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StadtWildTiere – added value and impact of transnational urban wildlife community science projects

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We present and exemplify the potential of the long-term community science (= citizen science) project StadtWildTiere (German for 'urban wildlife') in a transnational context. StadtWildTiere gathers opportunistic sightings of urban wildlife to raise awareness of, increase knowledge of, and promote biodiversity in urban areas across Central Europe. Transnationally similar methodologies enable direct comparisons concerning occurrence, distribution, and trends of urban wildlife populations and allow for new insights into and potential conservation and management measures of these otherwise unmonitored wildlife populations. We advocate the use and promotion for such community-based science projects, which align with the guiding principles of awareness, knowledge, and action. Such projects should whenever possible connect with similar initiatives in other countries to benefit from comparisons and get a strong impact on a transnational level.

KEYWORDS

urban ecology, citizen science, monitoring, wildlife population, discover trends

1 Introduction

Community science (= citizen science; here we are using the less well known but more inclusive term 'community science') – the collection and/or processing of data as a part of a scientific study through non-professional volunteers – has grown in importance within the last decade and has been successful in advancing scientific knowledge in various fields, including

ecology and the environmental sciences, and as such provides a great potential in conservation research (e.g., Bonney et al., 2009; Silvertown, 2009; Sullivan et al., 2014; Theobald et al., 2015; Füchslin et al., 2019; Callaghan et al., 2020). Fueled by easily available technological tools (e.g., environmental sensors, mobile Apps), community science enables to gather a great amount of otherwise difficult to obtain baseline data over extensive spatial and temporal scales, and therefore to investigate scientific questions in a relatively cost- and time-effective way whilst engaging the public and raising scientific literacy and interest (Pattengill-Semmens and Semmens, 2003; Jordan et al., 2009; Dickinson et al., 2012; Frigerio et al., 2018).

Increasing knowledge about and raising awareness of wildlife is particularly important in urban areas, which are steadily growing worldwide and often negatively affect biodiversity (e.g., McKinney, 2002; Grimm et al., 2008; Elmqvist et al., 2013). Nonetheless, many species can cope with such altered environmental conditions (McDonnell and Hahs, 2015; Szulkin et al., 2020; Fung et al., 2023) thereby providing connectivity among potentially isolated populations in non-urban areas and a reservoir for unique genotypes that are adapted for potential future changes to currently non-urban habitats (Dearborn and Kark, 2010). Even more, urban areas may provide refuges for certain species that find more favorable habitats within the urban realms than on intensively managed agricultural lands (e.g., Taucher et al., 2020; Boakes et al., 2023). Further, the awareness of urban nature and rich biodiversity may facilitate people's connection with nature and provide environmental education, which are important prerequisites to counteract the 'extinction of experience' and loss of interest in nature and its conservation (Miller, 2005; Soga and Gaston, 2016). Finally, urban nature is also of direct use to humans: urban populations may not only inform studies on and mitigation action against adverse effects of the climate and biodiversity crises, but also improve human well-being and health and provide ecosystem services, such as climate control, air purification, noise reduction, pollination, and carbon sequestration (e.g., Dearborn and Kark, 2010; Braczkowski et al., 2018).

Despite their importance, urban wildlife often lives hidden, most populations are not monitored, and our knowledge of them is often scarce. In this study we introduce the long-term, transnational community science project StadtWildTiere (German for 'urban wildlife'), which aims at filling such voids. We highlight the value and potential – while acknowledging limitations – of the project StadtWildTiere for discovering otherwise undetected patterns and trends in urban wildlife's ecology across different Central European cities, which again serve as a basis for the implementation of conservation measures and management strategies. For this, we present recent, ongoing, and future case studies in three participating, major Central European cities: Berlin (Germany), Vienna (Austria), and Zurich (Switzerland).

2 Introducing the community science project StadtWildTiere

The goals of the project StadtWildTiere are (1) to raise awareness among local residents of the great diversity of wildlife in urbanized areas (Frigerio et al., 2018), (2) to gather data on urban wildlife for scientific analyses with the help of the community, and (3) to promote nature in urbanized areas using the collected knowledge from these analyses. This threefold approach (awareness/knowledge/action) functions as a 'virtuous cycle' in which active participation in research raises awareness and interest in nature and therefore interest in its conservation (e.g., Miller, 2005; Fritz et al., 2019; de Sherbinin et al., 2021; Kloetzer et al., 2021) while also contributing data to increase knowledge on the very same parts of nature and therefore support the potential for their conservation and the mitigation of human–wildlife conflicts. The communication of results of such research projects is important to integrate the volunteers in the research process, value their effort and increase motivation (Frigerio et al., 2018). Working together with the community is thus a crucial part of the project StadtWildTiere.

StadtWildTiere was initiated in 2013 in the city of Zurich, Switzerland and has since been expanded into totally 13 cities across Germany, Austria, and Switzerland, including Berlin and Vienna (Desvars-Larrive et al., 2018; Frigerio et al., 2018; Geiger et al., 2018; Walter et al., 2018; Taucher et al., 2020), while new cities and urban areas are welcome.

StadtWildTiere is collecting opportunistic data on incidental encounters (presence-only data) with wildlife in urban neighborhoods on a shared online platform and database.

Via collaborations with museums, schools, and universities and a variety of formats such as press releases, newsletters, poster campaigns, and flyer distribution in community centers and town halls, as well as presentations and street campaigns, the project StadtWildTiere recruits and encourages people to report their wildlife encounters on the online platform. Priority programs, focusing on different species or groups of species, are pursued in different years and in different cities. Such programs are usually associated with further activities, such as talks and excursions for the public, as well as training programs for more engaged volunteers (see below).

Observations can be reported through the websites stadtwildtiere.de, stadtwildtiere.at, and stadtwildtiere.ch, or through a mobile app (Wildtiere). When reporting a sighting, volunteers are asked to provide (1) the location of their observation on an online map (or via GPS-coordinates), (2) their identification of the species, (3) the date and the time, and (4) the kind of observation (e.g., live animal, spawn, dens, droppings, footprints, carcasses). Finally, volunteers are asked to upload photographs or videos of their observation and to report any further remarks (e.g., behavior). Every uploaded observation is validated (see below). The validated reports are subsequently added to the database and displayed on a publicly available online map. Geographical locations of records for (potentially) controversial species or retreat sites for the animals (e.g., badger setts, fox dens) are hidden (or can be hidden individually by the person who is filing the report) and only made available on request for professional purposes to ensure the safety of wildlife. On the same website, people can obtain general information on the biology of various urban species, as well as tips for observing and improved human-animal interactions. This general information potentially improves the quality of reporting, e.g., concerning the reporter's

ability to identify the sighted species. In sum, the database of StadtWildTiere to date contains more than 115,700 entries (retrieved 18 December 2023) of wildlife sightings.

In addition to the gathering of data on occasional wildlife encounters, focused and systematic research projects in single cities led by StadtWildTiere are conducted with particularly dedicated volunteers, to get a better understanding of particular aspects of urban wildlife ecology. These volunteers are involved in training programs for the collection of systematically assembled datasets according to a protocol, which serve to complement and validate the opportunistic sightings in the StadtWildTiere database. Examples of such research projects include the systematic deployment of camera traps or footprint tunnels. Combined, opportunistic and systematically gathered community science datasets provide valuable and otherwise often inaccessible information about the occurrence, distribution, and population trends of species in urbanized areas, such as the increase of urban badger (Geiger et al., 2018) or the decline of urban hedgehog populations (Taucher et al., 2020).

3 Strengths and limitations of the project StadtWildTiere – with examples of recent studies

The data obtained via the community science project StadtWildTiere provides a rare opportunity to survey urban wildlife populations that are otherwise not monitored. This in turn is a crucial prerequisite for considerations about aspects of human–animal commensalism within urbanized areas, e.g., concerning protection of species that are of conservation concern, but also potential nuisances and zoonoses (e.g., Soulsbury and White, 2015).

On the other hand, if community science data are not obtained in a standardized manner, such as the opportunistic sightings in the StadtWildTiere database, they may be associated with accuracy errors as well as biases in connection with human biology and culture (e.g., Dickinson et al., 2010; Crall et al., 2011; Lewandowski and Specht, 2015; Kosmala et al., 2016). However, such biases can be surmounted, e.g., via robust statistical methods and the inclusion of external data (Brown and Williams, 2019). For data analysis and interpretation, we have therefore developed a set of procedures to mitigate errors and biases.

As for data quality issues, variation in the volunteer's ability, skills, experience, and training might lead to incorrect species identification. To mitigate these errors, we provide detailed information on many of the species that may be encountered in local areas on our websites. Additionally, volunteers are regularly invited to training sessions, e.g., courses and talks on specific taxa. To maximize data quality, every database entry is verified by an expert (trained biologist). Observations are only used for further analyses if they contain photographs or videos that can be verified by an expert, or if characteristic and easily discernible species are reported in a likely habitat. Possible errors in the documentation of observations are mitigated through an easy to use and systematic user interface on the project website and in the app. Such quality control measures are time and cost intensive but optimize the data quality.

Opportunistic sightings in the StadtWildTiere dataset are subject to various biases: First, human-specific activity patterns and sociodemographic factors have been shown to influence the StadtWildTiere dataset. For example, in a study in Vienna it has been found that observations of foxes were less likely during the second part of the night despite the species' nocturnality – a pattern which is likely related to our own species' diurnality (Walter et al., 2018). Further, the predictability of fox sightings improved when considering sociodemographic factors: while number of reports of a fox sighting where positively linked with higher education levels, a negative link was found with an increasing district area and average household income (Walter et al., 2018). Second, 'recording' biases are an issue, with some volunteers recording an exceeding number of sightings of one species in their neighborhood, thereby artificially increasing the reported occurrence of that species in that area. Third, 'species' biases influence the data, with certain species being rarely recorded, while others are disproportionally frequently recorded. Notably, our information campaigns in the wake of priority programs focusing on one particular species in a given year and city are increasing the number of observers reporting that species, thus biasing accounts of occurrence of this species in that city (Figure 1A). Similarly, charismatic and easy to identify species (e.g., 'hedgehogs' and the Eurasian red squirrel; all scientific species names used are provided in the Supplementary Materials) are more frequently reported than species that can only be identified by experts (e.g., bats, Figure 1B) or species considered a nuisance, although they might in fact be similarly abundant (e.g., 'rats' vs. red squirrels, Figure 1B; Desvars-Larrive et al., 2018). Yet another example are bats, which are notoriously difficult to identify in the field. In the cities of Vienna and Zurich, the local bat conservation organizations provide reliable species identifications on bats that are found injured. Such programs are not in place in Berlin, where the number of records of bats is much lower compared to Vienna and Zurich (Figure 1B).

Information on detection probability and observation effort to account for such biases (e.g., Bird et al., 2014) are not gathered by default in the project StadtWildTiere. While future developments of this community science program could focus on developing tools to directly control for such biases, there are already ways implemented for mitigating such issues. For example, knowing that information campaigns are influencing the recording frequency of the species in question during a campaign year (Figure 1A) makes it possible to account for this bias, e.g., via correcting the number of sightings in campaign years using a factor that has been estimated from the mean difference of sightings in campaign years vs. non-campaign years across species and cities (Figure 1B). Further, independent datasets, e.g., from systematically conducted research projects or traffic casualty statistics from governmental bodies, can be used as an alternative to evaluate opportunistic observational data (e.g., Kindberg et al., 2008; Snäll et al., 2011; Petrovan et al., 2020;

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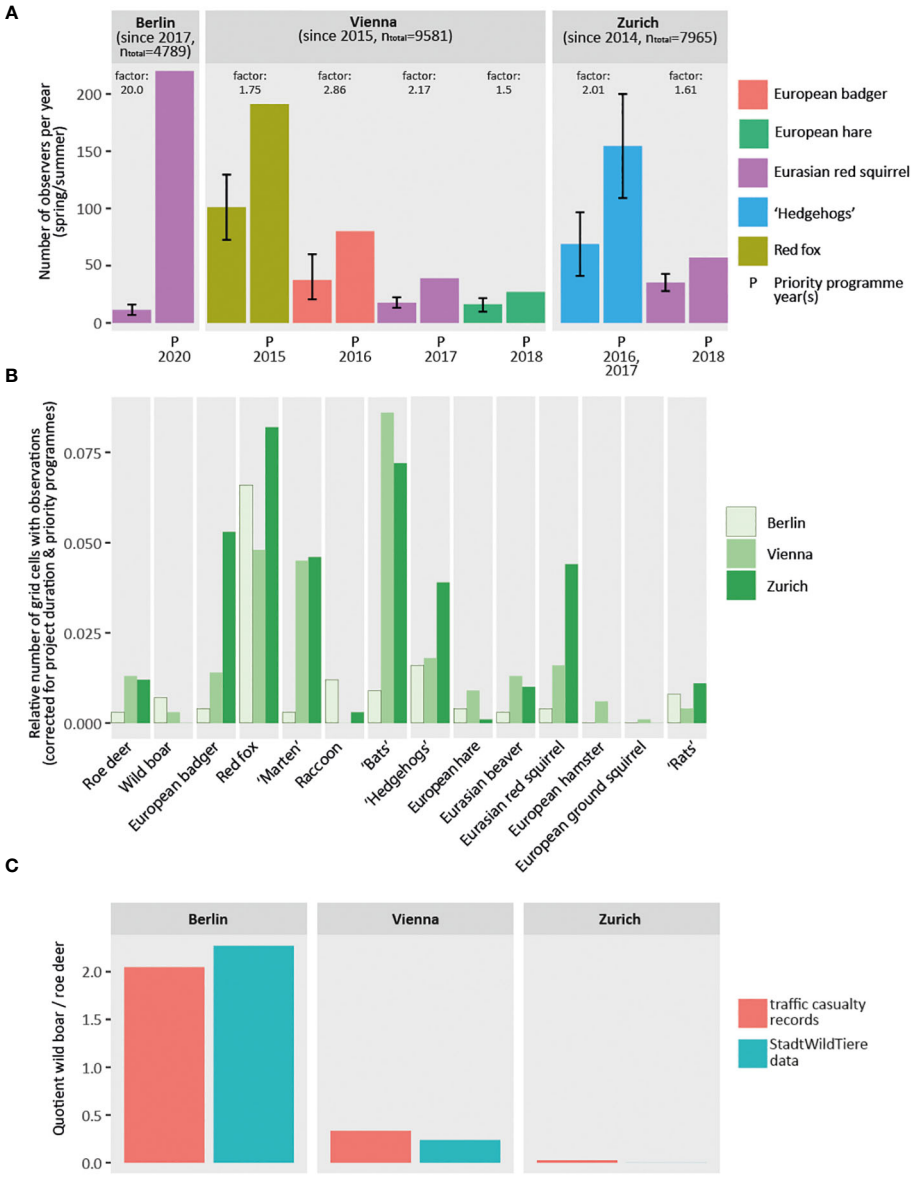

FIGURE 1
Potential and biases of the community science project StadtWildTiere. **(A)** The number of observers is by trend greater in years where priority programs (P) were conducted, compared to years with no priority programs. During priority program years (P), the project's information campaign was focused on a particular species in a given city (governmental boundaries; with year since the start of the project and total numbers of observations over all species and years = n_{total}). 'Factor' denotes the observer numbers difference between priority and non-priority years for that species and city, respectively. Whiskers denote 95% confidence intervals based on a bootstrap. We did not compute statistical tests here due to small sample size (max. 6 years per category) and non-independence of observer-data between priority and non-priority years (part of the observers was the same). **(B)** The relative number of grid cells with at least one report of a given species highlights several similarities and differences among the study cities concerning species composition and reporting frequencies (see also text for details). These values have been corrected for the total number of grid cells and duration of the project StadtWildTiere in that city, as well as for the implementation of a priority program concerning that species and city in at least one year. **(C)** Independent datasets can be deployed to account for biases related to human nature and habits. Comparisons with traffic casualty data from official sources in Berlin (Deutscher Jagdverband, www.jagdverband.de), Vienna (Statistik Austria, https://www.statistik.at/web_de/statistiken/wirtschaft/land_und_forstwirtschaft/viehbestand_tierische_erzeugung/jagd/index.html), and Zurich (Wildhut Stadt Zürich) also show that for certain species, the StadtWildTiere dataset provides independently reproducible frequency estimates. In this example, quotients of wild boar vs. roe deer traffic casualties and StadtWildTiere reports, respectively, show similar relative occurrence estimates for every city, an indication for reliable results of both methods. Further information on methods is provided in the Supplementary Material.

Figure 1C). As an example, traffic casualty data gathered by governmental bodies in the cities of Berlin, Vienna, and Zurich show that the proportion of reported individuals via StadtWildTiere and traffic casualties via the local game wardens and hunters were comparable in two species where there are reports from all three cities and both monitoring systems (Figure 1C).

Such bias-mitigation approaches have regularly been applied in the framework of the project StadtWildTiere, thus optimizing the

reliability of our research (e.g., Geiger et al., 2018; Taucher et al., 2020). However, one bias the project StadtWildTiere cannot always account for is the presence of positive reports only, i.e., it is not known if absence of evidence equals evidence of absence. This is a common issue that wildlife monitoring programs face. However, in the context of specific research projects, we are making efforts to optimize the evidence of absence, e.g., via poster campaigns asking for reports of sightings of particular species in areas that would seem suitable for that particular species but in which no observations have been reported. Conversely, this bias is often mitigated by the sheer number of observers in the urban habitat.

Finally, the project StadtWildTiere lays the basis for conservation programs. For example, a recent study conducted in the framework of StadtWildTiere found that the hedgehog populations in the city of Zurich have been declining in the past 25 years, possibly due a decrease in habitat quantity and quality, pesticides, or a combination of factors (Taucher et al., 2020). Consequently, the project team launched a still ongoing initiative in different Swiss cities, which aims at raising awareness of the issue, investigates the causes of the decline, and – for compensation – encourages the public to engage in increasing the connectivity among remnant green spaces, e.g., via purposely built-in holes in fences.

4 The wildlife footprint of a city: novel view highlighting a particular asset of the community project StadtWildTiere

The data on wildlife sightings gathered using the same methodology across different Central European cities and corrected for potential biases allows for unique comparisons of similarities and differences of their current faunal compositions: the cities' 'wildlife footprints'. Here, we provide a preliminary comparison of such 'wildlife footprints' in Berlin, Vienna, and Zurich (Figure 2). There are some conspicuous differences among the cities, even when focusing on comparable species only. The species unique to a single city are not taken into consideration, such as the European ground squirrel and the European hamster, which among the investigated cities only occur in Vienna (Figure 1B). For example, the European hare was relatively more often reported in Vienna compared to Berlin and Zurich (Figure 2). This in turn could be interpreted as European hare populations being larger and/or denser in Vienna compared to Berlin and Zurich and having the potential to persist on the outskirts of a large city. Similarly, wild boar could be interpreted to occur more frequently in Berlin compared to Zurich and Vienna (Figure 2), a pattern that has already been pointed out and investigated previously (Stillfried et al., 2017). Zurich, on the other hand, appears to be a city of badgers and red squirrels, compared to the other two cities (Figure 2). However, despite the applied corrections of various biases highlighted above (see also Figure 1), it appears as if cities with shorter project duration and fewer priority programs – such as Berlin in this case (Figure 1) – may still lack resolution concerning their 'wildlife footprint' (Figure 2). Further development of the StadtWildTiere database in these areas will improve the basis for comparisons of 'wildlife footprints' in the future of this dynamic project.

Conspicuous city-specific variation of 'wildlife footprints, such as reported for hares, wild boar, and other mammals here (Figure 2) warrant investigations into potential underlying mechanisms related to contemporary city characteristics (e.g., size and density of settlements, mean annual temperature, green space area), geographical location and the cities' historic development. Such considerations are useful for the sustainable planning and development of urban areas in the future, not only in the here investigated cities but also across a wider geographic area.

5 Potential avenues for future research

The project StadtWildTiere shows ongoing patterns and trends in various urban wildlife populations and across geographic areas, which in these otherwise unmonitored populations would probably have gone unnoticed. Such developments may be merely anecdotal evidence at first, only brought to our attention via superficially observing rough trends in the occasional sightings reported by the community. However, these hints may trigger and motivate systematic, larger scale studies. Recent examples of such studies highlight the great potential of the project StadtWildTiere in this context (Geiger et al., 2018; Walter et al., 2018; Taucher et al., 2020) but also for related fields as epidemiology (Deplazes et al., 2004) and social sciences (Hegglin et al., 2008).

Examples emphasizing the value of primary anecdotal evidence include recent colonialization processes of previously extirpated or invasive mammal species (e.g. also, Maistrello et al., 2016). Sightings of beavers within the city of Zurich reported on StadtWildTiere have shown in real-time the temporal progress of this ongoing colonialization; recent sightings of raccoons by residents have provided evidence of the occurrence of this species in novel areas, including the city of Zurich (Figure 1B).

6 Conclusions and outlook

To conclude, community-science projects such as StadtWildTiere provides a remarkable opportunity to investigate urban wildlife across a wide geographic area (e.g., Magle et al., 2019) and over long periods of time, especially as the project is steadily growing and expanding and is open for comprehensive analyses with similar projects. There are numerous and established ways to circumvent and mitigate errors and biases and to strengthen and standardize the opportunistic dataset, e.g., via independent and systematic approaches, to allow comparative analyses.

Urban ecology is still a young field and urban wildlife populations have not been the focus of many studies so far. The project StadtWildTiere enables us to detect previously obscure patterns and temporal trends e.g., under urban densification and

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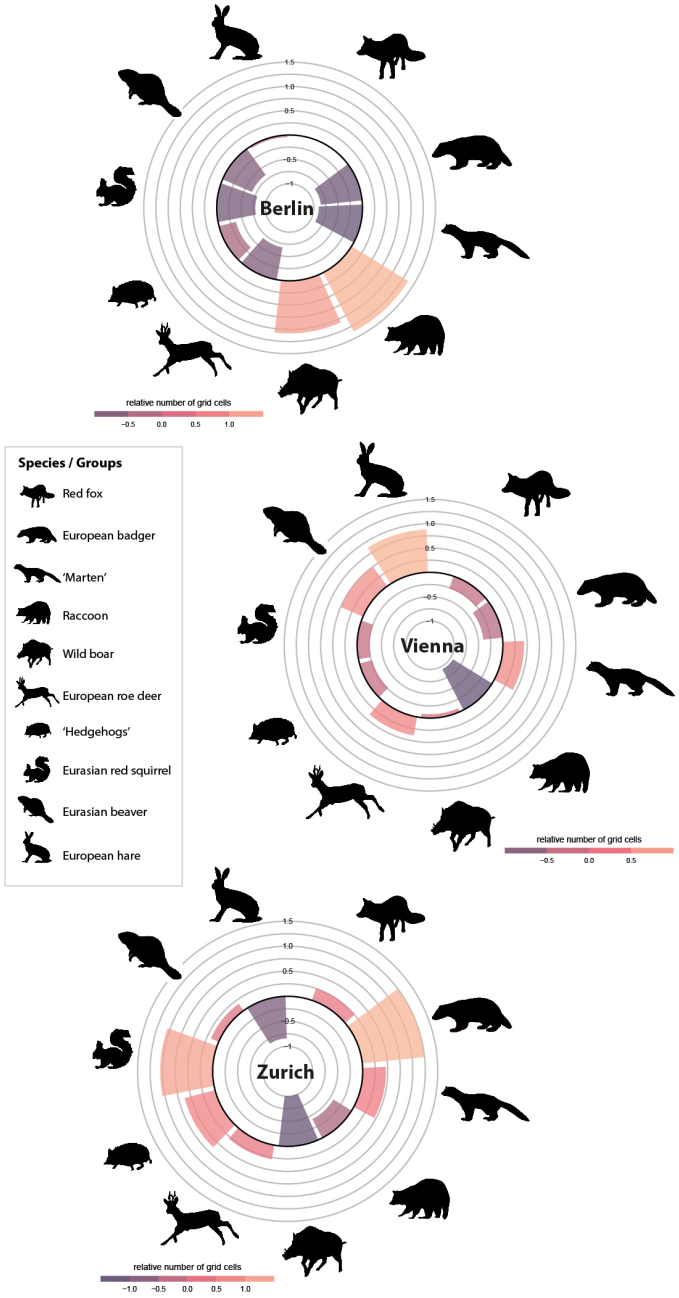

FIGURE 2
Among city comparisons of reported wildlife sightings for ten example species. If city-specific differences and overall biases are considered (Figure 1 and text), 'wildlife footprints' allow for a direct comparison of species composition among the study cities. Data and analyses are the same as described for Figure 1B, but deviation from across city mean per species are shown. Reading example: Hares are disproportionally frequently reported in Vienna and disproportionally infrequently reported in Zurich, while reportings of this species in Berlin are similar to the across city average.

heat island effects (especially regarding climate change) and thus can also act as a sensor of human-wildlife interactions for the future. In the long term, we suggest that projects such as StadtWildTiere provide a base for comparative monitoring across cities on a transnational level to fill the still existing knowledge gaps about urban wildlife populations. Such knowledge, however, is crucial for policy makers and wildlife managers regarding decisions about the kind of conservation measures and management strategies to implement and for which focus species. The project further provides an opportunity to tackle questions concerning the motivation of volunteers to participate and how they can effectively contribute to enhance the urban biodiversity.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

MG: Conceptualization, Formal Analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. AT: Conceptualization, Data curation, Methodology, Validation, Writing – review & editing. SG: Conceptualization, Methodology, Writing – review & editing. ML: Conceptualization, Data curation, Formal Analysis, Methodology, Writing – review & editing. SK: Conceptualization, Methodology, Writing – review & editing. SEK: Conceptualization, Methodology, Writing – review & editing. JS: Conceptualization, Methodology, Writing – review & editing. TW: Conceptualization, Methodology, Writing – review & editing. RZ: Conceptualization, Methodology, Writing – review & editing. FB: Conceptualization, Methodology, Project administration, Writing – review & editing. DH: Conceptualization, Methodology, Project administration, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2024.1363073/full#supplementary-material

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