



The high alpine bee fauna (Hymenoptera: Apoidea) of the Zillertal Alps, Austria

Silas Bossert †

† Department of Integrative Zoology, University of Vienna, Vienna, Austria

Corresponding author: Silas Bossert (silas.bossert@googlemail.com)

Academic editor: Gilberto M. M. Santos

Received: 20 May 2014 | Accepted: 20 Jun 2014 | Published: 23 Jun 2014

Citation: Bossert S (2014) The high alpine bee fauna (Hymenoptera: Apoidea) of the Zillertal Alps, Austria. Biodiversity Data Journal 2: e1115. doi: [10.3897/BDJ.2.e1115](https://doi.org/10.3897/BDJ.2.e1115)

Abstract

Bees from the Zemmgrund area in the Zillertal Alps (Austria, Tyrol) were collected and determined to investigate the species composition of the area. A total of 61 specimens were collected over a two year period; they represent 24 species from 8 genera. Building on these records, the first commented checklist for the area is presented, with notes on habitats and visited flowers.

Keywords

Tyrol, Zemmgrund Area, faunistic records, flower visits, *Bombus lucorum* complex, *Nomada glabella*

Introduction

Faunistic research on bees (Hymenoptera: Apoidea) in Tyrol enjoys a long tradition. Its foundations were laid by the great works of Dalla Torre (e.g. Dalla Torre 1873, Dalla Torre 1877a, Dalla Torre 1877b, Dalla Torre 1879, Dalla Torre 1882) and Schletterer (1887) that are related to the former County of Tyrol. Numerous complementary studies followed by a large number of authors concerning different parts of the region, for example the Ötztal

Alps (Schedl 1982), Lower Inn Valley (Schuler 1982), Tiroler Mittelland (Stöckl 1996), Upper Inn Valley (Stöckl 1998), tyrolean Lech area (Schmid-Egger 2011) and Silvretta Alps together with Kleinwalsertal in Vorarlberg (Kuhlmann and Tumbrinck 1996). Bellmann and Hellrigl (1996) assembled a species list for South Tyrol which has been updated several times (Hellrigl 2006, Hellrigl and Franke 2004, Hellrigl 2003). Furthermore, Kopf (2008) provided an excellent treatise on the bees of the Schlern region. Overviews for different taxonomic groups of bees have been conducted by Gusenleitner (1985) regarding *Andrena* in Northern Tyrol and records of Halictidae from Northern Tyrol were prepared by Ebmer (1988). Stöckl (2000) worked on the Megachilinae in North and South Tyrol and Neumayer and Kofler (2005) evaluated the bumblebee fauna of eastern Tyrol. Additional faunistic data was assembled within the framework of the "GEO-Tage der Artenvielfalt" in Tyrol in 2005, 2006, 2009 and 2011. Aside from the data in Kopf et al. (2010), records for the Zillertal Alps are very rare, and for the Zemmgrund area only a list of bumblebee species for a small transect study (Penninger 2008) could be found in the literature. The aim of this study is to help close this knowledge gap and contribute the first extensive faunistic data set concerning the high alpine bee fauna of the Zillertal Alps.

Materials and methods

Collections were conducted near the Berliner Hütte in three periods: July 4-10, 2012, July 3-9, 2013 and August 6-10, 2013. The focus within the area was on bees around and above the Berliner Hütte which is located on 2042 m above sea level. All sighted wild bees were collected manually and were transferred into an ethyl acetate killing jar. The majority of specimens were collected between an altitudinal range of 1850 m to 2400 m a.s.l. Four specimens were collected at lower altitudes as accidental findings during ascent and descent. GPS coordinates and altitudes were logged. The habitat of each collection site was categorized. Determinations were conducted using the identification keys of Amiet (Amiet 1996, Amiet et al. 1999, Amiet et al. 2001, Amiet et al. 2004, Amiet et al. 2007, Amiet et al. 2010), Dathe (Dathe 1977, Dathe 1980), Ebmer (Ebmer 1969, Ebmer 1971, Ebmer 1984), Gokcezade et al. (2010), Mauss (1994), Schmid-Egger and Scheuchl (1997) and Scheuchl (Scheuchl 1995, Scheuchl 2006). Critical specimens were sent to experts for examination: the author is indebted to Fritz Gusenleitner for helping with the specimens belonging to the genus *Andrena* and Maximilian Schwarz for specimens of *Nomada*. The suprageneric classification follows Michener (2007). All specimens are kept in the collection of the author. If the specimens were collected on flowers, the respective plant species was recorded. The plant species were determined using Rothmaler (2009) and Fischer et al. (2008). A list of the recorded plant species in the supplementary material (Suppl. material 1) provides further informations about the bee species visiting the respective flowers.

One collected specimen belongs to a cryptic bumblebee species group, the so-called *Bombus lucorum* complex. The status of three distinct species within the complex is widely accepted today (Bertsch et al. 2004, Bertsch et al. 2005, Murray et al. 2008, Bertsch 2009, Carolan et al. 2012, Williams et al. 2012). In contrast, there is heavy doubt about the

species identification based on morphology and there are implications that the species might be morphologically indistinguishable (Williams 2000, Waters et al. 2011, Carolan et al. 2012). Therefore, a partial sequence of the mitochondrial COI gene from the specimen was ascertained to ensure the morphological determination. The specimen was stored in pure ethanol and a single crushed midleg was used for the analysis. DNA was extracted using a Proteinase K digestion prior to a phenol-chloroform protocol (Sambrook et al. 1989). The so-called "Folmer region" was amplified with Polymerase chain reactions (PCR) using the primers LCO1490 and HC02198 (Folmer et al. 1994). The remaining PCR components were provided using the DreamTaq™ PCR Mastermix (2x) (Thermo Fisher Scientific Inc., Waltham, MA, USA) and the amplification profile was conducted following the manufacturer's protocol. The product was purified using the GeneJET™ PCR Purification Kit (Thermo Fisher Scientific Inc., Waltham, MA, USA) and sequencing was carried out by the VBC-Biotech Service GmbH (Vienna, Austria). The obtained sequence was checked manually using BioEdit 7.2.5 (Hall 1999). A BLAST search (Altschul et al. 1990), as implemented in GenBank, was conducted to estimate the query cover and identity to other sequences deposited in the databank.

The climate map of the study area (Fig. 1) is based on the recently updated Austrian digital climate atlas from 1971-2000 (Hiebl et al. 2011). Given the importance of dependable data concerning the altitudinal climate changes, the high resolution Austrian climate maps for 1971-2000 consider altitudinal changes by a digital elevation model. The GIS grids were kindly provided by Alexander Orlik from the *Zentralanstalt für Meteorologie und Geodynamik* (ZAMG) and handled with QGIS 2.2 (QGIS Development Team 2014).

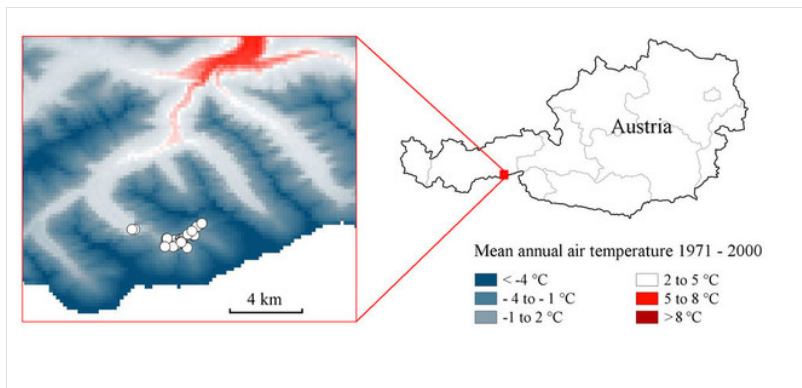


Figure 1.

A temperature-based climate map of the study area and its localization in Austria. The map shows the mean annual air temperature for the period 1971 – 2000 with linearized color interpolation and is based on the data of Hiebl et al. (2011). The white circles indicate the collection localities. The mean annual air temperature of these localities, based on the years 1971 – 2000, range from -0.7 to 3.7 °C.

The microscope images were created using a SMZ25 stereomicroscope and a DS-Ri1 U3 microscope camera (Nikon Corp., Tokyo, Japan).

Study area

The Zemmgrund is a valley located in the Zillertal Alps in Tyrol (Fig. 1) and is part of the Nature Park Zillertal Alps. It is located close to the main ridge of the Alps in northern direction and the southern boundary of the Upper Zemmgrund is the present-day border to Italy. Characteristic feature of the area are three glaciers, which are rapidly retreating at present (Gereben-Krenn et al. 2011): the Waxeggkees, Hornkees and the Schwarzensteinkees. The glaciers greatly influenced the geomorphology of the area and their moraines and remaining waters caused mosaics of diverse small-scaled habitats (Fig. 2). The predominant habitats of the area are alpine meadows and alpine pastures, especially above the treeline (Fig. 3). Other habitats are Swiss pine forests (*Pinus cembra* L.), aggregations of mountain pines (*Pinus mugo* Turra), tall forb meadows, dwarf shrub communities and wet meadows (Fig. 4). Great comprehensive information of the area, concerning the history, anthropogenic usage, climate and geology are available in Luzian and Pindur (2007). In addition, this compendium contains an extensive study about the flora of the area by Niklfeld and Schratt-Ehrendorfer (2007), a very useful source for melittologists!



Figure 2.

A photograph of the small scaled habitats that are characteristic for study area: A part of a Swiss pine forest (left side), aggregations of mountain pines (in the middle of the picture), an alpine pasture (in the foreground) and alpine meadows (upper right side).



Figure 3.

Alpine meadows and pastures are the predominant habitats in the study area.



Figure 4.

Wet meadows are present in the study area but are rarely frequented by wild bees.

Checklist of the Apoidea of the Upper Zemmgrund area

Family Colletidae

Subfamily Hylaeinae

Hylaeus nivalis (Morawitz, 1867)

Materials

- a. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2397; decimalLatitude: 47.036944; decimalLongitude: 11.829067; samplingProtocol: manual catch; eventDate: 7-7-12; habitat: alpine meadow; individualCount: 1; sex: male; occurrenceRemarks: on *Geum montanum* L.; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2195; decimalLatitude: 47.031153; decimalLongitude: 11.821665; samplingProtocol: manual catch; eventDate: 8-7-12; habitat: alpine meadow; individualCount: 1; sex: male; occurrenceRemarks: sheltering in *Leontodon hispidus* L.; recordedBy: S. Bossert
- c. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2311 m; decimalLatitude: 47.03458; decimalLongitude: 11.82542; samplingProtocol: manual catch; eventDate: 6-8-13; habitat: alpine meadow; individualCount: 1; sex: male; occurrenceRemarks: sheltering in *Leontodon hispidus* L.; recordedBy: S. Bossert
- d. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2159 m; decimalLatitude: 47.028735; decimalLongitude: 11.818161; samplingProtocol: manual catch; eventDate: 6-8-13; habitat: wet meadow; individualCount: 1; sex: male; occurrenceRemarks: sheltering in *Leontodon helveticus* Mérat; recordedBy: S. Bossert
- e. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2159 m; decimalLatitude: 47.028735; decimalLongitude: 11.818161; samplingProtocol: manual catch; eventDate: 6-8-13; habitat: wet meadow; individualCount: 1; sex: female; occurrenceRemarks: visiting *Campanula barbata* L., afterwards *L. helveticus*; recordedBy: S. Bossert

Distribution: The species occurs in the western European Alps and is strictly restricted to high-lying habitats (Dathe 1980, Dathe 2000).

Family Andrenidae

Subfamily Andreninae

Andrena lapponica Zetterstedt, 1838

Materials

- a. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2115 m; decimalLatitude: 47.028050; decimalLongitude: 11.823114; samplingProtocol: manual catch; eventDate: 4-7-12; habitat: alpine meadow / dwarf shrub community; individualCount: 1; sex: female; recordedBy: S. Bossert

- b. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2125 m; decimalLatitude: 47.030206; decimalLongitude: 11.822817; samplingProtocol: manual catch; eventDate: 4-7-12; habitat: alpine meadow / dwarf shrub community; individualCount: 1; sex: female; recordedBy: S. Bossert
- c. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2010 m; decimalLatitude: 47.018500; decimalLongitude: 11.818060; samplingProtocol: manual catch; eventDate: 6-7-12; habitat: alpine meadow; individualCount: 1; sex: female; recordedBy: S. Bossert
- d. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2397m; decimalLatitude: 47.036944; decimalLongitude: 11.829067; samplingProtocol: manual catch; eventDate: 7-7-12; habitat: alpine meadow; individualCount: 1; sex: female; recordedBy: S. Bossert
- e. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2044m; decimalLatitude: 47.019165; decimalLongitude: 11.801332; samplingProtocol: manual catch; eventDate: 4-7-13; habitat: alpine meadow; individualCount: 1; sex: female; recordedBy: S. Bossert

Distribution: A species with boreal-alpine distribution (Gusenleitner 1985).

Notes: The species is oligolectic on Ericaceae (Gusenleitner et al. 2012).

***Andrena rogenhoferi* Morawitz, 1872**

Material

- a. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 1904 m; decimalLatitude: 47.025414; decimalLongitude: 11.802853; samplingProtocol: manual catch; eventDate: 5.7.12; habitat: Swiss pine forest / tall forb meadow; individualCount: 1; sex: 1 female; recordedBy: S. Bossert

Distribution: According to Zettel et al. (2008), *A. rogenhoferi* is a high-alpine species distributed all over the European Alps.

Notes: Only few records of *A. rogenhoferi* have been reported so far (Zettel et al. 2008).

***Andrena coitana* (Kirby, 1802)**

Material

- a. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2033 m; decimalLatitude: 47.023599; decimalLongitude: 11.813907; samplingProtocol: manual catch; eventDate: 8-7-13; habitat: aggregation of mountain pines / tall forb meadow; individualCount: 1; sex: male; occurrenceRemarks: on *Leontodon hispidus*; recordedBy: S. Bossert

Distribution: The species is distributed in great parts of Europe and Asia (Warncke 1981).

***Andrena ruficrus* Nylander, 1848**

Material

- a. country: Austria; stateProvince: Tyrol; verbatimLocality: Zemmgrund; verbatimElevation: 2001 m; decimalLatitude: 47.022145; decimalLongitude: 11.814224; samplingProtocol: manual catch; eventDate: 7-7-13; habitat: alpine meadow; individualCount: 1; sex: female; occurrenceRemarks: on *Geum montanum*; recordedBy: S. Bossert

Distribution: According to Warncke (1981), the species is distributed between 43° and 70° north latitude in Europe and probably reaches Asia.

Notes: *A. ruficrus* is a rare species and Gusenleitner (1985) solely reports one single record of the species in Northern Tyrol.

Subfamily Panurginae

***Panurginus montanus* Giraud, 1861**

Materials

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2117 m; decimalLatitude: 47.028291; decimalLongitude: 11.822605; samplingProtocol: manual catch; eventDate: 07-04-12; habitat: alpine meadow / dwarf shrub community; individualCount: 1; sex: 1 male; occurrenceRemarks: on *Potentilla* sp.; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1904 m; decimalLatitude: 47.025414; decimalLongitude: 11.802853; samplingProtocol: manual catch; eventDate: 07-05-12; habitat: Swiss pine forest / tall forb meadow; individualCount: 1; sex: 1 male; occurrenceRemarks: on yellow flowering Cichorioideae; recordedBy: S. Bossert
- c. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2028 m; decimalLatitude: 47.023582; decimalLongitude: 11.813453; samplingProtocol: manual catch; eventDate: 07-09-12; habitat: aggregation of mountain pines / tall forb meadow; individualCount: 1; sex: 1 male; occurrenceRemarks: on *Leontodon hispidus*; recordedBy: S. Bossert
- d. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1882 m; decimalLatitude: 47.025294; decimalLongitude: 11.802437; samplingProtocol: manual catch; eventDate: 07-03-13; habitat: Swiss pine forest / tall forb meadow; individualCount: 2; sex: 2 males; occurrenceRemarks: on *Potentilla* sp.; recordedBy: S. Bossert

Distribution: The species is strictly restricted to the European Alps (Patiný 2003).

Notes: The males of *P. montanus* can easily be determined with the key from Amiet et al. (2010).

Panurginus cf. montanus* Giraud, 1861*Materials**

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2120 m; decimalLatitude: 47.028004; decimalLongitude: 11.822377; samplingProtocol: manual catch; eventDate: 07-08-12; habitat: alpine meadow / dwarf shrub community; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Potentilla* sp.; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2028 m; decimalLatitude: 47.023582; decimalLongitude: 11.813453; samplingProtocol: manual catch; eventDate: 07-09-12; habitat: aggregation of mountain pines / tall forb meadow; individualCount: 2; sex: 2 females; occurrenceRemarks: on *Leontodon hispidus*; recordedBy: S. Bossert
- c. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2067 m; decimalLatitude: 47.025407; decimalLongitude: 11.815162; samplingProtocol: manual catch; eventDate: 07-05-13; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Potentilla* sp.; recordedBy: S. Bossert

Notes: The “cf.” status of the females is discussed below.

Family Halictidae**Subfamily Halictinae*****Lasioglossum albipes* (Fabricius, 1781)****Material**

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2397 m; decimalLatitude: 47.036944; decimalLongitude: 11.829067; samplingProtocol: manual catch; eventDate: 07-07-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Leontodon* sp.; recordedBy: S. Bossert

Distribution: The species is distributed throughout the whole Palaearctic (Ebmer 1988).

Lasioglossum alpigenum* (Dalla Torre, 1877)*Materials**

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2064 m; decimalLatitude: 47.025140; decimalLongitude: 11.814797; samplingProtocol: manual catch; eventDate: 07-05-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Leontodon hispidus*; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2001 m; decimalLatitude: 47.022312; decimalLongitude: 11.814189; samplingProtocol: manual catch; eventDate: 07-06-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Potentilla* sp.; recordedBy: S. Bossert

Distribution: *L. alpingenum* is an alpine species with the main distribution in the European Alps (Ebmer 1988).

***Lasioglossum fratellum* (Pérez, 1903)**

Materials

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2004 m; decimalLatitude: 47.022352; decimalLongitude: 11.814313; samplingProtocol: manual catch; eventDate: 07-09-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Leontodon* sp.; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2001 m; decimalLatitude: 47.022312; decimalLongitude: 11.814189; samplingProtocol: manual catch; eventDate: 07-06-12; habitat: alpine meadow; individualCount: 2; sex: 2 females; occurrenceRemarks: on *Potentilla* sp. and *Myosotis* sp.; recordedBy: S. Bossert

Distribution: Western Palaearctic (Ebmer 1988).

***Lasioglossum morio* (Fabricius, 1793)**

Materials

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2120 m; decimalLatitude: 47.028004; decimalLongitude: 11.822377; samplingProtocol: manual catch; eventDate: 07-08-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Gentiana acaulis* L.; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2072 m; decimalLatitude: 47.025460; decimalLongitude: 11.815305; samplingProtocol: manual catch; eventDate: 07-07-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Leontodon hispidus*; recordedBy: S. Bossert

Distribution: Western Palaearctic (Ebmer 1988).

Subfamily Rophitinae

***Dufourea alpina* Morawitz, 1865**

Materials

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2117 m; decimalLatitude: 47.028291; decimalLongitude: 11.822605; samplingProtocol: manual catch; eventDate: 07-04-12; habitat: alpine meadow / tall forb meadow; individualCount: 5; sex: 5 males; occurrenceRemarks: on *Leontodon hispidus*; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1980 m; decimalLatitude: 47.019336; decimalLongitude: 11.807515; samplingProtocol: manual catch; eventDate: 07-05-12; habitat: alpine meadow; individualCount: 2; sex: 2 males; occurrenceRemarks: on *Leontodon* sp.; recordedBy: S. Bossert
- c. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2120 m; decimalLatitude: 47.028004; decimalLongitude: 11.822377; samplingProtocol: manual catch; eventDate: 07-08-12; habitat: alpine meadow / dwarf shrub community;

individualCount: 1; sex: 1 female; occurrenceRemarks: on *Phyteuma* sp.; recordedBy: S. Bossert

- d. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2004 m; decimalLatitude: 47.022352; decimalLongitude: 11.814313; samplingProtocol: manual catch; eventDate: 07-09-12; habitat: alpine meadow; individualCount: 2; sex: 2 females; occurrenceRemarks: on *Leontodon* sp.; recordedBy: S. Bossert
- e. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2381 m; decimalLatitude: 47.036318; decimalLongitude: 11.828558; samplingProtocol: manual catch; eventDate: 07-10-12; habitat: alpine meadow; individualCount: 1; sex: 1 male; occurrenceRemarks: on yellow flowering Cichorioideae; recordedBy: S. Bossert

Distribution: *D. alpina* occurs in the Pyrenees and in the European Alps. Further it has been reported from the Balkan Peninsula (Ebmer 1988).

Notes: Together with *P. montanus*, *D. alpina* was probably the most common solitary bee species during the investigation period. Especially the males can easily be recognized since they often take shelter in flowers as mentioned in Amiet and Krebs (2012).

***Dufourea paradoxa* Morawitz, 1867**

Material

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2117 m; decimalLatitude: 47.028291; decimalLongitude: 11.822605; samplingProtocol: manual catch; eventDate: 07-04-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Leontodon hispidus*; recordedBy: S. Bossert

Distribution: The species has an altimontane distribution in the western and central Palaearctic (Ebmer 1988).

Family Megachilidae

***Osmia inermis* (Zetterstedt, 1838)**

Material

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2040 m; eventDate: 07-06-12; individualCount: 2; sex: 2 females; recordedBy: B. A. Gereben-Krenn

Distribution: *O. inermis* was reported to be a boreal-alpine species, distributed throughout the Holarctic (Hicks 2009).

Osmia villosa (Schenck, 1853)

Materials

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1969 m; decimalLatitude: 47.021373; decimalLongitude: 11.811105; samplingProtocol: manual catch; eventDate: 07-08-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: collecting petalum of *Cerastium alpinum* L.; recordedBy: J. F. Gokcezade
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1985 m; decimalLatitude: 47.019727; decimalLongitude: 11.808610; samplingProtocol: manual catch; eventDate: 07-08-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Leontodon* sp.; recordedBy: J. F. Gokcezade
- c. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2043 m; decimalLatitude: 47.024478; decimalLongitude: 11.812889; samplingProtocol: manual catch; eventDate: 07-14-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; recordedBy: J. F. Gokcezade

Distribution: Central Europe (Warncke 1981). According to Gusenleitner et al. (2012), the species is distributed in high-lying habitats.

Family Apidae

Subfamily Nomadinae

Nomada panzeri Lepeletier, 1841

Materials

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2120 m; decimalLatitude: 47.028004; decimalLongitude: 11.822377; samplingProtocol: manual catch; eventDate: 07-08-12; habitat: alpine meadow / dwarf shrub community; individualCount: 1; sex: 1 female; occurrenceRemarks: sitting on a branch between flowers of *Rhododendron ferrugineum* L.; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1675 m; decimalLatitude: 47.032230; decimalLongitude: 11.778400; samplingProtocol: manual catch; eventDate: 07-08-13; habitat: alpine pasture; individualCount: 1; sex: 1 female; occurrenceRemarks: hovering over the ground and probably searching for a nest; recordedBy: S. Bossert

Distribution: Northern, western and central Europe (Scheuchl 1995).

Notes: Following host species are mentioned in Scheuchl (1995): *Andrena fucata*, *Andrena helvola*, *A. lapponica* and *A. synadelpha*. The species is extremely variable in size and color (Fig. 5).



Figure 5.

The two specimens of *Nomada panzeri* collected during the study. Note the great variation in size and color.

Subfamily Apinae

Bombus bohemicus Seidl, 1838

Material

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1904 m; decimalLatitude: 47.024517; decimalLongitude: 11.802833; samplingProtocol: manual catch; eventDate: 07-05-12; habitat: Swiss pine forest / tall forb meadow; individualCount: 1; sex: 1 queen; occurrenceRemarks: on yellow flowering Cichorioideae; recordedBy: S. Bossert

Distribution: *B. bohemicus* has an Euro-Siberian distribution (Amiet 1996).

Notes: According to Amiet (1996), *Bombus lucorum* is the host species of *Bombus bohemicus*. It is presently not known if the other closely related species of the so-called *Bombus lucorum*-complex serve as host species as well.

Bombus cryptarum (Fabricius, 1775)

Material

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2006 m; decimalLatitude: 47.022678; decimalLongitude: 11.813367; samplingProtocol: manual catch; eventDate: 07-05-13; habitat: alpine meadow / tall forb meadow; individualCount: 1; sex: 1 queen; occurrenceRemarks: on *Rhododendron ferrugineum* L.; recordedBy: S. Bossert

Distribution: The species seems to have a boreal distribution in great parts of the Palaearctic and even reaches western North America (Williams et al. 2012).

Notes: The specimen belongs to a cryptic species complex consisting of *B. cryptarum*, *B. lucorum* and *B. magnus* but could positively be determined as *B. cryptarum* with the analyses of the nucleotide sequence of the COI gene. For details, see the discussion.

***Bombus gerstaeckeri* Morawitz, 1882**

Material

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1603 m; decimalLatitude: 47.032362; decimalLongitude: 11.776317; samplingProtocol: manual catch; eventDate: 08-08-13; habitat: tall forb meadow; individualCount: 3; sex: 3 females; occurrenceRemarks: on *Aconitum napellus* L.; recordedBy: S. Bossert

Distribution: The species occurs in the Pyrenees, European Alps and on the Balkan Peninsula (Amiet 1996). Further it has been mentioned for the Carpathian and Caucasus Mountains (Ponchau et al. 2006).

Notes: *B. gerstaeckeri* is an oligolectic species and feeds on *Aconitum* spp. (Pittioni 1937, Amiet 1996, Utelli and Roy 2000).

***Bombus hortorum* (L., 1761)**

Material

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2057 m; decimalLatitude: 47.025236; decimalLongitude: 11.812656; samplingProtocol: manual catch; eventDate: 07-10-12; habitat: aggregation of mountain pines / alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Campanula barbata* L.; recordedBy: S. Bossert

Distribution: Palaearctic (Williams 1998, Williams 2014).

***Bombus mendax* Gerstaecker, 1869**

Material

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2079 m; decimalLatitude: 47.0256794; decimalLongitude: 11.8167508; samplingProtocol: manual catch; eventDate: 07-06-13; habitat: alpine meadow; individualCount: 1; sex: 1 queen; recordedBy: S. Bossert

Distribution: Palaearctic (Williams 1998, Williams 2014). Amiet (1996) reports *B. mendax* to occur above 1500 m a.s.l. and Neumayer (1998) proposes the species to exceed even 3000 m a.s.l.

Bombus monticola* Smith, 1849*Material**

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2041 m; decimalLatitude: 47.024797; decimalLongitude: 11.813171; samplingProtocol: manual catch; eventDate: 07-10-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Rhinanthus glacialis* Personnat; recordedBy: S. Bossert

Distribution: Palearctic (Williams 1998, Williams 2014).

Bombus pratorum* (L., 1761)*Material**

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2041 m; decimalLatitude: 47.024797; decimalLongitude: 11.813171; samplingProtocol: manual catch; eventDate: 07-10-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Campanula barbata* L.; recordedBy: S. Bossert

Distribution: Palearctic (Williams 1998, Williams 2014).

Bombus pyrenaeus* Pérez, 1879*Materials**

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1979 m; decimalLatitude: 47.024259; decimalLongitude: 11.808473; samplingProtocol: manual catch; eventDate: 07-05-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Campanula* sp.; recordedBy: S. Bossert
- b. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1896 m; decimalLatitude: 47.022036; decimalLongitude: 11.802090; samplingProtocol: manual catch; eventDate: 07-05-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Campanula barbata* L.; recordedBy: S. Bossert
- c. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1896 m; decimalLatitude: 47.022036; decimalLongitude: 11.802090; samplingProtocol: manual catch; eventDate: 07-05-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Campanula barbata* L.; recordedBy: S. Bossert
- d. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2004 m; decimalLatitude: 47.022304; decimalLongitude: 11.814452; samplingProtocol: manual catch; eventDate: 07-06-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Campanula* sp.; recordedBy: S. Bossert
- e. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 2041 m; decimalLatitude: 47.024797; decimalLongitude: 11.813187; samplingProtocol: manual catch; eventDate: 07-07-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; recordedBy: S. Bossert

Distribution: Palearctic (Williams 1998, Williams 2014).

***Bombus wurflenii* Radoszkowski, 1859**

Material

- a. country: Austria; stateProvince: Tyrol; locality: Zemmgrund; verbatimElevation: 1972 m; decimalLatitude: 47.021912; decimalLongitude: 11.812132; samplingProtocol: manual catch; eventDate: 07-05-12; habitat: alpine meadow; individualCount: 1; sex: 1 female; occurrenceRemarks: on *Rhinanthus glacialis* Personnat; recordedBy: S. Bossert

Distribution: Palaearctic (Williams 1998, Williams 2014).

Analysis

In total, 61 specimens were collected, representing 24 species from 8 genera. The list of bumblebee species provided in Penninger (2008) can be complemented with 4 species. The note about *B. lucorum* from this source is not evaluated due to the current unreliability of morphological identification of the species. Combining these records, 30 bee species have been recorded for the area. Of these, 15 are representatives of the genus *Bombus*.

Discussion

With increasing altitude, the climatic conditions in alpine environments become more extreme (Franz 1979). Especially the decreasing temperature (Fig. 1) and increasing insolation are of importance for terrestrial arthropods above the timberline (Sømme 1989). This also applies for bees: due to the short and cool summers in alpine regions in the European Alps, Neumayer and Paulus (1999) conclude a phenological window of solely three months for bumblebees to complete their life cycle. With respect to the nearly completed snowmelt in the study area by mid of June, it can be safely assumed that the three investigation periods were extensive enough to collect the majority of bee species that may occur in the area. Nonetheless, the species list above cannot be assumed to be complete with certainty. Therefore the investigation periods were not evenly distributed throughout the season since no collections have been conducted in September. Also the study area is almost completely restricted to the Upper Zemmgrund and species which potentially occur below 1900 m altitude are absent from the species list. This becomes particularly apparent when comparing the records with the species list of Kopf et al. (2010). This species list is based on collections from July 17-19, 2009 by four persons on eight collection sites approx. 13 to 17 km from the Zemmgrund Area as the crow flies. Therefore it is comparable by place, time and collection effort but differs in the altitudinal range: the collections were conducted between 1760 m and approx. 950 m a.s.l. Only seven of 47 species collected by Kopf et al. (2010) can be found in both lists, namely the widely distributed bumblebees *Bombus hortorum*, *B. monticola*, *B. pratorum*, *B. pyrenaeus* and the widespread *Lasioglossum albipes*, *L. fratellum* and *L. morio*. Therefore a great number of additional species can be expected at lower altitudes of the Zemmgrund area. Further the comparison of the lists indicates a decreasing species diversity along the rising

altitudinal gradient. This is in line with the described species decrease of terrestrial arthropods at the timberline (Sømme 1989). However, the species composition in the Upper Zemmgrund clearly reflects the high altitudes of the study area, since the majority of species have at least a montane distribution. Several records belong to explicit high-mountain species, such as *Hylaeus nivalis* (Dathe 1980, Dathe 2000), *Andrena rogenhoferi* (Gusenleitner 1985, Zettel et al. 2008), *Panurginus montanus* (Patin 2003), *Lasioglossum alpigenum* (Ebmer 1988), *Dufourea alpina* (Ebmer 1988) and the bumblebee species *Bombus mendax*, *B. monticola* and *B. wurflenii* (Neumayer 1998).

Some species determinations must be discussed: Since females from *P. montanus* cannot be separated from females of the closely related *Panurginus sericatus* Warncke, 1972 with the key of Amiet et al. (2010), the collected females are marked with “cf”. The species status of *P. sericatus* has been doubted (Ebmer 2001), but is valid after Patin (2003). However, since the males can easily be assigned by the shape of the gonostylus and both sexes were observed in the same area, it seems likely that the females belong to *P. montanus*.

Another species with difficult determination is *Bombus cryptarum*. An identification based on the characteristic color patterns of queens was shown to be unreliable (Carolan et al. 2012), and an examination on the reliability of traits described in the common keys is urgently needed since several characters overlap. In contrast, sequence analyses of the COI gene represents a confident method for identification (e.g. Bertsch et al. 2005, Murray et al. 2008, Bertsch 2009, Carolan et al. 2012, Williams et al. 2012). A BLAST search of the obtained 609 bp long sequence from the collected specimen (Suppl. material 2, GenBank acc. no. [KJ787691](#)) revealed an identity of 99% with a query cover of 100% to a *B. cryptarum* voucher (GenBank acc. no. [JQ843372.1](#)) and the next 40 hits by total score were assigned to *B. cryptarum*. Therefore it can safely be assumed that the specimen belongs to *B. cryptarum*. The specimen shows the ‘S’-shape of black hairs in the first collar (Fig. 6), which has been considered a characteristic trait for queens in the literature (Rasmont 1981, Rasmont 1984, Bertsch 1997, Bertsch et al. 2004). After Rasmont (pers. comm.), specimens showing the “S” belong to the subspecies *Bombus cryptarum cryptarum*. However, since Carolan et al. (2012) could show that this trait seems to be unreliable, further discussion about species identification of the cryptic species of the *Bombus lucorum* complex based on color patterns cannot be conducted until more safely determined specimens are accessible.



Figure 6.

The voucher of the collected queen of *Bombus cryptarum*. The black “S”-shape in the first collar is clearly visible.

As with many species of the genus, *Nomada panzeri* shows a great variation in color and size (Schwarz 1986). This also applies to the two collected specimens from this study which vary considerably (Fig. 5). The specimens were determined and labeled by the European expert for this group, Maximilian Schwarz, as “*Nomada glabella* auct.” (*Nomada glabella* Thomson, 1870) which is a junior synonym to *N. panzeri* (Schwarz 1986). Burger (2005) disagrees with the synonymy and argues with the clear distinguishability described in Stoeckert (1930). Further he proposes differences in distributional patterns between *N. panzer* and *N. glabella* and solely mentions *Andrena lapponica* and *A. fucata* as host species of *N. glabella*. In contrast, the majority of authors agree with the synonymy (e.g. Schwarz et al. 1996, Smit 2004, Straka et al. 2007, Westrich et al. 2008, Nilsson 2010, Gusenleitner et al. 2012). However, it can safely be assumed that the host species of *N. panzer* in the study area is *A. lapponica*.

Acknowledgements

I would like to thank J. Plant, B.A. Gereben-Krenn and H.W. Krenn for their helpful suggestions on the manuscript. Thanks go also to Thomas Schwaha for technical support with the microscope imaging and to Gabriela Gorgon for providing the photographs. Parts of this work were supported by the *Naturpark Kaunergrat*, the *Hochgebirgs-Naturpark Zillertaler Alpen*, the *Alpenpark Karwendel* and the *Amt der Tiroler Landesregierung Abteilung Umweltschutz, Naturschutzförderungen*.

References

- Altschul SF, Gish W, Miller W, Myers EW, Lipman DJ (1990) Basic Local Alignment Search Tool. *J. Mol. Biol.* 215 (3): 403-410. [In English].
- Amiet F (1996) Hymenoptera Apidae, 1. Teil - Allgemeiner Teil, Gattungsschlüssel, die Gattungen *Apis*, *Bombus* und *Psithyrus*. 12. *Insecta Helvetica Fauna*, 98 pp. [In German].
- Amiet F, Krebs A (2012) Bienen Mitteleuropas - Gattungen, Lebensweise, Beobachtung. 1. Auflage. Haupt Verlag, Bern, Stuttgart, Wien, 424 pp. [In German].
- Amiet F, Neumeyer R, Müller A (1999) *Fauna Helvetica. Apidae 2 - Colletes, Dufourea, Hylaeus, Nomia, Nomioides, Rhophitoides, Rophites, Sphecodes, Systropha*. Schweizerische Entomologische Gesellschaft, Neuchâtel, 219 pp. [In German].
- Amiet F, Herrmann M, Müller A, Neumeyer R (2010) *Fauna Helvetica. Apidae 6 - Andrena, Melitturga, Panurginus*. 26. Schweizerische Entomologische Gesellschaft, Neuchâtel, 318 pp. [In German].
- Amiet F, Herrmann M, Müller A, Neumeyer R (2001) *Fauna Helvetica. Apidae 3 - Halictus, Lasioglossum*. Schweizerische Entomologische Gesellschaft, Neuchâtel, 208 pp. [In German].
- Amiet F, Herrmann M, Müller A, Neumeyer R (2004) *Fauna Helvetica. Apidae 4 - Anthidium, Chelostoma, Coelioxys, Dioxys, Heriades, Lithurgus, Megachile, Osmia, Stelis*. 20. Schweizerische Entomologische Gesellschaft, Neuchâtel, 273 pp. [In German].
- Amiet F, Herrmann M, Müller A, Neumeyer R (2007) *Fauna Helvetica. Apidae 5 - Ammobates, Ammobatoides, Anthophora, Biastes, Ceratina, Dasypoda, Epeoloides, Epeolus, Eucera, Macropis, Melecta, Melitta, Nomada, Pasites, Tetralonia, Thyreus, Xylocopa*. 20. Schweizerische Entomologische Gesellschaft, Neuchâtel, 356 pp. [In German].
- Bellmann H, Hellrigl K (1996) Apoidea (Mellifera)-Bienen oder Blumenwespen. In: Hellrigl K (Ed.) *Die Tierwelt Südtirols. Veröffentlichungen des Naturmuseums Südtirol, Bozen*, 831 pp. [In German].
- Bertsch A (1997) Abgrenzung der Hummel-Arten *Bombus cryptarum* und *B. lucorum* mittels männlicher Labialdrüsen-Sekrete und morphologischer Merkmale (Hymenoptera, Apidae). *Entomol. Gener.* 22 (2): 129-145. [In German].
- Bertsch A (2009) Barcoding cryptic bumblebee taxa: *B. lucorum*, *B. cryptarum* and *B. magnus*, a case study. *Beiträge zur Entomologie* 59 (2): 287-310. [In English].
- Bertsch A, Schweer H, Titze A (2004) Discrimination of the bumblebee species *Bombus lucorum*, *B. cryptarum* and *B. magnus* by morphological characters and male labial gland secretions. *Beiträge zur Entomologie* 54 (2): 365-386. [In English].
- Bertsch A, Schweer H, Titze A, Tanaka H (2005) Male labial gland secretions and mitochondrial DNA markers support species status of *Bombus cryptarum* and *B. magnus* (Hymenoptera, Apidae). *Insectes Sociaux* 52 (1): 45-54. [In English].
- Burger F (2005) Rote Liste Wildbienen - Materialien zu Naturschutz und Landschaftspflege. Sächsisches Landesamt für Umwelt und Geologie, Dresden, 38 pp. [In German].
- Carolan JC, Murray TE, Fitzpatrick Ú, Crossley J, Schmidt H, Cederberg B, McNally L, Paxton RJ, Williams PH, Brown MJ (2012) Colour Patterns Do Not Diagnose Species:

- Quantitative Evaluation of a DNA Barcoded Cryptic Bumblebee Complex. *PloS one* 7 (1): e29251. [In English]. DOI: [10.1371/journal.pone.0029251](https://doi.org/10.1371/journal.pone.0029251)
- Dalla Torre KWv (1873) Beitrag zur Kenntnis der Hymenopterenfauna Tirols. - Die Apiden Tirols in ihrer horizontalen und vertikalen Verbreitung. *Ztschr. Ferdinandeum Innsbruck* 3 (18): 251-280. [In German].
 - Dalla Torre KWv (1877a) Die Apiden Tirols. Fortsetzung und Schluss. *Ztschr. Ferdinandeum Innsbruck* 3 (21): 161-196. [In German].
 - Dalla Torre KWv (1877b) Entomologische Alpenfauna. *Ent. Nachr.* 3: 169-171. [In German].
 - Dalla Torre KWv (1879) Bemerkungen zur Gattung *Bombus* Latr. I. 1. Die *Bombus*-Arten Tirols. *Ber. nat.-med. Ver. Innsbruck* 8 (3): 3-21. [In German].
 - Dalla Torre KWv (1882) Bemerkungen zur Gattung *Bombus* Latr. II. 3. Zur Synonymie und geographischen Verbreitung der Gattung *Bombus* Latr. *Ber. nat.-med. Ver. Innsbruck* 12: 14-31. [In German].
 - Dathe HH (1977) Diagnosen zu den europäischen Arten der *Hylaeus nivalis*-Gruppe (Hymenoptera: Apidae, Colletidae). *Mitt. zool. Mus. Berlin* 53 (2): 303-306. [In German].
 - Dathe HH (1980) Die Arten der Gattung *Hylaeus* F. in Europa (Hymenoptera: Apoidea, Colletidae). *Mitt. zool. Mus. Berlin* 56 (2): 207-294. [In German].
 - Dathe HH (2000) Studien zur Systematik und Taxonomie der Gattung *Hylaeus* F. (3). Revision der *Hylaeus nivalis*-Gruppe in Europa und Klärung weiterer westpaläarktischer Arten (Apidae, Colletinae). *Beitr. Ent.* 50 (1): 151-174. [In German].
 - Ebmer AW (1969) Die Bienen des Genus *Halictus* Latr. s.l. im Großraum von Linz (Hymenoptera, Apidae). Teil I. *Nat. Jb. Linz* 1969: 133-183. [In German].
 - Ebmer AW (1971) Die Bienen des Genus *Halictus* Latr. s.l. im Großraum von Linz (Hymenoptera, Apidae) Teil III. *Nat. Jb. Linz* 1971: 63-156. [In German].
 - Ebmer AW (1984) Die westpaläarktischen Arten der Gattung *Dufourea* Lepeletier 1841 mit illustrierten Bestimmungstabellen (Insecta: Hymenoptera: Apoidea: Halictidae: Dufoureainae). *Senckenbergiana biol.* 64: 313-379. [In German].
 - Ebmer AW (1988) Kritische Liste der nicht-parasitischen Halictidae Österreichs mit Berücksichtigung aller mitteleuropäischen Arten (Insecta: Hymenoptera: Apoidea: Halictidae). *Linzer biol. Beitr.* 20 (2): 527-711. [In German].
 - Ebmer AW (2001) Hymenopterologische Notizen aus Österreich-14 (Insecta: Hymenoptera: Apoidea). *Linzer biol. Beitr.* 33 (1): 435-460. [In German].
 - Fischer MA, Oswald K, Adler W (2008) Exkursionsflora für Österreich, Liechtenstein und Südtirol. 3. Auflage. Biologiezentrum der Oberösterreichischen Landesmuseen, Linz, 1392 pp. [In German].
 - Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular marine biology and biotechnology* 3 (5): 294-299. [In English].
 - Franz H (1979) Ökologie der Hochgebirge. Ulmen Verlag, Stuttgart, 495 pp. [In German].
 - Gereben-Krenn BA, Krenn HW, Strodl MA (2011) Initial Colonization of New Terrain in an Alpine Glacier Foreland by Carabid Beetles (Carabidae, Coleoptera). *Arctic, Antarctic, and Alpine Research* 43 (3): 397-403. [In English]. DOI: [10.1657/1938-4246-43.3.397](https://doi.org/10.1657/1938-4246-43.3.397)

- Gokcezade JF, Gereben-Krenn BA, Neumayer J, Krenn HW (2010) Feldbestimmungsschlüssel für die Hummeln Österreichs, Deutschlands und der Schweiz. Linzer biologische Beiträge 42/1: 5-42. [In German].
- Gusenleitner F (1985) Angaben zur Kenntnis der Bienengattung *Andrena* in Nordtirol (Österreich). Ber. nat.-med. Ver. Innsbruck 72: 199-221. [In German].
- Gusenleitner F, Schwarz M, Mazzucco K (2012) Apidae (Insecta: Hymenoptera). In: Schuster R (Ed.) Checklisten der Fauna Österreichs, No. 6. Österreichische Akademie der Wissenschaften, Wien, 162 pp. [In German].
- Hall TA (1999) BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41: 95-98. [In English].
- Hellrigl K (2003) Faunistik der Ameisen und Wildbienen Südtirols (Hymenoptera: Formicidae et Apoidea). Gredleriana 3: 143-208. [In German].
- Hellrigl K (2006) Synopsis der Wildbienen Südtirols: (Hymenoptera: Apidae). Forest observer 2 (3): 421-472. [In German].
- Hellrigl K, Franke R (2004) Faunistik der Wildbienen Südtirols: 1. Nachtrag (Hymenoptera: Apoidea). Forest observer 1: 141-152. [In German].
- Hicks B (2009) Observations of the nest structure of *Osmia inermis* (Hymenoptera: Megachilidae) from Newfoundland, Canada. Journal of the Acadian Entomological Society 5: 12-18. [In English].
- Hiebl J, Reisenhofer S, Auer I, Böhm R, Schöner W (2011) Multi-methodical realisation of Austrian climate maps for 1971–2000. Advances in Science and Research 6: 19-26. [In English]. DOI: [10.5194/asr-6-19-2011](https://doi.org/10.5194/asr-6-19-2011)
- Kopf T (2008) Die Bienenfauna (Hymenoptera: Apidae) des Schlerngebietes (Südtirol, Italien) mit Angaben zu den Artengemeinschaften ausgewählter Lebensräume. Gredleriana 8: 429-466. [In German].
- Kopf T, Zettel H, Link A, Ockermüller E (2010) Hautflügler - Pflanzenwespen und ausgewählte Stechimmen-Familien (Hymenoptera: "Symphyta" et Aculeata partim: Apidae, Chrysididae, Sapygidae, Sphecidae, Vespidae). In: Pagitz K (Ed.) GEO-Tag der Artenvielfalt 2009 in Tirol - Naturpark Zillertal. In: Wissenschaftliches Jahrbuch der Tiroler Landesmuseen. Innsbruck, 472 pp. [In German].
- Kuhlmann M, Tumbrinck K (1996) Wildbienen- und Wespenfunde (Hymenoptera Aculeata) aus dem Kleinwalsertal und aus den Silvretta-Alpen. Jb. Vorarlberger Landesmuseumsvereins-Freunde d. Landeskunde 1996: 25-33. [In German].
- Luzian R, Pindur P (2007) Prähistorische Lawinen: Nachweis und Analyse holozäner Lawinenereignisse in den Zillertaler Alpen, Österreich. BFW-Berichte 141/Mitt. Komm. Quartärforsch Österr. Akad. Wiss., Wien, 247 pp. [In German].
- Mauss V (1994) Bestimmungsschlüssel für Hummeln. 6. Auflage DJN (Hrsg.) Hamburg: 1-50. [In German].
- Michener CD (2007) The Bees of the World. Second Edition. The Johns Hopkins University Press, Baltimore, 953 pp. [In English].
- Murray TE, Fitzpatrick U, Brown MJ, Paxton RJ (2008) Cryptic species diversity in a widespread bumble bee complex revealed using mitochondrial DNA RFLPs. Conservation Genetics 9 (3): 653-666. [In English]. DOI: [10.1007/s10592-007-9394-z](https://doi.org/10.1007/s10592-007-9394-z)
- Neumayer J (1998) Habitatpräferenzen alpiner Hummelarten (Hymenoptera, Apidae, *Bombus*, *Psithyrus*): Meereshöhe und Lage im Gebirgsrelief als Faktoren der

- Nischentrennung. Wissenschaftliche Mitteilungen Nationalpark Hohe Tauern 4: 159-174. [In German].
- Neumayer J, Kofler A (2005) Zur Hummelfauna des Bezirkes Lienz (Osttirol, Österreich) (Hymenoptera: Apidae, *Bombus*). Linzer biol. Beitr. 37 (1): 671-699. [In German].
 - Neumayer J, Paulus HF (1999) Ökologie alpiner Hummelgemeinschaften: Blütenbesuch, Ressourcenaufteilung und Energiehaushalt. Untersuchungen in den Ostalpen Österreichs. Stapfia 67: 5-246.
 - Niklfeld H, Schrott-Ehrendorfer L (2007) Zur Flora des Zemmgrunds in den Zillertaler Alpen - Ein Auszug aus den Ergebnissen der Floristischen Kartierung Österreichs. In: Luzian R, Pindur P (Eds) Prähistorische Lawinen. Nachweis und Analyse holozäner Lawineneignisse in den Zillertaler Alpen, Österreich. BFW-Berichte 141/Mitt. Komm. Quartärforsch Österr. Akad. Wiss., Wien, 99-108 pp. [In German].
 - Nilsson LA (2010) The type material of Swedish bees (Hymenoptera, Apoidea) IV. Bees from Thomson's collection. Entomologisk Tidskrift 131: 73-94. [In English].
 - Patiny S (2003) Contemporary distributions of *Panurginus* species and subspecies in Europe (Apoidea: Andrenidae: Panurginae). Proceedings of the 13th International Colloquium of the European Invertebrate Survey, Leiden, 2-5 September 2001 1: 115-121. [In English].
 - Penninger H (2008) Aktivität alpiner Hummeln in Abhängigkeit klimatischer Faktoren. Diplomarbeit an der Universität Wien, 49 pp. [In German].
 - Pittioni B (1937) Bestäubung und Nektarraub beim Gelben Eisenhut (*Aconitum vulparia* Rchb). Aus der Heimat, Stuttgart 50: 209-213. [In German].
 - Ponchau O, Iserbyt S, Verhaeghe J-, Rasmont P (2006) Is the caste-ratio of the oligolectic bumblebee *Bombus gerstaeckeri* Morawitz (Hymenoptera: Apidae) biased to queens? Annales de la Société Entomologique de France 42 (2): 207-214. [In English].
 - QGIS Development Team (2014) QGIS Geographic Information System. Open Source Geospatial Foundation Project. URL: <http://qgis.osgeo.org>
 - Rasmont P (1981) Contribution à l'étude des bourdons du genre *Bombus* Latreille, 1802 sensu stricto (Hymenoptera, Apidae, Bombinæ). Faculté des Sciences Agronomiques de l'État Gembloux (Belgique), Gembloux, 146 pp. [In French].
 - Rasmont P (1984) Les bourdons du genre *Bombus* Latreille sensu stricto en Europe Occidentale et Centrale (Hymenoptera, Apidae). Spixiana 7 (2): 135-160. [In French].
 - Rothmaler W (2009) Exkursionsflora von Deutschland 3. Gefäßpflanzen: Atlasband. Herausgeg. v. E.J. Jäger & K. Werner. 11. Auflage. Spektrum Akademischer Verlag, Berlin, Heidelberg, 753 pp. [In German]. [ISBN 3827418429]
 - Sambrook J, Fritsch EF, Maniatis T (1989) Molecular cloning. 2. Cold spring harbor laboratory press, New York, 1626 pp. [In English].
 - Schedl W (1982) Über aculeate Hautflügler der zentralen Ötztaler Alpen (Tirol, Österreich) (Insecta: Hymenoptera). Ber. nat.-med. Ver. Innsbruck 69: 95-117. [In German].
 - Scheuchl E (1995) Illustrierte Bestimmungstabellen der Wildbienen Deutschlands und Österreichs. Band I: Anthophoridae. Eigenverlag, Velden, 158 pp. [In German].
 - Scheuchl E (2006) Illustrierte Bestimmungstabellen der Wildbienen Deutschlands und Österreichs. Band II: Megachilidae - Melittidae. Zweite erweiterte Auflage. Eigenverlag, 192 pp. [In German].
 - Schletterer A (1887) Die Bienen Tirols. Jber. k. k. Staatsrealschule II. Bez. Wien 12: 3-28. [In German].

- Schmid-Egger C (2011) Die Stechimmenfauna (Hymenoptera Aculeata) im Naturpark Tiroler Lech in Österreich. Linzer biol. Beitr. 43 (1): 549-563. [In German].
- Schmid-Egger C, Scheuchl E (1997) Illustrierte Bestimmungstabellen der Wildbienen Deutschlands und Österreichs. Band III: Andrenidae. 3. Eigenverlag, Velden, 180 pp. [In German].
- Schuler K (1982) Blütenbesuch durch Insekten an *Solidago canadensis* und *S. virgaurea*, eine vergleichende Studie. Ber. nat.-med. Ver. Innsbruck 69: 127-144. [In German].
- Schwarz M (1986) Revision der Nomada-Arten der Sammlung C. G. Thomson (Hymenoptera, Apoidea). Entomofauna 7 (35): 469-484. [In German].
- Schwarz M, Gusenleitner F, Westrich P, Dathe HH (1996) Katalog der Bienen Österreichs, Deutschlands und der Schweiz (Hymenoptera, Apidae). Entomofauna Supplement 8: 1-398. [In German].
- Smit J (2004) De Wespbijen (*Nomada*) van Nederland (Hymenoptera: Apidae). Nederlandse Faunistische Mededelingen 20: 33-126. [In Dutch].
- Sømme L (1989) Adaptions of Terrestrial Arthropods to the Alpine Environment. Biological Reviews 64 (4): 367-407. [In English]. DOI: [10.1111/j.1469-185X.1989.tb00681.x](https://doi.org/10.1111/j.1469-185X.1989.tb00681.x)
- Stöckl P (1996) Artengarnitur und Blütenbesuch von Wildbienen an vier xerothermen Standorten zwischen Kranebitten und Zirl (Nordtirol, Österreich)(Hymenoptera: Apoidea). Ber. nat.-med. Ver. Innsbruck 83: 279-289. [In German].
- Stöckl P (1998) Die Wildbienen ausgewählter Xerothermstandorte des Oberinntales (Nordtirol, Österreich). Ber. nat.-med. Ver. Innsbruck 85: 287-327. [In German].
- Stöckl P (2000) Synopsis der Megachilinae Nord-und Südtirols (Österreich, Italien). Ber. nat.-med. Ver. Innsbruck 87: 273-306. [In German].
- Stoeckert E (1930) *Nomada* F. In: Schmiedeknecht O (Ed.) Die Hymenopteren Nord- und Mitteleuropas. 2. Auflage. Gustav Fischer, Jena, 1062 pp. [In German].
- Straka J, Bogusch P, Přidal A (2007) Apoidea: Apiformes (včely). In: Bogusch P, Straka J, Kment P (Eds) Annotated checklist of the Aculeata (Hymenoptera) of the Czech Republic and Slovakia. Komentovaný seznam žahadlových blanokřídlych (Hymenoptera: Aculeata) České republiky a Slovenska. Supplementum, 11. Acta Entomologica Musei Nationalis Pragae, Praha, 300 pp. [In English and Czech].
- Utelli AB, Roy BA (2000) Pollinator abundance and behavior on *Aconitum lycoctonum* (Ranunculaceae): an analysis of the quantity and quality components of pollination. Oikos 89 (3): 461-470. [In English].
- Warncke K (1981) Die Bienen des Klagenfurter Beckens (Hymenoptera, Apidae). Carinthia II 171 (91): 275-348. [In German].
- Waters J, Darvill B, Lye GC, Goulson D (2011) Niche differentiation of a cryptic bumblebee complex in the Western Isles of Scotland. Insect Conservation and Diversity 4: 46-52. [In English]. DOI: [10.1111/j.1752-4598.2010.00101.x](https://doi.org/10.1111/j.1752-4598.2010.00101.x)
- Westrich P, Frommer U, Mandery K, Riemann H, Ruhnke H, Saure C, Voith J (2008) Rote Liste der Bienen Deutschlands (Hymenoptera, Apidae)(4. Fassung, Dezember 2007). Eucera 1 (3): 33-87. [In German].
- Williams PH (1998) An annotated checklist of bumble bees with an analysis of patterns of description (Hymenoptera: Apidae, Bombini). Bulletin of The Natural History Museum (Entomology) 67: 79-152. [In English].

- Williams PH (2000) Are *Bombus lucorum* and *magnus* separate species? BWARS Newsletter 2000 (1): 15-17. [In English].
- Williams PH (2014) *Bombus* - Species world-wide listed by old and new subgenera. Accessed 09/06/2014. URL: <http://www.nhm.ac.uk/research-curation/research/projects/bombus/subgenericlist.html>
- Williams PH, Brown MJ, Carolan JC, An J, Goulson D, Aytekin AM, Best LR, Byvaltsev AM, Cederberg B, Dawson R, Huang J, Ito M, Monfared A, Raina RH, Schmid-Hempel P, Sheffield CS, Šima P, Xie Z (2012) Unveiling cryptic species of the bumblebee subgenus *Bombus* s. str. worldwide with COI barcodes (Hymenoptera: Apidae). Systematics and Biodiversity 10 (1): 21-56. [In English]. DOI: [10.1080/14772000.2012.664574](https://doi.org/10.1080/14772000.2012.664574)
- Zettel H, Ebmer AW, Wiesbauer H (2008) Zur Kenntnis der Wildbienen (Hymenoptera: Apidae) in Wien, Niederösterreich und dem Burgen land (Österreich) – 4. Beiträge zur Entomofaunistik 9: 13-30. [In German].

Supplementary materials

Suppl. material 1: Plant species and flower visiting bee species

Authors: Silas Bossert

Data type: Flower records

Brief description: The list provides the plant species on which flower visits by bees could be observed during this study. Additionally, the respective flower visiting bee species are listed.

Filename: flower_visits.xlsx - [Download file](#) (10.23 kb)

Suppl. material 2: Partial COI sequence of the *Bombus cryptarum* voucher

Authors: Silas Bossert

Data type: mitochondrial DNA sequence

Brief description: The fasta file contains the partial cds of the COI gene from the *Bombus cryptarum* voucher investigated in this study.

Filename: partial_cds_bombus_cryptarum.fas - [Download file](#) (658.00 bytes)