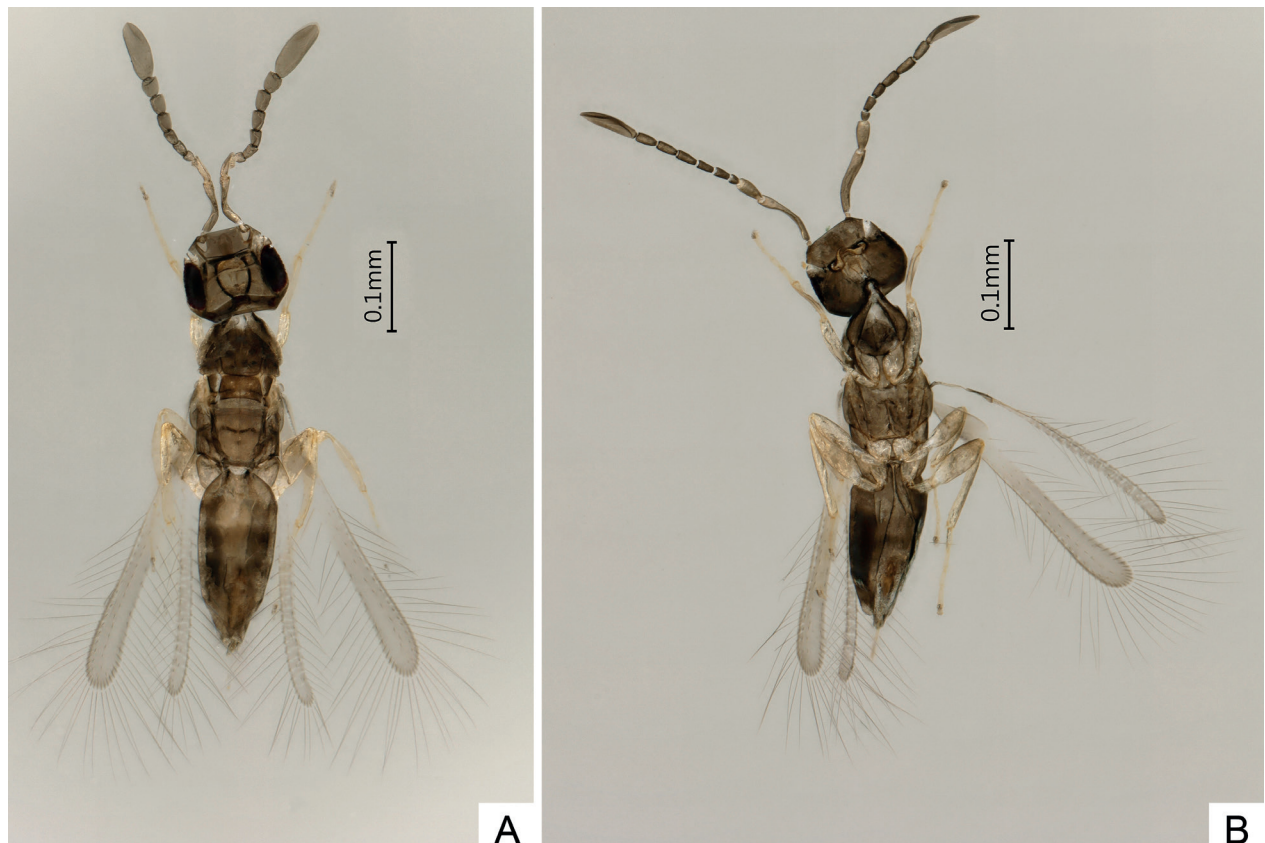


Figure 9. Geflügelte ♀♀ der neuen *Cleruchus*-Art. **A)** Exemplar in Dorsalansicht, Totfund vom 26.VII. 2021 aus Probe 914; **B)** Exemplar in Ventralansicht, einziger Totfund aus Probe 915 vom 26.VII.2021. Fotos: M. Borer, 24.VIII.2021, Nachbearbeitung: A. Coray.

7°33'42.9"E. Nische: *Stereum hirsutum* (Willd.) Pers. an *Fagus sylvatica*. 3.IX.2016. – 1♀ vom 4.IX.2016.

Auf Basidiocarprien von *Stereum*-Arten hat sich eine kleine Gruppe von Ciidae spezialisiert, die als Opfer in Frage kommen. In den erwähnten Proben (Nr. 517 und Nr. 661) konnten Exemplare von *Cis festivus* (Panzer, 1793) nachgewiesen werden.

Phoretische Milben mit *Cis chinensis* als Tragwirt

An mycetobionten Käfern lassen sich immer wieder auch Milben feststellen, wir können uns jedoch nicht entsinnen, jemals einen derart starken Befall an Ciidae gesehen zu haben, wie an den *Cis chinensis* der *Antrodia xantha*-Proben. Der weitaus überwiegende Teil der in den ersten 1½ Wochen aussortierten Käfer, war nämlich durch knapp 0,2 mm grosse dorso-ventral abgeplattete Deutonymphen besetzt, die sich fast ausschliesslich auf der Ventralseite befanden – in der Analgegend besitzen diese Haftscheiben zum Anheften an die glatte Kutikula ihre Transporttiere.

Wir vermuten, dass es sich um Hornmilben (Oribatida s.l. [Astigmatina]) der Familie Histiostomatidae handelt; bei deren Deutonymphen ist das 3. und 4. Beinpaar an einem Trochanter-Femur-Gelenk gebeugt und in Transportstellung deutlich nach vorne gerichtet (Wirth 2004). Die Art oder auch nur die Gattung konnten wir nicht näher

bestimmen, da die Belege nur in trockenem Zustand vorliegen. Die Resultate zeigt Table 2.

Table 2. Milbenbefall bei *Cis chinensis*-Individuen.

Probe	Käfer				Total	Milben			
	1. Auswertung		2. Auswertung			Befall und Anzahl			
	Datum	Anzahl	Datum	Anzahl		befallen	%	R	Ø
914	28.VI.	24	08.VII.	1	25	17	68%	0-11	2,36
915	30.VI.	28	06.VII.	2	30	24	80%	0-11	2,17
916	11.VII.	16	14.VII.	5	21	21	100%	4-31	11,90

Der weitaus überwiegende Teil der Milben wurde bereits bei der Erstausswertung festgestellt. Extrem stark (100%) war der Besatz mit Milben bei den Exemplaren der Probe 916. Im Pilzsubstrat der Proben konnten erstaunlicherweise keinerlei Milben nachgewiesen werden, und auch die später (gegen Mitte/Ende Juli 2021) aussortierten Ciidae-Imagines waren dann vollkommen milbenfrei.

Ciidae auf dem UPK-Campus und ihre Brutpilze

Da wir wissen wollten, ob *Cis chinensis* nicht bereits andere Baumpilze auf dem UPK-Campus besiedeln konnte, entnahmen wir dort, neben einer zusätzlichen Probe von *Antrodia xantha* (Nr. 960), zwischen Januar und März 2022 noch einige weitere

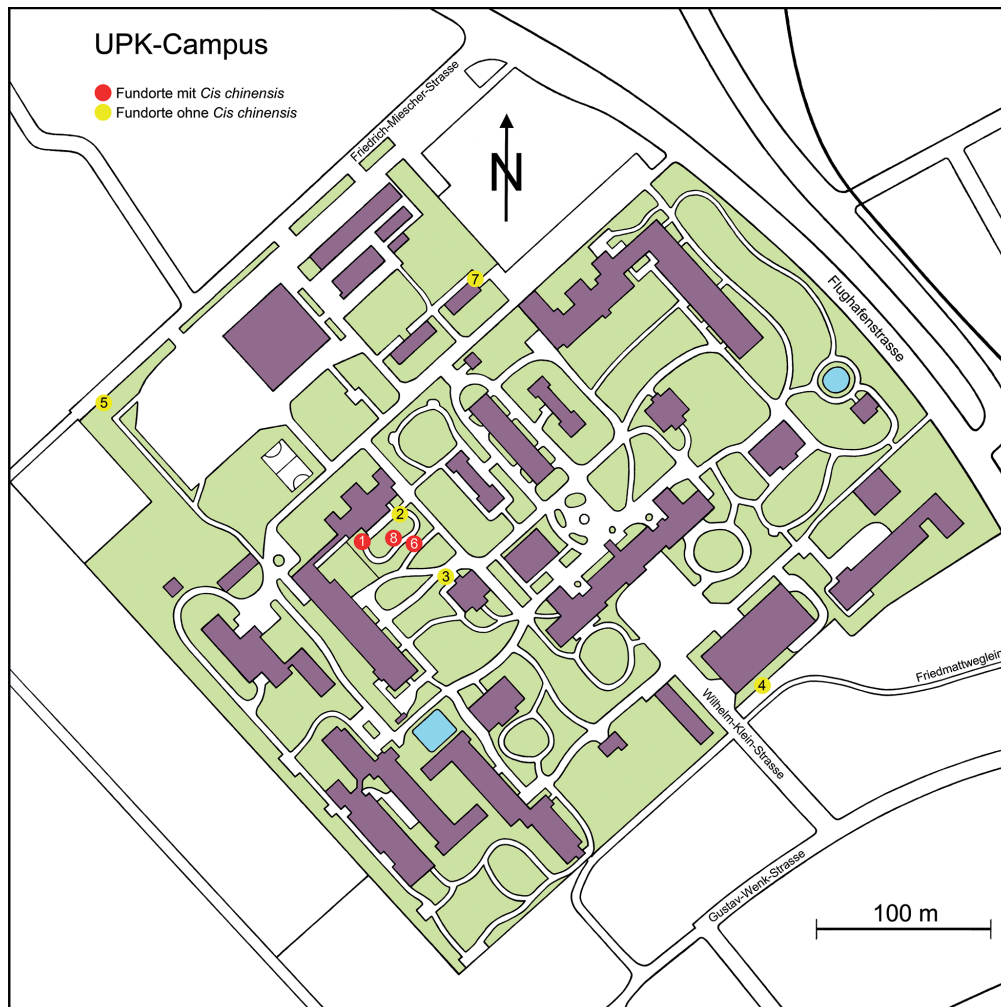


Figure 10. Lageplan der Universitären Psychiatrischen Kliniken Basel (UPK-Campus), ohne umgebende Überbauungen, mit den Fundorten der 2021–22 gesammelten Pilzproben. Rote Punkte bezeichnen Fundorte mit Nachweisen von *Cis chinensis*, wobei der Fundort 1 die Kernpopulation in *Antrodia xantha* im Therapiegarten bezeichnet. – Zeichnung: A. Coray (unter Verwendung des UPK-Lageplans, modifiziert).

Pilzproben (Nr. 959, 961–966, 968–969). Zwar hatten wir schon am 11. Juli 2021 auch andere Pilze gesammelt (Nr. 917–920), diese enthielten jedoch ausschliesslich einheimische Ciidae.

Alle gesammelten Pilz-Proben verzeichnet nachfolgende Liste. Einige der aufgelisteten Fundorte wurden mehrmals aufgesucht, wobei dort zum Teil auch verschiedene Arten entnommen wurden. Nummeriert sind die Fundorte nach dem Erstbesuch, die Positionen derselben sind aus der beigefügten Karte (Fig. 10) ersichtlich:

Fundort 1

- Nr. 914: *Antrodia xantha* (Fr.) Ryv. (27.06.2021)
- Nr. 915: *Antrodia xantha* (Fr.) Ryv. (28.06.2021)
- Nr. 916: *Antrodia xantha* (Fr.) Ryv. (11.07.2021)
- Nr. 960: *Antrodia xantha* (Fr.) Ryv. (16.01.2022)

Fundort 2

- Nr. 917: *Corioloopsis gallica* (Fr.) Ryv. (11.07.2021)
- Nr. 964: *Corioloopsis gallica* (Fr.) Ryv. (09.02.2022)

Fundort 3

- Nr. 918: resupinater Porling [unbestimmt] (11.07.2021)
- Nr. 969: *Stereum hirsutum* (Willd.) Pers. (12.03.2022)

Fundort 4

- Nr. 919: *Trametes hirsuta* (Wulf.) Lloyd (11.07.2021)
- Nr. 920: *Schizophyllum commune* Fr. (11.07.2021)

Fundort 5

- Nr. 959: *Inonotus cuticularis* (Bull.) P. Karst. (16.01.2022)

Fundort 6

- Nr. 961: *Meripilus giganteus* (Pers.) P. Karst. (16.01.2022)
- Nr. 963: *Pleurotus ostreatus* (Jacq.) P. Kumm. (09.02.2022)
- Nr. 968: *Meripilus giganteus* (Pers.) P. Karst. (12.03.2022)

Fundort 7

- Nr. 962: *Trametes versicolor* (L.) Lloyd (16.01.2021)
- Nr. 965: *Trametes* cf. *versicolor* (09.02.2022)

Fundort 8

- Nr. 966: *Schizophyllum commune* Fr. (09.02.2022)

Nicht in allen der gesammelten Proben fanden sich Ciidae. Table 3 verzeichnet die Ciidae-Arten, die wir nachweisen konnten.

Table 3. Liste der Ciidae-Arten des UPK-Campus.

Art	Proben-Nr.	Anmerkungen
<i>Octotemnus glabriculus</i> (Gyllenhal, 1827)	962	
<i>Ropalodontus novorossicus</i> Reitter, 1901	917	
<i>Sulcaxis nitidus</i> (Fabricius, 1792)	919	
<i>Sulcaxis fronticornis</i> (Panzer, 1805)	919, 962, 965	
<i>Cis chinensis</i> Lawrence 1991	914, 915, 916, 960, 961, 963, 966	961 = 1 Larve, 963 = 1 ♀ + Zucht, 966 = 1 ♀ + 2 ♂♂ (†) + Zucht
<i>Cis comptus</i> Gyllenhal, 1827	917, 919, 964	
<i>Cis fusciclavus</i> Nyholm, 1953	968	
<i>Cis micans</i> (Fabricius, 1792)	919	
<i>Cis villosulus</i> (Marsham, 1802)	919, 920, 965	920 = Einzelfund
<i>Cis boleti</i> (Scopoli, 1763)	962	Einzelfund
<i>Orthocis reflexicollis</i> (Abeille de Perrin, 1874)	920, 966	

Gesamthaft wurden 11 Ciidae-Arten auf dem UPK-Campus und dessen unmittelbarer Umgebung (Fundort 4) festgestellt. *Ropalodontus novorossicus* und *Orthocis reflexicollis* sind dabei als einzige Arten monophag an *Corioloopsis gallica* respektive *Schizophyllum commune*. Normalerweise sind v. a. an *Schizophyllum commune*-Fruchtkörpern keine anderen Ciidae zu erwarten; bei der Erstauswertung der Probe Nr. 966 fanden sich jedoch, neben *Orthocis reflexicollis*, auch Exemplare von *Cis chinensis*, darunter auch ein lebendes ♀. Lopes-Andrade (2008) konnte die Art in *Schizophyllum commune* züchten, was nun auch uns gelang. Bis Mitte April 2022 liessen sich zwar nur *Orthocis reflexicollis*-Imagines feststellen, im Laufe des Sommers wurden die Fruchtkörper des Pilzes jedoch vollständig von *Cis chinensis* okkupiert und schliesslich nahezu völlig zersetzt. Danach machten sich die Larven und Imagines gar über die purpurbraunen kugeligen Fruchtkörper einer kleinen *Hypoxylo-*Art her, die zufällig mit der Pilzprobe mitgekommen waren. *Hypoxylo-* gehört aber zu den Schlauchpilzen (Ascomycota), mit denen Ciidae normalerweise nichts anzufangen wissen. Bis Anfang September 2022 konnten wir 264 Imagines und mehrere Dutzend Larven von *Cis chinensis* aussortieren – von *Orthocis reflexicollis* war hingegen keine Spur mehr vorhanden. Auch aus den Fruchtkörpern von *Pleurotus ostreatus* (Nr. 963) gingen, nach einem ursprünglichen ♀-Fund von *Cis chinensis*, schliesslich 45 Imagines und mehrere Larven hervor. Zu erwähnen ist schliesslich noch das Einzelexemplar einer mutmasslichen Larve von *Cis chinensis* (4. Stadium: Kopfkapsel = 0,35 mm) in *Meripilus giganteus* (Nr. 961). Leider haben jedoch die Ausdünstungen des Pilzes im verschlossenen Quickbeutel sämtliche darin befindlichen Wirbellosen (überwiegend Diptera-Larven) abgetötet, wir zögern deshalb *Merulipes giganteus* als weiteren Brutpilz von *Cis chinensis* aufzuführen. Eine zusätzliche Probe dieses Pilzes (Nr. 968) erbrachte keine Bestätigung. Alle Nachweise von *Cis chinensis* ausserhalb des Fundortes von *Antrodia xantha* (Fundort 1) fanden sich noch im Therapiegarten (Fundort 8) oder dessen unmittelbarer Nähe (Fundort 6), also weniger als 40 m vom vermuteten Ausgangspunkt entfernt (Fig. 10).

Diskussion

In urbaner Umgebung, insbesondere in Gärten und Parklandschaften, können sich immer wieder fremdländische Insekten ansiedeln. Begünstigt wird dies durch die zunehmende Mobilität und die weltweiten Handelsbeziehungen des Menschen, bei denen es nicht selten zu ungewollter Verschleppung oder auch bewusster Aussetzung gebietsfremder Arten und damit zur Störung etablierter Ökosysteme kommen kann. Ausgehend vor allem von Siedlungsräumen und insbesondere urbanen Zentren können sich solche Arten allmählich ausbreiten, etablieren und zu invasiven Arten werden, verbunden mit der Verdrängung einheimischer Arten und mit wirtschaftlichen oder ökologischen Schäden (Baur 2021). Dass *Cis chinensis* durchaus über bemerkenswerte Fähigkeiten verfügt, demonstriert nicht nur dessen ungewöhnlich breites Brutpilz-Spektrum, sondern auch die Verdrängung von *Orthocis reflexicollis* aus unserer *Schizophyllum commune*-Probe Nr. 966.

Die Frage nach dem Einschleppungsweg von *Cis chinensis* können wir nicht beantworten, da es sich hier um einen Freilandfund handelt. Am plausibelsten erscheint die Einschleppung mit kontaminierten Waren, beispielsweise mit Trockenpilzen aus Südost-Asien. Jedenfalls besiedelt die Art gewiss nicht erst seit 2021 das UPK-Areal, dafür ist die Population an *Antrodia xantha* viel zu gross – sie dürfte damals schätzungsweise mehrere Tausend Individuen umfasst haben. Unser Fund ist auch nicht der erste Schweizer Nachweis: Alexander Szallies konnte die Art bereits 2020 auf dem Areal des SBB-Bahnhofs Basel in Flugfallen feststellen, ohne sie wirklich bestimmen zu können (A. Szallies in litt., 2021) – ein Fingerzeig, dass sich die Art schon damals in unserer Gegend aufhielt.

Die eigentliche Heimat dieser asiatischen Art ist unbekannt, inzwischen ist sie jedoch nahezu weltweit verbreitet (nähere Angaben hierzu bei Souza-Gonçalves & Lopes-Andrade 2018). Beim ältesten bekannten Nachweis aus Europa handelt es sich um Freilandfunde aus Italien von 1978 (Lohse and Reibnitz 1991 – fehlbestimmt als *Cis multidentatus*), gefolgt 1990 von Funden aus Deutschland (in Tofu [!], siehe Lohse and Reibnitz 1991; bzw. Reibnitz and Kunz 2011) und 1998 aus Frankreich (Rose 2009), es folgten 2000 Malta (Lopes-Andrade 2008), 2010 Spanien (Dieguez Fernández 2013) und 2013 Ungarn (Németh et

Table 4. Brutpilze von *Cis chinensis* (C) und *Cis mikagensis* (M).

Brutpilz (Art und Familie)	Gast	Literatur
<i>Agaricus</i> sp. (Agaricaceae)	C	Németh et al. 2017
<i>Antrodia xantha</i> (Fr.) Ryv. (Fomitopsidaceae)	C	Coray et al. 2022
<i>Armillaria mellea</i> (Vahl) P. Kumm. (Physalacriaceae)	M	Jung 2013
<i>Coprinus</i> sp. (Agaricaceae)	C	Németh et al. 2017
<i>Daedaleopsis confragosa</i> (Bolton) J. Schroet. (Polyporaceae)	M	Jung 2013
<i>Daedaleopsis nitida</i> (Durieu et Mout.) Zmitr. et Malysheva (Polyporaceae)	C	Rose 2012
<i>Fomitopsis pinicola</i> (Sw.) P. Karst. (Fomitopsidaceae)	C	Rose 2009
<i>Ganoderma applanatum</i> (Pers.) Pat. (Ganodermataceae) [= <i>Ganoderma lipsiense</i> (Batsch) G. F. Atk.]	M	Jung 2013
« <i>Ganoderma lucidum</i> » (Ganodermataceae)	C	Lawrence 1991; Lohse and Reibnitz 1991; Madenjian et al. 1993; Jinachai et al. 2002; Rose 2009; Lawrence 2016
<i>Ganoderma neojaponicum</i> Imazeki (Ganodermataceae)	M	Kawanabe 1998 [Zucht]
<i>Gloeophyllum abietinum</i> (Bull.) P. Karst. (Gloeophyllaceae)	C	Rose 2012
<i>Gloeophyllum subferrugineum</i> (Berk.) Bond. et Sing. (Gloeophyllaceae)	M	Kawanabe 1996 [Zucht]
<i>Hericium erinaceus</i> (Bull.) Pers. (Heriaceae)	M	Jung 2013
<i>Lactarius</i> sp. (Russulaceae)	C	Németh et al. 2017
<i>Lenzites</i> sp. (Polyporaceae)	M	Nobuchi 1955 [2 Zuchten]
<i>Pholiota aurivella</i> (Batsch) P. Kumm. (Strophariaceae)	M	Jung 2013 [Zucht]
<i>Pleurotus ostreatus</i> (Jacq.) P. Kumm. (Pleurotaceae)	C	Németh et al. 2017; Coray et al. 2022 [Zucht]
<i>Russula</i> sp. (Russulaceae)	C	Németh et al. 2017
<i>Schizophyllum commune</i> Fr. (Schizophyllaceae)	C	Lopes-Andrade 2008 [Zucht]; Coray et al. 2022 [Zucht]
<i>Trametes</i> sp. (Polyporaceae)	C	Lohse and Reibnitz 1991 [Zucht]
<i>Trametes gibbosa</i> (Pers.) Fr. (Polyporaceae)	C	Rose and Zagatti 2016

al. 2017). Der nächstgelegene, uns bekannte Fundort liegt etwa 110 km nördlich von Basel im Rheinhafen von Kehl in Südbaden (Reibnitz and Kunz 2011). Es ist durchaus bezeichnend, wenn man gebietsfremde Arten zuerst in der Umgebung von Warenumschlagsplätzen findet.

Hinsichtlich der Wahl von Brutpilzen ist *Cis chinensis* nicht sehr wählerisch, dies gilt im Übrigen auch für *Cis mikagensis*. Sie besiedeln beide ein ungewöhnlich breites Spektrum recht unterschiedlicher Pilzfruchtkörper. Unsere diesbezügliche Zusammenstellung (Table 4) basiert primär auf den Angaben in Souza-Gonçalves and Lopes-Andrade (2018) und integriert auch unsere eigenen Ergebnisse.

Die meisten durch sie befallenen Pilze besitzen ± konsolenförmige Fruchtkörper – *Antrodia xantha* fällt hier durch ihre grossflächig-zusammenhängende, effuso-reflexe Wuchsform etwas aus dem Rahmen –, jedoch sind auch solche mit klassischer Hutform darunter. Die Liste enthält also nicht nur die klassischen Holzpilze der Ordnung Polyporales, sondern auch einige an Holz wachsende Vertreter aus den Ordnungen Agaricales (Champignonartige) und Russulales (Täublingsartige). Auffällig ist auch die mehrfache Erwähnung des Glänzenden Lackporlings (*Ganoderma lucidum*), einer eigentlich europäischen Art. Dieser ist jedoch nicht identisch mit dem echten Ling Zhi (China), dem Reishi (Japan) oder dem Jong si (Korea), die wohl eigentlich gemeint sind. Es sind dies Heilpilze, die in der Traditionellen Asiatischen Medizin breite Anwendung finden und eine grosse kommerzielle Bedeutung besitzen.

Über die Entwicklungsdauer von *Cis chinensis* (Ei – Imago) konnten wir in der Literatur keine Angaben finden. Für andere Ciidae-Arten werden etwa 8 Wochen, also weniger als 2 Monate angegeben (Madenjian et al. 1993). Diese Angaben beruhen jedoch auf Zuchten, im Freiland dürfte die Entwicklungsdauer etwas länger sein, aber kaum mehr als 3–4 Monate.

Im Frühling/Sommer 2021 waren die Entwicklungsbedingungen in unserer Region ziemlich unterschiedlich: In den Monaten April und Mai war es überwiegend nass und kalt, wohingegen der Juni 2021 sich als fünftwärmster seit Aufzeichnung der Basler Messreihe im Jahre 1755 erwies (nach den Daten der lokalen Messstation Basel-Binningen). Der April war zwar etwas niederschlagsarm, die Monate Mai, Juni und speziell auch der Juli (im 2. Monatsdrittel) – was freilich keine Auswirkungen mehr auf unsere Proben hatte – dagegen überdurchschnittlich regenreich (Werner 2021a–d). Förderlich für die Entwicklung dürften primär die aussergewöhnlich hohen Durchschnittstemperaturen im Juni gewesen sein, von denen besonders die Larven aus Probe 916 profitierten. Dies mag auch erklären, weshalb deren Imagines durchschnittlich signifikant höhere Werte bei der Körpergrösse aufweisen als jene aus den Proben 914+915 (siehe Fig. 7) und unterstreicht die Dynamik der Ontogenese.

Unser Versuch die Anzahl der Larvenstadien von *Cis chinensis* festzustellen, blieb unbefriedigend. Aufgrund der geringen Menge an Larven ($n = 37$) waren wir gezwungen die Exemplare beider Serien zusammenzuziehen. Dies mag die etwas verwirrenden Messresultate, insbesondere bei den späten Stadien, erklären, wenn man bedenkt, dass die zweite Serie unter günstigeren Bedingungen aufwachsen konnte. Die «Signatur», die wir bei unserer Datenanalyse erhielten, deutet zwar am ehesten auf fünf Larvenstadien, denkbar wären teilweise aber auch bloss vier – hingewiesen sei hier auf die grosse Spannweite bei der Körpergrösse der Imagines.

Die hohe Abundanz an adulten Exemplaren von *Cis chinensis* in Kombination mit den Witterungsbedingungen, die sich Ende Juni/Anfang Juli 2021 eingestellt hatten, könnten auch erklären, weshalb sich damals so viele phoretische Milben auf den Ciidae befanden. Vielleicht war dies für sie

ein Zeichen einer beginnenden Schwärmpphase. Eine Metamorphose zum Wandernymphenstadium erfolgt aufgrund bestimmter Umweltreize (meist Nahrungs- oder Wassermangel), die Nymphen suchen dann aktiv einen Tragwirt.

Das Auffinden der neuen *Cleruchus*-Art als Eiparasitoid von *Cis chinensis* war ein willkommener Nebeneffekt, denn von den meisten *Cleruchus*-Arten ist der eigentliche Wirt ja unbekannt, wenngleich sich einige in Baumpilzen fanden, die vorzugsweise von Ciidae besiedelt waren. Nach vorläufigen Befunden kommt die neue *Cleruchus*-Art in überwiegend resupinat (flächig dem Substrat aufliegend) oder halbresupinat wachsenden Fruchtkörpern vor (*Antrodia xantha* und *Stereum*-Arten), während man andere Arten in Baumpilzen mit konsolenförmigen Basidiocarprien findet; zu nennen wären hier *Cleruchus pieloui* (Yashimoto, 1971), *Cleruchus puchus* Triapitsyn, 2008, *Cleruchus polypori* Trapitsyn & Moraal, 2008 und *Cleruchus kivach* Triapitsyn, 2014. Wir vermuten, dass der Fruchtkörper-Typ, den die verschiedenen *Cleruchus*-Arten aufsuchen, neben olfaktorischen Kennzeichen, ein wichtiges Auswahlkriterium darstellen könnte.

Danksagung

Den Universitären Psychiatrischen Kliniken Basel, namentlich Verena Winkler (Medizinisch-Therapeutische Dienste), Thierry Muller (Gärtnerei, Teamleiter) und Dieter Deiss (Leiter Bau- und Facility Management), danken wir für Hintergrundinformationen und für die Bewilligung von Pilz-Entnahmen. Daniel Burckhardt und Matthias Borer vom Naturhistorischen Museum Basel danken wir für hilfreiche Diskussionen und die Unterstützung bei den Makroaufnahmen. Informationen und Literatur lieferten uns Johannes Reibnitz (D-Tamm), Hannes Baur (Naturhistorisches Museum Bern), Patrizia Gamarra (Bibliothekarinnen des Naturhistorischen Museums Basel), Henryk Luka (FiBL, CH-Frick), Alexander Szallies (Zürcher Hochschule für Angewandte Wissenschaften, CH-Wädenswil), und John T. Huber (Canadian Forest Service, Ottawa), der auch den Kontakt zu Serguei V. Triapitsyn (Entomology Research Museum, University of California, Riverside) vermittelte. Thomas Brodtbeck (CH-Riehen / BS) und Markus Wilhelm (CH-Allschwil / BL) vom Verein für Pilzkunde Basel danken wir für mykologische Hinweise, den Revisoren für ihre kritischen Anmerkungen und Christoph Germann (Naturhistorisches Museum Basel) für seine Hilfeleistung beim Einreichen des Manuskripts.

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A new species of *Cleruchus* (Hymenoptera, Mymaridae), an egg parasitoid of the invasive *Cis chinensis* (Coleoptera, Ciidae) in Switzerland, with new records of other congeners in Europe

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<https://zoobank.org/790BEA60-9D12-465E-A11D-7D8E6DE844E5>

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Academic editor: Andreas Müller ♦ Received 21 May 2022 ♦ Accepted 1 November 2022 ♦ Published 18 November 2022

Abstract

A fairyfly (Hymenoptera, Mymaridae) *Cleruchus breviclava* Triapitsyn & Coray, **sp. nov.** is described and illustrated. The new species is an egg parasitoid of the invasive *Cis chinensis* Lawrence (Coleoptera, Ciidae) in *Antrodia xantha* fungus (Polyporales, Fomitopsidaceae) in Basel, Switzerland; it is also known from low mountains in Germany and Switzerland. Supporting data on the “barcoding” region of the mitochondrial cytochrome c oxidase subunit I gene, as well as separate regions of nuclear ribosomal RNA, the D2 region of 28S and the internal transcribed spacer 2, provide strong evidence of conspecificity of the morphologically variable macropterous and strongly brachypterous individuals of *C. breviclava*. Macropterous females of the new species are most similar to those of *C. detritus* Bakkendorf, also known from Switzerland. New records are provided for some other species of *Cleruchus* Enock in Europe. A key to both sexes of the described European species of the genus is given.

Key Words

Integrative taxonomy, molecular analysis, Chalcidoidea, distribution, Palearctic, brachyptery

Introduction

Members of the cosmopolitan fairyfly genus *Cleruchus* Enock (Hymenoptera, Mymaridae) are not very commonly collected in Europe although they are definitely not rare there, particularly in some habitats such as mixed and deciduous forests. Most likely, as egg parasitoids of Coleoptera in leaf litter and soil or in certain concealed microhabitats, e.g. of various Ciidae in bracket fungi (Polyporales) and of some leaf-rolling Rhynchitinae (Attelabidae) (Bakkendorf 1964; Novicky 1965; Viggiani 1970; Triapitsyn and Moraal 2008; Triapitsyn et al. 2011; Triapitsyn 2014), they do not very often get into sweep and Malaise trap samples. However, they are more frequently found in yellow pan, flight interception and pitfall trap samples, as well as in Winkler and Berlese funnel extractors (Triapitsyn 2014). One species, *C. janetscheki* Novicky, was

collected at moderately to high altitudes in Alpine habitats in Austria (Novicky 1965) and Italy (Viggiani 1970).

The Palearctic species of *Cleruchus* were reviewed and keyed (both sexes) by Triapitsyn (2014). However, they still remain rather poorly known as their minute size and common brachyptery or aptery in some species make their identification quite difficult in the absence of genetic libraries, morphometric data on intraspecific variability, and good quality preparations of historic specimens.

The most recent generic diagnosis of *Cleruchus*, given by Triapitsyn (2014), is accepted here; according to it *Cleruchus* is more narrowly defined as having an entire clava of the female antenna; all the Palearctic species of the genus have this feature. In Europe, both sexes of *Cleruchus* can be recognized using the generic key in Samková et al. (2020). Unlike some other Mymaridae, males of the genus can be quite diagnostic.

Here we describe an interesting new species of *Cleruchus* which was reared from the invasive minute tree-fungus beetle *Cis chinensis* Lawrence (Ciidae) in *Antrodia xantha* fungus (Polyporales, Fomitopsidaceae) in Basel, Switzerland (Coray et al. 2022), which has both macropterous and strongly brachypterous individuals of both sexes that are quite variable morphologically. Their conspecificity is demonstrated by the genetic data presented. We also provide new records of some other species of *Cleruchus* in Europe and a key to both sexes of its described European species.

Materials and methods

Specimen collection

On three days (June 27/28 and July 11 2021), samples of the fungus *Antrodia xantha* infested with *Cis chinensis* were collected on a block of *Pinus strobus* in the therapy garden of the campus of the University Psychiatric Clinics in Basel (Switzerland) (47°34'16.75"N, 7°33'50.15"E, 266 m). Almost exclusively in the June 27 sample, a large series of an unknown Mymaridae was noted between July 8 and 26. Live specimens of these emerged wasps were preserved by A. Coray in 90% and 75% ethanol, identified as a possible new *Cleruchus* sp., and shipped to the first author for mounting and further determination. These specimens were used for both molecular analyses and taxonomic studies (as type material of the new species described below).

Additional material of *Cleruchus* spp. from some other European countries was sent to the first author for identification from the insect collection of Mitox Consultants, Amsterdam, Netherlands.

Taxonomic studies

Morphological terms used in the taxonomic description of the new species and the key follow Gibson (1997) and Triapitsyn (2014). Most measurements (as length or length: width for the wings) are given in micrometres (μm) unless specified otherwise for body length (in mm) other than in the description. Abbreviations used in the description and key are:

- F** funicle segment of the female antenna or flagellomere of the male antenna;
mps multiporous plate sensillum or sensilla on the antennal flagellar segments (= longitudinal sensillum or sensilla, or sensory ridge(s)).

Due to their minute size, specimens were dissected and slide-mounted in Canada balsam directly from ethanol. Slide mounts were examined under a Zeiss Axioskop 2 plus compound microscope (Carl Zeiss Microscopy,

LLC, Thornwood, New York, USA) and photographed using the Auto-Montage system (Syncroscopy, Princeton, New Jersey, USA). Photographs were retouched where necessary using Adobe Photoshop (Adobe Systems, Inc., San Jose, California, USA).

Specimens examined are deposited in the collections with the following acronyms:

- MCAN** Insect collection of Mitox Consultants, Amsterdam, Netherlands;
NHMB Naturhistorisches Museum Basel, Basel, Basel-Stadt, Switzerland;
UCRC Entomology Research Museum, Department of Entomology, University of California, Riverside, California, USA.

DNA extraction, amplification, and sequencing

DNA was extracted from four individual wasps, one macropterous female (PR21-581, UCRC_ENT 00541371), one strongly brachypterous female (PR21-583, UCRC_ENT 005413713), one macropterous male (PR21-582, UCRC_ENT 00541372), and one strongly brachypterous male (PR21-584, UCRC_ENT 00541374) using the “HotSHOT” method of Truett et al. (2000), in a total volume of 80 μL . This non-destructive method allowed for the recovery and slide-mounting of each specimen following extraction; each slide was then labeled with the assigned P. F. Rugman-Jones’ primary molecular voucher PR number and UCRC database UCRC_ENT number.

The polymerase chain reaction (PCR) was employed to amplify the “barcoding” region of the mitochondrial cytochrome c oxidase subunit I gene (COI) using the primers C1-J-1718 (5'-GGAGGATTTGGAAATTGATTAGTTCC-3') and C1-N-2191 (5'-CCCGGTAAAATTA-AAATATAAACTTC-3'; Simon et al. 1994), as described in Rugman-Jones et al. (2012). We also amplified two separate regions of nuclear ribosomal RNA, the D2 region of 28S (28S-D2) and the internal transcribed spacer 2 (ITS2), using primers and protocols described in Rugman-Jones et al. (2010) and Morse et al. (2016), respectively. All three loci have been widely used for investigating species boundaries among insects. Amplifications were confirmed by gel electrophoresis, purified using a PCR Product Pre-Sequencing Kit (Applied Biosystems, Waltham, MA, USA), and direct sequenced in both directions at the Institute for Integrative Genome Biology, University of California at Riverside. The parity of forward and reverse reads was checked using SEQUENCHER 4.9 (Gene Codes Corporation, Ann Arbor, Michigan, USA) and priming regions were removed manually in BioEdit version 7.0.5.3 (Hall 1999). The online tool, EMBOSS Transeq (Rice et al. 2000) was used to translate the protein coding COI sequence into its amino acid chain, confirming the absence of indels and pseudogenes. All sequences were deposited in GenBank (Benson et al. 2008).

Genetic analysis

Since our primary goal for the genetic analysis was obtaining molecular support of the likely conspecificity of the macropterous and strongly brachypterous individuals of both sexes of the reared *Cleruchus* species, direct comparison of the sequences was sufficient. Given a complete absence of any DNA sequence from positively identified species of *Cleruchus* in public repositories (i.e. GenBank and BOLD), further molecular identification was not possible.

Results

Taxonomy

Cleruchus breviclava Triapitsyn & Coray, sp. nov.

<https://zoobank.org/D740697D-79BA-4EDB-AD6E-DE2A5171DA4A>
Figs 1–5

Cleruchus sp.: Coray et al. 2022: 89–90 (host association, list of specimens reared in Basel, descriptive notes, illustrations).

Type material. *Holotype* female (macropterous individual), deposited in NHMB, on slide labeled: 1. “SWITZERLAND: Basel-Stadt Basel, Universitäre Psychiatrische Kliniken 47°34'16.75"N, 7°33'50.15"E, 266 m 27.vi.2021, P. Vlček. Associated with *Cis chinensis* Lawrence in *Antrodia xantha* fungus on *Pinus strobus* block, subsequent series 9.vii.2021, A. Coray”; 2. “Mounted by V. V. Berezovskiy 2021 in Canada balsam”; 3. [magenta] “*Cleruchus breviclava* Triapitsyn & Coray HOLOTYPE ♀”; 4. “Det. by S. V. Triapitsyn 2021”; 5. [barcode database label/unique identifier] “UCRC [bold] UCRC_ENT 00541415”. The holotype (Figs 1, 2a–c) has a pair of wings detached and mounted under the same coverslip.

Paratypes. 7 females and 3 males on slides [including 2 females (1 macropterous and 1 strongly brachypterous) and 2 males (1 macropterous and 1 strongly brachypterous), UCRC (molecular vouchers PR21-581–584, UCRC_ENT 00541371–00541374)], same data as holotype. All other specimens listed in Coray et al. (2022) from the type locality (as *Cleruchus* sp.) and deposited in NHMB are also included in the paratype series.

Additional specimens from Germany and Switzerland (other than from the same rearing at the type locality in Basel), listed by Coray et al. (2022), are not included in the type series; these are mostly stored in ethanol in NHMB.

Diagnosis. Morphologically, fully winged female individuals of *C. breviclava* are most similar to those of the Palaearctic species *C. detritus* Bakkendorf, the type series of which was collected from soil in Chancy, Geneva, Switzerland (Bakkendorf 1964). Its lectotype female (Fig. 6) was designated by Triapitsyn et al. (2013) from one of the two macropterous original syntypes. In macropterous *C. breviclava*, the female antennal clava

(Fig. 2a) is consistently relatively shorter than that in fully winged *C. detritus* (Fig. 6), in which it is approximately the same length as combined length of F3–F6 according to the redescription in Triapitsyn (2014), being slightly shorter than the combined length of F4–F6 (but about as long as F4–F6 in the smaller, brachypterous female of *C. breviclava*). The body of *C. breviclava* is notably longer (0.6–0.76 mm in macropterous, slide-mounted females) than that of macropterous females of *C. detritus* (0.45 mm according to Bakkendorf 1964), and the gaster is markedly longer (compare Figs 1a, 2c and Fig. 6b, respectively), which is common in fungus dwelling species of the genus. Combined with notably shorter setae on the fore wing venation in *C. breviclava* (Fig. 1b), and a different habitat (fungus versus soil for *C. detritus*), this strongly supports that these two species are clearly distinct despite having some morphological similarities in proportions of female funicular segments and fore wing chaetotaxy.

A key to both sexes of the European species of *Cleruchus*, which is based on that of the Palaearctic species in Triapitsyn (2014), is provided below to further facilitate their recognition.

Description. Female (holotype). Body (Fig. 1a) brown to dark brown (gaster a little lighter, often basally only); scape and pedicel light brown, flagellum brown; legs mostly light brown. Head (Fig. 2b) a little wider than long in dorsal view, and about as wide as mesosoma. Vertex smooth; ocelli present but somewhat reduced, oval. Face subquadrate, small, faintly sculptured, with one seta near inner lower side of each torulus; torulus large, subtriangular, slightly below lower level of eyes, touching pre-orbital trabecula. Mandible bidentate. Antenna (Fig. 2a) with scape smooth, 4.5× as long as wide (including small radicle); pedicel smooth, 1.7× as long as wide, much longer than F1; F1 about as long as wide, much shorter than following funiculars; F2–F5 longer than wide, F2 shorter than following funiculars, F4 and F5 the longest and F6 the widest funiculars; F4–F6 each with 1 mps; clava a little shorter than F4–F6 combined, entire, 2.6× on one antenna and 2.7× on the other antenna as long as wide, with 6 mps. Mesosoma (Fig. 2b) mostly smooth except axilla with a faint sculpture. Mesoscutum wider than long, its midlobe with a pair of adnotaular setae. Axilla with 1 weak seta. Scutellum a little shorter than mesoscutum. Metanotum narrow, strap-like and hardly noticeable, with 2 very weak setae. Propodeum long, longer than mesoscutum or scutellum. Mesophragma broadly U-shaped, almost extending to posterior margin of propodeum. Macropterous (Fig. 1a–c). Fore wing (Fig. 1b) 10.4× as long as wide, with venation typical of the genus; both macrochaetae very short; blade infusate throughout, with 2 rows of microtrichia along anterior margin and 1 almost complete row of microtrichia along posterior margin; longest marginal seta 4.4× greatest width of wing. Hind wing (Fig. 1c) 21× as long as wide; blade slightly infusate, with one incomplete row of microtrichia closer to anterior margin; longest marginal seta 6.2× greatest

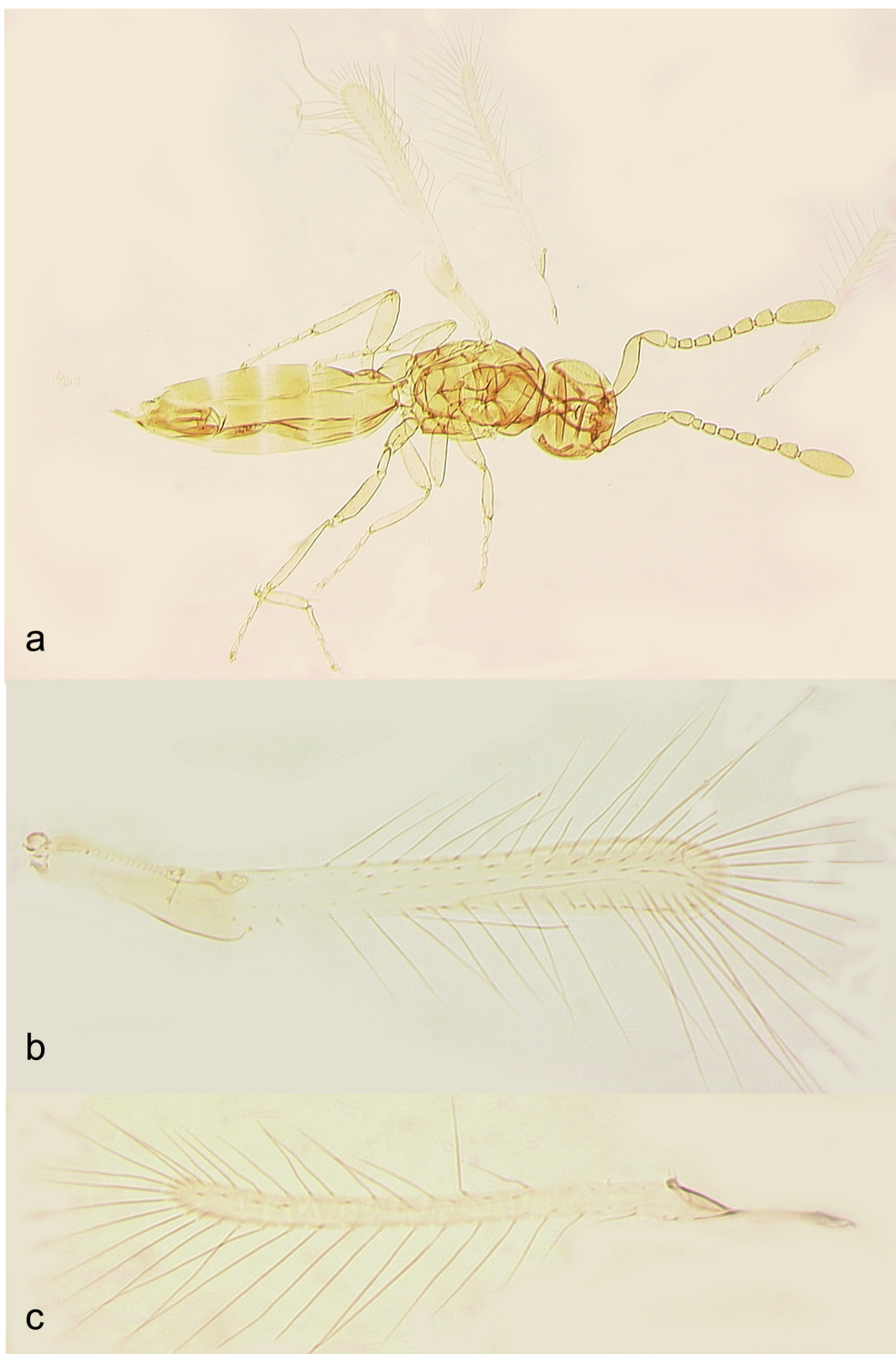


Figure 1. *Cleruchus breviclava* sp. nov., holotype female. **a.** Habitus (slide-mounted); **b.** Fore wing; **c.** Hind wing.

width of wing. Petiole (Fig. 2b, c) short but clearly visible in slide-mounted specimens, 2.0× as wide as long. Gaster (Fig. 2c) elongate, twice as long as mesosoma in the slide-mounted specimen; ovipositor 1.25× length of metatibia and about 0.4× length of gaster, exerted beyond its apex.

Measurements (µm) of the holotype (as length or length: width). Body: 665; mesosoma 185; petiole 19; gaster 370; ovipositor 152. Antenna: scape (including radicle) 97; pedicel 36; F1 12; F2 18; F3 23; F4 27; F5 27; F6 25; clava 82. Fore wing 376: 36; longest marginal seta 157. Hind wing 378: 18; longest marginal seta 112.

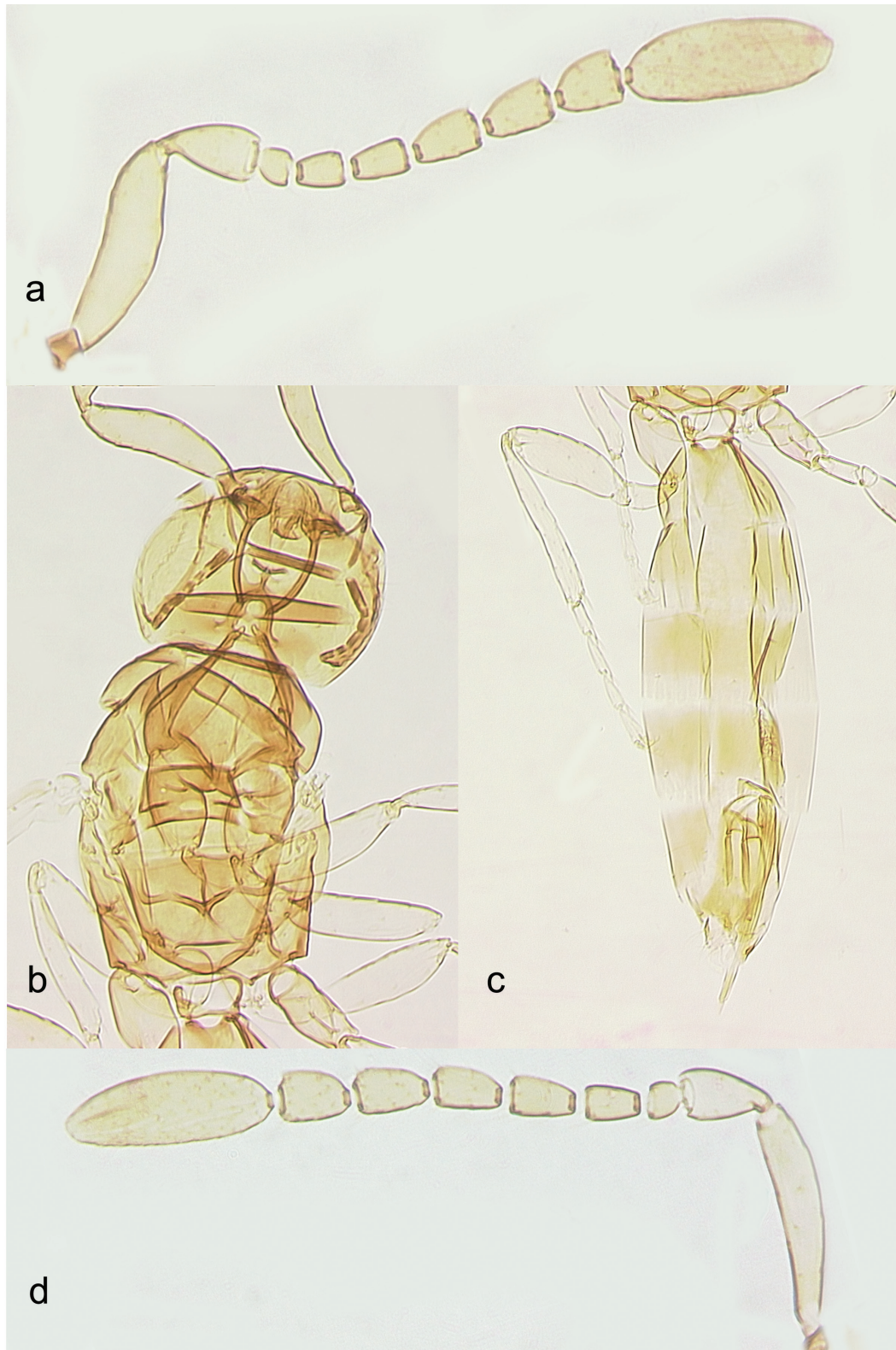


Figure 2. *Cleruchus breviclava* sp. nov., female. **a.** Antenna (holotype; mps on F4–F6); **b.** Head, mesosoma and petiole (holotype); **c.** Metasoma (holotype); **d.** Antenna (macropterous paratype; mps on F3–F6).

Variation. Macropterous paratypes: body length of slide-mounted specimens 600–760 μm ; mps usually on F4–F6 (1 on each) but sometimes F3 with 1 mps (Fig. 2d) on one or both antennae, clava 2.6–2.8 \times as long as wide; fore wing 8.6–9.5 \times as long as wide; ovipositor 1.2–

1.3 \times length of metatibia. Strongly brachypterous paratype (Fig. 3a, b): body length of slide-mounted specimen (Fig. 3b) 515 μm ; ocelli present but relatively more reduced than in macropterous individuals; antenna (Fig. 3c) relatively shorter than in macropterous individuals,

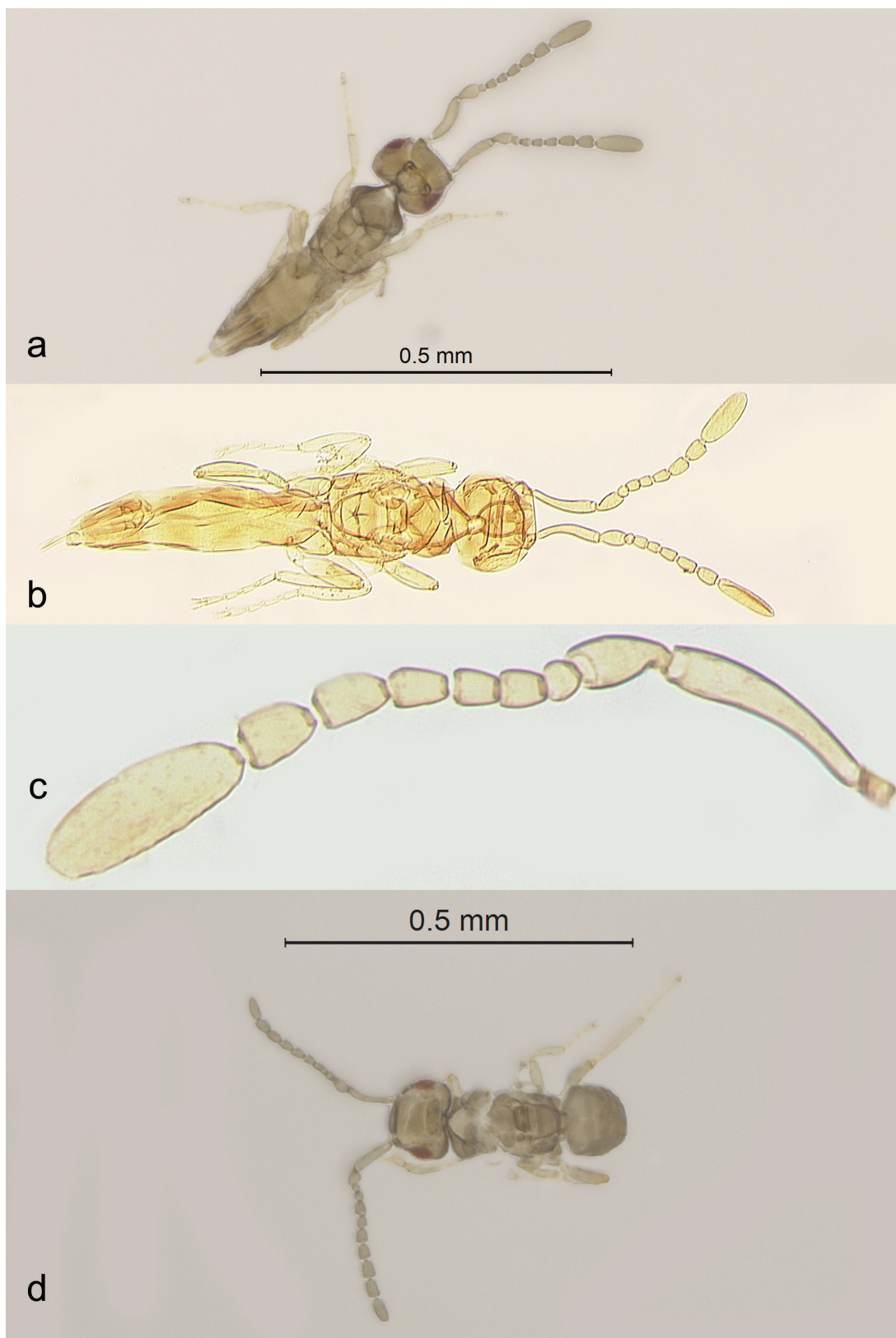


Figure 3. *Cleruchus breviclava* sp. nov. (strongly brachypterous paratypes). **a.** Habitus of female (in ethanol); **b.** Habitus of the same female (slide-mounted); **c.** Female antenna (mps on F5–F6); **d.** Habitus of male (in ethanol).

particularly F2–F4, mps only on F5 and F6 (1 on each), clava as long as F4–F6 combined; fore wing reduced to small, very short stub with a few short setae; hind wing apparently absent; ovipositor length 120 μm , 1.3 \times length of metatibia.

Male. Macropterous paratypes (Fig. 4c): body length of slide-mounted specimens 585–590 μm . Ocelli (Fig. 5c) as in macropterous females. Antenna (Fig. 5a) with flagellum 10-segmented; scape (including radicle) 5.3 \times as long as wide; F1 shorter than following flagellomeres and with-

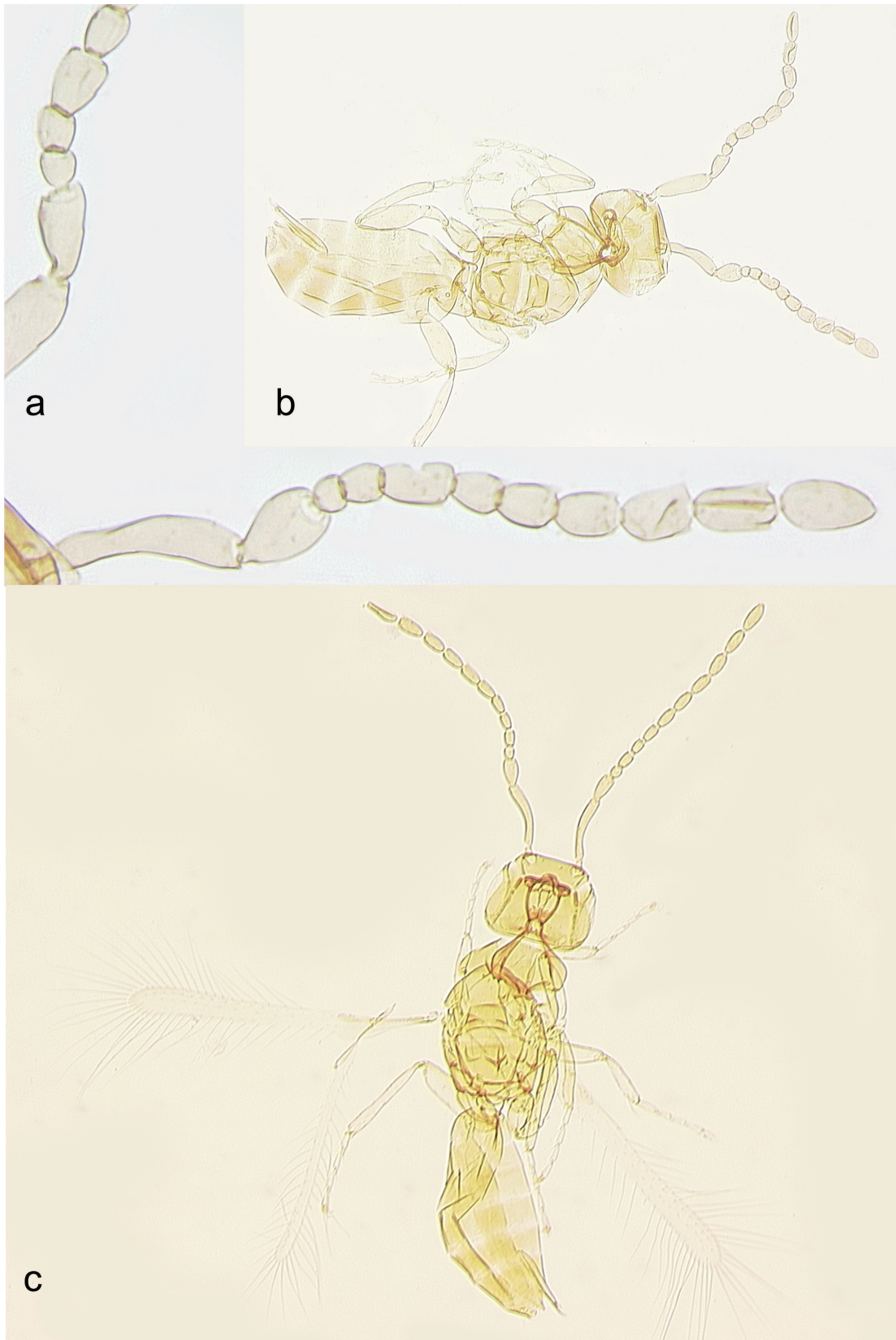


Figure 4. *Cleruchus breviclava* sp. nov., male (paratypes). **a.** Antennae (strongly brachypterous individual; F3 and F4 partially fused on one antenna and completely fused on the other antenna); **b.** Habitus of strongly brachypterous individual (slide-mounted, same specimen as on Fig. 3d); **c.** Habitus of macropterous individual (slide-mounted).

out mps; F2–F10 each with at least 1 mps, F10 the longest flagellomere. Fore wing (Fig. 5b) 9.8–10.4× as long as wide. Gaster 1.3–1.4× as long as mesosoma; genitalia (Fig.

5d) length 106 μm. Strongly brachypterous paratype (Figs 3d, 4b): body length of slide-mounted specimen 470 μm. Ocelli apparently absent. Antenna (Fig. 4a) notably short-

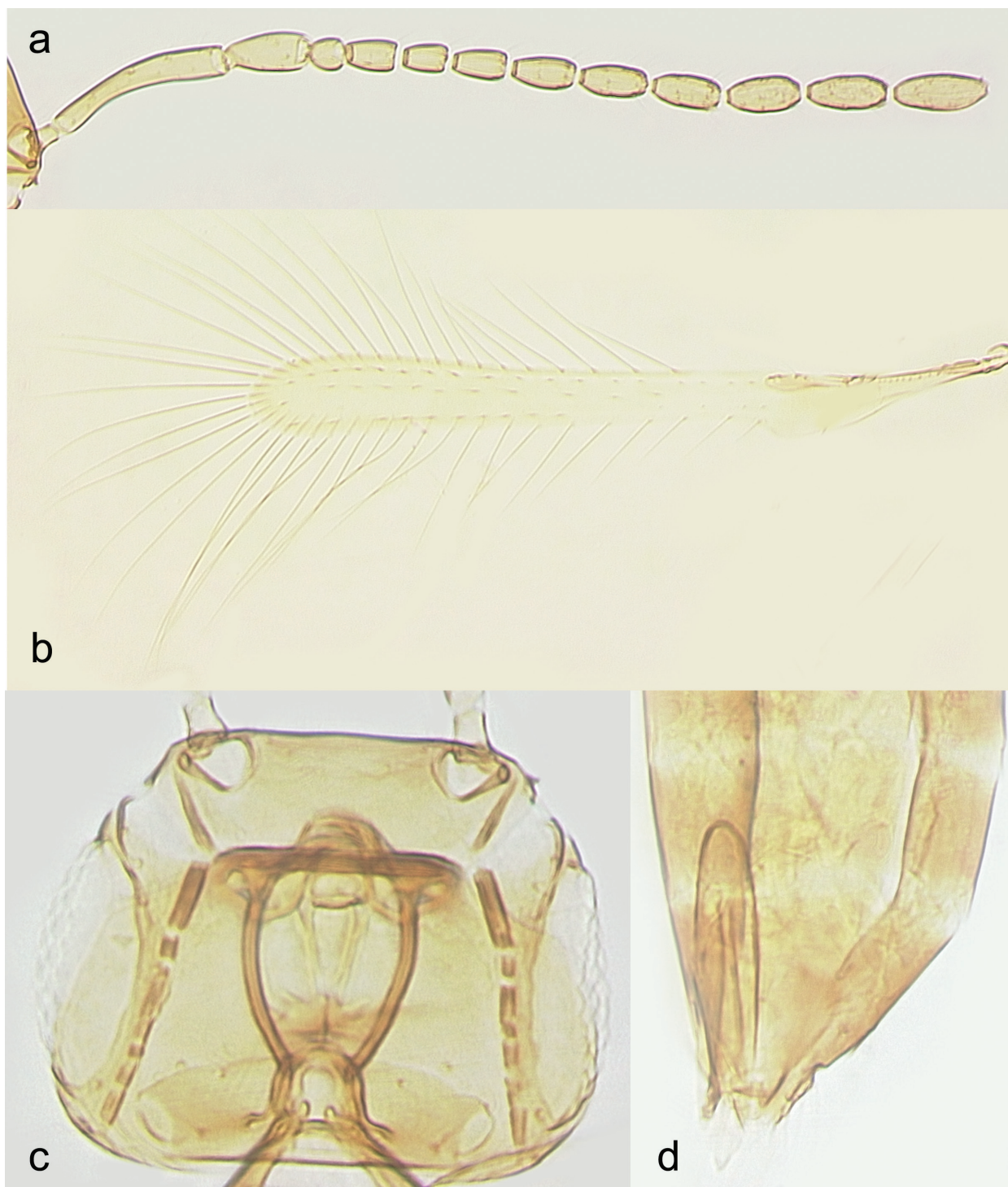


Figure 5. *Cleruchus breviclava* sp. nov., male (macropterous paratypes). **a.** Antenna; **b.** Fore wing; **c.** Head in dorsal view; **d.** Genitalia in dorsal view.

er than in macropterous individuals (some flagellomeres relatively shorter), with flagellum 9-segmented (F3 and F4 completely fused on one antenna but only partially fused on the other), scape (including radicle) 4.2× as long as wide, F1 and F2 without mps. Genitalia length 94 μm.

Etymology. The new species name is a noun in apposition referring to a relatively short antennal clava, compared to that in otherwise more or less similar congeners such as *C. detritus*.

Distribution. Palearctic region: Switzerland, and Germany (Coray et al. 2022 [as *Cleruchus* sp.]).

Host. Coleoptera, Ciidae: *Cis chinensis* Lawrence, 1991 in *Antrodia xantha* fungus (Polyporales, Fomitopsidaceae) on a block of *Pinus strobus* (Pinaceae).

Molecular analysis. Four specimens of *C. breviclava* were extracted but only three yielded amplifiable DNA: PR21-581, PR21-582, and PR21-584. The DNA sequences of the COI (502 bp) and 28S-D2 (519

bp) regions were identical across all three specimens (GenBank accessions: OP758808–OP758810 and OP755253–OP755255, respectively). The ITS2 region (432 bp) of the two male specimens was also sequenced and found to differ at only a single nucleotide position (A-T at position 222; OP755251–OP755252). Taken together, the almost identical nature of these three loci provided unambiguous evidence that at least the three

individual wasps of *C. breviclava* from which we were able to amplify and sequence DNA (one macropterous female, one macropterous male, and one strongly brachypterous male) are clearly conspecific. Although the DNA extraction from the fourth specimen (a strongly brachypterous female) appears to have failed, we believe it represents the same species. That is corroborated by the fact that all the wasps emerged from the same fungus.

Key to both sexes of the described species of *Cleruchus* in Europe

- 1 Female (antenna with flagellum 7-segmented, consisting of a 6-segmented funicle and an entire clava) 2
- Male (antenna with flagellum filiform, 9-, 10-, or 11-segmented)..... 19
- 2 Apterous or strongly brachypterous (all wing stubs, if present, with membrane strongly reduced, at most extending a little beyond apex of venation)..... 3
- Macropterous or slightly to moderately brachypterous (fore wing disc, even if somewhat reduced, extending far beyond apex of venation) 8
- 3 Most funiculars either a little wider than long or at most as long as wide (a few may be a little longer than wide) *C. szelenyi* Novicky (also apterous paralectotypes of *C. detritus* Bakkendorf that may or may be not conspecific with *C. szelenyi*)
- Most funicle segments clearly longer than wide (a few may be about as long as wide) 4
- 4 F2–F6 each with 1 mps 5
- At most F5 and F6 each with 1 mps..... 6
- 5 Body length (of dry-mounted specimens) at least 0.5 mm; body relatively more elongate; funiculars relatively longer and clava at least 3.7× as long as wide *C. polypori* Triapitsyn & Moraal (part)
- Body length (of dry-mounted specimens) at most 0.46 mm; body relatively less elongate; funiculars relatively shorter and clava at most 2.9× as long as wide *C. kivach* Triapitsyn (part)
- 6 Ovipositor at most 0.65× length of metatibia *C. janetscheki* Novicky (part)
- Ovipositor at least 1.3× length of metatibia..... 7
- 7 F1 notably longer than wide; F5 apparently without mps and longer than F6 *C. terebrator* Viggiani
- F1 about as long as wide; F5 with 1 mps and about as long as F6 *C. breviclava* Triapitsyn & Coray, sp. nov. (part)
- 8 Ocelli absent 9
- Ocelli present..... 11
- 9 F2 and F3 each with 1 mps; fore wing normal (not reduced, with many marginal setae) 10
- F2 and F3 without mps; fore wing very narrow, with disc reduced (but extending far beyond apex of venation), and with a few discal and most marginal setae short except for 2 or 4 very long marginal setae at wing apex *C. biciliatus* (Ferrière)
- 10 Body length (of dry-mounted specimens) at least 0.5 mm; body relatively more elongate; funicle segments relatively longer and clava at least 3.7× as long as wide *C. polypori* Triapitsyn & Moraal (part)
- Body length (of dry-mounted specimens) at most 0.46 mm; body relatively less elongate; funicle segments relatively shorter and clava at most 2.9× as long as wide *C. kivach* Triapitsyn (part)
- 11 Admarginal row of discal setae along posterior margin of fore wing absent or incomplete (at most composed of a few setae behind and just beyond stigmal vein and also at wing apex)..... 12
- Admarginal row of discal setae along posterior margin of fore wing present and complete or almost complete (Fig. 1b)... 13
- 12 Fore wing with discal setae of the median row relatively long *C. megatrichus* Novicky
- Fore wing with discal setae of the median row relatively short..... *C. leptosoma* Debauche
- 13 F3 with 1 mps at least on one antenna 14
- F3 without mps 16
- 14 F1 either wider than long or about as long as wide (Fig. 2a, d)..... 15
- F1 longer than wide..... *C. nikaknet* Triapitsyn
- 15 Clava either a little shorter or subequal, or slightly longer than combined length of F3–F6 (Fig. 6a) *C. detritus* Bakkendorf
- Clava slightly shorter than combined length of F4–F6 (Fig. 2a, d) *C. breviclava* Triapitsyn & Coray, sp. nov. (part)
- 16 F4 with 1 mps *C. breviclava* Triapitsyn & Coray, sp. nov. (part)
- F4 without mps 17
- 17 Clava notably lighter than funicle; F1 clearly longer than wide *C. janetscheki* Novicky (part)
- Clava concolorous with funicle; F1 either about as long as wide or at most slightly longer than wide..... 18
- 18 Collected in northern Europe during summer [male antenna 12-segmented]..... *C. pluteus* Enock
- Collected in northern Europe during spring [male antenna 13-segmented]..... *C. taktochno* Triapitsyn

- 19 Apterous or strongly brachypterous (all wing stubs, if present, with membrane strongly reduced, at most extending a little beyond apex of venation)..... 20
 – Macropterous or slightly to moderately brachypterous (fore wing disc, even if somewhat reduced, extending far beyond apex of venation) 25
 20 Ocelli present..... 21
 – Ocelli absent 22
 21 Antenna with flagellum 9-segmented and F1–F6 wider than long..... *C. raignieri* Debauche
 – Antenna with flagellum 10-segmented and F1–F6 at least a little longer than wide *C. janetscheki* Novicky
 22 Antenna with flagellum 9-segmented or appearing 9-segmented (when 10-segmented in macropterous individuals but in strongly brachypterous, smaller individuals with F3 and F4 completely or partially fused, Fig. 4a)..... 23
 – Antenna with flagellum 11-segmented 24
 23 F2 wider than long *C. szelenyi* Novicky
 – F2 slightly longer than wide; F3 and F4 completely or partially fused (Fig. 4a)
 *C. breviclava* Triapitsyn & Coray, sp. nov. (part)
 24 F1 relatively smaller and subglobular (about as long as wide) *C. polypori* Triapitsyn & Moraal
 – F1 relatively larger and a little longer than wide *C. kivach* Triapitsyn
 25 Antenna with flagellum 10-segmented 26
 – Antenna with flagellum 11-segmented 27
 26 F1 with 1 mps; admarginal row of discal setae along posterior margin of fore wing complete..... *C. pluteus* Enock
 – F1 without mps (Fig. 5a); admarginal row of discal setae along posterior margin of fore wing not complete (Fig. 5b) ...
 *C. breviclava* Triapitsyn & Coray, sp. nov. (part)
 27 Fore wing with discal setae of the median row relatively long *C. megatrichus* Novicky
 – Fore wing with discal setae of the median row relatively short *C. taktochno* Triapitsyn

New records of some other species of *Cleruchus* in Europe

Cleruchus megatrichus Novicky, 1965

Cleruchus megatrichus Novicky, 1965: 59–60 (in key). Type locality (of the lectotype designated by Triapitsyn et al. 2013: 10): forest at Mienia, Mińsk Mazowiecki, Mińsk County, Masovian Voivodeship, Poland.

Cleruchus megatrichus Novicky: Triapitsyn et al. 2013: 10–12 (information on type series, redescription, illustrations, distribution); Triapitsyn 2014: 7–8 (key), 20–22 (taxonomic history, distribution, diagnosis, illustrations).

Material examined. SPAIN, Valencia, Valencia, 25.vi.2021, citrus orchard [1 macropterous female, MCAN].

Distribution. Finland, France (Triapitsyn et al. 2020), Poland (Novicky 1965), Spain (Triapitsyn 2014).

Hosts. Unknown.

Cleruchus szelenyi Novicky, 1965

Cleruchus szelenyi [sic] Novicky, 1965: 58, 60 (in key). Type locality (of the lectotype designated by Triapitsyn et al. 2013: 12): Svábhegy [hill], Budapest, Hungary (according to the original description but on the labels on the syntypes probably the correct locality is indicated – Köhegy, Pomáz, Pest County, Hungary (Triapitsyn et al. 2013)).

Cleruchus szelenyi Novicky (specimens from Hungary only): Triapitsyn et al. 2013: 12–14 (information on type series, redescription, illustrations, distribution); Triapitsyn 2014: 6, 8 (key), 40 (taxonomic history, diagnosis, distribution).

Material examined. GERMANY, Rheinland-Pfalz, Winden, 7.vi.2013, pitfall trap in apple orchard [1 apterous female,

MCAN]. Netherlands, Gelderland, Renkum, Sinderhoeve, 30.vi.2010, pitfall trap in grassland [3 apterous females, MCAN (2), UCRC (1)].

Distribution. Hungary (Novicky 1965), Germany (new record), Netherlands (new record).

Hosts. Unknown. The original syntypes were collected by sifting from lawn soil (Novicky 1965; Triapitsyn et al. 2013).

Cleruchus taktochno Triapitsyn, 2014

Cleruchus taktochno Triapitsyn, 2014: 41–47. Type locality: Heverlee, Leuven, Flemish Brabant, Belgium.

Material examined. NETHERLANDS, Gelderland, Renkum, Sinderhoeve, 30.vi.2010, pitfall trap in grassland [1 macropterous male, MCAN].

Distribution. Belgium, Denmark (Triapitsyn 2014), Finland (Triapitsyn et al. 2020), Netherlands (new record), Poland (Triapitsyn 2014).

Hosts. Unknown.

Discussion

Although the minute tree-fungus beetle *Cis chinensis* is invasive in Switzerland (Coray et al. 2022), its egg parasitoid *C. breviclava* is most likely native to the country, as *Cleruchus* species are unlikely to be monophagous and most probably can easily switch to parasitize eggs of congener hosts in similar habitats, in this case from other *Cis* spp. native to Europe. Indeed, *C. breviclava* was also reported, as *Cleruchus* sp. (Coray et al. 2022), from

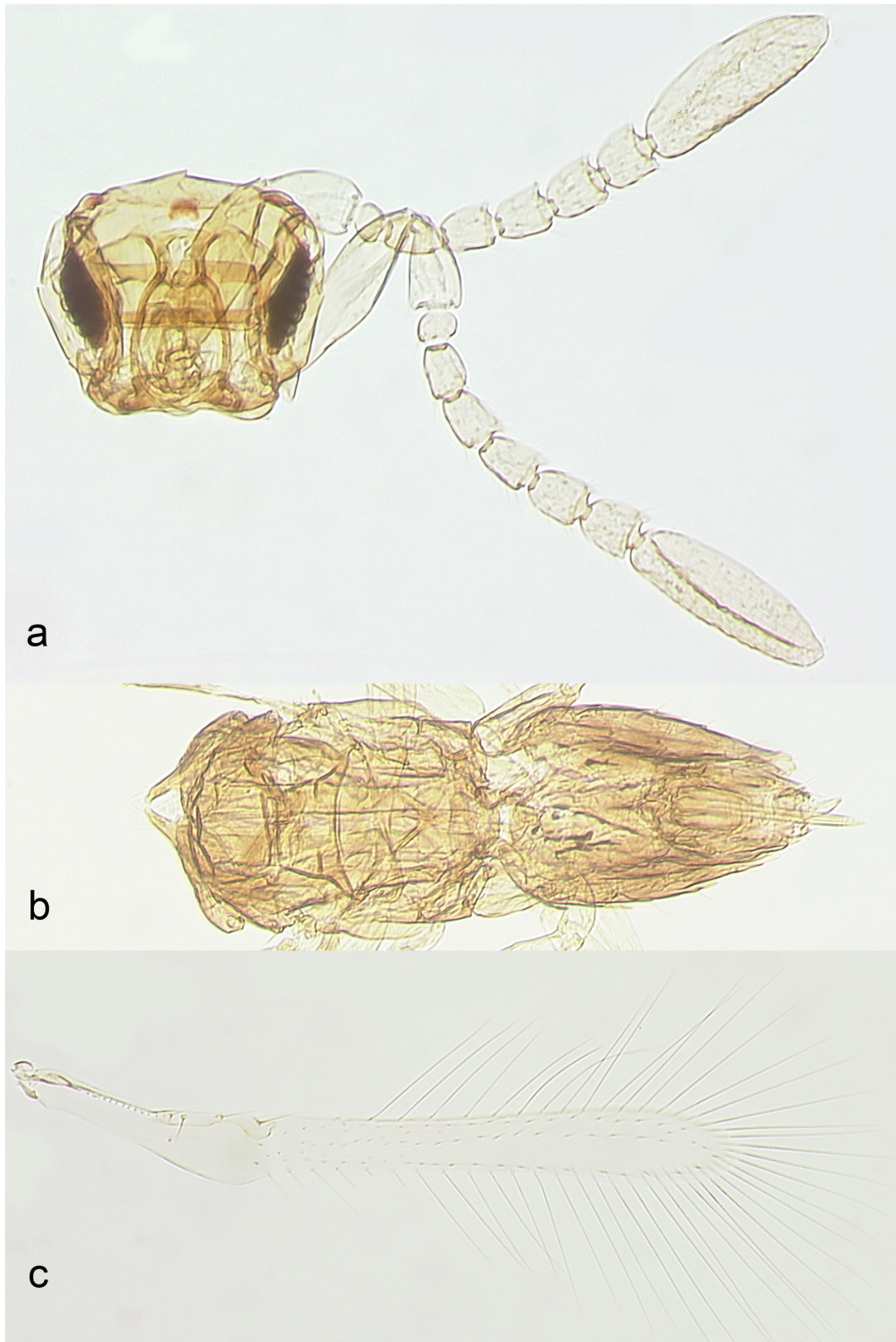


Figure 6. *Cleruchus detritus* Bakkendorf, female (lectotype): **a.** Head and antennae; **b.** Mesosoma and metasoma; **c.** Fore wing.

low mountains in Germany (Baden-Württemberg) and Switzerland (Basel-Landschaft Canton) from *Stereum* spp. (Russulales: Stereaceae) fungi infested with native *Cis* spp. That is also supported by the fact that our COI sequences of *C. breviclava* from Basel are 97.6% similar to that of an unidentified female of *Cleruchus* sp., only partially released in BOLDSYSTEMS (BOLD Record

BCHYM5773-15, accessed 15.iv.2022), which is also very similar morphologically according to its digital image, from the nearby Grenzach-Wyhlen, Baden-Württemberg, Germany (47.5547°N, 7.6658°E, 357 m, collected 27.viii.2011 by D. Doczkal and A. Ssymank, deposited in Zoologische Staatssammlung München, Bavaria, Germany [SNSB], BC-ZSM-HYM-22592-G01).

Diversity of *Cleruchus* species in Europe is still poorly known, due to their often concealed habitats requiring laborious sampling of various ecological microniches. Because of significant intraspecific variability and frequent occurrence of brachypterous and apterous individuals of the same species with conspecific macropterous individuals, and associated reductions and fusions of flagellar segments in males, possible reduction or lacking of ocelli in smaller individuals with reduced or absent wings, and apparent size-dependent reduction of the number of mps on female funicular segments of the antenna, which are all commonly used diagnostic features for *Cleruchus* species recognition (Triapitsyn 2014), use of molecular methods and building of genetic libraries are of primary importance for taxonomy of the genus. That task, however, is unfortunately not feasible to be achieved for all the already described species of the genus either in the near or even a more distant future, due to the aforementioned difficulties in their collection and recognition.

This is the first attempt to apply an integrative taxonomy approach to this genus, albeit to a single species, while genetic data for other positively identified congeners are currently lacking. Thus, the true number of valid *Cleruchus* species in Europe is likely to increase in the future (for instance, see information on the four undescribed species in Triapitsyn 2014), although some nominal species, particularly those described based on strongly brachypterous or apterous individuals, may turn out to be synonymous with other species with only macropterous individuals known so far.

Genetically confirmed conspecificity of the morphologically quite different macropterous female and both macropterous and strongly brachypterous males of *C. breviclava*, which are also quite variable in body size, casts doubt on correctness of the treatment of the type series of *C. detritus* as being two different species, the macropterous females as true *C. detritus* (based on the lectotype designation by Triapitsyn et al. 2013) and the apterous females as *C. szelenyi* (Triapitsyn et al. 2013; Triapitsyn 2014). The latter were treated as an “apterous form” by Bakkendorf (1964) and “forma aptera” by Novicky (1965). The original syntypes of *C. detritus* consisted of 11 apterous and 2 macropterous females collected by washing from soil (“lavage de terre”) (Bakkendorf 1964) which may or may not be conspecific, as this collecting method could easily yield two different species in the same location. However, the other scenario, in which the apterous, slightly smaller females of *C. detritus* (with ocelli absent) could be conspecific with somewhat larger, macropterous ones (with ocelli apparently present) is also possible in spite of the two types of females being morphologically quite different also in the following: female antenna of the apterous syntypes usually lacks mps on all funicular segments (except sometimes 1 mps apparently may be present on F6) whereas these are present on F3–F6 of the macropterous syntypes (Triapitsyn et al. 2013; Triapitsyn 2014). Thus,

genetic studies on freshly collected specimens, both macropterous and apterous, from the type locality of *C. detritus* are needed to reveal the true identity of this nominal species. Resulting sequences will also need to be compared with those of *C. breviclava* (particularly with brachypterous individuals) and *C. szelenyi*, at least, although for the latter they are not yet available either.

Acknowledgements

We thank Petr Vlček (Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft WSL, Birmensdorf, Switzerland) for collecting the host fungus in Basel, Elias de Bree (Mitox Consultants, Amsterdam, Netherlands) for sending European specimens of *Cleruchus* for identification and donating some of them to the UCRC, and Vladimir V. Berezovskiy (UCRC) for mounting selected specimens, including the molecular primary vouchers, on slides. Very useful comments and corrections by the reviewers are much appreciated.

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Annotated checklist of the Coccinellidae (Coleoptera, Coccinelloidea) of Switzerland

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Academic editor: Stève Breitenmoser ♦ Received 24 June 2022 ♦ Accepted 12 November 2022 ♦ Published 18 November 2022

Abstract

An updated checklist of the Swiss species belonging to the family Coccinellidae is presented and briefly discussed. This checklist includes 81 species (82 taxa including the subspecies) and is based on 33'976 occurrences obtained from the identification of specimens held in museum and private collections, as well as from records taken from the literature. *Exochomus oblongus* Weidenbach, 1859, *Hyperaspis peezi* Fürsch, 1976, *Hyperaspis pseudopustulata* Mulsant, 1853, *Nephus bisignatus* (Fürsch, 1984), *Rhyzobius forestieri* (Mulsant, 1853), *Scymniscus anomus* (Mulsant & Rey, 1852) and *Scymnus doriae* Capra, 1924 are recorded for the first time in Switzerland. In parallel, *Chilocorus similis* (P. Rossi, 1790), *Bulaea lichatschovii* (Hummel, 1827), *Ceratomegilla rufocincta rufocincta* (Mulsant, 1850), *Coccinella undecimpunctata undecimpunctata* Linnaeus, 1758, *Chnootriba elaterii* (P. Rossi, 1794), *Henosepilachna vigintioctopunctata* (Fabricius, 1775), *Hyperaspis quadrimaculata* (Redtenbacher, 1843), *Scymnus marginalis* (P. Rossi, 1794) and *Novius cardinalis* (Mulsant, 1850) were recorded from Switzerland in the past but are excluded from this list, either due to insufficient documentation or because they represent isolated cases of introductions of non-indigenous species that never became established in Switzerland.

Key Words

Insecta, beetle, ladybird, species list, new country records, faunistics, distribution

Introduction

Considered for a long time as a member of the super-family Cucujoidea, the beetle family Coccinellidae now belongs to the super-family Coccinelloidea (Robertson et al. 2015). More than 6'000 species of Coccinellidae are described worldwide (Vandenberg 2002; Kovář 2007), among them about 100 species occurring in Central Europe (Nedvěd 2015; Klausnitzer et al. 2022) and 196 in Continental Europe (Nedvěd and Đurić 2022). The majority of the European species are predators of phytophagous arthropods, particularly aphids (Aphidoidea), coccids (Coccoidea), whiteflies (Aleyrodoidea), spider mites (Acari) and larvae of chrysomelid beetles (Chrysomelidae) (Hodek and Honěk 2009; Weber and Lundgren 2009). Due to this diet, they are regularly used for biological control in agriculture

and forestry. As an unexpected consequence, certain species of exotic Coccinellidae, initially introduced as biological control agents, have become invasive species (Soares et al. 2018). Other diets exist, however, to a lesser extent within this family, with some species either phytophagous or mycophagous (Sutherland and Parrella 2009; Klausnitzer 2019a).

Despite the fact that this is a charismatic family, no overview has been published in Switzerland since the catalog of Stierlin (1900). Since this last publication, our knowledge of the systematics and distribution of the species has evolved considerably, so that an update of this list was necessary. In addition, several introduced species used in biological control have now acclimatized and are reproducing in the field in Switzerland, so that they are now part of the fauna of Switzerland.

This publication aims to present an annotated checklist of the species in Switzerland. It is based on a review of the Swiss museum and private collections, as well as of the literature and data gathered by naturalists. Thus, resident species are distinguished from species that are mistakenly mentioned for Switzerland, insufficiently documented and those introduced but not established in the country.

Materials and methods

In order to present a complete list of the Swiss fauna, based on all existing information, we performed an exhaustive examination of the relevant material present in major Swiss museum collections, as was recently done for other beetle groups (see for example Sanchez et al. 2020; Chittaro et al. 2021). 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)
KMLI	Kantonsmuseum Baselland, Liestal (Marc Limat)
LEBA	Laboratoire d'écologie et biologie aquatique (UNIGE), Genève
MHNF	Musée d'histoire naturelle de Fribourg (Sophie Giriens)
MHNG	Muséum d'histoire naturelle de 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 (Lucia Pollini Paltrinieri)
MZL	Musée cantonal de zoologie, Lausanne (Anne Freitag)
MZA	Museum zu Allerheiligen, Schaffhausen (Urs Weibel)
NMAA	Naturama, Aarau (Janine Mazenauer)
NMB	Naturhistorisches Museum Basel (Matthias Borer)
NMBE	Naturhistorisches Museum Bern (Hannes Baur)
NMLU	Natur-Museum, Luzern (Marco Bernasconi)
NMSG	Naturmuseum St. Gallen (Karin Urfer)
NMTG	Naturmuseum Thurgau, Frauenfeld (Barbara Richner)
NMSO	Naturmuseum, Solothurn (Marc Neumann)

We also cited data gathered from three museums outside Switzerland:

MAMU	Manchester Museum, Great Britain
TLMF	Tiroler Landesmuseen, Innsbruck, Austria
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 individuals. They are classified in alphabetical order. The municipality and the abbreviated canton of residence are indicated in brackets: Bastien Guibert (Gy GE), Berndt Eismann (Kreuzlingen TG), Hansjörg Brägger (Amriswil TG), Kevin Gurcel (France, Annecy), Stève Breitenmoser (Givrins VD) and Werner Marggi (Thun BE).

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.

The subfamily and tribal classifications adopted here follow Bouchard et al. (2011), Seago et al. (2011) and Robertson et al. (2015). Nomenclature and systematics followed are those of the “Catalogue of Palaearctic Coleoptera” (Kovář 2007), with the following exceptions:

- *Exochomus flavipes* (Thunberg, 1781) does not belong to the Palaearctic fauna and is therefore absent from this catalogue (Kovář 2007). For this species, we followed Fürsch (1961).
- Like Tomaszewska (2010), we preferred the combinations *Rhyzobius forestieri* (Mulsant, 1853) and *Rhyzobius lophanthae* (Blaisdell, 1892) instead of *Lindorus forestieri* (Mulsant, 1853) and *Lindorus lophantae* (Blaisdell, 1892).
- Based on morphological and molecular examination, we considered the combination *Chnootriba elaterii* (P. Rossi, 1794) instead of *Henosepilachna elaterii* (P. Rossi, 1794), as proposed by Tomaszewska and Szawaryn (2016).
- As proposed by Pang et al. (2020), we use here the combination *Novius cardinalis* instead of *Rodolia cardinalis* (Mulsant, 1850).

The specimens were identified using the following publications: Fürsch (1961, 1965, 1984), Canepari (1983), Canepari et al. (1985), Nedvěd (2015), Biranvand et al. (2017, 2020).

When not otherwise specified, general information on species' distributions is taken from Kovář (2007), Coutanceau (2014) and Nedvěd (2015).

The list of the main synonyms of each taxon is provided in “Catalogue of Palaearctic Coleoptera” (Kovář 2007) and is therefore not reported here.

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 (the majority of these species are illustrated in Fig. 1). 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 or absence of these species on the checklist. When not otherwise specified, all examined material was identified or reviewed by the first author.

There are various genera and species groups in Coccinellidae (mainly among the genera *Nephus*, *Scymnus* and *Hyperaspis*) for which the only known reliable characters are the male genitalia. For those species, only dissected males are counted as “verified” records, while records based exclusively upon 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 insect 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 Charles Maerky collection, held by the Natural History Museum of Geneva, 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 labeling, 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, FR = Fribourg, GE = Geneva, GR = Grisons, JU = Jura, LU = Lucerne, TI = Ticino, VD = Vaud, VS = Valais.

Results

Swiss fauna Coccinellidae list

We consider that the 81 species (82 taxa) listed in bold and without square brackets “[]” either currently do or formerly did form populations in Switzerland, even if only scant information is available for many of them. We also consider here several allochthonous species, originating from other regions of the world (sometimes introduced), which maintain (or have maintained) continuous populations in Switzerland during several years.

On the other hand, the 14 species (15 taxa including the subspecies) 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), 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 as doubtful. Other species may eventually be found in the Swiss territory, but currently available data are not sufficient to confirm their establishment in Switzerland. We also consider here allochthonous species (but not established) certainly found in Switzerland but whose observation results each time from either new or attested or probable imports.

To facilitate the species’ search in this document, taxa appear in alphabetical order for subfamilies, tribes, genera, subgenera, species and subspecies.

All collected information represents 33’976 occurrences within the concerned family.

Updated distribution maps of these species are available on the info fauna – CSCF cartographic server (<http://lepus.unine.ch/cart/>). All the valid data are also available in <http://www.GBIF.org> (<https://doi.org/10.15468/dl.w7yjnn>).



Figure 1. A. *Exochomus oblongus*; B. *Parexochomus nigromaculatus*; C. *Rhyzobius lophanthae*; D. *Calvia quindecimguttata*; E. *Ceratomegilla alpina redtenbacheri*; F. *Coccinella venusta adalioides*; G. *Coccinella trifasciata trifasciata*; H. *Oenopia impustulata*; I. *Hyperaspis concolor*, habitus; J. aedeagus ventral view; K. *Hyperaspis peezi*, habitus; L. aedeagus ventral view; M. *Hyperaspis pseudopustulata*, habitus; N. aedeagus ventral view; O. *Hyperaspis reppensis*, habitus; P. aedeagus ventral view; Q. *Clitostethus arcuatus*; R. *Nephus bisignatus*, habitus; S. aedeagus ventral view; T. aedeagus lateral view; U. *Scymniscus anomus*, habitus; V. aedeagus ventral view; W. *Scymnus doriae*, habitus; X. aedeagus ventral view. When no scale is specified, the scale bar is equal to 1 mm.

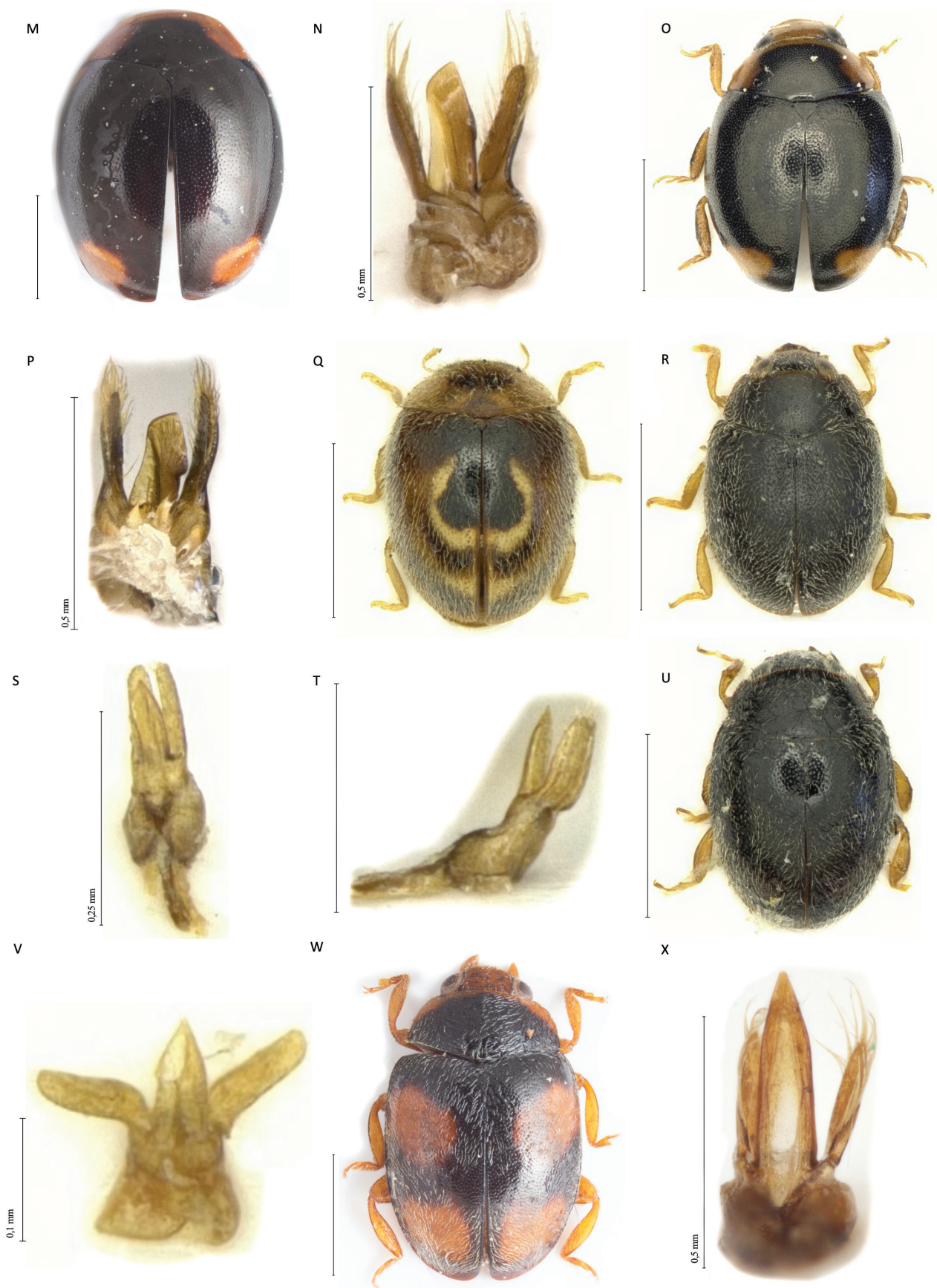


Figure 1. Continued.

Checklist of the Swiss species

Coccinellinae Latreille, 1807

Chilocorini Mulsant, 1846

Chilocorus bipustulatus (Linnaeus, 1758)

Chilocorus renipustulatus (L. G. Scriba, 1791)

[*Chilocorus similis* (P. Rossi, 1790)] C1

Exochomus oblongus Weidenbach, 1859 C2

Exochomus quadripustulatus (Linnaeus, 1758)

Parexochomus nigromaculatus (Goeze, 1777) C3

Coccidulini Mulsant, 1846

Coccidula rufa (Herbst, 1783)

Coccidula scutellata (Herbst, 1783)

[*Cryptolaemus montrouzieri montrouzieri* Mulsant, 1853] C4

Rhyzobius chrysomeloides (Herbst, 1792)

Rhyzobius forestieri (Mulsant, 1853) C5

Rhyzobius litura (Fabricius, 1787)

Rhyzobius lophanthae (Blaisdell, 1892) C6

Coccinellini Latreille, 1807

Adalia (Adalia) bipunctata (Linnaeus, 1758)

Adalia (Adalia) decempunctata (Linnaeus, 1758)

Adalia (Adaliomorpha) conglomerata (Linnaeus, 1758)

Anatis ocellata (Linnaeus, 1758)

Anisosticta novemdecimpunctata (Linnaeus, 1758)

Aphidecta obliterated (Linnaeus, 1758)

[*Bulaea lichatschovii* (Hummel, 1827)] C7

Calvia decemguttata (Linnaeus, 1767)

Calvia quatuordecimguttata (Linnaeus, 1758)

Calvia quindecimguttata (Fabricius, 1777) C8

Ceratomegilla (Adaliopsis) alpina alpina (A. Villa & G. B. Villa, 1835)

Ceratomegilla (Adaliopsis) alpina redtenbacheri (Capra, 1928) C9

Ceratomegilla (Ceratomegilla) notata (Laicharting, 1781)

Ceratomegilla (Ceratomegilla) rufocincta doderoi (Capra, 1944)

[*Ceratomegilla (Ceratomegilla) rufocincta rufocincta* (Mulsant, 1850)]
C10

Ceratomegilla (Ceratomegilla) undecimnotata (D. H. Schneider, 1792)

Coccinella (Chelonitis) venusta adalioides (Capra, 1944) C11

Coccinella (Coccinella) hieroglyphica hieroglyphica Linnaeus, 1758

Coccinella (Coccinella) magnifica L. Redtenbacher, 1843

Coccinella (Coccinella) quinquepunctata Linnaeus, 1758

Coccinella (Coccinella) septempunctata Linnaeus, 1758

Coccinella (Coccinella) trifasciata trifasciata Linnaeus, 1758 C12

[*Coccinella (Spilota) undecimpunctata undecimpunctata* Linnaeus,
1758] C13

Coccinula quatuordecimpustulata (Linnaeus, 1758)

Halyzia sedecimguttata (Linnaeus, 1758)

Harmonia axyridis (Pallas, 1773)

Harmonia quadripunctata (Pontoppidan, 1763)

Hippodamia (Hemisphaerica) septemmaculata (DeGeer, 1775)

Hippodamia (Hemisphaerica) tredecimpunctata (Linnaeus, 1758)

Hippodamia (Hippodamia) variegata (Goeze, 1777)

Myrrha (Myrrha) octodecimguttata (Linnaeus, 1758)

Myzia oblongoguttata oblongoguttata (Linnaeus, 1758)

Oenopia conglobata conglobata (Linnaeus, 1758)

Oenopia impustulata (Linnaeus, 1767) C14

Oenopia lyncea agnatha (Rosenhauer, 1847)

Propylea quatuordecimpunctata (Linnaeus, 1758)

Psyllobora (Thea) vigintiduopunctata (Linnaeus, 1758)

Sospita vigintiguttata (Linnaeus, 1758)

Tytthaspis sedecimpunctata (Linnaeus, 1761)

Vibidia duodecimguttata (Poda von Neuhaus, 1761)

Epilachnini Mulsant, 1850

[*Chnootriba elaterii* (P. Rossi, 1794)] C15

Cynegetis impunctata (Linnaeus, 1767)

Henosepilachna argus (Geoffroy, 1785)

[*Henosepilachna vigintioctopunctata* (Fabricius, 1775)] C16

Subcoccinella vigintiquatuorpunctata (Linnaeus, 1758)

Hyperaspidini Mulsant, 1846

Hyperaspis (Hyperaspis) campestris (Herbst, 1783)

Hyperaspis (Hyperaspis) concolor (Suffrian, 1843) C17

[*Hyperaspis (Hyperaspis) erythrocephala* (Fabricius, 1787)] C18

Hyperaspis (Hyperaspis) peezi Fürsch, 1976 C19

Hyperaspis (Hyperaspis) pseudopustulata Mulsant, 1853 C20

[*Hyperaspis (Hyperaspis) quadrimaculata* (Redtenbacher, 1843)] C21

Hyperaspis (Hyperaspis) reppensis (Herbst, 1783)

Noviini Mulsant, 1850

[*Novius cardinalis*] (Mulsant, 1850) C22

Platynaspidini Mulsant, 1846

Platynaspis luteorubra (Goeze, 1777)

Scymnini Mulsant, 1846

Clitostethus arcuatus (P. Rossi, 1794) C23

Nephus (Bipunctatus) bipunctatus (Kugelann, 1794)

Nephus (Bipunctatus) bisignatus (Fürsch, 1984) C24

[*Nephus (Bipunctatus) kiesenwetteri* (Mulsant, 1850)] C25

[*Nephus (Nephus) binotatus* (C. N. F. Brisout de Barneville, 1863)] C26

Nephus (Nephus) quadrimaculatus (Herbst, 1783)

Nephus (Nephus) redtenbacheri (Mulsant, 1846)

Scymniscus anomus (Mulsant & Rey, 1852) C27

[*Scymniscus horioni* (Fürsch, 1965)] C28

Scymnus (Neopullus) ater Kugelann, 1794

Scymnus (Neopullus) haemorrhoidalis Herbst, 1797

Scymnus (Neopullus) limbatus Stephens, 1832

Scymnus (Parapullus) abietis (Paykull, 1798)

Scymnus (Pullus) auritus Thunberg, 1795

Scymnus (Pullus) ferrugatus (Moll, 1785)

[*Scymnus (Pullus) fraxini* Mulsant, 1850] C29

Scymnus (Pullus) impexus Mulsant, 1850

Scymnus (Pullus) subvillosus (Goeze, 1777)

Scymnus (Pullus) suturalis Thunberg, 1795

Scymnus (Scymnus) apetzii Mulsant, 1846

Scymnus (Scymnus) doriae Capra, 1924 C30
Scymnus (Scymnus) femoralis (Gyllenhal, 1827)
Scymnus (Scymnus) frontalis (Fabricius, 1787)
Scymnus (Scymnus) interruptus (Goeze, 1777)
[*Scymnus (Scymnus) marginalis* (P. Rossi, 1794)] C31
Scymnus (Scymnus) nigrinus Kugelann, 1794
Scymnus (Scymnus) rubromaculatus (Goeze, 1777)
Scymnus (Scymnus) schmidti Fürsch, 1958
Scymnus (Scymnus) suffrianioides apetzoides (Capra & Fürsch, 1967)

Stethorini Dobrzanskiy, 1924

Stethorus (Stethorus) pusillus (Herbst, 1797)

Commented species

C1) [*Chilocorus similis* (P. Rossi, 1790)]

Published data. ^{1,8)}Aigle by Jaccard H. (Jaccard 1890); ^{1,8)}Puschlav [Poschiavo] by Killias E., ^{1,8)}Chur in der Au, 1848, by Kriechbaumer J. and ^{1,8)}Chur, 1887, by Killias E. (Caflich 1894); ^{1,8)}[Schweiz] (Stierlin 1898).

Comment. None of the numerous citations in the older literature are reliable, as none of them are supported by specimens in the examined collections. In the Palearctic region, *C. similis* is only known from Italy, but absent from Sardinia (Canepari 2011).

C2) *Exochomus oblongus* Weidenbach, 1859

Fig. 1A

Examined material. 1 ex., GR, Eng. [Engadin], V. d'Uina, VII.1972, leg. Toumayeff G., MHNG.

Comment. This very rare species which develops on pines (probably *Pinus mugo* Turra in Switzerland) and perhaps also on spruce (*Picea* spp.) and juniper (*Juniperus* spp.) in peat bogs, is only present in Germany (Bavarian region and Baden-Württemberg), in Austria and Italy (Tyrol), and very sporadically in Czech Republic, and Bosnia and Herzegovina. Only one specimen was found in Switzerland in the canton of Grisons at 1800 meters above the sea level, close to the Tyrol region. Considered as belonging to the Swiss fauna, the species has not been found in Switzerland for 50 years, and further research is necessary to identify a real native population.

C3) *Parexochomus nigromaculatus* (Goeze, 1777)

Fig. 1B

Examined material. 7 ex., Bern, leg. Benteli F., det. Kreissl E., NMBE; 1 ex., Genève, Gr. Saconnex, leg. Anonymous, coll. Zehr S., MHNG; 1 ex., Genf, leg. Lasserre, ETH; ^{3,4,6)}1 ex., Wallis, leg. Anonymous, det. Kreissl E., NMBE; ^{3,4,6)}1 ex., Helvet. [Helvetia], leg. Anonymous, ETH; ³⁾² ♂, Kt. Genf, leg. Täschler M., coll. Linder A., ETH; 3 ex., Pomy, leg. & coll. Mellet L., MZL; ^{3,4,6)}1 ex., Wallis, leg. Anonymous, NMBE; 1 ex.,

Peney, VII.1908, leg. Tournier H., MHNG; 1 ex., Genève, Jussy, 2.VII.1918, leg. Zehr S., MHNG; 1 ex., Châtelaïne, 27.V.1921, leg. & coll. Simonet J., MHNG; 1 ex., London [Allondon], 15.VI.1943, leg. & coll. Simonet J., MHNG.

Published data. ¹⁾Genf by Chevrier F. (Stierlin and Gautard 1867); ¹⁾Seeland b. Kerzers by Rätzer A. (Rätzer 1888); Switzerland, uncertain data (Nedvěd 2015).

Comment. *Parexochomus nigromaculatus* is widely distributed in Europe. It is known from all France and Corsica (Nicolas and Pique 2008; Callot 2009; Nicolas 2009; Coutanceau 2014) but its presence was considered uncertain in Switzerland by Nedvěd (2015). However, several Swiss specimens exist in the examined collections, especially in the Geneva area, but the species has not been found for almost 80 years. Further research is needed to confirm if this species is still present in Switzerland. It is found on different species of deciduous and coniferous trees and plants, including pine trees (*Pinus* spp.), European blueberry (*Vaccinium myrtillus* L.), willows (*Salix* spp.), heathers (*Calluna* spp., *Erica* spp.), gorses (*Ulex* spp.), brooms (*Cytisus* spp.), junipers (*Juniperus* spp.) and oaks (*Quercus* spp.) (Nicolas and Pique 2008; Nedvěd 2015; Classen et al. 2016; Klausnitzer 2019b, 2020), especially in the moorlands, where it feeds on coccids (and aphids (Coutanceau 2014)), especially *Peliococcus calluneti* (Lindinger, 1912), *Phyllostroma myrtilli* (Kaltenbach, 1874) and *Rhizococcus devoniensis* (Green, 1896) (Klausnitzer 2019b).

C4) [*Cryptolaemus montrouzieri montrouzieri* Mulsant, 1853]

Examined material. ⁸⁾11 ex., Suisse, Lucerne, Grossdietwil, IV.1993, leg. & det. Andermatt Biocontrol Suisse AG, MHNG.

Comment. This Australian species is now established in the Palearctic region after several introductions on the continent for biological control of mealybugs (Hemiptera, Pseudococcidae) (Franco et al. 1994; Roy and Migeon 2010; Klausnitzer 2020). It was first recorded in Europe in Italy in 1908 (Canepari 2007; Roy and Migeon 2010) and in 1918 in France (Coutanceau 2014) where it is now principally known from the Mediterranean coast (Midi and Corsica), even if a case of urban reproduction (specimens escaped from a green house) was also reported in the north of the country (Cloupeau et al. 2012; Coutanceau 2014). In Switzerland, 11 specimens were found in 1993 in the canton of Luzern by a company commercializing this species as a biological control agent. They are therefore certainly the result of introductions. Nevertheless, it seems that this species has not become established and therefore is not considered as belonging to the Swiss fauna. *Cryptolaemus montrouzieri montrouzieri* is sensitive to cold and it seems that it cannot overwinter in the field in Central Europe at the moment (Klausnitzer 2020). Nevertheless, the species is still commercialized for biological control in Switzerland and may therefore be found again in the future.

C5) *Rhyzobius forestieri* (Mulsant, 1853)

Examined material. 1 ex., Brissago TI, 3.VII.2022, leg. & coll. Chittaro Y.; 1 ♂, Mendrisio TI, 5.VII.2022, leg. & coll. Chittaro Y.

Comment. *Rhyzobius forestieri* is a species of Australian origin imported in Europe in the 1980s for the biological control of the Olive Scale *Saissetia oleae* (Olivier, 1791) (Hemiptera, Coccidae) (Katsoyannos 1984). In Switzerland's neighboring countries, it is acclimatized since 1987 in France (Cloupeau and Durand 2010) and in Italy (Canovai and Raspi 1999), but never seems to have been reported in Germany or in Austria. In 2022, two specimens were found in the canton of Ticino in Switzerland, in two localities several tens of kilometers apart, in good natural environments. Since to our knowledge the species has never been introduced in Switzerland, we suspect a natural colonization of Ticino from Italy.

C6) *Rhyzobius lophanthae* (Blaisdell, 1892)

Fig. 1C

Examined material. 1 ex., CH, TI, Lugano, Mt. Brè-Vetta, 11.–20.VII.1983, leg. Rezbanyai-Reser L., NMLU; 1 ex., CH, TI, Meride, San Antonio, 1.–10.-VIII.1991, leg. Rezbanyai-Reser L., NMLU; 1 ex., TI, S. Pietro, Mte Albano, VIII.1991, leg. Station fédérale de recherches agronomiques Changins, MHNG; 1 ex., CH, TI, Mezzana, Balerna, 11.–20.VI.1997, leg. Rezbanyai-Reser L., NMLU; 1 ex., Meinier GE, 30.V.–5.VI.2015, leg. Faye J. D., LEBA; 5 ex., Meinier GE, 30.VI.–15.VII.2015, 15.–31.VII.2015, 31.VII.–15-VIII.2015, leg. Faye J. D., LEBA; 2 ex., Meyrin GE, 28.VI.–11.VII.2016, 11.–25.VII.2016, leg. Monod V., LEBA; 1 ex., Gy GE, 26.VI.–10.VII.2017, leg. Bessat M., LEBA; 1 ♂, Jaun FR, 4.–24.VI.2019, leg. Hauser G., MHNF; 1 ♂, Jaun FR, 15.VII.–11.VIII.2019, leg. Giriens S., coll. Chittaro Y.; 1 ex., Morges VD, 22.II.2020, leg. & coll. Chittaro Y.; 1 ex., Signy-Avenex VD, 8.VII.–1.VIII.2020, leg., det. & coll. Breitenmoser S.; 1 ex., Fully VS, 20.VII.2022, leg. Sierro A., coll. Chittaro Y.

Published data. Most of the data above in Sanchez et al. (2021).

Comment. The situation of this exotic species, now established in Switzerland, was extensively detailed in Sanchez et al. (2021). Since this publication, several new specimens have been found in the country, which seems to show that *R. lophanthae* continues its expansion in the country.

C7) [*Bulaea lichatschovii* (Hummel, 1827)]

Examined material. ^{3,4,6,8}3 ex., Genève, leg. Poncy E., coll. Maerky C., MHNG; ^{3,4,6,8}3 ex., Genève, Lancy, leg. Fries A., coll. Maerky C., MHNG; ^{3,8}4 ex., Genf, leg. Lasserre H., ETH; ^{3,4,6,8}2 ex., Suisse, Nyon, leg. Poncy E., coll. Maerky C., MHNG.

Published data. ^{1,8}[Schweiz] by Heer O. (Bremi-Wolf 1856); ^{1,8}Genf by Chevrier F. (Stierlin and Gautard 1867); ^{1,8}Visp by Rätzer (Rätzer 1888).

Comment. This species is present in Africa and in the eastern Palearctic region and has been occasionally introduced in Central Europe (Ali et al. 2014; Nedvěd 2015; Biranvand et al. 2017). All the examined specimens belong to problematic collections (see Monnerat et al. 2015) and therefore this species is not considered as belonging to the Swiss fauna. *Bulaea lichatschovii* feeds on plants (mostly pollen) of Chenopodiaceae.

C8) *Calvia quindecimguttata* (Fabricius, 1777)

Fig. 1D

Examined material. ³1 ex., Tessin, leg. Ghidini A., coll. Maerky C., MHNG; 1 ex., Mendrisio, 21.VII., leg. Frey-Gessner E., MHNG; ³1 ex., Suisse, Mendrisio, 24.VII., leg. & coll. Maerky C., MHNG; ³3 ex., Suisse, Agno, 29.VII., leg. & coll. Maerky C., MHNG; 1 ex., TI, Locarno, V.1934, leg. & coll. Toumayeff G., MHNG; 1 ex., Bioggio, 24.V.1955, leg. & coll. Simonet J., MHNG; 1 ex., CH, LU, Sempach, Vogelwarte, IX.1980, leg. Rezbanyai-Reser L., det. Herger P., NMLU.

Published data. ¹Genf and Vallorbes by Lasserre H., ¹Schaffhausen by Stierlin G. and ¹Wallis by Venetz I. (Stierlin and Gautard 1867); Mendrisio by Frey-Gessner E. (Stierlin 1883); ¹Alpes de Moerell [Mörel] and ¹Glacier d'Aletsch by Martin C. (Favre 1890); ¹[Schweiz] and ¹Schaffhausen (Stierlin 1898); ¹Chiasso by Fontana P. (Fontana 1947); 1 ex., LU, Sempach, Vogelwarte, 21.–30. IX.1980, leg. Rezbanyai-Reser L. (Rintelen and Herger 1997); Switzerland (Kovář 2007; Nedvěd 2015).

Comment. Even though this species was frequently recorded from Switzerland in the old literature, only a small number of records can be reliably assigned to this species, confirming the presence of a few scattered populations within the country. Very rare and localized in Switzerland, this species was principally found in the south of the country, in the canton of Ticino, although one specimen was found in the canton of Luzern in 1980 using a light trap (the attraction by light was already noticed by Klausnitzer (2019, 2020)). *Calvia quindecimguttata* lives in deciduous forests in wetlands, marshes and pond banks, mainly on alders (*Alnus* spp.) and willows, where it feeds on aphids, psocopterans and immature stages of chrysomelids (probably *Agelastica alni* (Linnaeus, 1758) or *Plagiosterna aenea* (Linnaeus, 1758)) (Nedvěd 2015; Klausnitzer 2019b, 2020). It is fairly widely distributed in Central Europe but is always considered as rare.

C9) *Ceratomegilla alpina redtenbacheri* (Capra, 1928)

Fig. 1E

Examined material. 1 ex., Suisse, Grisons, Val Mora, 3.VIII.1974, leg. Besuchet C., det. Fürsch H., MHNG.

Comment. *Ceratomegilla alpina* is represented by two subspecies in the Palearctic region: *C. a. alpina* is present in Austria, France (Alps), Italy (north), Liechtenstein and Switzerland, and *C. a. redtenbacheri* is present in Austria (Alps), Bosnia and Herzegovina (Kulijer 2015), Bulgaria, Germany (Bayern), Poland (Tatra), Romania, Slovakia (Tatra) and

Ukraine (Karpaty). If the nominal subspecies is very widely distributed in the Alps in Switzerland and sometimes quite abundant at altitude, the same is not true for the subspecies *redtenbacheri*, which is only known from one specimen, captured in flight at 2200 m in the Val Müstair region, bordering the Tyrol, where the species is also known. Specific research is necessary to confirm the presence of a real native population or the validity of the subspecies distinction.

C10) [*Ceratomegilla (Ceratomegilla) rufocincta rufocincta* (Mulsant, 1850)]

Published data. ¹Switzerland (Kovář 2007).

Comment. *Ceratomegilla rufocincta* is represented by two subspecies in Europe: *C. r. rufocincta* and *C. r. doderoi*. No specimens referring to the nominal subspecies were found in the controlled collections in Switzerland, but the alpine subspecies *doderoi* occurs in our country at high elevation. Kovář (2007) announced the nominal subspecies from Italy (Alps) and Switzerland. Coutanceau (2014) does not consider any subspecies and announced *C. rufocincta* from the southern Alps in France, Italy and Switzerland. This taxon is not considered as belonging to the Swiss fauna.

C11) *Coccinella (Chelonitis) venusta adalioides* (Capra, 1944)

Fig. 1F

Examined material. 1 ex., Kt. Wallis, Col de Fenêtre, VII.1903, leg. [Steck T.], coll. Linder A., ETH; 1 ex., Simplon VS, 26.VI.2013, leg. Marggi W., coll. Sanchez A.

Published data. Col de Fenêtre, VII.1903, coll. Steck T. (Linder 1953); Walliser Alpen (Fürsch 1967); ¹1 ex., VS, Breithorn, 18.VII.1984 by Kiener S. (Kiener 1995).

Comment. This species is represented by two subspecies: *C. venusta venusta* (J. Weise, 1879) and *C. venusta adalioides*. Kovář (2007) announces the nominal subspecies only from the French Alps and the subspecies *adalioides* only from the Italian Alps. Coutanceau (2014) announces the nominal subspecies from the French Alps and from Italy, whereas he mentions *adalioides* from the Alpes-maritimes in France and from Italy. In Switzerland, only two specimens belonging to the subspecies *adalioides* were found, in the Alps in the canton of Valais. The specimen from the Breithorn cited by Kiener (1995) was not found in any collection. *Coccinella venusta adalioides* is found in high altitude meadows, in low vegetation, under rocks and at the foot of cliffs, sometimes with the morphologically similar *Ceratomegilla rufocincta doderoi*. Additional surveying in the Valais may yield reliable data on this species.

C12) *Coccinella (Coccinella) trifasciata trifasciata* Linnaeus, 1758

Fig. 1G

Examined material. 1 ex., Helvet., leg. Anonymous, ETH; 2 ex., Stürvis, leg. & coll. Killias E., BNM; 2 ex., Stürvis, leg. Anonymous, det. Besuchet C., BNM; ³1 ex., Suisse,

leg. Mellet A., coll. Maerky C., MHNG; ³1 ex., Hte Engadine, VIII., leg. & coll. Toumayeff G., MHNG; 2 ex., Alp La Schera, 28.VII.1919, 3.VIII.1921, leg. & coll. Handschin E., BNM; 1 ex., Stavelchod, 10.VIII.1921, leg. & coll. Handschin E., BNM; 1 ex., Albula, Zavretta, 30.V.1950, leg. Wolf J.-P., ETH; 1 ex., Albula, 13.VII.1950, leg. Wolf J.-P., ETH; 1 ex., Buffalora, 17.VI.1952, leg. & coll. Handschin, BNM; 23 ex., Kt. Graubünden, Scans, VII.1952, leg. Linder A., coll. Besuchet C., MZL, coll. Linder A., ETH, coll. Louis P., NMBE, coll. Schenk H., NMBE, coll. Toumayeff G., MHNG; 2 ex., Bernina, VIII.1964, leg. & det. Linder A., NMBE; 1 ex., Bernina, VIII.1964, leg. & det. Linder A., coll. Kiener S., MHNG; 1 ex., Flumserberg, Zieger, 13.VII.1965, leg. Hugentobler H., MHNG; 1 ex., GR, PNS [Parc national Suisse – swiss national park], Munt la Schera, 8.VIII.1977, leg. & coll. Scherler P., NMBE; 1 ex., Ofenpass, 17.VII.1985, leg. Rössler G., det. Besuchet C., TLMF; 1 ex., Pontresina, 22.VII.1986, leg., det. & coll. Köstlin R., SMNS; 2 ex., Zermatt VS, 8.VII.2022, 18.VII.2022, leg. & coll. Sanchez A.

Published data. Morteratsch-Gletscher and am Paradies by Meyer-Dür R. L. (Stierlin 1862); Stürviser Alp in Bündten by Killias E. (Stierlin 1883); Davos by Nagel H. and Stürviser Alp by Stoffel A. (Caflich 1894); Oberengadin (Stierlin 1898); Alp la Schera, 28.VII.1919, by Handschin E., Alp la Schera, 3.VIII.1921, Stabelchod, 10.VIII.1921, by Handschin E. and Buffalora, VI.1953, by Aubert J. (Handschin 1963); Flumserberg, Zieger, VII.1965, by Hugentobler H. (Hugentobler 1966); Arosa by Müller-Rutz J., Bernina and Scans by Linder A. and Vals by Jörger J. B. (Linder 1967).

Comment. In the Palearctic region, this species is only represented by the nominal subspecies, distributed in Austria, Belarus, Finland, Italy, Norway, Russia, Sweden and Switzerland. In this last country, *C. trifasciata trifasciata* is rare and localized and seemed restricted to the east, where it was not found for more than 30 years. Nevertheless, it was found in 2022 in an alpine meadow located at 2640 m, in the region of Zermatt, located much further west. Little information is available concerning its ecology except for its presence at high altitude in Switzerland.

C13) [*Coccinella (Spilota) undecimpunctata undecimpunctata* Linnaeus, 1758]

Examined material. ³1 ex., Genève, Sierne, leg. & coll. Maerky C., MHNG; ³1 ♂, Genf, leg. Lasserre H., ETH; ³1 ex., Suisse, Valais, leg. Odier J., coll. Maerky C., MHNG; ³1 ex., Veyrier, 15.VI., leg. Maerky C., MHNG; ³1 ex., Alpes, Forclaz, 21.VI., leg. & coll. Maerky C., MHNG; ³7 ex., Zurich, VIII., leg. & coll. Toumayeff G., MHNG; ³3 ex., Chancy, 2.IX., leg. Maerky C., MHNG; ³1 ex., Alpes vaudoises, 21.VII.1887, leg. & coll. Gaud A., MZL.

Published data. ¹Suisse (Fuesslin 1775); ³Genf by Lasserre H., ¹Lausanne by Mellet L. and ¹Peney by Genf by Tournier H. (Stierlin and Gautard 1867); ¹Chiasso by Fontana P. (Fontana 1947); ²Blaisch Bella, 9.VII.1945 and ¹Val Plavna, 30.VII.1953 by Handschin E. (Handschin 1963).

Comment. All examined specimens belong to problematic collections that should not be considered (see Monnerat et al. 2015). None of the numerous citations in the older literature are reliable, as none of them are based on dissected male specimens and may refer to other species. Therefore, this species is not considered as belonging to the Swiss fauna according to the scarce information available. Concerning the literature data from Handschin (1963), two specimens from Blaisch Bella (9.VII.1945) were found in the Handschin collection at the BNM but they were *C. quinquepunctata*. For the data from Val Plavna, no specimens with such information were found in the Handschin's collection. This species has halophilic preferences and usually lives near the sea or in salt marshes, conditions that obviously do not exist in Switzerland. *Coccinella undecimpunctata undecimpunctata* is rare in Central Europe : Austria, Belgium, Czech Republic, Denmark, Georgia, Germany, Hungary, Luxembourg, Netherlands, Poland and Slovakia (Kovář 2007; Klausnitzer B. pers. comm.). The species is mainly aphidophagous, but can also feed on coccids, nectar and pollen (Nicolas and Pique 2008; Nicolas 2009; Canepari 2011; Nedvěď 2015). According to Nicolas and Pique (2008), it has been caught in Aisne in France on herbaceous plants found in wastelands and along roadsides, on black pines (*Pinus nigra* J. F. Arnold) but also on deciduous trees like *Salix cinerea* L. and *Quercus robur* L. It overwinters among stones and in buildings (Nedvěď 2015).

C14) *Oenopia impustulata* (Linnaeus, 1767)

Fig. 1H

Examined material. 5 ex., Katz. [Katzensee], leg. & coll. Hugentobler H., ETH; 2 ex., Genève, La Batie, VI.1949, leg. & coll. Toumayeff G., MHNG; 1 ex., Genève, Chancy, IV.1956, leg. & coll. Toumayeff G., MHNG; 7 ex., 29.IV.–23.V.2022, 22.VI.–12.VII.2022, 12.VII.2022, 12.VIII.2022, Les Ponts-de-Martel NE, leg. & coll. Chittaro Y.; 2 ex., 1 ♂, 1 ♀, 22.V.2022, Les Ponts-de-Martel NE, leg. & coll. Chittaro Y. & Sanchez A.

Published data. ^{1,8}[Schweiz] by Heer O. (Bremi-Wolf 1856); ¹St. Gallen by Täschler M. (Täschler 1872); ¹Sierre et environs by Schacht W. (Schacht 1879); ¹Fully, ¹La Souste and ¹Lausanne by Bugnion E. (Favre 1890).

Comment. This species is rare in Central Europe. In France, it is present in the Rhône Valley, in Alsace and in Seine-et-Loire (Coutanceau 2014). In Switzerland, only a very small number of specimens from four localities in the cantons of Geneva, Neuchâtel and Zürich confirm the occurrence of this species, where it appears to be rare. In 2022, after 60 years without any record in Switzerland, one specimen was found using an interception trap and eight specimens by beating birches (*Betula* sp.), all in a birch forest bordering a bog. It lives in heath, sand and bog areas, where it feeds on aphids almost exclusively on birches (especially *Betula pendula* Roth and *B. pubescens* Ehrh.) (Ziegler and Teunissen 1992; Nicolas 2009; Nedvěď 2015; Klausnitzer 2020). It is important

to note that *O. impustulata* can easily be confused with dark forms of *O. conglobata*, a widespread species in Switzerland.

C15) [*Chnootriba elaterii* (P. Rossi, 1794)]

Examined material. ^{3,4,6,8}1 ex., Genève, Chancy, leg. & coll. Maerky C., MHNG; ^{3,4,6,8}5 ex., Genève, Peney, leg. Täschler H., coll. Maerky C., MHNG; ^{3,4,6,8}1 ex., Genf, leg. Täschler M., MHNG; ^{3,4,6,8}1 ex., Jura, Dôle, leg. & coll. Maerky C., MHNG.

Published data. ^{1,8}Switzerland (Kovář 2007; Nedvěď 2015).

Comment. This phytophagous species living on Cucurbitaceae and Solanaceae is known from Europe, North Africa and Western Asia. In France, it is only found in Corsica (Coutanceau 2014). All specimens examined belong to the problematic collection of C. Maerky (see Monnerat et al. 2015) and are therefore not retained as valid records. *C. elaterii* does not belong to the Swiss fauna.

C16) [*Henosepilachna vigintioctopunctata* (Fabricius, 1775)]

Published data. ^{1,8}[Schweiz] by Heer O. (Bremi-Wolf 1856); ^{1,8}Genf by Tournier H. and Schaffhausen by Stierlin G. (Stierlin and Gautard 1867).

Comment. *Henosepilachna vigintioctopunctata* is a species native to Asia which is not present in Central Europe. Despite several publications announcing it from Switzerland, no specimen was found in the collections examined.

C17) *Hyperaspis (Hyperaspis) concolor* (Suffrian, 1843)

Fig. 1I, J

Examined material. 1 ♀, Kt. Tessin, Taverne, VI.1938, leg. & coll. Linder A., ETH; 1 ex., Tessin, Biasca, 30.VII.1948, leg. Wolf J.-P., ETH; 1 ex., Kt. Tessin, Mendrisio, VI.1949, leg. & coll. Linder A., ETH; 1 ♂, Kt. Graubünden, Grono, V.1952, leg. & coll. Linder A., ETH; 1 ex., TI, Stabio, 18.VI.1971, leg. Spälti A., det. Klausnitzer B., MHNG; 3 ex., 2 ♂, Suisse, TI, Meride, 14.VIII.1976, 11.VI.1982, leg. & coll. Scherler P., NMBE; 2 ex., CH, TI, Somazzo, Torretta-O.[Ost], 16.V.1990, 1.VIII.1990, leg. Rezbanyai-Reser L., det. Herger P., NMLU; 1 ♂, Courroux JU, 4.–27.V.2016, leg. & coll. Chittaro Y.; 1 ♂, Vollèges VS, 17.VII.–15.VIII.2017, leg. & coll. Sanchez A.; 1 ♂, Fully VS, 11.IV.–9.V.2019, leg. & coll. Chittaro Y.; 1 ♂, 1 ♀, Sion VS, 7.IV.–29.VII.2020, leg. & coll. Sanchez A.

Published data. Switzerland (Kovář 2007; Nedvěď 2015).

Comment. *Hyperaspis concolor* is a rare and localized species in Europe. In the neighbouring countries, it is known from France (from the Mediterranean region, from Paris (Bois de Boulogne) and from Indre-et-Loire (Coutanceau 2014)), from Austria, Germany and

Italy. While also quite rare in Switzerland, there are scattered records from various parts of the country, particularly in the south. This thermophilic species lives in xerothermic meadows, pastures and forest margins, on grass, herbs and deciduous trees (Nedvěď 2015; Klausnitzer 2020).

C18) [*Hyperaspis (Hyperaspis) erythrocephala* (Fabricius, 1787)]

Published data. ^{1,8)}Switzerland, uncertain data (Nedvěď 2015).

Comment. *Hyperaspis erythrocephala* is a rare and thermophilic species present in Central-Eastern Europe in Austria, Czech Republic, Hungary, Poland and Slovakia. Its presence is considered uncertain in Germany and Switzerland by Nedvěď (2015). We didn't find any specimens belonging to this species in the examined collections and we therefore advise the removal of this species from the list of the Swiss fauna.

C19) *Hyperaspis (Hyperaspis) peezi* Fürsch, 1976

Fig. 1K, L

Examined material. 1 ♂, Sierre, 22.VII., leg. Favre E., MHNG; 3 ♂, Kt. Wallis, Brig, VIII.1935, leg. & coll. Linder A., ETH; 2 ♂, Kt. Wallis, Leuk, VI.1937, leg. & coll. Linder A., ETH; 1 ♂, 2 ♀, Suisse, Valais, s/Gampel, 14.VII.1996, leg. Besuchet C., MHNG; 1 ♂, 1 ♀, Suisse, Valais, Gampel, 14.VIII.1996, leg. Besuchet C., MHNG; 1 ♂, Leuk VS, 31.III.2012, leg. & coll. Chittaro Y., det. Büche B.; 1 ♂, Anniviers VS, 14.–30.VIII.2013, leg. & coll. Sanchez A.; 1 ♂, Varen VS, 3.VII.–5.VIII.2015, leg. & coll. Chittaro Y., det. Büche B.; 1 ♂, Lens VS, 26.III.–18.IV.2019, leg. & coll. Sanchez A.

Comment. *Hyperaspis peezi* is a very rare and localized species, only known from southeastern France and Corsica (Coutanceau 2014), Croatia, Italy, Slovenia and Switzerland. In Switzerland, the species seems restricted to the canton of Valais. Very little information is available on its ecology, but all Swiss specimens were collected in sunny, hot, dry areas, where pines (*Pinus sylvestris* L.) and oaks are dominant. Very close to *H. reppensis* (Fig. 1O, P), its identification requires the examination of the male genitalia.

C20) *Hyperaspis (Hyperaspis) pseudopustulata* Mulsant, 1853

Fig. 1M, N

Examined material. 1 ♂, Helvetia, Ticino, Medeglia, torbiera Boscior, 6.V.1992, leg. Rampazzi F., MSNL; ¹⁾1 ex., Allondon, 7.V.1992, leg. & det. Johnson C., MAMU.

Published data. Switzerland, uncertain data (Nedvěď 2015).

Comment. The presence of this species in Switzerland is supported by only one male captured in 1992 in a peat bog in the canton of Ticino in the south of the country. The identification of the specimen from Ge-

neva (Allondon) has not been confirmed for the moment and a misidentification with *H. reppensis* remains possible without the observation of the male genitalia. *H. pseudopustulata* is widely distributed in Central Europe (Nedvěď 2015; Klausnitzer 2020) but is always rare, and its presence in Switzerland was considered as uncertain (Nedvěď 2015). In France, it is present in the northern half of the country, but probably also in the southern half (Coutanceau 2014). It is a thermophilic species living at water margins on semiaquatic plants (Nedvěď 2015; Klausnitzer 2020), but some authors hypothesize that it may also live in drier biotopes (Bogaert et al. 2012; Biranvand et al. 2020).

C21) [*Hyperaspis (Hyperaspis) quadrimaculata* (Redtenbacher, 1843)]

Examined material. ^{3,4,6,8)}1 ex., Veyrier, leg. Maerky C., MHNG.

Published data. ^{1,8)}[Schweiz] (Breimi-Wolf 1856).

Comment. This species is only distributed in Eastern Europe: Albania, Austria, Bulgaria, Czech Republic, Hungary, Greece, Romania and Slovakia. The only specimen with “a Swiss label” belongs to the problematic collection of Charles Maerky, which should not be considered (Monnerat et al. 2015). Therefore, the data available are insufficient to retain this species as part of the Swiss fauna.

C22) [*Novius cardinalis* (Mulsant, 1850)]

Examined material. 17 ex., Tessin, Locarno, 6.VIII.1946, leg. & coll. Simonet J., MHNG; 2 ex., Locarno, 27.IX.1951, leg. & coll. Schenk H., NMBE; 10 ex., Kt. Tessin, Locarno, IX.1951, leg. & coll. Linder A., ETH; 5 ex., Tessin, leg. Anonymous, ETH; 2 ex., Morcote, VI.1960, leg. & coll. Van de Gümster J., MHNG; 17 ex., CH, TI, Isola Brissago, 28.VIII.1992, 23.VII.1993, 24.VII.1993, 6.VIII.1993, 7.VIII.1993, leg. Rezbanyai-Reser L., coll. Focarile A., MHNG & MSNL.

Published data. 15 ex., Locarno, 6.VIII.1945, leg. Simonet J. and 10 ex., Locarno, IX.1951 (Linder 1968).

Comment. *Novius cardinalis* is an Australian species which has been introduced in many countries in the World (including Europe) for the biological control of *Icerya purchasi* Maskell, 1879 (Hemiptera, Monophlebidae), an important pest of citrus trees (Martin 2016). In France, it has been introduced several times and is now acclimatized in various parts of the country, especially in the southern region and in Corsica, in the Jura and in Paris (Coutanceau 2014). In Switzerland, it has occasionally been found between 1946 and 1993 in Ticino, in Locarno and on the Isola di Brissago, where there is a botanical garden. Numerous specimens have been found each time and it seems that these mentions in Switzerland are the result of multiple introductions. As the species has almost never been found two years in a row, it is assumed that it cannot overwinter here. Up till now, the species is therefore not considered naturalized in Switzerland.

C23) *Clitostethus arcuatus* (P. Rossi, 1794)

Fig. 1Q

Examined material. 2 ex., Kt. Waadt, Clarens, III.1944, II.1945, leg. & coll. Linder A., ETH; 1 ex., Préverenges, 6.VI.1950, leg. & coll. Besuchet C., MZL; 1 ex., Vidy, 18.VI.1950, leg. & coll. Besuchet C., MZL; 1 ex., Genève, London [Allondon], IV.1956, leg. & coll. Toumayeff G., MHNG; 1 ex., Suisse, Vaud, St. Légier, 11.IV.1959, leg. & coll. Scherler P., NMBE; 1 ex., Suisse, Vaud, Mormont, 6.VI.1959, leg. & coll. Scherler P., NMBE; 1 ex., VD, Bavois, VI.1974, leg. Toumayeff G., MHNG; 1 ex., TI, Loco, IV.1975, leg. Toumayeff G., MHNG; 4 ex., Suisse, VD, Grangettes, 20.VI.1995, 13.VII.1995, 19.VII.1995, 3.VIII.1995, leg. Anonymous, det. Calame F., MZL; 1 ex., CH, AG, Untersiggenthal, Iflue, 16.VII.1998, leg. & det. Walter T., ETH; 4 ex., Meinier GE, 15.–30.V.2015, 30.V.–14.VI.2015, 30.VI.–15.VII.2015, leg. Faye J.-D., LEBA; 1 ex., Gy GE, 6.VI.2016, leg. Guibert B.; 1 ex., Vully-les-Lacs VD, 25.VII.–7.VIII.2018, leg. Knoblauch A., coll. Chittaro Y.; 1 ex., Chevroux VD, 8.–25.V.2020, leg. Perret-Gentil N., coll. Chittaro Y.

Published data. ¹Basel by Imhoff L. (Stierlin and Gautard 1867); ¹Fully, ¹Martigny and ¹Ravoire by Favre E. (Favre 1890); Switzerland (Kovář 2007; Nedvěd 2015).

Comment. *Clitostethus arcuatus* is a Mediterranean species which has expanded its range northward into Central Europe in recent decades, probably possible due to the effects of global warming (Bathon and Pietrzyk 1986; Pütz et al. 2000). While quite rare in Switzerland, there are scattered records from various parts of the country, always found as isolated individuals, although it was reported that it could be found in large numbers in Italy (Canepari 2011). It is one of the smallest European ladybird species and it moves very quickly in hot weather, so it can easily go unnoticed. Thermophilic, it lives on deciduous and coniferous trees, also in parks and gardens, where adults and larvae feed on Aleyrodidae (Homoptera), Aphididae (Hemiptera) and Tetranychidae (Acari) (Gourreau 1974; Canepari 2011; Nedvěd 2015; Klausnitzer 2019b, 2020). According to Pütz et al. (2000), Coutanceau (2014), Klausnitzer (2019) and Szawaryn and Marczak (2021), it is regularly found on or near ivy (*Hedera helix* L.), but also on hawthorn (*Crataegus* spp.), blackthorn (*Prunus spinosa* L.), apple tree (*Malus* spp.), blackberry (*Rubus* spp.), skipping weed (*Impatiens* spp.), celandine (*Chelidonium* spp.), wood vine (*Clematis* spp.) and various cultivated plants. In winter, it can be found overwintering in the leaf litter (Nedvěd 2015).

C24) *Nephus (Bipunctatus) bisignatus* (Fürsch, 1984)

Fig. 1R–T

Examined material. 2 ♂, 1 ♀, 3 ex., Davos, Seeh. [Seehorn], 6.XI.1935, leg. Wolf J.-P., ETH; 1 ♂, Filisur, 1.III.1936, leg. Wolf J.-P., ETH; 1 ♂, Davos, 29.III.1936, leg. Wolf J.-P., ETH; 2 ♂, 1 ♀, 2 ex., Davoser Tal, Se. [Seehorn], 24.X.1936, leg. Wolf J.-P., ETH; 1 ♂, 1 ♀, Davos, Seeh. [Seehorn], 13.X.1937, leg. Wolf J.-P., ETH; 1 ♂, Gola di Lago, 8.VIII.1962, leg. & coll. Scher-

ler P., NMBE; 4 ♂, Svizzera, TI, Locarno, Monte Bré, 13.–20.V.1997, leg. Moretti M., MSNL; 1 ♂, Wengi BE, 27.VI.2019, leg. Fürst J., coll. Sanchez A.; 1 ♂, Messen SO, 6.VI.2019, leg. Fürst J., coll. Sanchez A.

Published data. Switzerland (without mention of the subspecies) (Nedvěd 2015).

Comment. *Nephus bisignatus* is represented in the Palearctic region by two subspecies: *N. b. bisignatus* (Boheman, 1850) distributed in the Azores, Croatia, Czech Republic, Denmark, Finland, France, Great Britain, Greece, Netherlands, Norway, Portugal, Slovakia and Sweden and *N. b. claudiae* present in Austria, Germany, Hungary, Netherlands and Sweden (Kovář 2007; Klausnitzer B. pers. comm.). In the bordering countries, only the subspecies *bisignatus* is present in Italy (Canepari 2011) and France (Coutanceau 2014) and only the subspecies *claudiae* is present in Austria and Germany (Kovář 2007). Therefore, both subspecies are potentially present in Switzerland. Nevertheless, due to the difficulties of attributing the Swiss specimens to one or the other of these subspecies with certainty, we prefer to identify this taxon only to the specific level. Future research may perhaps clarify the situation in Switzerland. *N. bisignatus* is a thermophilic species which lives on woody plants, in herbaceous and dwarf shrub vegetation, where it feeds on mealybugs (Nedvěd 2015; Klausnitzer 2019b). According to Nedvěd (2015) and Klausnitzer (2019), the species has psammophil preferences and lives near the sea coasts. In Switzerland, where these conditions do not occur, the specimens were found between 600 and 1800 m above the sea level.

C25) [*Nephus (Bipunctatus) kiesenwetteri* (Mulsant, 1850)]

Examined material. ^{3,4,6,8}1 ex., Suisse, Tessin, leg. Odier J., det. Fürsch H., coll. Maerky C., MHNG.

Comment. In Europe, this species is only present in the Mediterranean region: France (only Corsica), Italy (mainland, Sardinia and Sicily), Malta and Spain (mainland and Balearic Islands) (Kovář 2007; Canepari 2011; Coutanceau 2014). In Switzerland, the only specimen examined belongs to the problematic collection of C. Maerky (see Monnerat et al. 2015) and is therefore not retained as a valid record. Moreover, *N. kiesenwetteri* grows on *Tamarix* spp. (Canepari 2011; Coutanceau 2014; Nedvěd and Đurić 2022), a plant genus absent from Switzerland.

C26) [*Nephus (Nephus) binotatus* (C. N. F. Brisout de Barneville, 1863)]

Examined material. ^{3,4,6,8}1 ex., Tessin, leg. Ghidini A., det. Fürsch H., coll. Maerky C., MHNG.

Comment. The only specimen cited here belongs to the problematic collection of C. Maerky (see Monnerat et al. 2015) and is therefore not retained as a valid record. *Nephus binotatus* is only present in the Mediterranean region, in southern France and Corsica, in Spain and the Balearic Islands and in Portugal (Coutanceau 2014; Soares 2021; Nedvěd and Đurić 2022).

C27) *Scymniscus anomus* (Mulsant & Rey, 1852)

Fig. 1U, V

Examined material. 1 ♂, Helv., Ticino, Gerre di Losone, leg. & coll. Focarile A., det. Canepari C., MSNL; 1 ♂, Gerre di Losone, 20.–24.VI.1981, leg. Franscella C., det. Canepari C., MSNL.

Comment. *Scymniscus anomus* is a Mediterranean species only known from the Mediterranean region (and Corsica) in France (Coutanceau 2014), Austria (Klausnitzer B. pers. comm.), Greece, Italy, Hungary, Slovakia and Spain. In Italy, it is considered as widespread but uncommon (Canepari 2011). In Switzerland, two males were caught in a wetland in the canton of Ticino (the second using a pitfall trap) and thus allow us to record this species as new for the country.

C28) [*Scymniscus horioni* (Fürsch, 1965)]

Published data. ^{1,8)}Switzerland, uncertain data (Nedvěd 2015).

Comment. This species, known in Europe from Albania, Austria, Bosnia and Herzegovina, Croatia, Czech Republic, Greece, Hungary, Italy and Slovakia, is not considered indigenous to Switzerland on the basis of the available data: only one publication announces it for Switzerland, without any specimen referring to this species in the examined collections. Moreover, Nedvěd (2015) already considered its presence in Switzerland to be uncertain.

C29) [*Scymnus (Pullus) fraxini* Mulsant, 1850]

Examined material. ^{3,4,6,8)}1 ex., Suisse, Tessin, leg. Odier J., det. Fürsch H., coll. Maerky C., MHNG.

Comment. The only specimen labelled from Switzerland belongs to the problematic collection of C. Maerky (see Monnerat et al. 2015) which should not be considered. This species is principally distributed in the Mediterranean region and the near East, but has also been found in France in Alsace (Gourreau 1974) and in Indre-et-Loire (Cloupeau et al. 2012), and in Austria and Slovakia (Klausnitzer B. pers. comm.). Therefore, it could also be found in Switzerland. According to Coutanceau (2014), *S. fraxini* feeds on coccids.

C30) *Scymnus (Scymnus) doriae* Capra, 1924

Fig. 1W, X

Examined material. 1 ♂, 1 ♀, 1 ex., Helvetia, Ticino, Magadino, leg. & coll. Focarile A., MSNL; 1 ♂, Helvetia, Ticino, Chiasso, 8.VII.1938, leg. Fontana P., det. Canepari C., MSNL; 1 ♂, VS, Rarogne, VII.1974, leg. Toumaïeff G., MHNG.

Comment. *Scymnus doriae*, originally described from Florence, is a rare species known from the Mediterranean Region and Corsica in France (Coutanceau 2014), Austria (Tyrol), Bulgaria, Hungary, Italy, Poland, Serbia and Montenegro, and in eastern Germany (Klausnitzer B.

pers. comm.). Only a very small number of specimens from three localities confirm the occurrence of this species in Switzerland, where it appears to be rare. This species may be only distinguished from the very similar *S. frontalis* (and other species from this group) by the examination of the male genitalia. According to Klausnitzer (2020), *S. doriae* may be expanding its distribution northward in Europe.

C31) [*Scymnus (Scymnus) marginalis* (P. Rossi, 1794)]

Examined material. ^{3,4,6)}1 ex., Genève, leg. Melly A., det. Fürsch H., coll. Maerky C., MHNG; ^{3,4,6)}2 ex., Suisse, Tessin, leg. Odier J., det. Fürsch H., coll. Maerky C., MHNG.

Published data. ^{1,4,6)}[Schweiz] by Stierlin G. (Breim-Wolf 1856); ^{1,4,6)}Genf by Chevrier F., ^{1,4,6)}Schaffhausen by Stierlin G. and ^{1,4,6)}Vevey by de Gautard V. (Stierlin and Gautard 1867); ^{1,4,6)}Mendrisio by Frey-Gessner E. (Stierlin 1883); ^{1,4,6)}Fully and Martigny by Favre E. (Favre 1890).

Comment. All Swiss literature records are very old and not verifiable, while the three specimens examined belong to the problematic collection of C. Maerky (see Monnerat et al. 2015). Therefore, this species should not be considered as native in Switzerland. *Scymnus marginalis* is a Mediterranean species living in dry biotopes and is known from the Mediterranean region and Corsica in France (Coutanceau 2014), Austria, Greece, Italy, Malta and Ukraine. Being present throughout Italy (also in the Aosta Valley (Canepari 1983)), the presence of this species in southern Switzerland remains possible.

Discussion

This commented list on the Swiss Coccinellidae is in keeping with other syntheses on various beetle families published in the past years (see for exemple Sanchez et al. 2020 or Chittaro et al. 2021). It thus improves the overall understanding of Swiss fauna. Thanks to the distribution maps based on the collected data (available on the info fauna cartographic server, www.cscf.ch and www.gbif.org), this work provides a thorough faunistic overview of the current understanding of the species of Coccinellidae in Switzerland.

Coccinellidae are represented by 81 species (82 taxa) in Switzerland, which represent about 80% of all known species in Central Europe (Nedvěd 2015). If the large colored ladybirds (for example *Coccinella septempunctata*) are well known and their presence in Switzerland attested by many records, the story is quite different for most of the Scymnini species. Indeed, the latter are much more discreet, difficult to find and more challenging to identify because their identification almost always requires the examination of the male genitalia. Therefore, reliable data concerning these species are scarce and our understanding of their distribution in Switzerland remains incomplete. Consequently, several species went unnoticed in Switzerland up until this

publication, even if some specimens were collected long ago and were available in museum collections. This is the case, for example, of *Hyperaspis pseudopustulata*, *Scymniscus anomus*, *Scymnus doriae* and *Nephus bisignatus*, all mentioned here for the first time for Switzerland. The systematic dissection of all specimens in collections and the examination of the male genitalia has made it possible to bring them to light in Switzerland. These species are often only known from a few isolated specimens, so most are in urgent need of additional documentation. Targeted sampling of certain species or species groups in the future, while systematically extracting the genitalia of those specimens if necessary, will likely add new discoveries to our fauna.

Although there is no red list of Coccinellidae in Switzerland, several species seem to show strong decline in Switzerland or are maybe already extinct (?). This is particularly the case for several species linked to wetlands, like *Parexochomus nigromaculatus* and *Calvia quindecimguttata*, that have not been found in Switzerland for more than 40 years. As for other insect groups linked to wetlands (OFEV 2017), ladybirds are probably threatened in Switzerland as well.

Ladybirds are polyphagous but are mainly predators of phytophagous insects (Weber and Lundgren 2009). Therefore, they have been used for decades for biological control in crops and, as a consequence, have been introduced in several European countries. However, several species have been able to acclimatize to the local climatic conditions and thus to establish in Europe, the most obvious example being the Asian ladybird (*Harmonia axyridis*), today cosmopolitan and present in all European countries (Roy et al. 2016). In Switzerland, the presence of the following species is the result of accidental or intentional introductions made in this country or in neighboring countries: *Cryptolaemus montrouzieri montrouzieri*, *Novius cardinalis*, *Rhyzobius forestieri* and *R. lophanthae*. These four species will probably not be a problem for native species: the first two do not appear to have formed populations in the wild in Switzerland and the two *Rhyzobius*, even if they are now established, are unlikely to disrupt natural ecosystems, given their small size and their diets exclusively coccidophagous. The situation of the large and polyphagous species *H. axyridis* is quite different, as it has already been shown (van Lenteren et al. 2008; Honěk et al. 2019). In northwestern Switzerland, long-term monitoring of ladybirds showed that *H. axyridis* quickly became the dominant species on broadleaved trees and shrubs just a few years after its arrival in 2004. Following this invasion, the native species *Adalia bipunctata* clearly declined and this once dominant species has almost disappeared from the region (Kenis et al. 2020). This trend, demonstrated for a small region in northern Switzerland, seems to be confirmed on a national scale. According to the available Swiss data set, *A. bipunctata*, once a very common species, was no longer found in many localities throughout the country. The same situation was also shown in Germany (Klausnitzer 2017).

From a conservation point of view, it can be said that Switzerland harbors several rare and highly specialized species or subspecies that only occur at high altitudes in the Alps. This is the case for *Ceratomegilla rufocincta doderoi*, *C. alpina alpina*, *C. alpina redtenbacheri*, *Coccinella trifasciata trifasciata* or *C. venusta adalioides*, which are regularly found above 2000 m. Other species are very rare in Europe, like *Exochomus oblongus* or *Hyperaspis peezi*, and Switzerland plays an important role in the conservation of these species.

In the future, other species could be found in Switzerland, especially cosmopolitan species introduced in Europe for biological control, or southern species that would benefit from global warming to extend their distribution to the north.

Acknowledgments

We would like to acknowledge Claude Besuchet (1930–2020) who managed to get a large number of 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.

Special thanks are due to Oldřich Nedvěd (CZ-České Budějovice) and Johan Bogaert (B-Mechelen) for their helpful advice on some of the above-mentioned species. Finally, we are grateful to Stève Breitenmoser (AGRO), Bernhard Klausnitzer (D-Dresden), Jessica Litman (MHNN) and Oldřich Nedvěd for their meaningful comments on the manuscript and to Michel Sartori (MZL) for providing us with the photographic equipment.

We are also thankful to all the Swiss museum curators, 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.

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A double defensive mutualism? A case between plants, extrafloral nectaries, and trophobionts

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Academic editor: Thibault Lachat ♦ Received 16 September 2022 ♦ Accepted 29 October 2022 ♦ Published 18 November 2022

Defensive mutualisms are common in tropical plants (Rosumek et al. 2009). In these interactions, ants can reduce plant herbivory through a combination of direct predation on herbivores and/or aggressive behavior toward herbivores that avoid ant-infested plants or are expelled when they arrive (Rosumek et al. 2009). Plants often attract ants by offering food resources such as extrafloral nectaries (EFNs), beltian bodies, or shelters such as domatia (Bronstein et al. 2006). Another type of protection is provided by trophobiosis, which is the interaction between ants and phytophagous hemipterans that secrete sugary exudates. The main benefit provided by the attendant ants

to their trophobionts is protection from predators and parasitoids. In contrast, the damage that herbivores cause to their host plants can be minimized by the suppressive effect of predatory ants that forage on foliage (Styrsky and Eubanks 2007). In all of these interactions, ants patrol the plants reducing herbivore abundance, increasing plant defenses, and benefiting plants through increased vigor and reproduction (Rosumek et al. 2009).

A very particular case involving different biotic defenses occurs in an endemic plant from Brazil that occurs in the Cerrado region (Fig. 1). This species, *Zeyheria montana* Mart. (Bignoniaceae, Fig. 2A), has EFNs on the leaf blade

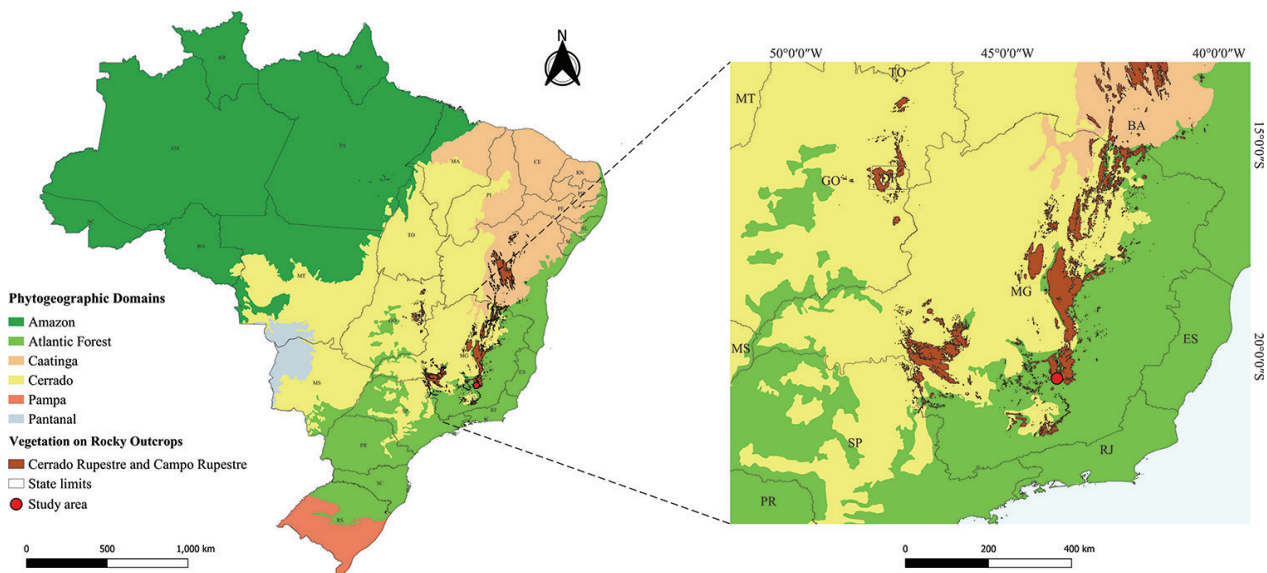


Figure 1. Map of the geographic location of the population of *Zeyheria montana* Mart. studied in the Cerrado Rupestre of Minas Gerais, Brazil. The boundaries of Brazilian phytogeographic domains were adapted from shapefiles available from the Instituto Brasileiro de Geografia e Estatística (2022) and the global ecoregions of Dinerstein et al. (2017). The vegetation on rocky outcrops is the combination of shapefiles from the rupestrian grasslands by Newton Barbosa and the iron outcrops of Serra dos Carajás in the State of Pará provided by Fernando Santos. Map design: Cássio Cardoso Pereira.

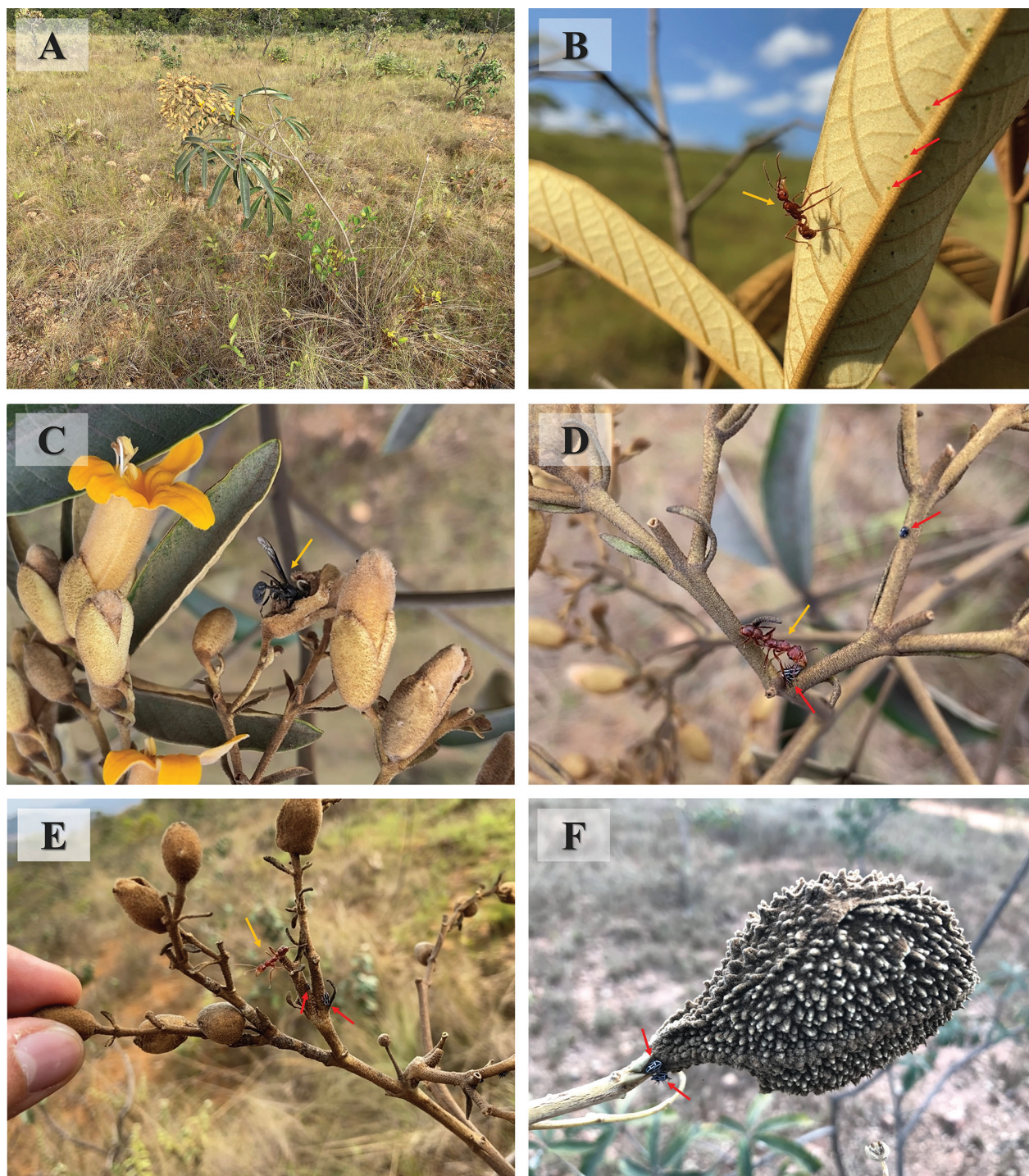


Figure 2. **A.** Individual of *Zeyheria montana* Mart. on rocky outcrops in Minas Gerais, southeastern Brazil; **B.** *Ectatomma tuberculatum* (Olivier, 1792) on the leaf blade of the *Z. montana*. The yellow arrow points to the ant and the red arrows point to the extrafloral nectaries; **C.** Wasp (yellow arrow) removing nectar inside the flower bud of *Z. montana*; **D.** Interaction between the ant *E. tuberculatum* and the treehopper *Guayaquila xiphias* (Fabricius, 1803), which provides honeydew in exchange for protection. The yellow arrow points to the ant and the red arrows point to the treehoppers; **E.** Reaction of the aggressive *E. tuberculatum* ant, which protects the treehoppers from attacking invaders. The yellow arrow points to the ant and the red arrows point to the treehoppers; **F.** The treehoppers *G. xiphias* (red arrows) at the base of *Z. montana* fruits.

(Machado et al. 2008). These EFNs attract patrolling ants such as the aggressive *Ectatomma tuberculatum* (Olivier, 1792), which in turn defends the leaves against herbivores (Fig. 2B). While EFNs are an important resource attracting ants to the leaves, they might also function to distract

ants from the costly flowers and reproductive parts, preventing them from driving away visitors and potential pollinators (Villamil et al. 2019). Thus, keeping ants away from reproductive tissues can benefit florivores and nectar thieves that usually approach flowers (Fig. 2C).

This does not seem to be a problem for *Z. montana*. Surprisingly, in a population of this shrub that occurs in the Cerrado Rupestre, a rare ecosystem on rocky outcrops above 800 m altitude in Minas Gerais (Pereira and Fernandes 2022), southeastern Brazil (Fig. 1), we observed a second defensive mutualism occurring on these plants throughout 2021. The reproductive tissues of this shrub host the treehopper *Guayaquila xiphias* Fabricius, 1803 (Membracidae), which provides honeydew to *E. tuberculatum* in exchange for protection (Fig. 2D). This trophobiotic relationship persisted throughout the plant's reproductive period and seems to be effective not only as a defensive strategy for flower buds and flowers (Fig. 2E) but also for the fruit (Fig. 2F), which, although is a dry fruit and dispersed by wind, was attacked by weevils because it contains a significant amount of water during its development (personal observation). Finally, although these ants fight florivores, nectar robbers, and frugivores, they probably do not harm pollination because *Z. montana* is mainly pollinated by hummingbirds (Araújo et al. 2013), which, in addition to not landing on flowers and being larger, were not chased away by ants (personal observation).

This is the first case reported in the literature involving EFNs, ants, and trophobionts occurring simultaneously on a plant species. Future studies shall be carried out to assess whether this combination of defensive mutualisms can increase the fitness of these plants. We wonder how frequent simultaneous defensive mutualisms can be, which are generally not quantified or reported in the literature.

Common or not, we emphasize that insect–plant interactions such as those presented here are at serious risk of disappearing along with the rare environments in which they occur (Pereira and Fernandes 2022). Biodiversity has been increasingly impacted by climate change, pollution, habitat destruction, invasive alien species, and overexploitation of natural environments, which lead several species to population collapse (Cardinale et al. 2012). The extinction of a single species involved in mutualism can lead, in the long term, to the disappearance of other species dependent on the interaction, affecting other levels in the large network of relationships between species. This cascade effect can affect the functioning of ecosystems, leading to dramatic changes in community composition, including the loss of species, interactions, functions, and ecosystem services (Galetti et al. 2013). Therefore, in addition to preserving more natural areas, we urgently need measures to mitigate human impacts on biodiversity so that interactions such as those presented here can be maintained and preserved.

Acknowledgements

The authors would like to thank UFMG, PPG-ECMVS, CNPq, Fapemig and CAPES for continuous support. GWF and TC thank CNPq and FAPEMIG for grant sup-

ports. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

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A new species of *Alainites* (Ephemeroptera, Baetidae) from Thailand

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Academic editor: Dávid Murányi ♦ Received 13 October 2022 ♦ Accepted 17 November 2022 ♦ Published 30 November 2022

Abstract

A new species of Baetidae, *Alainites siamensis* **sp. nov.**, is described from Thailand. This new species is closely related to *Alainites lingulatus* Tong & Dudgeon, 2000, *Alainites laetificus* (Kang & Yang, 1994) and *Alainites yixiani* (Gui & Lu, 1999). Species delimitation based on morphological and molecular (mitochondrial COI sequences) evidence is provided. The discovery of this species confirms the wide distribution of *Alainites* Waltz & McCafferty, 1994 in Southeast Asia.

Key Words

distribution, diversity, mayflies, Southeast Asia, systematic

Introduction

The small minnow mayflies (Ephemeroptera: Baetidae) are one of the most common and widespread mayfly family. This family comprises ca. 1,070 species assigned to 110 genera (Sartori and Brittain 2015; Jacobus et al. 2019; Kaltenbach et al. 2020).

The European species of *Baetis* s.l. Leach, 1815 were firstly classified and divided into eleven species groups by Müller-Liebenau (1969). The *muticus* species group was subsequently raised to the generic level under *Alainites* Waltz & McCafferty, 1994 (Waltz et al. 1994; McCafferty and Waltz 1997; Zrelli et al. 2012; Yanai et al. 2022). *Nigrobaetis* Novikova & Kluge, 1987 was erected for the *niger* species group (Waltz et al. 1994). Finally, *Takobia* Novikova & Kluge, 1987 was established and encompassed a single species originally described as *Centroptilum maxillare* Braasch & Soldán 1983.

Alainites, *Nigrobaetis* and *Takobia* were considered as belonging to the *Indobaetis* complex (Kluge and Novikova 2014). The status of the three genera was widely debated in various studies (Müller-Liebenau 1969;

Novikova and Kluge 1987, 1994; Waltz et al. 1994; Waltz and McCafferty 1997; Kluge and Novikova 2014). However, the revisions were not based on examination of type material and detailed descriptions of the type species were missing (see details in Sroka et al. 2021; Yanai et al. 2022). In the last comprehensive studies (Sroka et al. 2021; Yanai et al. 2022), it was highly encouraged to continue to consider *Alainites*, *Nigrobaetis* and *Takobia* as valid genera and wait for a global phylogeny based on molecular and morphological evidence before proposing a definitive classification.

The genus *Alainites* originally encompassed nine species (Waltz et al. 1994); at that time the diagnostic characters of the larval stage were as follows: i) paraproct with an elongated prolongation; ii) prostheca of the right mandible bifid, reduced to two bristle-like feathered appendages; iii) absence of villopore; and iv) body laterally compressed. At the imaginal stages: i) hindwings, when present, with three longitudinal veins, the second being bifurcated; and ii) segment III of the male forceps spherical to slightly elongated and curved (Waltz et al. 1994; Zrelli et al. 2012; Yanai et al. 2022).

In the Oriental realm, seven species were assigned to *Alainites*. Part of these species were originally attributed to *Baetis*, including *Baetis laetificus* Müller-Liebenau, 1984, *Baetis (Acerbaetis) clivosus* Kang & Yang, 1994 and *Baetis (Acerbaetis) yehi* Kang & Yang, 1994. Afterward, these three *Baetis* species were transferred to *Alainites* by Waltz et al. (1994). The Chinese species, *Alainites yixinia* (Gui & Lu, 1999) was also first attributed to *Baetis* (Gui and Lu 1999). Two new species of *Alainites* from Hong Kong, *Alainites acutulus* Tong & Dudgeon, 2000 and *Alainites lingulatus* Tong & Dudgeon, 2000, were subsequently described (Tong and Dudgeon 2000). The last described species of *Alainites* in South East Asia, *Alainites pascalae* Gattolliat, 2011, was reported from Borneo (Gattolliat 2011).

The knowledge of the diversity of Baetidae in Thailand has notably increased recently. Thanks to two large scale surveys of the Baetidae in Thailand project many taxa have been continuously discovered during the last decade (Tungpairjwong and Bae 2015; Phlai-ngam and Tungpairjwong 2018; Suttinun et al. 2018, 2020, 2021, 2022; Phlai-ngam et al. 2022; Tunjpairjwong et al. 2022). Many new taxa have been reported, some of them remain undescribed. Presently, ten genera and 14 species of Baetidae are recorded from this area (Phlai-ngam 2017; Suttinun 2021; Suttinun et al. 2021, 2022; Boonsoong 2022; Phlai-ngam et al. 2022; Tungpairjwong et al. 2022). Based on the remaining under prospected areas and the still unstudied but potentially diversified genera (*Baetis*, *Labiobaetis* Novikova & Kluge, 1987, *Nigrobaetis*), the species diversity of Thai Baetidae will continue to increase rapidly.

Herein, we provide the description and illustration of larval stage of a new species of *Alainites* from Thailand. The morphological comparison of this new species to related species, provides diagnostic key characters. The species delimitation is also supported by molecular evidence (mitochondrial COI sequences). Additionally, a key to species of the larvae of *Alainites* from Southeast Asia is also provided.

Materials and methods

Collecting samples

Larval specimens were collected by using a hand net or picked manually and sorted from the debris and sediments by using D-framed dip net method. This new species was collected for the first time during a survey of aquatic macroinvertebrates in Phetchabun Province and the survey of aquatic macroinvertebrates project of Kanchanaburi Province (Thailand). The additional specimens were collected during the survey of baetid mayflies in Tak and Kamphaengphet Provinces (Table 1). They were sampled in headwater streams. The specimens were preserved in 95% ethanol. The examined material is deposited in the Collection of Aquatic Insect of Department of Biology at Khon Kaen University in Khon Kaen, Thailand (**KKU-AIC**) and in the Museum of Zoology in Lausanne, Switzerland (**MZL**).

Table 1. GPS coordinates of locations of examined specimens.

Species	Provinces	GPS coordinates	Altitudes (m a.s.l.)
<i>A. siamensis</i> sp. nov.	Phetchabun	16°44'27.92"N, 101°34'46.52"E	832
	Tak	17°04'52.68"N, 98°45'16.73"E	405
		17°01'44.35"N, 98°30'24.47"E	719
	Kamphaengphet	17°02'34.94"N, 98°58'39.83"E	154
	Kanchanaburi	14°45'08.00"N, 98°48'40.00"E	660

Morphological examination

Part of the specimens were dissected and mounted on microscope slides fixed in Euparal, as specified in the material examined sections below. Ethanol-preserved specimens were studied under a Leica M205 stereomicroscope; microscope slides were drawn from a camera lucida on an Olympus BX51 compound microscope and were subsequently scanned for illustration with the Procreate application (iOS application). Photographs of larvae were taken with a Canon EOS 6D camera and edited with Adobe Lightroom (<http://www.adobe.com>). Final plates were prepared and processed with Adobe Photoshop (<http://www.adobe.com>). The distribution map was generated with the SimpleMappr software (<https://simplemappr.net>).

Genetics

DNA of part of the specimens was extracted using non-destructive methods allowing subsequent morphological analysis (see details in Vuataz et al. 2011). The specimens were amplified for a 658 bp fragment of the mitochondrial gene cytochrome oxidase subunit 1 (COI) using the primers LCO 1490 (GGTCAACAAATCATAAAGATATTGG) and HCO 2198 (TAAACTTCAGGGTGACCAAAAATCA) (Folmer et al. 1994).

The polymerase chain reaction (PCR) was conducted with an initial denaturation temperature of 94 °C for 5 min followed by a total of 35 cycles with denaturation temperature of 94 °C for 30 sec, an annealing temperature of 48 °C for 40 sec and an extension at 72 °C for 1 min, final extension at 72 °C for 5 min. The sequencing was based the Sanger's method as developed in Vuataz et al. (2011). Sequences editing and ClustalW alignment were provided. Genetic variability between specimens was calculated using Kimura-2-parameter distances (K2P) model. The molecular reconstruction was analyzed by a maximum likelihood (ML). The best evolution model obtained was Tamura-Nei (TN93+G+I) as the most appropriate for reconstruction based on the lowest AICc and BIC scores, with 100 runs and 1000 bootstrap replicates. All genetic analytical methods were performed by MEGA-X (Kumar et al. 2018). Additional *Alainites* sequences were obtained from GenBank (<http://www.ncbi.nlm.nih.gov/>) and new *Alainites* sequences (this work) were also added in GenBank to update the nucleotides database (Table 2).

Table 2. Sequenced specimens of *Alainites* (bold text showing new sequences).

Species	Locality	GenBank Accession Number (GenSeq Nomenclature)
<i>A. talasi</i>	Kyrgyzstan	MZ983799.1; MZ983800.1
<i>A. sadati</i>	Algeria	ON072439
<i>A. gasithi</i>	Israel	ON072440
<i>A. kars</i>	Armenia	MZ983797.1; MZ983798.1
<i>A. bengunn</i>	Sardinia	HG934996.1; HG934997.1
<i>A. albinatii</i>	Corsica	HG934994.1
<i>A. yixiani</i>	China	GU479735.1
<i>A. muticus</i>	Spain	SR10E08
	Russia	SR13E10
<i>A. siamensis</i> sp. nov. (PHET1)	Phetchabun, Thailand	OP903356
<i>A. siamensis</i> sp. nov. (PHET2)	Phetchabun, Thailand	OP903357
<i>A. siamensis</i> sp. nov. (PHET3)	Phetchabun, Thailand	OP903358
<i>A. siamensis</i> sp. nov. (TAK1)	Tak, Thailand	OP903355
<i>A. siamensis</i> sp. nov. (TAK2)	Tak, Thailand	OP903359
<i>A. siamensis</i> sp. nov. (KAMP)	Kamphaengphet, Thailand	OP903360

Results

Alainites siamensis sp. nov.

<https://zoobank.org/DF090CF3-0863-4454-A90B-EB58DFB6D49D>

Material. Holotype: Thailand • Larva; Phetchabun Province, Nam Nao National Park, Yakruae stream; Alt. 832 m. 16°44'27.92"N, 101°34'46.52"E; 7 Mar. 2022; Coll. S. Phlai-ngam and V. Vannachak; 1L on slide GBIFCH00763744 [MZL].

Paratypes: Thailand • 20 larvae; same data as holotype; 3L on slides GBIFCH00763745–GBIFCH00763747, [MZL]; 10L in alcohol GBIFCH00763748 [MZL]; 7L in alcohol [KKU-AIC].

Other material. Thailand • 70 larvae; **Tak Province**, Mae Ra Mad District; Alt. 405 m. 17°04'52.68"N, 098°45'16.76"E; 12 Feb. 2022; Coll. K. Koomput and P. Dapsibhai; 1L on slides GBIFCH00763749 [MZL]; 8L in alcohol GBIFCH00763750 [MZL]; 10L in alcohol [KKU-AIC]. **Tak Province**, Mae Sod District, small stream near the road (unnamed stream); Alt. 719 m. 17°01'44.35"N, 098°30'24.47"E; 8 Oct. 2020; coll. S. Phlai-ngam; 1L on slide [KKU-AIC]; 14L in alcohol [KKU-AIC]; 1L in alcohol GBIFCH 00673245 [MZL]. **Kanchanaburi Province**, Thong Pha Phumi District, small stream near the Mining Dr. Phol Kleepbuathe; Alt. 660 m. 14°45'08.00"N, 98°48'40.00"E; 16 Nov. 2022; Coll. S. Phlai-ngam; 1L on slide GBIFCH00763751 [MZL]; 7L in alcohol GBIFCH00763752 [MZL], 8L in alcohol [KKU-AIC]. **Phetchabun Province**, Nam Nao National Park, Yakruae stream; Alt. 832 m. 16°44'27.92"N, 101°34'46.52"E; 23 Nov. 2020; Coll. S. Phlai-ngam; 15L in alcohol [KKU-AIC]. **Kamphaengphet Province**, Klong Lan District, Pong Nam Ron, Alt. 154 m. 17°02'34.94"N, 98°58'39.83"E; 12 Feb. 2022; Coll. K. Koomput and P. Dapsibhai; 4L in alcohol [KKU-AIC].

Description. Coloration (Figs 1, 2). General coloration medium brown. Head uniformly medium brown, slightly darker between ocelli and at insertion of antennae. Turbinate eyes in male larva dark orange. Thorax medium brown with indistinct pattern. Pronotum slightly paler than mesonotum and metanotum. Thoracic sternites mostly pale brown. Abdominal tergites medium brown, slightly darker in middle area, distal margin with darker transverse band. Abdominal sternites light brown. Cerci and median caudal filament light brown without bands or pattern.

Body. Maximum length 4.2 mm. Median caudal filament ca. 2/3 of cerci.

Head. Capsule medium brown. Antennae medium brown, filiform.

Mouthparts. Labrum (Fig. 3A): dorsal surface with one central seta and an arc of setae reduced to two lateral setae; about twenty fine stout setae scattered over surface. Ventral surface with five small acute setae near lateral margin. Distal margin fringed with two kinds of setae: long lateral setae strongly feather-like and medially with a shorter row of slightly feather-like setae.

Left mandible (Fig. 3B–D): inner and outer incisors almost fused, formed by seven blunt denticles (Fig. 3C); prostheca with eleven small pointed denticles apically, (Fig. 3D); edge between prostheca and mola only slightly crenelate near mola; mola with an enlarged triangular pointed tooth, fine setae present apically; proximal part with scattered fine setae, not shagreened (Fig. 3B). Right mandible (Fig. 3E–G): inner and outer incisors almost fused, formed by eight blunt denticles (Fig. 3F), prostheca bifid, both filaments feathered, outer filament half length inner filament (Fig. 3G); edge between prostheca and mola crenelate; proximal part with scattered fine setae, not shagreened (Fig. 3E). Maxilla (Fig. 3H–I): galea-lacinia with 3 enlarged acute teeth on apex (Fig. 3I), 2 rows of long dense basal setae on galea-lacinia; maxillary palpus (Fig. 3H) 2-segmented with scattered small hair-like setae; segment II rounded at apex. Labium (Fig. 3J): glossa slightly shorter than paraglossa; a row of stout setae along outer, inner and apical margins, sub-apical setal tuft present; paraglossae with 3 rows of simple setae along apical margin; labial palpus 3-segmented with scattered fine setae; segment I slightly shorter than segments II and III combined; segment III subrectangular covered with long robust setae mostly in distal half, short pointed setae mostly along outer margin and abundant fine setae. Hypopharynx with rounded lingua and superlinguae, covered with abundant hair-like setae sub-apically (Fig. 3K).

Thorax. Hindwing pads well developed.

Foreleg (Fig. 4A). Femur: dorsal margin with a regular row of eight to eleven long robust setae and two sub-apical setae; ventral margin with abundant short spine-like setae; lateral margin with scale bases, bare and not shagreened, femoral villopore absent.

Tibia (Fig. 4B): dorsal margin of fore-tibia with less than five strong setae (usually with 3–4 setae), short fine setae roughly arranged in row; ventral margin with

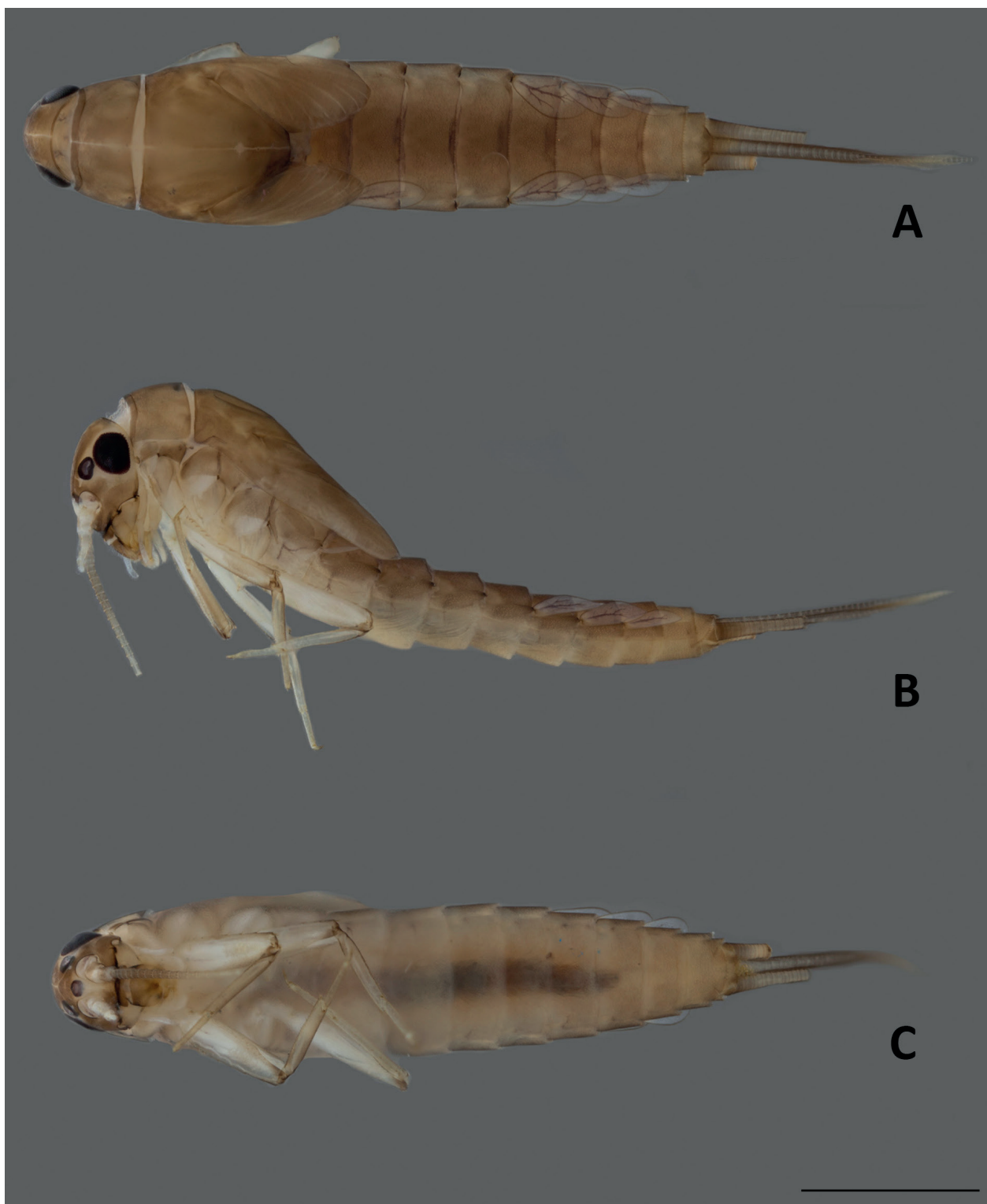


Figure 1. *Alainites siamensis* sp. nov., female larva (middle instar larva) habitus: **A** Dorsal view; **B** Lateral view; **C** Ventral view. Scale bar: 1 mm.

abundant short stout setae ending with patch of long stout feathered setae; lateral margin with abundant scale bases, tibiopatellar suture with short spine-like setae. Tarsus: dorsal margin with few fine setae, ventral margin with abundant pointed setae only slightly increasing in length toward apex, lateral margin with abundant scale bases and a few fine setae. Tarsal claws (Fig. 4E) with one

row of 7–9 denticles, increasing in size distally, subapical setae absent. **Midleg and hindleg.** Similar to foreleg; except ventral margin of femur of hindleg with reduced number of short spine-like setae, generally one or two setae; dorsal margin of mid-tibia (Fig. 4C) and hind-tibia (Fig. 4D) with more than five strong setae (usually more than nine).



Figure 2. *Alainites siamensis* sp. nov., male larva (middle instar larva) habitus: **A** Dorsal view; **B** Lateral view; **C** Ventral view. Scale bar: 1 mm.

Abdomen. Posterior margin of tergite I smooth; posterior margin of tergite II with a few triangular spines mainly in the middle area; posterior margin of tergites III–IX with triangular spines along central portion, absent laterally (Fig. 4F–G). Surface of all tergites not shagreened, with numerous scale bases and few setae. Sternites I–VIII

similar to tergites except distal margin smooth, sternite IX distal margin with triangular spines. Gills (Fig. 5A–D) on segments I–VII, with well visible main tracheation but reduced ramification; gill I smallest (Fig. 5A), length of gill I equal to half of tergite II; gill IV (Fig. 5B) and gill V larger than others, length of gill IV equal to tergite V plus half of

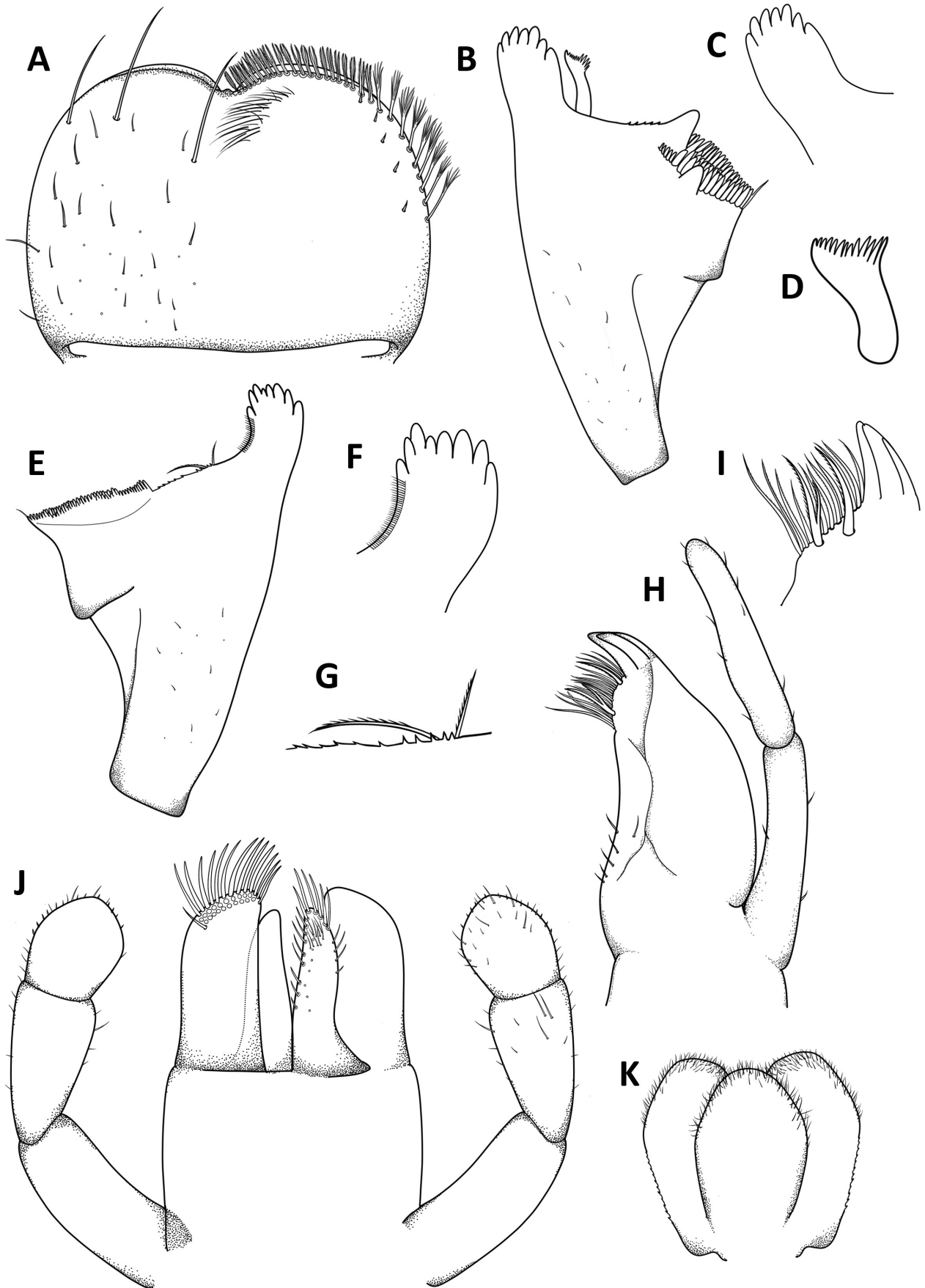


Figure 3. *Alainites siamensis* sp. nov., larval morphology: **A** Labrum (right: dorsal; left: ventral); **B** left mandible; **C** left incisor; **D** left prosthema; **E** Right mandible; **F** Right incisor; **G** Right prosthema; **H** Maxilla; **I** Apex of galea-lacinia; **J** Labium (right: dorsal; left: ventral); **K** Hypopharynx.

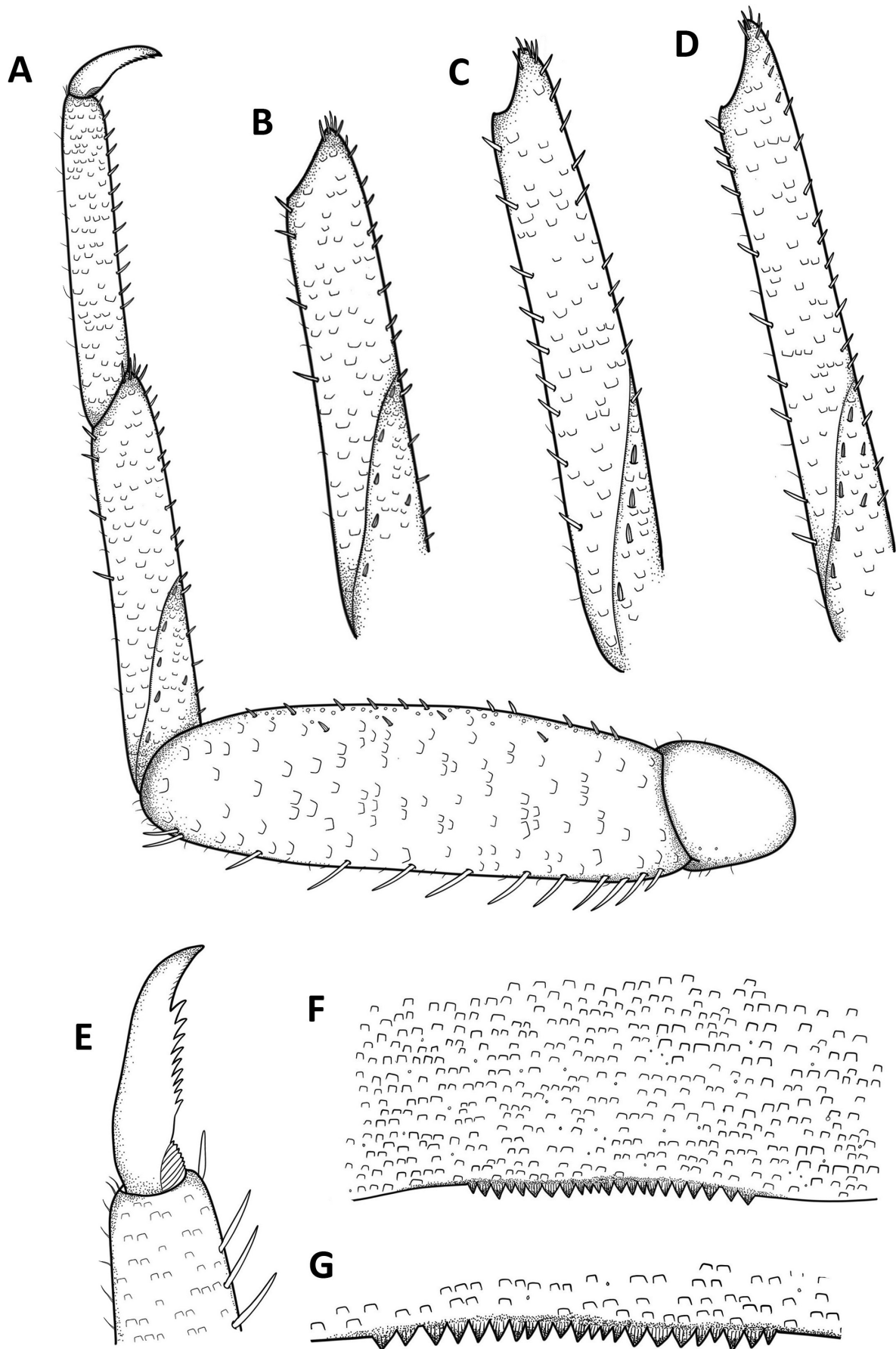


Figure 4. *Alainites siamensis* sp. nov., larval morphology: **A** Foreleg; **B** Fore-tibia; **C** Mid-tibia; **D** Hind-tibia; **E** Tarsal claw; **F** Abdominal tergite IV; **G** Posterior marginal spines of tergite IV.

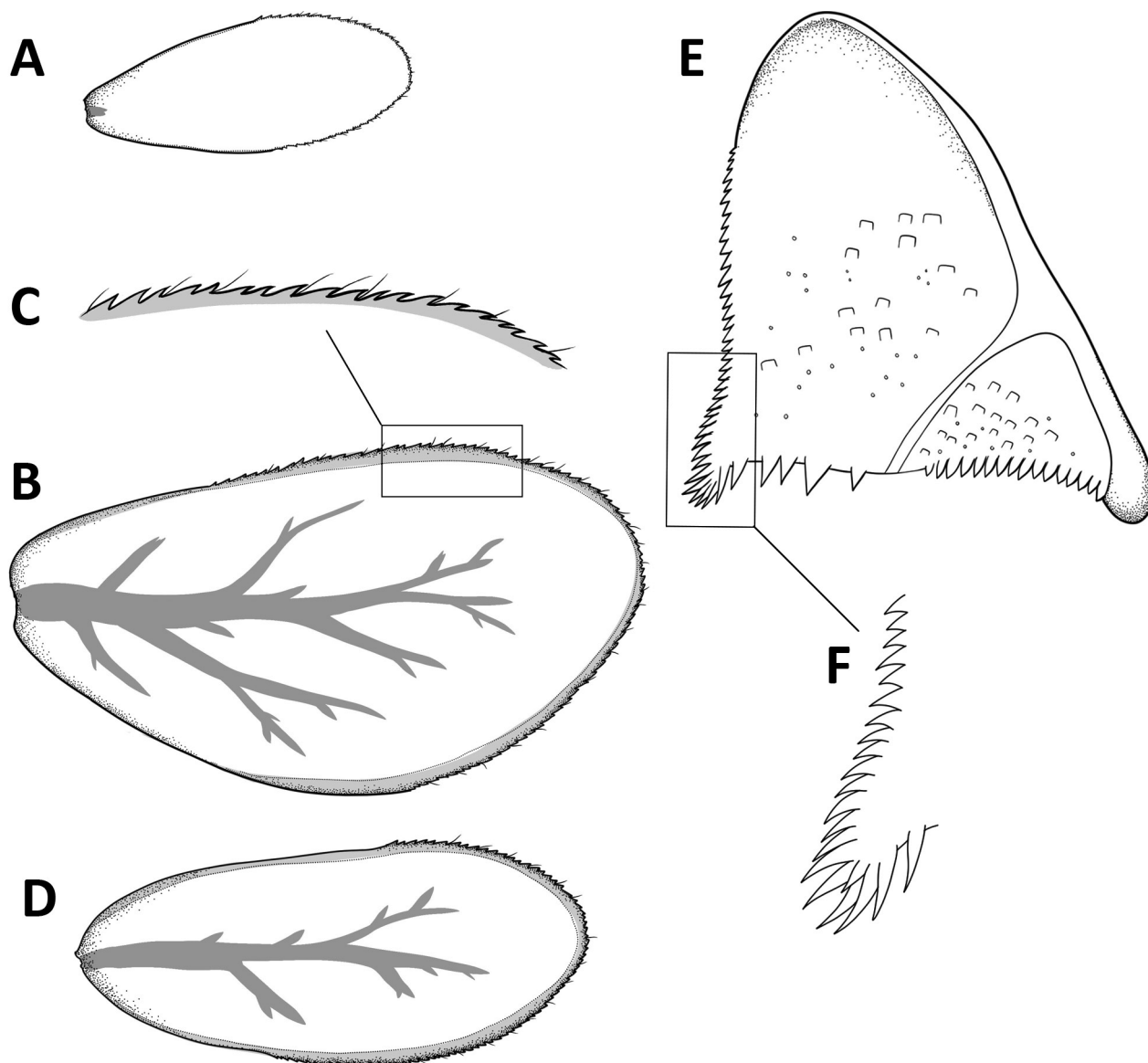


Figure 5. *Alainites siamensis* sp. nov., larval morphology: **A** Abdominal gill I; **B** Abdominal gill IV; **C** Gill margin; **D** Abdominal gill VII; **E** Paraproct; **F** Paraproct prolongation.

tergite VI; length of gill V equal to tergite VI plus half of tergite VII; length of gill VII (Fig. 5D) equal to tergite VIII plus half of tergite IX. Surface smooth without any setae or pores, margin serrated with fine simple setae (Fig. 5C). Paraproct (Fig. 5E–F) covered with scale bases and micropores on surface; distal margin with well-developed prolongation; lateral margins of prolongation with numerous small spines, surface without spines (Fig. 5F); distal margin inner to prolongation with 5 huge spines, distal margin outer to prolongation with numerous medium spines (around 20–30 spines); cercotractor with scale bases, distal margin with about 14–16 medium spines (Fig. 5E). Cerci with fine swimming setae along inner margin. Median filament with swimming setae on both margins.

Diagnosis. *Alainites siamensis* sp. nov. is closely related to *A. lingulatus*, *A. laetificus* and *A. yixiani*; these species are distributed in the Southeast Asia. The new species

can be separated from the other species by the following combination of characters: i) the shape of labial palp, ii) the setation on tibia, iii) the number of denticles of the claws, iv) the degree of development and spination of paraproct prolongation, v) the number of spines on distal margin of paraproct, vi) number of pairs of gills (Table 4).

Ecological notes. The larvae of *Alainites siamensis* sp. nov. mainly live among aquatic plants and roots of riparian plants in slow to moderately flowing streams (Fig. 6). The species seems to be rather widely distributed in the northwestern and northern Thailand, but is rare and not abundant (Fig. 7).

Etymology. The specific epithet of this species, *siam* (noun), refers to the old name of Thailand and to the known distribution of the species.

Molecular result. Sequences of 658 bp, corresponding to a fragment of the COI gene, were obtained from



Figure 6. The sampling sites and habitats of *Alainites siamensis* sp. nov. larvae: **A–B** Yakruae stream, Nam Nao National Park, Phetchabun Province (type locality); **C–D** Stream in Mae Ra Mad District, Tak Province; **E–F** Stream near the Mining Dr. Phol Kleepbuathe, Thong Pha Phum District, Kanchanaburi Province.

six specimens collected in three localities; the new sequences are deposited in GenBank under accession numbers specified in Table 2. The K2P analysis for genetic distances analysis shows that the three populations of *Alainites siamensis* sp. nov. have very low intraspecific variation (0% to < 2%). The interspecific distances between *A. siamensis* sp. nov. and other *Alainites* species show distances between 17% and 28% (Table 3). In the COI reconstruction, the six larval specimens of *Alainites*

from Thailand were grouped together into the same clade and clearly separated from all other sequenced species of *Alainites* (Fig. 9).

Discussion

The new described mayfly species from Thailand, *Alainites siamensis* sp. nov., is assigned to the



Figure 7. Distribution map of *Alainites siamensis* sp. nov. larvae: Closed red triangle shows the type locality, opened red triangle shown other localities.

Table 3. Genetic distances (COI) between sequenced specimens, using the Kimura 2-parameter.

	1	2	3	4	5	6	7	8	9
1 <i>A. siamensis</i> sp. nov.	0.00–0.02								
2 <i>A. yixiani</i>	0.20	-							
3 <i>A. albinatii</i>	0.21	0.21	-						
4 <i>A. kars</i>	0.24	0.20	0.20	0.00					
5 <i>A. talasi</i>	0.21	0.24	0.28	0.25	0.00				
6 <i>A. sadati</i>	0.22	0.24	0.23	0.23	0.25	-			
7 <i>A. bengunn</i>	0.26	0.26	0.20	0.25	0.27	0.24	0.01		
8 <i>A. gasithi</i>	0.22	0.23	0.23	0.19	0.24	0.24	0.22	0.00	
9 <i>A. muticus</i>	0.22	0.23	0.17	0.22	0.28	0.24	0.20	0.23	0.02

Table 4. Comparison of larval morphological characters of *Alainites siamensis* sp. nov. with the closely related Southeast Asian species with seven pairs of gills. Character states based on the original descriptions of individual species.

Characters	<i>A. clivus</i>	<i>A. lingulatus</i>	<i>A. yixiani</i>	<i>A. siamensis</i> sp. nov.
Shape of terminal segment of labial palp	Sub-rectangular shaped; lateral margin slightly rounded	Sub-rectangular shaped; lateral margin almost straight	Sub-rectangular shaped; lateral margin slightly rounded	Sub-rectangular shaped; lateral margin almost straight
Setation of dorsal margin of foretibia	More than five strong setae	More than five strong setae	More than five strong setae	Less than five strong setae (usually 3–4 setae)
Number of denticles of the tarsal claws	11–13 denticles	8–11 denticles	9–11 denticles	7–9 denticles
Abdominal tergites	Uniformly medium brown	Uniformly medium brown in mature female; tergites I–VI light brown and tergites VII–X brown in mature male larvae	Tergites I–VIII uniformly medium brown; IX and X light brown	Uniformly medium brown
Distal margin of abdominal tergites	Tergite I smooth; tergites II–X with triangular spines along central portion, absent laterally	Tergite I smooth, tergites II–X with triangular spines	?	Tergite I smooth; tergite II with a few triangular spines mainly in the middle area; tergites III–IX with triangular spines along central portion, absent laterally
The degree of development of paraprot prolongation	Moderately developed	Well-developed tongue-like	Moderately developed	Well-developed
Distribution	Taiwan	Hong Kong	China mainland	Thailand
Reference	Kang et al. (1994)	Tong and Dudgeon (2000)	Gui and Lu (1999)	This work

genus *Alainites* Waltz and McCafferty, 1994 based on the following characters: frons with a medial ridge between antenna, absence of distal lobe on antennal scape, protheca of the right mandible bifid, absence of villopore, paraprot with prolongation (Waltz et al. 1994; Fujitani et al. 2003; Zrelli et al. 2012; Yanai et al. 2022). This new species presents similarities with the type species of the genus, *Alainites muticus* (Linnaeus, 1758); both species possess seven pairs of gills and well-developed paraprot prolongation. The two species can be separated by inconspicuous characters such as the number of setae on dorsal margin of tibia, setation of distal margin and prolongation of paraprot. *Alainites muticus* is not reported from Southeast Asia and from the Oriental realm in general; the closest report seems to be in Korea (Bae and Park 1998).

Among the Southeast Asian species, *Alainites siamensis* sp. nov. can be identified by the shape of labial palp, the setation of tibia, the number of denticles of the claws, the degree of development and spination of paraprot prolongation, the number of spines on distal margin of paraprot and the number of pairs of gills (Table 4). The presence of seven pairs of gills in *Alainites siamensis* sp. nov. allow the separation of this species from *A. aculatus* Tong & Dudgeon, 2000, *A. laetificus* Müller-Liebenau, 1984, *A. pascalae* Gattolliat, 2011 and *A. yehi* (Kang & Yang, 1994) which all possess six pairs of gills.

The new species differs from the other species with seven pairs of gills (*A. lingulatus* Tong & Dudgeon, 2000, *A. clivus* (Chang & Yang, 1994) and *A. yixiani* (Gui & Lu, 1999)) by presence of less than five strong setae on dorsal margin of foretibia (usually with 3–4 setae), tarsal claws with 7–9 denticles, well-developed paraprot prolongation, in opposition to *A. clivus* and *A. yixiani* which possess more than five strong setae on dorsal margin of foretibia and tarsal claws with more than nine denticles. *Alainites clivus* can be distinguished from *A. yixiani* by the abdominal tergites uniformly medium brown while *A. yixiani* has tergites IX and X lighter than the remaining tergites.

Alainites siamensis sp. nov. can be distinguished from *A. lingulatus* by the shape of the prolongation of the paraproct and by claws with 7–9 denticles while *A. lingulatus* has paraproct with a well-developed tongue-like prolongation and claws with 8–11 denticles (Table 4).

Alainites laetificus and *A. pascalae* share with the new species the distal margin of tergite IV with spines and prolongation of paraproct well developed with numerous spines. *Alainites siamensis* can be easily separated from these two species by the number of gills.

The molecular analysis clearly confirms that *Alainites siamensis* sp. nov. is a valid new species as shown by genetic distances between species ranging from 17% to 28% (Table 3), which are greater than 3% generally considered as the maximum value for intraspecific divergence (Hebert et al. 2003). The intraspecific divergences are rather reduced, generally lower than 2%. The genetic distances were calculated between the eight available species, i.e. *A. talasi* (Novikova & Kluge, 1994), *A. sadati* Thomas, 1994, *A. gasithi* Yanai & Gattolliat, 2022, *A. kars* (Thomas & Kazanci, 1989), *A. bengunn* Yanai & Gattolliat, 2022, *A. albinatii* (Sartori & Tomas, 1989), *A. muticus* (Linnaeus, 1758), and *A. yixiani*. However, several sequences are missing for part of the *Alainites* species, especially for the morphologically closely related species *A. lingulatus* and *A. laetificus*. *Alainites yixiani* is the only sequenced species from Southeast Asia available for calculation.

The morphological comparison between species is often challenging by the short inaccurate original description and the poor quality of the illustrations; this remains true also for recently described species such as *A. yixiani*. A revision of this species is high request and will be necessary to confirm the characters isolated for species

identification. However, the molecular analysis based on COI sequences confirm the distinctness of these two species (K2P distance = 20% between the two clades). A complete molecular data analysis of the Southeast Asian *Alainites* might take time for integrating all previous species reports from this area. We hope that, in a close future, integrative approach including molecular data, accurate descriptions and geographic distribution will help to securely identify the different species of *Alainites* in Southeast Asia.

Alainites is widely distributed in Southeast Asia, but the eight species are reported from a single country (Fig. 8). Amazingly, five of the eight are only reported from islands. The new species, *Alainites siamensis* sp. nov. is only known from Thailand which represents a new report from an inland country in midway between the previous reports in Southeast Asia.

According to ecological requirement and the presumed dispersal abilities of *Alainites*, we may expect a wider distribution in Southeast Asia which includes most of inland countries of the area, as well as overseas colonization of some islands in particular in the Philippines, as supported by the presence of the genus in Taiwan, Borneo and Hong Kong (Müller-Liebenau 1984; Kang et al. 1994; Tong and Dudgeon 2000; Gattolliat 2011). As already mentioned, almost all species show restricted distribution and are only known from a single country. This is at least partially due to the lack of data in some areas. We can expect new reports from Cambodia, Laos, Myanmar (Burma), or Vietnam; they will almost certainly increase the distribution of part of the species or allow the discovery of new ones. A global molecular study of the different species will greatly help to understand the mechanism of dispersion and speciation within these taxa.

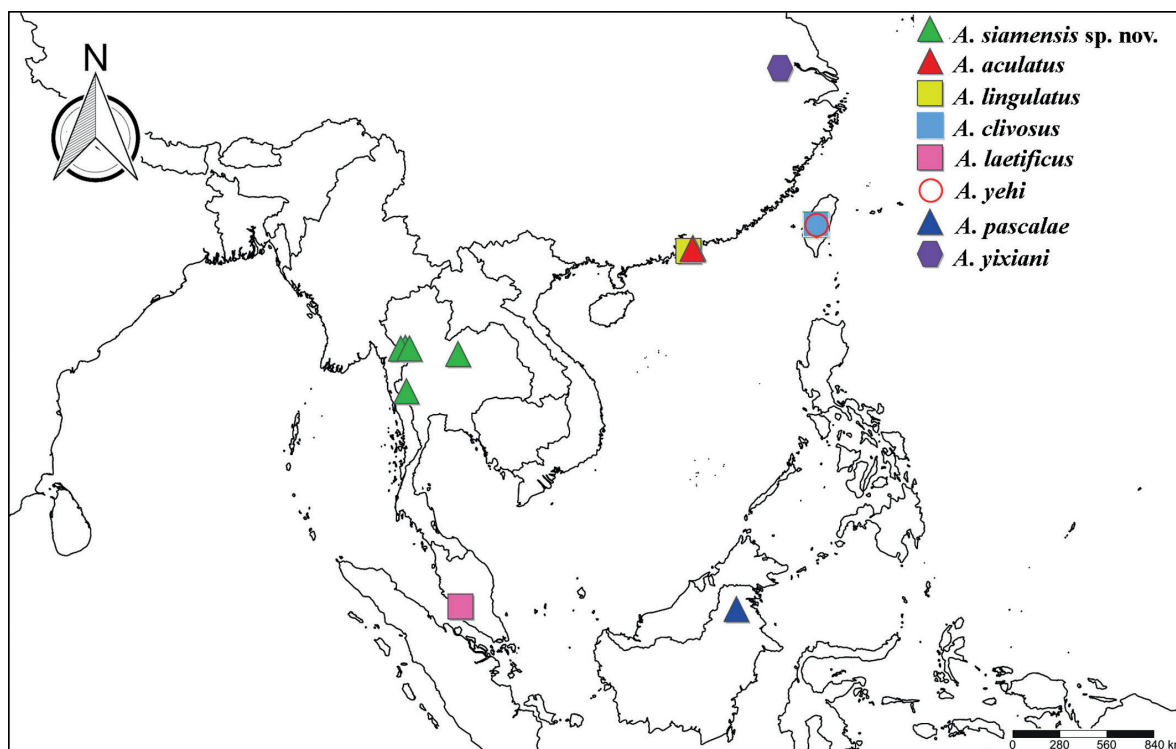


Figure 8. Distribution map of *Alainites* species in Southeast Asia.

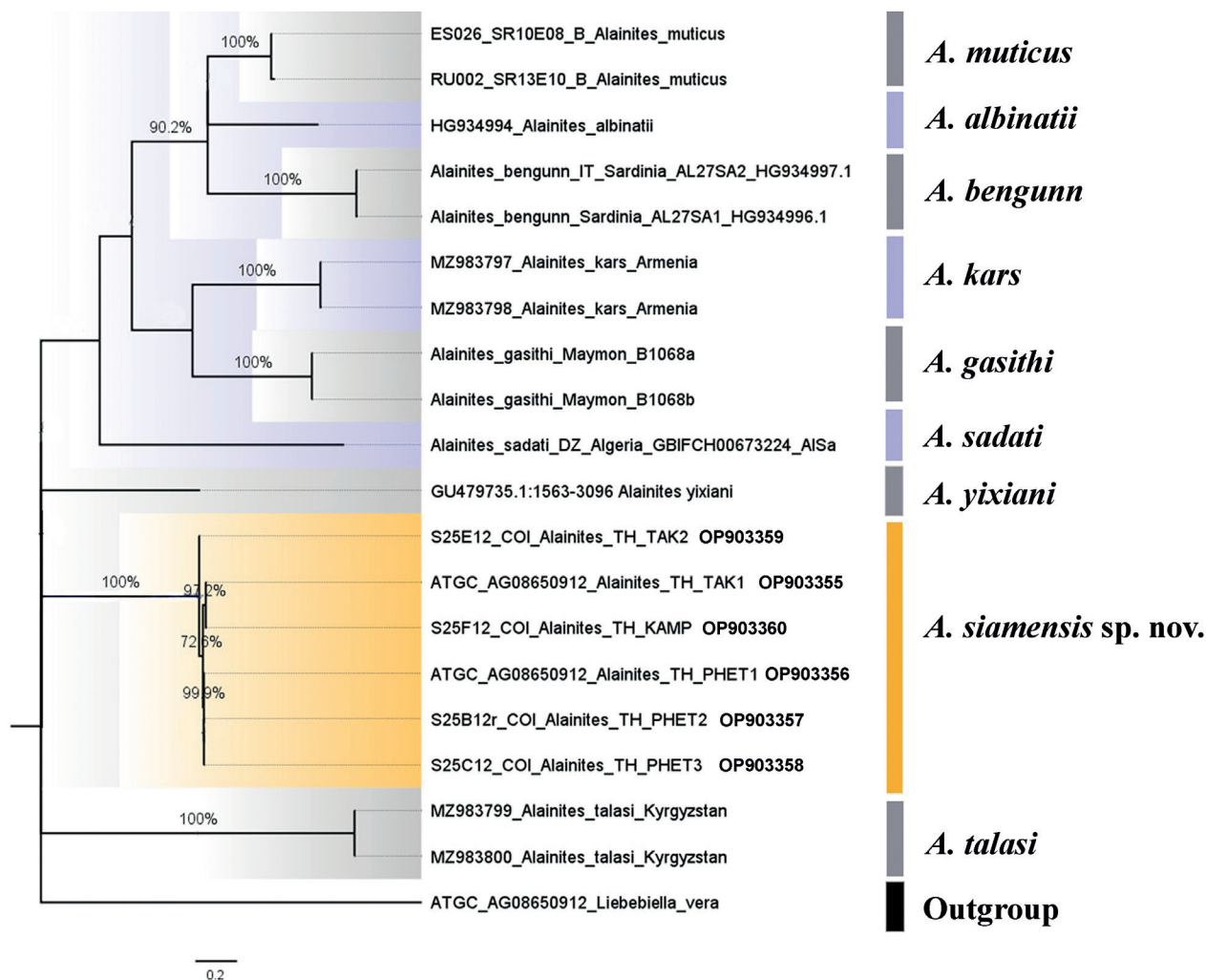


Figure 9. Phylogenetic reconstruction of *Alainites* species based on maximum likelihood analysis of sequences of the mitochondrial COI gene. The reconstruction includes representatives of the new species, *Alainites siamensis* sp. nov. (Orange background), other *Alainites* species (Blue and gray background) and *Liebebiella vera* (Black color) as outgroup.

Key to the larvae of *Alainites* from Southeast Asia*

- 1 7 pairs of gills..... 2
- 6 pairs of gills..... 5
- 2 Paraproct with a tongue-like prolongation, broader apically than medially *A. lingulatus*
- Paraproct with a moderately or well-developed prolongation, not tongue-like..... 3
- 3 Abdominal tergites uniformly medium brown..... 4
- Abdominal tergites I–VIII uniformly medium brown; tergites IX and X light brown..... *A. yixiani*
- 4 Tarsal claws with 7–9 denticles..... *A. siamensis* sp. nov.
- Tarsal claws with 11–13 denticles..... *A. clivus*
- 5 Distal margin of tergite IV with spines; prolongation of paraproct well developed with numerous spines..... 6
- Distal margin of tergite IV without spines; prolongation of paraproct moderately developed or well-developed tongue-like projection 7
- 6 More than ten strong setae on the dorsal margin of mid tibia; short spine-like setae between prostheca and mola *A. pascalae*
- Less than five strong setae on the dorsal margin of mid tibia; long spine-like setae between prostheca and mola *A. laetificus*
- 7 Paraproct with short, slightly acute prolongation (moderately developed); ventral margin of fore femora with robust, simple setae *A. acutulus*
- Paraproct with well-developed tongue-like prolongation; ventral margin of fore femora without setae..... *A. yehi*

* Based on the original description and illustration.

Acknowledgements

The research was funded by a Science Achievement Scholarship of Thailand (SAST) and Research and Graduate Studies Khon Kaen University. We are thankful to our colleagues for kind support throughout field trips. We are very grateful to the Graduate School of Khon Kaen University for providing a grant to come to the Museum of Zoology, Lausanne (MZL). We are grateful to Céline Stoffel (MZL) for her support with lab work, and Laurent Vuataz (MZL) for his valuable suggestions. We would like to thank the team of MZL, as well as the Department of Biology, Faculty of Science at Khon Kaen University for their assistance and facility supports. Lastly, the authors are grateful to the reviewers, Pavel Sroka and Zohar Yanai, for their valuable recommendations and comments on the manuscript.

This research has been reviewed and approved by the Institutional Animal Care and Use Committee of Khon Kaen University, based on the Ethic of Animal Experimentation of National Research Council of Thailand (Record No. IACUC-KKU-65/63) for collecting mayfly specimens.

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Eryngiofaga perrara sp. nov. (Hemiptera, Psylloidea) from Mount Pilatus (Obwalden), a new species of a genus previously unknown from Switzerland or the Alps

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<https://zoobank.org/74F9780D-4AEC-4CDF-AC51-68F827CB87BB>

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Academic editor: Thibault Lachat ♦ Received 15 November 2022 ♦ Accepted 23 November 2022 ♦ Published 6 December 2022

Abstract

Eryngiofaga perrara sp. nov. is described, diagnosed and illustrated from two adult specimens found on Mount Pilatus (Switzerland, Obwalden). The new species is morphologically most similar to *E. matura* (Loginova, 1972), a species from Mongolia, from which it differs in the light genal processes and in details of the terminalia. *Eryngiofaga* consists of 13 previously described species of which five occur in Central and Western Europe. Up to now, the genus was not known from Switzerland or the Alps. The host plant of *E. perrara* remains unknown, but *Bupleurum ranunculoides* L. (Apiaceae) is a likely candidate.

Key Words

Sternorrhyncha, Triozidae, systematics, phytophagy, Central Switzerland, Prealps

Introduction

Jumping plant lice or psyllids constitute a superfamily of Sternorrhyncha with slightly over 4000 described species worldwide. As immatures, most species are mono- or oligophagous, i.e. they develop only on one or several phylogenetically close plant species. Often related psyllid species develop on related host taxa and many genera are restricted to a single plant genus or family (Burckhardt et al. 2014, 2021; Ouvrard et al. 2015). A genus illustrating this pattern is *Eryngiofaga* Klimaszewski, 1968 (Triozidae) with 13 described species associated with *Bupleurum* and *Eryngium* (Apiaceae) (Ouvrard 2022). Several species have been misidentified in the older literature, but Loginova (1977) revised the genus and provided an identification key diagnosing most of the constituent species. For the lack of material, *E. mesomela* (Flor, 1861), *E. loewiana* (Šulc, 1913) and *E. expectata* Klimaszewski, 1971 were not treated. The last species is only known from one female. Most species occur in temperate Asia and Eastern Europe, but five species are also

found in Central and Western Europe. The genus has not yet been reported from Switzerland or the Alps.

Studies on the psyllid fauna of the Central Swiss Prealps in the last 45 years showed an unexpected psyllid diversity (Burckhardt 1983, 1994), including four species that were, at the time, new to science (Burckhardt et al. 1991; Burckhardt and Lauterer 2002a, b). Pilatus, which rises from Lake Lucerne at about 430 m a.s.l. to just over 2100 m a.s.l., is one of the mountains that has been regularly visited. An alpine meadow with rocks called “Chilchsteine” is located on the southern slope between 1850 and 1900 m a.s.l. About a dozen psyllid species were found at this site, of which *Aphalara longicaudata* Wagner & Franz, 1961 on *Polygonum bistorta* and *Bactericera femoralis* (Foerster, 1848) on *Alchemilla* spp. were by far the most common species. In 2000, a single female of an unknown species was discovered. Despite intensive search, no additional specimens turned up until in 2010, at the same place, one male was discovered. The two specimens turned out to be a new species of the genus *Eryngiofaga*. Here the new species is described and its relationships to other congeners are discussed.

Material and methods

For the identification of the specimens, following species from the psyllid collections of the Muséum d'histoire naturelle, Genève, Switzerland (MHNG) and the Naturhistorisches Museum, Basel, Switzerland (NHMB) were examined: *Eryngiofaga deserta* Loginova, 1977, *E. hungarica* (Klimaszewski, 1968), *E. lautereri* Loginova, 1977, *E. matura* (Loginova, 1972) and *E. mesomela*. In addition, the key of Loginova (1977) was used. The holotype and paratype of the new species are deposited in NHMB. The morphological terminology follows Halbert and Burckhardt (2020). Measurements were taken as follows: adult body length from dry mounted specimens, measuring the distance between the fore margin of the head and the tip of the forewings when folded over the body; the measurements of the terminalia were taken from temporary mounts on a slide in glycerine, the other structures from dry mounted specimens. The measurements and ratios are given as range. The classification and nomenclature of Psylloidea follow Burckhardt et al. (2021) and Ouvrard (2022).

Results

Taxonomy

Eryngiofaga Klimaszewski

Remarks. *Eryngiofaga* is a palaeartic genus comprising 13 described species (Loginova 1977). Based on the

paramere shape, two species groups can be recognised. The *mesomela* group, with digitiform parameres bearing a small basal sclerotised process on the inner face, includes *E. babugani* (Loginova, 1964), *E. deserta*, *E. dlabolai* (Vondráček, 1957), *E. lautereri*, *E. loewiana* and *E. mesomela*. The *congenita* group, with lamellar or triangular parameres bearing a large sclerotised process usually arising on the inner face from the middle, is composed of *E. armeniaca* (Gegechkori, 1974), *E. congenita* (Loginova, 1966), *E. hungarica*, *E. maga* (Loginova, 1966), *E. matura* and *E. refuga* (Loginova, 1966). An additional species, *E. expectata*, is known from a single female only.

Eryngiofaga perrara sp. nov.

<https://zoobank.org/153CB420-A251-4F01-A70D-6B9787EF2520>

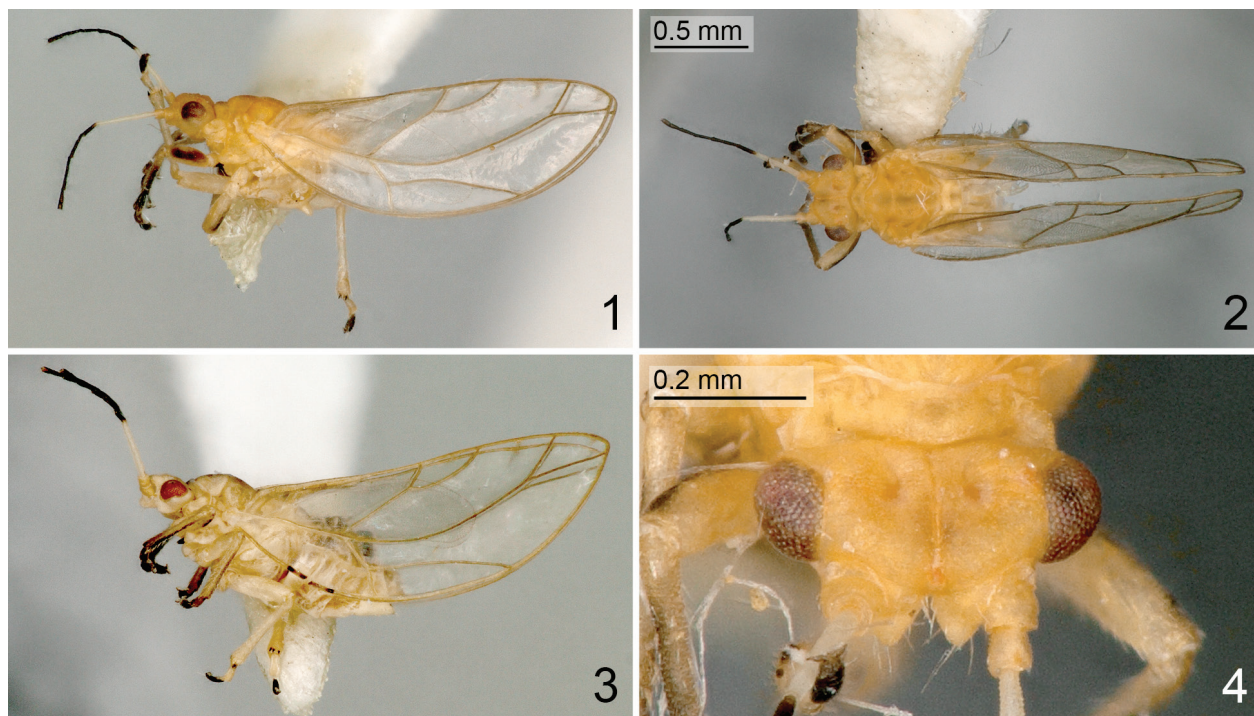
Figs 1–8

Type locality. Switzerland, Obwalden, Pilatus, Chilchsteine, 46.9758°N, 8.2542°E, 1850 m.

Holotype. Male. SWITZERLAND: Obwalden, Pilatus, Chilchsteine, 46.9758°N, 8.2542°E, 1850 m, 12.vii.2010, D. Burckhardt & I. Zürcher // herbaceous vegetation with *Alchemilla*, *Astrantia*, *Bupleurum*, *Cerastium* // *Eryngiofaga perrara* sp. nov., holotype, det. D. Burckhardt, 2022 // NMB-PSYLL0007231 // NHMB, dry.

Paratype. SWITZERLAND, 1 female, Obwalden, same data as holotype but 18.vii.2000, D. Burckhardt // herbaceous vegetation // PSYLL NHMB 00002446 // NHMB, dry.

Diagnosis. Adult yellow to orange (Figs 1–3); genal processes light apically (Fig. 4); with more or less dis-



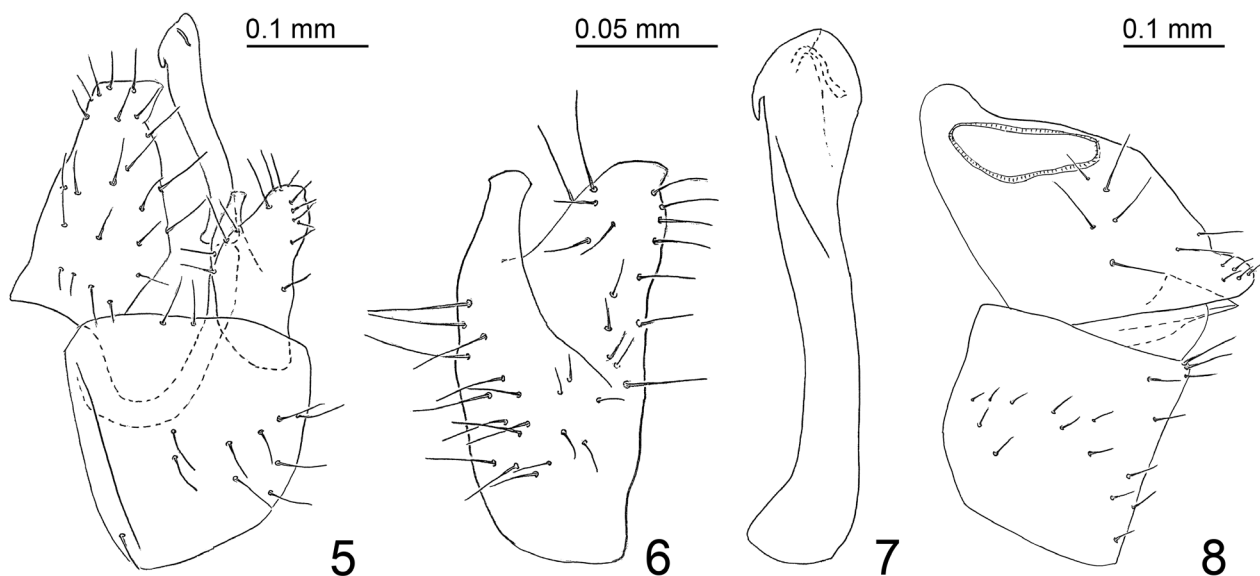
Figures 1–4. *Eryngiofaga perrara* sp. nov. 1–3. Habitus, adults; 1. Male, in lateral view; 2. Male, in dorsal view; 3. Female in lateral view; 4. Head, in dorsal view. Scale bars: 0.5 mm (1–3); 0.2 mm (4).

tinct greyish brown longitudinal medial stripe on head and thorax. Antennal segments 1–3 yellow, segments 4–10 almost black. Forewing transparent, colourless. – Genal processes conical, subacute apically, 0.3–0.4 times as long as vertex along midline. Antenna 1.9–2.2 times as long as head width. Forewing (Figs 1, 3) 4.3–4.4 times as long as head width, 2.8 times as long as wide; costal margin strongly, evenly curved, anal margin almost straight; vein Rs short, distinctly concave; surface spinules lacking apart from base of wing. Paramere bifid (Figs 5, 6); with narrow inner anterior process which is sclerotised apically bearing each a small anterior and posterior toothlet, and with broader outer posterior lobe which is irregularly narrowing to strongly sclerotised apex forming apical tooth. Distal segment of aedeagus (Fig. 7), hardly expanded basally, weakly expanded apically with small subapical hook ventrally. Female terminalia (Fig. 8) short; proctiger ending in small apical tubercle.

Description. Adult (Figs 1–8). Colouration. Yellow to orange (Figs 1, 3). Head and thorax with a greyish brown longitudinal medial stripe, very light in male (Fig. 2), darker in female. Tips of genal processes light (Fig. 4). Eyes red to greyish. Antennal segments 1–3 yellow, segments 4–10 almost black (Figs 1–3). Legs yellow with apical tarsal segments dark brown; pro- and mesofemora dark brown laterally; pro- and mesotibiae yellow in basal quarter, greyish brown otherwise; basal segment of pro- and mesotarsi greyish brown. Forewing (Figs 1, 3) transparent, colourless with yellow to light brown veins. Hindwing whitish, transparent. Abdominal tergites in male ochreous, in female brown. Male with slightly less expanded and distinct dark colour.

Structure. Conforming to the generic description of Loginova (1977). Body length ♂ 2.5 mm, ♀ 2.7 mm (1 ♂, 1 ♀). Head hardly inclined from longitudinal body axis (Figs 1, 3). Vertex subtrapezoidal (Fig. 4). Genal processes conical, subacute apically, 0.3–0.4 times as long as

vertex along midline (Fig. 4). Antenna 1.9–2.2 times as long as head width; relative length of flagellar segments as 1.0 : 0.3 : 0.3 : 0.3 : 0.3 : 0.2 : 0.2 : 0.2; segment 3 longer than segments 4–6 together; relative length of segment 10 and terminal setae as 1.0 : 0.7 : 0.4. Rostrum short, only tip of apical segment visible in lateral view. Metatibia 0.9–1.2 times as long as head width. Forewing (Figs 1, 3) 4.3–4.4 times as long as head width, 2.8 times as long as wide; costal margin strongly, evenly curved, anal margin almost straight; wing widest near the middle; subacute apically, wing apex lying in cell r_2 ; vein Rs short, distinctly concave; m_1 cell value 1.2–1.5, cell cu_1 value 1.7–1.9; surface spinules lacking apart from base of wing; radular spinules present in cells m_1 , m_2 and cu_1 . Hindwing two thirds length of forewing, membranous; costal setae not grouped. Terminalia as in Figs 5–8. Male proctiger (Fig. 5) 0.5 times as long as head width, sparsely beset with long setae, weakly produced posteriorly; posterior margin slightly angular in basal third. Paramere (Figs 5, 6) bifid; in lateral view, with narrow inner anterior process which is sclerotised apically, bearing each a small anterior and posterior toothlet, and with broader outer posterior lobe which is irregularly narrowing to strongly sclerotised apex forming an apical tooth; the outer face bears long setae mostly on the outer posterior lobe; the inner face with long setae along the anterior margin in basal half and on the outer posterior lobe in apical two thirds. Distal segment of aedeagus (Fig. 7) hardly expanded basally, weakly expanded apically, bearing small subapical hook ventrally; sclerotised end tube of ductus ejaculatorius moderately long, weakly sinuous. Female terminalia (Fig. 8) short; proctiger 0.8 times as long as head width, sparsely beset with long setae in the middle and short setae apically; dorsal outline, in lateral view, strongly narrowing towards apex which forms a small tubercle; circumanal ring oval, 0.6 times as long as proctiger, consisting of two unequal rows of pores.



Figures 5–8. *Eryngiofaga perrara* sp. nov., terminalia. 5. Male terminalia, in lateral view; 6. Inner face of paramere; 7. Distal portion of aedeagus; 8. Female terminalia, in profile. Scale bars: 0.1 mm (5, 8); 0.05 mm (6, 7).

Female subgenital plate 0.6 times as long as proctiger, acute apically; sparsely beset with moderately long setae laterally. Dorsal valvulae, in lateral view, triangular; ventral valvulae straight, lacking teeth.

Measurements (in mm; 1 ♂, 1 ♀). Head width 0.46–0.50; antenna length 0.96–1.00; forewing length 1.98–2.20; male proctiger length 0.24; paramere length 0.16; length of distal segment of aedeagus 0.22; female proctiger length 0.40.

Immature unknown.

Etymology. From Latin *perrarus* = very rare, in reference to the paucity of available material.

Distribution. Known only from Mount Pilatus (Switzerland, Obwalden).

Host plant unknown. As host plants of *Eryngiofaga* species are restricted to the genera *Bupleurum* and *Eryngium* (Apiaceae) a likely host of *E. perrara* is *Bupleurum ranunculoides* L. which grows at the site “Chilchsteine” on Mount Pilatus.

Comments. The morphology of the parameres places *E. perrara* in the *congenita* group. It differs from *E. armeniaca* and *E. maga* in the basally more slender distal segment of the aedeagus, and from *E. congenita*, *E. refuga*, *E. hungarica* and *E. matura* in the much shorter subapical ventral hook on the distal segment of the aedeagus. It differs also from the other species of the *congenita* group in details of the paramere. In *E. hungarica* the anterior process of the paramere is broad (slender in all the other species); in *E. congenita*, *E. maga* and *E. matura* the posterior lobe of the paramere, in lateral view, is narrowly triangular and distinctly longer than the anterior one (broadly triangular and only slightly longer in the other species); in *E. armeniaca* the posterior lobe is big and the incision between anterior and posterior lobes is shallow not reaching the apical quarter of paramere (posterior lobe narrower and incision deep reaching basal third in *E. perrara*); in *E. refuga* the anterior process of the paramere is strongly curved along fore margin terminating in a posteriorly directed tooth (anterior process weakly curved anteriorly and terminating in each a forward and backward directed toothlet in *E. perrara*). The head, thorax and abdomen of *E. congenita*, *E. refuga* and *E. hungarica* are dark brown or almost black, but yellow, ochreous or, at most, light brown in *E. perrara*. The new species also differs markedly in the distribution from its putatively closest relatives (based on paramere shape): Switzerland (*E. perrara*) versus Caucasus, Kazakhstan, Siberia and Mongolia (*E. armeniaca*, *E. congenita*, *E. matura* and *E. refuga*).

Discussion and conclusions

Hosts are known for only five of the 13 previously described *Eryngiofaga* species (Loginova 1977). Three species of the *mesomela* group develop on *Eryngium* species, and one species each of the *congenita* group and the *mesomela* group on *Bupleurum falcatum*. Li (2011)

reported also *E. babugani* from this host based on a single male from China with reference to Loginova (1964). Judging from figure 867, Li's (2011) species is not *E. babugani* but resembles more *E. congenita*. Furthermore, Loginova (1964) treated under *E. babugani* a mix of *E. babugani* and *E. lautereri*. Loginova (1977) when revising the taxonomy, listed *B. falcatum* as host of the latter and wrote that the host of the former is unknown. The available data suggest that species of *Eryngiofaga* are monophagous. The host of *E. perrara* is unknown but the presence of *B. ranunculoides* at the type locality makes this plant a likely host.

Even though narrow geographic endemism is generally rare in psyllids (Burckhardt and Queiroz 2021), there are at least five species restricted to the Alps: *Craspedolepta carinthica* Ossiannilsson, 1963, *Cyamophila prohaskai* (Priesner, 1927), *Livilla vicina* (Löw, 1886), *L. vittipennella* (Reuter, 1875) and *Trioza remaudierei* Burckhardt & Lauterer, 2002. The biogeographic pattern of *E. perrara* is similar to that of *C. prohaskai* the only species known of the Alps of a genus very species rich in Central Asia.

It is unlikely, that *E. perrara* occurs only on Mount Pilatus, judging from the much wider distribution of the potential host plant. With only two specimens known, it is impossible to explain why *E. perrara* was so rarely collected and only at a single locality. More intensive and targeted fieldwork is needed to unravel the many questions surrounding this rare species.

Acknowledgements

I am very grateful to Igor Malenovský (Masaryk University, Brno, Czech Republic) and Roland Mühlethaler for their valuable comments and suggestions on a previous manuscript draft.

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In Memoriam: Dr. Jacques Derron – agronome et entomologiste (1945–2022)

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Academic editor: Thibault Lachat ♦ Received 30 November 2022 ♦ Accepted 30 November 2022 ♦ Published 6 December 2022

C'est un vendredi, le 29 juillet 2022, que Jacques nous a quitté subitement dans sa 77^{ème} année.

Jacques Derron, né le 16 septembre 1945 au Vully, a effectué la majorité de sa carrière à Agroscope, sur le site de Changins, dans le service d'entomologie dont il prit la tête jusqu'à sa retraite en 2008.



Figure 1. Jacques Derron (Photo Agroscope).

Issu d'une famille d'agriculteurs, Jacques grandit dans le Vully au bord du Lac de Morat où tout petit il s'émerveille déjà devant les batraciens et autres insectes qu'il observe dans sa région. Il accomplit sa scolarité au Vully, à Fribourg et à Neuchâtel où il obtient la maturité scientifique.

Il choisit ensuite d'étudier l'agronomie à l'EPFZ où il est très vite attiré par l'entomologie et séduit par la production intégrée. C'est ainsi qu'il consacre son travail de diplôme à la lutte biologique contre la Mouche de la cerise. Il part ensuite, avec son épouse Monique, également ingénieur agronome, pour l'île de São Tomé (Golfe de Guinée). Pendant trois ans, il y effectue des recherches sur l'entomofaune dans les plantations de cacao et y découvre, entre autres, de nouvelles espèces dont toute une série de coccinelles, parmi lesquelles *Nephus derroni* et *Thea moniqueae*. Ces recherches aboutissent à sa thèse de doctorat défendue en 1977: «Approche écologique de l'entomofaune des cacaoyères de São Tomé», sous la direction du Prof. Dr. V. Delucchi, Institut d'Entomologie EPFZ.

La même année, Jacques intègre le Service phytosanitaire du canton de Genève où il se consacre notamment à la jaunisse nanisante de l'orge et ses vecteurs, à savoir les pucerons. A cette époque, il s'intéresse déjà beaucoup à la thématique des seuils d'intervention contre les ravageurs des cultures. Ceci afin de pouvoir offrir aux agriculteurs un outil décisionnel permettant de savoir si une intervention phytosanitaire dans les cultures est justifiable et rentable.

Après cette période genevoise, Jacques postule à Agroscope, appelé encore Station fédérale de recherches agronomiques de Changins. Il y est engagé en janvier 1980 dans le Service d'entomologie. Il travaille alors sur de nombreux thèmes, notamment les questions épidémiologiques liées aux vecteurs de virus dans les pommes de terre et les céréales, la recherche de solution aux dégâts d'insectes du colza et les premiers cas de résistances aux insecticides, l'élaboration de seuils d'intervention et la participation active à la lutte biologique à l'aide des

Trichogrammes contre la pyrale du maïs. Cette dernière, s'avère plus que jamais d'actualité avec la recherche d'alternatives durables dans la gestion des bioagresseurs des plantes. De ces travaux découlent de nombreux échanges avec des collègues au niveau national, notamment avec les interlocuteurs cantonaux, l'interprofession, les firmes, les agriculteurs, tout comme à l'international avec notamment le projet Euraphid. Pendant plusieurs années il donne, avec des collègues de divers domaines comme la phytopathologie, des cours sur la production intégrée aux étudiants d'agronomie à l'EPFZ. Il est un des membres fondateurs de la Société suisse de Phytiairie qui se charge de l'étude des facteurs contribuant à la conservation et à l'amélioration de la santé des plantes.

Parallèlement à cette thématique «d'insectes ravageurs des cultures», Jacques avait bien compris que pour trouver des solutions phytosanitaires, il fallait comprendre le système dans son ensemble, c'est-à-dire l'étude synécologique dans l'espace agroenvironnemental. Il a donc étudié les échanges entre espèces, notamment les relations entre auxiliaires et ravageurs, ainsi que la biodiversité dans la zone agricole. Il prit part aux projets de mise en place et d'évaluation des premières surfaces de promotion de la biodiversité (appelée jadis surfaces de compensation écologique) avec ses collègues de Reckenholz et de nombreux partenaires dont l'OFAG, Agridea (SRVA), le Fibl, le WSL, la Station ornithologique suisse, les Universités de Bâle et Berne. Cela l'a conduit à étudier la faune carabique des surfaces cultivées ainsi que des milieux semi-naturels. Il participa d'ailleurs au récent

travail de terrain pour la réactualisation de la Liste rouge des carabes sous l'égide d'Info Fauna/CSCF. Arrivé à la retraite, il se passionne pour les champignons, encore un monde ... sans fin, qu'il va étudier sans relâche. Mais comme tous les chemins mènent à l'entomologie, Jacques faisait de belles découvertes de coléoptères mycétophages ou fongicoles trouvés dans des champignons qu'il me faisait partager. Pour l'anecdote, je me souviens, il y a peu, qu'il m'avait envoyé le plus petit coléoptère existant en Europe, à savoir *Baranowskiella ehnstromi*, trouvé dans un champignon lignicole sur saule.

Jacques a publié de nombreux articles scientifiques sur la thématique de la protection des plantes et de l'entomologie. Il a aussi formé de nombreux apprentis laborantins et suivis des travaux de diplômes et thèses de doctorat. Il était membre de la Société suisse de Phytiairie, de la Société suisse d'entomologie, des Sociétés de mycologie de Fribourg et de La Côte. Au moment de son décès, il était impliqué dans le projet «Inventaire des Champignons de la Grande Carîaie».

Jacques était un grand scientifique, toujours intéressé à comprendre le monde qui nous entoure. Il était également un amoureux des voyages, tout particulièrement des îles volcaniques (en souvenir de São Tomé), qu'il visitait avec son épouse et leurs deux filles. Il appréciait aussi grandement la lecture, notamment les traités historiques et géopolitiques, ainsi que la musique classique. Pour moi, Jacques était avant tout un homme généreux avec qui il faisait bon discuter et partager de bons moments d'amitié. Jacques, mon ami, tu vas nous manquer.

Protokoll der Jahresversammlung der Schweizerischen Entomologischen Gesellschaft vom 20. und 21. Mai 2022 am Museo cantonale di storia naturale Lugano

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Bedingt durch die andauernde Coronapandemie wurde die Jahresversammlung der SEG auf Ende Mai verschoben. Dadurch konnte sie aber wie gewohnt mit physischer Präsenz durchgeführt werden, diesmal auf Einladung des Museo cantonale di storia naturale in Lugano.

Der Themenschwerpunkt am Freitag galt den Insekten im Lebensraum Wald. Beat Wermelinger von der WSL Birmensdorf lieferte dafür mit seinem Hauptvortrag den perfekten Einstieg. Er gab darin einen Überblick über waldbewohnende Insekten und ihre ökologischen Funktionen: Bestäubung, Umsetzung von Pflanzenmasse etwa durch Holzabbau, Verwertung von Aas und Schaffung von Mikrohabitaten für andere Arten, um nur einige zu nennen. Die Präsentation wurde dabei durch Beat Wermelingers eigene Fotoaufnahmen sehr anschaulich illustriert. Passend zum Themenschwerpunkt am Samstag wurde das Vortragsprogramm am ersten Tag bereits erfolgreich durch das zweite Thema „invadiert“.

Folgende zehn Vorträge wurden am Freitag gehalten:

- Die Bedeutung von Insekten im Ökosystem Wald.
Beat Wermelinger, WSL, Birmensdorf
- Entlarvt: Mit parasitoiden Schlupfwespen gegen den Buchdrucker (*Ips typographus* L.) - Aktuelle Fragestellungen aus den Projekten EIVES und IPSolut.
Anna Lawall & Elisabeth Spann, Institut für Waldbau und Waldschutz, Technische Universität Dresden
- Die wärmeliebenden Wälder am Vierwaldstättersee – eine Fundgrube für seltene Käferarten.
Roman Graf

- Naturwaldreservate in Buchenwäldern der Schweiz: ein Refugium für xylobionte Käfer?
Thibault Lachat, Berner Fachhochschule, HAFL
- *Hylurgus ligniperda*: a poorly known, highly invasive European bark beetle.
Eckehard Brockerhoff, WSL, Birmensdorf
- Einheimische Pilze gegen invasiven Käfer.
Tanja Sostizzo, Agroscope Reckenholz
- Gebietsüberwachung von walddrelevanten Quarantäneorganismen in der Schweiz.
Doris Hölling, Waldschutz Schweiz / WSL, Birmensdorf & Aline Knoblauch, Bundesamt für Umwelt BAFU
- La lutte biologique classique contre la drosophile à ailes tachetées en Suisse.
Lukas Seehausen, CABI, Delémont
- Attraction of *Drosophila* by killer yeasts.
Claudia Buser, Eawag, Dübendorf
- A machine learning algorithm approach for species determination in Sepsid flies.
Ramon Dallo, Universität Zürich

Das Samstagsprogramm galt vollständig den invasiven Insekten. Dies ist gerade für den Kanton Tessin ein hochrelevantes Thema, da viele potenzielle Schädlinge ihren Weg aus dem Süden über das Tessin in die Schweiz finden und dieser Trend in den letzten Jahren immer mehr zunimmt. Mit diversen Vorträgen zur aktuellen Forschungslage und den getroffenen Massnahmen gegen (potenziell) invasive Insektenarten gab es einen interessanten Einblick zur derzeitigen Situation in der Schweiz.

Den Anfang machte Davide Rassati von der Universität Padua, der mit seinem Hauptvortrag einen passenden Einstieg in das Thema gab. Darin präsentierte er einen Überblick der Mechanismen und Voraussetzungen, damit eine Art invasiv werden kann und welche Massnahmen zur Prävention und Eindämmung ergriffen werden können. Sein Fokus lag dabei auf holzbewohnenden Käfern, einer der wichtigsten Gruppen unter den invasiven Insekten. Da der weltweite Handel mit Gütern stetig zunimmt und Verpackungsmaterial beim Transport oft nicht fachgerecht untersucht wird, können sich xylobionte Arten ausgehend von Häfen oder Flugplätzen über nahe Wälder in einem nicht heimischen Areal ausbreiten. Für die Etablierung einer invasiven Art spielen neben einer genügend grossen Anzahl an eingeschleppten Tieren auch die klimatischen Bedingungen und die Verbreitung geeigneter Nahrungspflanzen eine entscheidende Rolle.

Folgende zehn Vorträge wurden am Samstag gehalten:

- Invasions of non-native forest insects: mechanisms and management.
Davide Rassati, Universität Padua
- American grapevine leafminer, *Aspilanta oinophilla* (van Nieukerken & Wagner, 2012), an emerging pest for viticulture.
Riccardo Battelli, Servizio fitosanitario cantonale, Bellinzona
- Le frelon asiatique (*Vespa velutina*) : situation en Suisse et premières tentatives de contrôle.
Lukas Seehausen, CABI, Delémont
- Successful control of *Tapinoma magnum* (Hymenoptera, Formicidae) in the city of Zurich, Switzerland.
Marcus Schmidt, Umwelt- und Gesundheitsschutz der Stadt Zürich
- Exploring the potential of parasitoids to control the tomato leafminer: efficacy, compatibility and specificity.
Jérémy Gonthier, Agroscope Reckenholz
- Arrival, spread and control of invasive mosquitoes in Switzerland.
Eleonora Flacio, University of applied sciences of Southern Switzerland – SUPSI, Mendrisio
- Das Potenzial natürlicher Gegenspieler zur Regulierung von gebietsfremden Schadinsekten nutzen.
Dominique Mazzi, Agroscope Cadenazzo
- *Erasmoneura vulnerata*: un nouveau ravageur de la vigne d'origine américaine. Attilio Rizzoli, Agroscope Cadenazzo

- Der Japankäfer im Tessin: Verbreitung, Trends und Risiken. Cristina Marazzi, Servizio fitosanitario cantonale, Bellinzona
- Les insectes exotiques, peuvent-ils perturber un système de production ? Mauro Jermini, Agroscope Cadenazzo

Lucia Pollini Paltrinieri, Bärbel Koch und dem Rest des Teams des Museo cantonale di storia naturale sei herzlich für die hervorragende Organisation der Jahresversammlung und der kulinarischen Highlights am Freitagabend und Samstagnachmittag gedankt.

Generalversammlung

Begrüssung

Der Präsident Oliver Martin eröffnet die Generalversammlung um 10:00 Uhr und begrüsst die anwesenden 16 Mitglieder und drei Gäste (total 19 Personen).

Protokoll der Generalversammlung und ausserordentlichen Versammlung 2021 via Videokonferenz

Das Protokoll wird kommentarlos und unverändert genehmigt.

Bericht des Präsidenten, Oliver Martin

Administratives

Im administrativen Bereich wurden wir 2021 wiederum durch das Centre Suisse de Cartographie de la Faune (CSCF) in Neuchâtel unterstützt. Die SEG ist Mitglied der Plattform Biologie der Akademie der Naturwissenschaften Schweiz (SCNAT) in Bern und wurde dort von der Leiterin der Plattform Pia Stieger und dann ab Juni 2021 von ihrer Nachfolgerin Claudia Rutte betreut. <https://biol.scnat.ch/de>.

Finanzielle Unterstützung

Die Gesuche des Präsidenten um finanzielle Unterstützung wurden von den angefragten Institutionen vollumfänglich bewilligt. Es handelt sich dabei um folgende Beträge: Akademie der Naturwissenschaften Schweiz (SCNAT) in Bern: CHF 12'040.– und Biedermann-MantelStiftung in Zürich: CHF 6'000.–. Wir sind diesen zwei Geldgebern für ihre wichtigen Beiträge sehr dankbar.

Jahresversammlung, Generalversammlung und Vorstandssitzungen

Die entomo.ch fand pandemiebedingt diesmal in abgeänderter Form auf einen Tag reduziert am Freitag, 5 März 2021 als Videokonferenz statt. Die Generalversammlung

(GV) fand ebenfalls via Zoom am Freitag, 5. März 2021 um 13.30 statt. Ein zweiter Teil der GV (für die Präsentation des Berichts der Quästorin) fand am 21. Juni ebenfalls via Zoom statt. Es fanden drei Vorstandssitzungen statt: Freitag, 5. März via Zoom (1. reguläre halbjährliche Sitzung), 21. Juni via Zoom (ausserordentliche Sitzung gekoppelt mit dem zweiten Teil der GV) und Mittwoch, 3. November 2021 am Naturhistorischen Museum in Bern (2. Reguläre halbjährliche Sitzung).

Prix Moulines

Im Jahr 2021 wurde einmal mehr der prestigeträchtige Prix Moulines für eine herausragende entomologische Publikation vergeben (an der entomo.ch 2021 online via Zoom). Der Preisträger war Rudolf Bryner, dessen Publikation «Adelidae (Lepidoptera) - Beitrag zur Kenntnis der Biologie und Bestimmungshilfe für die europäischen Arten.» (2020, Contributions to Natural History, 38: 1–475) sich gegen die hochkarätige Konkurrenz durchsetzen konnte. Dieses preisgekrönte Werk ist öffentlich zugänglich via e-periodica: <https://www.e-periodica.ch/digbib/view?pid=cnh-001:2020:0::495#4>.

Website

Die Website der SEG, u.a. mit Informationen zur Jahrestagung entomo.ch, war auch dieses Jahr wieder im Portal Naturwissenschaften Schweiz der Akademie der Naturwissenschaften Schweiz (SCNAT) abrufbar: <https://entomo.ch/de>.

Für die Betreuung danke ich besonders Mariella Hobi, Nicola Frieden (beide Administration, Geschäftsstelle SCNAT), Marcel Falk (Leiter Kommunikation) und Andres Jordi (Chefredaktor Web).

Digitalisierung von entomologischen Zeitschriften

Weitere SEG-Projekte zur Digitalisierung von entomologischen Zeitschriften wurden gestartet mit folgenden zusätzlichen Reihen: «Mitteilungen der Entomologischen Gesellschaft Basel» und «Insecta Helvetica» (Fauna & Catalogus). Diese neuen Projekte entstehen wiederum in Zusammenarbeit mit der ETH-Bibliothek in Zürich und dank der grosszügigen finanziellen Unterstützung der SCNAT. Unsere Ansprechpartnerin bei der ETH-Bibliothek war weiterhin Regina Wanger, die Leiterin des DigiCenters. Dank der SEG-Digitalisierungsprojekte werden künftig sämtliche Bände von vielen entomologischen Zeitschriften der Schweiz im PDF-Format online verfügbar sein: www.e-periodica.ch.

Insekt des Jahres

In Zusammenarbeit mit entomologischen Gesellschaften in Deutschland und Österreich wurde für das Jahr 2022 die Schwarzhalsige Kamelhalsfliege (*Venustoraphidia nigricollis*, Raphidiidae) zum Insekt des Jahres bestimmt.

Dazu wurde wiederum ein Flyer publiziert, welcher über die SEG bezogen werden kann: https://entomo.ch/de/portrait/insect_of_the_year/insekt_des_jahres_2022.

Im Namen des Vorstandes und der SEG-Mitgliedschaft bedanke ich mich nochmals sehr herzlich bei allen genannten Institutionen, Gremien und Personen für ihre wertvolle Unterstützung und ihren Einsatz!

Bericht des Bibliothekars, Philippe Jeanneret

En 2021, il n'y a pas eu d'activité de la bibliothèque de la Société.

Bericht des Redaktors der Fauna Helvetica, Daniel Burckhardt

Im Berichtsjahr wurde kein Band publiziert. Band 33, Ökologie und Atlas der Staphylinidae (ohne Pselaphinae und Scydmaeninae), ist im Druck und sollte nächstens herauskommen. Dies wird der erste Band der Fauna Helvetica sein, der ausschliesslich digital publiziert wird. Ein Manuskript über die Bombyliidae ist weit fortgeschritten. Weitere Manuskripte sind in Vorbereitung.

Für die gute Zusammenarbeit möchte ich Dr. Yves Gonseth und den Mitarbeiterinnen und Mitarbeitern vom CSCF ganz herzlich danken.

Bericht des Chefredaktors von Alpine Entomology, Thibault Lachat

The fifth issue of Alpine Entomology was delivered before Christmas 2021. The new issue of our journal consisted of 17 articles across 124 pages: 8 research articles, 4 short communications, 1 checklist, 1 in memoriam, 1 book review, 1 editorial, and the yearly report of the SES.

An editorial board composed of Prof. Dr. Inon Scharf, Prof. Dr. Lyubomir Penev, Dr. Yves Basset, Dr. Seraina Klopstein, Dr. Oliver Martin and I was created to support our journal for strategic issues.

We have launched our first topical collection focusing on trends in arthropods of aquatic ecosystems. Dr. Jean-Luc Gattolliat and Dr. Dávid Murányi are the editors of this collection. Authors invited to submit a manuscript will be granted a fee waiver. This topical collection is open for a duration of two years. Further collections will be launched in the future. Thanks to the excellent contributions of the subject editors and the permanent support of Pensoft, we were able to further reduce the delay between submission and acceptance of manuscripts. The average duration from submission to publication was 2.6 months. The goals for Alpine Entomology remain the same: qualify for an impact factor (not only by Scopus but also by Clarivate) by securing a consistent flow of manuscripts and becoming more international by reaching authors from around the world.

Bericht der Quästorin, Sandra Choffat-L'Eplattenier

Aus der Jahresrechnung 2021 von Frau Choffat-L'Eplattenier ist folgende Tabelle entnommen:

Positionen / Objets	Ausgaben / Dépenses	Einnahmen / Revenus
Publikationskosten / Charges de publications:		
Publikation AE - impression	3'104,82	
Pensoft: Website, Open access	16'542,00	
Publikation „Fauna Helvetica“	38,81	
Verwaltung / Administration	8'632,75	
Beitrag scjnat / Cotisation scjnat	1'554,00	
Arbeitsgruppenförderung / Groupes soutien de travail	325,00	
Verkauf Mitteilungen / Ventes bulletins		2'103,00
Mitgliederbeiträge / Cotisations		1'4378,24
Verkauf Fauna Helvetica / Ventes Fauna Helvetica		5'451,63
Beiträge / Subventions:		
scjnat		8'662,88
Syngenta		0,00
Biedermann-Mantel-Stiftung		6'000,00
Spenden und sonstige Einnahmen / Dons et autres produits		1'693,90
Zinsen / Intérêts:		
SEG-Konten / Comptes SEG	80,20	
Fauna Helvetica-Konto / Compte Fauna Helvetica	60,00	
Erhöhung von Rücklagen / Augmentation de réserve (résultat Fauna Helvetica)	5'027,82	
Total / Totaux	35'365,40	38'289,65
Jahresgewinn / Bénéfice annuel 2021	2'924,25	
	38'289,65	38'289,65

Die Erfolgsrechnung für das Jahr 2021 schloss mit einem Gewinn von CHF.- 2'924,25 und einem Vermögen von CHF.- 112'907,56.

Den Herren Hans Schmocker, Hubert Buholzer und Ladislaus Rezbanyai-Reser wird für ihre finanziellen Spenden im Jahr 2021 gedankt.

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 2021 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.

Der Quästorin wird von den anwesenden Mitgliedern einstimmig Decharge erteilt. Michel Sartori, der seine Tätigkeit als Revisor niederlegt, wird für sein langjähriges Engagement im Amt verdankt.

Budget und Mitgliederbeiträge

Budget

Der Präsident stellt das Budget für 2022 vor, welches einen Gewinn von CHF 1'146.- vorsieht.

Mitgliederbeiträge 2022

Die Beiträge bleiben erneut gleich: Mitglieder in der Schweiz zahlen CHF 60.-, Studierende oder sich anderweitig in Ausbildung befindende Mitglieder zahlen während drei Jahren nur die Hälfte des ordentlichen Beitrags (CHF 30.-). Mitgliedern im Ausland, die die gedruckte Version von Alpine Entomology wünschen, werden zusätzlich CHF 15.- Versandkosten verrechnet.

Das Budget und die Mitgliederbeiträge werden einstimmig genehmigt.

Personelles

Todesfälle

Den verstorbenen SEG-Mitgliedern Peter Hättenschwiler (Experte für Psychidae, ehem. Vorstandsmitglied der SEG: Sektionsvertreter; 1927–2021), Stefan Naglis (Universität Zürich, Experte für Dolichopodidae; 1958–2021) und Georg Benz (Professor ETH Zürich, ehem. Vorstandsmitglied der SEG: Bibliothekar, Präsident, Redaktor der Mitteilungen und Ehrenmitglied; 1926–2021) wird mit einer Schweigeminute gedacht.

Jahresversammlung 2023

Die nächste Jahresversammlung, die entomo.ch 2023, soll am 3. und 4. März an der ETH Zürich stattfinden.

Ende der Generalversammlung um 11:00 Uhr.

Walterswil SO im November 2022,
der Sekretär Marc Neumann.

Time to change after six issues of Alpine Entomology

Thibault Lachat^{1,2}

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Academic editor: Oliver Martin ♦ Received 10 December 2022 ♦ Accepted 13 December 2022 ♦ Published 16 December 2022

Dear readers, authors, reviewers, subject editors and editorial board members

You hold in your hands the 6th issue of Alpine Entomology, the journal of the Swiss Entomological Society (SEG), that I have had the pleasure and honor to publish as Editor-in-Chief.

In spring 2017, I was approached by the former SEG President Hannes Baur to take over the recently created journal, with a newly defined focus and scope and an agreement with the publisher Pensoft. I was thus offered this new journal on a silver platter, waiting to be filled with exciting articles. The new journal Alpine Entomology replaced the traditional SEG journal. The famous “Mitteilungen der Schweizerischen Entomologischen Gesellschaft/Bulletin de la Société Entomologique Suisse” was to disappear and be substituted with an online and open access journal. A real revolution suiting the current trend towards democratization of scientific journals.

So here I was, an Editor-in-Chief of a new journal that should be published for the first time at the end of 2017, before Christmas. We have continued to follow this tradition, and the journal was typically published at the end of the year (except in 2020 and in this present year). Of course, this tradition is losing some of its meaning given the immediate access to new articles online as soon as final versions can be produced after acceptance.

Despite its seemingly exclusive title, Alpine Entomology is actually not at all limited to the Alps. From the very beginning, we made it clear that our journal is open to all publications related to insects and other arthropods, not only from the Alps, but also from other mountainous regions (Lachat and Baur 2017). It was up to me as the Editor-in-Chief to decide whether the link with the mountains was strong enough to forward a manuscript to the subject editor, who always helped me to make a decision in case of doubt.

My declared ambition from the beginning was to get the journal indexed in bibliographic databases. We needed

to be patient but were finally indexed by Scopus in 2020. Furthermore, Alpine Entomology will also be granted its first impact factor in 2023 by Clarivate Analytics. Despite a modest number of articles published annually, I am proud of what Alpine Entomology has become. In six years, we have published almost a hundred articles ranging from scientific papers to the annual report of the society through checklists for Switzerland. Some of these articles have acquired more than 3000 unique views on our website <https://alpineentomology.pensoft.net>. This confirms the success of the online open access format for our journal and proves that Alpine Entomology is frequently consulted by the national and international communities of entomologists beyond the members of the SEG.

After the publication of the 5th volume, I had taken the decision to step down from my position as Editor-in-Chief once an ideal successor could be found. I am very pleased that we have selected a successor, a brilliant person to take over the reins of our journal. Unfortunately, I cannot announce the name of the new Editor-in-Chief yet, as the candidate will be officially elected at the next general meeting of the society in March 2023.

The future challenge for my successor will be to consolidate the scientific and international orientation of our journal. With the broader indexing of Alpine Entomology and the new Editor-in-Chief, I hope that the number of articles published annually will increase even more. The two topical collections we have recently launched on aquatic arthropods and alien insects should also help to ensure a growing interest in submitting manuscripts to our journal (Lachat and Martin 2021).

Over the past six years, I have led Alpine Entomology, with the support of a team of highly dedicated subject editors and the editorial board, to its current position. I would like to thank all the people who have contributed to the success of our journal during these years. Finally, I wish my successor every success and pleasure in his/her work and a long and fulfilled life to Alpine Entomology.

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