

The Northern Birch Mouse (*Sicista betulina*) in Austria: A Review of Occurrence Records and Insights into Its Fragmented Distribution

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The Northern Birch Mouse (*Sicista betulina*) is among the least studied mammal species in Austria. Despite its wide distribution across Eurasia, populations at the western edge of its range, including Austria, are fragmented and often isolated. This study compiles confirmed records (photo-documented record or voucher) of the species in Austria based on scientific literature, biodiversity databases, museum collections, and field surveys. A total of 78 occurrence record localities (sites) from the period 1964–2025 were identified and georeferenced. The analysis identifies three spatially distinct subareas in Austria: (1) Mühlviertel + = Mühlviertel including a small part of the northwestern Waldviertel (Upper and Lower Austria, north of the Danube), as part of a transboundary occurrence; (2) Styrian Northern Alps–Central Alps = encompassing the Northern Alps of Styria and the adjacent southwestern Central Alpine regions in Salzburg, Styria, and Carinthia; and (3) the Bregenzerwald = a montane region in Vorarlberg in western Austria. The study highlights the need for further targeted surveys to better assess potential genetic isolation among populations within these subareas and to reliably evaluate the actual conservation status of this specialised species.

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Die Waldbirkenmaus (*Sicista betulina*) zählt zu den am wenigsten untersuchten Säugetierarten Österreichs. Trotz ihres großen Verbreitungsgebiets in Eurasien sind die Vorkommen am westlichen Rand, worunter in Österreich, fragmentiert und oft isoliert. Diese Studie stellt bestätigte Nachweise der Art (Nachweis durch Fotodokumentation oder Belegexemplar) in Österreich auf Basis wissenschaftlicher Literatur, Biodiversitätsdatenbanken, Museumssammlungen und Feldstudien zusammen. Insgesamt wurden 78 Nachweisstandorte (Fundorte) aus dem Zeitraum 1964–2025 identifiziert und georeferenziert. Die Analyse weist drei räumlich getrennte Teilareale in Österreich aus: (1) Mühlviertel+ = Mühlviertel einschließlich eines kleinen Bereichs im nordwestlichen Waldviertel (Ober- und Niederösterreich, nördlich der Donau) als Teil eines grenzüberschreitenden Vorkommens; (2) Steirische Nordalpen–Zentralalpen = umfassend die nördlichen Kalkalpen der Steiermark sowie die angrenzenden südwestlichen Zentralalpenräume in Salzburg, der Steiermark und Kärnten; und (3) Bregenzerwald = eine montane Region in Vorarlberg in Westösterreich. Die Studie unterstreicht den Bedarf an weiteren gezielten Erhebungen, um eine mögliche genetische Isolation von Populationen innerhalb der Teilareale besser zu beurteilen und die tatsächliche Gefährdungslage dieser spezialisierten Art verlässlich einschätzen zu können.

Keywords: *Sicista betulina*, occurrence record, fragmented populations, small mammals, biogeography, databases, conservation, Austria.

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Introduction

With a body length of 5.8–7.6 cm and a body mass of 5–10 g (up to 13.5 g directly prior to hibernation (Grimmberger 2017)), *Sicista betulina* belongs to the smaller rodent species in Central Europe. A distinctive morphological characteristic is the narrow, dark-pigmented dorsal stripe, approximately 2–3 mm in width, running continuously along the midline from the forehead across the nape and back to the base of the tail. The fur is typically greyish brown to yellowish, and the sparsely haired tail measures approximately 130 % of the body length (Pucek 1982; Grimmberger 2017).

The species' distribution extends from Denmark in the west to Lake Baikal in Russia in the east, and from Romania in the south to Norway, Finland and Russia in the north. At the western end of its range namely in Norway, Sweden, Denmark, Germany, the Czech Republic, and Austria—occurrences are typically small and isolated (Mitchell-Jones 1999; Pilats & Pilats 2009; Meinig et al. 2016). This pattern is also observed in Austria, where traditionally two main occurrence areas were distinguished: a population in the Mühlviertel of Upper Austria, extending across the border into Germany and Czech Republic as part of a transboundary range (Resch et al. 2023a; Poledník et al. 2024), and a second occurrence area in the Austrian Alps, extending from Vorarlberg in the west to the Rax massif in Lower Austria in the east, with most record sites located in the Central Alps (Hable & Spitzenberger 1989; Spitzenberger 2001). Based on the updated dataset compiled in the present study, the Alpine occurrences can be further subdivided into two spatially distinct subareas: (1) the Styrian Northern Alps–Central Alps region and (2) the Bregenzerwald in western Austria.

Sicista betulina inhabits moist, open to semi-open habitats with dense ground vegetation. In the Alps, the species typically occurs in transitional and mosaic habitats such as alpine meadows, open mountain forests, moors, and dwarf-shrub heaths, mostly at higher elevations near the tree line (Hable & Spitzenberger 1989; Spitzenberger 2001). In contrast, in the Mühlviertel, the species also occurs at lower altitudes in extensively managed grasslands, wet meadows, and forest edges (Poledník et al. 2024; Resch et al. 2023a). These specialised habitats are increasingly under anthropogenic pressure. It is assumed that climate change – particularly the loss of wetlands – together with infrastructure development (e.g. ski resorts and renewable-energy facilities) contribute to the ongoing fragmentation of the species' range. In addition, the decline in insect biomass as an important food source represents a further threat. This decline is driven by intensive agriculture, insecticide use, and forestry practices that remove excessive amounts of deadwood (Spitzenberger 2001, 2006; Zulka 2005; Poledník et al. 2024; Resch & Resch 2024). In the Alpine region, both the abandonment of traditional alpine farming and the intensification of land use further reduce habitat availability (Resch & Resch 2021, 2024).

Despite the species' vulnerable status, considerable knowledge gaps remain regarding its current distribution and population structure in Austria. Under the EU Habitats Directive, the conservation status of *S. betulina* was assessed as “unfavourable – inadequate” for the 2013–2018 reporting period (Council Directive 92/43/EEC). The most recent published Red List of endangered animal species in Austria classifies *S. betulina* as “vulnerable (VU)” (Zulka 2005). Regional surveys in Vorarlberg, Salzburg, Upper Austria, Styria, and Carinthia

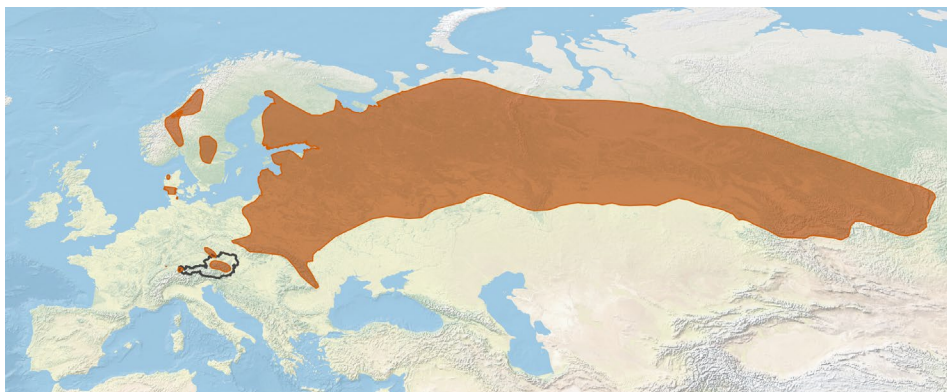


Fig. 1: Distribution of the Northern Birch Mouse (*Sicista betulina*), with Austria highlighted; Base map: IUCN (2016-vers.3.1). | **Abb. 1:** Verbreitung der Waldbirkenmaus (*Sicista betulina*), Österreich hervorgehoben (Kartengrundlage: IUCN (2016-vers.3.1.)

have yielded valuable data in recent years (Blatt & Resch 2014; Resch & Resch 2019; Resch et al. 2021, 2023b, 2026; van der Kooij et al 2025). Nevertheless, the available information on the species' distribution in Austria remains outdated: the last systematic compilation including years of record and types of evidence was published by Hable & Spitzenberger (1989) and the most recent nationwide distribution map appeared in “*Die Säugetierfauna Österreichs*” in 2001 (Spitzenberger 2001). *Sicista betulina* therefore remains one of the least studied mammal species in Austria. Limited detectability – particularly when using conventional small-mammal survey methods applied in the past – has contributed substantially to this lack of knowledge (Meinig et al. 2015).

Recent technological advances and decreasing costs have enabled the effective use of camera traps even for small mammals, particularly members of Muridae, Arvicolinae, Gliridae, and Soricidae (Di Cerbo & Biancardi 2013; Resch & Blatt 2017b; Mölle et al. 2022; Kleiven et al. 2022; Hopkins et al. 2024; Verhees et al. 2024). As a result, new occurrences of *S. betulina* have been documented through systematic faunistic surveys in recent years (van der Kooij et al. 2016, 2025; Resch & Blatt 2017a; van der Kooij & Möller 2017, 2018; Stille et al. 2018; Schulz & Schulz 2021; Poledník et al. 2024; Resch & Resch 2019, 2024).

The aim of this paper is to compile and present recent occurrence sites of *Sicista betulina* in Austria. This updated dataset is intended to improve understanding of the species' ecological requirements and fragmented distribution and to provide a robust basis for further faunistic surveys.

Material and Methods

Data Compilation on Species Occurrence

To assess the distribution of *S. betulina* in Austria, we conducted a data-driven distributional analysis incorporating confirmed records from the published literature as well as photographic evidence submitted via public reporting platforms. Confirmed records (“C1”)

followed the categorisation used in recent small-mammal syntheses (Kubista et al., 2025; Resch & Resch, 2025; Meinig et al., 2023) and included (i) verified literature records (e.g. photo-documented observations, voucher specimens deposited in collections, or specimens donated, collected, or otherwise secured) and (ii) verifiable photographic submissions from public reporting platforms.

The following data sources were considered:

Scientific publications including record type descriptions: Hable & Spitzenberger (1989), which summarises earlier findings from Gortlieb (1951), Wettstein (1955, 1965a, 1965b), Bauer (1964), Bauer & Wettstein (1965), Hable (1964, 1971a–c, 1976, 1978), Kepka & Mayrhofer (1973), Kepka (1974), Zejda (1970), Petz (1979), Krainer (1986), and Frey & Walter (1986); as well as Spitzenberger (2006), Slotta-Bachmayr & Gressel (1994), Engleder et al. (2005), Engleder & Roth (2006), Sackl et al. (2016), Resch & Resch (2017, 2019, 2020, 2024), Resch et al. (2021, 2023), Poledník et al. (2024) and van der Kooij et al. (2025).

Biodiversity databases: naturbeobachtung.at (Naturschutzbund Österreich 2026), GeoMaus (2026), GBIF.org (2026) including records from iNaturalist (2026) and observation.org (2026), Biodiversity Database Salzburg (Haus der Natur Salzburg 2026), and the Zoological Research Museum Alexander Koenig, Bonn (2026).

Museum collections and specimen records: Landesmuseum Oberösterreich (May 2025), Landessammlungen Niederösterreich (May 2025), Tiroler Landesmuseen (May 2025), inatura – Erlebnis Naturschau Dornbirn (May 2025), Universalmuseum Joanneum (May 2025), Landesmuseum Kärnten (May 2025), and Naturhistorisches Museum Wien (May 2025).

Duplicate records were removed, giving preference to published sources as these are publicly accessible and often provide more detailed information on individual records (e.g. habitat data or the type of voucher). To avoid overrepresentation of intensively surveyed localities – particularly in subsequent assignments to ecoregions – only the most recent record date was retained where multiple records referred to the same site, as the objective of this study was to compile occurrence sites rather than to analyse temporal reporting intensity at individual localities. For the purpose of this study, an occurrence site was defined as being separated from any other site by at least 500 m; records falling within this distance were treated as referring to the same site. This 500 m threshold was chosen as a conservative operational rule to reduce pseudo-replication by consolidating nearby records that likely refer to the same locality into a single occurrence site. For systematic camera-trap studies (Resch & Blatt 2017a, 2017b; Resch & Resch 2019, 2020, 2024; Resch et al. 2021, 2023b; van der Kooij et al. 2025), a representative point of the study area was used instead of individual detection locations. The resulting dataset therefore represents occurrence sites and is not intended to provide a complete list of all individual reports per site.

The resulting records, spanning the period from 1964 (the first confirmed occurrence of *Sicista betulina* in Austria; Hable 1964) to 2025, were georeferenced in the WGS 84 coordinate system with a precision of at least two decimal degrees, corresponding to a positional uncertainty of approximately 1 km.

Visualisation and Spatial Analysis

The dataset was mapped in two formats: (1) as exact occurrence points grouped into four time intervals (1964–1990, 1990–2009, 2010–2019, and 2020–2025), and (2) as spatially aggregated records within a 10 km × 10 km ETRS89-LAEA grid. This grid corresponds to the standard used for distribution mapping in Article 17 reporting under the Habitats Directive (European Environment Agency 2020) and thus ensures national and international comparability. Moreover, this grid resolution provides a robust overview of broad-scale patterns and reduces artefacts caused by uneven sampling effort, which can influence finer grids. Within each grid cell, only the most recent record was retained and assigned to the same four time intervals to ensure comparability between point-based and grid-based visualizations. The time intervals were defined based on the temporal distribution of the available data: they begin with the first confirmed record in Austria (1964) and represent a stepped temporal resolution, with older periods aggregated more broadly, while recent records (2020–2025) were shown as a separate class to highlight their recency.

Subsequently, all occurrence points were spatially assigned to five out of ten Austrian ecoregions according to Umweltbundesamt GmbH (2024): Central Alps – Central part; Central Alps – Southeastern part; Granite and Gneiss Highlands; Eastern Northern Alps, Western and Central Northern Alps,

Results

A total of 80 verified occurrence sites of *Sicista betulina* in Austria were compiled. These sites originate from the following sources:

- **Scientific publications (n = 58):** Hable & Spitzenberger (1989) (32), Spitzenberger (2006) (3), Slotta-Bachmayr & Gressel (1994) (1), Engleder et al. (2005) (2), Petz (1979) (1), Engleder & Roth (2006) (1), Sackl et al. (2016) (1), Resch & Blatt (2017a) (1), Resch & Resch (2019) (2), Resch & Resch (2020) (1), Resch et al. (2021) (3), Resch et al. (2023) (3), Poledník et al. (2024) (1), Resch & Resch (2024) (2), van der Kooij et al. (2025) (5) and Resch & Resch (2026) (1)
- **Biodiversity databases (n = 10):** naturbeobachtung.at (2), GeoMaus (1), GBIF.org (7; including iNaturalist [1], observation.org [2], Biodiversity Database Salzburg [3], Zoological Research Museum Alexander Koenig, Bonn [1])
- **Museum collections (n = 8, unpublished records not included in the other data sources):** Naturhistorisches Museum Wien (6), inatura – Erlebnis Naturschau Dornbirn (2)

The records are distributed across the following Austrian ecoregions (Fig. 1):

- **Granite and Gneiss Highlands:** Eleven records originate from the Mühlviertel in Upper Austria (10) and the Waldviertel in Lower Austria (1). This region is situated in northern Austria and forms part of the ecoregion Granite and Gneiss Highlands, a geologically distinct unit within the southern margin of the Bohemian Massif.

- Eastern Northern Alps: nine records originate from the eastern part of the Northern Alps within the Styrian Northern Alps.
- Central Alps (Central and Southeastern part): The majority originate from this ecoregion ($n = 50$), with 37 records located in the central part and 13 in the south-eastern part.
- Western and Central Northern Alps: eight records originate from the western part of the Northern Alps, specifically the Bregenzerwald region in Vorarlberg.

Based on the spatial clustering of records, three distinct distributional subareas were delineated (Fig. 2):

1. Mühlviertel+ (Subarea 1): Includes parts of the Bohemian Forest, the *Leonfelder Hochland and the Freiwald* region (Upper Austria), with “+” indicating a small adjacent area in the north-western Waldviertel (Lower Austria). The occurrence of *Sicista betulina* in the northern Mühlviertel forms part of a transboundary population range extending along the Austrian–Czech–German border (Poledník et al. 2024). Within the Austrian range considered here, occurrence sites have been documented in the Bohemian Forest between 1968 and 2024: Plöckenstein, Schwarzenberg am Böhmerwald municipality (most recently in 2019; Resch et al. 2023b), Klaffer am Hochficht municipality (last recorded in 1968; Petz 1979), and Aigen-Schlögl municipality (most recently in 2024; Resch & Resch 2026). Further east, confirmed occurrence sites are known from the eastern Mühlviertel – Sandl municipality (most recently in 2005; Engleder et al. 2005), Leopoldschlag municipality (2016; Resch & Blatt 2017a), and Liebenau municipality (2025; GeoMaus 2025). In addition to the Mühlviertel, a small adjacent area in the Waldviertel of Lower Austria has been documented (Poledník et al. 2024), with the most recent record from 2017 in Stadlberg, municipality of Bad Großpertholz.

2a. Styrian Northern Alps (Subarea 2a): Covers the Ennstal Alps, the Hochschwab Group, and the *Mürzsteiger Alps* in the federal state *Styria*. The known distribution area comprises three mountain ranges: the Ennstal Alps, the Hochschwab Group, and the Mürzsteg Alps. In the Ennstal Alps, the most recent record was obtained during a mapping survey in Gesäuse National Park in 2019, specifically at the Scheucheggalm and Sulzkaralm (Resch & Resch 2019). In the Hochschwab Group, an incidental observation was documented near the Fölzsattel in 2015 (iNaturalist). In the Mürzsteg Alps, the most recent confirmed record dates to 2021 (naturbeobachtung.at). As outlined by Resch & Resch (2024), populations in the Styrian Northern Alps are assumed to be isolated due to the region’s pronounced topographic structure. The Paltental Valley, a prominent longitudinal valley oriented from south-east to north-west, constitutes a natural boundary between the Northern and Central Alps and likely acts as a present-day barrier to dispersal into subarea 2b.

2b. Central Alps (Subarea 2b): Including the High and Low Tauern, as well as the Nockberge; covering the federal states of Salzburg, Styria, and Carinthia. The distribution range includes High and Low Tauern as well as the Nockberge. Within this range, occurrences seemingly are highly fragmented, and transverse alpine valleys may represent important topographic barriers to dispersal. Due to the absence of systematic survey efforts, the

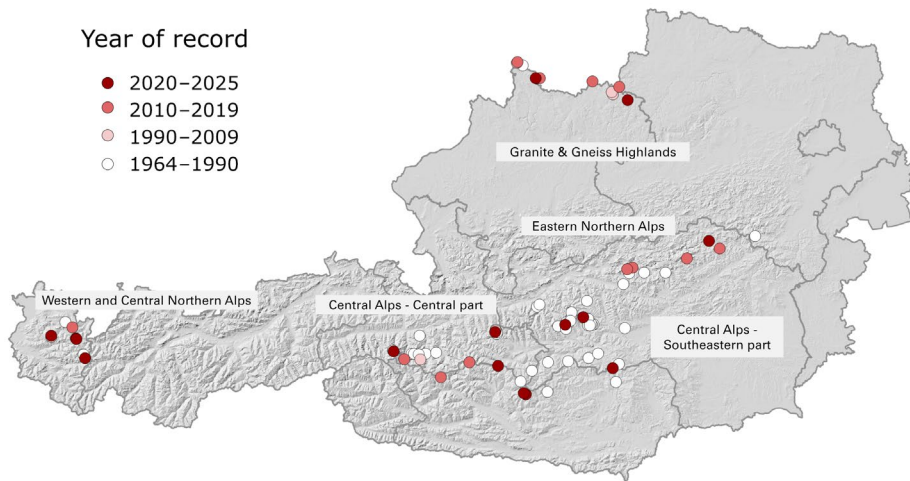


Fig. 2: Record localities of the Northern Birch Mouse (*Sicista betulina*) in Austria (compiled as occurrence sites documented by photo records or voucher specimens), shown within major ecoregions (grey line). Base map: DEM – Digital Elevation Model Land Kärnten (2015), Ecoregions: Umweltbundesamt GmbH (2024). | **Abb. 2:** Nachweise der Birkenmaus (*Sicista betulina*) in Österreich (zusammengestellt als Vorkommen, die durch Fotoaufnahmen oder Belegexemplare dokumentiert sind), dargestellt innerhalb der wichtigsten Ökoregionen (graue Linie). Basiskarte: DGM – Digitales Geländemodell des Landes Kärnten (2015); Ökoregionen: Umweltbundesamt GmbH (2024).

degree of isolation among subpopulations cannot yet be reliably assessed. The species' presence in the High Tauern (Glocknergruppe, Goidberggruppe and Ankoglergruppe) is supported by recent records from the municipalities Fusch an der Großglocknerstraße (2019; Resch & Resch 2020) and Kaprun (2020; naturbeobachtung.at). In the Low Tauern, records originate from the Radstädter, Schladminger, and Wölzer Tauern, with recent records from 2021–2025 in the municipalities St. Peter am Kammerberg and Pusterwald (Resch & Resch 2024), as well as Muhr and Untertauern (observation.org). The distribution further extends into the Nock Mountains of Carinthia, as confirmed by recent records from 2024 in the municipalities of Bad Kleinkirchheim and Hüttenberg (van der Kooij et al. 2025).

3. Bregenzerwald (Subarea 3): Most record localities are situated within the Bregenzerwald region in Vorarlberg (Spitzenberger 2006; Resch et al. 2021). This area represents the westernmost known occurrence of the species in Austria and, together with Denmark and Norway, marks the known western limit of its distribution in Europe. Recent records from 2019–2025 originate from the sites Krüz, Bellischegg Alpe, and Sulzried Alpe (Resch & Resch 2021), as well as Damüls (inataura Erlebnis – Naturschau Dornbirn 2025). The populations in this subarea are likely connected to those in the adjacent Allgäu region in Bavaria, Germany (Stille et al. 2018; Meinig et al. 2015), but are otherwise likely isolated from other occurrences in Europe. Targeted surveys may reveal additional occurrences in adjacent Tyrol (Resch et al. 2021).

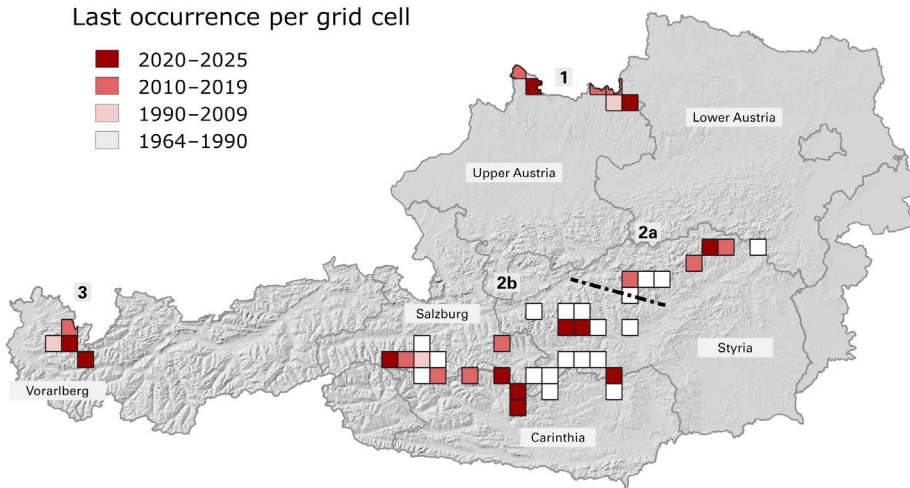


Fig. 3: Occurrence of *Sicista betulina* in Austria (compiled as occurrence sites documented by photo records or voucher specimens) displayed within a 10km grid. Subareas are delineated as follows: 1 – Mühlviertel+; 2a – Styrian Northern Alps; 2b – Central Alps; 3 – Bregenzerwald and Lechtal Alps. Federal state boundaries are shown as grey lines. (Base map: DEM – Digital Elevation Model (Land Kärnten 2015), Grid: ETRS89-LAEA 10km; Federal state boundaries: BEV 2025). | **Abb 3:** Vorkommen von *Sicista betulina* in Österreich (dargestellt als durch Fotobelege oder Belegexemplare dokumentierte Fundorte) auf Basis eines 10-km-Rasters. Die Teilgebiete sind wie folgt abgegrenzt: 1 – Mühlviertel+; 2a – Steirische Nordalpen; 2b – Zentralalpen; 3 – Bregenzerwald und Lechtaler Alpen. Die Bundesländergrenzen sind als graue Linien dargestellt. (Basiskarte: DGM – Digitales Geländemodell (Land Kärnten 2015), Raster: ETRS89-LAEA 10km; Bundesländergrenzen: BEV 2025).

A complete list of all occurrence sites is provided as a table in the Supplementary Material. The table includes (1) a continuous unique ID (1–78), (2) year, (3) type of evidence, (4) locality (assigned to the nearest locality according to Statistik Austria – data. statistik.gv.at (2025) (5) municipality, (6) district and (7) federal state (5–7: based on administrative boundaries (BEV 2025) (8) data source with a link for further information (9) ecoregion based on Umweltbundesamt GmbH (2025); and (10) Cell-Code, (11) EofOrigin (12) NofOrigin (10–12: ETRS-LAEA 10km Austria grid; Pfeifer 2011).

Discussion

The results show that *Sicista betulina*, although rare, is still present in suitable habitats in Austria. Its main distribution area remains the Alps, including the Bregenzerwald, the Central Alps in Salzburg, Carinthia, and Styria, as well as the Styrian Northern Alps. A further occurrence is located in the Mühlviertel region within the Bohemian Massif (Fig. 1 and 2).

The results of this study indicate an apparently fragmented distribution of *Sicista betulina* in Austria. The pronounced spatial separation of populations – particularly between the subareas 1 Mühlviertel+, 2 Styrian Northern Alps and Central Alps and 3 Bregenzerwald – strongly suggests population isolation. All three occurrence areas are relatively small, and even within these otherwise contiguous ranges, ongoing habitat loss may lead to further fragmentation and isolation of subpopulations. Such isolation may impede gene flow, potentially resulting in reduced genetic diversity and increased susceptibility to environmental change. Anthropogenic pressures, including wetland drainage, infrastructure development, and the intensification of land use in both agriculture and forestry (Spitzenberger 2001, 2006; Resch & Resch 2021, 2024) have likely exerted severe pressure on local populations. Climate-change-related effects such as altered precipitation regimes and increased temperature variability have probably resulted in less stable snow cover. This instability may have compromised the species' ability to endure prolonged and harsh winter conditions during torpor, potentially leading to the extirpation of local populations (van der Kooij et al. 2025). Consequently, genetic isolation among subpopulations is likely to have increased over the past 50 years.

However, due to species' historically poor detectability, additional occurrences may still remain undetected. Some populations that currently appear isolated may therefore still be functionally connected. Undiscovered populations are of particular importance for conservation planning. Because species occurrences are typically considered in planning and permitting procedures only when they are known; likewise, the implementation of targeted habitat improvement measures depends on reliable information on current presence. Targeted surveys employing specialised camera traps should therefore be conducted, especially in apparent distribution gaps and in areas lacking recent records. Continued use of citizen-science platforms may further contribute valuable occurrence data.

Finally, a comprehensive genetic analysis encompassing samples from the entire Austrian distribution range is recommended to assess genetic diversity and levels of isolation among populations. If preserved museum specimens allow for reliable DNA extraction, comparisons between historical and contemporary genetic variation should be undertaken to evaluate temporal changes in genetic structure.

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Electronic Supplement

S1: List of all occurrence sites | **S1:** Liste aller Fundorte

https://www.zobodat.at/pdf/supp/Resch_et_al_Supplement.xlsx

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