



Give me a call! The Characteristic Sounds of the Garden Dormouse *Eliomys quercinus* (Linnaeus, 1766) (Rodentia: Gliridae) Used as a Detection Method in an Urban Habitat in Germany

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Abstract: The garden dormouse shows an ongoing decline all over Europe. Glirids are difficult to monitor due to their nocturnal activity and their relatively low densities. In this study, we used a very simple and easy detection method in the city of Wiesbaden (Germany), which has a stable garden dormouse population. In the summer 2019, characteristic vocalizations of the animals were used to map the occurrence of the species. Within 20 summer nights, 128 acoustic detections of garden dormice were obtained, which resulted in records for 55 out of 61 investigated km² grids. The species was found almost all over the area, mainly in semi-open areas like gardens and allotments but also in highly built-up and cultivated areas. Our study showed that using a simple, cost-effective and non-invasive method, in combination with citizen science projects, could provide valuable data for dormice monitoring.

Key words: In Search of the Garden Dormouse, acoustic, vocals, monitoring, distribution

Introduction

The ongoing loss of biodiversity is one of the biggest problems of our times. For the conservation of threatened and endangered species, monitoring wildlife is an essential component (CONSERVATION MEASURES PARTNERSHIP – CMP 2020, NICHOLS & WILLIAMS 2006, SALAFSKY et al. 2001), which can be very challenging (MACKENZIE et al. 2005, 2006) due to animal's small sizes, low densities, time of activity or any local restrictions. Different monitoring methods have been established depending on the practicability and the target species (e.g. ZUHDI

2017). Each method has its advantages and limitations (ZWERTS et al. 2021). As resources and budgets are often limited, it can be difficult to choose an appropriate method (STEPHENSON 2020, STEPHENSON et al. 2020). Using animal sounds as a detection method is widespread and has long been used as a biodiversity monitoring technique (DORCAS et al. 2009). Producing characteristic sounds can be observed in different taxa such as insects (MANKIN et al. 2011), anurans (MELO et al. 2021), birds (FROMMOLT & TAUCHERT 2010) and mammals – bats (TEETS et al. 2019), whales (HILDEBRAND et al. 2015) and wolves (SUTER et al. 2017, PAPIN et al. 2018). Since

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these sounds are often species-specific, acoustic surveys can be used to determine, e.g., species occurrence or relative abundance (CRUMP et al. 2017, DURARTE et al. 2019, WILLACY et al. 2015). As a result, animal sounds have been a crucial clue for biodiversity appraisal and ecological research for decades (LAILOLO 2010). Automated and therefore passive acoustic recording technology is accessible today and allows the collection of large amounts of data (FROIDEVAUX et al. 2014). However, costs, time and effort may be limiting factors for using this method. Therefore, active acoustic perception by humans is still an alternative to modern recording technology and automated analyses. In combination with citizen science activities and the support of volunteers, large amounts of data can also be collected in a short time by using active acoustic monitoring.

Among European mammals with the most rapidly shrinking rate of its range is a rodent, i.e. the garden dormouse *Eliomys quercinus* (Linnaeus, 1766). The reasons for the rapid decline remain unclear (BERTOLINO 2007, 2017). Considering the harsh decline and the need for active conservation, it is very urgent to know the recent distribution and the species-specific needs. The garden dormouse occupies very different habitats such as coniferous, deciduous or mixed forests, gardens, vineyards and even urban areas and cities (STORCH 1978, VATERLAUS-SCHLEGEL 2001, BERTOLINO 2017). However, little is known about the specific life of garden dormice in the city. Due to their nocturnal activity and their mostly arboreal lifestyle, dormice are difficult to monitor. Detecting the presence of various small mammals remains a challenge, despite the availability of a variety of methods (MELCORE et al. 2020); it becomes especially difficult in the city where live trapping or the use of camera traps on many different private properties are not appropriate. Within the dormouse family, acoustic communication plays an important role. Already within the first days after birth, garden dormice communicate via vocalisations (VALENTIN & BAUDOIN 1984). This type of communication can also be observed in adults, whereby different characteristic vocalisations can be distinguished (HUTTERER & PETERS 2001). Acoustic communication is particularly important during the mating season (STORCH 1978, SCHLUND 2005). Due to the nocturnal activity of the animals, it is also assumed that acoustics are used not only for communication with conspecifics but also for orientation, as it has been observed in related species such as edible dormouse *Glis glis* (KAHMANN & OSTERMANN 1951). Consequently, as acoustics play an important role in communication for the garden dormouse this

can be utilised in monitoring surveys. Locating dormice by reference to their calls has already been successfully used for the edible dormouse (JURCZYSZYN 1995, 2001, ADAMÍK 2019). The characteristic sound of the garden dormouse, which can be heard loudly, especially during the mating season (STORCH 1978) also holds potential for conducting studies about the distribution of this species. The calls of the garden dormouse can be easily distinguished from those of other dormouse species because the calls of both edible dormouse and the hazel dormouse (*Muscardinus avellanarius*) are in different frequency ranges (HUTTERER & PETERS 2001, ANCILLOTTO et al. 2014) than those of the garden dormouse (MEINIG et al. 2022).

In this study, conducted as part of the project *In Search of the Garden Dormouse* (BÜCHNER et al. 2024), the specific calls of the garden dormouse were used for the first time for this species to conduct a mapping study collecting presence/absence.

Materials and Methods

Study area

The study area was the city of Wiesbaden, central Germany. Wiesbaden covers 203.8 km² and has approximately 291,000 inhabitants (December 2018, Landeshauptstadt Wiesbaden 2018a, 2018b). Within Germany, Wiesbaden is one of the areas where relatively stable populations of the garden dormouse can still be found, along with the lowlands of Rhineland-Palatinate, Baden-Württemberg and parts of Lower Saxony (MEINIG & BÜCHNER 2012, BERTOLINO 2017). For Wiesbaden, especially for the city centre, the occurrence of the garden dormouse has been known for decades and the animals are found in gardens, allotments, garden sheds and even in flats and houses (BITZ 1994, LANG 2012, MEINIG & BÜCHNER 2012, BÜCHNER et al. 2018). The species is widely known amongst the residents of the city.

Acoustic detection of the garden dormouse

The study area was divided into several 1 km² grid cells based on the European reference grid EEA (10 km x 10 km; BUNDESAMT FÜR KARTOGRAPHIE UND GEODÄSIE 2018), which resulted into approximately 203 study plots of 1 km² according to the size of the city. The aim was to obtain at least one record of a garden dormouse per investigated grid cell, with a particular focus on urban areas in and around the city centre, which comprised 61 grid cells. The acoustic search for garden dormice took place from mid of July until late August 2019. For the acoustic sampling, potential places (green zones,



Fig. 1. Current distribution of the garden dormouse in Europe (right, IUCN 2008) and the study site in Wiesbaden (left), outlines and 1 km² grids, ©EEA 2022, ©MultiBase 2022. Points: locations where garden dormice were acoustically detected. Grey: grids with acoustic detections. Shaded: grids investigated but no garden dormouse was detected. QGIS Version Madeira 3.14.5.

woody plants, rich vegetation terrains) were selected in advance via satellite images using Google Maps (GOOGLE MAPS 2019, www.google.de/maps). Due to the nocturnal activity of dormice, the sampling took place between dusk (sunset in July was approximately 21.30, reducing to 20.30 by August, UTC +2) and sunrise (approximately 04.00, UTC +2). Two trained and experienced persons walked slowly along the pre-selected sites, carefully listening for potential calls of garden dormice. If no acoustic proof could be provided for the grid cell (1 km²) within 60 minutes during the first night, the inspection was repeated at another night. After two nights without any call, this grid was classified as without presence of garden dormouse.

At each survey point the date, time (UTC +2), coordinates and weather (cloud coverage, precipitation, wind, humidity and temperature) were noted if available. Missing data were subsequently added (LANDESHAUPTSTADT WIESBADEN 2019). At positive points additional information was recorded, including visible details about the land cover, habitat, structure and any other details about the observation, including an optional recording of the garden dormouse's call for further analysis (MEINIG et al. 2022, THIVIERGE et al. 2022). For the analysis, the times of presence data were summarised in categories of 30 minutes (half hours \pm 15 minutes).

For the subsequent visualization of the results, the program R Studio (version 4.2.1., package FMSB, NAKAZAWA 2019) was used.

Results

Within 20 nights, 128 acoustic detections of garden dormice were obtained in 55 out of 61 investigated 1 km² grids (Fig. 1). Associated with the acoustics, it was also possible to obtain 17 visual detections of garden dormice. In total, this resulted in evidence of at least 168 individuals.

The garden dormouse was found in almost the entire study area, mainly in near-natural and semi-open areas such as allotments and gardens. It was also found in highly built-up areas, in the immediate vicinity of humans, including playgrounds, car parks and, in some cases, even inside buildings (Table 1).

The garden dormice were often located within hedges, bushes and shrub complexes. More detections were in bushes without trees than in bushes with larger trees. However, the exact structure could not always be identified due to the distance to the animal (Table 2).

The calls could be heard up to a distance of 40 m (\bar{x} = 10 m, min. 0.6 m, max. 40 m). The height at which the animals were located ranged from 0 m (on the ground, visual proof) to 15 m (in buildings, acoustic proof, \bar{x} = 2.9 m). The time the garden dormice in Wiesbaden started calling during a particular night was between 20.50 and 23.56 (UTC +2). On average, the first acoustic detection could be identified 69.8 minutes after the start of the investigation (min. 0 minutes, max. 181 minutes). The highest

Table 1. Categories of land use where Garden Dormice were found by acoustics.

Category	Land cover	No. of detections	%
Near-natural	Allotment	49	38.3
	Garden	21	16.4
	Green area (grass verge)	13	10.2
	Open area	13	10.2
	Park	3	2.3
	Cemetery	3	2.3
	Forest	1	0.8
Highly built-up	Building	11	8.6
	Car park	11	8.6
	Playground	3	2.3
Total		128	100.0

Table 2. Acoustic detection of garden dormice by habitat.

Habitat structure	No. of detections	%
Unknown	50	39.1
Bushes/scrub complex without larger trees	41	32.0
Hedge	17	13.3
Tree	11	8.6
Scrub complex with larger trees	9	7.0
Total	128	100.0

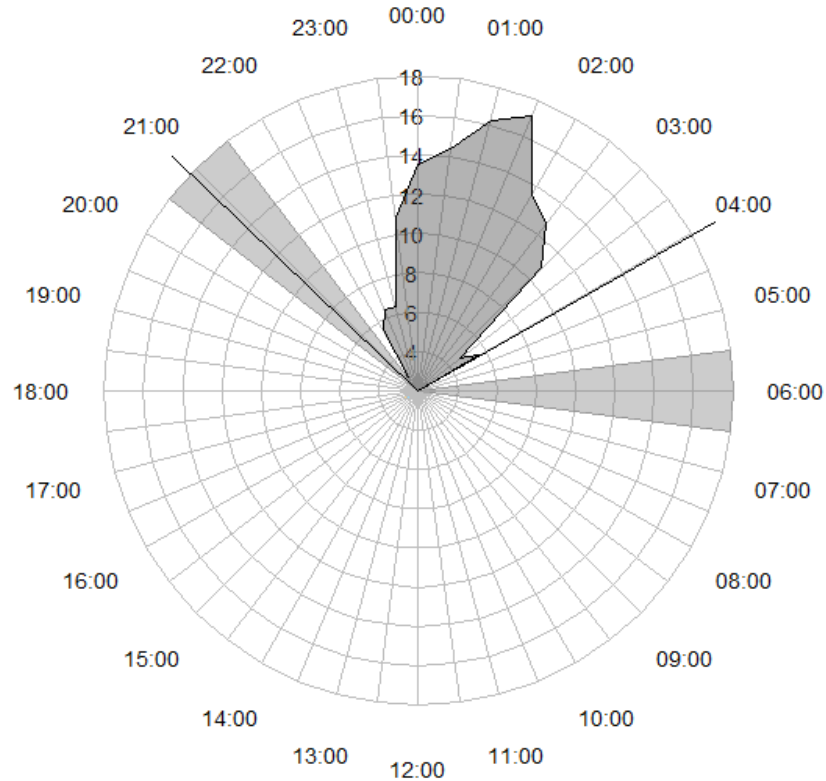


Fig. 2. Time (UTC+2, summarized in categories ± 15 minutes) the calls (n) of the garden dormouse could be heard (grey with black outline). First call was heard at 20:50, last call at 04:03 (black lines). Sunset was between 21:31 and 20:29 and sunrise between 05:36 and 06:31 (grey).

number of acoustic detections was between 1.00 ± 15 minutes and 1.30 ± 15 minutes (Fig. 2).

The temperature when most of the acoustic evidence could be collected varied between 15 and 21 °C, with a mean temperature of 18.5 °C and when the overall mean night temperature was 19.4 °C. Vocal evidence could be detected at humidity levels between 32 % and 99 % ($\bar{x} = 71.9$ %). Of these vocal records, 96 % could be heard at humidity levels higher than 50 %. The most records ($n = 93$) were sampled while there was no precipitation at all. Garden dormice were calling when the average wind speed of 0.58 m/s (min. 0.1 m/s, max. 2.6 m/s) was lower than the average wind speed of all nights ($\bar{x} = 0.718$ m/s, min. 0.0, max. 3.3 m/s).

Discussion

Garden dormice were detected throughout the urban area of the city of Wiesbaden. There, the species is widespread and could be easily detected by its calls. As these data could be collected with the simple method of acoustic detections of calling animals, it showed that the applied method seemed to be very suitable for monitoring the garden dormouse. The specific sounds are easy to identify and, therefore, it is easy to obtain a large amount of presence data in a short time with little effort and at very low costs. However, we are aware that garden dormice may not be as vocal in all habitats as in the urban areas described here. The likelihood of detection may also vary across the night and across seasons (PEARSE et al. 2015), and by the animals' shyness and habituation (MARINI et al. 2009, THOMAS et al. 2010), especially in cities. In addition, it is still not yet certain the role of each parameter for the activity of the acoustic behaviour of garden dormice and how great their impact is.

We assume that the time of call initiation, the duration of call activity, the peaks of call activity as well as the intensity and frequency of calls during the night depend on meteorological and physical factors, in the same way as it is known for vocalization in birds (ROBBINS 1981). In general, mild nights without rain and with little or no wind seem to be the most suitable for the detection of garden dormice by human hearing in urban conditions. The acoustic activity of the garden dormouse may depend on the intensity of the predation risk as well as the availability of food, typical of the general activity of small mammals (WRÓBEL & BOGDZIEWICZ 2015). Further studies are needed on this topic.

The garden dormouse uses different habitats in Wiesbaden. It is indeed a very adaptable species (VATERLAUS-SCHLEGEL 2001, BERTOLINO et al.

2001) and flexible in its ecological requirements (BERTOLINO 2017). Semi-open areas seem to play an important role for garden dormice in cities and urban areas (BAKER & HARRIS 2007). Gardens (and allotments probably even more, see GASTON et al. 2005) offer many hiding places plus potential food and can thus embody a valuable habitat or at least a haven, as they do for other rodents in cities (BAKER & HARRIS 2007). Contrary to other studies that show that the garden dormouse is less arboreal than other dormouse species (STORCH 1978, VATERLAUS 1998, FILIPPUCI 1999, BERTOLINO et al. 2003, BERTOLINO & CORDERO DI MONTEZEMOLO 2007), our data show that it can be often found above the ground, using bushes and trees for movement. This may be due to partial heavily built-up areas within the city but areas with streets do not seem to represent a total barrier. Garden dormice can also colonise fragmented areas (VATERLAUS 1998). Built-up areas such as buildings, which are likely to be used for shelter and nesting rather than for foraging (VATERLAUS 1998), could be an alternative to rocky areas where nesting is very common in natural habitats (BERTOLINO 2007). Such structures are a source of warmth and can reduce the thermal stress of the animals (BERTOLINO et al. 2001, BERTOLINO & CORDERO DI MONTEZEMOLO 2007). In this way, buildings could provide the garden dormouse with stable and suitable microhabitat conditions all year round, regardless of the season.

The use of buildings by the garden dormouse and their vocal behaviour led to many residents becoming aware of the species. Consequently, the recording of garden dormice by their calls has great potential for Citizen Science projects dealing with distribution mapping in urban areas. Recordings of calls made with mobile phones during the mapping can be used to verify the evidence retrospectively. Active acoustic mapping is a simple, easy-to-learn, cheap, non-invasive method to provide data for biodiversity monitoring within a short timescale and should now be considered for monitoring of garden dormice elsewhere. Following ADAMÍK et al. (2019), we emphasise the importance of further acoustic studies (MEINIG et al. 2022). Once this method is standardised, it can become a promising tool for monitoring and observing species such as the endangered garden dormouse.

Acknowledgement: Special thanks to Tobias Reiners (Senckenberg Society for Nature Research) for providing basic data and for the help in processing the data as well as for technical support at the beginning. Thanks to Joscha Rauber, who also helped with the data preparation, processing and analysis. We

thank Susanne Steib (BUND, Friends of the Earth Germany) and Yvonne Maak (Environmental Agency Wiesbaden) for the cooperation and for support on the ground. Without them, the start of the study would hardly have been possible. Thanks to Petra Quillfeldt (Working Group for Behavioural Ecology and Ecophysiology, Institute for Animal Ecology and Special Zoology, Justus-Liebig-University Giessen) for the expert advice during planning and analysis. We would like to thank all the volunteers from Wiesbaden who were involved in the study and in the project “In Search of the Garden Dormouse”, especially the families Bauer, Baldus, Kempe, Maas, Schreiber, Scholl-Steffan and Thrun. This project was funded by the German Federal Agency for Nature Conservation with resources from the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection.

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