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# New immigrants among old graves: records of the non-native land snail species *Hygromia cinctella* (DRAPARNAUD 1801) from urban cemeteries in Berlin (Stylommatophora: Hygromiidae)

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**Abstract:** While urban cemeteries can be important refuges for biodiversity, they may also harbour significant numbers of non-native species. Examinations of four cemeteries in different parts of Berlin, which were performed in 2022 based on visual search and soil sampling, resulted in records of the non-native land snail species *Hygromia cinctella* (DRAPARNAUD 1801). The new records fit well into the species' general trend of range extension in Europe and Germany running in northern and eastern direction, while presumably involving cemeteries as entry points in some regions. A survey of citizen science data showed that *H. cinctella* is present in Berlin at least since 2019. The dispersal of this species to Berlin was probably human-mediated, potentially with plant material or soil. *Hygromia cinctella* was found to be already well-established at the two larger studied cemeteries, the Wilmersdorf and Buschkrugallee cemeteries. At the old garrison cemetery, a single live individual, and at Turiner Strasse cemetery, only one old empty shell were found, indicating that establishment at these smaller cemeteries may be more difficult. Many empty shells showed indications of predatory activities, probably involving rodents and beetles.

**Keywords:** alien species, Germany, predation, urban green space

**Zusammenfassung:** Urbane Friedhöfe können wichtige Rückzugsorte für Biodiversität darstellen, aber auch beträchtliche Zahlen nicht einheimischer Arten beherbergen. Untersuchungen von vier Friedhöfen in verschiedenen Teilen Berlins, welche 2022 mittels visueller Suche und Bodenbeprobung durchgeführt wurden, führten zu Nachweisen der nicht einheimischen Landschneckenart *Hygromia cinctella* (DRAPARNAUD 1801). Die neuen Funde fügen sich gut in den allgemeinen Trend der Ausbreitung dieser Art in Europa und Deutschland ein, der in nördliche und östliche Richtung verläuft, wobei in einigen Regionen vermutlich Friedhöfe als Eintrittspforten fungieren. Eine Überprüfung von Citizen-Science-Daten zeigte, dass *H. cinctella* mindestens seit 2019 in Berlin vorkommt. Die Ausbreitung der Art nach Berlin erfolgte wahrscheinlich durch den Menschen, möglicherweise mit Pflanzenmaterial oder Erde. *Hygromia cinctella* erwies sich auf den beiden größeren untersuchten Friedhöfen, den Friedhöfen Wilmersdorf und Buschkrugallee, bereits als gut etabliert. Auf dem Alten Garnison-Friedhof wurde ein einziges lebendes Individuum und dem Friedhof Turiner Straße nur ein altes Leergehäuse gefunden, was auf eine erschwerte Etablierung auf diesen kleineren Friedhöfen hindeuten könnte. Viele Leergehäuse zeigten Anzeichen von Prädation, an welcher wahrscheinlich Nagetiere und Käfer beteiligt waren.

## Introduction

Cemeteries can represent habitat islands and important refuges for biodiversity within cities (LÖKI & al. 2019). While sharing many features with parks and other urban green spaces, they exhibit several unique characteristics including a lower disturbance frequency, a comparatively high habitat stability, and the presence of walls and sepulchral monuments such as gravestones that provide rock-like surfaces (KOWARIK & al. 2016, SÄUMEL & al. 2023). Various rare and endangered plant and animal species have been recorded from cemeteries (see LÖKI & al. 2019) and these spaces have been considered important for the survival of rare native terrestrial gastropods in the urban environment (ÖRSTAN 2004, ÖRSTAN & KÖSEMEN 2009). However, cemeteries have also been found to harbour significant numbers of non-native and even invasive species, in particular plants (RUTKOVSKA & al. 2011, WALUSIAK & KRZTOŃ 2021), but also terrestrial gastropods (ŠTEFFEK & al. 2008, REISCHÜTZ 2014). Over 200 cemeteries exist in the German capital Berlin, which cover a total area of more than 1,000 hectares (SenUMVK 2020a). In the present study, we report records of the non-native land snail species *Hygromia cinctella* (DRAPARNAUD 1801) from several cemeteries in Berlin. To our knowledge, no records of this species from Berlin or Brandenburg have been published in the scientific literature so far. According to BECKMANN & KOBIALKA (2008), the presumed native range of *H. cinctella* includes the Italian Peninsula as well as Sicily

and possibly Corsica, and neighbouring regions of France, Switzerland, Slovenia and Croatia, while being restricted to the north by the Alpine arch. The species was found in Germany for the first time in 1995 at the river Danube in central Bavaria (FALKNER 1995). Until now, it has spread widely within Europe and has even reached North America and New Zealand (summarised in NEIBER & HAACK 2019).

## Material & Methods

We examined terrestrial gastropods at four cemeteries located in different parts of Berlin, Wilmersdorf cemetery (Friedhof Wilmersdorf, 101,200 m²), Buschkrugallee cemetery (Friedhof Buschkrugallee, 57,133 m²), the old garrison cemetery (Alter Garnison-Friedhof, 8,926 m²) and Turiner Strasse cemetery (Friedhof Turiner Straße, 14,789 m²), between 24 May and 21 November 2022 (see SenUMVK 2020b). Each cemetery was visited several times on different days. At each sampling site (ca. 10-40 m²), a visual search (ca. 1-2 person-hours) for live specimens and shells was conducted. In addition, soil samples were taken at each sampling site and checked under a stereo microscope. Living *H. cinctella* individuals were transferred into 75 % ethanol, while those collected during the visual search were narcotised in water with menthol crystals before. Broken empty shells with less than 50 % left were typically discarded. All material has been deposited at the Museum für Naturkunde in Berlin (see Tab. 1 for accession numbers), while tissue samples taken from five specimens were stored frozen in 95 % ethanol (museum accession numbers ZMB.Moll 273206, ZMB.Moll 273211-1, ZMB.Moll 273224-1, ZMB.Moll 273226-1 and ZMB.Moll 273228-1). Damages on empty *H. cinctella* shells that could be an indication for predatory activities were examined from the six sampling sites with the highest numbers of empty shells (see results). Juvenile specimens with a shell width smaller than 4.5 mm were excluded for this, resulting in a total number of 101 examined shells.


**Fig. 1:** Examples of sampling sites where *Hygromia cinctella* was recorded (photos: P. V. VON OHEIMB); A) site DE2022-020 (Wilmersdorf cemetery), B) site DE2022-001 (Buschkrugallee cemetery), C) site DE2022-008 (old garrison cemetery), D) site DE2022-027 (Turiner Strasse cemetery).

## Results

We sampled a total of 32 sites at the four studied cemeteries (see Fig. 1 for examples). *Hygromia cinctella* was found at eight out of nine sites at Wilmersdorf cemetery, at seven out of eight sites at Buschkrugallee cemetery, at one out of six sites at the old garrison cemetery (one individual only), and at one out of nine sites at Turiner Strasse cemetery (one old empty shell only) (Tab. 1).

**Tab. 1:** *Hygromia cinctella* sampling sites and collection material. All material is held at the Museum für Naturkunde, Berlin. The material was collected by E. HACKENBERG, K. C. M. VON OHEIMB and P. V. VON OHEIMB (DE2022-001, DE2022-002, DE2022-003), or by K. C. M. VON OHEIMB and P. V. VON OHEIMB (all other sampling sites).

| Sampling site | Lat. (WGS84) | Long. (WGS84) | Locality | Collection date | Museum accession numbers (number of specimens, preservation) |
|---|---|---|---|---|---|
| **Wilmersdorf cemetery** | | | | | |
| DE2022-019 | 52.4844°N | 13.3111°E | Area with urn graves in the south of cemetery | 11.07.2022 | ZMB.Moll 273211 (6, ethanol), ZMB.Moll 273212 (12, dry) |
| DE2022-020 | 52.4846°N | 13.3134°E | Area with graves at wall in the southeast of cemetery | 15.07.2022 | ZMB.Moll 273213 (30, ethanol), ZMB.Moll 273214 (11, dry) |
| DE2022-021 | 52.4857°N | 13.3117°E | Area with graves at wall in the centre of cemetery | 15.07.2022 | ZMB.Moll 273216 (15, ethanol), ZMB.Moll 273215 (23, dry) |
| DE2022-023 | 52.4869°N | 13.3118°E | Area with graves in the north of cemetery | 15.07.2022 | ZMB.Moll 273217 (16, ethanol), ZMB.Moll 273218 (10, dry) |
| DE2022-024 | 52.4842°N | 13.3104°E | Area with graves in the south of cemetery | 16.07.2022 | ZMB.Moll 273219 (1, ethanol) |
| DE2022-025 | 52.4853°N | 13.3095°E | Area near war graves in the west of cemetery | 16.07.2022 | ZMB.Moll 273221 (2, ethanol), ZMB.Moll 273220 (1, dry) |
| DE2022-031 | 52.4859°N | 13.3127°E | Area with graves at wall in the east of cemetery | 21.11.2022 | ZMB.Moll 273228 (3, ethanol), ZMB.Moll 273229 (2, dry) |
| DE2022-032 | 52.4850°N | 13.3106°E | Area near graves in the south of cemetery | 21.11.2022 | ZMB.Moll 273230 (3, ethanol), ZMB.Moll 273231 (2, dry) |
| **Buschkrugallee cemetery** | | | | | |
| DE2022-001 | 52.4606°N | 13.4432°E | Area with graves at wall in the north of cemetery | 24.05.2022 | ZMB.Moll 273200 (93, ethanol), ZMB.Moll 273202 (3, dry) |
| DE2022-002 | 52.4594°N | 13.4428°E | Area with urn graves in the west of cemetery | 24.05.2022 | ZMB.Moll 273201 (8, ethanol), ZMB.Moll 273203 (2, dry) |
| DE2022-003 | 52.4595°N | 13.4456°E | Area with graves and walls in the east of cemetery | 24.05.2022 | ZMB.Moll 273204 (14, ethanol), ZMB.Moll 273205 (6, dry) |
| DE2022-010 | 52.4601°N | 13.4418°E | Area with urn graves at wall in the northwest of cemetery | 29.06.2022 | ZMB.Moll 273207 (3, ethanol), ZMB.Moll 273208 (19, dry) |
| DE2022-011 | 52.4591°N | 13.4416°E | Service yard in the southwest of cemetery | 29.06.2022 | ZMB.Moll 273209 (2, ethanol), ZMB.Moll 273210 (32, dry) |
| DE2022-029 | 52.4603°N | 13.4459°E | Area with graves in the east of cemetery | 17.11.2022 | ZMB.Moll 273224 (43, ethanol), ZMB.Moll 273225 (12, dry) |
| DE2022-030 | 52.4605°N | 13.4418°E | Area at wall in the northwest of cemetery | 17.11.2022 | ZMB.Moll 273226 (4, ethanol), ZMB.Moll 273227 (9, dry) |
| **Old garrison cemetery** | | | | | |
| DE2022-008 | 52.5280°N | 13.4042°E | Area with war graves in the south of cemetery | 14.06.2022 | ZMB.Moll 273206 (1, ethanol) |
| **Turiner Strasse cemetery** | | | | | |
| DE2022-027 | 52.5490°N | 13.3593°E | Area with graves at wall in the east of cemetery | 03.11.2022 | ZMB.Moll 273222 (1, dry) |

Adults and juveniles in various shell sizes were present at the Wilmersdorf and Buschkrugallee cemeteries. High numbers of live specimens have been found at some sampling sites, in particular at DE2022-001, DE2022-020 and DE2022-029 where ≥ 30 live specimens were collected. Individuals of *H. cinctella*

were often found attached to dry leaves on the ground (Fig. 2A). Specimens were also regularly present on gravestones (Fig. 2B) and the stone edging of graves as well as on living plants. Most empty shells found were fresh, with the periostracum still present.

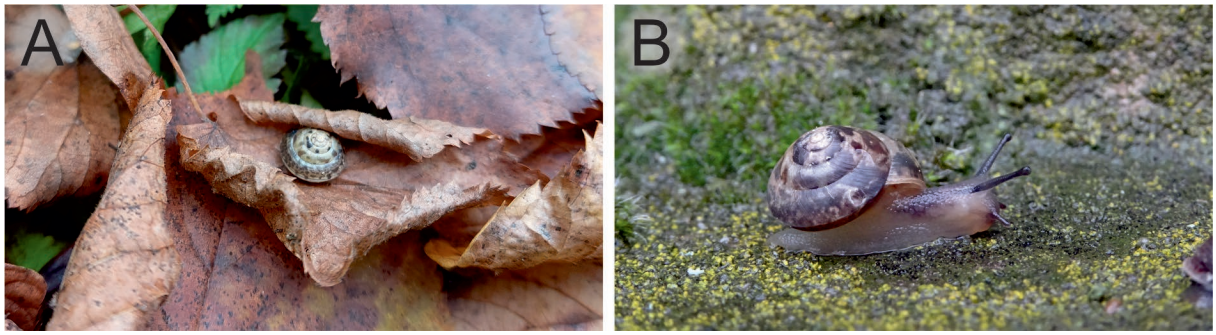


**Fig. 2:** Live *Hygromia cinctella* individuals at Buschkrugallee cemetery (photos: K. C. M. VON OHEIMB); A) in leaf litter on the ground, B) crawling on a gravestone.

At the six sites, where empty shells have been examined, several types of potential predatory damages were recorded. These were damages to the side of the shell (Fig. 3A), damages only to the first whorls, often with a missing apex (Fig. 3B), damages to the aperture (Fig. 3C), and combinations of these damage types. Furthermore, there were spiral shaped damages, starting from the aperture (Fig. 3D). Potential predatory shell damages have been found in 11 of the 12 examined shells from site DE2022-019, in 7 of 10 from site DE2022-020, in 12 of 22 from site DE2022-021 (all Wilmersdorf cemetery), in 16 of 17 from site DE2022-010, in 12 of 29 from site DE2022-011, and in 6 of 11 from site DE2022-029 (all Buschkrugallee cemetery).


**Fig. 3:** Examples for potential predatory damages of *Hygromia cinctella* shells (photos: M. NEUMANN & K. C. M. VON OHEIMB); A) damaged side of the shell (museum accession number ZMB.Moll 273208-1), B) damaged first whorls and missing apex (ZMB.Moll 273212-1), C) damaged aperture (with detail; ZMB.Moll 273208-3), D) spiral shaped damages (ZMB.Moll 273208-2).

## Discussion

We have recorded the non-native land snail species *H. cinctella* at several urban cemeteries in Berlin. These new records fit well into the general trend of range extension of the species in Europe and Germany, which runs in northern and eastern direction (NEIBER & HAACK 2019). Interestingly, cemeteries appear to have played an important role for the establishment and further spread of *H. cinctella* in some regions of its non-native range. The first records of *H. cinctella* in Hungary were made in Budapest in the 1930s (WAGNER 1938, WAGNER 1940), where this species was found near former cemeteries (see PETRÓ 1984). In 1980, the species was found in Kaposvár, the first records from Hungary outside Budapest, where it again was only found at or in close proximity to cemeteries (PETRÓ 1984). In Austria, *H. cinctella* was recorded for the first time in 1978 from a railway embankment in Vienna in close proximity to a cemetery (STOJASPAL 1978, LEISS & REISCHÜTZ 1996). The second record of the species in Austria was made in 2005 at another cemetery in Vienna (REISCHÜTZ 2005). Further records at Austrian cemeteries include the presumably first record outside Vienna in 2008 (DUDA & MRKVICKA 2014) and the first record in Styria in 2009 (FISCHER 2010). In Germany, *H. cinctella* initially spread mainly along major streams, which presumably facilitated the range extension of the species via passive waterborne dispersal (BECKMANN & KOBIALKA 2008). Given the lack of records of potential source populations from the upstream catchments of the rivers Havel and Spree (NEIBER & HAACK 2019, GBIF 2023, iNaturalist 2023), however, this mechanism did probably not enable the species to reach the Berlin area. Instead, human-mediated dispersal with living plants, dead plant material and soil, or possibly attached to vehicles, stones or building materials could have been responsible (see PETRÓ 1984, LEISS & REISCHÜTZ 1996, FISCHER & al. 2010, KAPPES 2019). Passive dispersal has likely facilitated the species' further spread within the Berlin area as well. In particular, the transport of dry leaves via wind (see references in KAPPES 2019) or due to gardening activities could have promoted the dispersal of attached snails, given that *H. cinctella* individuals were often found in leaf litter.

Citizen science data can provide valuable information on the distribution of terrestrial gastropods when appropriate quality control is ensured (BARBATO & al. 2021, ROSA & al. 2022), and have been shown to be especially useful for recording the spread of non-native species including *H. cinctella* (VENDETTI & al. 2018, KAPPES 2019). Data generated by citizen scientists have also been used for recording cemetery biodiversity in particular (FILEK & al. 2023). A survey of citizen science data available from the Global Biodiversity Information Facility (GBIF) and iNaturalist (GBIF 2023, iNaturalist 2023) revealed that *H. cinctella* is present in Berlin at least since 2019, with the oldest observation for Berlin (and Brandenburg) dating to 27 April 2019 on iNaturalist (mister_bumble 2019, identification confirmed from photos by the authors). Notably, the respective observation was made in close proximity to the Holy Trinity cemetery III (Dreifaltigkeitsfriedhof III). More recent citizen science data show *H. cinctella* being present at different parts of Berlin and in several surrounding regions of Brandenburg.

Given that *H. cinctella* was found at most sampling sites (and in different seasons of the year) at the Wilmersdorf and Buschkrugallee cemeteries, partly in high individual numbers including juveniles of various sizes, the populations at these cemeteries can be considered as well-established. It remains unknown whether the old garrison cemetery, where only a single live individual was found, harbours an established population. The Turiner Strasse cemetery might not have been successfully colonised yet, given that only one old empty shell was found there. The latter two cemeteries have a far smaller area, which could render an establishment of *H. cinctella* more difficult. Lower amounts of plant material and soil that reach smaller cemeteries likely decrease the immigration probability. Furthermore, a lower total number of suitable habitats could increase the risk for cemetery-wide extinction.

The damages of empty *H. cinctella* shells seen in Figs. 3A-C resemble those identified as being caused by small mammals by MILLAR & WAITE (2004). Damages to the sides and first whorls of *H. cinctella* shells from Mecklenburg-Vorpommern, similar to those in Figs. 3A, B, have been assumed to result from mice (GÖLLNITZ 2008). The apertural damages (Fig. 3C) might also be linked to mice, which were found to break some gastropod shells from the aperture (ROSIN & al. 2011). Among the murid rodents that feed on terrestrial gastropods (see ALLEN 2004) and occur at cemeteries in Berlin are the wood mouse (*Apodemus sylvaticus*), the house mouse (*Mus musculus*), and the brown rat (*Rattus norvegicus*) (TREPL & KRAUß 1984). The spiral bite marks (Fig. 3D) could have been caused by predatory beetles (MILLAR & WAITE 2004, NĚMEC & HORSÁK 2019). While further predators that do not leave specific

shell damages may be involved as well, the many shells with potential predatory damages indicate that the local fauna at cemeteries in Berlin is interacting with the newcomers, likely using them as a food source.

Our records at cemeteries in different parts of the city, as well as additional citizen science observations, show that *H. cinctella* is already relatively widespread and locally well-established in the Berlin area. Within this region, it will likely spread into further suitable habitats in near future. While human-mediated dispersal will probably allow *H. cinctella* to further extend its range to not yet colonised but potentially vulnerable regions (see PROĆKÓW & al. 2019), cemeteries should be considered as possible entry points for this species.

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