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Threat Ahead? An Experts' Opinion on the Need for Red Lists of Bees to Mitigate Accelerating Extinction Risks – The Case of Austria

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Introduction

Wild bees are among the most important pollinators for zoophilous wild plants and crops (Klein et al., 2007; Kremen et al., 2007; Ollerton et al., 2011). They provide a key ecosystem function, as zoophilous plants depend on adapted visitors for effective reproduction, and many organisms of other trophic levels in turn depend on plant products as food resources (Abrol, 2012). Land use change along with agricultural intensification are major drivers for biodiversity loss (Beckmann et al., 2019; Butchart et al., 2010). The close relation of wild bees and plants increases the risk of cascading extinctions with severe consequences for resilient ecosystem function (Papanikolaou et al., 2017). Therefore the protection and successful conservation of both wild bees and plants is of utmost importance to cope with ongoing biodiversity loss and ensure human well-being (Potts et al., 2016; Senapathi et al., 2015).

Red Lists are important tools for nature conservation, especially if up-to-date information on the threat status of species is available. By using standardized methods for the risk assessments, like the IUCN criteria and guidelines (IUCN, 2012), Red Lists can serve as baseline for policy recommendations to foster species and habitat conservation and help to increase public awareness regarding biodiversity loss (IUCN, 2015; Zulka, 2005). Further, by re-evaluating the species' status periodically, conservation trends can be demonstrated.

Why Do we Need a National Red List of Wild Bees in Austria?

Due to the high diversity of habitats (e.g., elevation and climatic zones) within a small area, Austria's wild bee diversity is high compared to other Central European countries, with currently 702 species listed (Wiesbauer, 2020). Austria is also a bumble bee (*Bombus* spp.) diversity hot-spot (Williams, 1996) and hosts 46 of the globally approximately known 250 species (Rasmont et al., 2015); therefore the country has a particularly high conservation responsibility towards bumble bees. It is therefore surprising, if not embarrassing, that Austria is one of the last Central European countries where no national Red List of Bees has yet been published (Figure 1) and only a probably outdated Red List of Bees of the federal state of Carinthia exists (Ebmer, 1999). The conservation status of species listed in the European Red List of Bees (Nieto et al., 2014) or in other national Red Lists, e.g., the German Red List (Westrich et al., 2011), cannot be considered identical for the Austrian bee fauna, due to its differing geographical framework. In February 2020 wild bee experts from Austria established the Austrian Wild Bee Council ("Österreichischer Wildbienenrat," see Naturschutzbund Österreich, 2020) and decided that the compilation of an Austrian Red List of Bees is an important goal in the near future. The present article is a starting point for achieving this goal and evaluates extinct wild bee species in

Austria. We stress the urgent need for an up-to-date Red List of Bees in Austria, which will provide a tool for wild bee conservation and contribute to cope with ongoing biodiversity loss in the country.

How Was the Extinction of a Species Evaluated?

The national border of Austria defines the geographic scope for the species selection, and the Austrian wild bee checklist (Gusenleitner et al., 2012) provided the base for the species considered in this

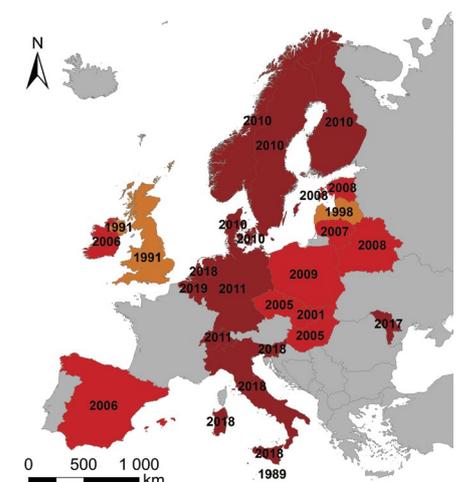


Figure 1. Map of Europe presenting countries with (red) and without (grey) national Red Lists of Bees including year of latest published Red List per country according to Wood et al. (2020). Different shades of red were used for different decades of publication.

Table 1. List of extinct wild bee species in Austria including their last record per federal state and the information source.

Species	Last record per Federal State	Source
<i>Amegilla quadrifasciata</i> (Villers, 1789)	B: 1940 N: 1935	B + N: Pittioni and Schmidt, 1942
<i>Ammobatooides abdominalis</i> (Eversmann, 1852)	B: 1962 N: 1954	B + N: Coll: OÖLM*
<i>Andrena granulosa</i> Pérez, 1902	N: 1942	Pittioni and Schmidt, 1943
<i>Andrena hungarica</i> Friese, 1887	N: 1937	Pittioni and Schmidt, 1943
<i>Andrena morio</i> Brullé, 1832	B: 1965 N: 1934	B: Coll. Max Schwarz* N: Pittioni and Schmidt, 1943
<i>Andrena simillima</i> Smith, 1851	N: 1930ies O: 1951	N: Pittioni and Schmidt, 1943 O: Coll. OÖLM*
<i>Andrena transitoria</i> Morawitz, 1871	B: 1960 N: 1942	B: Coll. Max Schwarz* N: Pittioni and Schmidt, 1943
<i>Anthophora borealis</i> Morawitz, 1865	B: 1965	Schwarz and Gusenleitner, 1997
<i>Anthophora plagiata</i> (Illiger, 1806)	O: 1953 W: 1942	O: Coll. OÖLM* W: Pittioni and Schmidt, 1942
<i>Bombus armeniacus</i> Radoszkowski, 1877	B: 1951 N: 1930	B + N: Coll. NHMW*
<i>Bombus fragrans</i> Pallas, 1771	B: 1967 N: 1967	B + N: Malicky, 1975
<i>Bombus laesus</i> ¹ Morawitz, 1875	B: 1960 N: 1955	B: Coll. Bav. State Coll. of Zoology, Munich N: Coll. Mus. Humboldt-Univ., Berlin
<i>Colletes albomaculatus</i> (Lucas, 1849)	N: 1952	Apidat; Coll: OÖLM°
<i>Colletes punctatus</i> Mocsáry, 1877	B: 1940 N: 1962 W: <1962	B: Pittioni, n.d.; manuscript N: Coll. Ebmer* W: Coll. OÖLM*
<i>Dasygaster braccata</i> Eversmann, 1852	B: 1940 N: 1940	B + N: Pittioni and Schmidt, 1943
<i>Dasygaster suripes</i> (Christ, 1791)	B: 1932 N: 1940	B + N: Pittioni and Schmidt, 1943
<i>Epeolus fasciatus</i> Friese, 1895	B: 1940	Pittioni and Schmidt, 1942
<i>Eucera pannonica</i> Mocsary, 1878	B: <1961	Gusenleitner et al., 2012; Coll. ETHZ°
<i>Halictus scardicus</i> Blüthgen, 1936	N: 1904	Ebmer, 1988
<i>Hoplitis manicata</i> Morice, 1901	B: 1962	Coll. OÖLM*
<i>Hylaeus crassanus</i> (Warncke, 1972)	W: <1900	Coll. NHMW*
<i>Nomada basalis</i> Herrich-Schäffer, 1839	B: 1954	Apidat
<i>Nomada blepharipes</i> Schmiedeknecht, 1882	B: 1940 K: 1951	B: Pittioni and Schmidt, 1943 K: Apidat; Coll. Ferdinandeum°
<i>Nomada bluethgeni</i> Stoekchert, 1943	St: <1947	Apidat; Coll. Joanneum°
<i>Nomada corcyraea</i> Schmiedeknecht, 1882	B: <1967	Apidat; Coll. Max Schwarz°
<i>Nomada flavilabris</i> Morawitz, 1875	N: 1955	Apidat
<i>Nomada mauritanica</i> Morawitz, 1872	B: 1962 N: 1937 W: 1960	B: Apidat N: Pittioni index cards W: Apidat
<i>Nomada melathoracica</i> Imhoff, 1834	N: 1953 St: before 1967 W: before 1943	N: Apidat; Coll. Max Schwarz° St: Apidat; Coll. Joanneum° W: Pittioni and Schmidt, 1943
<i>Nomada pulchra</i> Arnold, 1888	W: 1887	Coll. NHMW*
<i>Nomada tridentirostris</i> Dours, 1873	W: 1885	Coll. NHMW*
<i>Pseudapis femoralis</i> (Pallas, 1773)	N: 1954	Coll. OÖLM*
<i>Tetraloniella pollinosa</i> (Lepeletier, 1841)	B: 1886 N: 1935	B + N: Pittioni and Schmidt, 1942
<i>Thyreus ramosus</i> (Lepeletier, 1841)	B: <1942 N: <1942 T: <1921	B + N: Molitor, 1942 T: Meyer, 1921

Note:

Abbreviations: B = Burgenland, N = Lower Austria, K = Carinthia, O = Upper Austria, St = Styria, T = Tyrol, V = Vorarlberg, W = Vienna; < = before; Coll. = Collection; OÖLM = Biology Centre Linz; NHMW = Natural History Museum Vienna; NÖLM = Lower Austrian Museum; Apidat = Database of the Entomological working group of the Biology Centre Linz.

¹A single specimen found in the Vienna Botanical Garden in 1998 is treated as brought in – maybe with plant material, as the author suspects (Hölzler, 2000).

*Voucher specimen present in respective collection and reviewed.

°Database entry or literature refers to a collection, but voucher specimen not reviewed.

For an expanded list – including detailed reference according to IUCN Red List homepage, habitat requirements and evaluating expert – see supplementary materials: Table S1.



Figure 2. One example of a species we evaluated Extinct for Austria is *Tetraloniella pollinosa* (picture © Heinz Wiesbauer). The species is xero-thermophilic, solitary and prefers open grasslands with sandy soils as habitat (Quaranta, 2014).

evaluation. The nomenclature for this work is according to Scheuchl and Willner (2016). Following Zülka (2009), a species was evaluated “Extinct” (EX) if it was not recorded in the past 50 years in its known or expected distribution area (IUCN, 2012). The species were split up into taxonomic groups (genus level) and the respective experts (Table S1) evaluated the status of the assigned species. Taxa for which our expertise was insufficient, were also split up and the responsible persons consulted the respective experts during the evaluation process. Information was gathered from literature, data extraction from Apidat (Database of the Entomological working group of the Biology Centre Linz), databases and collections at museums or universities and private collections. Since we focused on the Austrian bee fauna, the literature database Zobodat (www.zobodat.at) and mainly local faunistic journals (e.g., “Beiträge zur Entomofaunistik” ISSN: 1563-1400 or “Linzer biologische Beiträge” ISSN: 0253-116X) were screened for relevant literature. After evaluation by the experts the findings were discussed in the group and therefore represent scientific consensus.

Results and Discussion

In total, we evaluated 33 (4.7%) wild bee species of the 702 species listed for Austria (Wiesbauer, 2020) as Extinct for this country (Table 1; Figure 2). Over 65% of these 33 species are xero-thermophilic and over 85% require habitats with open vegetation characteristics such as steppe-like habitats, extensively managed grasslands, fallows or field and road margins (Table S1). It is also noteworthy, that over 30% of the extinct species are brood parasitic, which is an alarming sign, because population condition of a parasitic species also reflects the

population condition of its host (Hudson et al., 2006). To enhance resilient ecosystem function it is essential to protect the genetic diversity and regional populations of species, enabling adaptation to environmental changes such as climate change.

Species not threatened at the European level, may be threatened or even extinct in Austria. This is also highlighted by our results, because about 50% of the species we evaluated Extinct for Austria (Table S1) were considered Near Threatened (NT) or Least Concern (LC) by Nieto et al. (2014), indicating that the European Red List of Bees is not an adequate reference for the threat status of wild bee species in Austria. This can be explained by the habitat requirements and the distribution of these species (derived from Scheuchl and Willner, 2016): Most of them are xero-thermophilic, reach their northern limit in Austria and are mainly distributed in the Mediterranean region. The highest amounts of extinct species are present in the federal states of Lower Austria, Vienna and Burgenland, which are also the federal states with the highest bee species richness in Austria (Gusenleitner et al., 2012). This points out the utmost need of a tool, such as a Red List, to foster adequate wild bee conservation measures in Eastern Austria – the region in Austria which underwent severe land-use change during the last 70 years (e.g., Krausmann et al., 2003). But also many alpine regions came under pressure by increasingly intensive grassland management or tourism development as well as climate change (e.g., Tasser et al., 2017).

We came across several questionable species for which occurrence in Austria is not certain (Table S2) due to taxonomic problems, possible misidentification, the existence of only a single record without any traceable vouchers or possibly mistaken location documentary. Table S2 only shows a part of questionable species in Austria and many more have to be reviewed in the course of working on the Austrian Red List of Bees. It has to be decided for each case whether questionable species should remain in the Austrian wild bee checklist after the complete revision. Data deficiency is a major obstacle when compiling such lists (Nieto et al., 2014), which is also true for Austria. Available wild bee records across Austria need to be merged into one national database, which also involves the digitization and spatial localization of many vouchers present in museums

and other collections. Especially existing records of numerous old vouchers and questionable species make revisions by experts essential to provide a solid database for the following threat assessments. Further, it is important to identify locations or regions where re-collection of species with deficient data is needed. Experts need to work on re-collection and assess whether habitats for the species of interest still exist within the species’ distribution areas, or have fallen victim to land use changes in recent decades. It may be possible, that species evaluated Extinct here, may be found again during re-collection activities.

The reasons for compiling an up-to-date national Red List of Bees are clear. Although there are justified concerns of increased bureaucratic obstacles for experts to conduct research and monitoring on wild bees once a national Red List exists, we argue that a national Red List of Bees is crucial to meet conservation targets for this ecologically highly important organism group. The members of the Austrian Wild Bee Council are eager to roll up their sleeves and accomplish all necessary tasks for a Red List of Bees, but adequate funding for this very comprehensive project is urgently required.

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Supplementary material

Supplementary Tables S1 and S2 are available via the “Supplementary” tab on the article’s online page (<http://dx.doi.org/10.1080/10.1080/0005772X.2021.1940734>).

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Sophie Kratschmer*

Institute of Zoology, University of Natural Resources and Life Sciences, Vienna, Austria

*Email: sophie.kratschmer@boku.ac.at
<https://orcid.org/0000-0002-6538-694X>

Herbert Zettel, Dominique Zimmermann, Sabine Schoder, and Katharina Zenz

2nd Zoological Department, Natural History Museum, Vienna, Austria
 Herbert Zettel <https://orcid.org/0000-0002-7760-0472>

Dominique Zimmermann <https://orcid.org/0000-0002-3075-6752>

Sabine Schoder <https://orcid.org/0000-0002-2822-2196>

Katharina Zenz <https://orcid.org/0000-0002-8103-2711>

Esther Ockermüller

Biology Centre Linz, Linz, Austria
<https://orcid.org/0000-0001-6279-9442>

Johann Neumayer

Independent Entomologist, Elixhausen, Austria

<https://orcid.org/0000-0001-9577-6618>

Fritz Gusenleitner

Independent Entomologist, St. Georgen/Gusen, Austria

Karl Mazzucco

Independent Entomologist, Vienna, Austria

Andreas W. Ebmer

Science Consultant of the Federal State Government of Upper Austria, Austria

Michael Kuhlmann

Zoological Museum of Kiel University, Kiel, Germany

<https://orcid.org/0000-0003-3664-6922>

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Autor(en)/Author(s): Kratschmer Sophie Anna, Zettel Herbert, Ockermüller Esther, Zimmermann Dominique, Neumayer Johann, Gusenleitner Fritz Josef [Friedrich], Zenz Katharina, Mazzucco Karl jun., Ebmer Andreas Werner, Kuhlmann Michael

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