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Front cover: *Idiasta dichrocera* Konigsmann, 1960. © Bart Minnebo.

Remarks on Hymenoptera on urban green roofs in Belgium

Fons Verheyde [1], Jeffrey Jacobs [2], Wouter Dekoninck [3], Kees van Achterberg [4], Jeroen de Rond [5], Tim De Blanck [6], Karel Schoonvaere [7], Hans Nieuwenhuijsen [8], Augustijn De Ketelaere [9], Bart Minnebo [10] & Mar Ferrer-Suay [11]

[1] Aartshertoginnestraat 58/01, B-8400 Ostend, Belgium (corresponding author: fonsverheyde@hotmail.com)
[2] UHasselt, Centre for Environmental Sciences, Agoralaan Gebouw-D, B-3590 Diepenbeek, Belgium
[3] Royal Belgian Institute of Natural Sciences, Vautierstraat, 29, B-1000 Brussels, Belgium
[4] Zhejiang University Hangzhou, China
[5] Wederiklaan 10, NL-8245, Lelystad, the Netherlands
[6] Wakkensteenweg 50a, B-8710 Sint-Baafs-Vijve, Belgium
[7] Krekelstraat 59, B-9840 De Pinte, Belgium
[8] Frans Halsstraat 10, NL-1816, Alkmaar, the Netherlands
[9] Noendreef 7, B-8730 Beernem, Belgium
[10] Oude-Provenstraat 39, B-8978 Watou, Belgium
[11] Dpt. Zoologia, Fac. Ciencies Biològiques - Universitat de València, C/ Dr. Moliner, 50, ES-46100 Burjassot, Valencia, Spain

Abstract

In this paper, we discuss all Hymenoptera (10,085 specimens) captured on several urban green roofs in Belgium during 2020 and 2021. Our research aims to establish connections between species' ecology and the specific habitat of extensive green roofs. Based on our findings, we propose potential life communities that can thrive in these habitats. Notably, six species out of 119 taxa are reported for the first time in Belgium: Gonatopus lunatus (var. bifasciatus) Klug, 1810 (Aculeata: Dryinidae); Synacra paupera Macek, 1995 (Parasitica: Diapriidae); Alysia lucicola Haliday, 1838, Idiasta dichrocera Konigsmann, 1960, and Leiophron deficiens (Ruthe, 1856) (Parasitica: Braconidae), along with Gelis declivis Forster, 1850 (Parasitica: Ichneumonidae).

Keywords: Urban biodiversity, typology, environmental management, community structures

Introduction

At current times with habitat loss, pollution, climate change and many more stressors triggering biodiversity loss, researchers have more or less agreed urban green roofs can provide a solution, at least to some extent, for invertebrates (Ksiazek, 2014; Scott MacIvor & Ksiazek, 2015). Current biodiversity research often wants to analyze which factors are essential for a stable and viable ecosystem and detailed inventories can either support or deny these statements.

How roof factors influence biodiversity will be elaborated in another upcoming paper (see Jacobs *et al*., 2023, forthcoming). For now, it suffices to say most studies indicate that the soil substrate type and its depth are important abiotic factors regulating green roof biodiversity (Brenneisen, 2006; Madre *et al*., 2013; Dusza *et al*., 2016). Additionally, vegetation characteristics like plant diversity and the proportion of total vegetation cover are estimated to be good indicators of general arthropod diversity (McIntyre, 2000; Schindler, Griffith & Jones, 2011). Less clear is the importance of the total roof size, age and height or presence of green space in the vicinity. Some studies suggest this is irrelevant, partially depending on the mobility of certain arthropod communities (Schindler, Griffith & Jones, 2011), but some also contradict these conclusions (Braaker *et al*., 2014; McIvor, 2015; Dromgold *et al*., 2020). Considering these

studies, there is one thing clear: it is very difficult to generalize statements relevant for all communities, simply because these communities are very diverse and results are also somewhat dependent on catching methods.

More specifically, inventories have shown how green roofs are especially interesting to beetles and spiders. There has also been some attention to wild bees; as these are important pollinators (Jacobs *et al*., 2023). Other Hymenoptera, and certainly parasitoid wasps, have only been very scarcely studied or mentioned in the results (examples are Schindler, Griffith & Jones, 2011; Scott MacIvor, 2016; Drukker, De Boer & Fatouros, 2018). Quantitative analyses in depth (at least at family level) are virtually absent. One rare exception is a survey made by Diethelm, Masta & Starry conducted at the Portland State University in 2015 (Diethelm *et al*., 2016).

This absence is probably caused by the difficulties regarding identification. Therefore, another goal of this survey was to make an overview of the absolute numbers found within Parasitica on (super)family level (see Discussion and Table 3), and to identify to species level where it was possible. It is important to identify specimens to species level, because the knowledge of a certain species' ecology provides us with insights to better understand the relationship between the species and the urban green roof biotope, as will be demonstrated with our results.

Roof gardens have a long history, going back to the hanging gardens of Babylon (estimated 4000 years ago; Dalley, 1993). Extensive green roofs on a large scale are a modern take on the roof-garden concept. They typically have shallower substrates, require less maintenance, and serve a more limited purpose than intensive living roofs or roof gardens. In their most basic form, extensive green roofs are made up of a root barrier layer, an insulation layer, a waterproofing membrane, a layer of growing medium and a layer of vegetation. Plants that are suitable for extensive green roofs have adaptations that allow them to survive in harsh environments. These plants have the ability to withstand stress periods for longer periods of time, such as drought or heat. Low-growing *Sedum* species have been shown to be suitable for use in green roofs due to their superior survival in substrate layers as thin as 2 to 3 cm (Van Woert *et al*., 2005).

Many factors influence the composition and character of green-roof vegetation. Substrate depth, to a large extent, determines vegetation diversity and the range of possible species. Shallow substrate depths of 2 to 5 cm have faster rates of desiccation and are more susceptible to temperature fluctuations, but they can support simple *Sedum*-moss communities. Substrate depths of 7 to 15 cm can support a more diverse mix of grasses, geophytes, alpines, and drought-tolerant herbaceous perennials, but they are also more hospitable to weeds (Oberndorfer *et al*., 2007).

Material and methods

Localities

In total 20 green roofs were monitored. The green roofs had an average area of 280.6 m² (range: 8 m² to 896 m²), an average age of 8.4 years (range: 3–14 years), and an average height of 10.4 m. (range 4–23m; Table 1). A homogeneous, shallow layer of rocky bedrock measuring 5 to 20 cm thick makes up the roofs. Usually, *Sedum* species or other drought-tolerant plants are planted there (e.g. species of mosses and grasses such as *Calamagrostis epigejos*).

Roofs were categorised into two groups according to this vegetation type: 11 *Sedum* roofs (e.g. Fig. 2) and 9 herbaceous roofs (see Table 1; e.g. Fig. 1). All green roofs receive additional nutrients through annual or multi-annual compost amendment.

Fig. 1. Green roof BRA (Brandweer, Antwerpen), Antwerp, Belgium. © Jeffrey Jacobs.

Fig. 2. Green roof RPBER (Recycling park Berchem), Berchem, Belgium, with *Sedum album*. © Jeffrey Jacobs.

Table 1. Overview of the roofs with their reference name, age, surface area, height above ground level and dominant vegetation.

Name roof	Reference	Location	Age (y)	Surface (m^2)	Height (m)	Dominant vegetation
OCMW Arena	ARENA	Deurne (N51.199°, E4.459°)	13	72	6	*Sedum*
Atlas	ATLAS	Antwerpen (N51.130°, E4.253°)	8	320	8	*Sedum, herbs and grasses*
Administrative centre Den Bell	BELL	Antwerpen (N51.205°, E4.399°)	12	85	21	*Sedum*
Boekenberg park 1	BOEK 1	Deurne (N51.197°, E4.463°)	14	108	5	*Sedum, herbs and grasses*
Boekenberg park 2	BOEK 2	Deurne (N51.197°, E4.462)	14	85	4	*Sedum, herbs and grasses*
Brandweer	BRA	Antwerpen (N51.251°, E4.418°)	12	777	17	*Sedum, herbs and grasses*
District	DIS	Wilrijk (N51.169°, E4.394°)	13	320	9	*Sedum, herbs and grasses*
Ecohuis 1	ECO 1	Borgerhout (N51.125°, E4.260°)	3	35	12	*Sedum*
Ecohuis 2	ECO 2	Borgerhout (N51.125°, E4.260°)	3	8	12	*Sedum, herbs and grasses*
Ellerman	ELL	Antwerpen (N51.230°, E4.415°)	6	312	9	*Sedum, herbs and grasses*
Hardenvoort	HARD	Antwerpen (N51.135°, E4.251°)	5	630	20	*Sedum, herbs and grasses*
Urban childcare centre Strandloper	IGLO	Antwerpen (N51.225°, E4.380°)	9	896	5	*Sedum*
Middelheim 1	MID 1	Antwerpen (N51.184°, E4.420°)	7	260	10	*Sedum*
Middelheim 2	MID 2	Antwerpen (N51.184°, E4.419°)	7	45	10	*Sedum*
Onyx	ONYX	Berchem (N51.193°, E4.417°)	7	708	23	*Sedum*
Plantin Moretus museum	PM	Antwerpen (N51.218°, E4.398°)	5	84	15	*Sedum*
Recycling park Berchem	RPBer	Berchem (N51.194°, E4.439°)	7	154	4	*Sedum*
Recycling park Deurne	RPDeu	Deurne (N51.237°, E4.457°)	7	142	4	*Sedum*
Recycling park Wilrijk	RPWil	Wilrijk (N51.160°, E4.390°)	7	164	4	*Sedum, herbs and grasses*
Red Star Line museum	RSL	Antwerpen (N51.135°, E4.241°)	10	408	10	*Sedum*

Data Collection

In order to evaluate the Hymenoptera biodiversity, the second author randomly put pan traps with a diameter of 12 cm and a height of 4 cm on the green roofs between March and September of 2020 and 2021 (one blue, yellow, red and white; see Shrestha *et al.,* 2019). The pan traps were filled with propylene glycol and were emptied after 24 hours. Invertebrates were stored in 70% ethanol. Pitfall traps were also used (diameter = 8 cm, height = 6 cm) to assess ground dwelling Hymenoptera biodiversity on the green roofs (Cooper & Whitmore, 1990; Oberprieler *et al*., 2019). At each site, we installed four pitfall traps at random. The pitfall traps were covered with a lid to keep rain out of the traps, and propylene glycol was used to fill the traps to catch

the invertebrates. Every three weeks traps were emptied and invertebrates were preserved in 70% ethanol.

Data preservation and Identifications

Apidae are included in our analytic part and discussion, but are excluded from the results as these are published elsewhere (Jacobs *et al*., 2023).

Several specimens of parasitoid wasps still need to be analysed and identified. This is true for Aphidiinae (Korana Kocic), Braconidae (excluding Aphidiinae; Augustijn De Ketelaere), Figitidae (Jonathan Vogel) and Platygastridae (Jessica Awad). These and all remaining (unidentified) specimens were (or will be) returned and donated to RBINS.

The dataset can be requested from the corresponding author. Some observations will be posted on the citizen science portal waarnemingen.be.

Occurrence = Recorded at one locality at one certain moment of time (catching moment) New reports for Belgium are marked with an asterisk in the Results-section.

Fig. 3. Map of the city of Antwerp and localities. © Jeffrey Jacobs.

Abbreviations

Institutes

RBINS = Royal Belgian Institute of Natural Sciences, Brussels
RMNH = Naturalis, Leiden

Personal collections

ADK = coll. Augustijn De Ketelaere
FV = coll. Fons Verheyde
JDR = coll. Jeroen de Rond
JV = coll. Jonathan Vogel
KK = coll. Korana Kocic
KS = coll. Karel Schoonvaere
KVA = coll. RMNH (via Kees van Achterberg)
MFS = coll. Mar Ferrer-Suay
WN = coll. Winfried Vertommen

Results

Order **Hymenoptera** Linnaeus, 1758
Infraorder **Aculeata**

Superfamily **Apoidea** Latreille, 1802
[11 species, 21 specimens]

Family **Crabronidae** Latreille, 1802
[11 species, 21 specimens]

***Astata boops* (Schrank, 1781)**

BELGIUM: • 1♂; N51.135° E4.241°; vii/2020; J. Jacobs leg.; coll. KS; pitfall trap; K. Schoonvaere det.

***Cerceris rybyensis* (Linnaeus, 1771)**

BELGIUM: • 1♂; N51.135° E4.241°; viii/2021; J. Jacobs leg.; coll. KS; pan trap (blue); K. Schoonvaere det.

***Crossocerus exiguus* (Vander Linden, 1829)**

BELGIUM: • 2♂♂; N51.135° E4.241°; viii/2021; J. Jacobs leg.; coll. KS; pan trap (yellow); K. Schoonvaere det. [see also the complex below]

Crossocerus elongatulus/exiguus

BELGIUM: • 2♀♀; N51.225° E4.380°; viii/2021; J. Jacobs leg.; coll. KS; pan trap (yellow); K. Schoonvaere det.

***Diodontus insidiosus* Spooner, 1938**

BELGIUM: • 1♀; N51.218° E4.398°; vi/2020; J. Jacobs leg.; coll. KS; pitfall trap; K. Schoonvaere det.

***Diodontus minutus* (Fabricius, 1793)**

BELGIUM: • 1♀; N51.237° E4.457°; vi/2021; J. Jacobs leg.; coll. KS; pan trap (blue); K. Schoonvaere det.

***Mellinus arvensis* (Linnaeus, 1758)**

BELGIUM: • 1 ♀; N51.197° E4.462°; ix/2021; J. Jacobs leg.; coll. KS; pan trap (white); K. Schoonvaere det.

Mimumesa dahlbomi/wuestneii

BELGIUM: • 1 ♀; N51.197° E4.463°; vii/2021; J. Jacobs leg.; coll. KS; pan trap (white); K. Schoonvaere det. • 1 ♀; N51.160° E4.390°; vii/2021; J. Jacobs leg.; coll. KS; pan trap (white); K. Schoonvaere det. [2 occ. (1 year), 2 roofs]

***Pemphredon rugifer* (Dahlbom, 1844)**

BELGIUM: • 1 ♀; N51.218° E4.398°; vi/2021; J. Jacobs leg.; coll. KS; pan trap (yellow); K. Schoonvaere det.

***Spilomena mocsaryi* Kohl, 1898**

BELGIUM: • 1 ♀; N51.125° E4.260°; vi/2021; J. Jacobs leg.; coll. KS; pitfall trap; K. Schoonvaere det. • 1 ♀; N51.135° E4.241°; vii/2021; J. Jacobs leg.; coll. KS; pan trap (yellow); K. Schoonvaere det. • 1 ♀; N51.135° E4.241°; ix/2021; J. Jacobs leg.; coll. KS; pan trap (blue); K. Schoonvaere det. [3 occ. (1 year), 3 roofs]

Remarks:

This is the rarest crabronid wasp on a national level which was encountered in this study. The species was erroneously mentioned in several previous studies but its definitive presence was only very recently confirmed based on females observed on old city walls in Liège, between 2018 and 2022 (Baugnée & Barbier, 2023).

The species is not very easy to identify. The scutellum has no grooves anteriorly and the clypeus is equally rounded, without any aberrations. There are grooves however on the hind margin of the mesonotum, the wing veins are hyaline or somewhat light yellowish and finally, the mandibles are yellow, apically with a red-brown border (Jacobs, 2007).

Spilomena spp. are known to nest in vegetation or in dead wood (using tunnels of saproxylic beetles). Preys are larvae of thrips (Thysanoptera) (Van Lith, 1955; Blüthgen, 1960).

***Tachysphex unicolor* (Panzer, 1809)**

BELGIUM: • 1 ♀; N51.130° E4.253°; vi/2021; J. Jacobs leg.; coll. KS; pan trap (white); K. Schoonvaere det.

***Trypoxylon minus* de Beaumont, 1945**

BELGIUM: • 2 ♂♂; N51.197° E4.463°; v/2021; J. Jacobs leg.; coll. KS; pan trap (yellow); K. Schoonvaere det. • 1 ♀; N51.130° E4.253°; vi/2021; J. Jacobs leg.; coll. KS; pan trap (yellow); K. Schoonvaere det. • 1 ♀; N51.218° E4.398°; vi/2021; J. Jacobs leg.; coll. KS; pan trap (white); K. Schoonvaere det. [3 occ. (1 year), 3 roofs; see the complex below]

Trypoxylon medium/minus

BELGIUM: • 1 ♂; N51.197° E4.462°; v/2021; J. Jacobs leg.; coll. KS; pan trap (blue); K. Schoonvaere det.

Superfamily **Chrysidoidea** Latreille, 1802
[4 species, 25 specimens]

Family **Chrysididae** Latreille, 1802
[1 species, 1 specimen]

***Hedychrum nobile* (Scopoli, 1763)**

BELGIUM: • 1 ♂; N51.197° E4.462°; viii/2020; J. Jacobs leg.; coll. WN; pan trap (yellow); F. Verheyde det.

Family **Dryinidae** Haliday, 1833
[3 species, 24 specimens]

***Gonatopus clavipes* (Thunberg, 1827)**

- var. *barbipes*

BELGIUM: • 1 ♀; N51.218° E4.398°; vi/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 3 ♀♀; N51.225° E4.380°; vii/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det.

- var. *sespoides*

BELGIUM: • 1 ♀; N51.218° E4.398°; vi/2020; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det.• 1 ♀; N51.184° E4.420°; vii/2020; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 1 ♀; N51.135° E4.241°; vii/2020; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 1 ♀; N51.218° E4.398°; ix/2020; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 1 ♀; N51.169° E4.394°; vi/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 1 ♀; N51.184° E4.420°; vi/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 3 ♀♀; N51.193° E4.417°; vi/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 2 ♀♀; N51.218° E4.398°; vi/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 2 ♀♀; N51.193° E4.417°; vii/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 1 ♀; N51.218° E4.398°; vii/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pan trap (blue); J. de Rond det. • 1 ♀; N51.194° E4.439°; vii/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pan trap (blue); J. de Rond det.

[13 occ. (2 years), 7 roofs]

***Gonatopus lunatus* (var. *bifasciatus*) Klug, 1810 - Belg. sp. nov.**
(Fig. 4)

BELGIUM: • 1 ♀; N51.225° E4.380°; v/2020; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 1 ♀; N51.218° E4.398°; ix/2020; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. • 2 ♀♀; N51.251° E4.418°; vi/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det. [3 occ. (2 years), 3 roofs]

Fig. 4. *Gonatopus lunatus* Klug, 1810; Hoek van Holland (2018-07-14). © Dick Belgers.

Remarks:

Although there is additional data on the citizen science portal waarnemingen.be and atlas.hymenoptera.net, this species has not yet been published officially and is missing (for Belgium) in Pauly & Olmi 1988. Females can be recognized by the typical "pincers" or chela on the fore tarsi and relatively thin flagellomeres. Next to that the mesoscutum is elongated medially and marked yellow (Perkins, 1976; Olmi, 1994 & de Rond, 2004).

Females of this variety differ from the typical variety in having at least one tergite with yellow spot or band, and the lower side of the head extensively colored red. The typical variety tends to have all tergites and the lower part of the head fully blacK. Most varieties with extensively colored head treated by Kieffer (1914) were collected either in Italy, France or Hungary. In literature only a single female resembling var. *bifasciatus* appears to have been collected in Northwest Europe. This specimen, from Swanage, Purbeck Isle (Dorset, UK) was published as *Gonatopus marshalli* Kieffer 1905. Minor details in the original description differ from *Gonatopus bifasciatus*, but the same taxon could be involved. The host preference range of variety *bifasciatus* is unknown. *Gonatopus lunatus* is mainly found in dry sandy grasslands where it accepts many species of Deltocephalinae (Cicadellidae) planthoppers as host. The exclusive occurrence of remarkably light colored females on green roofs therefore may indicate a separate taxonomic position.

***Gonatopus planiceps* Kieffer, 1904**

BELGIUM: • 1 ♀; N51.194° E4.439°; vii/2021; J. Jacobs leg.; coll. JDR (FV/RBINS); pitfall trap; J. de Rond det.

Superfamily **Evanioidea** Latreille, 1802

Family **Gasteruptiidae** Latreille, 1796
[1 species, 1 specimen]

***Gasteruption minutum* (Tournier, 1877)**

BELGIUM: • 1 ♂; N51.251° E4.418°; vii/2020; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde & A. De Ketelaere det.

Remarks:

Based on the specimens in the collection of RBINS, this species is rather uncommon in Belgium. It appears to have a more southern distribution (van Achterberg, 2013) and is thus possibly thermophilic. Typical for this species are the lateral protuberances just below the eyes (frontal view).

Superfamily **Formicoidea** Latreille, 1802

Family **Formicidae** Latreille, 1809
[17 species, 6986 specimens]

***Anergates atratulus* Schenck, 1852**

BELGIUM: • 1 alate gyne; N51.230° E4.415°; vi/2021; J. Jacobs leg.; coll. RBINS; pan trap (blue); W. Dekoninck det.

Remarks:

Anergates atratulus is an obligate parasitic and workerless species in nests of *Tetramorium impurum*/*caespitum* in Belgium (Vankerkhoven & Dekoninck, 2022). On the roof where we collected the *A. atratulus* gyne no *Tetramorium*-workers were found and hence we have no indication for any *Tetramorium* nests and settlement of this parasitic species on that rooF. It

seems a gyne of this species arrived on the roof during her search for a nest to parasite, but this search was unsuccessful.

***Chthonolasius* sp.**

BELGIUM: • 1 ♂; N51.125° E4.260°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; T. De Blanck & W. Dekoninck det. • 2 ♂♂; N51.125° E4.260°, N51.225° E4.380°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [3 occ., 2 roofs]

Remarks:

Males of the subgenus *Chthonolasius* -which are temporary parasitic species of *Lasius* s.str. species- are very difficult to identify based on morphology alone. These males might belong to the species *Lasius umbratus* of which several gynes were found on other roofs.

***Hypoponera eduardi* (Forel 1894)**

BELGIUM: • 1 ♀ (worker); N51.197° E4.462°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det.

Remarks:

This ant species was only recently added to the Belgian fauna after being discovered on 2 green roofs both near Antwerp of which one finding is reported here and the other one in Van Dyck *et al*., (2023). As on both green roofs workers were found it seems the species has settled on the roofs (in Van Dyck *et al*., 2023, 3 workers were found). In nearby countries this holomediterranean ant species, is known from greenhouses and botanical gardens (Boer & Vierbergen, 2008; Seifert, 2018; Noordijk, 2021). Seifert (2018) suggests related to climate change, it is possible that this species can also establish itself outdoors in our region. The warm and dry conditions that arise on extensive green roofs probably offer a suitable habitat for this species to settle outdoors.

***Hypoponera punctatissima* (Roger, 1859)**

BELGIUM: • 1 alate gyne; N51.218° E4.398°; v/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 alate gyne; N51.218° E4.398°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 alate gyne; N51.194° E4.439°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 alate gyne; N51.184° E4.420°; ix/2021; J. Jacobs leg.; coll. RBINS; pan trap (yellow); T. De Blanck & W. Dekoninck det. [4 occ. (2 years), 3 roofs]

Remarks:

Of this *Hypoponera* species we only found alate gynes and no workers. This suggests that it probably did not settle on the green roofs we sampled, however attempts might be successful in the future. This cosmopolitical species is known from greenhouses in north Europe and sometimes also settles outdoors in compost heaps, accumulated litter of mowing activities etc. Also in Belgium and the Netherlands this species has been found already several times in litter and compost heaps (Dekoninck *et al*.; 2012; Boer *et al*., 2014). Maybe green roofs in Flanders might be a potential place for this species to settle in the future, if enough litter is accumulated on the roofs.

***Lasius brunneus* (Latreille, 1798)**

BELGIUM: • 1 ♂; N51.218° E4.398°; vi/2020; J. Jacobs leg.; coll. RBINS; pan trap (red); W. Dekoninck det. • 1 ♀ (worker); N51.197° E4.463°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂; N51.197° E4.462°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂; N51.125° E4.260°; vii/2021; J. Jacobs leg.; coll. RBINS;

pitfall trap; W. Dekoninck det. • 1 ♀ (worker); N51.184° E4.420°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♀ (worker); N51.184° E4.419°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [6 occ. (2 years), 6 roofs]

Remarks:

Of *Lasius brunneus* we found only a few specimens of which 3 males that were collected by hazard after or during nuptial flights. On 3 different green roofs, 1 worker was found each time. Gynes of *L. brunneus* found nests under bark, in bore holes of xylophagous insects or in crevices of branch breaks, typically in heights between 3 and 22 m above ground (Seifert, 2018). Later workers start with active mining of the wood and emigrate to lower parts of the tree stem. Sometimes nests can also be found indoors in wooden constructions of buildings (Dekoninck *et al*., 2021). We assume that the workers found here are not belonging to a nest on the green roofs but probably are foraging from nest in the neighborhood. Hence we do not consider this species as a part of the ant community on green roofs.

***Lasius flavus* (Fabricius, 1782)**

BELGIUM: • 3 ♂♂; N51.197° E4.463°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂; N51.237° E4.457°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂; N51.197° E4.462°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 2 ♂♂; N51.184° E4.420°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 alate gyne, 3 dealate gynes, 4 ♂♂; N51.199° E4.459°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap and pan trap (red); W. Dekoninck det. • 1 ♂ + 1 dealate gyne; N51.197° E4.463°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂; N51.197° E4.462°; viii/2021; J. Jacobs leg.; coll. RBINS; pan trap (blue); W. Dekoninck det. • 1 ♂; N51.184° E4.419°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂; N51.135° E4.241°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [9 occ. (2 years), 7 roofs]

Remarks:

We only found males and gynes of *Lasius flavus* and not a single worker. Also for this species we have no evidence of nests on the green roofs we sampled. In normal situations this species makes small (or sometimes big) mounds in grassland and tends aphids on the roots of these grasses (Dekoninck *et al*., 2012; Seifert, 2018). Parts of the nest can be very deep in the ground especially during dry summers when grasses dry out. This is probably not an option for this species on green roofs.

***Lasius fuliginosus* (Latreille, 1798)**

BELGIUM: • 1 ♂; N51.135° E4.241°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; T. De Blanck det.

***Lasius niger* (Linnaeus, 1758)**

BELGIUM: • 6683 ex.; all roofs except for HARD; 2020-2021; J. Jacobs leg.; coll. RBINS; pitfall & pan trap; T. De Blanck & W. Dekoninck det. [for more details see the dataset] [131 occ. (2 years), 18 roofs]

Remarks:

Lasius niger seems to be a common ant species on green roofs. This ant species is often a pioneering species and the first to establish in new created habitats of very different kind.

***Lasius psammophilus* Seifert, 1992**

BELGIUM: • 2♂♂; N51.205° E4.399°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1♀ (worker); N51.199° E4.459°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [2 occ. (2 years), 2 roofs]

***Lasius umbratus* (Nylander, 1846)**

BELGIUM: • 1 dealate gyne; N51.197° E4.463°; v/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne; N51.169° E4.394°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne; N51.205° E4.399°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne; N51.125° E4.260°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne; N51.199° E4.459°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne; N51.135° E4.241°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [6 occ. (2 years), 6 roofs]

Remarks:

Only dealate gynes of this species were found and not a single worker. These gynes are probaly collected shortly after their nuptial flight when foraging to find a *Lasius* s. str. nest to parasitize (temporary), most likely *Lasius niger*. The lack of workers during this sampling campaign indicates that settlement by *L. umbratus* was so far not successful on the sampled green roofs. Probably this species and other *Chthonolasius* spp. have no options to settle on these roofs. After the temporary parasitic phase they normally prefer to make nests that are situated deep in the ground where they tend aphids on roots of grasses and/or herbs with rosettes.

***Lasius* sp.**

BELGIUM: • 1♀ (workers); N51.251° E4.418°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 4♀♀ (workers); N51.184° E4.419°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 2♀♀ (workers); N51.218° E4.398°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1♀ (worker); N51.130° E4.253°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 2♀♀ (worker); N51.205° E4.399°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1♀ (worker); N51.197° E4.462°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne; N51.197° E4.463°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [7occ.,6 roofs]

***Myrmecina graminicola* (Latreille, 1802)**

BELGIUM: • 1 dealate gyne**;** N51.199° E4.459°; vi/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1♂**;** N51.193° E4.417°; viii/2021; J. Jacobs leg.; coll. RBINS; pan trap (blue); T. De Blanck & W. Dekoninck det. • 1♂**;** N51.125° E4.260°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; T. De Blanck & W. Dekoninck det. • 1 alate gyne**;** N51.184° E4.420°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; T. De Blanck & W. Dekoninck det. • 1♂**;** N51.193° E4.417°; ix/2021; J. Jacobs leg.; coll. RBINS; pan trap (blue); T. De Blanck & W. Dekoninck det. [5 occ. (1 year), 5 roofs]

Remarks:

Of *Myrmecina graminicola* four winged individuals and one dealate gyne were found and no workers. We therefore have no evidence for settlement on the green roofs.

***Myrmica rubra* (Linnaeus, 1758)**

BELGIUM: • 1 alate gyne**;** N51.193° E4.417°; viii/2021; J. Jacobs leg.; coll. RBINS; pan trap (yellow); W. Dekoninck det.

***Myrmica rugulosa* Nylander, 1849**

Belgium: • 1 dealate gyne; N51.205° E4.399°; v/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂, 3 dealate gynes; N51.205° E4.399°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂; N51.205° E4.399°; ix/2020; J. Jacobs leg.; coll. RBINS; W. Dekoninck det. • 1 dealate gyne; N51.125° E4.260°; iv/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne; N51.197° E4.463°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne; N51.135° E4.241°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♀ (worker); N51.197° E4.463°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [7 occ. (2 years), 4 roofs]

Remarks:

Males and dealate gynes of *M. rugulosa* were found on several other green roofs. However workers were found on only one green rooF. We consider this species as a rare species on green roofs.

***Myrmica scabrinodis* Nylander, 1846**
(Fig. 5)

BELGIUM: • 2 ♀♀ (workers)**;** N51.130° E4.253°; v/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne**;** N51.197° E4.463°; v/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne**;** N51.205° E4.399°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 2 dealate gynes + 4 ♀♀ (workers)**;** N51.197° E4.463°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne**;** N51.125° E4.260°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 2 dealate gynes + 1 ♀ (worker)**;** N51.197° E4.463°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♀ (worker)**;** N51.197° E4.463°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 dealate gyne**;** N51.225° E4.380°; vi/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 5 ♀♀ (workers)**;** N51.197° E4.463°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 3 ♀♀ (workers)**;** N51.197° E4.463°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [10 occ. (2 years), 5 roofs]

Fig. 5. Worker of *Myrmica scabrinodis* Nylander, 1846. © RBINS.

***Ponera coarctata* (Latreille, 1802)**

BELGIUM: • 1 ♂**;** N51.197° E4.463°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det.

***Tetramorium caespitum* (Linnaeus, 1758)**

BELGIUM: • 8 ♀♀ (workers)**;** N51.225° E4.380°; v/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 5 ♀♀ (workers) + 1 dealate gyne**;** N51.225° E4.380°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂**;** N51.184° E4.419°; vi/2020; J. Jacobs leg.; coll. RBINS; pan trap (white); W. Dekoninck det. • 1 ♀ (worker)**;** N51.251° E4.418°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 11 ♀ (workers)**;** N51.135° E4.251°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 2 ♀♀ (workers)**;** N51.218° E4.398°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 3 ♀♀ (workers)**;** N51.225° E4.380°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 11 ♀ (workers)**;** N51.160° E4.390°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♂**;** N51.184° E4.419°; ix/2020; J. Jacobs leg.; coll. RBINS; pan trap (white); W. Dekoninck det. • 1 ♀ (worker)**;** N51.160° E4.390°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♀ (worker)**;** N51.135° E4.251°; iv/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 2 ♀♀ (workers)**;** N51.225° E4.380°; v/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 2 ♀♀ (workers)**;** N51.160° E4.390°; vi/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♀ (worker)**;** N51.130° E4.253°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 4 ♀♀ (workers)**;** N51.130° E4.253°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 22 ♀♀ (workers)**;** N51.225° E4.380°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 35 ♀♀ (workers)**;** N51.160° E4.390°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♀ (worker)**;** N51.199° E4.459°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 1 ♀ (worker)**;** N51.130° E4.253°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 3 ♀♀ (workers)**;** N51.197° E4.463°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 85 ♀♀ (workers)**;** N51.160° E4.390°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. • 11 ♀ (workers)**;** N51.160° E4.390°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; W. Dekoninck det. [22 occ. (2 years), 9 roofs]

Remarks:

Tetramorium caespitum can be very abundant on sandy and thermophilic soils in Flanders (Dekoninck *et al.*, 2012). Together with *Lasius niger* it is often the first to establish in newly created sites on sandy soils.

***Tetramorium impurum* (Foerster, 1850)**

BELGIUM: • 1 ♂**;** N51.197° E4.463°; viii/2021; J. Jacobs leg.; coll. RBINS; pan trap (white); W. Dekoninck det.

Superfamily **Vespoidea Ashmead, 1903**
[6 species, 91 specimens]

Family **Pompilidae Latreille, 1805**
[3 species, 3 specimens]

***Agenioideus cinctellus* (Spinola, 1808)**

BELGIUM: • 1 ♀; N51.130° E4.253°; vi/2020; J. Jacobs leg.; coll. FV (RBINS); pan trap (red); H. Nieuwenhuijsen det.

***Agenioideus sericeus* (Vander Linden, 1827)**

BELGIUM: • 1 ♀; N51.160° E4.390°; viii/2021; J. Jacobs leg.; coll. FV (RBINS); pitfall trap; H. Nieuwenhuijsen det.

Remarks:

This species belongs to the Subfamily Pompilinae, meaning it has a typical wing venation in the front wing, while any grooves on sternite 2 are missing. *Agenioideus* spp. have a narrow pterostigma (length of 2r-rs is smaller or equal to its width) and narrow antennal segments. Females of *A. sericeus* are more or less black with the propodeum smooth (Nieuwenhuijsen, 2005).

Species in the genus are typically found on walls. It was once typified as rare in the Netherlands (Nieuwenhuijsen, 2002), but in Belgium it has always been slightly more common (see also Gros & Wahis, 2002). Last decades seem to suggest an increase of the species in both countries, with several new locations on citizen science portals. Presumably, the species (or some of its main preys) are thermophilic and are possibly influenced by climate change. It is not surprising then this species was found on green roofs in both countries (see Discussion and Drukker, De Boer & Fatouros, 2018).

***Dipogon subintermedius* (Magretti, 1886)**

BELGIUM: • 1 ♀; N51.130° E4.253°; v/2020; J. Jacobs leg.; coll. FV (RBINS); pan trap (red); H. Nieuwenhuijsen det.

Family **Vespidae** Latreille, 1802
[3 species, 88 specimens]

***Polistes dominula* (Christ, 1791)**

BELGIUM: • 1 ♂; N51.197° E4.462°; v/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 2 ♀♀ 4 ♂♂; N51.218° E4.398°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap and pan trap (yellow); F. Verheyde det. • 1 ♂; N51.135° E4.251°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♂; N51.225° E4.380°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♂; N51.218° E4.398°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.135° E4.241°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♂; N51.160° E4.390°; viii/2020; J. Jacobs leg.; coll. RBINS; pan trap (yellow); F. Verheyde det. • 1 ♀; N51.184° E4.419°; vi/2021; J. Jacobs leg.; coll. RBINS; pan trap (yellow); F. Verheyde det. [8 occ. (2 years), 7 roofs]

***Vespula germanica* (Fabricius, 1793)**

BELGIUM: • 1 ♀; N51.130° E4.253°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♂; N51.130° E4.253°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀ 1 ♂; N51.225° E4.380°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.218° E4.398°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♂; N51.130° E4.253°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀ 1 ♂; N51.197° E4.463°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap • 1 ♀ 2 ♂♂; N51.218° E4.398°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap • 1 ♀ 1 ♂; N51.237° E4.457°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap • 2 ♀♀ 4 ♂♂; N51.130° E4.253°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap • 1 ♂ 1 ex.; N51.125° E4.260°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap • 1 ♂; N51.193° E4.417°; ix/2020; J. Jacobs leg.;

coll. RBINS; pitfall trap • 1 ♀ 4 ex.; N51.218° E4.398°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap • 3 ♀♀; N51.237° E4.457°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap • 1 ♀; N51.160° E4.390°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap • 2 ♀♀; N51.130° E4.253°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap • 1 ♀; N51.225° E4.380°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap • 4 ♀♀; N51.135° E4.241°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap • 5 ♀♀; N51.130° E4.253°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap • 2 ♀♀; N51.193° E4.417°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap • 10 ♀♀ 1 ex.; N51.135° E4.241°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap and pan trap (yellow) [20 occ. (2 years), 9 roofs]

***Vespula vulgaris* (Linnaeus, 1758)**

BELGIUM: • 1 ♀; N51.130° E4.253°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.197° E4.463°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.125° E4.260°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♂; N51.218° E4.398°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.197° E4.463°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 2 ♂♂; N51.194° E4.439°; viii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 2 ♂♂ 1 ex.; N51.184° E4.420°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 4 ♂♂; N51.193° E4.417°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♂; N51.218° E4.398°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♂; N51.160° E4.390°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.184° E4.419°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.125° E4.260°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. [12 occ. (2 years), 9 roofs]

Infraorder **Parasitica**

Superfamily **Ceraphronoidea**
[240 specimens]

Family **Ceraphronidae**
[233 specimens]

Ceraphronidae indet.

BELGIUM: • 233 ex.; multiple locations; 2020-2021; J. Jacobs leg.; coll. RBINS; pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Family **Megaspilidae**
[6 specimens]

Megaspilidae indet.

BELGIUM: • 1 ex.; N51.135° E4.241°; vi/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ex.; N51.197° E4.463°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ex.; N51.199° E4.459°; v/2021; J. Jacobs leg.; coll. RBINS; pan trap (blue); F. Verheyde det. • 1 ex.; N51.135° E4.251°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ex.; N51.218° E4.398°; ix/2021; J. Jacobs leg.; coll. RBINS; pan trap (blue); F. Verheyde det. • 1 ex.; N51.160° E4.390°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.

Superfamily **Chalcidoidea**
[1 species, 22 specimens]

Family **Aphelinidae**
[2 specimens]

Aphelinidae indet.

BELGIUM: • 1 ♀; N51.135° E4.251°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.251° E4.418°; viii/2021; J. Jacobs leg.; coll. ADK; pan trap (yellow); A. De Ketelaere det.

Family **Encyrtidae**
[2 specimens]

Encyrtidae indet.

BELGIUM: • 1 ex.; N51.251° E4.418°; vi/2020; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde det. • 1 ex.; N51.169° E4.394°; vi/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.; specimen damaged

Family **Eurytomidae**
[2 specimens]

Eurytomidae indet.

BELGIUM: • 1 ♀; N51.251° E4.418°; viii/2021; J. Jacobs leg.; coll. RBINS; pan trap (red); F. Verheyde det. • 1 ex.; N51.184° E4.420°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.

Family **Pteromalidae**
[1 species, 3 specimens]

***Callitula bicolor* Spinola, 1811**

BELGIUM: • 1 ex.; N51.251° E4.418°; vi/2020; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde det.

Pteromalidae indet.

BELGIUM: • 1 ex.; N51.205° E4.399°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ♀; N51.199° E4.459°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.

Superfamily **Cynipoidea**
[1 species, 10 specimens]

Family **Figitidae**
[1 species, 9 specimens]

***Alloxysta arcuata* (Kieffer, 1902)**

BELGIUM: • 1 ex.; N51.251° E4.418°; vi/2020; J. Jacobs leg.; coll. MFS; pitfall trap; M. Ferrer-Suay det. • 1 ♀; N51.237° E4.457°; v/2021; J. Jacobs leg.; coll. MFS; pitfall trap; M. Ferrer-Suay det.

Figitidae indet.

BELGIUM: • 1 ex.; N51.125° E4.260°; vi/2020; J. Jacobs leg.; coll. JV; pan trap (red); F. Verheyde det. • 1 ex.; N51.135° E4.241°; iv/2021; J. Jacobs leg.; coll. JV; pitfall trap; F. Verheyde det. • 1 ex.; N51.130° E4.253°; vi/2021; J. Jacobs leg.; coll. JV; pan trap (yellow); F. Verheyde det. • 1 ex.; N51.135° E4.251°; vii/2021; J. Jacobs leg.; coll. JV; pan trap (yellow); F. Verheyde det. • 1 ex.; N51.205° E4.399°; viii/2021; J. Jacobs leg.; coll. JV; pitfall trap; F. Verheyde det. • 1 ex.; N51.199° E4.459°; ix/2021; J. Jacobs leg.; coll. JV; pitfall trap; F. Verheyde det. • 1 ex.; N51.135° E4.241°; ix/2021; J. Jacobs leg.; coll. JV; pitfall trap; F. Verheyde det.

Superfamily **Diaprioidea**
[1 species, 89 specimens]

Family **Diapriidae**
[1 species, 89 specimens]

***Spilomicrus* sp.**

BELGIUM: • 1 ♀; N51.125° E4.260°; vi/2020; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det.

***Synacra paupera* Macek, 1995 - Belg. sp. nov.**

BELGIUM: • 1 ♀; N51.184° E4.419°; viii/2020; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det.

Remarks:

This small genus of diapriid wasps can be recognized by the number of antennal segments in females (12) and the melanic to yellow body (Kozlov, 1988). Determination to species used to be difficult but recently a new key appeared. *S. paupera* is one of the easier species to recognize by the presence of fully developed notauli and the clavate female antennae apically (A8-12 distinctly compressed) (Chemyreva & Kolyada, 2019).

Interestingly, this species is a known parasitoid of the sciarid fly *Bradysia impatiens* (Johannsen, 1912) (= *Bradysia paupera* Tuomikoski, 1960); which is a known pest species in greenhouses (Notton, 1997).

***Synacra* sp.**

BELGIUM: • 1 ♀; N51.135° E4.241°; v/2021; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det.

Diapriidae indet.

BELGIUM: • 84 ex.; multiple locations; 2020-2021; J. Jacobs leg.; coll. FV; pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Superfamily **Ichneumonoidea**
[15 species, 232 specimens]

Family **Braconidae**
[7 species, 125 specimens]

Subfamily **Alysiinae**
[2 species, 27 specimens]

***Alysia lucicola* Haliday, 1838 - Belg. sp. nov.**

BELGIUM: • 1 ♀; N51.197° E4.463°; v/2021; J. Jacobs leg.; coll. KVA; pan trap (yellow); K. van Achterberg det.

Remarks:

This braconid wasp is a member of the Subfamily Alysiinae, which are associated with Diptera and have exodont mandibles. Identification is difficult. One of the more recent keys to get to genera within the Subfamily is Zhu *et al*., 2017. *A. lucicola* has been well described by Fischer 1965. The species is easy to recognize within the genus by its very elongate first tergite.

***Aphaereta* sp.**

BELGIUM: • 1 ♀; N51.130°, E4.253°; v/2020; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det. • 1 ♀; N51.130°, E4.253°; ix/2020; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det. • 2 ♀♀; N51.230°, E4.415°; viii/2021; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det. • 1 ♀; N51.251°, E4.418°; ix/2021; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det.

***Dinotrema* sp. (Fig. 6)**

BELGIUM: • 1 ♀; N51.205°, E4.399°; v/2020; J. Jacobs leg.; coll. ADK; pan trap (yellow); A. De Ketelaere & K. van Achterberg det. • 1 ♂; N51.130°, E4.253°; ix/2020; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det. • 1 ♀; N51.169°, E4.394°; ix/2020; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det. • 1 ♀; N51.135°, E4.241°; viii/2021; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det. • 1 ♀; N51.197°, E4.462; viii/2021; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det. • 1 ♀; N51.251°, E4.418°; ix/2021; J. Jacobs leg.; coll. ADK; pan trap (yellow); A. De Ketelaere det.

Fig. 6. *Dinotrema* sp.; Administrative centre Den Bell (May 2020). © Augustijn De Ketelaere.

***Idiasta dichrocera* Konigsmann, 1960 - Belg. sp. nov.**
(Fig. 7)

BELGIUM: • 1 ♂; N51.130° E4.253°; vi/2021; J. Jacobs leg.; coll. KVA; pan trap (blue); K. van Achterberg det. • 1 ♀; N51.135° E4.251°; vii/2021; J. Jacobs leg.; coll. ADK; pan trap (yellow); F. Verheyde det. • 1 ♀; N51.125° E4.260°; viii/2021; J. Jacobs leg.; coll. KVA; pitfall trap; K. van Achterberg det. • 1 ♀; N51.135° E4.241°; viii/2021; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde det. [4 occ. (1 year), 4 roofs]

Fig. 7. *Idiasta dichrocera* Konigsmann, 1960; Hardenvoort (July 2021). © Bart Minnebo.

Remarks:

Originally, this species was reported as one of the more remarkable species of green roofs in the Netherlands (Drukker, van Achterberg & de Boer, 2019). Only after an additional specimen was collected of the "Erasmusschildwesp", it became clear that both Dutch specimens (RMNH) belong to the very closely related *I. picticornis* (Ruthe, 1854). The assumption in a key by Fischer (2008) that *I. dichrocera* has both females with and without pale subapical part of the antenna is not explained. Therefore, there is no reason to accept such extreme variation without additional research.

***Orthostigma* sp.**

BELGIUM: • 1 ♀; N51.125°, E4.260°; vii/2020; J. Jacobs leg.; coll. KVA; pitfall trap; A. De Ketelaere det.

Pentapleura* cF. *angustula
(Fig. 8)

BELGIUM: • 1 ♀; N51.160°, E4.390°; ix/2020; J. Jacobs leg.; coll. ADK; pan trap (yellow); A. De Ketelaere & K. van Achterberg det.; specimen was dirty and in bad condition, it was not possible to confirm the identification with certainty.

Remarks:

This species would be unreported in Belgium, but more specimens are needed.

Fig. 8. *Pentapleura* cf. *angustula*; Recycling park Wilrijk (May 2020). © Augustijn De Ketelaere.

Alysiinae indet.

BELGIUM: • 9 ex.; multiple locations; 2020-2021; J. Jacobs leg.; coll. ADK & RBINS; pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Subfamily **Aphidiinae**
[46 specimens]

Aphidiinae indet.

BELGIUM: • 46 ex. ; multiple locations ; 2020-2021 ; J. Jacobs leg. ; coll. KK, pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Subfamily **Brachistinae**
[1 species, 2 specimens]

***Blacus* sp.**

BELGIUM: • 1 ♂; N51.135° E4.251°; ix/2021; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det.

***Blacus diversicornis* (Nees, 1834)**

BELGIUM: • 1 ♂; N51.135° E4.241°; ix/2021; J. Jacobs leg.; coll. KVA; pitfall trap; K. van Achterberg det.

Subfamily **Euphorinae**
[2 species, 21 specimens]

***Leiophron deficiens* (Ruthe, 1856) - Belg. sp. nov.**
(Fig. 9)

Fig. 9. *Leiophron deficiens* (Ruthe, 1856); OCMW Arena (May 2021). © Bart Minnebo.

BELGIUM: • 1 ♀; N51.193° E4.417°; v/2020; J. Jacobs leg.; coll. FV; pan trap (blue); J. Stigenberg & F. Verheyde det. • 1 ♀; N51.125° E4.260°; vi/2020; J. Jacobs leg.; coll. RMNH (Arise); pitfall trap; F. Verheyde • 1 ♀; N51.193° E4.417°; vi/2020; J. Jacobs leg.; coll. RMNH (Arise); pitfall trap; F. Verheyde • 4 ex.; N51.194° E4.439°; viii/2020; J. Jacobs leg.; coll. RMNH (Arise); pitfall trap; F. Verheyde • 3 ex.; N51.199° E4.459°; v/2021; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde • 2 ♀♀; N51.205° E4.399°; vi/2021; J. Jacobs leg.; coll. KVA; pitfall trap; K. van Achterberg • 2 ex.; N51.184° E4.420°; vi/2021; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde • 1 ♀; N51.184° E4.419°; vi/2021; J. Jacobs leg.; coll. KVA; pan trap (yellow); K. van Achterberg det. • 1 ♀; N51.193° E4.417°; vi/2021; J. Jacobs leg.; coll. KVA; pan trap (red); K. van Achterberg det. • 1 ♂; N51.130° E4.253°; ix/2021; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde det. • 1 ♀; N51.135° E4.241°; ix/2021; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde det. [11 occ. (2 years), 9 roofs]

A very small but very common species on the green roofs (see Discussion). The genus *Leiophron* is closely related to the genus *Peristenus*, of which we also encountered a species on the roofs (see below). *L. deficiens* has a yellowish body (although colors may vary) and subhyaline wings with reduced wing venation. Its scapus is short and at most two times as long as broad (Stigenberg & van Achterberg, 2015).

Hosts are Miridae. A detailed inventory of these has happened (Jacobs *et al*., 2023, forthcoming) on the roofs and therefore we are able to make a good assessment on the plausible (unreported) hosts. Two mirid bugs were absolutely dominant on the green roofs and were found on eight of the nine roofs where *L. deficiens* was also caught: *Chlamydatus evanescens* (Boheman, 1852) and *C. pullus* (Reuter, 1870). There is a third less likely candidate (there are Lygidae associated with *Leiophron* spp., but more rarely): *Nysius huttoni* F.B. White, 1878. Interestingly, all these heteropterans are bivoltine, which helps explaining the diverse phenology of *L. deficiens* in our country, from May to September, which is in contrast to Stigenberg & van Achterberg 2015 mentioning August-October as flight period).

***Meteorus* sp. nov. (?)**

BELGIUM: • 1 ♀; N51.199° E4.459°; vii/2021; J. Jacobs leg.; coll. KVA; pitfall trap; K. van Achterberg det.; specimen damaged, more material is needed

***Peristenus relictus* (Ruthe, 1856)**

BELGIUM: • 2 ex.; N51.194° E4.439°; vii/2021; J. Jacobs leg.; coll. KVA; pitfall trap; K. van Achterberg det.

Subfamily **Macrocentrinae**
[1 species, 2 specimens]

***Macrocentrus collaris* (Spinola, 1808)**

BELGIUM: • 1 ♀; N51.135° E4.251°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.; specimen damaged, more material is needed • 1 ♀; N51.199° E4.459°; viii/2021; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det. [2 occ., 2 roof]

Subfamily **Microgastrinae**
[5 specimens]

***Microplitis* sp.**

BELGIUM: • 1 ♀; N51.125° E4.260°; vi/2020; J. Jacobs leg.; coll. FV; pan trap (red); K. van Achterberg det. • 1 ex.; N51.230° E4.415°; vi/2021; J. Jacobs leg.; coll. ADK; pan trap (yellow); A. De Ketelaere det. • 1 ex.; N51.135° E4.251°; vi/2021; J. Jacobs leg.; coll. ADK; pan trap (yellow); A. De Ketelaere det.

Microgastrinae indet.

BELGIUM: • 1 ex.; N51.160° E4.390°; v/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ex.; N51.184° E4.420°; ix/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.

Subfamily **Rogadinae**
[1 species, 1 specimens]

***Aleiodes similis* (Curtis, 1834) s.l.**

BELGIUM: • 1 ♂; N51.184° E4.420°; v/2020; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det.

Braconidae indet.

BELGIUM: • 21 ex. ; multiple locations ; 2020-2021 ; J. Jacobs leg. ; coll. KK, pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Family **Ichneumonidae**
[8 species, 107 specimens]

Subfamily **Banchinae**
[1 species, 3 specimens]

***Exetastes adpressorius* (Thunberg, 1822)**

BELGIUM: • 1 ♂; N51.230° E4.415°; vi/2021; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det. • 1 ♂; N51.135° E4.251°; vi/2021; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det. • 1 ♂; N51.135° E4.251°; vii/2021; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det. [3 occ. (1 year), 2 roofs]

Subfamily **Campopleginae**
[2 species, 6 specimens]

***Diadegma claripenne* (Thomson, 1887)**

BELGIUM: • 1 ♀; N51.218° E4.398°; vi/2020; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det.

***Meloboris collector* (Thunberg, 1824)**

BELGIUM: • 1 ♀; N51.130° E4.253°; ix/2020; J. Jacobs leg.; coll. RMNH (Arise); pitfall trap; F. Verheyde det. • 1 ♀; N51.169° E4.394°; ix/2020; J. Jacobs leg.; coll. RMNH (Arise); pitfall trap; F. Verheyde det. • 1 ♂; N51.225° E4.380°; iv/2021; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det. • 1 ♀; N51.199° E4.459°; vi/2021; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det. [4 occ. (2 years), 4 roofs]

Campopleginae indet.

BELGIUM: • 1 ex.; N51.197° E4.463°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.; specimens damaged (metasoma missing)

Subfamily **Cryptinae**
[1 species, 3 specimens]

***Trychosis legator* (Thunberg, 1822)**

BELGIUM: • 1 ♀; N51.197° E4.462°; v/2020; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det. • 1 ♀; N51.194° E4.439°; vi/2020; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det. [2 occ. (1 year), 2 roofs]

Cryptinae indet.

BELGIUM: • 1 ♂; N51.251° E4.418°; vii/2021; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det.

Subfamily **Diplazontinae**
[1 species, 1 specimen]

***Sussaba flavipes* (Lucas, 1849)**

BELGIUM: • 1 ♀; N51.130° E4.253°; ix/2021; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det.

Subfamily **Ichneumoninae**
[1 species, 1 specimen]

***Spilothyrateles illuminatorius* (Gravenhorst, 1820)**

BELGIUM: • 1 ♀; N51.130° E4.253°; viii/2021; J. Jacobs leg.; coll. RMNH (Arise); pitfall trap; F. Verheyde det.

Subfamily **Metopiinae**
[1 specimen]

***Exochus* sp.**

BELGIUM: • 1 ♀; N51.160° E4.390°; ix/2020; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det.

Subfamily **Orthocentrinae**
[52 specimens]

Orthocentrinae indet.

BELGIUM: • 52 ex. ; multiple locations ; 2020-2021 ; J. Jacobs leg. ; coll. FV, pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Subfamily **Phygadeuontinae**
[2 species, 40 specimens]

***Gelis declivis* (Foerster, 1850) - Belg. sp. nov.**

BELGIUM: • 1 ♀; N51.193° E4.417°; v/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. • 1 ♀; N51.135° E4.241°; v/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. • 1 ♀; N51.193° E4.417°; vi/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. • 1 ♀; N51.125° E4.260°; viii/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. • 3 ♀♀; N51.135° E4.241°; ix/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. [5 occ. (1 year), 3 roofs]

Remarks:

Gelis spp. are difficult to identify, therefore the specimens were send to Ika Österblad, who carefully identified these using her experience and existing keys like Schwarz, 2002. Both *G. declivis* and the species below, *G. festinans*, are darker and small species. Females are apterous. Both species can be placed in the group of species with a distinct and deep furrow at the malar space, with the genal carina nearly always joining oral carina at mandibular base. Further identification is mostly based on a combination of characters. A distinct character within the so called *G. festinans*-complex are the meso- and metapleuron, which are completely connected to each other in *G. declivis*. The host is unknown, but is probably similar to *G. festinans* (see Discussion).

***Gelis festinans* (Fabricius, 1798)**

BELGIUM: • 1 ♀; N51.135° E4.251°; iv/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. • 1 ♂; N51.135° E4.251°; v/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. • 2 ♂♂; N51.194° E4.439°; v/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. • 1 ♂; N51.135°

E4.251°; vi/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. • 2♀♀; N51.160° E4.390°; viii/2021; J. Jacobs leg.; coll. FV; pitfall trap; I. Österblad det. [5 occ. (1 year), 3 roofs]

***Gelis* sp.**

BELGIUM: • 1♀; N51.193° E4.417°; vi/2020; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde det. • 1♀; N51.230° E4.415°; viii/2021; J. Jacobs leg.; coll. ADK; pitfall trap; F. Verheyde det.

Phygadeuontinae indet.

BELGIUM: • 24 ex.; multiple locations ; 2020-2021 ; J. Jacobs leg. ; coll. FV, pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Superfamily **Platygastroidea**
[147 specimens]

Family **Platygastridae**
[49 specimens]

Platygastridae indet.

BELGIUM: • 49 ex.; multiple locations; 2020-2021 ; J. Jacobs leg. ; coll. JA, pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Family **Scelionidae**
[49 specimens]

Subfamily **Scelioninae**
[4 specimens]

***Baeus* sp.**

BELGIUM: • 1 ex.; N51.125° E4.260°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ex.; N51.230° E4.415°; viii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.

***Scelio* sp.**

BELGIUM: • 1 ex.; N51.197° E4.463°; vii/2020; J. Jacobs leg.; coll. JA; pitfall trap; F. Verheyde det. • 1 ex.; N51.125° E4.260°; ix/2020; J. Jacobs leg.; coll. JA; pitfall trap; F. Verheyde det.

Subfamily **Teleasinae**
[10 specimens]

***Trimorus* sp.**

BELGIUM: • 10 ex.; multiple locations; 2020-2021 ; J. Jacobs leg. ; coll. JA, pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Subfamily **Telenominae**
[3 specimens]

***Trissolcus* sp.**

BELGIUM: • 1♀;.; N51.251° E4.418°; vii/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ex.; N51.205° E4.399°; ix/2020; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det. • 1 ex.; N51.130° E4.253°; vii/2021; J. Jacobs leg.; coll. RBINS; pitfall trap; F. Verheyde det.

Scelionidae indet.

BELGIUM: • 32 ex.; multiple locations; 2020-2021 ; J. Jacobs leg. ; coll. ADK & RBINS, pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Superfamily **Proctotrupoidea**
[3 species, 5 specimens]

Family **Proctotrupidae**
[3 species, 5 specimens]

***Exallonyx* sp.**

BELGIUM: • 1 ♀; N51.135° E4.251°; vi/2021; J. Jacobs leg.; coll. ADK; pitfall trap; A. De Ketelaere det.

***Exallonyx formicarius* Kieffer, 1904**

BELGIUM: • 1 ♀; N51.135° E4.241°; ix/2021; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde & V. Kolyada det.

***Phaneroserphus calcar* (Haliday, 1839)**

BELGIUM: • 1 ♀; N51.135° E4.241°; vi/2020; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det.

***Proctotrupes gravidator* (Linnaeus, 1758)**

BELGIUM: • 1 ♀; N51.197° E4.462°; viii/2020; J. Jacobs leg.; coll. FV; pan trap (red); F. Verheyde det.

Proctotrupidae indet.

BELGIUM: • 1 ♂; N51.135° E4.251°; vi/2021; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det.

Complex Mymaridae (Chalcidoidea) & Mymarommatidae (Mymarommatoidea)

Mymaridae/Mymarommatidae indet.

BELGIUM: • 1245 ex.; multiple locations; 2020-2021 ; J. Jacobs leg. ; coll. ADK & RBINS, pitfall & pan trap; F. Verheyde det. [for more details see the dataset]

Infraorder **Symphyta**

Family **Tenthredinidae**
[3 species, 6 specimens]

***Athalia circularis* (Klug, 1815)**

BELGIUM: • 2 ♀♀; N51.251° E4.418°; vii/2020; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det.

***Athalia cornubiae* Benson, 1931**

BELGIUM: • 1 ♀; N51.135° E4.241°; v/2021; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det. • 1 ♀; N51.130° E4.253°; ix/2021; J. Jacobs leg.; coll. FV; pan trap (yellow); F. Verheyde det.

***Athalia rosae* (Linnaeus, 1758)**

BELGIUM: • 1 ♀; N51.251° E4.418°; viii/2020; J. Jacobs leg.; coll. FV; pitfall trap; F. Verheyde det.

***Pristiphora* sp.**

BELGIUM: • 1 ♀; N51.125° E4.260°; vi/2021; J. Jacobs leg.; coll. FV; pan trap (red); F. Verheyde det.

Discussion

Part I. Defining Hymenoptera communities on green roofs

Several approaches should be considered to assess whether the species occurrence on the green roof is a mere coincidental find or whether it has a relationship with the rooF. Occurrences can also be measured in different ways; for example by measuring absolute numbers (and biomass) or taxonomic diversity (amount of species) in certain families. The main disadvantage for the first approach is the difference in life style of the species encountered. Social wasps and parthenogenetic parasitoid wasps are able to reach huge numbers locally, but could be bound to a specific area stimulated by unknown reasons. Related to the second approach, the disadvantage here is that it is much harder (or sometimes even impossible) to identify parasitoid wasps in comparison to aculeate wasps. Therefore, the total number of different species or morphotypes is ambiguous. Another factor, even more difficult to take into account, is the high mobility or migration of these mostly (flying) insects; or indeed the need to distinguish occasional foraging or nesting behavior (Ksiazek, 2014).

In order to consider these aspects, we integrated the amount of samples of each species (in one or two years) and the number of roofs where the species was collected. Conclusively in Table 2, we estimate that when a species was found on one or two roofs, more data is needed (cat. A; we did not include this category in Table 2). When it is found on three to five roofs it is considered as possibly colonizing green roofs (cat. B) and when it is found on more than five roofs (> 25% of the roofs) we can consider it as typical for green roofs (cat. C). In total 37 species (63%) belong to cat. A, 11 species belong to cat. B (20%) and 10 species belong to cat. C (17%). This means only one third of the species caught can be seen as (potentially) typical for green roofs.

Although scaled occurrences could be some indication for colonization, we again have to emphasize this Table should not be read as conclusively stating a species is reproducing at a roof, and thus bound to it. This is most clear for ants where establishment can only be deduced from the presence of wingless workers, that in normal conditions and for most species are not able to reach the green roof itself (see also Discussion below on the second community). The same could be said for aculeates, where establishment could be deduced by the presence of cuckoo wasps (although we then have to ignore the fact migration is also possible here). In the end, the question here is mainly conceptual; should we see a green roof species as a species that reproduces on the roof; or should we see a green roof species as a species that often visits or occurs on green roofs?

Structuring these species ecologically, we are able to identify three different communities. Strictly speaking, the first two can be seen as more typical for green roofs and are higher on the roof/occurrence table (see Table 2). The third community, consisting of predators and remaining parasites, has a more opportunistic association. This is also demonstrated by the high number of different species of crabronid wasps, but the low absolute number.

The first community is directly or indirectly bound to the plants used on the green roofs. On the first level we have different organisms using the plants, i.e. Miridae like *Chlamydatus* spp. on for example *Sedum* spp., the sawfly *Athalia cornubiae* on *Sedum* spp., aphids, etc. On the next level we encounter parasitoid wasps like *Leiophron deficiens*, which parasitizes the abovementioned mirid bugs, Aphidiinae on aphids, Dryinidae on Auchenorrhyncha, *Idiasta dichrocera* and *Synacra paupera* on fly larvae, etc. (for an elaborate food web analysis, see

Table 2. Hymenoptera species occurring on min. three roofs in Belgium (2020-21). Species which are probably migratory are marked in red.

Infraorder	Superfamily - Family	Absolute numbers	Species identified
Aculeata		*7879*	*79*
	Apoidea	**773**	**52**
	Andrenidae	169	9
	Apidae	190	6
	Colletidae	97	6
	Crabronidae	21	11
	Halictidae	253	11
	Megachilidae	36	8
	Melittidae	7	1
	Chrysidoidea	**25**	**4**
	Chrysididae	1	1
	Dryinidae	24	3
	Evanioidea	**1**	**1**
	Gasteruptiidae	1	1
	Formicoidea	**6989**	**16**
	Formicidae	6989	16
	Vespoidea	**91**	**6**
	Pompilidae	3	3
	Vespidae	88	3
Parasitica		*2200*	*37*
	Ceraphronoidea	**240**	
	Ceraphronidae	233	
	Megaspilidae	6	
	Chalcidoidea	**22**	**1**
	Aphelinidae	2	
	Encyrtidae	2	
	Eurytomidae	2	
	Pteromalidae	3	1
	Cynipoidea	**10**	**1**
	Figitidae	9	1
	Diaprioidea	**89**	**1**
	Diapriidae	89	1
	Ichneumonoidea	**442**	**31**
	Braconidae	228	14
	Ichneumonidae	214	17
	Mymaridae/Mymarommatidae indet.	**1245**	
	Platygastroidea	**147**	
	Platygastridae	49	
	Scelionidae	49	
	Proctotrupoidea	**5**	**3**
	Proctotrupidae	5	3
Symphyta		*6*	*3*
	Tenthredinoidea	**6**	**3**
	Tenthredinidae	6	3
		10.085	119

Jacobs *et al*., 2023, forthcoming). As demonstrated above *L. deficiens* was one of the most commonly encountered species. This is very interesting, because the species is probably rather rare outside its wild habitat, being associated with *Sedum* spp. It is a strong confirmation of the presence of rare and mostly xero-thermophilic species on the roofs mentioned from other species groups (i.e. Madre *et al*., 2013). Most of these species can only occur on stony or sandy habitats (near coastal areas, ports, railways, industrial terrains, etc.) where the associated plant is abundant enough to support stable host populations. In Belgium, and especially in Flanders, these conditions are rare.

A second community is not directly or exclusively bound to certain plants (although they could benefit from them), but to the substrate type of the green roofs: more or less open, stony soil. Here we find ants. As clear in Tables 1 and 2, ants reach the highest abundance within all identified Hymenoptera. Within the family, 10 of the 16 species discovered belong to the abovementioned categories B or C. Of the 16 species recorded, 8-9 were found to have only males and females. The lack of workers indicates strongly that these species have not settled on the green roofs sampled. We assume that these flying ants ended up on the roof during their nuptial flights, and that the conditions on the roof are too harsh to establish colonies. Dealate gynes might be caught during a search for a suitable nest place on the green roofs. For some ant species like *Lasius flavus*, *Lasius fuliginosus* and *Lasius brunneus*, it seems unlikely that the right soil conditions, depth of litter and other characteristics are not present to allow a successful settlement. However, follow-up studies are needed to confirm our assumptions.

Finally, a third community consists of predators and parasites. Spiders also live on these substrates. In their turn, they are, again, hosts of different parasitoid wasps. It was remarkable for example only two *Gelis* spp. were found, both quite common on different roofs, not finding any other species. At least one species, *G. festinans*, is a known parasitoid of egg cocoons of spiders. The presence of specifically those two species could be related to the (unknown) host, but could also be related to their coping mechanism to survive the winter (see below). Another parasitoid wasp associated with spiders is the ichneumonid wasp *Trychosis legator*.

Predatory species are more opportunistic and often urban like *Vespula* spp. Specifically for crabronid wasps, but also for pompilid wasps (Pompilidae), spots to nest and to store prey are important. It would not be surprising if a crabronid wasp like *Trypoxylon minus* is able to find its way to crevices, bricks or anything else in the vicinity, since the genus is known to be bound to buildings and it is one of the few crabronid species observed more often in our survey. As mentioned above, most species seem to be less specific to roofs, but are able to use urban infrastructure. In a rare example of analyzing wasp nesting activity on green roofs in Canada, *Trypoxylon* spp. were also encountered. *Spilomena mocsaryi* potentially is another example (see Table 2). A *Perithous* sp. (Ichneumonidae) and *Monodontomerus* sp. (Torymidae) are other examples (Scott MacIvor, 2016). Both parasitoid wasp species parasitize crabronid wasps and solitary bees, respectively. This all demonstrates that at least some species of this third community are not only foraging, but are also able to nest on the roof or in the close vicinity. It is noteworthy that many of these species (including *Spilothyrateles illuminatorius*; see below) are also often associated with bee hotels. Presumably, predatory crabronids and sphecid wasps will be smaller due to the difficulties of carrying prey up to the roof (Scott MacIvor, 2016), but so far this has not been quantified.

A last important aspect to sustain stable populations on green roofs is that of hibernation or diapause. Writing this paper, we realized quite a good number of species encountered are

known to hibernate as cocoons or adults, very often in decaying vegetation. Adult hibernators are the two *Gelis* spp. (Schwarz, 2002) and *S. illuminatorius* (Gravenhorst, 1820) (Verheyde & Quicke, 2022). Diapause in cocoons is a method used by *Leiophron deficiens* (Stigenberg & Van Achterberg, 2015) and possibly many more species with an unknown life cycle. This suggests the environment should be treated with at least some care in the winter months; and it is worth leaving litter, plants or even dead wood (which is also be used as nesting places by many solitary bees or crabronid wasps; see above and Kadas, 2006) in natural decay without (re)moving or mowing it.

It is clear more research is needed in order to be able to properly consider specific aculeate and parasitoid wasp species or communities as characteristic urban green roof species. However, it is a good sign that with a relatively small pool of species, at least some observations were similar to species encountered in the ongoing research in the Netherlands; with *A. sericeus* and *Idiasta* spp. as examples (see Results).

Part II. Context and methodology – communities and food webs

Some have stated parasitism rates are highest on intensive vegetated roofs, or have connected plant diversity to a higher diversity at the top of the food web (McIvor, 2015; Drukker *et al*., 2018; Diethelm & Masta, 2022). We could not find any correlation between the amount of plant species and absolute numbers of parasitoids. What was clearly shown is that roofs managed extensively also provide valuable numbers of parasites. We were able to identify everything to superfamily level and most of the specimens to family level (see Table 3). This allows us to say something on food webs and associated insect communities.

Within Aculeata we mentioned the high abundance of Formicidae. Leaving them out, the amount of parasitoid wasps is higher than that of the aculeate wasps. Microhymenoptera are best represented with nearly 75% from Ceraphronoidea and the Mymaridae/Mymarommatidae complex. Apart from the complex Chalcidoidea were only scarcely caught, which may demonstrate a gap in the highest trophic levels on urban green roofs.

There are clear differences with the small study done so far on parasitoid communities by Diethelm & Masta (2022). For example, only two specimens of Aphelinidae were found in our study, while this family was the most prominent one in their samples. On the other hand, Ceraphronoidea and the Mymaridae/Mymarommatidae complex were much more common in our samples. However, the sampling period was very short in their survey and only pitfall traps were used. In their survey 119 specimens were found from 10 different families and 20 taxa; in our survey 2200 specimens were discovered from 15 different families and 37 taxa were identified to species level (there are many more morphospecies). This clearly demonstrates the need for much more systematic research. Food webs and host preferences will be discussed in an upcoming paper (Jacobs *et al*., 2023), but following Diethelm & Masta and some of our remarks above it is indeed clear Hemiptera play a crucial role on the green roofs..

A final point of interest are the catching methods. Generally speaking, species in Table 2 (cat. C) were disproportionately caught more often with pitfall traps, while species from cat. B and A were more often caught by pan traps. This suggests pitfall traps could possibly be more useful to search for species specifically colonizing the roof, while pan traps have more by-catch of foraging species or migratory species. This is especially true for flying Hymenoptera (ants for example are of course also often caught with pitfall traps). The small but winged parasitoid wasps *Leiophron deficiens* and *Meloboris collector* were nearly exclusively caught with pitfall traps, while crabronid wasps often preferred pan traps. This could be caused by rotten material in the pitfall traps, which lures ants and vespid wasps.

Table 3. Hymenoptera families occurring on green roofs; absolute numbers and species

Cat.	Species	Family	Roofs (n=20)	Occurences (n = 273)
C.	*Lasius niger*	Formicidae	18	131
	Bombus terrestris-compl.	Apidae	16	53
	Lasioglossum morio	Halictidae	16	36
	Hylaeus hyalinatus	Colettidae	15	31
	Lasioglossum laticeps	Halictidae	13	40
	Bombus pascuorum	Apidae	11	23
	Megachile rotundata	Megachilidae	11	17
	Lasioglossum nitidulum	Halictidae	10	26
	Tetramorium caespitum	Formicidae	9	22
	Vespula germanica	Vespidae	9	20
	Vespula vulgaris	Vespidae	9	12
	Leiophron deficiens	Braconidae	9	11
	Apis mellifera	Apidae	8	14
	Bombus lapidarius	Apidae	7	17
	Gonatopus clavipes	Dryinidae	7	13
	Lasius flavus	Formicidae	7	9
	Polistes dominula	Vespidae	7	8
	Lasius brunneus	Formicidae	6	6
	Lasius umbratus	Formicidae	6	6
	Myrmica scabrinodis	Formicidae	5	10
	Myrmecina graminicola	Formicidae	5	5
	Dasypoda hirtipes	Melittidae	5	5
	Myrmica rugulosa	Formicidae	4	7
	Hylaeus pictipes	Colettidae	4	5
	Idiasta dichrocera	Braconidae	4	4
	Meloboris collector	Ichneumonidae	4	4
B.	*Spilomena mocsaryi*	Crabronidae	3	3
	Trypoxylon minus	Crabronidae	3	3
	Gonatopus lunatus	Dryinidae	3	3
	Hypoponera punctatissima	Formicidae	3	4
	Gelis declivis	Ichneumonidae	3	5
	Gelis festinans	Ichneumonidae	3	5
	Anthidium manicatum	Megachilidae	3	3
	Andrena nitida	Andrenidae	3	3
	Hylaeus communis	Colettidae	3	3

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