universität wien

# MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

**„Temporal trends & dynamics of neonative species in Austria"**

verfasst von / submitted by

Jasmin Halbmayr BA

angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien, 2022 / Vienna, 2022

| | |
|---|---|
| Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet: | A 066 879 |
| Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet: | Masterstudium Naturschutz und Biodiversitätsmanagement |
| Betreut von / Supervisor: | Assoz.-Prof. Mag. Dr. Franz Essl |
| Mitbetreut von / Co-Supervisor: | |

## Acknowledgements

My sincere thanks to my supervisor Assoz. -Prof. Mag. Dr. Franz Essl for his professional assistance, patience and providing feedback in any part of the process.
I would also like to thank Mag. Dr. Wolfgang Rabitsch for his valuable guidance during the production of my master thesis. Thank you very much for your support and understanding over the past years.

And I gratefully recognize the help of the scientific experts for their support and professional expertise.

Furthermore, I'd like to give a thank to Michael Glaser, MSc for his kind support and help.

# Table of Contents

# Abstract

Global warming has led to a shift in climatic conditions in many regions of the world, leading to poleward and upslope range shifts. This makes range expansion of various species increasingly likely, and insects, as ectotherms, are particularly good indicator groups for climate change. Hence, I selected insect groups such as Auchenorrhyncha, Heteroptera, Hymenoptera, Coleoptera, Lepidoptera, Orthoptera, Diptera and Odonata for my study.

I checked which and how many species were first recorded in Austria between 1990 and 2019 and classified them into neonative, native and alien species with the help of experts. The temporal accumulation of these three groups, i.e. in which year the first discovery took place, and whether a link with changing annual mean temperatures in Austria can be identified, was analyzed. In this study, I focus on neonative species, i.e. species that expand into new areas by natural disperal and without human intervention.

To obtain pertinent information whether a northward migration of neonative species can be observed, I created distribution maps showing their "native range", i.e. their European country of origin, and their "current range", i.e. the area where they were first recorded. Species attributes such as dispersal capacity, body size, feeding types and habitat affiliation were collected to analyze ecological patterns.

A total of 182 newly recorded species were documented, including 39 neonative, 81 native and 62 alien species. For neonative species, a pattern of migration routes from neighbouring countries to the south and east was detected. The main gateway for neonative species is in the eastern regions of Austria, which can be explained on the one hand by the location of the Alps and on the other hand by the warm Pannonian biogeographical region, which offers suitable climatic conditions for most first recorded neonative species. The majority of the neonative species were mobile species and the habitat type of the first place of discovery was the same as in their native region. But no preference for body size could be detected.

This study offers an overview of the number of first recorded species or orders and their place of first discovery from 1990 to 2019 in Austria and their native distribution according to Fauna Europaea. Based on the results of this work, further studies would be needed, e.g. to find out whether neonative species have been able to establish in Austria and beyond since their first discovery, and if so, have the species settled in the same habitat as in their native habitat?

# Zusammenfassung

Die globale Erwärmung hat in vielen Regionen der Welt zu einer Verschiebung der klimatischen Bedingungen geführt, was eine Verschiebung der Klimazonen polwärts sichtbar macht. Dadurch wird eine Arealausweitung verschiedener Arten immer wahrscheinlicher, wobei sich Insekten, als ektotherme Tiere, als gute Indikatorgruppen für Klimaveränderungen eignen. Aus diesem Grund habe ich in meiner Studie Insektengruppen wie Auchenorrhyncha, Heteroptera, Hymenoptera, Coleoptera, Lepidoptera, Orthoptera, Diptera und Odonata, herangezogen. Meine Recherchen richteten sich darauf, welche und wieviele Erstnachweise dieser Arten von 1990 bis 2019 in Österreich publiziert und anschließend mit Hilfe von Experten in „Neonative", „Native" und „Alien" Arten eingeteilt wurden. Der zeitliche Verlauf dieser drei Gruppen, also in welchem Jahr der Erstfund stattfand, und ob ein Zusammenhang mit dem jährlichen Temperaturmittel (°C) in Österreich ersichtlich ist, wurde analysiert. Der Fokus der neugefundenen Arten liegt in dieser Studie auf „Neonative" Arten, das sind Arten, die sich aus eigener Kraft und ohne menschliche Hilfe in neue Gebiete ausbreiten. Um relevante Informationen zu erhalten, ob eine Nordwärtswanderung der „Neonative" zu beobachten ist, erstellte ich Verbreitungskarten, in denen ihr „current range", also ihr Aufenthaltsort bei ihrem Erstfund und ihr „native range", ihr europäisches Herkunftsgebiet, dargestellt werden. Um zu sehen, ob man artspezifische Rückschlüsse aus ihren Art-Eigenschaften ziehen kann, wurden Ausbreitungskapazität, Körpergröße, Nahrungstyp und Lebensraumzugehörigkeit aufgenommen.

Insgesamt wurden 182 Erstnachweise dokumentiert, wobei es sich um 39 „Neonatives", 81 „Natives" und 62 „Aliens" handelt. Bei den „Neonatives" ist ein Muster der Einwanderungsrouten von benachbarten südlich und östlich gelegenen Ländern zu erkennen und ihr Haupteinfallsportal zeigt sich daher in den östlichen Regionen Österreichs. Was sich einerseits durch die Lage der Alpen erklären lässt, andererseits durch die Pannonische biogeographische Region, die einen bevorzugten Lebensraum vieler „Neonatives" darstellt. Zudem wurde festgestellt, dass es sich unter den „Neonatives" überwiegend um mobile Arten handelt und es sich bei dem Erstfundort um den gleichen Lebensraumtyp handelt, wie in ihrem heimischen Vorkommensgebiet. Bei der Körpergröße wurde keine Präferenz gefunden.

Diese Studie bietet einen Überblick über die Anzahl an Erstnachweisen ausgewählter Insektenarten bzw. -ordnungen und deren Erstfundort von 1990 bis 2019 in Österreich sowie deren Herkunftsländer laut Fauna Europaea. Aufbauend auf diese Arbeit, bieten sich weitere

Fragestellungen an, z.B. konnten sich „Neonatives“ seit ihrem Erstfund in Österreich und auch darüber hinaus etablieren? Falls ja, haben sich die Arten im gleichen Lebensraum wie in ihrem ursprünglichen Vorkommensgebiet etabliert?

**Keywords***: Alien species, climate change, current range, first recorded species, native range, native species, neonative species, newly recorded species, range-shift*

# Introduction

The International Panel on Climate Change defines climate change as “any change in climate over time, whether due to natural variability or as a result of human activity” (IPCC, 2001). So, it includes natural and anthropogenic environmental changes whereby there is scientific consensus that the warming over the 50 years is due to human activities (Karuppaiah & Sujayanad, 2012).

Global warming has caused a shift in climatic conditions in many regions of the world and with increasing warming, climate zones can further shift poleward and upslope (IPCC, 2019) and as a result, climatic conditions may enable species to expand their ranges into newly climatically suitable regions by shifting their range boundaries (Christelle & Alain, 2010; Essl et al., 2019). The terms global warming and climate change are often used in this study, but they are not equivalent. Global warming is only one aspect of climate change and “refers to the rise in global temperatures due mainly to the increasing concentrations of greenhouse gases in the atmosphere”. Climate change “refers to the increasing changes in the measures of climate over a longer period of time – including precipitation, temperature and wind patterns” (USGS, 2022).

Since 1990, there has been an increasing debate on the effects of climate change on ecology and nature conservation (Ott, 2010) and it is assumed that global mean surface temperature may increase by 1.4 to 5.8 °C from 1990 to 2100, depending on future greenhouse gas emissions (Karuppaiah & Sujayanad, 2012). Since pre-industrial times, the global mean temperature has already increased by about 1.0 °C, most likely due to the pronounced increase in anthropogenic greenhouse gas emissions (Figure 1) (ZAMG, 2022).

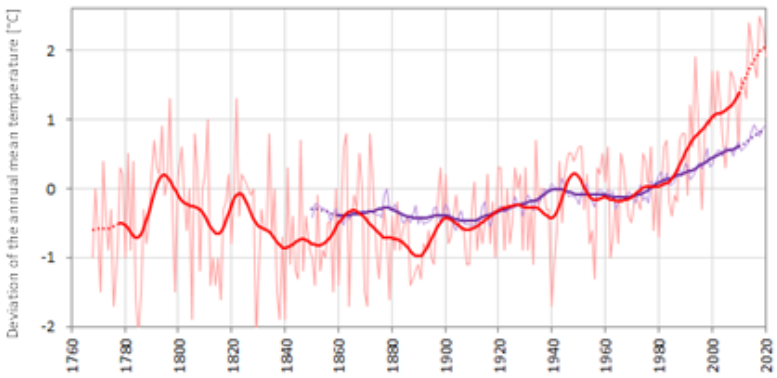



Figure 1: Development of mean annual temperature worldwide 1850–2020 (violett) and in Austria 1768 to 2020 (red). Shown are the annual deviations from the mean value of the years 1961–1990 (thin lines) and their smoothed trends (thick lines, 21-year Gaussian low-pass filter) (ZAMG, 2022).

In Austria, there has been a rise in mean annual temperature twice as strong as the global average, which can be explained by the faster warming of temperatures over continental areas than the thermally inert oceans (ZAMG, 2022).

Due to human activities like the transport of propagules or live individuals to new regions or modifications of the environment, such as climate change, land-use change, overharvesting and pollution, the spatial distribution of species is changing (Essl et al., 2018). Barriers that have so far impeded the spread of species may be weakened by human-induced environmental changes like climate change and may increase the accessibility or suitability of a region for a particular species, allowing new geographical areas to be colonized at different rates (Christelle & Alain, 2010; Essl et al., 2019). In response to climate warming mobile species in particular have often been documented undergoing range expansions into higher latitudes and altitudes (Christelle & Alain, 2010; Essl et al., 2019). Nevertheless, range expansions occur at different rates, which could be explained by differences in climate sensitivity, resource requirements, reproductive rates, phenotypic plasticity, dispersal ability or biotic interactions (Platts et al., 2019).

In this study, I focus on the insect orders Orthoptera, Auchenorrhyncha, Heteroptera, Hymenoptera, Diptera, Odonata, Lepidoptera and Coleoptera because insects are ectothermic and particularly sensitive to ambient temperatures and likely react more quickly to increasing temperatures (Christelle & Alain, 2010). Further, the typical life history traits of insects - such as high dispersal ability, short generation times and high fecundity - allow them to colonize new regions rapidly once abiotic conditions become favourable (Stange & Ayres, 2010). Temperature thresholds often delimit the geographical range of a species. For instance, in Europe, the climatic isotherms have moved northwards on average 120 km in the last century, and 63% of non-migratory European butterflies have extended their range by 35 to 240 km northwards (Christelle & Alain, 2010) while only 3% have shifted towards the south (Parmesan, 1999). When the climatic conditions change, the distribution of species should also change (Ott, 2008).

The aim of this study was to investigate, which species that occur in adjacent regions have spread to Austria since 1990 with no direct human help, presumably as a result of global environmental change. For such species, the term “neonative” has recently been proposed; it encompasses those taxa that “respond to human-induced environmental changes by expanding their ranges without any specific human assistance into new regions that are often

adjacent to their native range" (Essl et al., 2019). Native taxa occur in regions where they have evolved in their current range or migrated during natural range expansion without any human intervention since the end of the last glaciation. Alien taxa are those that have been intentionally or unintentionally introduced by humans, or that have been using anthropogenic corridors such as canals, roads, pipelines or tunnels (IUCN, 2019).

Specifically, I ask the following questions: In which federal provinces and districts in Austria are neonative species most frequent? Which taxa are most affected by climate change-induced range-shifts? In which year where the most first records documented? Do these first records track annual mean temperature or is there a delay? Did range shifts occur from all geographic directions? Is there any evidence that species with specific attributes are spreading more frequently?

# Material and Methods

### Taxonomic groups considered

Insects are the most diverse group of animals on earth and currently, about one million species are known, which corresponds to more than 60% of all animal species (Rabitsch et al., 2020). The selected taxonomic groups I used for the study include the better known insect groups in Austria such as Orthoptera, Auchenorrhyncha, Heteroptera, Hymenoptera, Diptera, Odonata, Lepidoptera, and Coleoptera.

### Literature search on first records of species in Austria

This study is based on an extensive search of newly recorded species of the target groups in Austria. It is based on faunistic literature sources, which were complemented and checked by experts of the respective taxonomic groups. Data sources I consulted were e.g. Zobodat (https://www.zobodat.at/), natural history journals like "Beiträge zu Entomofaunistik (ÖGEF), "Linzer biologische Beiträge", "Joannea Zoologie", "Carinthia II", reports from national museums such as Biologiezentrum Linz and books like "Die Zikaden Deutschlands - Bestimmungstafeln für alle Arten" (Biedermann & Niedringhaus, 2004).

Since the state of knowledge of distribution data on insect groups in Austria is rather heterogeneous and current distribution maps or comparable publications are only available for some (popular) insect groups (Rabitsch et al., 2020), I especially used the zoological-

botanical database "ZOBODAT" for identifying scientific publications, where first records of species of the selected groups in Austria since 1990 were reported, and necessary data for the species attribute tables (Appendix I, II and III) were extracted. ZOBODAT contains a large collection of digitized faunistic literature from other sources (e.g. natural history journals).

## Species attributes

I carried out a comprehensive data compilation of species attributes for the studied species (Table 1) and in order to make inferences which species are neonatives and to process the required data sets, species attribute tables were created (Appendix I, II and III).

Table 1: Species attribute table for all newly recorded species.

| **Species attributes** | |
|---|---|
| Taxonomic classification | (order, family, genus and species) |
| Date of first record in Austria | (month and year) |
| District and federal province of first record in Austria | (current range) |
| Native range | (European countries) |
| Dispersal capacity | (species capable/incapable of flight) |
| Maximum body length | (< 0.50 cm, 0.50 - 1.00 cm, > 1.00 cm) |
| Nutrition types | (haematophagous, phytophagous, polylectic, polyphagous, zoophagous, zoophytophagous) |
| Native habitat affiliation | |
| Habitat affiliation the first record is located in | |
| Annual mean temperature [°C] of Austria | |
| Criterion for being classified as a neonative, native or alien species | |
| Data sources | (references) |

For the current distribution of the species in Europe I used "Fauna Europaea", to check if the species is present to nearby countries. Even though species that are native slightly further away can potentially spread to Austria due to climate change, it is more likely that range expansion without human assistance occurs from adjacent regions (Essl et al., 2019). Fauna Europaea (https://fauna-eu.org/) provides a web-based information infrastructure with scientific names (including important synonyms) of all living European land and freshwater

animals, their geographical distribution, and some additional, optional information (Yde de Jong et al., 2014).

Table 2: Criteria and definitions (based on Mastrandrea et al., 2010) used for the categories to classify newly recorded species. (Mastrandrea et al., 2010)

| Criterion "Unassisted spread" | Definition | Category |
|---|---|---|
| Very likely fulfilled | 90 - 100% probability of occurrence | 1 |
| Likely fulfilled | 66 - 90% probability of occurrence | 2 |
| About as likely as not fulfilled | 33 - 66% probability of occurrence | 3 |
| Unlikely fulfilled | 0 - 33% probability of occurrence | 4 |

For all species that were newly recorded after 1990, I assessed if the occurrences in Austria are (most likely) the result of unassisted spread in response to environmental (i.e. climate) changes or if they are previously undocumented natives or the result of anthropogenic introductions, i.e. alien species. This assessment was done based on literature and through support from scientific experts (Table 4).

Species that very likely fulfilled the classification criterion for unassisted spread (Categories 1 and 2, Table 2), were considered to be neonative species in Austria. The species that did not fulfil the classification criteria (Category 3 and 4, Table 2) were considered either alien species or native species that had previously been undocumented (e.g. because their occurrences were overlooked) and were excluded from further analyses.

In addition, ecological data such as habitat affiliation was collected. A distinction was made between species' native habitat affiliation, i.e. habitat requirements that are typical for this species in its native range, and the habitat affiliation where the first recorded species was located in Austria (Table 3).

Table 3: Classification of habitat affiliation of newly recorded species in Austria.

| Habitat affiliation | Definition |
|---|---|
| Aquatic | In water or shore areas |
| Forest and shrub-dominated habitat | Mainly covered with trees or larger bushes |
| Grassland | Area mostly covered with grasses, herbaceous plants and barely any trees |
| Cropland | Land used for agricultural purpose |
| Urban habitat | Parks, gardens, buildings, tree alley, … |
| Swamp and wetland | Mostly or partially wet areas |
| n.a. | No data available or other habitats |

Table 4: Assessment for the classification of the criteria “unassisted spread” by scientific experts for the different taxonomic groups considered.

| Order | Scientific experts |
|---|---|
| Auchenorrhyncha | Gernot Kunz (Hemiptera) |
| Coleoptera | Andreas Eckelt |
| Diptera | Helge Heimburg |
| Heteroptera | Wolfgang Rabitsch |
| Hymenoptera | Bärbel Pachinger (Apoidea) &<br>Martin Schwarz (remaining groups) |
| Lepidoptera | Andreas Drack |
| Odonata | Andreas Chovanec |
| Orthoptera | Franz Essl |

To check whether there is a link between the occurrence of newly recorded species and the change in temperature, the mean annual air temperature (°C) for each year from 1990 to 2019 in Austria was determined from the website of the Central Institute for Meteorology and Geodynamics from the climate monitoring section (ZAMG, 2022).

## Analyses

After completion of the species attribute table (Appendix I, II and III) and the assessment of the external scientific experts (Table 4), the species were divided into neonative, native and alien species (Table 2). In addition, the annual temperature mean was plotted to graphs showing the temporal accumulation patterns of the three classification groups of newly recorded species.

To find out how the three groups differ in relation to each other and the year, the R programme is used (R Core Team, 2021; Wickham et al., 2019; Dowle & Srinivasan, 2021).

Maps of the number of neonative, native and alien species per federal province have been created and in addition, a distribution map showing the native and current range of neonative species in Europe and the federal provinces and districts of first records in Austria as well as a table of native ranges of native and alien species in the neighbouring countries of Austria were produced. The Austrian distribution map was crated with Power Map by Excel and the European distribution map with MapChart (https://mapchart.net/).

Species attributes were tabulated and illustrated in figures. The dispersal capacity was differentiated in species capable and incapable of flight, the differences in body size were summarized in the maximum body length of each species (<0.50cm, 0.50 – 1.00cm and

>1.00cm), the nutrition types were divided into phytophagous, polyphagous, polylectic, zoophagous, zoophytophagous and haematophagous species. The habitat affiliation was categorised (Table 3) and matched.

# Results

## Number of newly recorded species from 1990 to 2019 in Austria

Table 5: Number and percentage of newly recorded neonative, native and alien species in Austria from 1990 to 2019.

| Order | Number of neonative species | % | Number of native species | % | Number of alien species | % | Total | % |
|---|---|---|---|---|---|---|---|---|
| Auchenorrhyncha | 9 | 5 | 26 | 14 | 26 | 14 | 61 | 34 |
| Coleoptera | 4 | 2 | 6 | 3 | 7 | 4 | 17 | 9 |
| Diptera | 1 | 1 | 1 | 1 | 2 | 1 | 4 | 2 |
| Heteroptera | 13 | 7 | 13 | 7 | 11 | 6 | 37 | 20 |
| Hymenoptera | 8 | 4 | 6 | 3 | 13 | 7 | 27 | 15 |
| Lepidoptera | 3 | 2 | 22 | 12 | 2 | 1 | 27 | 15 |
| Odonata | | | 1 | 1 | | | 1 | 1 |
| Orthoptera | 1 | 1 | 6 | 3 | 1 | 1 | 8 | 4 |
| **Total** | **39** | **22** | **81** | **44** | **62** | **34** | **182** | **100** |

Between 1990 and 2019, a total of 182 species were recorded for the first time in Austria. These species were assigned to 39 (22%) neonative, 81 (44%) native and 62 (34%) alien species. The most first records for neonative species were from Heteroptera with 7% (13 species), the least with 1% from Diptera and Orthoptera (1 species each) and no records of Odonata.

## Temporal accumulation patterns of neonative, native and alien species

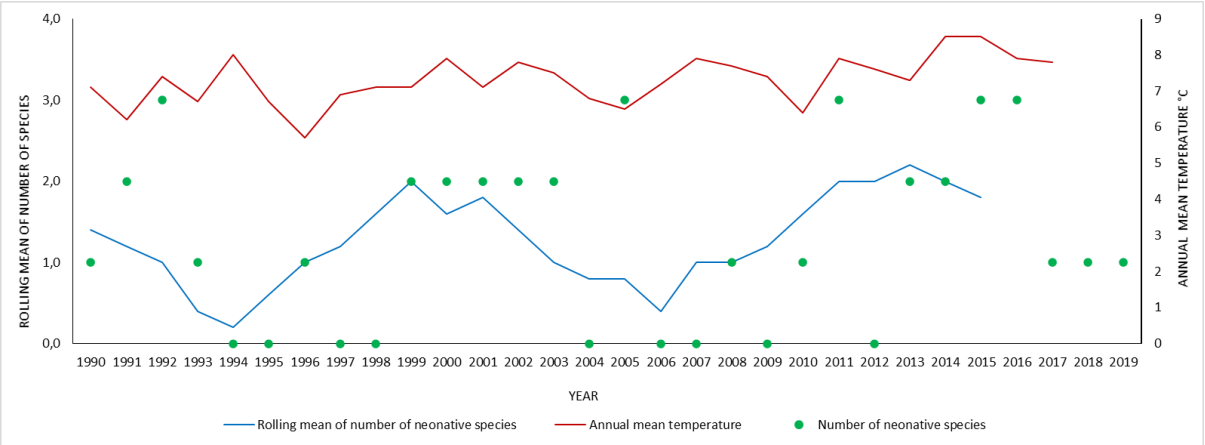



Figure 2: Rolling mean (window size = 5 years) of number of species from 1990 to 2015 (blue), the annual number of first recorded neonative species from 1990 to 2019 (green dots) and the annual average temperature (red) in Austria.

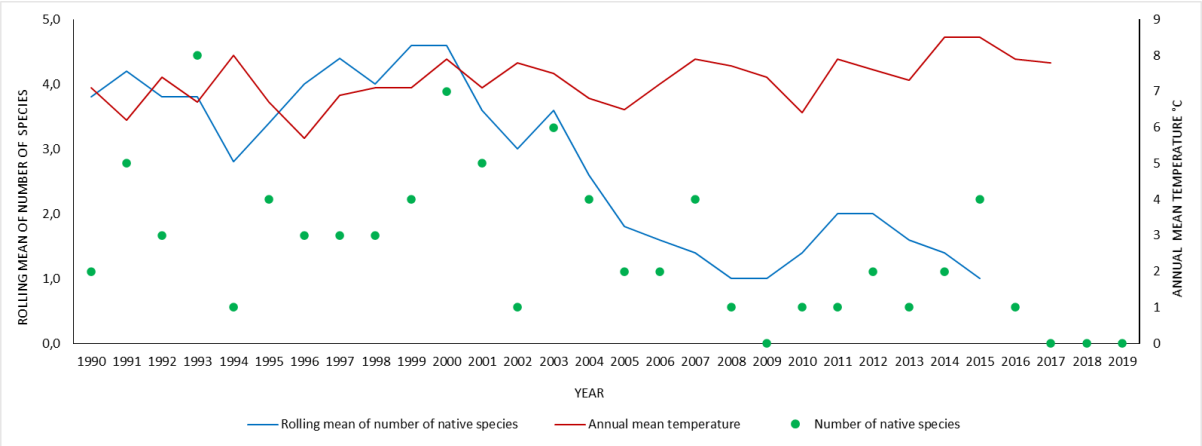



Figure 3: Rolling mean (window size = 5 years) of number of species from 1990 to 2015 (blue), the annual number of first recorded native species from 1990 to 2019 (green dots) and the annual average temperature (red) in Austria.

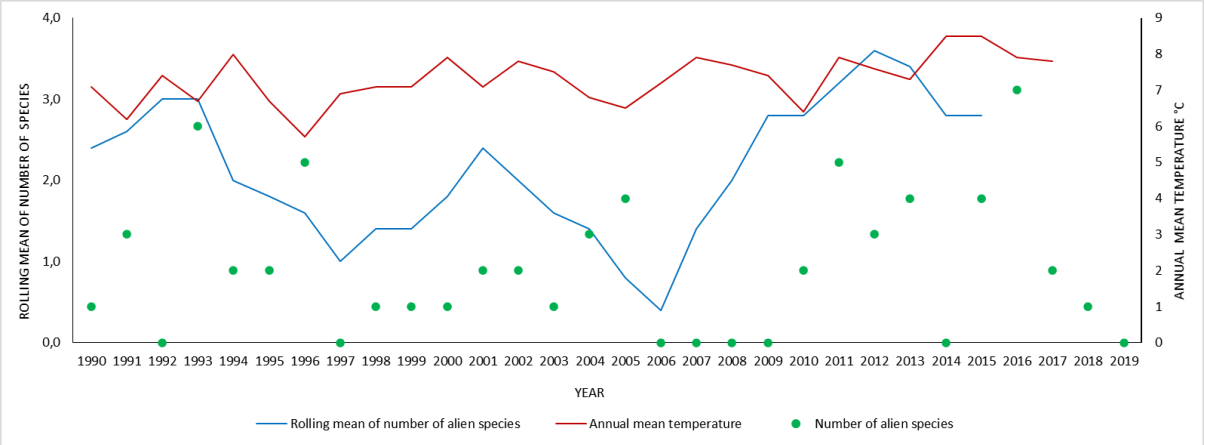



Figure 4: Rolling mean (window size = 5 years) of number of species from 1990 to 2015 (blue), the annual number of first recorded alien species from 1990 to 2019 (green dots) and the annual average temperature (red) in Austria.

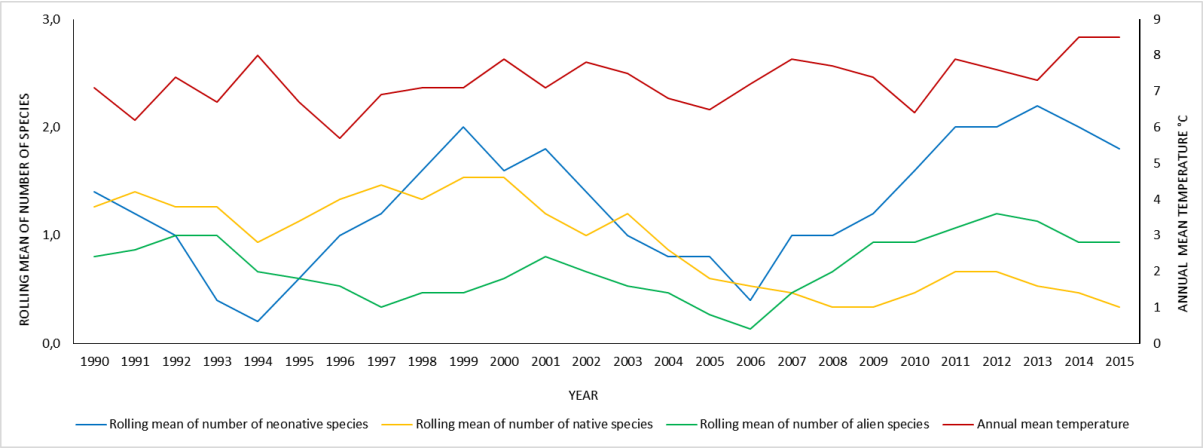



Figure 5: Rolling mean (window size = 5 years) of all three groups (neonative: blue, native: yellow and alien species: green) from 1990 to 2015 and the annual average temperature (red) in Austria.

Figures 2, 3 and 4 present the rolling mean with an interval of 5 years of numbers of first recorded species and annual numbers of first recorded neonative, native and alien species from 1990 to 2015. The red line shows the annual mean temperature in Austria. All three rolling means of the first records are shown for a better comparison (Figure 5). Neonative and alien species show a slightly positive trend since 2007. Native species show a negative trend, so over the years fewer species are being found.

Table 6: Model 1 contains the neonative, Model 2 the native and Model 3 the alien species. S.W. test is the Shapiro-Wilk normality test, $R^2$ is the R-squared.

| | **Response** | **Predictor(s)** | **S.W. test (0,95)** | **$R^2$** | **AIC** |
|---|---|---|---|---|---|
| **Model 1** | Number of species per year | year*group | 0.00437 | 22.9% | 355.2448 |
| **Model 2** | | year | 4.47e-05 | 2% | 368.1388 |
| **Model 3** | | group | 0.001017 | 9.3% | 363.8809 |

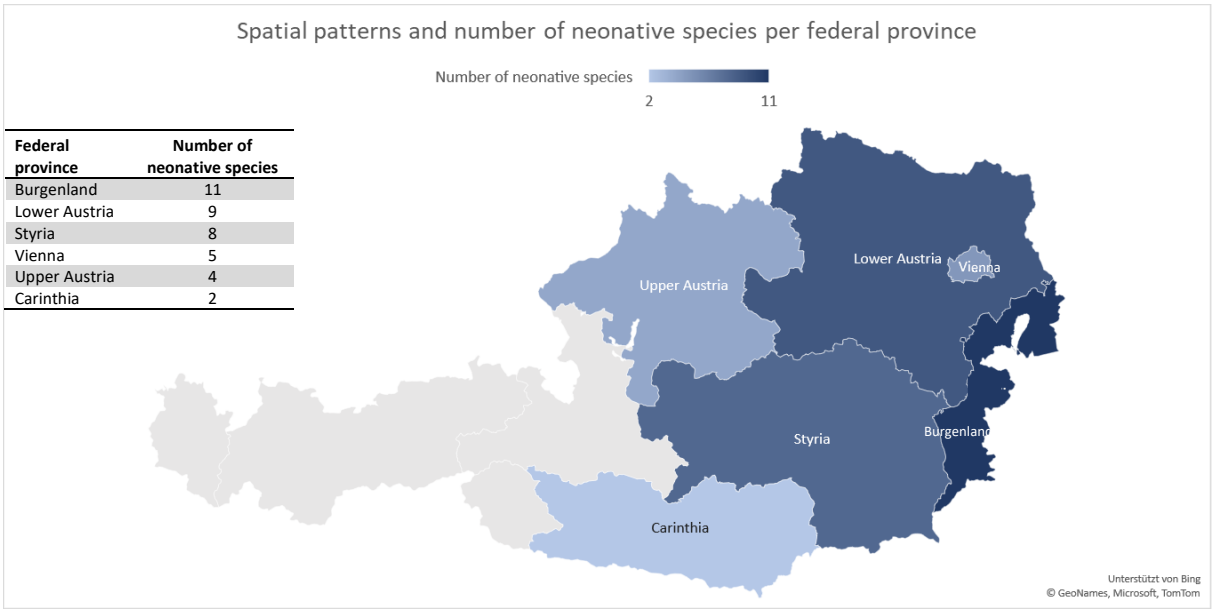
I calculated a linear model with sum contrasts for the species group and the year as predictors and the number of species per year as response to understand how much the year in connection with the group explain. To get the multiple correlation coefficient between three variables, the R-squared was calculated and it represents the proportion of the variance in the response variable of a regression model that can be explained by the predictor variables. Model 1 explains 22.9% of the variance (Table 6).

In a model using the year as a predictor of species number the r-squared was 2% and by using the groups, the R-squared was 9.3% of the variance, so the year and the group are not

significant predictors (Model 2 and 3, Table 6). The data of the three models were tested for normality with the Shapiro-Wilk test. All three tests are significant, so our residuals are not normally distributed and so thus significances aren't interpretable. Comparing the models fitted by maximum likelihood to the same data, the smaller the AIC, the better the fit but according to the calculated AIC, the years do not matter for the model.

## Spatial patterns of newly recorded species from 1990 to 2019 in Austria

Neonative species




| Federal province | Number of neonative species |
|---|---|
| Burgenland | 11 |
| Lower Austria | 9 |
| Styria | 8 |
| Vienna | 5 |
| Upper Austria | 4 |
| Carinthia | 2 |

Figure 6: Spatial patterns and number of newly recorded neonative species per federal province in Austria.

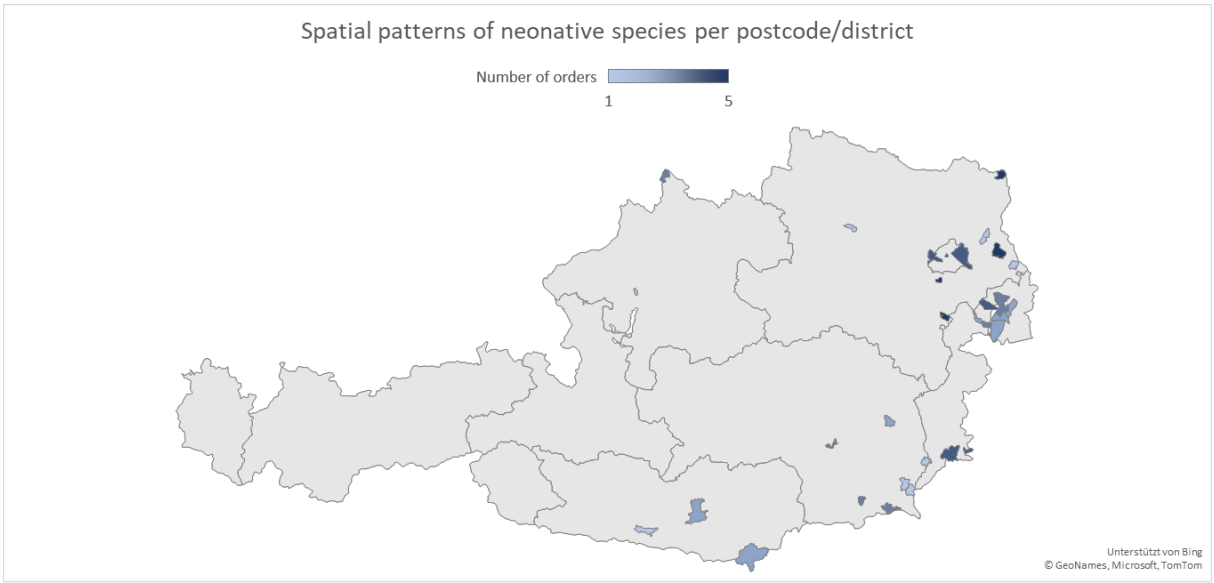
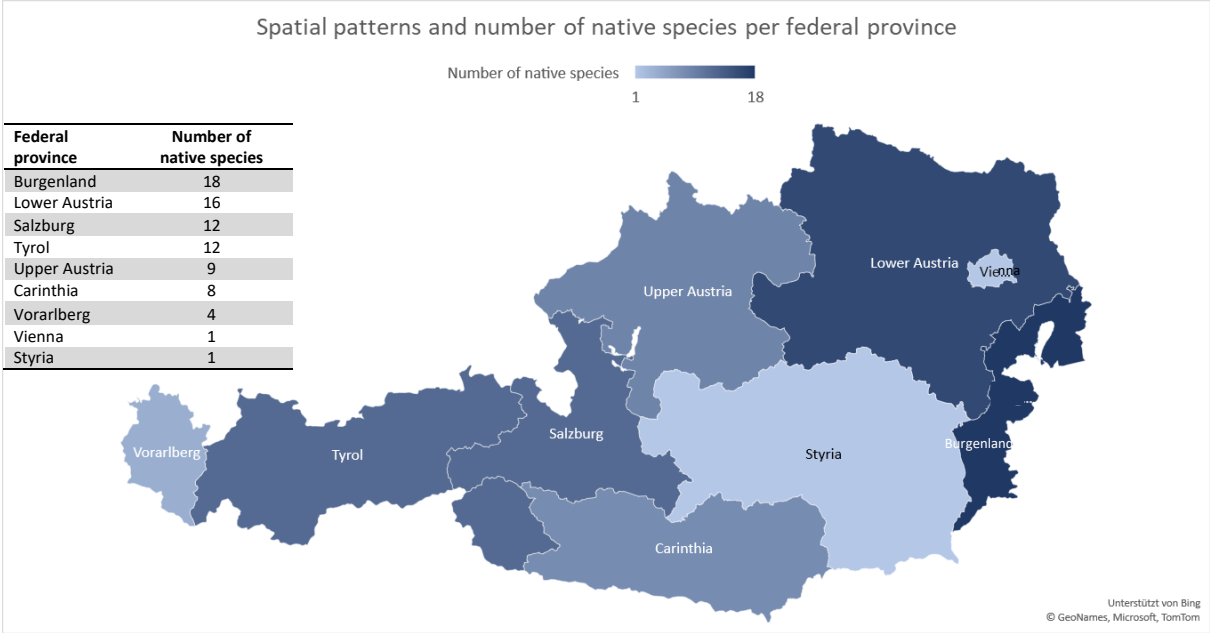



Figure 7: Spatial patterns and numbers of newly recorded neonative species per district in Austria.

Figures 6 and 7 show that regions in the south-east like Burgenland (11 species) and Styria (8 species) and Lower Austria (9 species) are used as gateways for neonative species.

## Native species

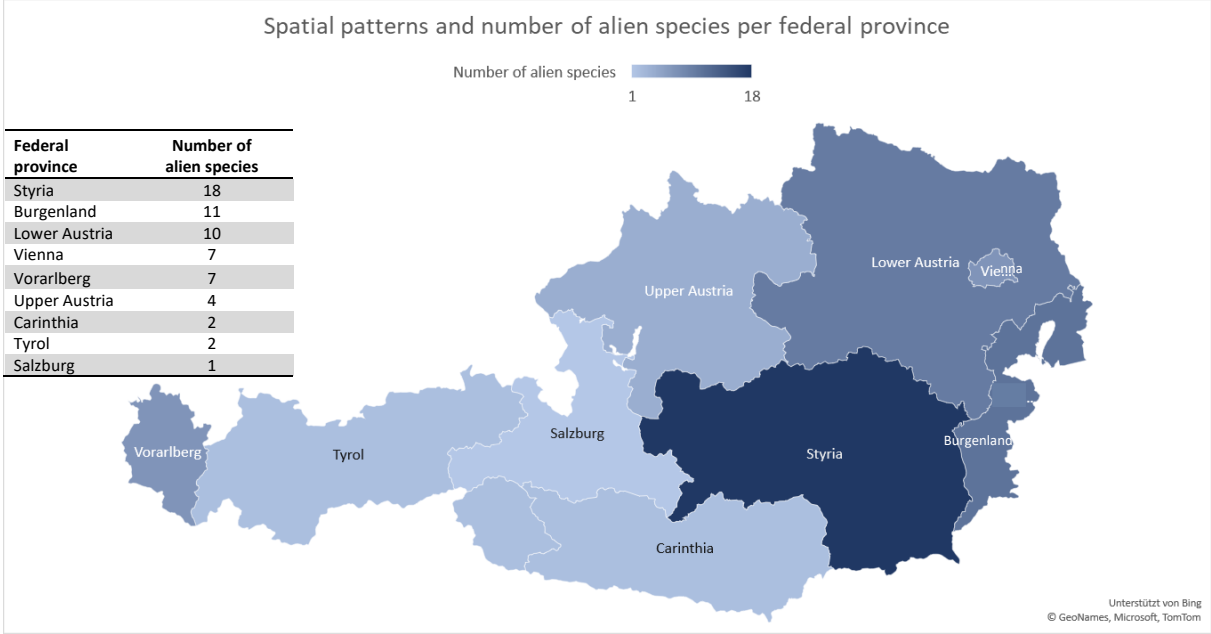



| Federal province | Number of native species |
|---|---|
| Burgenland | 18 |
| Lower Austria | 16 |
| Salzburg | 12 |
| Tyrol | 12 |
| Upper Austria | 9 |
| Carinthia | 8 |
| Vorarlberg | 4 |
| Vienna | 1 |
| Styria | 1 |

Figure 8: Spatial patterns and number of newly recorded native species per province in Austria.

Newly recorded native species occur in all federal provinces of Austria but most in north-eastern regions such as Lower Austria (16 species) and Burgenland (18 species) but also Salzburg (12 species) and Tyrol (11 species).

## Alien species




| Federal province | Number of alien species |
|---|---|
| Styria | 18 |
| Burgenland | 11 |
| Lower Austria | 10 |
| Vienna | 7 |
| Vorarlberg | 7 |
| Upper Austria | 4 |
| Carinthia | 2 |
| Tyrol | 2 |
| Salzburg | 1 |

Figure 9: Spatial patterns and number of newly recorded alien species per province in Austria.

Newly recorded alien species occur in all federal provinces of Austria but especially in north-eastern and southern regions such as Lower Austria (10 species), Burgenland (11 species) and Styria (18 species).

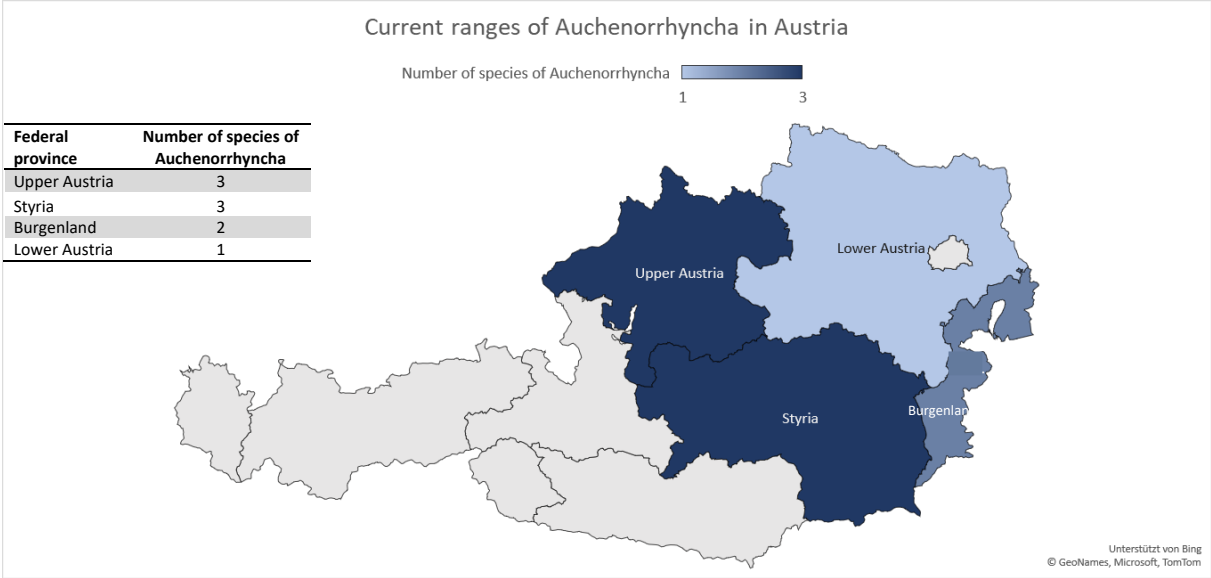
Table 7: Newly recorded neonative, native and alien species in Austria that do not have their native range in neighbouring countries.

| | | | | Distribution according to FAUNA EUROPAEA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Order** | **Species** | **Year of first record** | **Federal province of first record** | **AT** | **DE** | **CZ** | **SK** | **HU** | **SI** | **IT** | **CH** | **Neonative, native, alien species** |
| Auchenorrhyncha | *Cicadula rubroflava* | 2011 | Upper Austria | | | | | | | | | neonative |
| Coleoptera | *Otiorhynchus albidus* | 2013 | Lower Austria | | | | | | | | | neonative |
| Hymenoptera | *Birka alpina* | 2000 | Upper Austria | | | | | | | | | native |
| Lepidoptera | *Monochroa moyses* | 2012 | Vienna | | | | | | | | | native |
| Lepidoptera | *Dryadaula irinae* | 1995 | Vorarlberg | | | | | | | | | native |
| Auchenorrhyncha | *Javesella bottnica* | 1994 | Styria | | | | | | | | | alien |
| Hymenoptera | *Lasioglossum pressithorax* | 2017 | Burgenland | | | | | | | | | alien |
| Coleoptera | *Cryptamorpha desjardinsi* | 2010 | Lower Austria | | | | | | | | | alien |

According to Fauna Europaea, two of 39 neonative, three of 81 native and three of 62 newly recorded alien species in Austria do not have their native range in neighbouring countries (Table 7), all other species occur in neighbouring countries (Appendix II). These species probably have neonative occurrences in neighbouring countries.

## Current ranges of neonative species in Austria and their native ranges in Europe

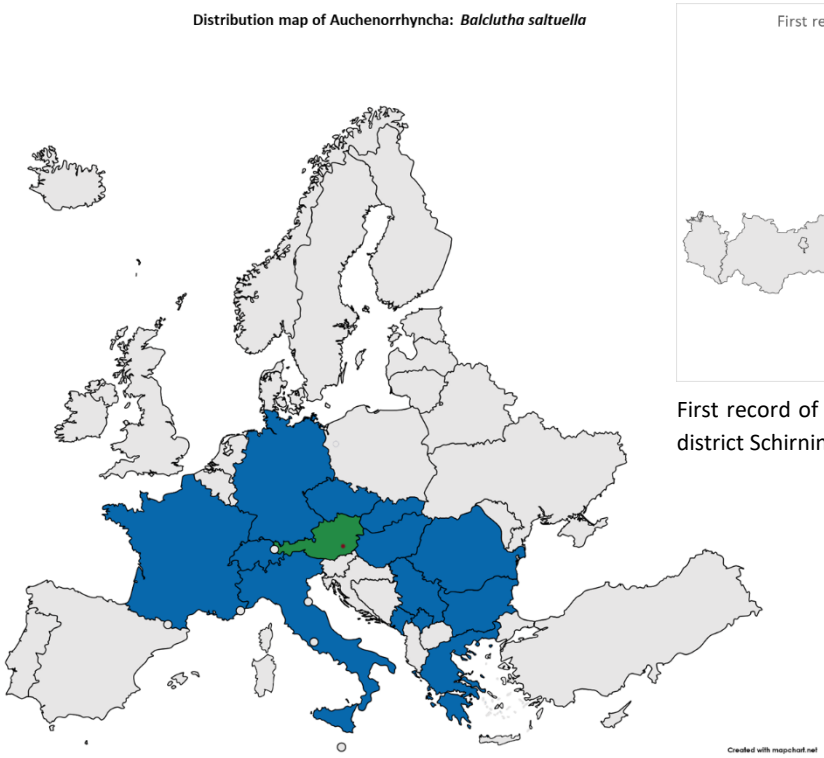
### Auchenorrhyncha

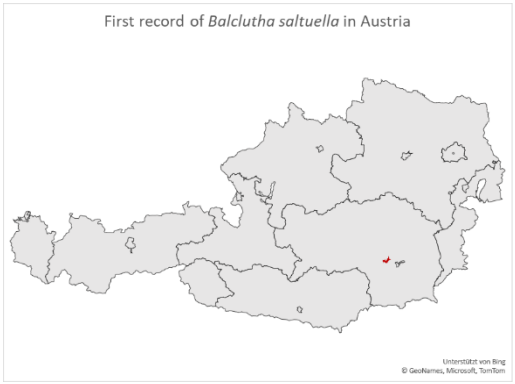



| Federal province | Number of species of Auchenorrhyncha |
|---|---|
| Upper Austria | 3 |
| Styria | 3 |
| Burgenland | 2 |
| Lower Austria | 1 |

Figure 10: Number of species of Auchenorrhyncha and the first records in federal provinces.

### *Balclutha saltuella*

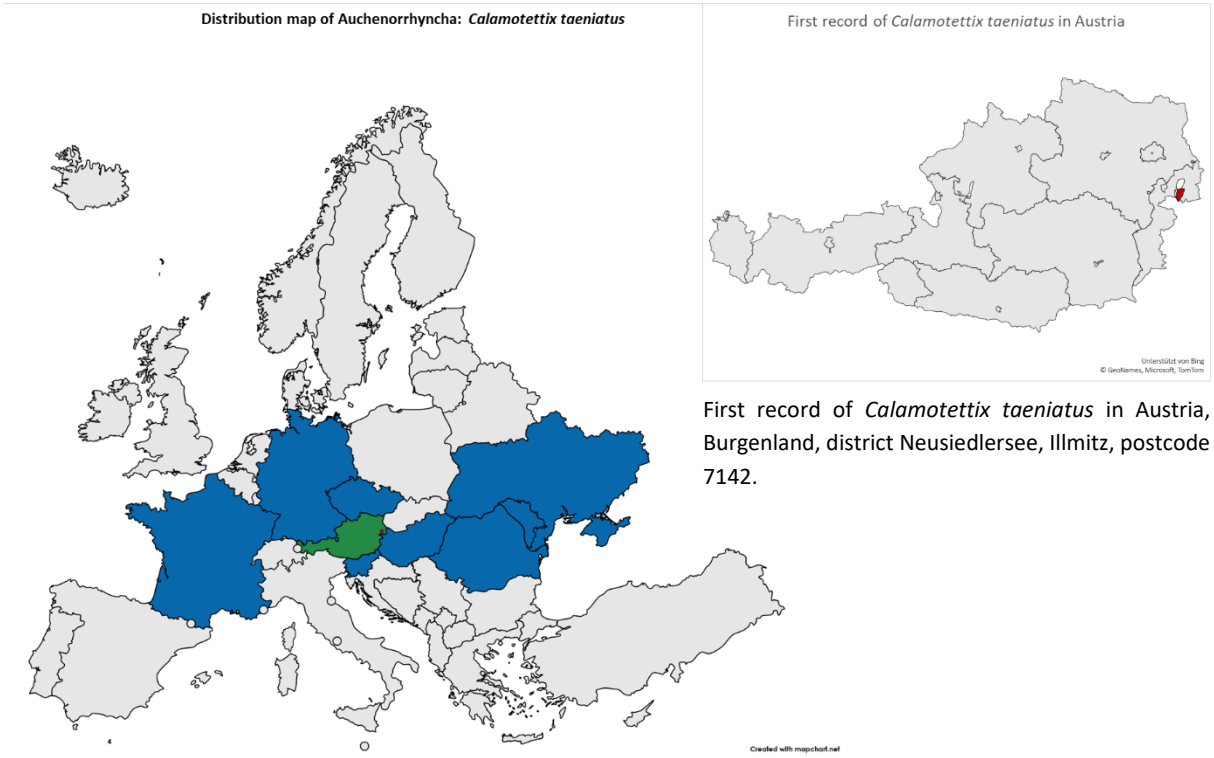



First record of *Balclutha saltuella* in Austria, Styria, district Schirning, postcode 8112.

Figure 11: Countries in blue show European native ranges of *Balclutha saltuella*. Country in green and the red point show first record in Austria, Styria.

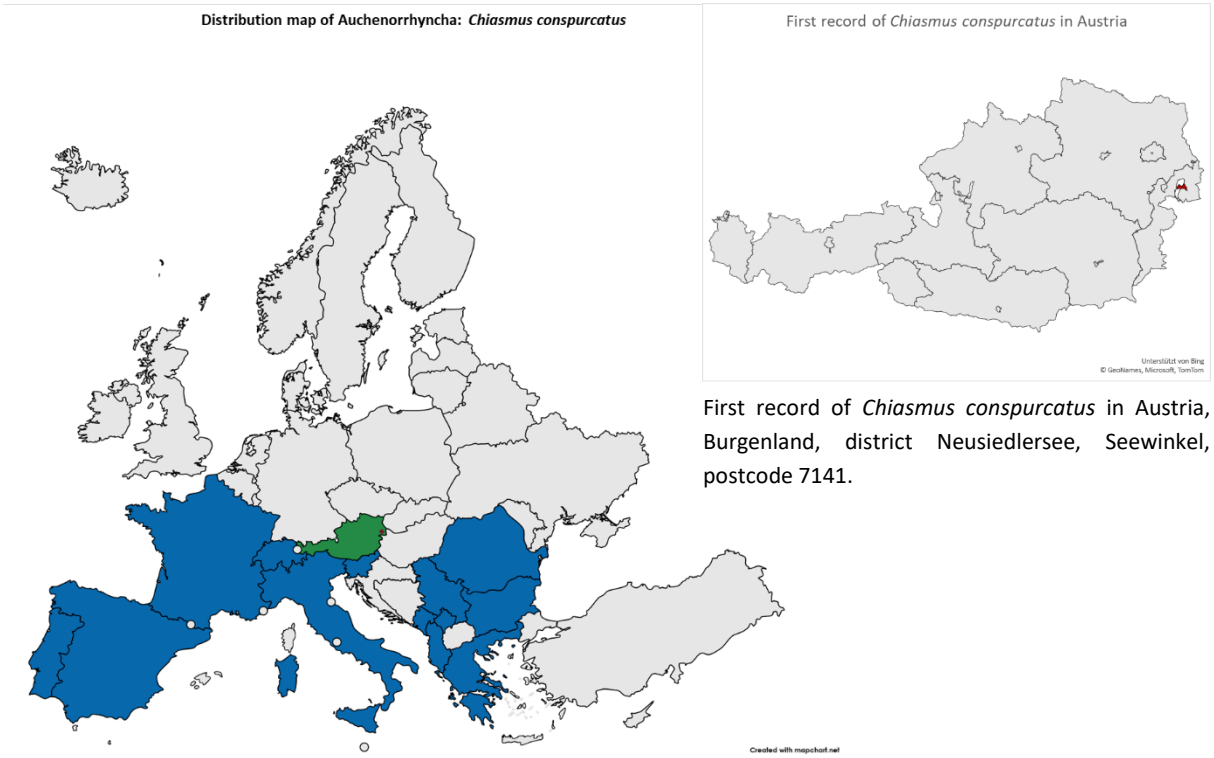
## *Calamotettix taeniatus*




First record of *Calamotettix taeniatus* in Austria, Burgenland, district Neusiedlersee, Illmitz, postcode 7142.

Figure 12: Countries in blue show native ranges of *Calamotettix taeniatus*. Country in green and the red point show first record in Austria, Burgenland.

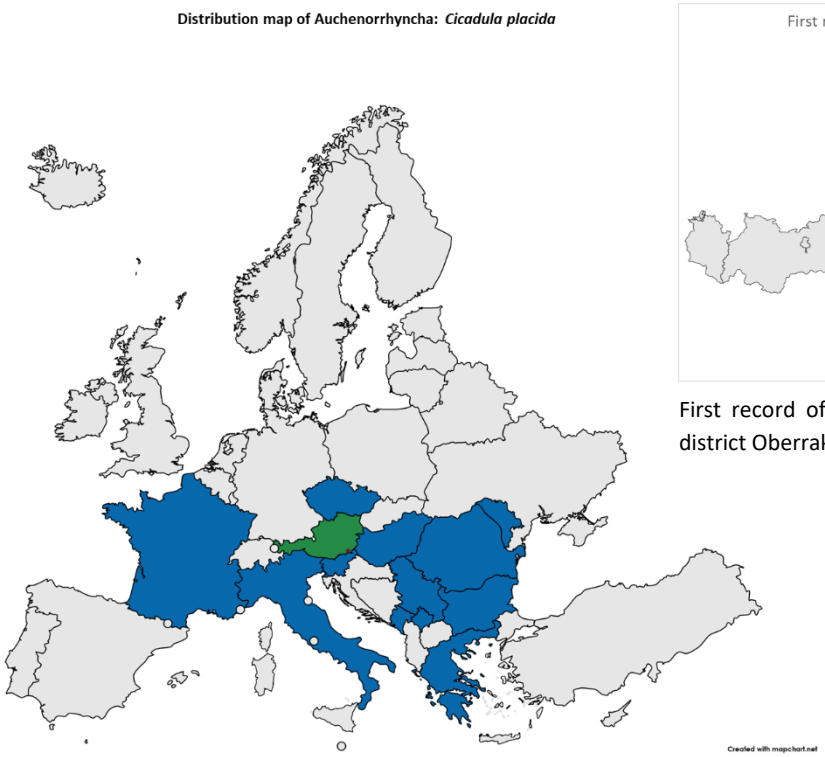
## *Chiasmus conspurcatus*

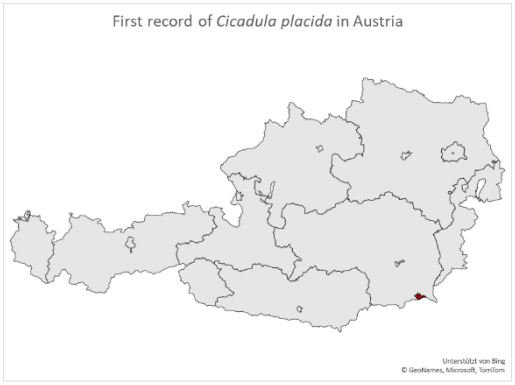



First record of *Chiasmus conspurcatus* in Austria, Burgenland, district Neusiedlersee, Seewinkel, postcode 7141.

Figure 13: Countries in blue show native ranges of *Chiasmus conspurcatus*. Country in green and the red point show first record in Austria, Burgenland.

## *Cicadula placida*

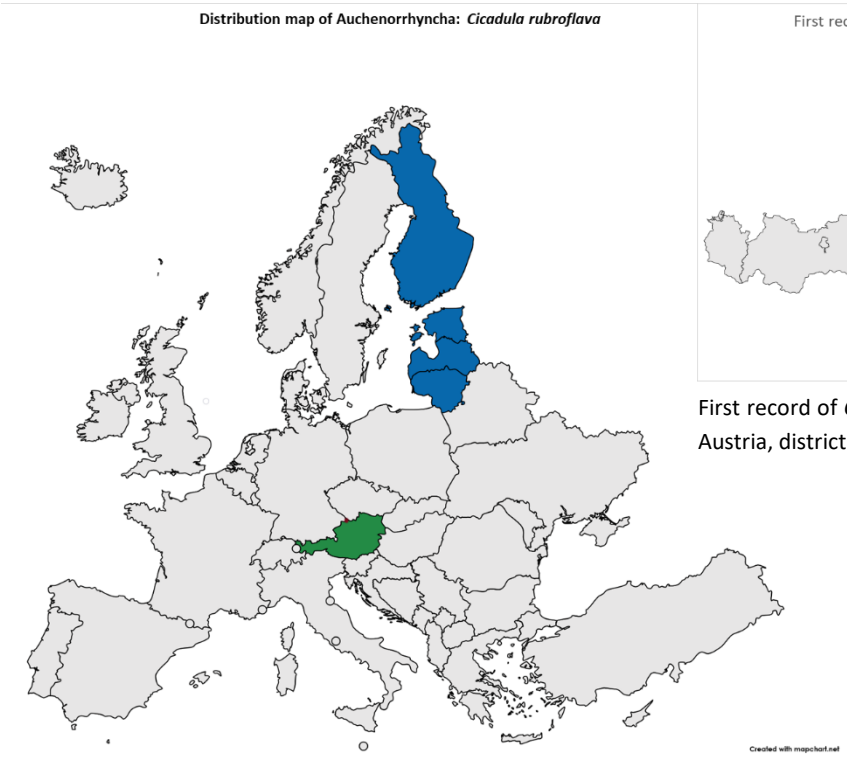


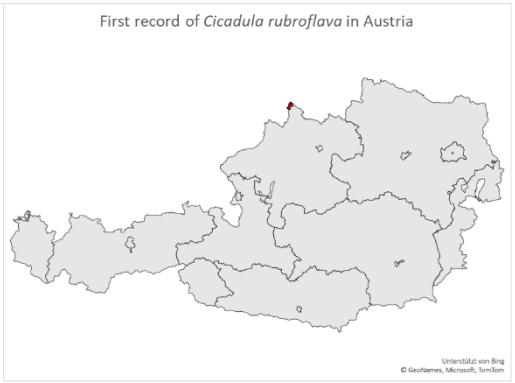




First record of *Cicadula placida* in Austria, Styria, district Oberraktisch, postcode 8480.

Figure 14: Countries in blue show native ranges of *Cicadula placida*. Country in green and the red point show first record in Austria, Styria.

## *Cicadula rubroflava*

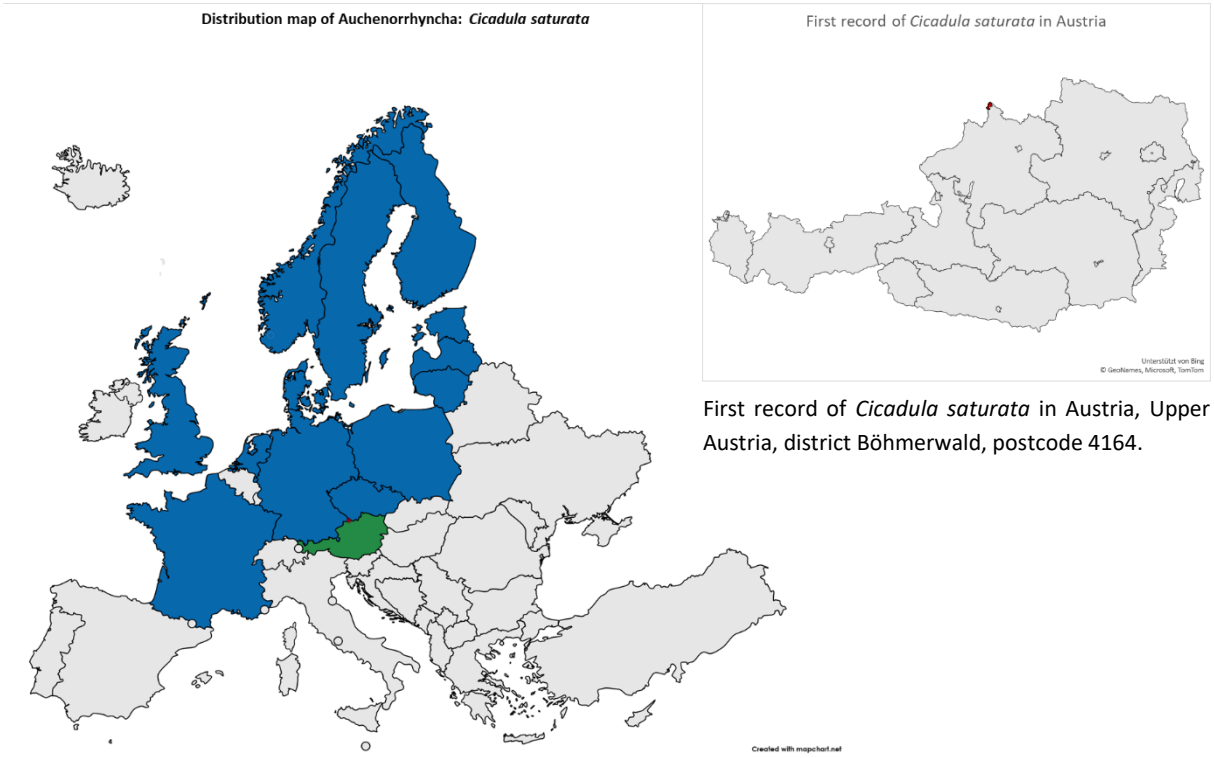



First record of *Cicadula rubroflava* in Austria, Upper Austria, district Böhmerwald, the postcode 4164.

Figure 15: Countries in blue show native ranges of *Cicadula rubroflava*. Country in green and the red point show first record in Austria, Upper Austria.

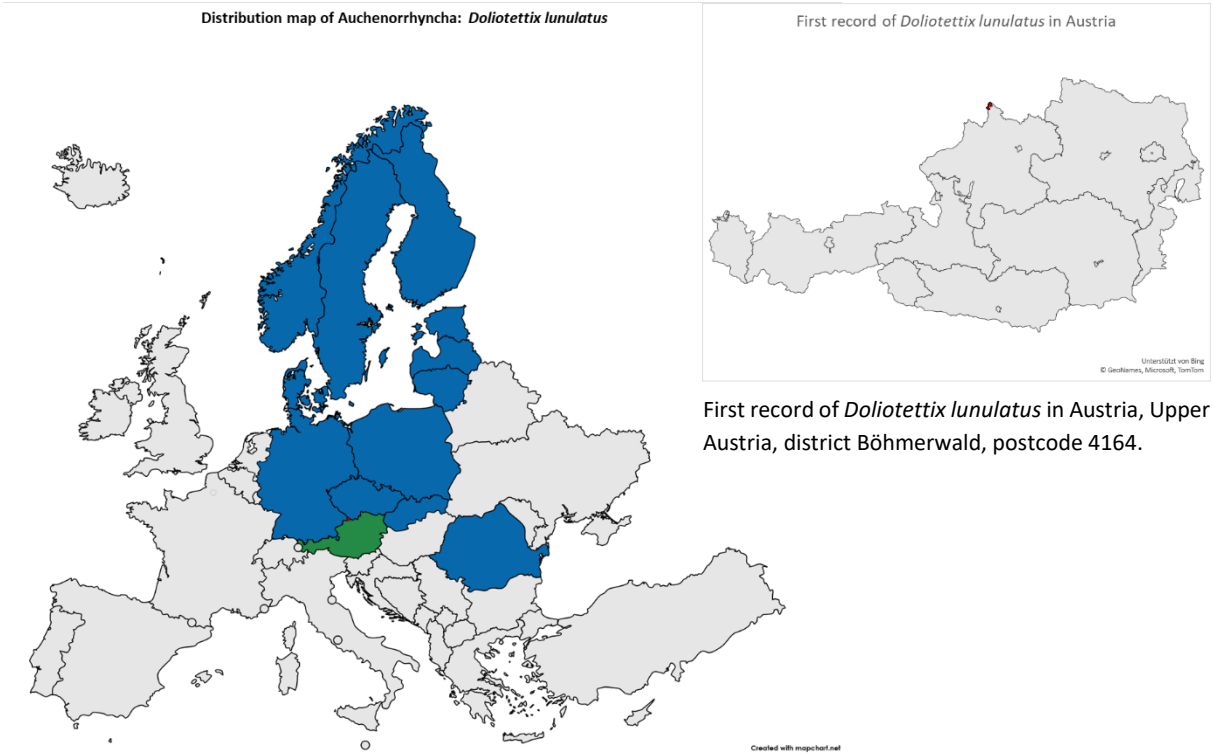
## *Cicadula saturata*




First record of *Cicadula saturata* in Austria, Upper Austria, district Böhmerwald, postcode 4164.

Figure 16: Countries in blue show native ranges of *Cicadula saturata*. Country in green and the red point show first record in Austria, Upper Austria.

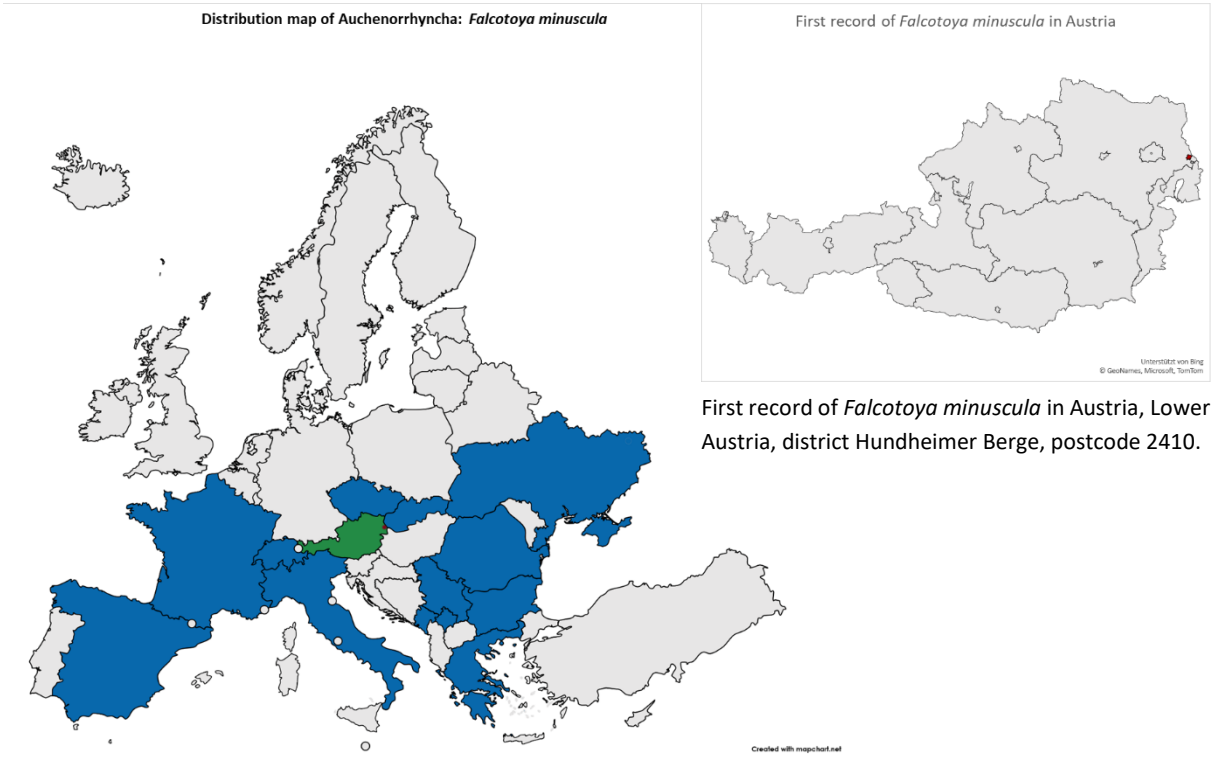
## *Doliotettix lunulatus*




First record of *Doliotettix lunulatus* in Austria, Upper Austria, district Böhmerwald, postcode 4164.

Figure 17: Countries in blue show native ranges of *Doliotettix lunulatus*. Country in green and the red point show first record in Austria, Upper Austria.

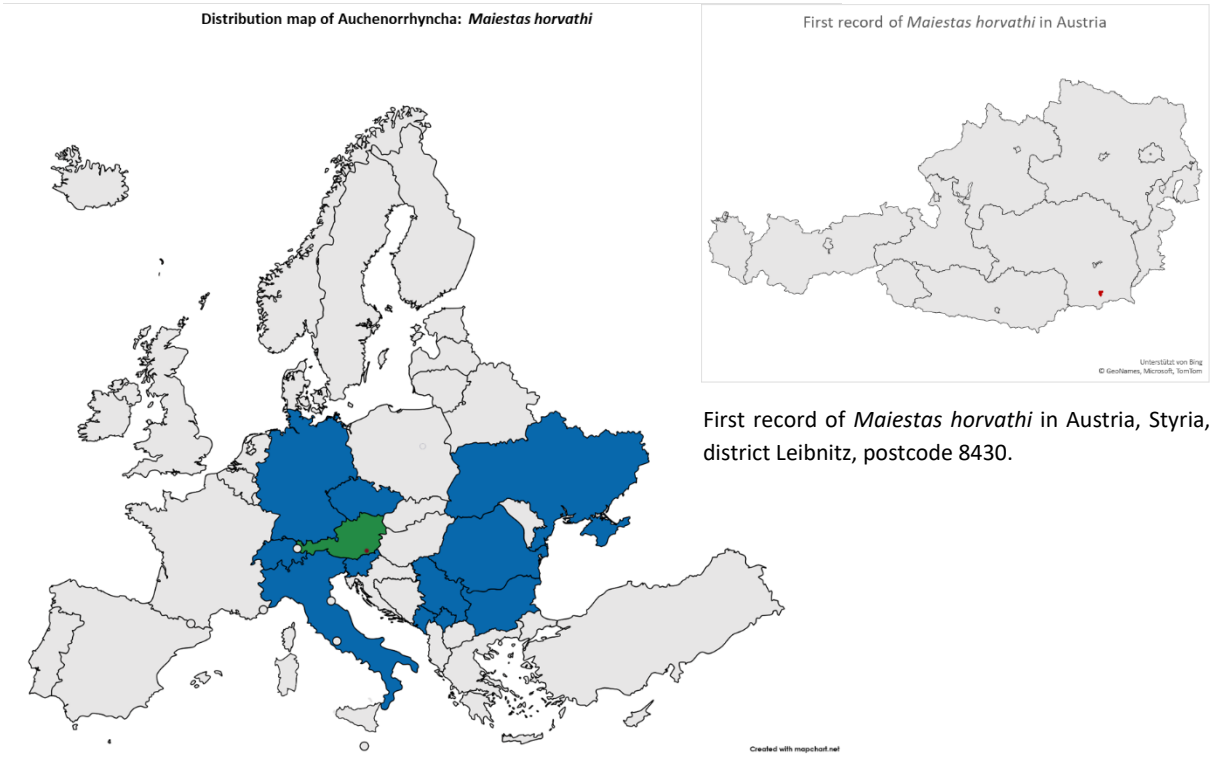
## *Falcotoya minuscula*




First record of *Falcotoya minuscula* in Austria, Lower Austria, district Hundheimer Berge, postcode 2410.

Figure 18: Countries in blue show native ranges of *Falcotoya minuscula*. Country in green and the red point show first record in Austria, Lower Austria.

## *Maiestas horvathi*




First record of *Maiestas horvathi* in Austria, Styria, district Leibnitz, postcode 8430.

Figure 19: Countries in blue show native ranges of *Maiestas horvathi*. Country in green and the red point show first record in Austria, Styria.

Figure 10 to 19 (also Appendix IV) include all European countries where neonative species occur. Current range means the regions where its first record was documented in Austria. Native range describes its indigenous countries or regions.

Neonative Auchenorrhyncha have their current range in the northern and eastern regions of Austria (Figure 10). The species *B. saltuella, C. taeniatus* and *C. placida* have their native European range in the north and east of Austria which fits well with the first place of discovery (Figures 11, 12 and 14). *M. horvathi* is also native in the south and was first recorded in the south of Austria (Figure 19). *C. conspurcatus* is mainly native in the neighbouring south but was recorded first in the east of Austria. The species is native in e.g. Romania and Serbia, so a dispersal through Hungary is possible (Figure 13). *C. rubroflava* (Figure 15) occurs in Upper Austria but has its native region in the baltic states and Finland. *C. saturate* and *D. lunulatus* have both a northern origin and were discovered first in Upper Austria (Figures 16 and 17). *F. minuscula* is a northern and south-western native resident and occurs in Lower Austria (Figure 18).

Neonative Heteroptera have their current range in the north-eastern and eastern regions with a small part of the south (Figure 30). The native region of eight of these 13 species is the Mediterranean but most of them are Ponto-mediterranean (*K. aethiops, C. fasciiventris, M. naso, T. fulvipennis, M. annulosus, D. sinuatocollis, O. lavaterae, G. validus*) and all of them were recorded in the direction of their native range except of *D. sinuatocollis*, who is native in the south-west and *K. aethiops* was found in the eastern region but there is no country directly bordering to Austria (Figures 31, 32, 34, 36, 38, 40, 42 and 43). *C. roseus* and *H. hellenica* have been recorded in the northeast of Austria (Figures 33 and 39). *P. lentigo* is also in the north of Austria native and was found in the north, too (Figure 37). *D. flavilinea* has its native range around Austria except from the east but was first recorded in the east (Figure 35). *P. helenae* live in the south but also in the north of Europe and was found in the north of Austria (Figure 41).

Neonative Coleoptera have their current range in the north-east of Austria (Figure 44). *O. albidus* has its current range in the north-east of Austria and its native range is in the eastern countries, but they are not directly bordering to Austria (Figure 45). *M. quadrimaculata* only has its native range in Italy and occurs in the north-eastern regions (Figure 46). *T. dilaticollis* and *C. philoctetes* are native in the neighbouring east and were recorded in the east, too (Figures 47 and 48).

Neonative Hymenoptera have their current range in the eastern and southern regions of Austria (Figure 49). Six of 8 neonative species were recorded in the east and have their native region in the east and in the west, too (Figures 50 to 54 and 56). *G. planifrons* was found in the south and has its native range almost all around Austria (Figure 57). *A. hispanicus* was found in the south, while it has its native range in the south-west regions (Figure 55).

Neonative Lepidoptera have their current range in the northern, north-west and eastern regions of Austria (Figure 58). The northern recorded species *C. erate* has its native region in the north (Figure 59), the eastern recorded *O. incarnatalis* in the east (Figure 60) and the north-west one *O. fasciuncula* in the north-west and east regions (Figure 61).

Neonative Orthoptera have their current range in the south-east region of Austria (Figure 62). *P. giornae* has its native range in the south-east of Europe and was found in the south-east of Austria (Figure 63).

Neonative Diptera have their current range only in the north-eastern of Austria (Figure 64). *S. lunata* is widespread in almost all neighbouring European countries and thus also in the north and east regions (Figure 65).

## Species attributes of newly recorded species

### Dispersal capacity

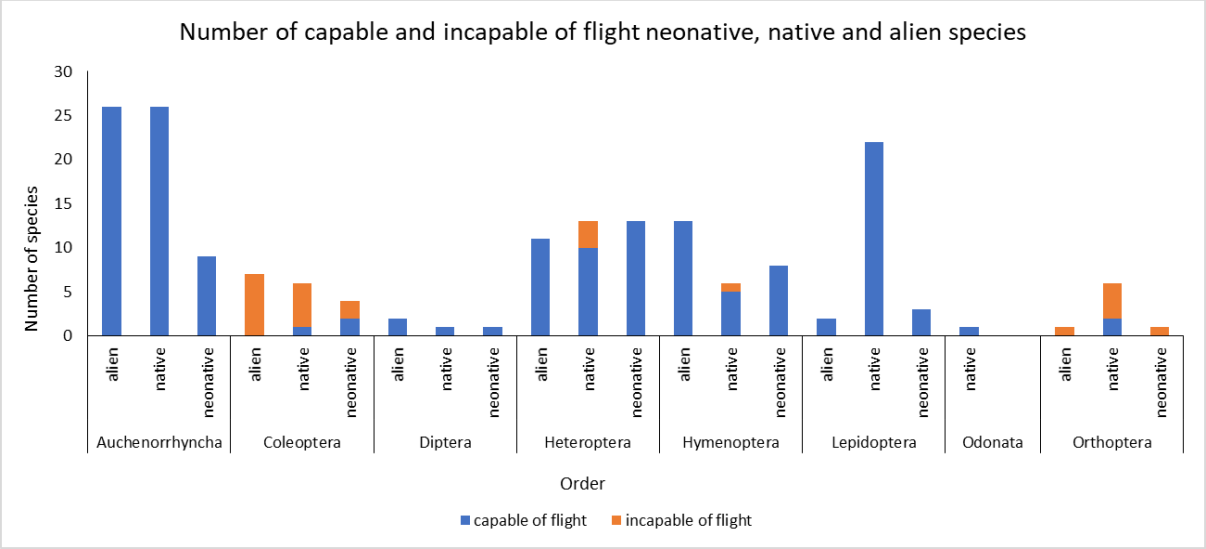



Figure 20: Number of capable and incapable of flight neonative, native and alien species split into orders.

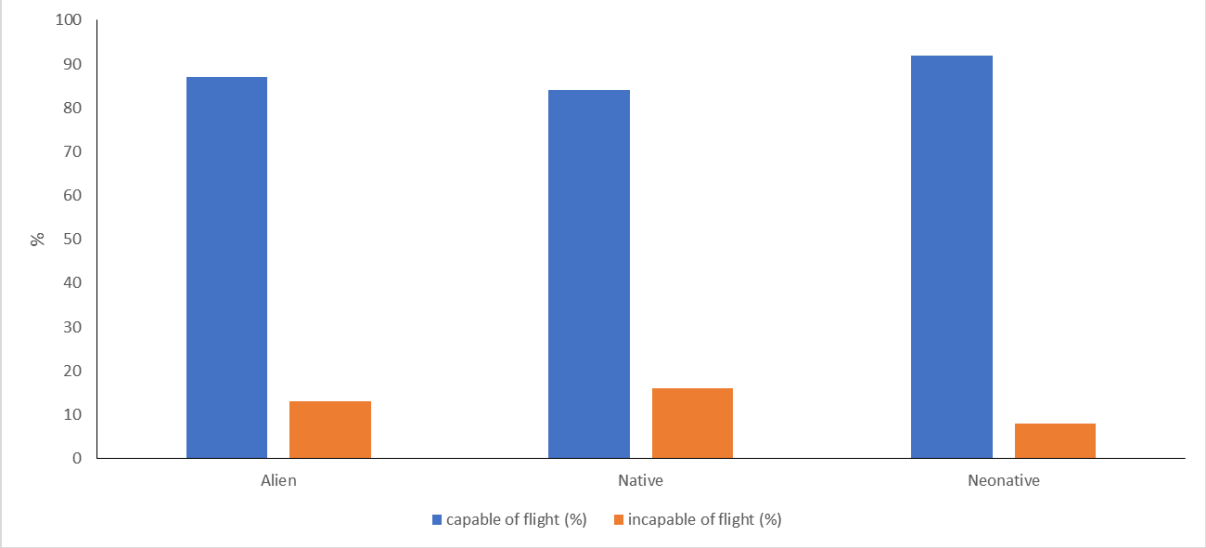



Figure 21: Percentage of number of neonative, native and alien species capable and incapable of flight.

Figures 20 and 21 demonstrate that 92% of neonative, 84% of native and 87% of alien species are capable of flight. Most species of Coleoptera and Orthoptera, regardless of whether they are neonative, native or alien species, are non-mobile species.

## Differences in body size

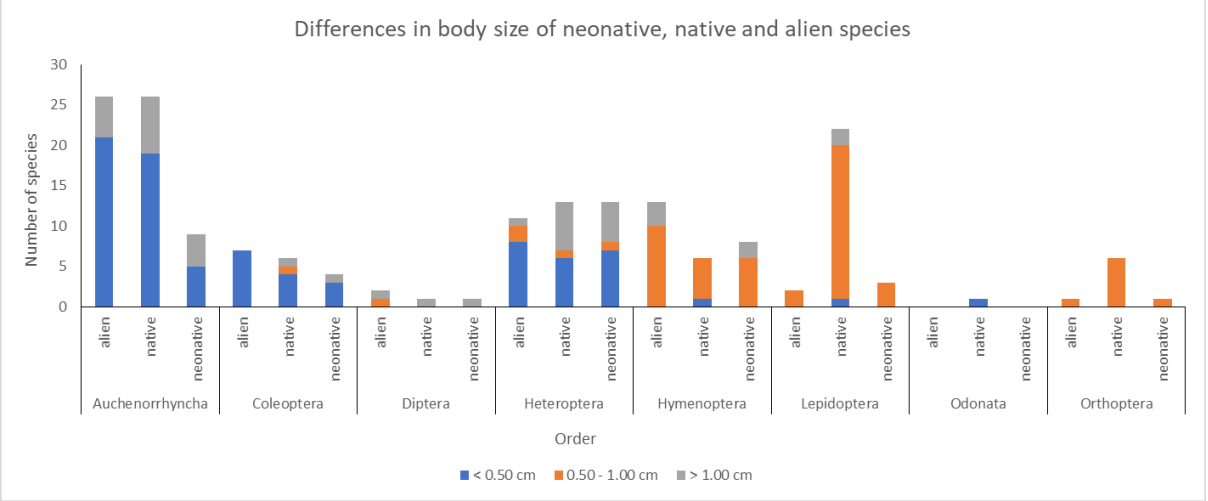



Figure 22: Differences in body size of neonative, native and alien species in the respective orders.

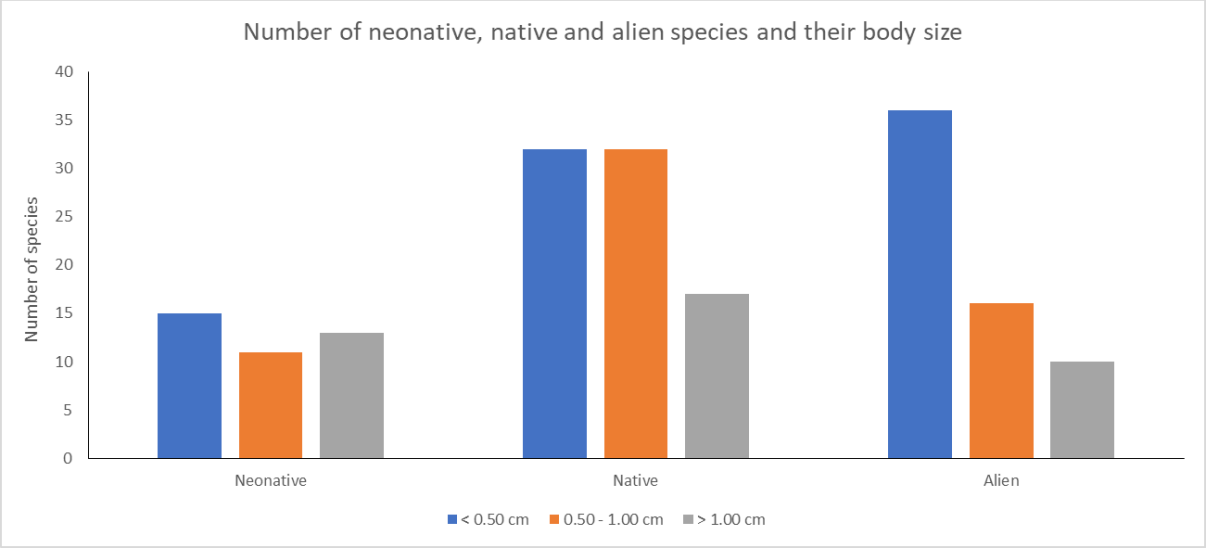



Figure 23: Number of neonative, native and alien species in different groups of their body size.

The body size is given as the maximum body length of the species and shown in the groups <0.50cm, 0.50 - 1.00 cm and >1.00 cm. Most of the Auchenorrhyncha are < 0.50cm and a few are >1.00cm. Hymenoptera, Lepidoptera and Orthoptera are mainly 0.50 - 1.00cm (Figure 22). In neonatives there is no major difference in body size represented but most alien species are under 0.50cm and in native species the sizes <0.50cm and 0.50 - 1.00cm are the prevailing classes of approximate equal distribution (Figure 23).

## Feeding types

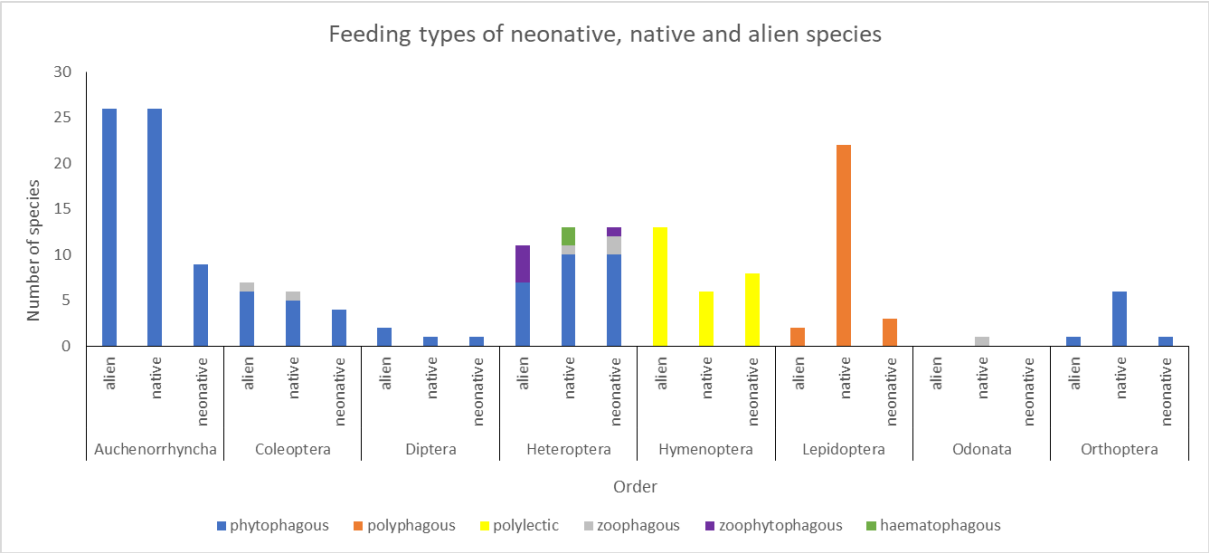



Figure 24: Different feeding types of orders and number of neonative, native and alien species.

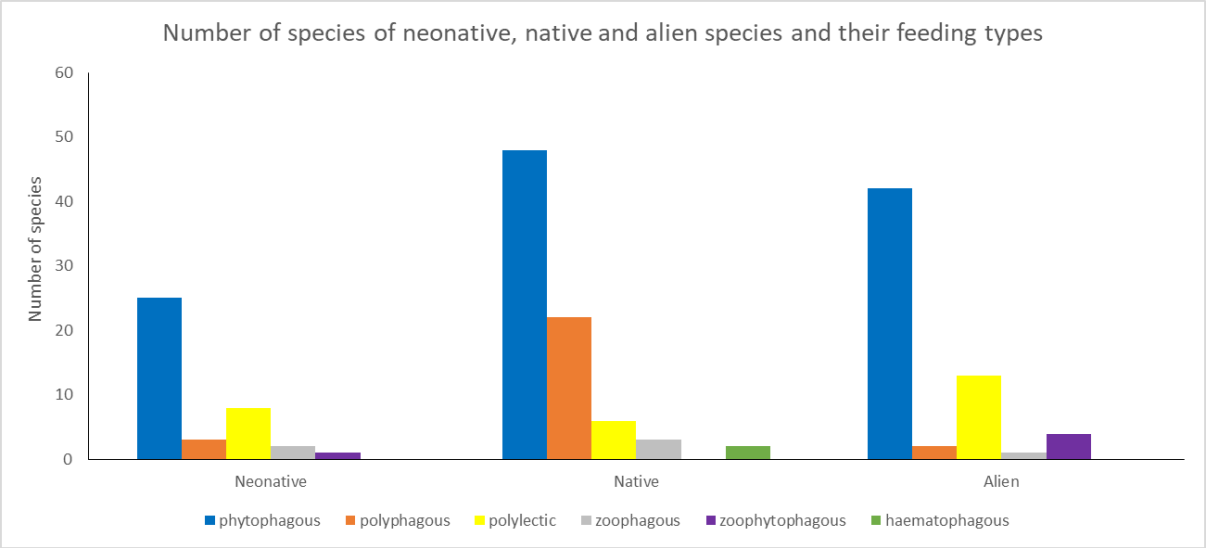



Figure 25: Number of neonative, native and alien species splited in different feeding types.

All three groups prefer a phytophagous diet. Neonative and alien species seem to have a slight tendency towards feeding polylectically and native species tend to be polyphagous. Zoophagous, zoophytophagous and haematophagous species are almost equally distributed between the groups.

## Habitat affiliation

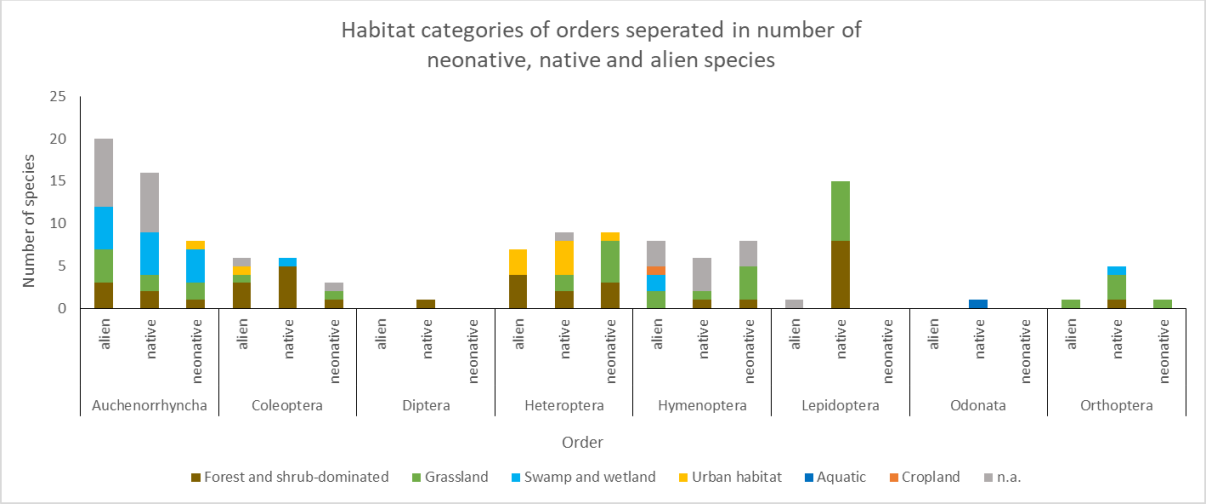



Figure 26: Different categories of habitats divided in orders and number of neonative, native and alien species.

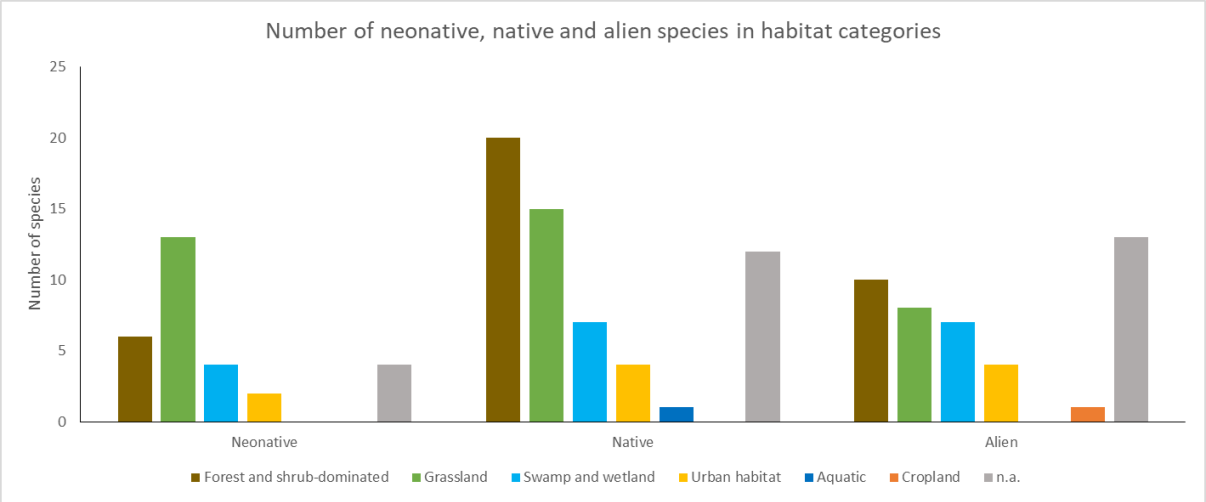



Figure 27: Number of neonative, native and alien species in different habitat categories.

For the neonative species, there was a 67% match between the habitat of the first place of discovery in Austria and their native habitat type (Figure 27). Most of the neonative species were found in grassland or forest and shrub-dominated land. For the native and alien species, there was a 72% and 68% match, respectively.

# Discussion

Several studies have investigated species' responses to climate change and have provided evidence that ectothermic animals in particular have altered their geographic ranges in response to rising global temperatures. In Europe, many cases of range shifts among insects have been attributed directly to increasing temperature (Sánchez-Guillén et al., 2013).

Regarding the number of newly recorded neonative species, my study shows that Heteroptera are the species with the most documented range shifts into Austria (Table 5). Almost all of these species are assumed to expand their range further, become more common in Austria and other European countries (Rabitsch, 2008). These 13 neonative species have probably arrived in Austria due to current beneficial climatic conditions, 13 native species have been overlooked and 11 alien species introduced likely with ornamental plants or by transport (Rabitsch, 2008).

The Heteroptera are followed by the Auchenorrhyncha with 9 neonative, 26 native and 26 alien species (Table 5). They are one of the most individual-rich animal groups in Austria and Europe and colonise almost all terrestrial and semi-terrestrial habitats from the lowland to the alpine level (Holzinger, 2009). The knowledge about local and regional distribution patterns of Auchenorrhyncha within Austria is heterogenous and, in general, not as well studied as the Heteroptera fauna. For example, Lower Austria and parts of Styria are studied quite well, while East Tyrol and Salzburg are not (Holzinger, 2009). Therefore, it is more difficult to assess which plant- and leafhoppers have spread northwards from the Mediterranean.

Generally, the lack of specialists must be considered because many areas and insect groups are poorly studied and therefore too little data are available. It is not always clear whether newly recorded species after 1990 are potential climate winners or whether they have always been present but were not found before or were overlooked because of rarity, poor detectability, small size, the fact that species look too similar to others or have similar sister species, due to taxonomic changes or their cryptic habitat (Rabitsch, 2008). Also, some faunas are better investigated than others and all these factors can influence the number, year and first place of discovery of a species.

A publication bias is also possible. Newly recorded species often concern recent introductions of aliens. Similarly, modern sampling methods such as d-vac suction samplers, a converted, motorised leaf vacuum cleaner that extracts ground-dwelling species out of the vegetation, made

it possible to record species that were previously very difficult or impossible to catch with a sweeping net.

Temporal accummulation patterns indicate that between 1990 and 2000, there was an increase in the number of first records of native species. Over time, fewer newly recorded native species were documented. This can be explained by the fact that species or populations that have always been present, eventually reach the level where no or few new native species are left to discover in Austria (Figures 2 to 5).

While neonative and alien species are more constantly immigrating and being introduced to Austria during 1990 to 2019, it can be a challenge to differentiate these two groups because sometimes it can be difficult to distinguish whether the species has spread on its own or through human interventions.

According to the results of the linear model, the significances between the year and the three groups (Table 6) cannot be interpreted because the residuals are not normally distributed. There is also a very high probability that newly recorded species were found much earlier and were only discovered and published later.

The spatial pattern of newly recorded neonative species in Austria clearly shows that the warm regions like Burgenland with 11 species and Lower Austria with 9 species, are the gateways of neonatives (Figures 6 and 7). This indicates that the newly recorded “climate change-immigrants” are species who predominantly arrive in the north-east of Austria, which may be a preferred invasion gateway for southeast-mediterranean species, due to the barrier effect of the Alps (Figure 28) (Rabitsch, 2008). Their northern limit of distribution is south of the Alps, and their main migration route is to the south and east of Austria.

Besides climatic factors, the availability of habitats is also crucial for species' establishments. Habitats with low anthropogenic influences are becoming exceedingly rare. In the case of neonative species, the conformity of habitats was at 67%, the rest which do not match with the native habitat include, inter alia, Heteroptera that have their native habitat in forests but were also found in urban habitats in Austria. Changes in habitat preference are considered to play an important role in recent additions to the Heteroptera inventory of Austria, especially the availability of ornamental plants in urban areas (Rabitsch, 2008).

Native and alien species occur throughout Austria but are more common in north-eastern and southern regions (Figures 8 and 9). Here, too, it is possible that the presence of newly recorded species especially in these regions is a consequence of better exploration in these

regions. Further monitoring, especially of neonative occurrence in Austria is needed to detect and verify whether they are able to establish populations and whether certain species have adapted to their habitat.

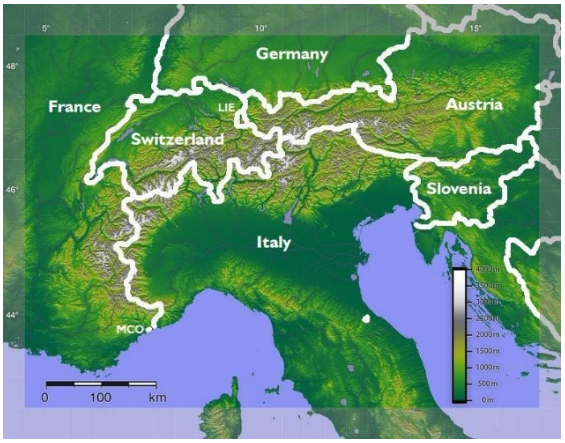



Figure 28: Map of the west-east course of the Alps with national borders (Wikipedia, 2009).

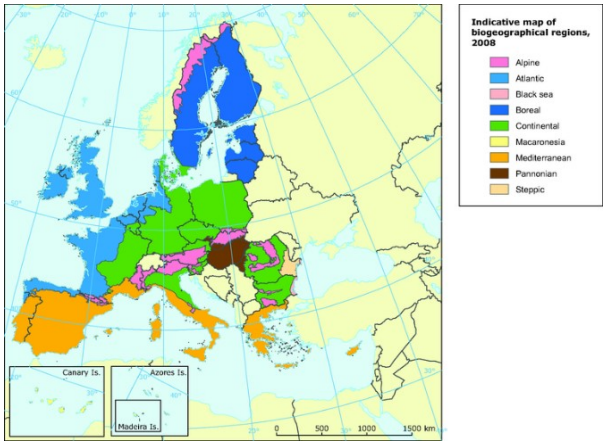



Figure 29: Biogeographical regions in Europe (EEA, 2017).

Central Europe is becoming more Mediterranean-like in temperature and precipitation and in species diversity so distributional shifts polewards and uphill are to be expected (Rabitsch, 2008; Parmesan, 2006). So, I created distribution maps to represent the current ranges of neonative species in Austria and their native ranges in Europe and whether there is a shift of geographic distribution toward higher latitudes (Figures 10 to 19 and Appendix IV).

Auchenorrhyncha show a mainly northern and eastern immigration to Austria (Figure 10). three of the 9 species have their native biogeography region in the north, whereby their first records were also northern (Figures 15 to 17). *C. rubroflava* for example, occurs in Upper Austria and has its native region in the baltic states and Finland (Figure 15). But the species has also been recorded in the Bavarian Alps and can be expected in the northern Alps and Pre-Alps of Austria (Holzinger et al., 2009). In the case of plant- and leafhoppers, for example, it is difficult to evaluate whether they have spread northwards from the Mediterranean region by themselves, as these species have been studied only insufficiently or slowly in recent years. In addition, some difficult Central European genera (e.g. Psammotettix, Macrosteles, Macropsis, Kybos) were revised only in the 20th, in part only in the 21st century, and could only then be reliably determined.

Heteroptera show a north-eastern and eastern drift to Austria (Figure 30). Eight of 13 species have their distribution area in the Mediterranean and most of them in the Ponto-Mediterranean. Just *C. roseus* has its native range in continental European regions (Figures 31 to 43).

Coleoptera show an eastward tendency to Austria (Figure 44). Three of 4 species have their native range in the east to (Figures 45, 47 and 48) and only one species *M. quadrimaculata,* has its native range in the south and the first record was in the east of Austria (Figure 46).

Hymenoptera show a south-eastern immigration (Figure 49). Two of 8 neonative species occur in the south (Figures 55 and 57), all other species appear in the east of Austria and all of them have their native range in neighbouring countries. Among Hymenoptera, for example, most species are represented with very few records, and this has not changed in recent years. An exception is *B. haematurus*, which has successively spread beyond Linz, so that today more than 100 locations are known in Austria (Figure 50). This is a good sign for dispersal and should be observed over the next years.

Lepidoptera were first recorded in north and in the centre of Austria which matches to the biogeography regions of their native range (Figures 58 to 61). Orthoptera appear in south-western and eastern countries of Europe and the one species was also found in the south-east (Figures 62 and 63). Diptera occur in Mediterranean, Continental and Pannonian regions and the one species was found in the east of Austria (Figures 64, 65 and 29).

Most species occur in the Pannonian region of Austria (Lower Austria and Burgenland) which may indicate an invasion gateway for Ponto-Mediterranean species. The fact that species rarely immigrate from the south, what would be expected regarding climate change, can be explained by the effective barrier of the Alps, which causes them to move east (Rabitsch, 2008) (Figure 28). Only two neonative, three native and three alien species are not present to a country bordering Austria (Table 7). This shows a very high likelihood that neonative species are able to spread through Austria's direct neighbours without human help.

Shifts in species distribution patterns can be temporary or permanent. In warm or hot summers, species often migrate to higher latitudes, but they are not able to persist. The decisive factor in this context is whether this movement is an oscillation or a trend. As mentioned before, climatic conditions are not the only factor determining or driving range expansions. Also habitat change or habitat characteristics are of particular importance for the successful establishment of

many species in a new area. Due to these interacting forces, many species are expanding their range, so their occurrence and distribution in Austria can be expected (Rabitsch, 2008). In order to track these processes, it is of crucial importance to create and keep up to date European wide data collections to identify these changes that deserve further study.

In my study, I gathered species attribute data to determine whether certain attributes indicate preferential immigration (Appendix IIITable 10). Species may lag behind climate change, for example, if they are immobile and cannot colonize across fragmented landscapes (Chen i-Ching et al., 2011). I analyzed whether there is a link between dispersal capacity and the range expansion. Most species in all three groups show a clear mobility and almost all neonative species, especially most of the newly recorded Auchenorrhyncha, Heteroptera and Hymenoptera are capable of flying (Figures 20 and 21). This suggests that these species are more capable of changing their range and thus more likely to do so. But it is worth noting, that the criterion "migration by own efforts" is not a distinction to be made trivially. In the case of Lepidoptera, for example, weather/climate/wind systems also play a significant role, as the appearance of newly recorded species is also possible due to strong southerly winds.

There seems to be no preference of body size in neonative species (Figures 22 and 23). This indicates that body size is not of particular relevance for predicting additions of newly recorded species in a given territory. For first recorded alien and especially native species, the assumption that small species are more easily overlooked is contradicted, but it is possible that a cryptic way of life prevails among previously overlooked species (Rabitsch, 2008).

It has been shown that climate change favours generalists and threatens specialists (Rabitsch et al., 2020). My results demonstrate, in all three groups, a phytophagous diet seemed to be predominant (Figures 24 and 25). Further research is needed to determine whether there is a high degree of host or food plant specialization, a climatic suitability for and the presence of host plants in this region, as phytophagous species are more subject to threats due to their dependence on host plants (Poloni et al., 2022).

Neonative species do not seem to prefer a particular type of habitat since they are found in a wide variety of habitat categories, but a preference for grassland or forest and shrub-dominated land was noticed (Figures 26 and 27). Habitat selection of newly recorded species revealed that 67% of the species who expanded their range were found in their preferred habitat types. This shows that newly recorded species colonize the same habitat in the new range as in

the native range. Where there was no match, the species were often found in urban habitats or there was a lack of data.

Based on this study, further important questions can be asked e.g. What is the phenology of neonative species in Austria, is it different from the native range and are there relationships with temperature? Trends in temperature over time also need to be studied in more detail, because if there is a link between range-shift and climate change, more detailed analysis at local scales are needed. In my study, there was no apparent correspondence between the annual mean temperature in Austria and range-expansions, so in future studies, temperature differences between years, months and districts or federal provinces should be considered.

Whether the first recorded neonative species became established is partly doubtful or unknown, as some are only known from a single record, have been overlooked in the past or were discovered only recently. It would be important to monitor the distribution of neonatives over the next years in Austria, to determine whether the species were able to establish populations, i.e. whether their presence was only an oscillation or an actual range shift. Also, the colonized habitats should be monitored to elucidate possible niche shifts and local adaptations to the new environemental conditions.

# Appendix

## Appendix I - Data of first recorded neonative species

Table 8: Scientific species name and number of current ranges in federal provinces, districts and postal codes in Austria, the order and the year of first records of neonative species.

| Order | Species | Federal province | District | Current range | Number of first records per federal province | Year of first record |
|---|---|---|---|---|---|---|
| Auchenorrhyncha | *Calamotettix taeniatus* | Burgenland | 7142 | Neusiedlersee, Illmitz | 11 | 2017 |
| Auchenorrhyncha | *Chiasmus conspurcatus* | Burgenland | 7141 | Neusiedelersee, Seewinkel | 11 | 2019 |
| Coleoptera | *Tanymecus dilaticollis* | Burgenland | 7100 | Neusiedl am See | 11 | 2015 |
| Coleoptera | *Mycetochara quadrimaculata* | Burgenland | 7071 | Rust | 11 | 2005 |
| Coleoptera | *Charopus philoctetes* | Burgenland | 7093 | Hackelsberg/Jois | 11 | 2015 |
| Heteroptera | *Oxycarenus lavaterae* | Burgenland | 7122 | Gols | 11 | 2001 |
| Heteroptera | *Psallus helenae* | Burgenland | 7064 | Oslip | 11 | 2014 |
| Hymenoptera | *Bombus haematurus* | Burgenland | 7540 | Güssing | 11 | 2002 |
| Hymenoptera | *Anthidium laterale* | Burgenland | 7142 | Illmitz | 11 | 1991 |
| Hymenoptera | *Lasioglossum laterale* | Burgenland | 7083 | Purbach | 11 | 2016 |
| Hymenoptera | *Hoplocryptus femoralis* | Burgenland | 7093 | Neusiedl am See/Jois | 11 | 2018 |
| Hymenoptera | *Argogorytes hispanicus* | Carinthia | 9135 | Vellacher Kotschna | 3 | 1996 |
| Hymenoptera | Gorytes planifrons | Carinthia | 9560 | Steuerberg | 3 | 1991 |
| Auchenorrhyncha | *Falcotoya minuscula* | Lower Austria | 2410 | Hundheimer Berge | 10 | 2005 |
| Coleoptera | *Otiorhynchus albidus* | Lower Austria | 2230 | Gänserndorf | 10 | 2013 |
| Diptera | *Stomorhina lunata* | Lower Austria | 2410 | Hainburger Berge | 10 | 2016 |
| Heteroptera | *Thyreocoris fulvipennis* | Lower Austria | 2275 | Bernhardsthal | 10 | 2001 |
| Heteroptera | *Psallus lentigo* | Lower Austria | 2275 | Bernhardsthal | 10 | 2003 |
| Heteroptera | *Megalocoleus naso* | Lower Austria | 2492 | Eggendorf | 10 | 1999 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Heteroptera | *Conostethus roseus* | Lower Austria | 2291 | Marchfeld | 10 | 1999 |
| Heteroptera | *Graptopeltus validus* | Lower Austria | 2340 | Mödling | 10 | 2015 |
| Lepidoptera | *Colias erate* | Lower Austria | 3601 | Dürnstein | 10 | 1990 |
| Auchenorrhyncha | *Cicadula rubroflava* | Upper Austria | 4164 | Böhmerwald | 4 | 2011 |
| Auchenorrhyncha | *Cicadula saturata* | Upper Austria | 4164 | Böhmerwald | 4 | 2011 |
| Auchenorrhyncha | *Doliotettix lunulatus* | Upper Austria | 4164 | Böhmerwald | 4 | 2011 |
| Lepidoptera | *Oligia fasciuncula* | Upper Austria | 4849 | Punzenberg | 4 | 1992 |
| Auchenorrhyncha | *Balclutha saltuella* | Styria | 8112 | Schirning | 8 | 2008 |
| Auchenorrhyncha | *Cicadula placida* | Styria | 8480 | Oberraktisch | 8 | 1992 |
| Auchenorrhyncha | *Maiestas horvathi* | Styria | 8430 | Leibnitz | 8 | 2014 |
| Heteroptera | *Kalama aethiops* | Styria | 8223 | Europaschutzgebiet Feistritzklamm-Herberstein | 8 | 2000 |
| Heteroptera | *Cardiastethus fasciiventris* | Styria | 8223 | Europaschutzgebiet Feistritzklamm-Herberstein | 8 | 2000 |
| Hymenoptera | *Liris nigra* | Styria | 8282 | Therme Loipersdorf | 8 | 1993 |
| Lepidoptera | *Orthopygia incarnatalis* | Styria | 8344 | Bad Gleichenberg | 8 | 2005 |
| Orthoptera | *Pezotettix giornae* | Styria | 8354 | St. Anna a. Aigen | 8 | 1992 |
| Heteroptera | *Deraeocoris flavilinea* | Vienna | 1090 | Alsergrund | 5 | 2002 |
| Heteroptera | *Harpocera hellenica* | Vienna | 1220 | Alte Schanze | 5 | 2010 |
| Heteroptera | *Metacanthus annulosus* | Vienna | 1140 | Hadersdorf | 5 | 2003 |
| Heteroptera | *Derephysia sinuatocollis* | Vienna | 1220 | Lobau | 5 | 2016 |
| Hymenoptera | *Harpactus transiens* | Vienna | 1220 | Lobau | 5 | 2013 |

## Appendix II - Native ranges and federal provinces of first record of the species

Table 9: Overview of order, species, year and federal province of first record and distribution according to Fauna Europaea in the neighbouring countries of neonative, native and alien species. x = doubtfully present; x = not found in Fauna Europaea but from scientific papers or internet sources. Abbreviations: AT = Austria; DE = Germany; CH = Switzerland; HU = Hungary; SK = Slovakia; SI = Slovenia; CZ = Czech Republic; IT = Italy.

| | | | | Distribution according to FAUNA EUROPAEA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Order** | **Species** | **Year of first record** | **Federal province of first record** | **AT** | **DE** | **CZ** | **SK** | **HU** | **SI** | **IT** | **CH** | **Neonative, Native, Alien species** |
| Auchenorrhyncha | *Calamotettix taeniatus* | 2017 | Burgenland | | x | x | | x | x | | | neonative |
| Auchenorrhyncha | *Chiasmus conspurcatus* | 2019 | Burgenland | x | | | | | x | x | x | neonative |
| Coleoptera | *Charopus philoctetes* | 2015 | Burgenland | | | | | x | | x | | neonative |
| Coleoptera | *Mycetochara quadrimaculata* | 2005 | Burgenland | | | | | | | x | | neonative |
| Coleoptera | *Tanymecus dilaticollis* | 2015 | Burgenland | | | x | x | x | | | | neonative |
| Heteroptera | *Psallus helenae* | 2014 | Burgenland | | | x | x | | | x | | neonative |
| Heteroptera | *Oxycarenus lavaterae* | 2001 | Burgenland | x | x | x | x | x | x | x | x | neonative |
| Hymenoptera | *Bombus haematurus* | 2002 | Burgenland | | | | | x | | | | neonative |
| Hymenoptera | *Anthidium laterale (=Icteranthidium laterale)* | 1991 | Burgenland | x | | | x | x | | x | x | neonative |
| Hymenoptera | *Lasioglossum laterale* | 2016 | Burgenland | | | | | x | | x | x | neonative |
| Hymenoptera | *Hoplocryptus femoralis* | 2019 | Burgenland | | | | | | | x | | neonative |
| Hymenoptera | *Argogorytes hispanicus* | 1996 | Carinthia | x | | | | | | x | x | neonative |
| Hymenoptera | *Gorytes planifrons* | 1991 | Carinthia | x | x | | | x | | x | x | neonative |
| Auchenorrhyncha | *Falcotoya minuscula* | 2005 | Lower Austria | | | x | x | | | x | x | neonative |
| Coleoptera | *Otiorhynchus albidus* | 2013 | Lower Austria | | | | | | | | | neonative |
| Diptera | *Stomorhina lunata* | 2016 | Lower Austria | | x | x | x | x | | x | x | neonative |
| Heteroptera | *Conostethus roseus* | 1999 | Lower Austria | x | x | x | | x | | | | neonative |
| Heteroptera | *Megalocoleus naso* | 1999 | Lower Austria | x | | | x | x | | | | neonative |
| Heteroptera | *Thyreocoris fulvipennis* | 2001 | Lower Austria | x | | x | x | x | | x | | neonative |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heteroptera | *Psallus lentigo* | 2003 | Lower Austria | x | | x | x | | x | | | neonative |
| Heteroptera | *Graptopeltus validus* | 2015 | Lower Austria | | | | x | x | x | x | | neonative |
| Lepidoptera | *Colias erate* | 1990 | Lower Austria | x | | x | x | x | | | | neonative |
| Auchenorrhyncha | *Cicadula rubroflava* | 2011 | Upper Austria | | | | | | | | | neonative |
| Auchenorrhyncha | *Cicadula saturata* | 2011 | Upper Austria | | x | x | | | | | | neonative |
| Auchenorrhyncha | *Doliotettix lunulatus* | 2011 | Upper Austria | | x | x | x | | | | | neonative |
| Lepidoptera | *Oligia fasciuncula* | 1992 | Upper Austria | x | x | x | | x | x | | x | neonative |
| Auchenorrhyncha | *Balclutha saltuella* | 2008 | Styria | | x | x | x | x | | x | x | neonative |
| Auchenorrhyncha | *Cicadula placida* | 1992 | Styria | x | | x | | x | x | x | | neonative |
| Auchenorrhyncha | *Maiestas horvathi* | 2014 | Styria | x | x | x | | | x | x | x | neonative |
| Heteroptera | *Kalama aethiops* | 2000 | Styria | x | | | x | | | x | | neonative |
| Heteroptera | *Cardiastethus fasciiventris* | 2000 | Styria | x | x | | | x | | x | x | neonative |
| Hymenoptera | *Liris nigra* | 1993 | Styria | x | x | x | x | x | | x | | neonative |
| Lepidoptera | *Orthopygia incarnatalis* | 2005 | Styria | | | | | x | | x | | neonative |
| Orthoptera | *Pezotettix giornae* | 1992 | Styria | x | | | x | x | x | x | x | neonative |
| Heteroptera | *Deraeocoris flavilinea* | 2002 | Vienna | x | x | x | | | x | x | x | neonative |
| Heteroptera | *Metacanthus annulosus* | 2003 | Vienna | | | | x | x | | x | | neonative |
| Heteroptera | *Harpocera hellenica* | 2010 | Vienna | | | x | | | | | | neonative |
| Heteroptera | *Derephysia sinuatocollis* | 2016 | Vienna | | x | | | | x | x | x | neonative |
| Hymenoptera | *Harpactus transiens (=Harpactus consanguineous)* | 2013 | Vienna | | | | | x | | x | | neonative |
| Auchenorrhyncha | *Metalimnus obtusus* | 1991 | Burgenland | x | | | | | | | | native |
| Lepidoptera | *Dryadaula irinae* | 1995 | Vorarlberg | | | | | | | | | native |
| Lepidoptera | *Monochroa moyses* | 2012 | Vienna | | | | | | | | | native |
| Auchenorrhyncha | *Anaceratagallia laevis* | 2001 | Burgenland | | | | | x | | x | x | native |
| Auchenorrhyncha | *Chloriona dorsata* | 2001 | Burgenland | | x | | | | | | | native |
| Auchenorrhyncha | *Chloriona glaucescens* | 1991 | Burgenland | x | x | x | | x | | x | x | native |
| Auchenorrhyncha | *Chloriona vasconica* | 1991 | Burgenland | x | x | x | | x | | x | | native |
| Auchenorrhyncha | *Gravesteiniella boldi* | 1993 | Burgenland | x | x | | x | x | | | | native |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Auchenorrhyncha | *Kelisia minima* | 2001 | Burgenland | | x | | | | | | x | | native |
| Auchenorrhyncha | *Kelisia sabulicola* | 1991 | Burgenland | | x | | | | | | | | native |
| Auchenorrhyncha | *Laburrus handlirschi* | 1993 | Burgenland | x | | x | x | x | | | | | native |
| Auchenorrhyncha | *Metalimnus steini* | 1993 | Burgenland | x | x | | | x | | | | | native |
| Auchenorrhyncha | *Mocydiopsis intermedia* | 1993 | Burgenland | x | x | x | | x | | | | | native |
| Auchenorrhyncha | *Muellerianella fairmairei* | 1996 | Burgenland | x | x | x | | | | x | x | | native |
| Auchenorrhyncha | *Psammotettix asper* | 1993 | Burgenland | x | | | x | x | | | | | native |
| Auchenorrhyncha | *Psammotettix provincialis* | 2001 | Burgenland | | | x | | x | | x | x | | native |
| Coleoptera | *Bythinus acutangulus* | 2003 | Burgenland | | | | x | x | x | | | | native |
| Lepidoptera | *Shargacucullia gozmanyi (=Cucullia gozmanyi)* | 2000 | Burgenland | x | | x | x | x | x | | | | native |
| Odonata | *Chalcolestes parvidens* | 2005 | Burgenland | x | x | | | x | | x | | | native |
| Orthoptera | *Isophya modesta* | 2014 | Burgenland | | | | | x | | | | | native |
| Auchenorrhyncha | *Cixidia lapponica* | 2014 | Carinthia | | | | x | | | | | | native |
| Heteroptera | *Phytocoris hirsutulus* | 2015 | Carinthia | | x | x | | | x | | | | native |
| Lepidoptera | *Coleophora meridionella* | 1993 | Carinthia | x | | | | | | x | | | native |
| Lepidoptera | *Crocallis tusciaria* | 1993 | Carinthia | x | x | x | x | x | x | x | x | | native |
| Lepidoptera | *Ethmia haemorrhoidella* | 1996 | Carinthia | x | | | x | x | | x | | | native |
| Lepidoptera | *Gillmeria miantodactylus* | 1996 | Carinthia | x | | | | x | | | | | native |
| Lepidoptera | *Paraplatyptilia metzneri* | 1999 | Carinthia | | | | | | | x | x | | native |
| Lepidoptera | *Phyllonorycter aemula* | 1998 | Carinthia | | | | | | | x | | | native |
| Auchenorrhyncha | *Delphacodes audrasi* | 2004 | Lower Austria | | | | | x | | | | | native |
| Auchenorrhyncha | *Florodelphax paryphasma* | 2006 | Lower Austria | | x | | | | | | | | native |
| Auchenorrhyncha | *Praganus hofferi* | 1993 | Lower Austria | x | x | x | | x | | | | | native |
| Coleoptera | *Ampedus suecicus* | 1999 | Lower Austria | x | | x | x | | | | | | native |
| Coleoptera | *Berginus tamarisci* | 2013 | Lower Austria | x | | | | | | x | x | | native |
| Coleoptera | *Micropeplus latus* | 2000 | Lower Austria | | | | x | | | | | | native |
| Diptera | *Pipizella virens* | 2001 | Lower Austria | | x | x | x | x | x | x | x | | native |
| Heteroptera | *Berytinus consimilis* | 2003 | Lower Austria | x | | x | x | x | | x | | | native |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heteroptera | *Cimex dissimilis* | 1997 | Lower Austria | x | x | x | x | x | | | x | | native |
| Heteroptera | *Lygocoris zebei* | 2000 | Lower Austria | x | x | x | | | | | | | native |
| Heteroptera | *Psallus pseudoplatani* | 2003 | Lower Austria | x | x | x | | | | x | | | native |
| Hymenoptera | *Colletes pallescens* | 2004 | Lower Austria | | | | | x | | | | | native |
| Lepidoptera | *Autographa buraetica* | 1991 | Lower Austria | x | x | x | | x | | | | | native |
| Orthoptera | *Isophya pienensis* | 2000 | Lower Austria | x | | x | x | | | | | | native |
| Orthoptera | *Poecilimon intermedius* | 2008 | Lower Austria | x | | x | x | x | | | | | native |
| Orthoptera | *Tetrix ceperoi* | 2015 | Lower Austria | | x | x | x | x | x | x | x | | native |
| Auchenorrhyncha | *Eupteryx signatipennis* | 2011 | Upper Austria | | x | | | | | x | x | | native |
| Coleoptera | *Agabus wasastjernae (=Ilybius wasastjernae)* | 2005 | Upper Austria | | x | x | | | | | | | native |
| Hymenoptera | *Birka alpina* | 2000 | Upper Austria | | | | | | | | | | native |
| Hymenoptera | *Dusona temnator* | 2007 | Upper Austria | | | x | | | | x | | | native |
| Hymenoptera | *Selandria melanosterna* | 1990 | Upper Austria | | x | x | x | | | x | x | | native |
| Lepidoptera | *Nematopogon gliriella (=Nemapogon gliriella)* | 2003 | Upper Austria | x | x | x | x | | | | | | native |
| Lepidoptera | *Pammene herrichiana* | 2010 | Upper Austria | | x | x | | | | | | | native |
| Lepidoptera | *Platyptilia capnodactyla (=Buszkoiana capnodactylus)* | 1992 | Upper Austria | x | x | x | x | x | | x | | | native |
| Lepidoptera | *Retinia perangustana* | 2007 | Upper Austria | | x | x | x | | | | x | | native |
| Heteroptera | *Cyrtopeltis geniculata* | 1994 | East Tyrol | x | | x | | | | x | x | | native |
| Auchenorrhyncha | *Alebra neglecta* | 2002 | Styria | | x | x | | | | | x | | native |
| Auchenorrhyncha | *Criomorphus williamsi* | 2016 | Styria | | x | x | | x | | | | | native |
| Auchenorrhyncha | *Edwardsiana lamellaris* | 2000 | Styria | | x | | x | x | | x | | | native |
| Auchenorrhyncha | *Fagocyba carri* | 2000 | Styria | | x | x | | | | x | x | | native |
| Auchenorrhyncha | *Kelisia praecox* | 1993 | Styria | | x | x | | | | | | | native |
| Auchenorrhyncha | *Macropsis albae* | 1995 | Styria | x | x | x | | | | x | x | | native |
| Coleoptera | *Euplectus sparsus* | 1992 | Styria | x | x | x | | | | x | x | | native |
| Heteroptera | *Phytocoris intricatus* | 2007 | Styria | x | x | x | | | | | x | | native |
| Heteroptera | *Xylocoridea brevipennis* | 2012 | Styria | | x | | | x | x | x | x | | native |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lepidoptera | *Paranthrene novaki* | 1990 | Styria | x | x | x | x | x | x | x | x | native |
| Orthoptera | *Podismopsis styriaca* | 2007 | Styria | x | | | | | | | | native |
| Orthoptera | *Pseudopodisma fieberi* | 2003 | Styria | x | | | | | x | x | | native |
| Heteroptera | *Psallus lapponicus* | 2004 | Tyrol | x | x | x | x | | | x | x | native |
| Heteroptera | *Atractotomus marcoi* | 2015 | Vorarlberg | | x | | | | | x | | native |
| Heteroptera | *Macrolophus rubi* | 2015 | Vorarlberg | | x | x | x | | | | | native |
| Hymenoptera | *Hylaeus taeniolatus* | 1997 | Vorarlberg | x | | | | | x | x | | native |
| Lepidoptera | *Acleris lacordairana* | 1998 | Vorarlberg | x | x | | | x | | x | x | native |
| Lepidoptera | *Acleris shepherdana* | 1992 | Vorarlberg | x | x | x | x | x | | x | x | native |
| Lepidoptera | *Argyresthia trifasciata* | 1995 | Vorarlberg | x | | x | x | x | | x | x | native |
| Lepidoptera | *Colostygia laetaria* | 1999 | Vorarlberg | x | x | | | | | x | x | native |
| Lepidoptera | *Eana freii* | 1998 | Vorarlberg | | | | | | | | x | native |
| Lepidoptera | *Epermenia falciformis* | 1995 | Vorarlberg | x | x | x | x | | | | | native |
| Lepidoptera | *Eupithecia absinthiata (=Eupithecia catharinae)* | 1999 | Vorarlberg | x | x | x | x | x | x | x | x | native |
| Auchenorrhyncha | *Toya propinqua* | 1923 | Vienna | x | x | x | x | x | x | x | x | native |
| Heteroptera | *Cimex columbarius* | 2004 | Vienna | x | x | | | | | x | | native |
| Hymenoptera | *Hylaeus incongruus* | 2006 | Vienna | | x | x | | | | x | x | native |
| Heteroptera | *Dichrooscytus gustavi* | 2003 | Vienna | x | x | x | x | x | | x | | native |
| Auchenorrhyncha | *Zygina griseombra* | 1993 | Styria | x | x | x | | | | x | x | alien |
| Auchenorrhyncha | *Doratura horvathi* | 1993 | Burgenland | x | x | x | x | | | x | | alien |
| Auchenorrhyncha | *Glossocratus foveolatus* | 2013 | Burgenland | | | x | | x | | | | alien |
| Auchenorrhyncha | *Macropsis elaeagni* | 1993 | Burgenland | x | x | x | | x | x | | | alien |
| Auchenorrhyncha | *Macrosteles quadripunctulatus* | 1991 | Burgenland | x | x | x | x | x | | x | x | alien |
| Auchenorrhyncha | *Paramesus major* | 1991 | Burgenland | x | x | x | | x | | | | alien |
| Coleoptera | *Clypastraea orientalis* | 2015 | Burgenland | | | | | x | | x | | alien |
| Heteroptera | *Belonochilus numenius* | 2010 | Burgenland | x | x | | | | | x | | alien |
| Hymenoptera | *Amegilla salviae* | 1991 | Burgenland | x | x | | x | x | | x | x | alien |
| Hymenoptera | *Coelioxys obtusa* | 1995 | Burgenland | x | | | | x | x | x | | alien |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hymenoptera | *Hoplitis mazzuccoi* | 1990 | Burgenland | | | | | | x | | | | alien |
| Hymenoptera | *Lasioglossum pressithorax* | 2017 | Burgenland | | | | | | | | | | alien |
| Auchenorrhyncha | *Haematoloma dorsatum* | 1996 | Carinthia | x | x | | | | | x | x | | alien |
| Coleoptera | *Stelidota geminata* | 2005 | Carinthia | | | | | | x | x | x | | alien |
| Auchenorrhyncha | *Psammotettix sabulicola* | 2004 | Lower Austria | | x | | | | | x | | | alien |
| Auchenorrhyncha | *Setapius apiculatus* | 2003 | Lower Austria | x | | x | | x | | | | | alien |
| Coleoptera | *Cryptamorpha desjardinsi* | 2010 | Lower Austria | | | | | | | | | | alien |
| Diptera | *Callopistromyia annulipes* | 2013 | Lower Austria | | x | | | | | x | x | | alien |
| Diptera | *Labigastera nitidula* | 2001 | Lower Austria | | | x | | | | | x | | alien |
| Hymenoptera | *Andrena cordialis* | 2001 | Lower Austria | | | | x | x | | | | | alien |
| Hymenoptera | *Chelostoma foveolatum* | 2005 | Lower Austria | | | | x | x | x | x | x | | alien |
| Hymenoptera | *Lasioglossum corvinum* | 2019 | Lower Austria | | x | | | x | x | x | | | alien |
| Hymenoptera | *Parammobatodes minutus* | 2002 | Lower Austria | x | | | x | x | | | | | alien |
| Orthoptera | *Eupholidoptera schmidti* | 2011 | Lower Austria | x | | | | | x | x | | | alien |
| Auchenorrhyncha | *Endria nebulosa* | 2011 | Upper Austria | | x | x | | | | | | | alien |
| Coleoptera | *Nemosoma caucasicum* | 2004 | Upper Austria | | | | x | | | | | | alien |
| Hymenoptera | *Thaumatogelis gallicus* | 2012 | Upper Austria | | x | | | | | x | | | alien |
| Lepidoptera | *Ditula angustiorana* | 2011 | Upper Austria | | | | | | x | x | x | | alien |
| Coleoptera | *Luperomorpha xanthodera* | 2011 | Salzburg | | x | | | | | x | x | | alien |
| Auchenorrhyncha | *Anoscopus carlebippus* | 2016 | Styria | | | | | | x | | | | alien |
| Auchenorrhyncha | *Cixius wagneri* | 2000 | Styria | | | | | x | | x | | | alien |
| Auchenorrhyncha | *Emeljanovianus medius* | 2016 | Styria | | | | | | x | x | x | | alien |
| Auchenorrhyncha | *Eupteryx filicum* | 1993 | Styria | x | x | x | | | | x | x | | alien |
| Auchenorrhyncha | *Javesella bottnica* | 1994 | Styria | | | | | | | | | | alien |
| Auchenorrhyncha | *Kelisia confusa* | 1996 | Styria | | x | | | x | x | x | | | alien |
| Auchenorrhyncha | *Kybos butleri* | 1996 | Styria | | x | | x | x | | x | x | | alien |
| Auchenorrhyncha | *Macropsis najas* | 1995 | Styria | | x | | | | | x | | | alien |
| Auchenorrhyncha | *Macropsis viridinervis* | 1996 | Styria | | x | x | x | | | x | | | alien |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Auchenorrhyncha | *Metcalfa pruinosa* | 1996 | Styria | x | | | | | x | x | x | | alien |
| Auchenorrhyncha | *Streptanus confinis* | 2004 | Styria | | x | x | | | | | x | | alien |
| Auchenorrhyncha | *Zyginidia pullula* | 1993 | Styria | x | x | x | x | x | | x | x | | alien |
| Heteroptera | *Beosus quadripunctatus* | 2016 | Styria | | | | | x | x | x | x | | alien |
| Heteroptera | *Orsillus reyi* | 1998 | Styria | | | | | | | x | | | alien |
| Heteroptera | *Orthotylus virescens* | 2012 | Styria | | x | x | | x | x | x | x | | alien |
| Heteroptera | *Stephanitis takeyai* | 2011 | Styria | | x | x | | | | x | x | | alien |
| Hymenoptera | *Andrena dorsalis* | 1994 | Styria | x | | | x | x | x | x | | | alien |
| Auchenorrhyncha | *Synophropsis lauri* | 2012 | Tyrol | | | | | x | x | x | x | | alien |
| Coleoptera | *Anthrenocerus australis* | 2005 | Tyrol | x | x | x | | | | x | x | | alien |
| Auchenorrhyncha | *Kybos mucronatus* | 2013 | Vorarlberg | | x | x | | | | | x | | alien |
| Auchenorrhyncha | *Oncopsis avellanae* | 1993 | Vorarlberg | | x | | | | | | | | alien |
| Auchenorrhyncha | *Sardius argus* | 2013 | Vorarlberg | | x | | | | | x | x | | alien |
| Coleoptera | *Coproporus immigrans* | 2005 | Vorarlberg | | x | | | | | | | | alien |
| Heteroptera | *Nezara viridula* | 2015 | Vorarlberg | x | x | | | x | x | x | x | | alien |
| Hymenoptera | *Sphecodes ruficrus* | 2002 | Vorarlberg | | x | | | x | | x | x | | alien |
| Lepidoptera | *Phthorimaea operculella* | 1999 | Vorarlberg | x | x | | | x | | x | x | | alien |
| Heteroptera | *Geotomus elongatus* | 2016 | Vienna | | x | | | x | x | x | x | | alien |
| Heteroptera | *Halyomorpha halys* | 2015 | Vienna | | | | | | | | x | | alien |
| Heteroptera | *Orthotylus caprai* | 2016 | Vienna | | x | | | | | | x | | alien |
| Heteroptera | *Tuponia brevirostris* | 2015 | Vienna | | x | | | | | x | | | alien |
| Heteroptera | *Tuponia montandoni (=Tuponia macedonica)* | 2016 | Vienna | | | x | | | | | | | alien |
| Hymenoptera | *Anthidium florentinum* | 2016 | Vienna | | | | x | x | | x | | | alien |
| Hymenoptera | *Megachile sculpturalis* | 2017 | Vienna | x | x | | | | x | x | x | | alien |

## Appendix III - Species attributes

Table 10: Species attributes of neonative, native and alien species. Dispercial capacity: o = capable of flight, x = incapable of flight.

| Order | Species | Dispercial capacity | Body size | Feeding types | Habitat affiliation | Habitat affiliation of first record | Neonative, native, alien species |
|---|---|---|---|---|---|---|---|
| Auchenorrhyncha | *Balclutha saltuella* | o | < 0.50 | phytophagous | 6 | 6 | neonative |
| Auchenorrhyncha | *Calamotettix taeniatus* | o | 0.50 - 1.00 | phytophagous | 7 | 7 | neonative |
| Auchenorrhyncha | *Chiasmus conspurcatus* | o | 0.50 - 1.00 | phytophagous | 4 | 7 | neonative |
| Auchenorrhyncha | *Cicadula placida* | o | 0.50 - 1.00 | phytophagous | 7 | 7 | neonative |
| Auchenorrhyncha | *Cicadula rubroflava* | o | < 0.50 | phytophagous | 7 | 7 | neonative |
| Auchenorrhyncha | *Cicadula saturata* | o | 0.50 - 1.00 | phytophagous | 7 | 7 | neonative |
| Auchenorrhyncha | *Doliotettix lunulatus* | o | < 0.50 | phytophagous | 3 | 3 | neonative |
| Auchenorrhyncha | *Falcotoya minuscula* | o | < 0.50 | phytophagous | 4 | 4 | neonative |
| Auchenorrhyncha | *Maiestas horvathi* | o | < 0.50 | phytophagous | 9 | 7 | neonative |
| Coleoptera | *Charopus philoctetes* | x | < 0.50 | phytophagous | 4 | 4 | neonative |
| Coleoptera | *Mycetochara quadrimaculata* | o | < 0.50 | phytophagous | 3 | 3 | neonative |
| Coleoptera | *Otiorhynchus albidus* | x | < 0.50 | phytophagous | 4 | 4 | neonative |
| Coleoptera | *Tanymecus dilaticollis* | o | 0.50 - 1.00 | phytophagous | 5 | 8 | neonative |
| Diptera | *Stomorhina lunata* | o | 0.50 - 1.00 | phytophagous | 4 | 5 | neonative |
| Heteroptera | *Kalama aethiops* | o | 0.50 - 1.00 | phytophagous | 4 | 4 | neonative |
| Heteroptera | *Cardiastethus fasciiventris* | o | < 0.50 | phytophagous | 4 | 4 | neonative |
| Heteroptera | *Conostethus roseus* | o | < 0.50 | zoophagous | 4 | 4 | neonative |
| Heteroptera | *Megalocoleus naso* | o | 0.50 - 1.00 | phytophagous | 3 | 3 | neonative |
| Heteroptera | *Thyreocoris fulvipennis* | o | < 0.50 | phytophagous | 4 | 4 | neonative |
| Heteroptera | *Deraeocoris flavilinea* | o | < 0.50 | phytophagous | 4 | 8 | neonative |
| Heteroptera | *Psallus lentigo* | o | 0.50 - 1.00 | zoophagous | 3 | 6 | neonative |
| Heteroptera | *Metacanthus annulosus* | o | 0.50 - 1.00 | phytophagous | 3 | 6 | neonative |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Heteroptera | *Harpocera hellenica* | o | < 0.50 | phytophagous | 3 | 3 | neonative |
| Heteroptera | *Derephysia sinuatocollis* | o | < 0.50 | phytophagous | 3 | 6 | neonative |
| Heteroptera | *Psallus helenae* | o | < 0.50 | zoophytophagous | 3 | 3 | neonative |
| Heteroptera | *Oxycarenus lavaterae* | o | 0.50 - 1.00 | phytophagous | 6 | 6 | neonative |
| Heteroptera | *Graptopeltus validus* | o | > 1.00 | phytophagous | 4 | 4 | neonative |
| Hymenoptera | *Bombus haematurus* | o | 0.50 - 1.00 | polylectic | 7 | 7 | neonative |
| Hymenoptera | *Anthidium laterale (=Icteranthidium laterale)* | o | > 1.00 | polylectic | 9 | 9 | neonative |
| Hymenoptera | *Harpactus transiens (=Harpactus consanguineous)* | o | > 1.00 | polylectic | 4 | 4 | neonative |
| Hymenoptera | *Lasioglossum laterale* | o | > 1.00 | polylectic | 4 | 6 | neonative |
| Hymenoptera | *Hoplocryptus femoralis* | o | 0.50 - 1.00 | polylectic | 4 | 4 | neonative |
| Hymenoptera | *Argogorytes hispanicus* | o | > 1.00 | polylectic | 3 | 8 | neonative |
| Hymenoptera | *Liris nigra* | o | > 1.00 | polylectic | 8 | 8 | neonative |
| Hymenoptera | *Gorytes planifrons* | o | > 1.00 | polylectic | 4 | 4 | neonative |
| Lepidoptera | *Colias erate* | o | > 1.00 | polyphagous | 4 | 4 | neonative |
| Lepidoptera | *Oligia fasciuncula* | o | > 1.00 | polyphagous | 7 | 9 | neonative |
| Lepidoptera | *Orthopygia incarnatalis* | o | > 1.00 | polyphagous | 3 | 3 | neonative |
| Orthoptera | *Pezotettix giornae* | x | > 1.00 | phytophagous | 4 | 4 | neonative |
| Auchenorrhyncha | *Metalimnus obtusus* | o | < 0.50 | phytophagous | 9 | 9 | native |
| Lepidoptera | *Dryadaula irinae* | o | > 1.00 | polyphagous | 3 | 3 | native |
| Lepidoptera | *Monochroa moyses* | o | 0.50 - 1.00 | polyphagous | 7 | 4 | native |
| Auchenorrhyncha | *Alebra neglecta* | o | < 0.50 | phytophagous | 9 | 6 | native |
| Auchenorrhyncha | *Anaceratagallia laevis* | o | < 0.50 | phytophagous | 9 | 9 | native |
| Auchenorrhyncha | *Chloriona dorsata* | o | 0.50 - 1.00 | phytophagous | 7 | 2 | native |
| Auchenorrhyncha | *Chloriona glaucescens* | o | 0.50 - 1.00 | phytophagous | 7 | 7 | native |
| Auchenorrhyncha | *Chloriona vasconica* | o | < 0.50 | phytophagous | 7 | 7 | native |
| Auchenorrhyncha | *Cixidia lapponica* | o | 0.50 - 1.00 | phytophagous | 3 | 3 | native |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Auchenorrhyncha | *Criomorphus williamsi* | o | < 0.50 | phytophagous | 4 | 4 | native |
| Auchenorrhyncha | *Delphacodes audrasi* | o | < 0.50 | phytophagous | 9 | 7 | native |
| Auchenorrhyncha | *Edwardsiana lamellaris* | o | < 0.50 | phytophagous | 9 | 9 | native |
| Auchenorrhyncha | *Eupteryx signatipennis* | o | < 0.50 | phytophagous | 7 | 7 | native |
| Auchenorrhyncha | *Fagocyba carri* | o | < 0.50 | phytophagous | 8 | 8 | native |
| Auchenorrhyncha | *Florodelphax paryphasma* | o | < 0.50 | phytophagous | 7 | 7 | native |
| Auchenorrhyncha | *Gravesteiniella boldi* | o | < 0.50 | phytophagous | 9 | 9 | native |
| Auchenorrhyncha | *Kelisia minima* | o | < 0.50 | phytophagous | 9 | 9 | native |
| Auchenorrhyncha | *Kelisia praecox* | o | < 0.50 | phytophagous | 4 | 9 | native |
| Auchenorrhyncha | *Kelisia sabulicola* | o | < 0.50 | phytophagous | 7 | 3 | native |
| Auchenorrhyncha | *Laburrus handlirschi* | o | 0.50 - 1.00 | phytophagous | 7 | 3 | native |
| Auchenorrhyncha | *Macropsis albae* | o | < 0.50 | phytophagous | 6 | 9 | native |
| Auchenorrhyncha | *Metalimnus steini* | o | 0.50 - 1.00 | phytophagous | 9 | 6 | native |
| Auchenorrhyncha | *Mocydiopsis intermedia* | o | 0.50 - 1.00 | phytophagous | 3 | 3 | native |
| Auchenorrhyncha | *Muellerianella fairmairei* | o | 0.50 - 1.00 | phytophagous | 7 | 7 | native |
| Auchenorrhyncha | *Praganus hofferi* | o | < 0.50 | phytophagous | 9 | 9 | native |
| Auchenorrhyncha | *Psammotettix asper* | o | < 0.50 | phytophagous | 9 | 4 | native |
| Auchenorrhyncha | *Psammotettix provincialis* | o | < 0.50 | phytophagous | 4 | 4 | native |
| Auchenorrhyncha | *Toya propinqua* | o | < 0.50 | phytophagous | 4 | 9 | native |
| Coleoptera | *Agabus wasastjernae (=Ilybius wasastjernae)* | x | 0.50 - 1.00 | zoophagous | 7 | 7 | native |
| Coleoptera | *Ampedus suecicus* | x | > 1.00 | phytophagous | 3 | 3 | native |
| Coleoptera | *Berginus tamarisci* | x | < 0.50 | phytophagous | 3 | 3 | native |
| Coleoptera | *Bythinus acutangulus* | x | < 0.50 | phytophagous | 3 | 3 | native |
| Coleoptera | *Euplectus sparsus* | x | < 0.50 | phytophagous | 3 | 3 | native |
| Coleoptera | *Micropeplus latus* | o | < 0.50 | phytophagous | 3 | 3 | native |
| Diptera | *Pipizella virens* | o | 0.50 - 1.00 | phytophagous | 3 | 3 | native |
| Heteroptera | *Atractotomus marcoi* | x | < 0.50 | haematophagous | 6 | 9 | native |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Heteroptera | *Berytinus consimilis* | o | 0.50 - 1.00 | phytophagous | 3 | 3 | native |
| Heteroptera | *Cimex columbarius* | x | < 0.50 | zoophagous | 3 | 3 | native |
| Heteroptera | *Cimex dissimilis* | o | 0.50 - 1.00 | phytophagous | 3 | 6 | native |
| Heteroptera | *Cyrtopeltis geniculata* | o | < 0.50 | phytophagous | 4 | 4 | native |
| Heteroptera | *Dichrooscytus gustavi* | x | 0.50 - 1.00 | haematophagous | 8 | 8 | native |
| Heteroptera | *Lygocoris zebei* | o | 0.50 - 1.00 | phytophagous | 4 | 4 | native |
| Heteroptera | *Macrolophus rubi* | o | 0.50 - 1.00 | phytophagous | 3 | 9 | native |
| Heteroptera | *Phytocoris hirsutulus* | o | < 0.50 | phytophagous | 6 | 6 | native |
| Heteroptera | *Phytocoris intricatus* | o | < 0.50 | phytophagous | 4 | 6 | native |
| Heteroptera | *Psallus pseudoplatani* | o | 0.50 - 1.00 | phytophagous | 6 | 6 | native |
| Heteroptera | *Psallus lapponicus* | o | < 0.50 | phytophagous | 6 | 6 | native |
| Heteroptera | *Xylocoridea brevipennis* | o | > 1.00 | phytophagous | 6 | 6 | native |
| Hymenoptera | *Birka alpina* | x | < 0.50 | polylectic | 9 | 9 | native |
| Hymenoptera | *Colletes pallescens* | o | > 1.00 | polylectic | 4 | 4 | native |
| Hymenoptera | *Dusona temnator* | o | > 1.00 | polylectic | 9 | 9 | native |
| Hymenoptera | *Hylaeus incongruus* | o | > 1.00 | polylectic | 8 | 9 | native |
| Hymenoptera | *Hylaeus taeniolatus* | o | > 1.00 | polylectic | 9 | 9 | native |
| Hymenoptera | *Selandria melanosterna* | o | > 1.00 | polylectic | 3 | 3 | native |
| Lepidoptera | *Acleris lacordairana* | o | > 1.00 | polyphagous | 3 | 3 | native |
| Lepidoptera | *Acleris shepherdana* | o | > 1.00 | polyphagous | 4 | 4 | native |
| Lepidoptera | *Argyresthia trifasciata* | o | > 1.00 | polyphagous | 4 | 4 | native |
| Lepidoptera | *Autographa buraetica* | o | < 0.50 | polyphagous | 3 | 7 | native |
| Lepidoptera | *Coleophora meridionella* | o | > 1.00 | polyphagous | 4 | 4 | native |
| Lepidoptera | *Colostygia laetaria* | o | > 1.00 | polyphagous | 3 | 3 | native |
| Lepidoptera | *Crocallis tusciaria* | o | > 1.00 | polyphagous | 3 | 3 | native |
| Lepidoptera | *Eana freii* | o | > 1.00 | polyphagous | 3 | 3 | native |
| Lepidoptera | *Epermenia falciformis* | o | > 1.00 | polyphagous | 7 | 3 | native |
| Lepidoptera | *Ethmia haemorrhoidella* | o | > 1.00 | polyphagous | 3 | 3 | native |

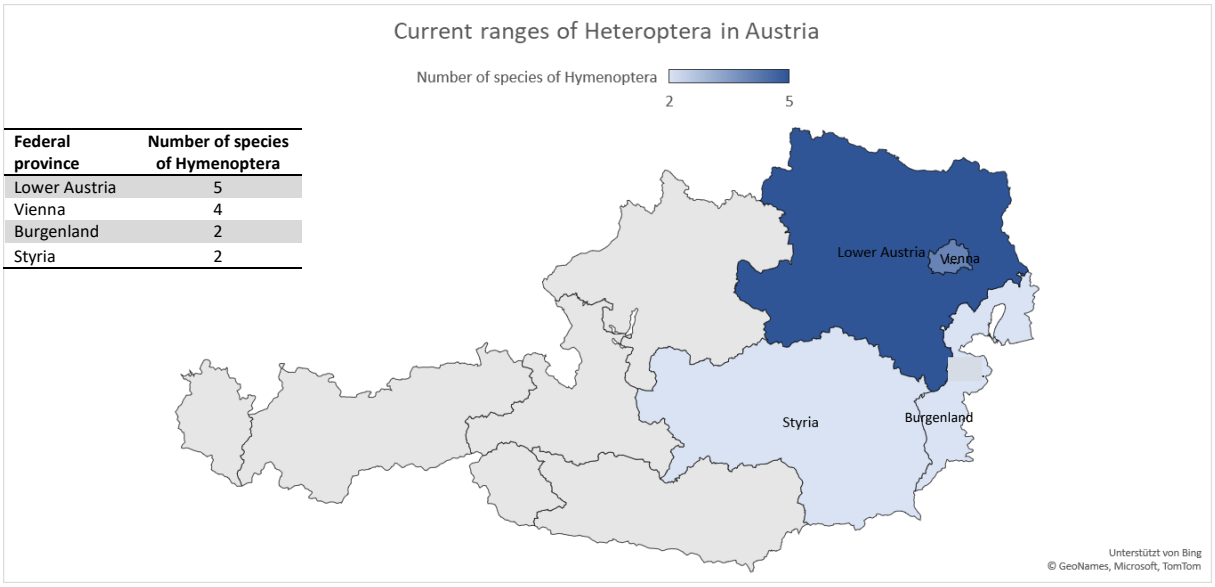
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lepidoptera | *Eupithecia absinthiata (=Eupithecia catharinae)* | o | > 1.00 | polyphagous | 4 | 7 | native |
| Lepidoptera | *Gillmeria miantodactylus* | o | > 1.00 | polyphagous | 4 | 3 | native |
| Lepidoptera | *Nematopogon gliriella (=Nemapogon gliriella)* | o | > 1.00 | polyphagous | 3 | 3 | native |
| Lepidoptera | *Pammene herrichiana* | o | > 1.00 | polyphagous | 3 | 9 | native |
| Lepidoptera | *Paranthrene novaki* | o | > 1.00 | polyphagous | 4 | 4 | native |
| Lepidoptera | *Paraplatyptilia metzneri* | o | > 1.00 | polyphagous | 9 | 4 | native |
| Lepidoptera | *Phyllonorycter aemula* | o | 0.50 - 1.00 | polyphagous | 4 | 4 | native |
| Lepidoptera | *Platyptilia capnodactyla (=Buszkoiana capnodactylus)* | o | > 1.00 | polyphagous | 4 | 4 | native |
| Lepidoptera | *Retinia perangustana* | o | > 1.00 | polyphagous | 3 | 3 | native |
| Lepidoptera | *Shargacucullia gozmanyi (=Cucullia gozmanyi)* | o | > 1.00 | polyphagous | 4 | 4 | native |
| Odonata | *Chalcolestes parvidens* | o | < 0.50 | zoophagous | 2 | 2 | native |
| Orthoptera | *Isophya modesta* | x | > 1.00 | phytophagous | 4 | 4 | native |
| Orthoptera | *Isophya pienensis* | x | > 1.00 | phytophagous | 4 | 6 | native |
| Orthoptera | *Podismopsis styriaca* | o | > 1.00 | phytophagous | 7 | 7 | native |
| Orthoptera | *Poecilimon intermedius* | o | > 1.00 | phytophagous | 4 | 4 | native |
| Orthoptera | *Pseudopodisma fieberi* | x | > 1.00 | phytophagous | 3 | 3 | native |
| Orthoptera | *Tetrix ceperoi* | x | > 1.00 | phytophagous | 4 | 4 | native |
| Auchenorrhyncha | *Zygina griseombra* | o | < 0.50 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Doratura horvathi* | o | < 0.50 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Glossocratus foveolatus* | o | < 0.50 | phytophagous | 7 | 7 | alien |
| Auchenorrhyncha | *Macrosteles quadripunctulatus* | o | < 0.50 | phytophagous | 4 | 4 | alien |
| Auchenorrhyncha | *Paramesus major* | o | < 0.50 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Macropsis elaeagni* | o | 0.50 - 1.00 | phytophagous | 7 | 3 | alien |
| Coleoptera | *Clypastraea orientalis* | x | < 0.50 | phytophagous | 3 | 3 | alien |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Heteroptera | *Belonochilus numenius* | o | 0.50 - 1.00 | phytophagous | 3 | 6 | alien |
| Hymenoptera | *Amegilla salviae* | o | > 1.00 | polylectic | 9 | 9 | alien |
| Hymenoptera | *Coelioxys obtusa* | o | > 1.00 | polylectic | 4 | 4 | alien |
| Hymenoptera | *Lasioglossum pressithorax* | o | > 1.00 | polylectic | 9 | 9 | alien |
| Hymenoptera | *Hoplitis mazzuccoi* | o | 0.50 - 1.00 | polylectic | 7 | 7 | alien |
| Auchenorrhyncha | *Haematoloma dorsatum* | o | 0.50 - 1.00 | phytophagous | 3 | 3 | alien |
| Coleoptera | *Stelidota geminata* | x | < 0.50 | phytophagous | 4 | 4 | alien |
| Auchenorrhyncha | *Psammotettix sabulicola* | o | < 0.50 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Setapius apiculatus* | o | 0.50 - 1.00 | phytophagous | 3 | 6 | alien |
| Coleoptera | *Cryptamorpha desjardinsi* | x | < 0.50 | phytophagous | 9 | 8 | alien |
| Diptera | *Labigastera nitidula* | o | > 1.00 | phytophagous | 4 | 3 | alien |
| Diptera | *Callopistromyia annulipes* | o | 0.50 - 1.00 | phytophagous | 3 | 9 | alien |
| Hymenoptera | *Andrena cordialis* | o | > 1.00 | polylectic | 9 | 3 | alien |
| Hymenoptera | *Lasioglossum corvinum* | o | > 1.00 | polylectic | 9 | 9 | alien |
| Hymenoptera | *Chelostoma foveolatum* | o | 0.50 - 1.00 | polylectic | 8 | 5 | alien |
| Hymenoptera | *Parammobatodes minutus* | o | 0.50 - 1.00 | polylectic | 4 | 4 | alien |
| Orthoptera | *Eupholidoptera schmidti* | x | > 1.00 | Phytophagous | 4 | 4 | alien |
| Auchenorrhyncha | *Endria nebulosa* | o | < 0.50 | phytophagous | 7 | 7 | alien |
| Coleoptera | *Nemosoma caucasicum* | x | < 0.50 | zoophag | 3 | 3 | alien |
| Hymenoptera | *Thaumatogelis gallicus* | o | > 1.00 | polylectic | 9 | 5 | alien |
| Lepidoptera | *Ditula angustiorana* | o | > 1.00 | polyphagous | 9 | 9 | alien |
| Coleoptera | *Luperomorpha xanthodera* | x | < 0.50 | phytophagous | 4 | 9 | alien |
| Auchenorrhyncha | *Anoscopus carlebippus* | o | < 0.50 | phytophagous | 4 | 4 | alien |
| Auchenorrhyncha | *Emeljanovianus medius* | o | < 0.50 | phytophagous | 4 | 4 | alien |
| Auchenorrhyncha | *Eupteryx filicum* | o | < 0.50 | phytophagous | 3 | 3 | alien |
| Auchenorrhyncha | *Javesella bottnica* | o | < 0.50 | phytophagous | 7 | 7 | alien |
| Auchenorrhyncha | *Kelisia confusa* | o | < 0.50 | phytophagous | 7 | 7 | alien |
| Auchenorrhyncha | *Kybos butleri* | o | < 0.50 | phytophagous | 7 | 7 | alien |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Auchenorrhyncha | *Macropsis viridinervis* | o | < 0.50 | phytophagous | 4 | 4 | alien |
| Auchenorrhyncha | *Metcalfa pruinosa* | o | < 0.50 | phytophagous | 4 | 9 | alien |
| Auchenorrhyncha | *Streptanus confinis* | o | < 0.50 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Zyginidia pullula* | o | < 0.50 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Cixius wagneri* | o | 0.50 - 1.00 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Macropsis najas* | o | 0.50 - 1.00 | phytophagous | 7 | 3 | alien |
| Heteroptera | *Beosus quadripunctatus* | o | < 0.50 | zoophytophagous | 3 | 3 | alien |
| Heteroptera | *Orthotylus virescens* | o | < 0.50 | phytophagous | 6 | 6 | alien |
| Heteroptera | *Stephanitis takeyai* | o | < 0.50 | phytophagous | 3 | 3 | alien |
| Heteroptera | *Orsillus reyi* | o | > 1.00 | zoophytophagous | 3 | 9 | alien |
| Hymenoptera | *Andrena dorsalis* | o | > 1.00 | polylectic | 9 | 4 | alien |
| Auchenorrhyncha | *Synophropsis lauri* | o | < 0.50 | phytophagous | 3 | 3 | alien |
| Coleoptera | *Anthrenocerus australis* | x | < 0.50 | phytophagous | 6 | 6 | alien |
| Auchenorrhyncha | *Kybos mucronatus* | o | < 0.50 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Oncopsis avellanae* | o | < 0.50 | phytophagous | 9 | 9 | alien |
| Auchenorrhyncha | *Sardius argus* | o | < 0.50 | phytophagous | 7 | 4 | alien |
| Coleoptera | *Coproporus immigrans* | x | < 0.50 | phytophagous | 3 | 3 | alien |
| Heteroptera | *Nezara viridula* | o | < 0.50 | phytophagous | 3 | 6 | alien |
| Hymenoptera | *Sphecodes ruficrus* | o | > 1.00 | polylectic | 9 | 4 | alien |
| Lepidoptera | *Phthorimaea operculella* | o | > 1,00 | polyphagous | 5 | 4 | alien |
| Heteroptera | *Geotomus elongatus* | o | < 0.50 | zoophytophagous | 3 | 3 | alien |
| Heteroptera | *Halyomorpha halys* | o | < 0.50 | zoophytophagous | 3 | 9 | alien |
| Heteroptera | *Orthotylus caprai* | o | < 0.50 | phytophagous | 6 | 6 | alien |
| Heteroptera | *Tuponia brevirostris* | o | < 0.50 | phytophagous | 3 | 3 | alien |
| Heteroptera | *Tuponia montandoni (=Tuponia macedonica)* | o | > 1.00 | phytophagous | 6 | 6 | alien |
| Hymenoptera | *Anthidium florentinum* | o | > 1.00 | polylectic | 7 | 7 | alien |
| Hymenoptera | *Megachile sculpturalis* | o | > 1.00 | polylectic | 5 | 5 | alien |

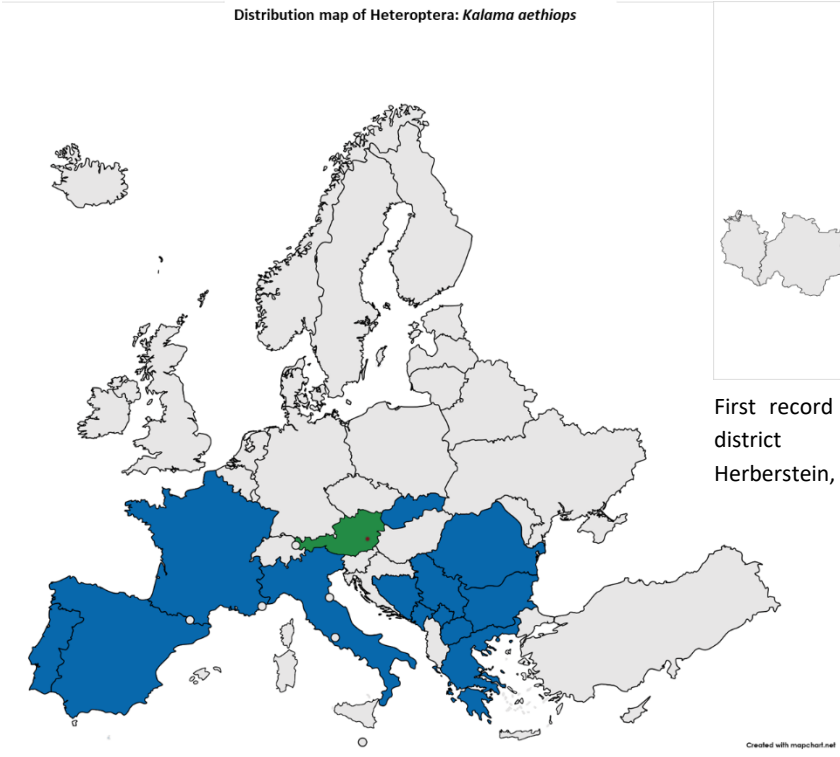
## Appendix IV - Current ranges of neonative species in Austria and their native ranges in Europe

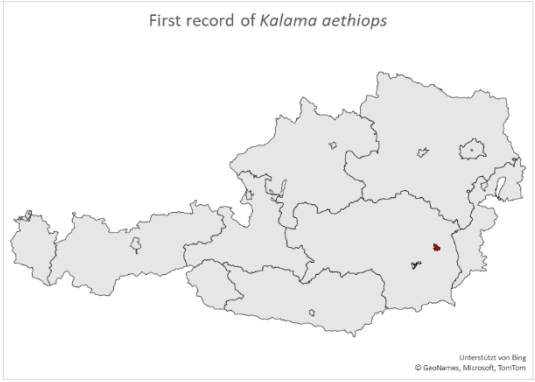
### Heteroptera




| Federal province | Number of species of Hymenoptera |
|---|---|
| Lower Austria | 5 |
| Vienna | 4 |
| Burgenland | 2 |
| Styria | 2 |

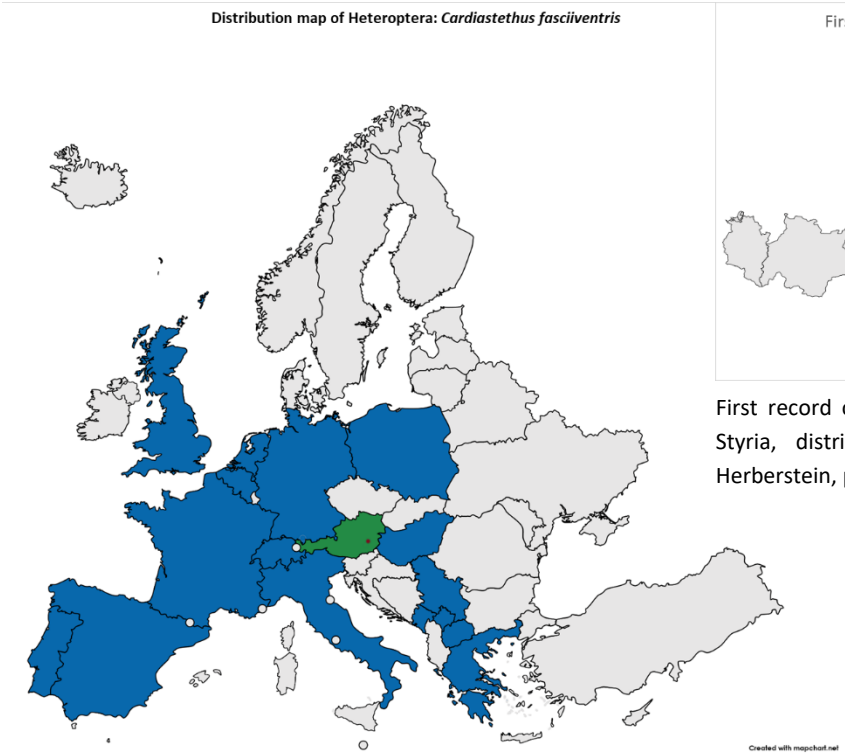
Figure 28: Number of species of Heteroptera and the first records in federal provinces.

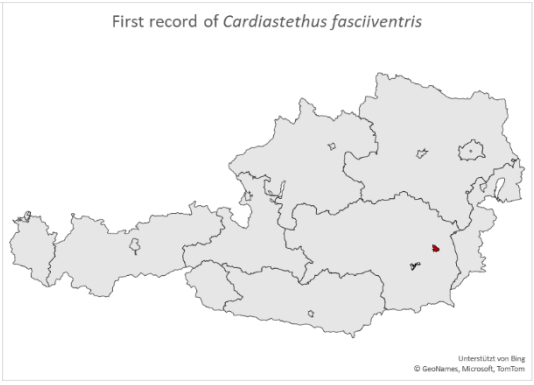



First record of *Kalama aethiops* in Austria, Styria, district Europaschutzgebiet Feistritzklamm-Herberstein, postcode 8223.

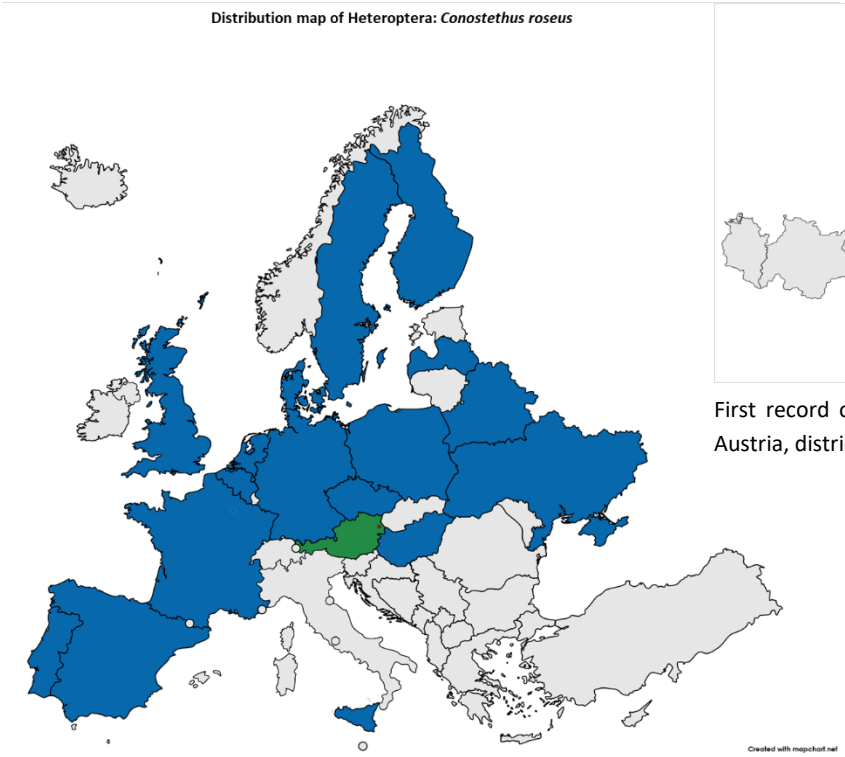
Figure 29: Countries in blue show European native ranges of *Kalama aethiops*. Country in green and the red point show first record in Austria, Styria.

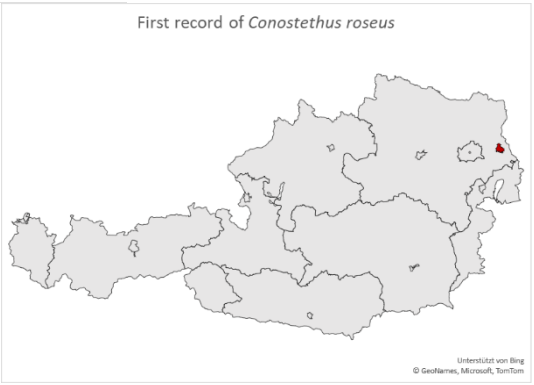



First record of *Cardiastethus fasciiventris* in Austria, Styria, district Europaschutzgebiet Feistritzklamm-Herberstein, postcode 8223

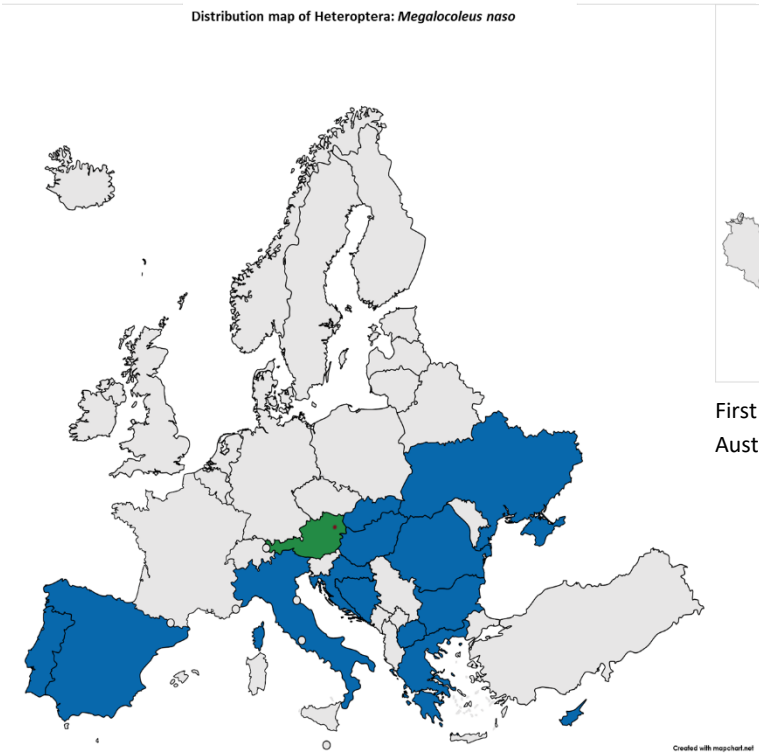
Figure 30: Countries in blue show European native ranges of *Cardiastethus fasciiventris*. Country in green and the red point show first record in Austria, Styria.

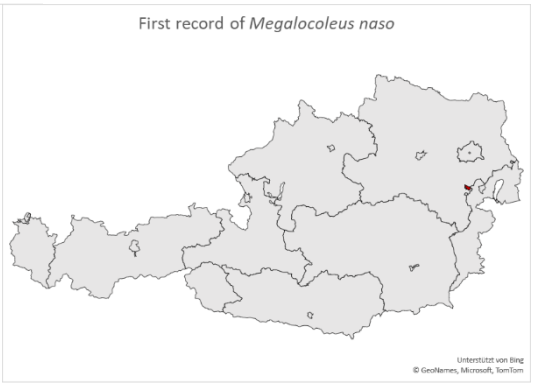



First record of *Conostethus roseus* in Austria, Lower Austria, district Marchfeld, postcode 2291.

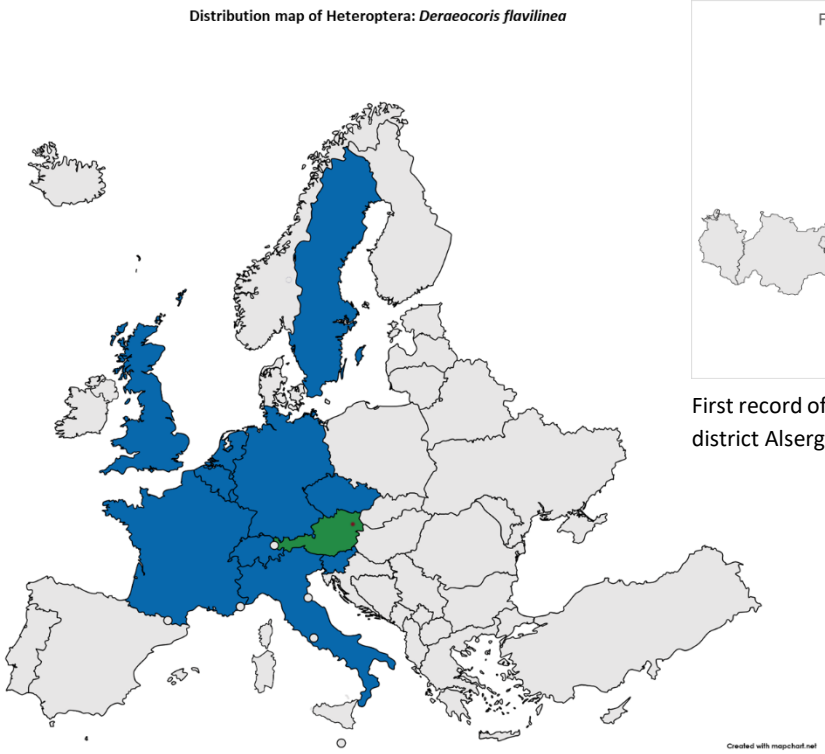
Figure 31: Countries in blue show European native ranges of *Conostethus roseus*. Country in green and the red point show first record in Austria, Lower Austria.

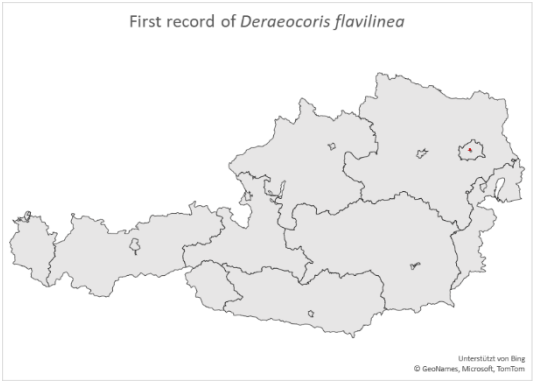



First record of *Megalocoleus naso* in Austria, Lower Austria, district Eggendorf, postcode 2492.

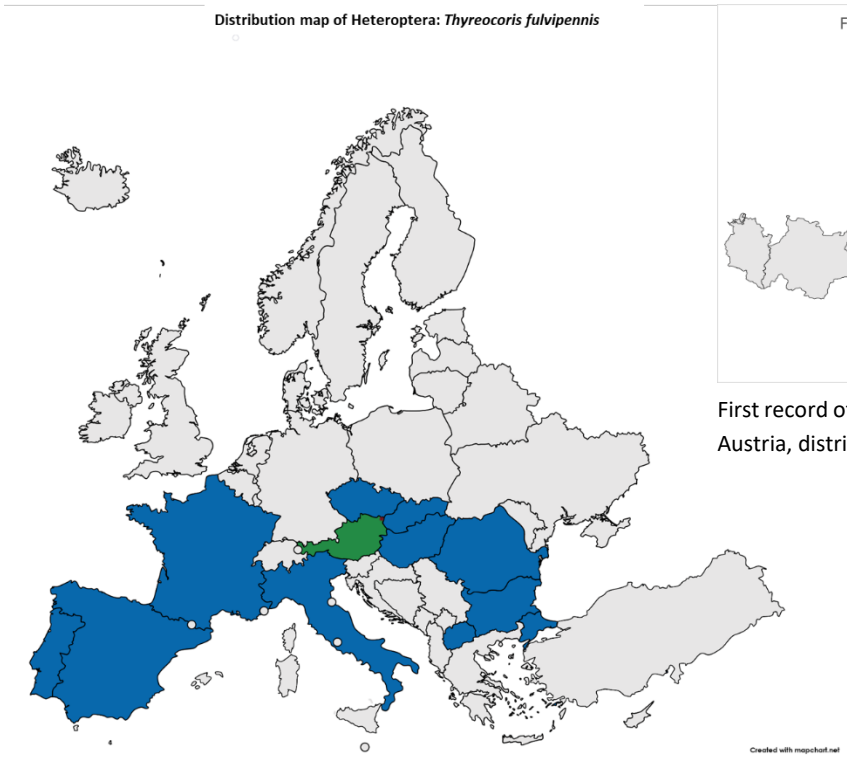
Figure 32: Countries in blue show European native ranges of *Megalocoleus naso*. Country in green and the red point show first record in Austria, Lower Austria.

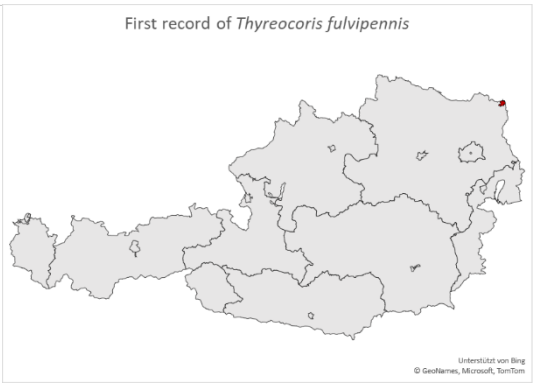



First record of *Deraeocoris flavilinea* in Austria, Vienna, district Alsergrund, postcode 1090.

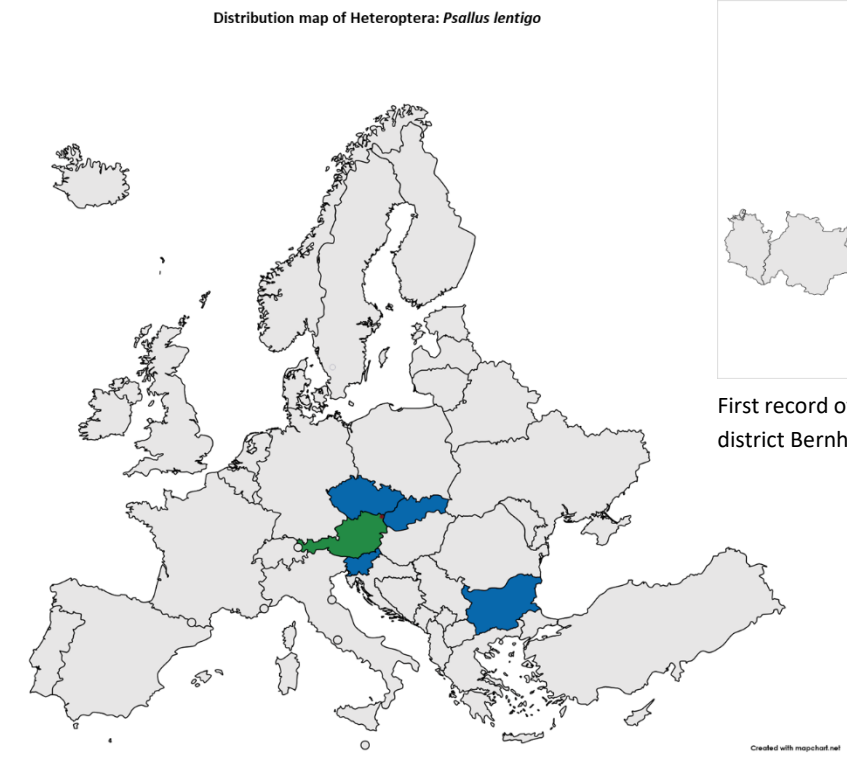
Figure 33: Countries in blue show European native ranges of *Deraeocoris flavilinea*. Country in green and the red point show first record in Austria, Vienna.




First record of *Thyreocoris fulvipennis* in Austria, Lower Austria, district Bernhardsthal, postcode 2275.

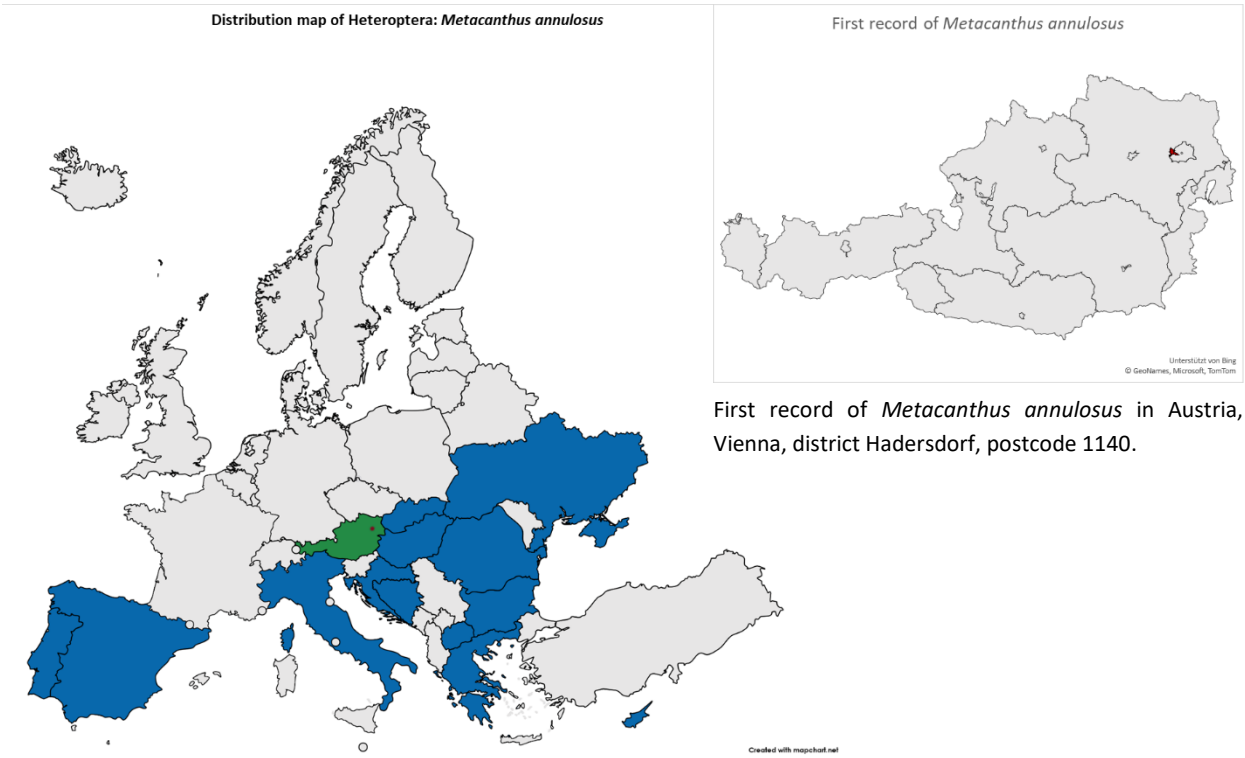
Figure 34: Countries in blue show European native ranges of *Thyreocoris fulvipennis*. Country in green and the red point show first record in Austria, Lower Austria.





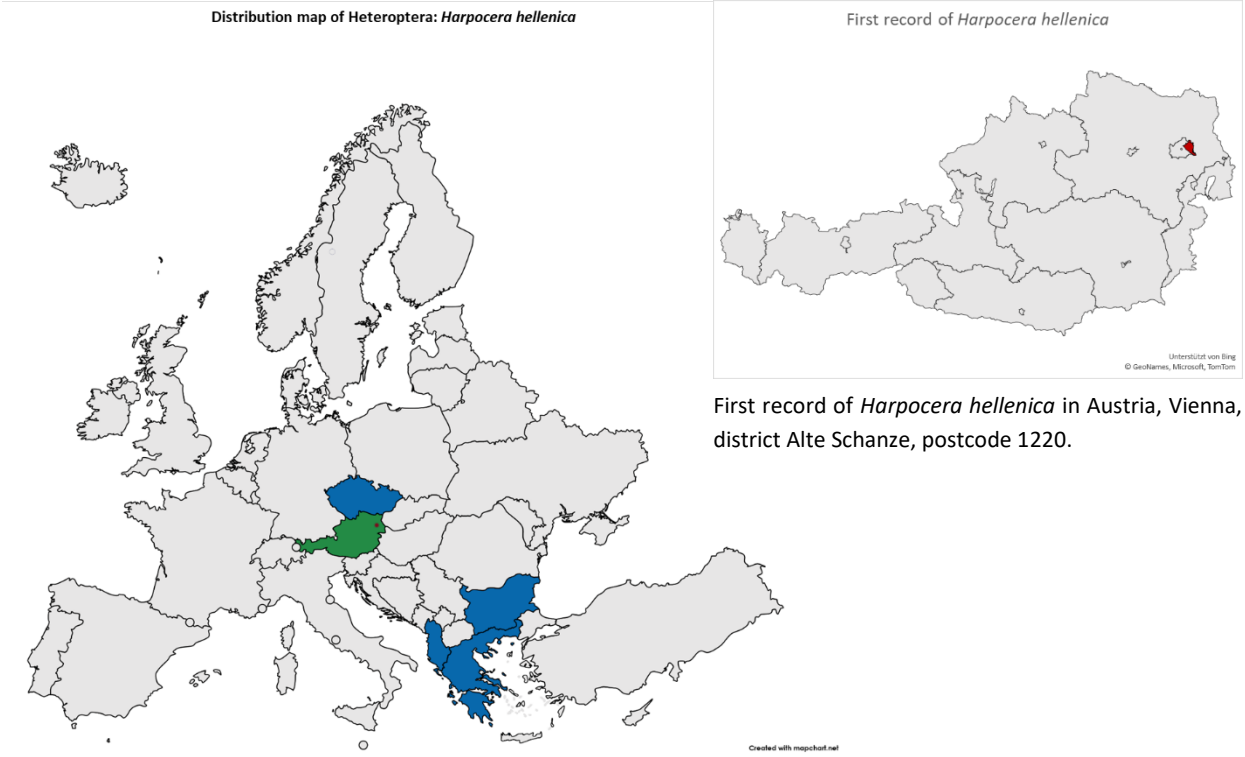
First record of *Psallus lentigo* in Austria, Lower Austria, district Bernhardsthal, postcode 2275.

Figure 35: Countries in blue show European native ranges of *Psallus lentigo*. Country in green and the red point show first record in Austria, Lower Austria.



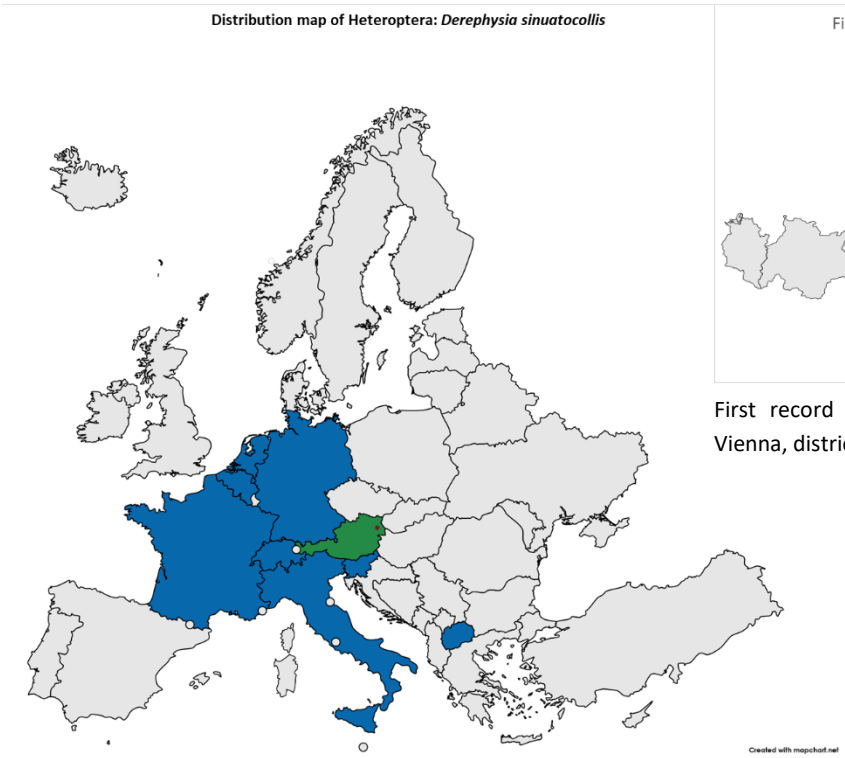

First record of *Metacanthus annulosus* in Austria, Vienna, district Hadersdorf, postcode 1140.

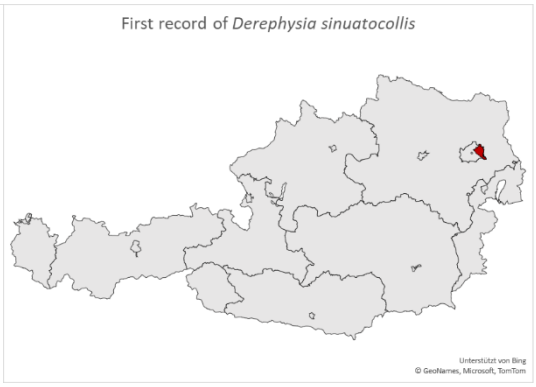
Figure 36: Countries in blue show European native ranges of *Metacanthus annulosus*. Country in green and the red point show first record in Austria, Vienna.




First record of *Harpocera hellenica* in Austria, Vienna, district Alte Schanze, postcode 1220.

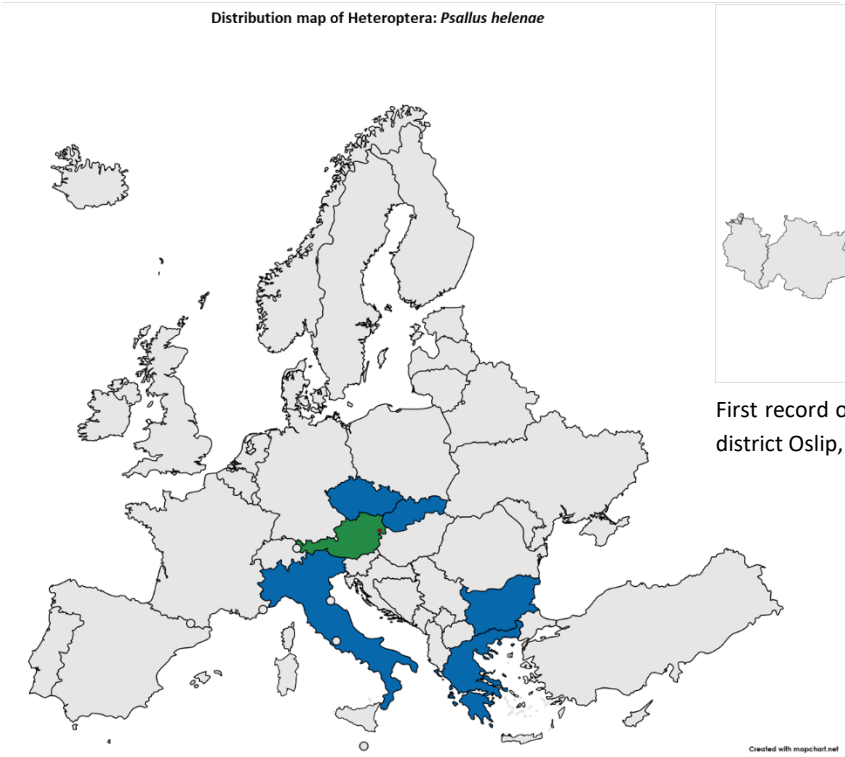
Figure 37: Countries in blue show European native ranges of *Harpocera hellenica*. Country in green and the red point show first record in Austria, Vienna.

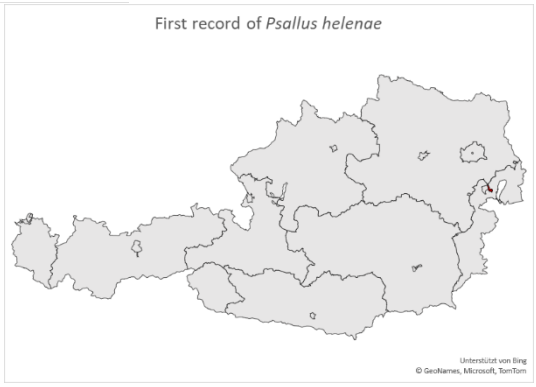



First record of *Derephysia sinuatocollis* in Austria, Vienna, district Lobau, postcode 1220.

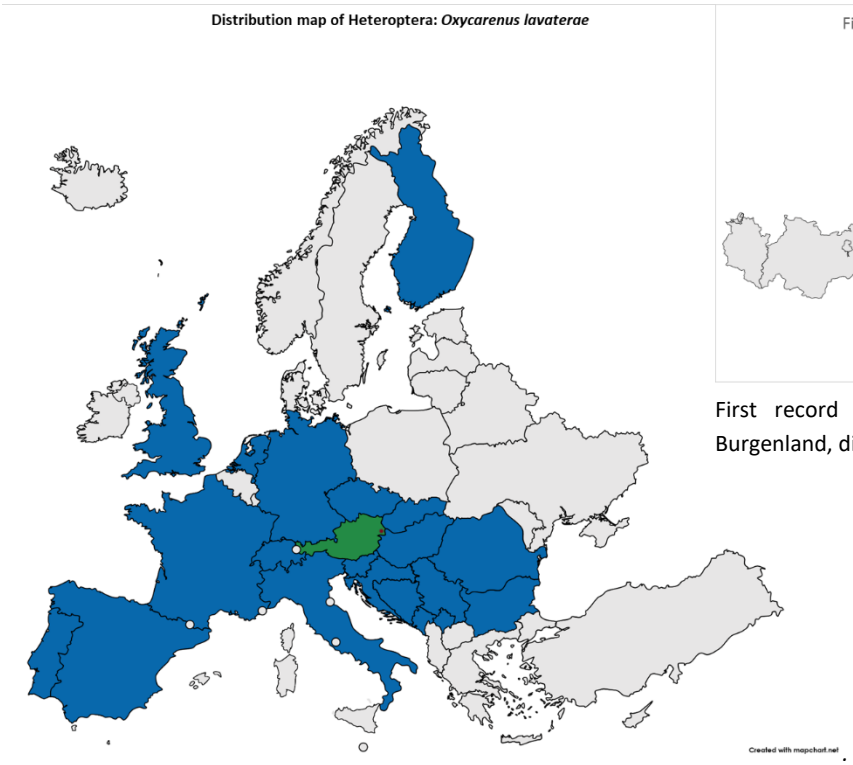
Figure 38: Countries in blue show European native ranges of *Derephysia sinuatocollis*. Country in green and the red point show first record in Austria, Vienna.

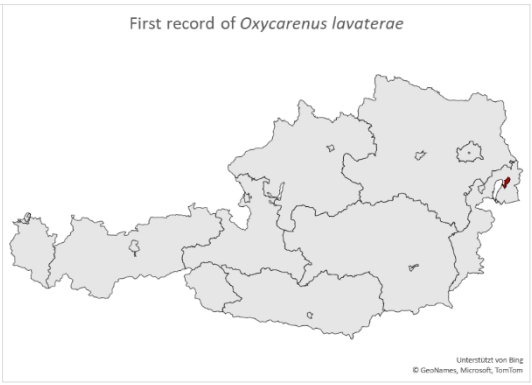



First record of *Psallus helenae* in Austria, Burgenland, district Oslip, postcode 7064.

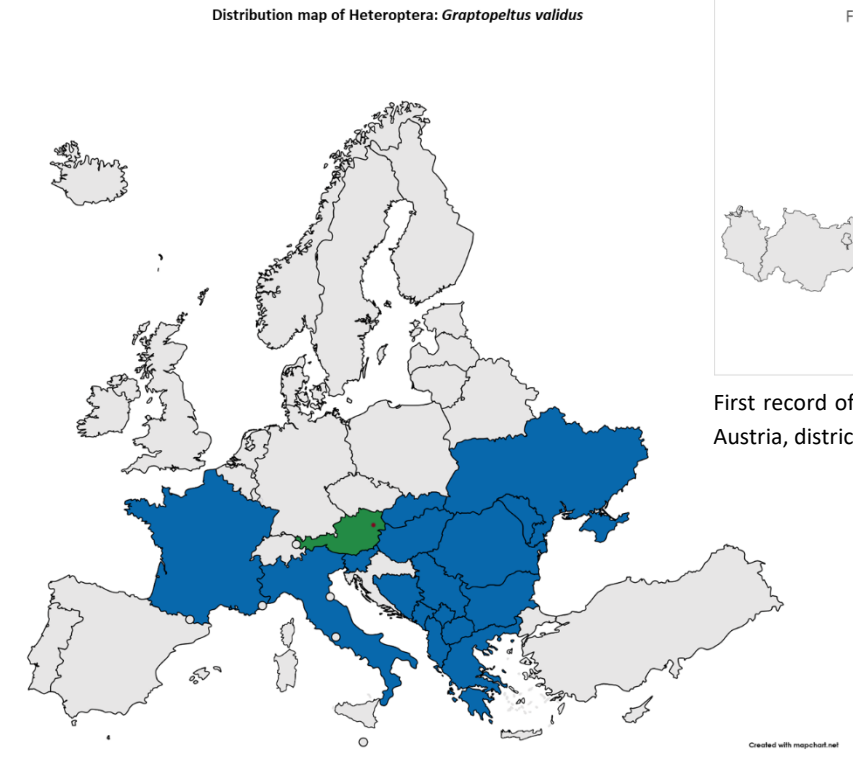
Figure 39: Countries in blue show European native ranges of *Psallus helenae*. Country in green and the red point show first record in Austria, Burgenland.

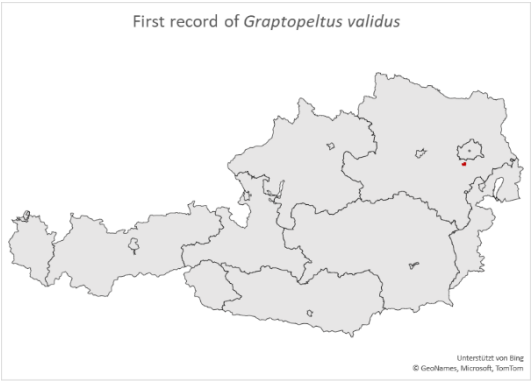



First record of *Oxycarenus lavaterae* in Austria, Burgenland, district Gols, postcode 7122.

Figure 40: Countries in blue show European native ranges of *Oxycarenus lavaterae*. Country in green and the red point show first record in Austria, Burgenland.

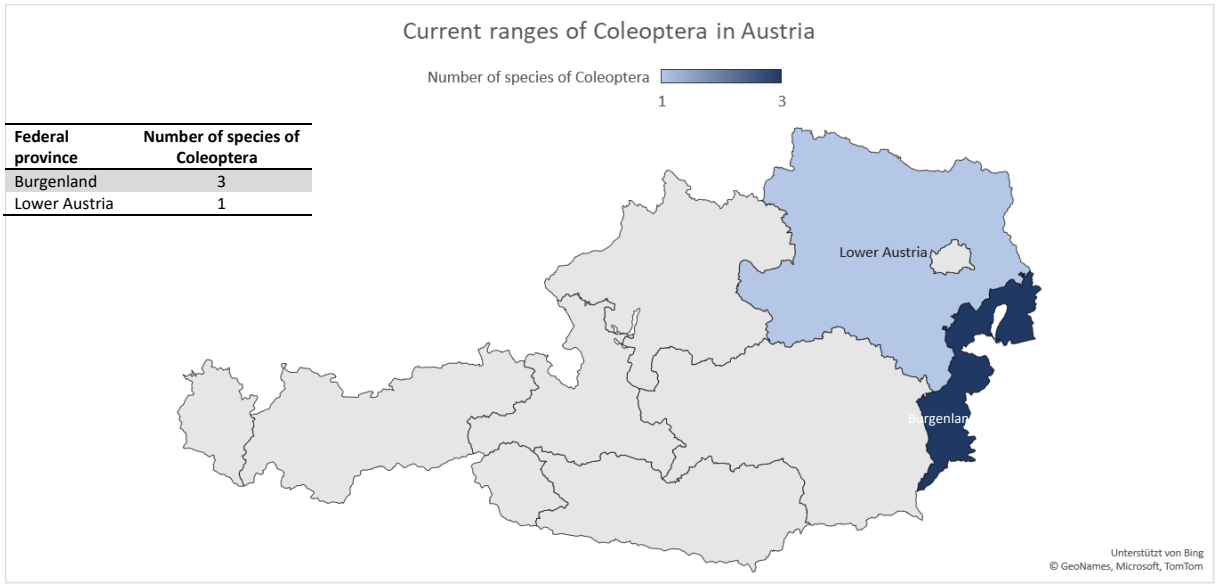



First record of *Graptopeltus validus* in Austria, Lower Austria, district Mödling, postcode 2340.

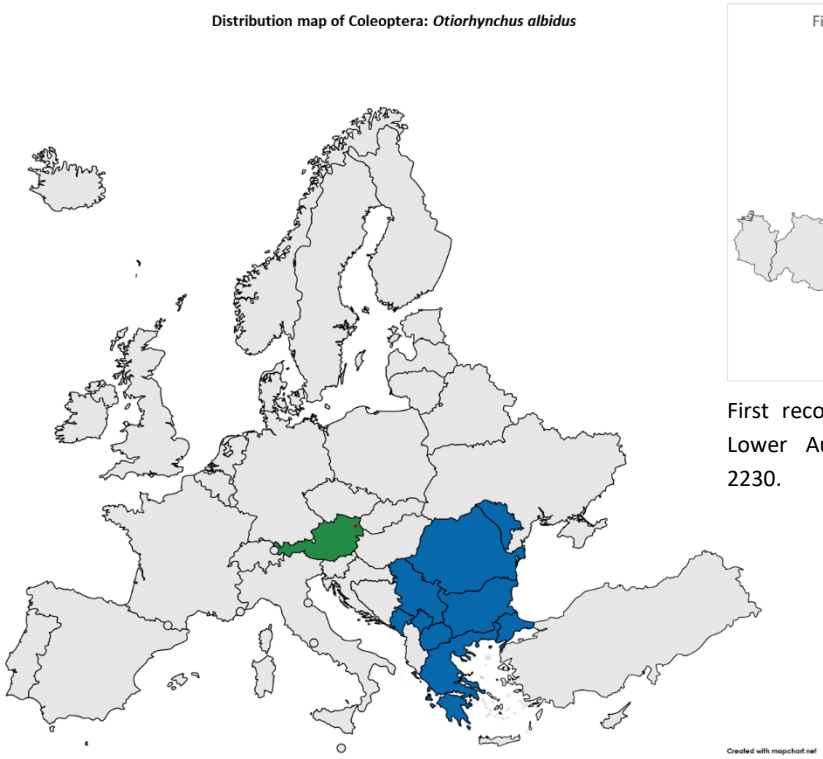
Figure 41: Countries in blue show European native ranges of *Graptopeltus validus*. Country in green and the red point show first record in Austria, Lower Austria

## Coleoptera




| Federal province | Number of species of Coleoptera |
|---|---|
| Burgenland | 3 |
| Lower Austria | 1 |

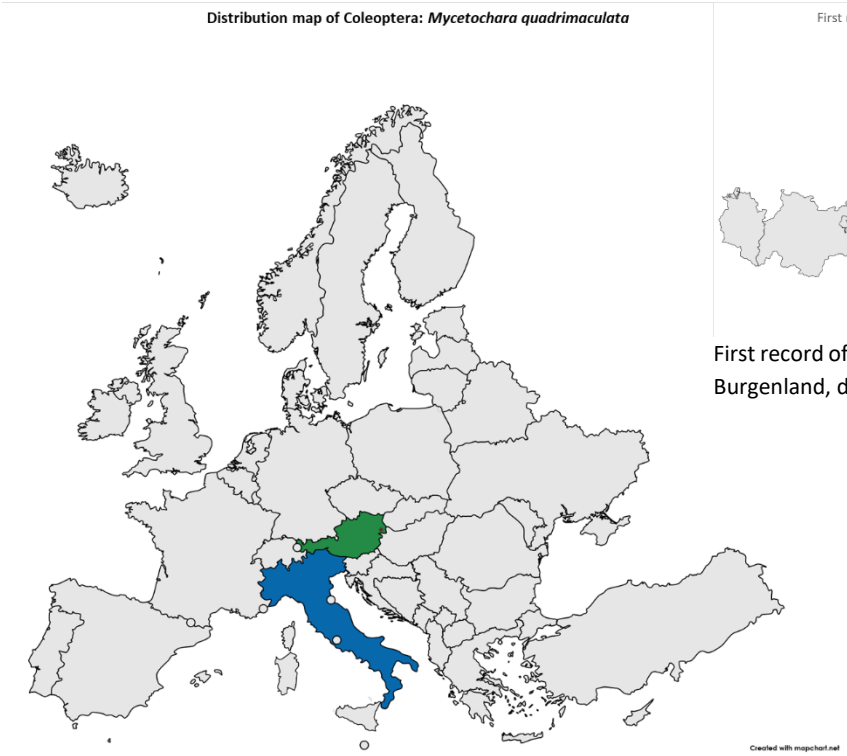
Figure 42: Number of species of Coleoptera and the first records in federal provinces.





First record of *Otiorhynchus albidus* in Austria, Lower Austria, district Gänserndorf, postcode 2230.

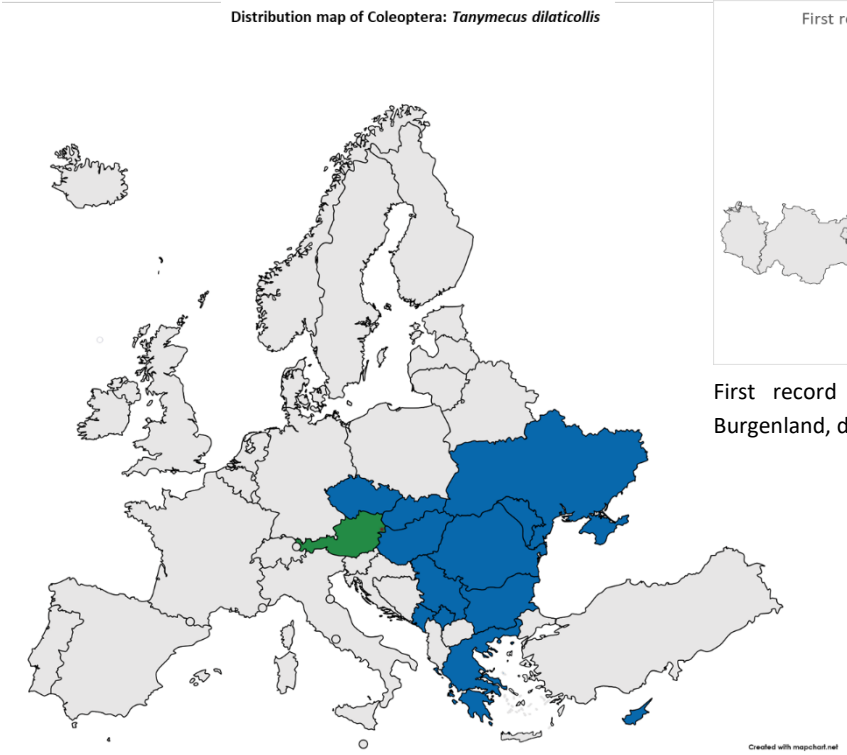
Figure 43: Countries in blue show native ranges of *Otiorhynchus albidus*. Country in green and the red point show first record in Austria, Lower Austria.

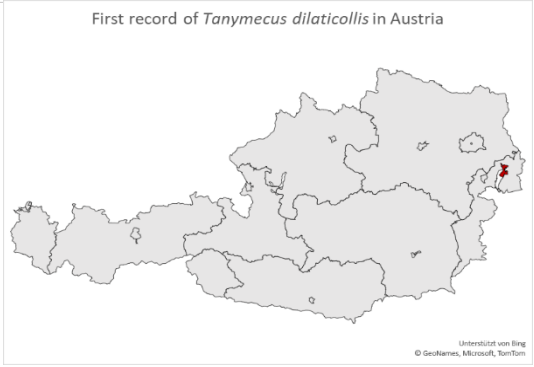




First record of *Mycetochara quadrimaculata* in Austria, Burgenland, district Rust, postcode 7071.

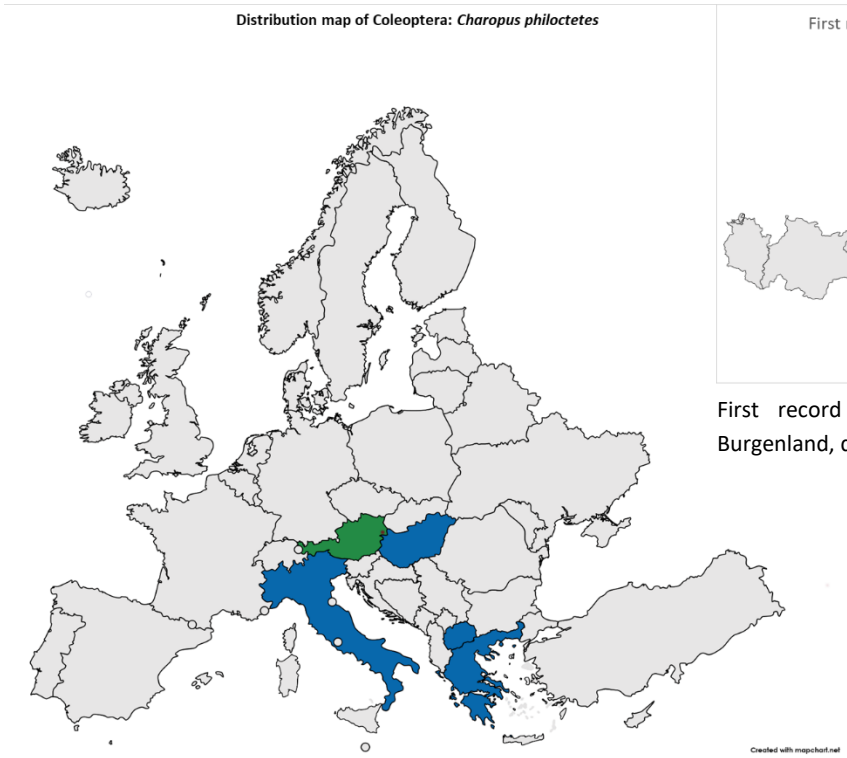
Figure 44: Countries in blue show native ranges of *Mycetochara quadrimaculata*. Country in green and the red point show first record in Austria, Burgenland.

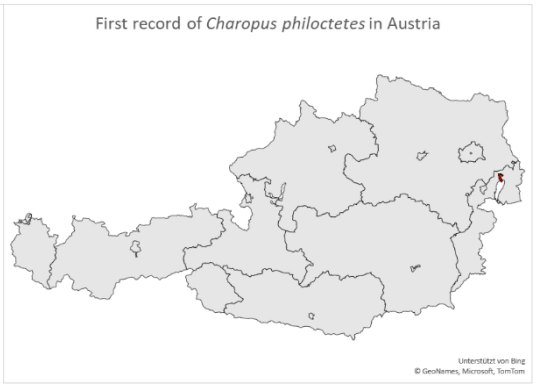



First record of *Tanymecus dilaticollis* in Austria, Burgenland, district Neusiedl am See, postcode 7100.

Figure 45: Countries in blue show native ranges of *Tanymecus dilaticollis*. Country in green and the red point show first record in Austria, Burgenland.

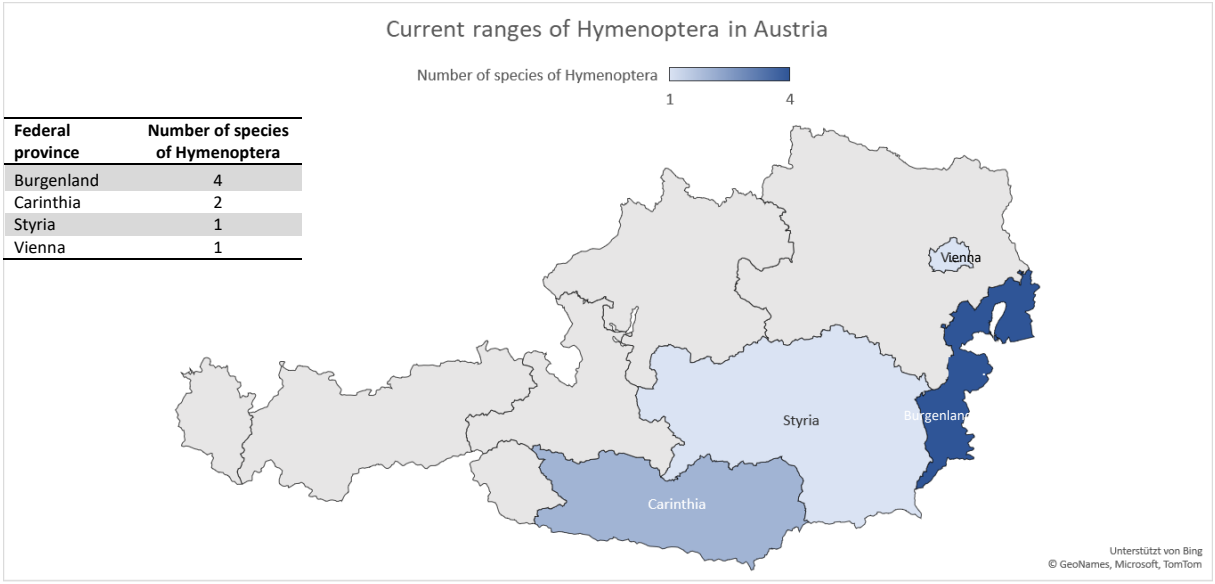



First record of *Charopus philoctetes* in Austria, Burgenland, district NSG Hackelsberg, postcode 7093.

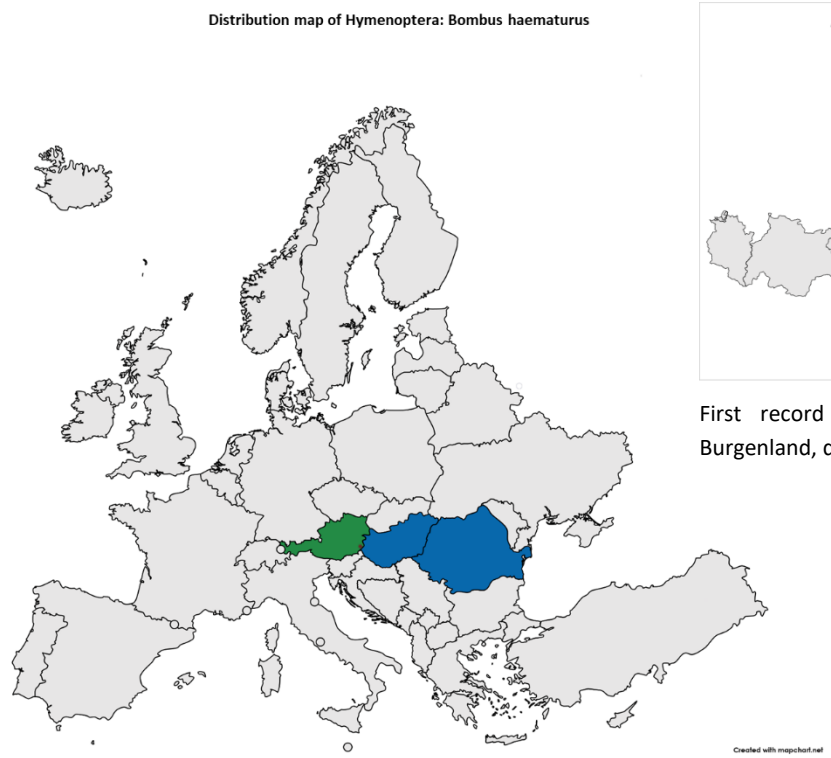
Figure 46: Countries in blue show native ranges of *Charopus philoctetes*. Country in green and the red point show first record in Austria, Burgenland.

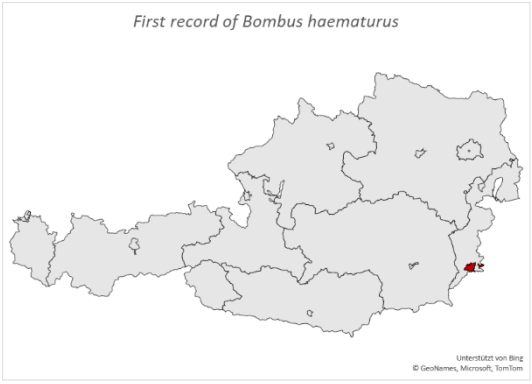
## Hymenoptera




| Federal province | Number of species of Hymenoptera |
|---|---|
| Burgenland | 4 |
| Carinthia | 2 |
| Styria | 1 |
| Vienna | 1 |

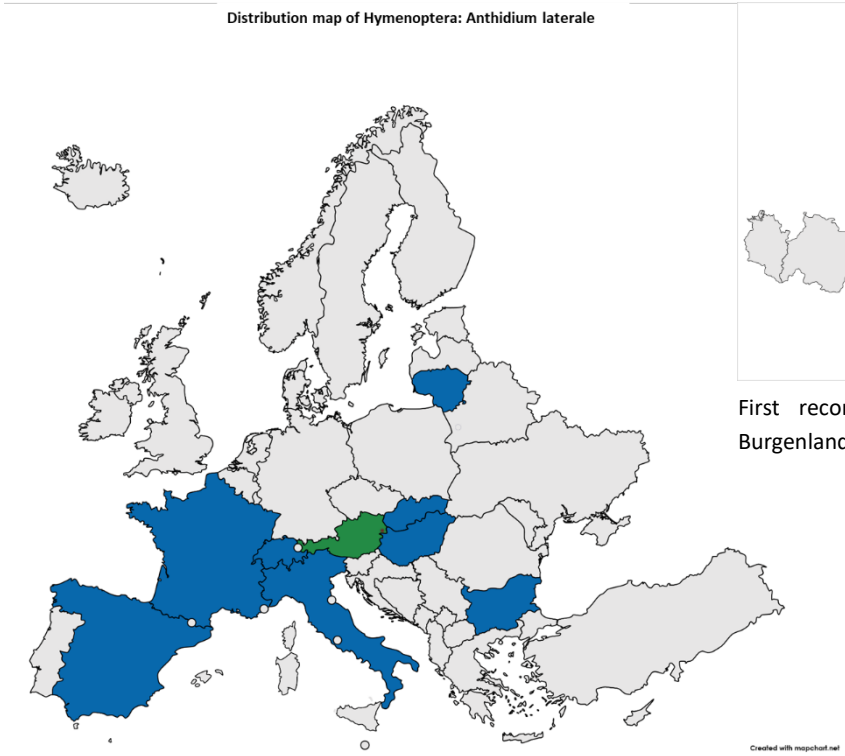
Figure 47: Number of species of Hymenoptera and the first records in federal provinces.

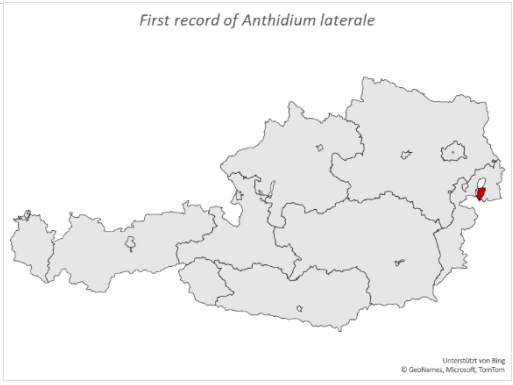



First record of *Bombus haematurus* in Austria, Burgenland, district Güssing, postcode 7540.

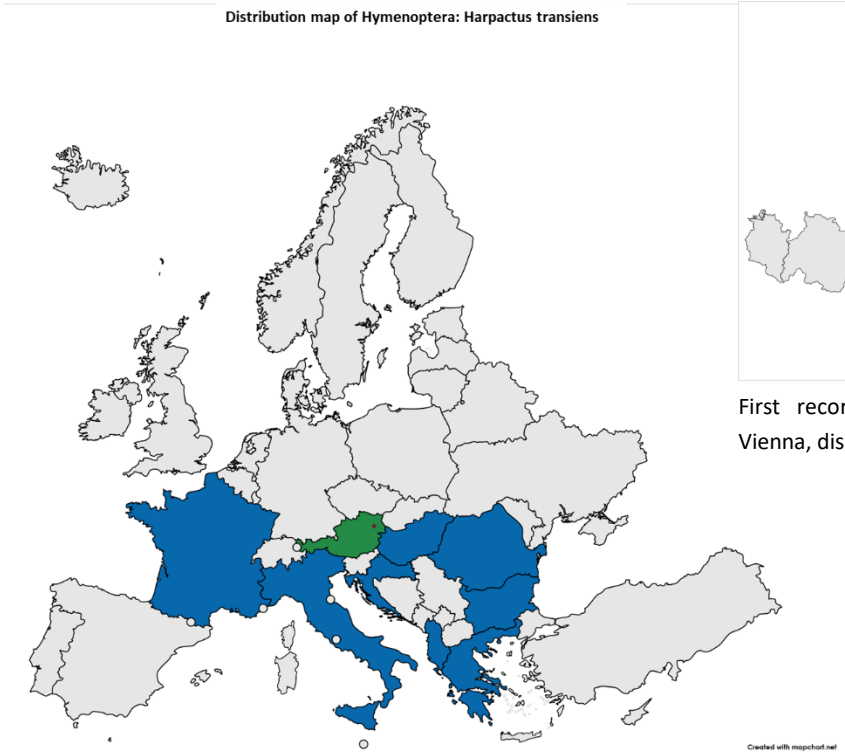
Figure 48: Countries in blue show native ranges of *Bombus haematurus*. Country in green and the red point show first record in Austria, Burgenland.

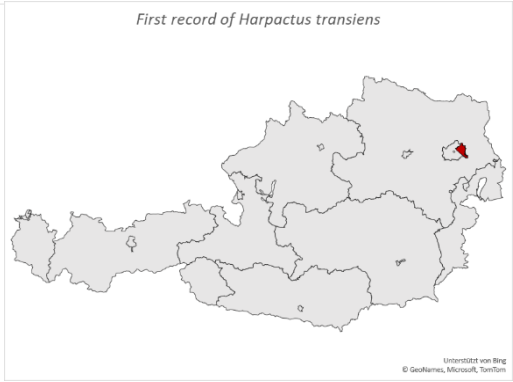



First record of *Anthidium laterale* in Austria, Burgenland, district Illmitz, postcode 7142.

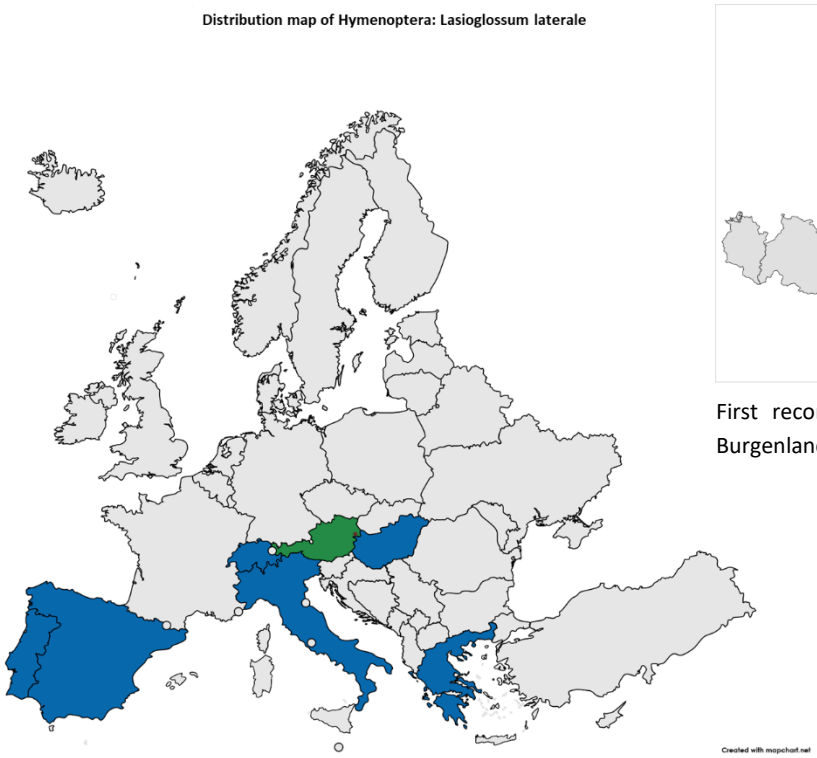
Figure 49: Countries in blue show native ranges of *Anthidium laterale*. Country in green and the red point show first record in Austria, Burgenland.

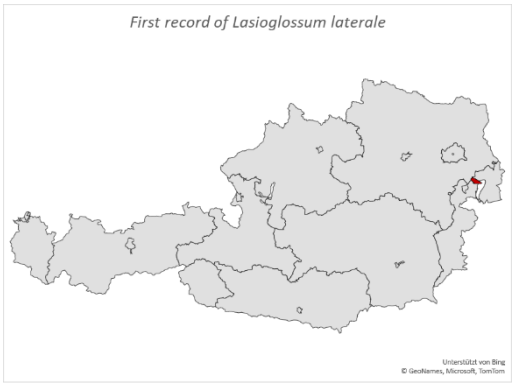



First record of *Harpactus transiens* in Austria, Vienna, district Lobau, postcode 7093.

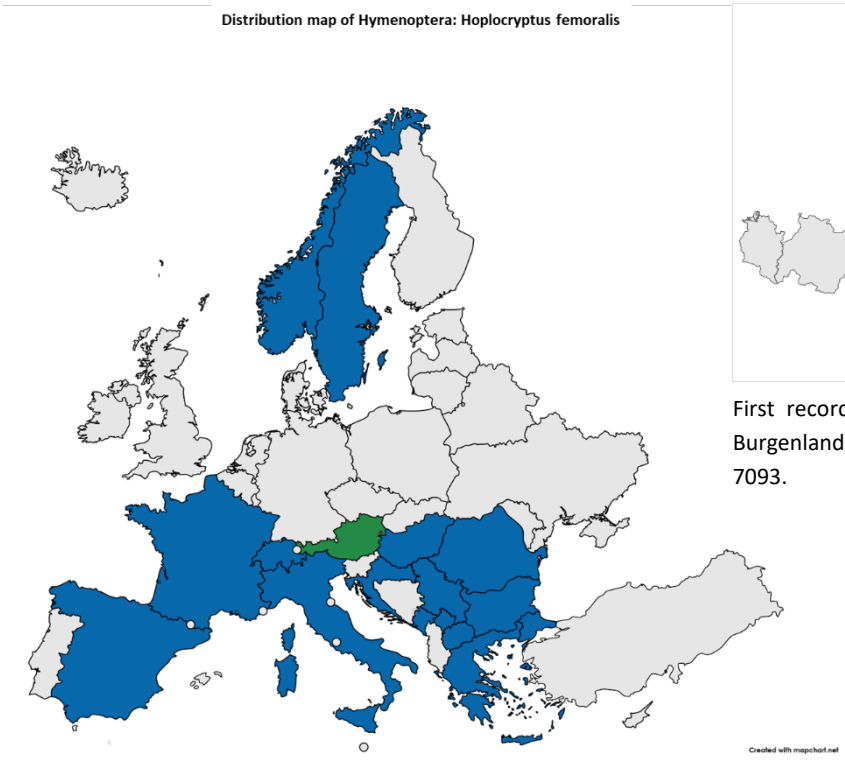
Figure 50: Countries in blue show native ranges of *Harpactus transiens*. Country in green and the red point show first record in Austria, Vienna.

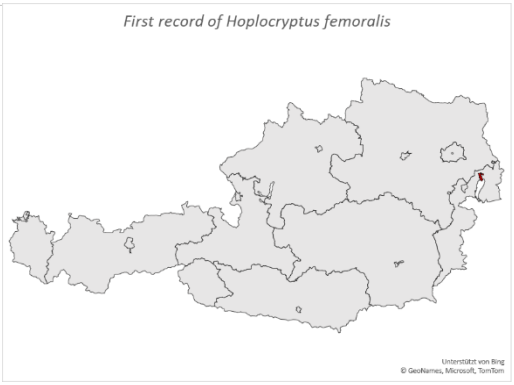



First record of *Lasioglossum laterale* in Austria, Burgenland, district Purbach, postcode 7083.

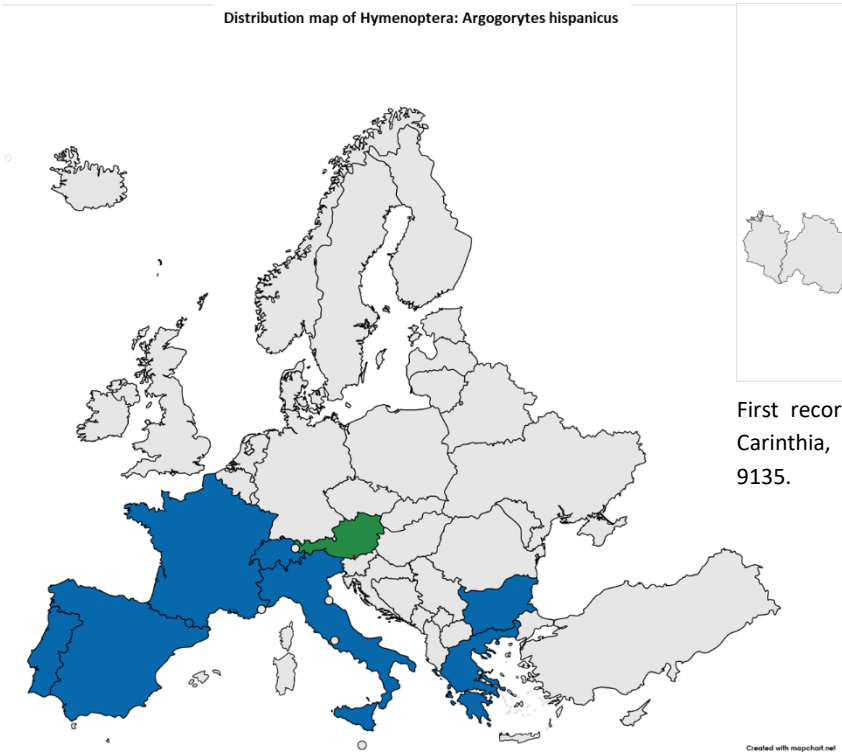
Figure 51: Countries in blue show native ranges of *Lasioglossum laterale*. Country in green and the red point show first record in Austria, Burgenland.




First record of *Hoplocryptus femoralis* in Austria, Burgenland, district Neusiedl am See, postcode 7093.

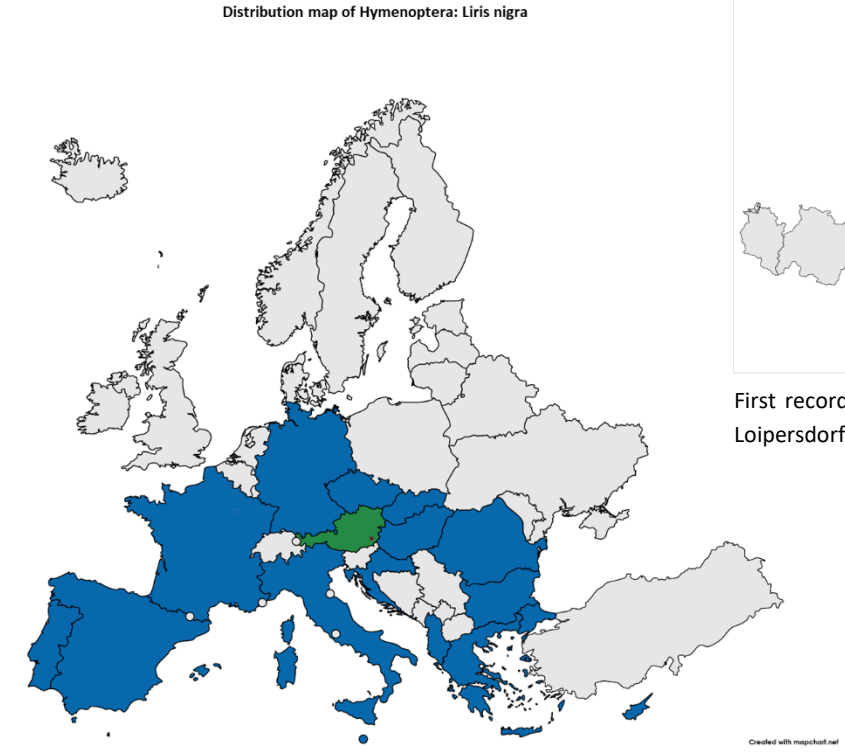
Figure 52: Countries in blue show native ranges of *Hoplocryptus femoralis*. Country in green and the red point show first record in Austria, Burgenland.





First record of *Argogorytes hispanicus* in Austria, Carinthia, district Vellacher Kotschna, postcode 9135.

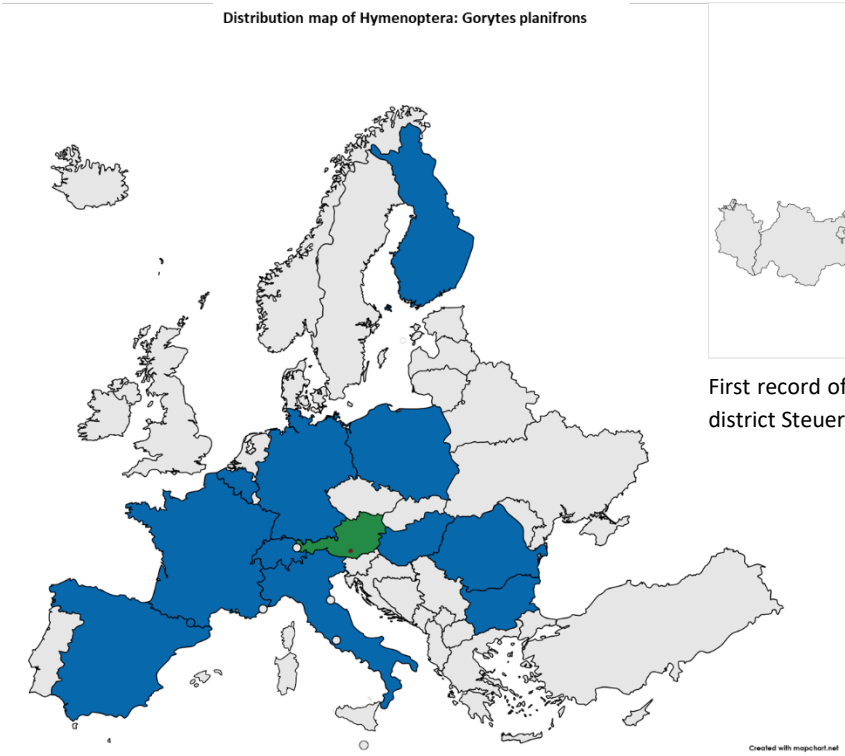
Figure 53: Countries in blue show native ranges of *Argogorytes hispanicus*. Country in green and the red point show first record in Austria, Carinthia.

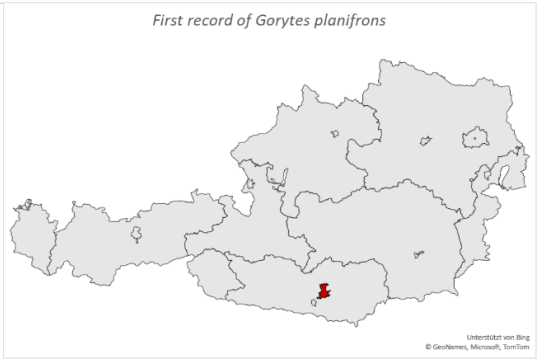




First record of *Liris nigra* in Austria, Styria, district Loipersdorf, postcode 8282.

Figure 54: Countries in blue show native ranges of *Liris nigra*. Country in green and the red point show first record in Austria, Styria.

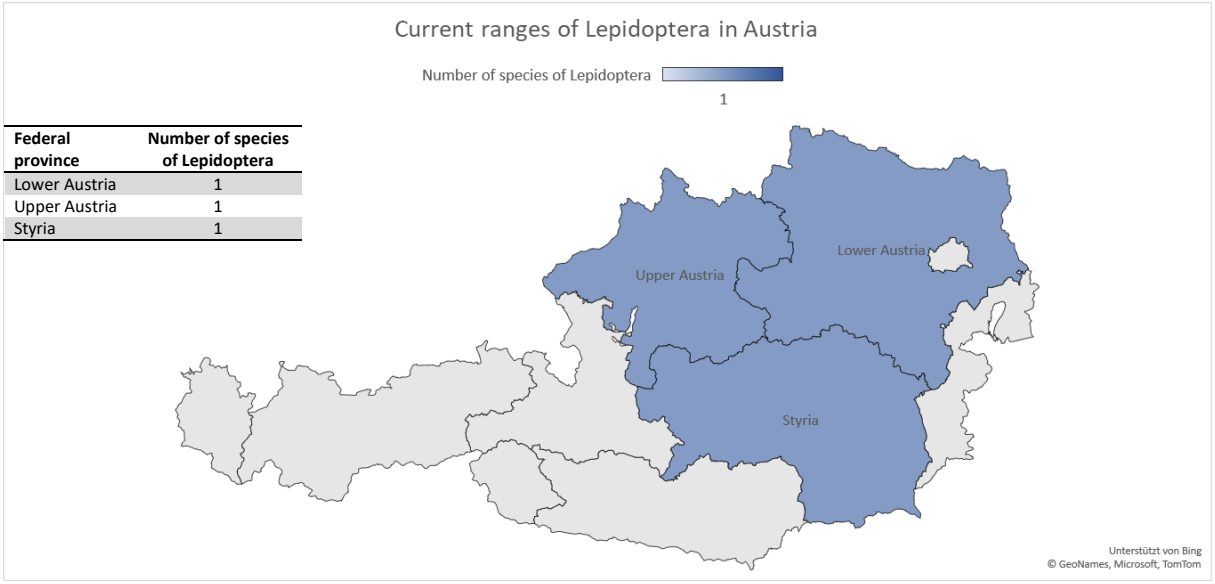



First record of *Gorytes planifrons* in Austria, Carinthia, district Steuerberg, postcode 9560.

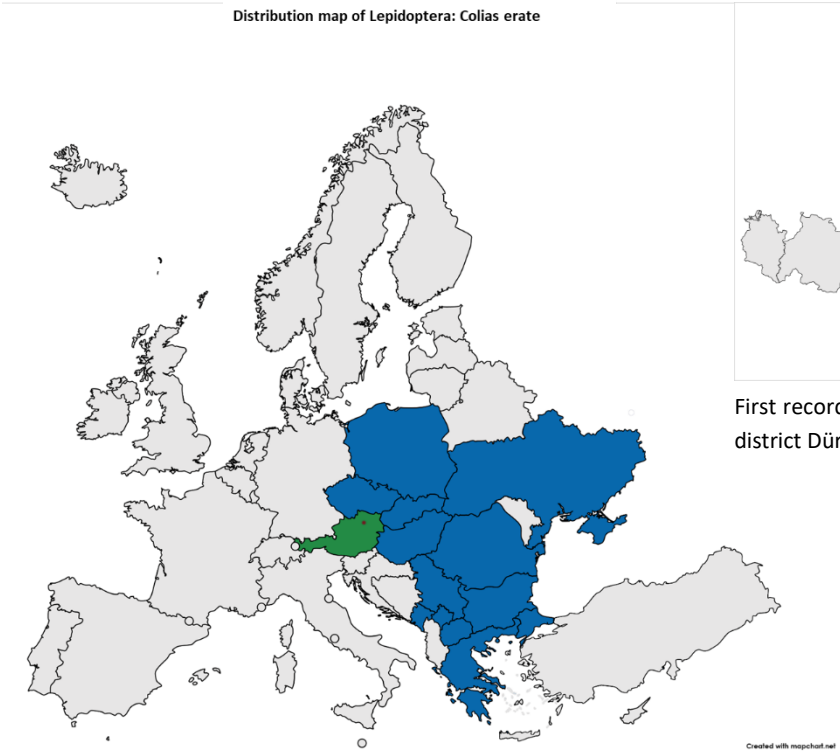
Figure 55: Countries in blue show native ranges of *Gorytes planifrons*. Country in green and the red point show first record in Austria, Carinthia.

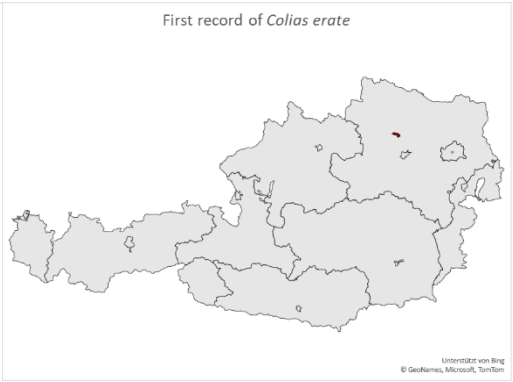
## Lepidoptera




| Federal province | Number of species of Lepidoptera |
|---|---|
| Lower Austria | 1 |
| Upper Austria | 1 |
| Styria | 1 |

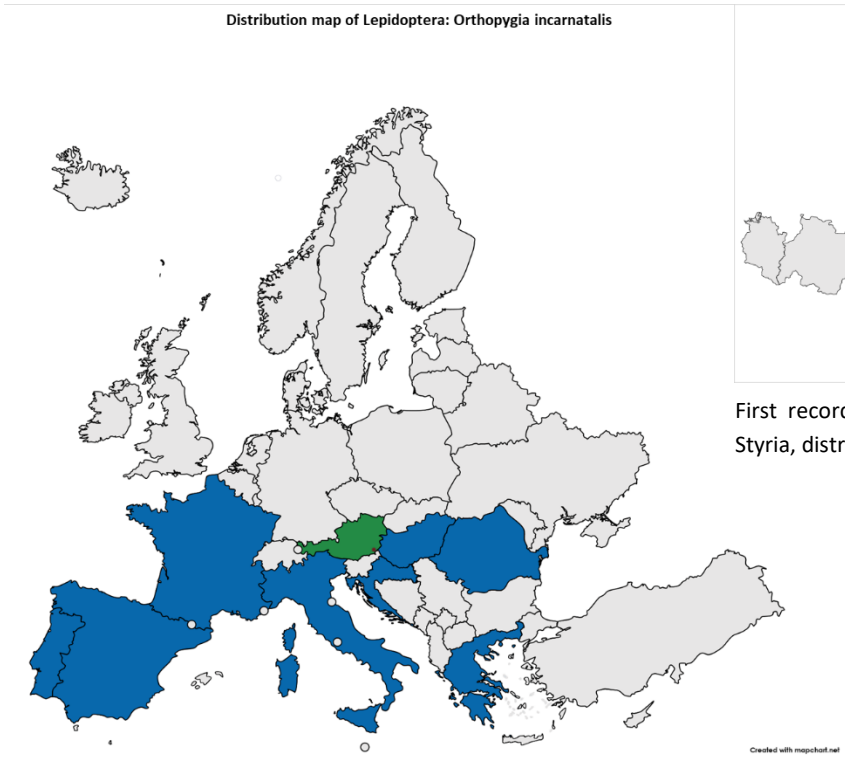
Figure 56: Number of species of Lepidoptera and the first records in federal provinces.

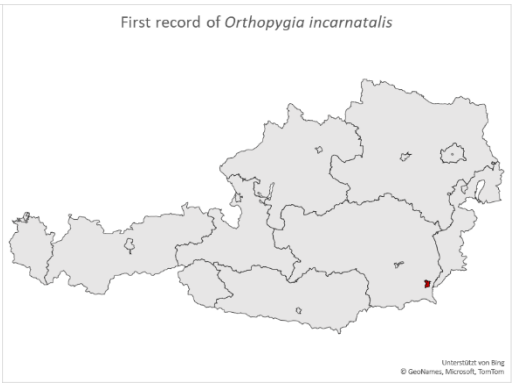



First record of *Colias eratein* Austria, Lower Austria, district Dürnstein, postcode 3601.

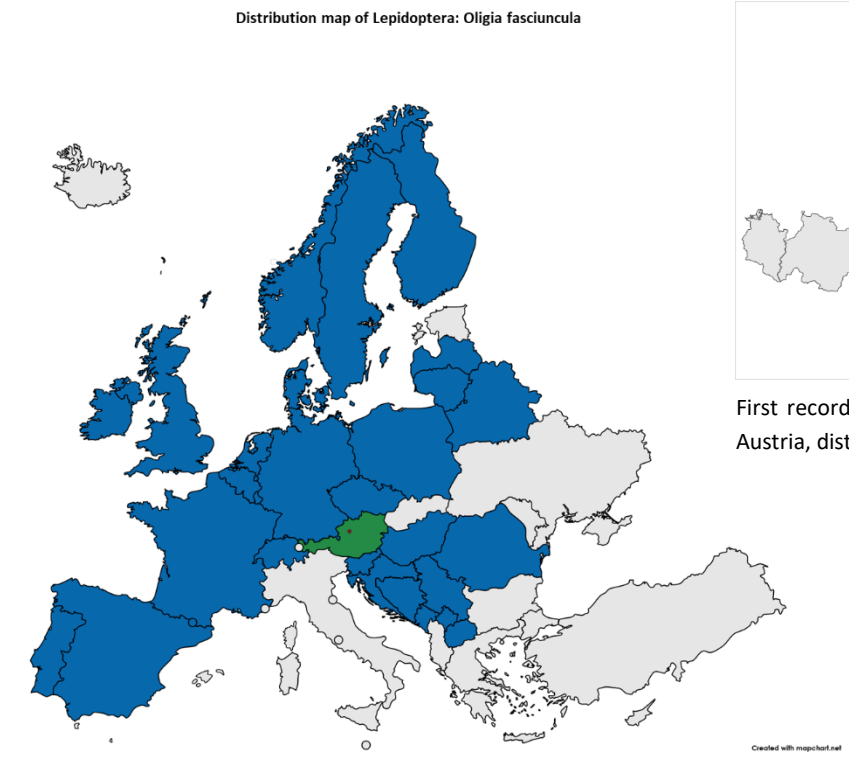
Figure 57: Countries in blue show native ranges of *Colias erate*. Country in green and the red point show first record in Austria, Lower Austria.




First record of *Orthopygia incarnatalis* in Austria, Styria, district Bad Gleichenberg, postcode 8344.

Figure 58: Countries in blue show native ranges of *Orthopygia incarnatalis*. Country in green and the red point show first record in Austria, Styria.

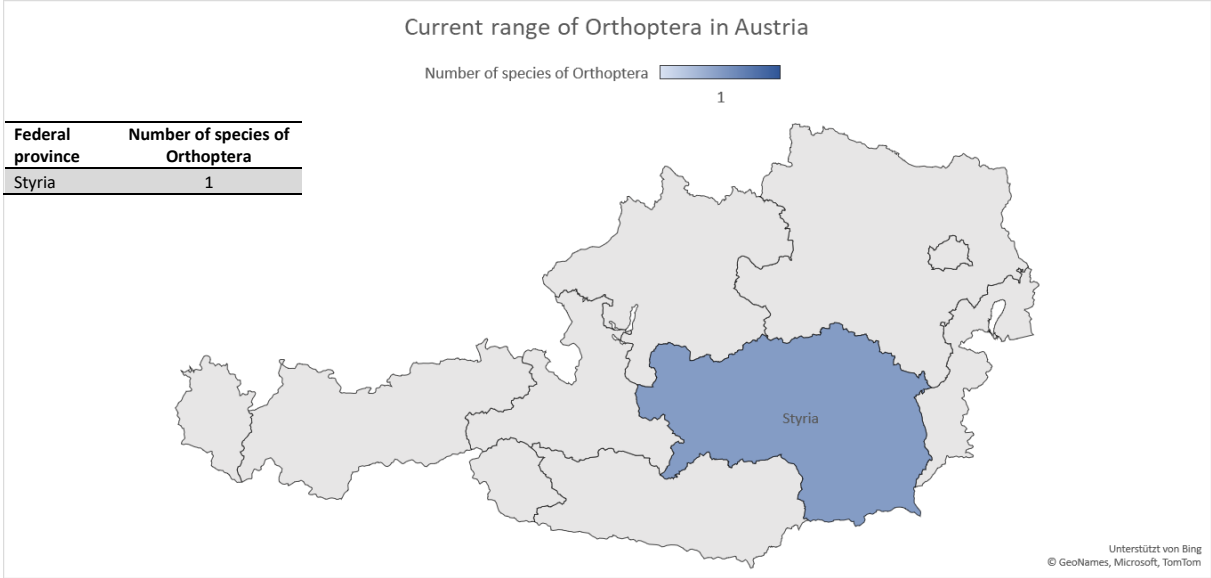




First record of *Oligia fasciuncula* in Austria, Upper Austria, district Punzenberg, postcode 4849.

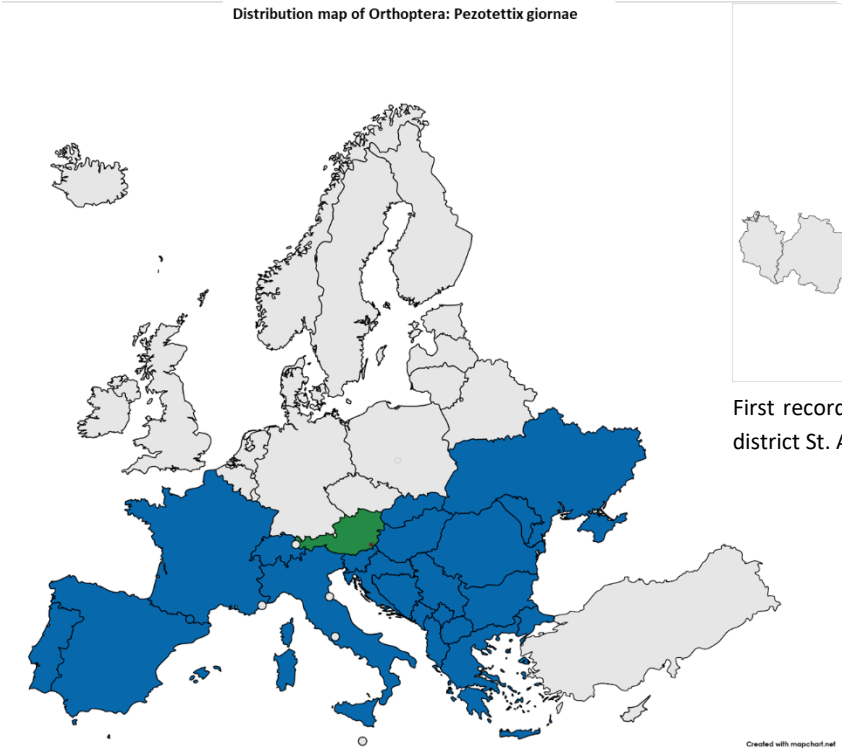
Figure 59: Countries in blue show native ranges of *Oligia fasciuncula*. Country in green and the red point show first record in Austria, Upper Austria.

## Orthoptera




| Federal province | Number of species of Orthoptera |
|---|---|
| Styria | 1 |

Figure 60: Number of species of Orthoptera and the first records in federal provinces.

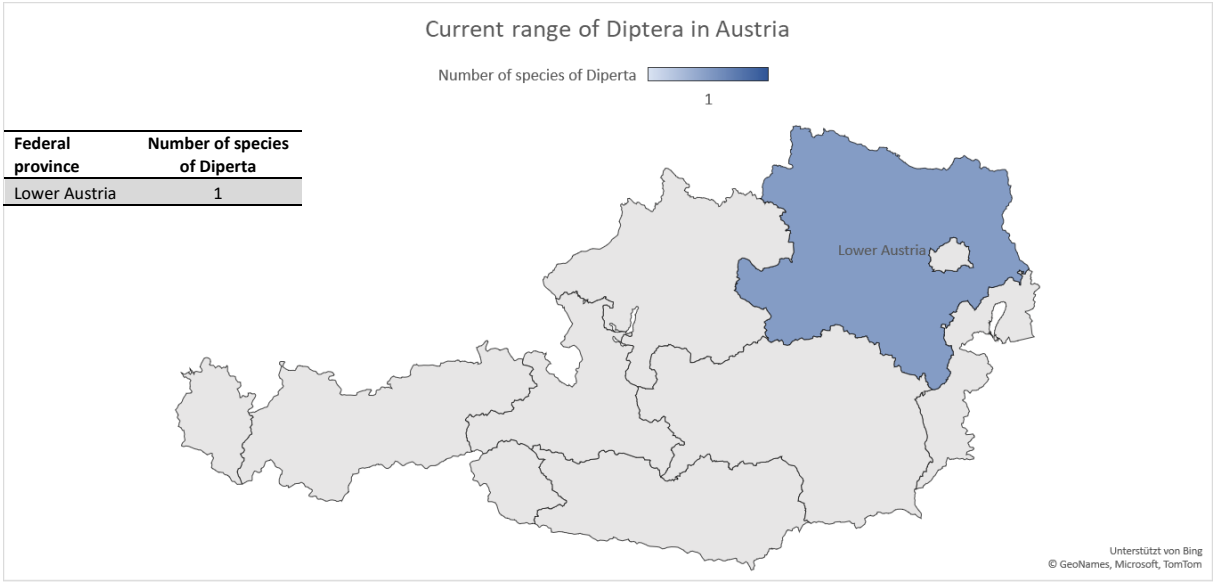




First record of *Pezotettix giornae* in Austria, Styria, district St. Anna a. Aigen, postcode 8354.

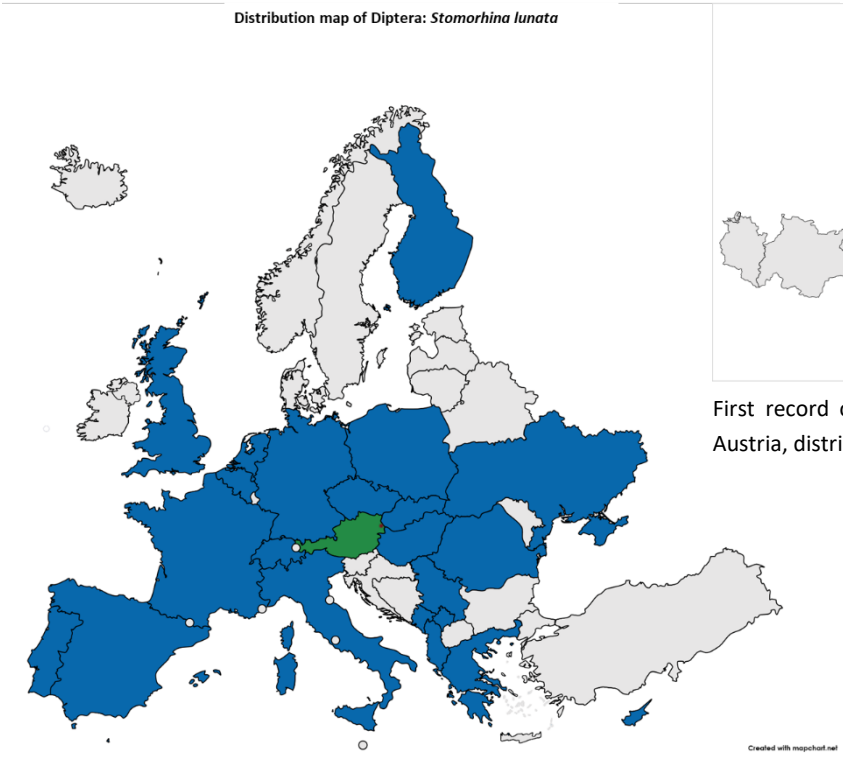
Figure 61: Countries in blue show native ranges of *Pezotettix giornae*. Country in green and the red point show first record in Austria, Styria.

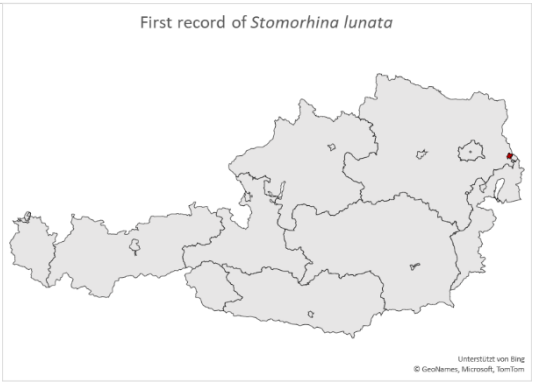
## Diptera




| Federal province | Number of species of Diperta |
|---|---|
| Lower Austria | 1 |

Figure 62: Number of species of Diperta and the first records in federal provinces.




First record of *Stomorhina lunata* in Austria, Lower Austria, district Hainburger Berge, postcode 2410.

Figure 63: Countries in blue show native ranges of *Stomorhina lunata*. Country in green and the red point show first record in Austria, Lower Austria.

# References


Biedermann, R., & Niedringhaus, R. (2004). *Die Zikaden Deutschlands - Bestimmungstafeln für alle Arten.*

Chen i-Ching, et al. (2011). *Rapid range shifts of species associated with high levels of climate warming.* Science Vol. 333.

Christelle, R., & Alain, R. (2010). *Direct impacts of recent climate warming on insect populations.* Integrative Zoology Volume 5, Issue 2. doi: https://doi.org/10.1111/j.1749-4877.2010.00196.x

Devictor V. et al. (2012). *Differences inthe climatic debts of birds and butterflies at a continental scale.* nature climate change. doi:DOI: 10.1038/NCLIMATE1347

EEA. (2017). *https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe*. Abgerufen am 2022 von https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe

Essl F. et al. (2018). *Which taxa are alien? Criteria, applications, and uncertainties.* BioScience 68. doi:https://doi.org/10.1093/biosci/biy057

Essl F. et al. (2019). *A Conceptual Framework for Range-Expanding Species that Track Human-Induced Environ-mental Change.* BioScience, Volume 69, Issue 11. doi:https://doi.org/10.1093/biosci/biz101

Halsch C. A. et al. (2020). *Insects and recent climate change.* PNAS. doi: https://doi.org/10.3897/neobiota.68.72849

Holzinger, W. E. (2009). *Checklisten der Fauna Österreichs 4: Auchenorrhyncha (Insecta).* Biosystematics and Ecology No. 26. doi:doi:10.1553/0x0022af06

Holzinger, W., Schedl, W., & Christian, E. (2009). *Checklisten der Fauna Österreichs, No. 4* (Bd. Biosystematics and Ecology Series No. 26). Wien: ÖAW. Von https://austriaca.at/9783700167938 abgerufen

https://www.gbif.org/. Abgerufen am 2022 von *https://www.gbif.org/dataset/8451afe2-9762-4888-b60b-6116f3dd3049*.

IPCC. (2001). *Climate change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press.

IPCC. (2019). *Summary for Policymakers.* In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Abgerufen am 2022 von https://www.ipcc.ch/srccl/chapter/summary-for-policymakers/

IUCN. (2019). *Environmental impact classification aof alien taxa (EICAT) Standard v1 consultation results.* Abgerufen am 2022 von https://www.iucn.org/sites/dev/files/content/documents/eicat_v1_consultation_2_comments_and_responses.pdf

Karuppaiah, V., & Sujayanad, G. (2012). *Impact of Climate Change on Population Dynamics of Insect Pests.* World Journal of Agricultural Sciences 8 (3). Abgerufen am 2022 von https://www.researchgate.net/publication/332012685_Impact_of_Climate_Change_on_Population_Dynamics_of_Insect_Pests

Keizi, K. (2013). *Different effects of climate change on the population dynamics of insects.* Applied Entomology and Zoology. doi:10.1007/s13355-012-0158-y

Mastrandrea et al. (2010). *Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Tratment of Uncertainties.* USA. Von https://www.ipcc.ch/site/assets/uploads/2017/08/AR5_Uncertainty_Guidance_Note.pdf abgerufen

Matt Dowle & Arun Srinivasan. (2021). data.table: Extension of `data.frame`. Von https://CRAN.R-project.org/package=data.table abgerufen

Ott, J. (2010). *Dragonflies and climatic change - recent trends in Germany and Europe.* BioRisk: 5. doi:10.3897/biorisk.5.857

Ott, Jürgen. (2008). *Libellen als Indikatoren der Klimaänderung - Ergebnisse aus Deutschland und Konsequenzen für den Klimaschutz.* Insecta, Heft 11. Von https://lupogmbh.de/editor/file/Insecta%20%20Heft%2011%20%20Libellen%20+%20Klimaaenderung.pdf abgerufen

Parmesan, C. (2006). *Ecological and evolutionary responses to recent climate change.* Annual Review of Ecology, Evolution and Systematic, 37. doi:10.1146/annurev.ecolsys.37.091305.110100

Parmesan, C. R. (1999). *Poleward shifts of species' ranges associated with regional warming.* Nature 399. doi:https://doi.org/10.1038/21181

Platts, P.J., et al. (2019). *Habitat availability explains variation in climate-driven range shifts across multiple taxonomic groups.* Sci Rep 9. 15039. doi:https://doi.org/10.1038/s41598-019-51582-2

Poloni, Riccardo; et al. (2022). *Conservation biogeography of high-altitude longhorn beetles under climate change.* Insect Conservation and Diversity. doi: https://doi.org/10.1111/icad.12570

R Core Team. (2021). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Von https://www.R-project.org/ abgerufen

Rabitsch et al. (2020). *Insekten in Österreich. Artenzahlen,Status, Trends, bedeutung und Gefährdung.* Umweltbundesamt, Wien.

Rabitsch, Wolfgang. (2008). *The times they are a-changin': driving forces of recent additions to the Heteroptera fauna of Austria.* Advances in Heteroptera Research. Sofia: Pensoft Publ.

Sánchez-Guillén, RA; et al. (2013). *Climate-Induced Range Shifts and Possible Hybridisation Consequences in Insects.* PLoS ONE 8(11): e80531. doi:10.1371/journal.pone.0080531

Stange, E. E., & Ayres, M. P. (2010). *Climate Change Impacts: Insects.* Encyclopedia of Life science, 2001. doi: https://doi.org/10.1002/9780470015902.a0022555

USGS Science for a changing world. *What is the difference between global warming and climate change?* Abgerufen am 2022 von https://www.usgs.gov/faqs/what-difference-between-global-warming-and-climate-change?qt-news_science_products=0#qt-news_science_products

Warren, Rachel; Price, Jeff; Jenkins, Rhosanna. (2021). *Chapter 4 - Climate change and terrestrial biodiversity.* doi:https://doi.org/10.1016/B978-0-12-822373-4.00025-2

Wickham, et al. (2019). Welcome to the tidyverse. Journal of Open Source Software. *4 (43)*, 1686. doi:https://doi.org/10.21105/joss.01686

Wikipedia. (2009). *https://en.wikipedia.org/wiki/Alps*. Abgerufen am 2022 von https://en.wikipedia.org/wiki/Alps

Yde de Jong, et al. (2014). *Fauna Europaea – all European animal species on the web.* Biodiversity Data Journal. doi:https://doi.org/10.3897/BDJ.2.e4034

ZAMG. *Klimamonitoring*. Abgerufen am 2022 von https://www.zamg.ac.at/cms/de/klima/klima-aktuell/klimamonitoring/?param=t&period=period-y-1990&ref=3

ZAMG. *Lufttemperatur*. Abgerufen am 2022 von https://www.zamg.ac.at/cms/de/klima/informationsportal-klimawandel/klimavergangenheit/neoklima/lufttemperatur