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Estimation of green toad *Bufotes viridis* population size based on photo-identification at two urban sites with different management histories

Dominika GRUSZKA [1], Jan M. KACZMAREK [1,2],
Klaudia SZALA [3], and Mikołaj KACZMARSKI [1,*]

1. Poznan University of Life Sciences, Institute of Zoology, Wojska Polskiego 71c, 60-625, Poznań, Poland,
2. Opole Region Landscape Parks Complex, Pokrzywna 11, 48-267 Jarnołtówek
3. Department of Avian Biology and Ecology, Faculty of Biology, Adam Mickiewicz University, ul. Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland
* Corresponding author: M. Kaczmarski, E-mail: traszka.com@gmail.com

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Abstract. Individual recognition during fieldwork is necessary when estimating the size of a population for conservation or management purposes. We used a non-invasive method of individual photo identification based on dorsal color patterns. Our study aimed to estimate the size of two green toad *Bufotes viridis* populations in an urban habitat to provide input for conservation activities. The study was conducted in the two largest known breeding sites of the species in Poznań, Western Poland: Cytadela Park (PC) and Rataje Park (PR). We collected animals within each site's breeding habitat twice during the mating season. Dorsal pattern photographs and morphometric measurements were taken, after which the animals were released immediately. We analyzed the pictures by single-eye matching to estimate the population size using the Chapman estimator. Most individuals caught were males, and no females were recaptured. Therefore, we used only data for males and then estimated the total population size based on a calculation using the sex ratio known from the literature. The number of captured toads was higher at the PC site than at the PR site. Toads from the PC population were noticeably larger and had higher condition value indices than those from the PR population. This result is consistent with the management and history of both sites. We observed habitat transition and potential mortality due to park construction the year before our study at the PR site. In contrast, the PC site is a mature green area with more than 50 years of stable management. Despite some limitations, photo-identification may be an essential first step in estimating population size in community-based conservation initiatives for the green toad, enabling conservationists to enter the public discussion about urban conservation, providing a reference for the conservation value of urban breeding sites, and as a consequently, providing input for active conservation and habitat management (e.g., fish removal and mowing regime modifications).

Keywords: amphibians, CMR, conservation, monitoring, multiple catch method, Poznań.

Introduction

Since the 1980s, there has been a worldwide decline in amphibian species abundance (Young et al. 2001, Collins 2010). Over 41% of known species are threatened with extinction, and the global trend is alarming (Luedtke et al. 2023). The main threats to amphibians include climate change, habitat loss, land use changes, pathogens such as chytrid fungus, and the invasion of alien species (Catenazzi 2015). Urbanization is a growing global threat that negatively affects terrestrial and (especially) aquatic environments crucial for amphibian breeding and generally reduces habitat capacity for wildlife, including amphibians (Nowakowski et al. 2018, Scheffers & Paszkowski 2012). A direct threat to amphibians in urban and suburban areas is the developing road infrastructure that contributes to habitat fragmentation and reduction in connectivity between suitable habitat patches, as well as road mortality (Hamer & McDonnell 2008, Sousa-Guedes et al. 2021, Tove & Eric 2001). Despite these challenges, some amphibians can still survive in highly transformed areas, and species richness may be comparable to the surrounding rural areas. Thus, urban areas support amphibian assemblages characterized by a high level of overall diversity (Kaczmarski et al. 2020). However, to assess what processes occur within urban populations, we need more detailed knowledge of distribution (Kaczmarek et al. 2015, Konowalik et al. 2020, Mazgajska & Mazgajski 2020), habitat occupancy (Vargová et al. 2024), population genetics (Mikulíček & Pišút 2012), and demography (Burgstaller et al. 2021b), especially such basic parameters as population size (Sistani et al. 2021) and preferably using a multi-seasonal approach. Knowledge about the size of amphibian populations is crucial to their effective conservation and management (Sterrett et al. 2019). However, such data are sparse and limited to very few species.

Identifying individuals is critical for collecting long-term population data (Dodd 2010). Various methods of marking animals exist; however, the number of techniques available is limited due to amphibian anatomy and ethical issues. Available techniques vary in invasiveness and require special equipment, training, or permits, especially if the species is legally protected (Dodd 2010). Toe clipping was the traditional technique for individual marking in amphibian studies (Donnelly et al. 1994), but it is now often replaced by PIT (passive internal transmitter) tags. These are glass capsules with a unique code (Roberts et al. 2021) or visible implanted elastomers (Antwis et al. 2014, Heard et al. 2008, Sapsford et al. 2015) which are inserted subcutaneously. Alternatively, photo-identification has been successfully applied in some species, including the Jollyville Plateau salamander *Eurycea tonkawae* (Bendik et al. 2013), Fletcher's frog *Lechriodus fletcheri* (Gould et al. 2021), great crested newt *Triturus cristatus* (Drechsler et al. 2015), as well as true toads (Bufonidae) such as the natterjack toad *Epidalea calamita* and the green toad *Bufotes viridis* (Reyne et al. 2021, Sistani et al. 2021). This method requires that every individual possesses a unique color pattern that does not change over time. After being captured, an individual is temporarily immobilized to be photographed (usually from the dorsal view) before being released. Particular individuals caught twice or more can be recognized based on a series of images from different capture sessions (Dodd 2010). Population estimates can then be made using this data. The population size can be estimated using the Lincoln–Petersen method or the Chapman estimator if sample sizes are small, which have already been successfully used to estimate the abundance of different amphibian species, including the Murree frog, *Nanorana vicina*, Hazara Torrent Frog *Allopaa hazarensis* and Kurdistan newt *Neurergus derjugini* (Batool et al. 2023, Heydari et al. 2021). This method involves capturing, marking/identifying, and recapturing (CMR) animals over a short period and is among the most accurate and widely used population size estimation methods (Böhning et al. 2017). The CMR may be used to obtain a wealth of information about the species' niche, life history, or migration, which is essential for implementing the best possible approaches to management and conservation (Dalibard et al. 2021).

The green toad is a tolerant, pioneer species exhibiting adaptation plasticity to various ecological factors (Dufresnes et al. 2019). This thermophilic species prefers to breed in warm, shallow, fish-free, temporary water bodies (Ensabella et al. 2003). Since it is highly resistant to desiccation, it tolerates dry, sandy, or stony habitats (Katzmann et al. 2003). Specific life history traits and habitat requirements mentioned above seem to shape the species' resistance to urbanization. There is a growing number of studies showing that this species can survive or colonize new sites, even in heavily transformed areas, and is an excellent example of an urban adapter (Ensabella et al. 2003, Kaczmarski et al. 2019, Kovács & Sas 2010, Sistani et al. 2021, Vargová et al. 2023, 2024, Zawadzki et al. 2017). Despite its widely known ability to adapt well to human-altered habitats and its global assessment as a species of 'least concern', many populations are dwindling, mainly in the northwest of the range (IUCN 2023). For instance, the substantial decline of the green toad has been exceptionally well documented in Germany, where it is now considered rare and has obtained an 'endangered' (EN) conservation category (AG Feldherpetologie und Artenschutz 2020). In Poland, the green toad is a strictly protected species that appears to maintain a stable population (Pabijan & Ogielska 2019). However, the loss of breeding sites, especially in urban areas, is already visible (Kaczmarek et al. 2015, Konowalik et al. 2020, Mazgajska & Mazgajski 2020). Therefore, there is a need to better understand this species' urban populations to implement or improve their conservation based on monitoring data, especially in the face of increasing urbanization and human pressure on habitats.

Our study aimed to estimate the size of two urban populations of the green toad using the CMR method coupled with photo-identification in preparation for future conservation strategies and proactive management.

Material and methods

Sites description

We studied potentially the two largest populations of the green toad in Poznań, western Poland: Rosarium in Cytadela Park (hereafter PC, 52°25′16″N, 16°56′07″E) and Rataje Park (hereafter PR, 52°23′05,3″N, 16°57′22,2″E) (cf. Kaczmarski et al. 2019). Despite the high importance of our study sites for preserving populations of the green toad in heavily urbanized areas (Kaczmarek et al. 2015, Kaczmarski et al. 2019), no reliable data on the size of these populations has yet been collected. The PC site is located in a city park of about 100 ha, created in the 1970s on a hill at the site of a former Prussian fortress. The park contains many remains of old fortifications, which provide additional shelter and wintering sites for the toads. It also includes overgrown areas with old deciduous tree stands, interspersed by wide, hardened walking paths, as well as extensive glades in the form of urban meadows that are maintained with varying intensity of care (Czarna 2016, Wrońska-Pilarek & Maliński 2008). This arrangement creates a mosaic of habitats with numerous ecotones, providing an abundant food base (Borowiak-Sobkowiak & Wilkaniec 2010). The only other amphibian in the park is a small population of the common toad *Bufo bufo* that has recently colonized or been introduced into the area (M. Kaczmarski pers. comm.). The green toad breeding pool in the PC site is a permanent water reservoir (area: ca. 5150 m^2) with a concrete bottom located within a stone amphitheater. Since 2018, conservation activities in the PC site include draining the breeding pond every three years in winter to remove any fish (mainly illegally stocked).

In contrast, the PR site was created in 2018 after the partial reclamation of the area. Before the 1960s, the area was used for orchards. In the mid-1960s, it was transformed into an industrial plant producing prefabricated concrete to build large-scale housing developments in the immediate vicinity. The factory was closed in the early 1990s when the area became a post-industrial wasteland, subject to plant succession. Finally, in 2018, a year before our study, part of this area was turned into an urban park. The new park has an irregular shape and an area of over 10 hectares, surrounded by scattered housing estates and infrastructure. It has been planted with ornamental plants, including many woody species, but its surroundings remain dominated by spontaneous ruderal vegetation with numerous alien plant species. This site is primarily open, sunlit, and dry due to the impermeable, partially hardened, post-industrial soil. Minimizing threats to the green toad population resulting from the transformation of this area into a park included the creation of a network of small ponds as new breeding sites. The largest of the four pools in the PR site has a surface of about 707 m^2. The next three largest have areas of about 157 m^2, 144 m^2, and 110 m^2. The bottoms of the ponds comprise an impermeable membrane below layers of small pebbles. The ponds are filled with precipitation water and often dry out in the late summer. They are surrounded by rocky boulders and lawns maintained as urban meadows. The newly created ponds are much larger and provide more stable conditions for tadpoles' development – making the toads less dependent on natural variation in breeding conditions resulting from the weather, mainly rainfall (cf. Saare & Rannap 2021).

Fieldwork

The fieldwork in the PC site was conducted during the mating season 2018; in the PR site, the fieldwork was carried out a year later, in 2019 (the year following the creation of the new ponds). We tried to choose a day favorable for intensive mating based on previous experience (Kaczmarski et al. 2019). We recaptured toads 12 days after the first capture in the PC site and two days afterward in the PR site. This difference between recapture sessions was related to weather conditions affecting amphibians' activity and logistical issues. We caught mating individuals in the water and in the vicinity of ponds during warm evenings in April, just after twilight (Table 1).

Table 1. Comparison of individual numbers of the green toad *Bufotes viridis* captured during two field sessions in two sites in Poznań, Poland.

	Rosarium in Cytadela Park (PC)	Rataje Park (PR)
Date of capture	*05 April 2018*	*27 April 2019*
No. of ♂	70	29
No. of ♀	15	7
Date of re-capture	*17 April 2018*	*29 April 2019*
No. of ♂	71	53
No. of ♀	2	9
No. of re-captured individuals	14	20

They were temporarily held in buckets with moistened paper towels. Once all observed individuals in the breeding site were captured, we measured body length (SVL - snout to vent length) [mm] using a caliper to the nearest 1 mm and body mass [g] to the nearest 1 g. We also took photographs of the dorsal side of each toad. For this purpose, every individual was put on a Petri dish alongside a scale bar and a piece of paper with a unique ID number and gently pressed from above with another Petri dish to immobilize it. Photographs were taken from above, in the light of headlamps, using a Pentax Model Optio WG-2 GPS camera to capture the dorsal pattern of every individual. After all measurements were taken, we released the toads at the edge of the breeding pond(s).

Analysis

We calculated the Scaled Mass Index (SMI) (Peig & Green 2009) as a proxy of individual conditions. To compare body condition between populations, we used a population mean length of L0 = 60 mm and a scaling factor of b = 3, following Landler et al. (2023).

Using the photographs, we recognized individuals to detect recaptures by single-eye matching (Reyne et al. 2021). We could not use an automatic photo-identification method due to the variable quality of the photos taken in the field. Generally, green toad coloration can vary in different geographic regions. However, its standard appearance consists of green spots of different sizes and shapes on a beige-grey background, with females having higher contrast between the spots and background coloration (Burgstaller et al. 2021a, Zhelev et al. 2020). These individual-specific features allow accurate individual identification and make green toads a suitable species for photo identification (Burgstaller et al. 2021a). In typically colored individuals, we paid attention to dorsal patterns, such as localization and shape of spots and the presence or absence of a bright dorsal stripe. We compared images of individuals from the first and second capture, aiming to find recaptures. At the PC site, some males exhibited uniform grass-green coloration with spots on the dorsum that were barely visible (Fig. 1). This coloration is described in the literature as relatively rare (Juszczyk 1987). In this case, we paid particular attention to any spots on the head and limbs of such individuals. The SVL data of the individuals supported the identification of recaptures, as the short period between captures did not allow for any visible growth of individuals.

To estimate the size of the two studied populations, we used the Chapman estimator, which is less affected by small sample sizes and is as follows:

$$N = (n_1+1)(n_2+1) / (m_2+1) - 1,$$

where N is the estimated population size; n_1 is the number of captured, marked, and released animals at time 1; n_2 is the number of captured animals at time 2; and m_2 is the number of previously marked animals that were recaptured at time 2 (Chapman 1951).

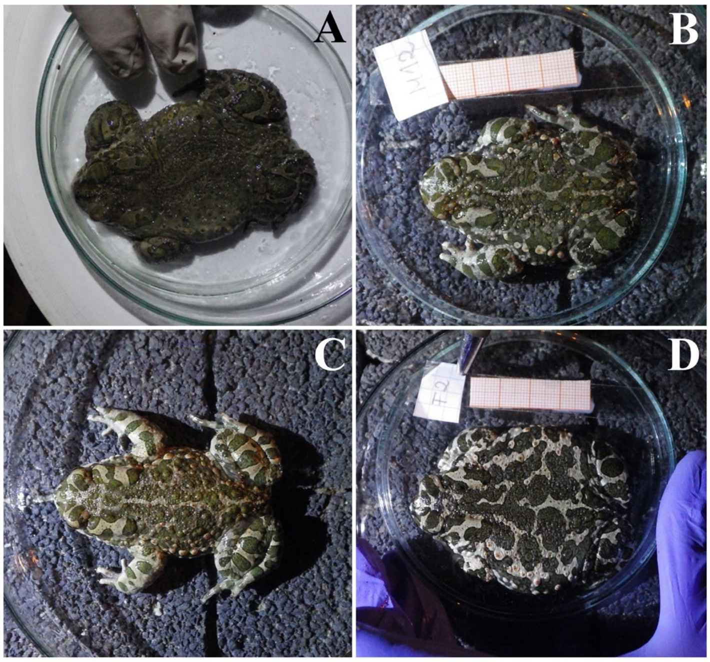

Figure 1. Diversity of dorsal patterns of the green toad *Bufotes viridis*. A) Male with a relatively uniform, low contrast pattern (the PC site). B) Male with typical green coloration and bright spots on the back. C) Male with a dorsal pattern arranged in a stripe. D) Typical coloration of females. (A - Rosarium Cytadela Park, Poznań, Poland; B, C, D - Rataje Park, Poznań, Poland).

We used the *recapr* package in R to estimate the population size and 95% confidence interval (CI) (Tyers 2021), with the letter calculated using bootstrapping with 10,000 replicates. No females were recaptured. Hence, we applied the Chapman estimator only to males, as was also the case in other studies (Reyne et al. 2021, Saare & Rannap 2021). Therefore, finally, we estimated the overall population size using both of the two known adult sex ratios (ASRs) for other populations from Poland, which were 1.3:1 (♂:♀) (Juszczyk 1987) and 1.4:1 (♂:♀) (Ciechańska 2008). Importantly, both values are close to those reported from urban populations in Vienna, Austria – 1.3:1 (♂:♀) (Staufer et al. 2023).

Statistical analyses were performed in R Studio (version 4.0.5, R Core Team 2022) using the *rstatix* package (Kassambara 2021). If biometric data had a normal distribution, groups were compared using the Student's *t*-test; otherwise, we used the non-parametric Wilcoxon test. In the case of individuals captured twice, we used only measurements from the first capture session to compare study sites and captures. Hence, we treated samples as independent. Plots were prepared in *ggplot2* (Wickham 2016).

Results

The number of captured toads was higher at the PC site than at the PR site, but we detected more recaptures in the sample from the PR site (Table 1). The number of males was higher than that of females for each capture session and site (Table 1). We estimated the number of males at 340 (95% CI: 231-567) for the PC population and 76 (95% CI: 57-115) for the PR population. Finally, the breeding population size was estimated at 601 individuals for the PC population and 134 individuals for the PR population with the ASR reported by Juszczyk (1987), and at 582 individuals for the PC population and 130 individuals for the PR population with ASR reported by Ciechańska (2008).

The two studied populations differed in SVL and mass measurements (Fig. 2, Table 2). The SVL has a higher value in the PC than in the PR population for both females (Student's independent samples *t*-test: $t = 8.33$, df = 30.7, $p < 0.001$; $N_{PC} = 17$, $N_{PR} = 16$) and males ($t = 12.2$, df = 118.2, $p < 0.001$, $N_{PC} = 126$, $N_{PR} = 62$). Furthermore, the two studied populations differed in condition (Wilcoxon rank sum test: effect size $r = 0.597$, $W = 9607$, $p < 0.001$, $N_{PC} = 143$, $N_{PR} = 78$; Fig. 3). Individuals from the second capture had higher condition values at the PC site ($r = 0.733$, $W = 340$, $p < 0.001$, $N_1 = 84$, $N_2 = 59$) but not at the PR site ($r = 0.098$, $W = 842$, $p = 0.391$, $N_1 = 36$, $N_2 = 42$).

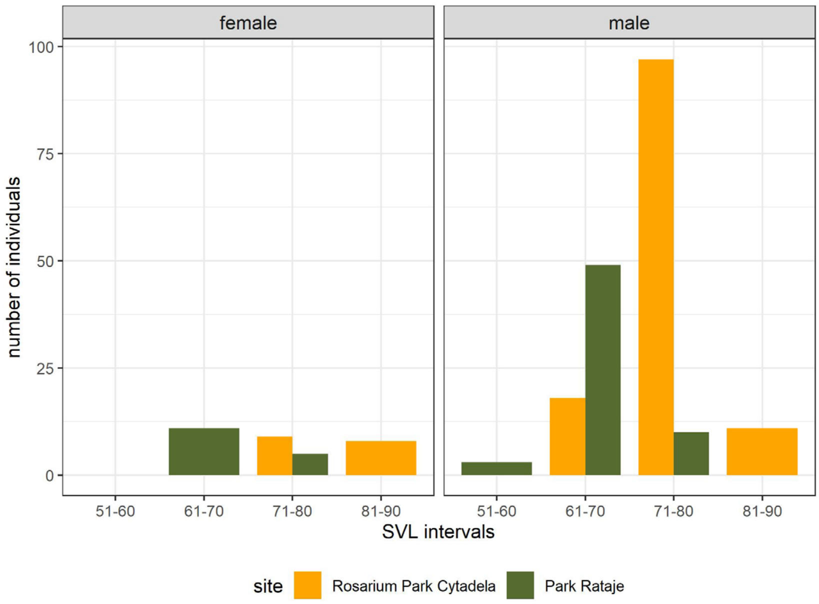

Figure 2. Comparison of the snout to vent length (SVL) categories [in mm] in two studied populations of the green toad *Bufotes viridis* in Poznań, Poland (Rosarium in Cytadela Park - PC site, Rataje Park – PR site).

Table 2. Comparison of the mean snout to vent length (SVL), mass, and SMI (predicted mass using Scaled Mass Index) of two green toad *Bufotes viridis* populations in Poznań, Poland.

	Rosarium in Cytadela Park (PC)		Rataje Park (PR)	
	♂	♀	♂	♀
N	126	17	62	16
SVL [mm]				
Mean±SD	74.9±4.2	80.9±4.8	66.9±4.3	68.2±4.0
Min-Max	64-89	73-89	57-78	62-74
Mass [g]				
Mean±SD	59.6±16.1	72.4±15.3	29.3±5.9	36.1±6.4
Min-Max	29-91	40-96	17-49	25-44
Scaled Mass Index [g]				
Mean±SD	30.9±9.1	29.4±5.0	21.0±2.2	24.4±1.7
Min-Max	19-49	23-41	16-29	20-27

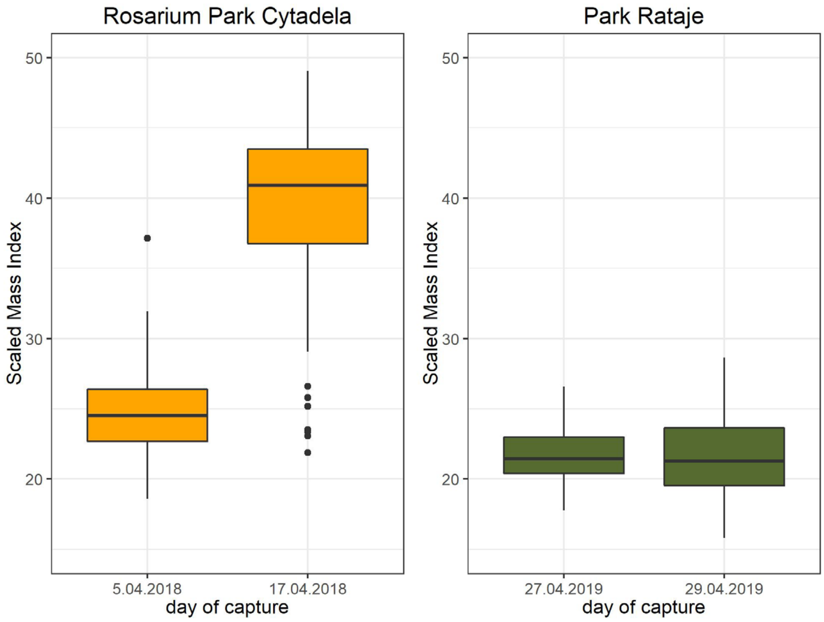

Figure 3. Comparison of the condition of two studied green toad *Bufotes viridis* populations in Poznań, Poland. The condition was calculated as predicted mass using the Scaled Mass Index (SMI). The day of capture refers to the capture-mark-recapture method used in this study to estimate the size of populations. For recaptured individuals, we used only the first observation in calculations of SMI – the sample size is N_1 = 84 (5.04.2018), N_2 = 59 (17.04.2018), N_1 = 36 (27.04.2019) and N_2 = 42 (29.04.2019).

Discussion

Any data on population size are helpful in amphibian population management, especially in small-scale urban conservation (e.g., Sistani et al. 2021), since they are often lacking. Since conservation and management of urban amphibian populations must deal with diverse stakeholders, pushing for modifying of existing green areas to meet their purposes (e.g., different types of recreation, renovation, and development or climate adaptation, etc.), the data on the size of populations is crucial in assessing their conservation value, justifying conservation action, and communicating its need to the general public (Lee et al. 2021). In our case, while the direct comparison of population size between the two sites was problematic due to slightly varying methodology between the two years of research (see below), the population estimates obtained were nevertheless valuable in justifying the need for further conservation of the two populations while communicating with land managers (our unpublished data).

For such practical applications, photo-identification has the lowest entry threshold of all CMR techniques: unlike injection of PIT tags or toe clipping, it is inexpensive and does not require invasive procedures, specialized equipment, or special permits. Pattern recognition software is readily available, although not indispensable: our analyses were performed visually. This was partly due to the insufficient quality of the photos taken in the field and partly due to individual toad characteristics. In the PC population, a greenish tint appears over the entire back of mating males, often blurring their unique, individual patterns. In our opinion, this might sometimes challenge automatic identification, as it did in our case. From the point of animal welfare perspective, selecting the appropriate technique for CMR studies is complex (Wilson & McMahon 2006). Injecting PIT tags under the amphibian skin is a more invasive procedure than photographing the individual. However, such animals spend less time being handled during recapture sessions than in repeated photography sessions. Therefore, PIT tags would be better for more intensively sampled populations (Roberts et al. 2021). However, the method we used (photo identification) appears best for short-term studies, and we recommend it.

The probability of recapture differed greatly between the two sexes. Females were less likely to be recaptured, consistent with published observations that females spend much less time at the breeding site than males and depart soon after oviposition, negatively affecting their probability of recapture (Kovács & Sas 2010, Reyne et al. 2021, Staufer et al. 2023). Consequently, we could only estimate the number of males and combine this with information about the total adult sex ratio (ASR) from the literature. While the operational sex ratio (OSR) within a breeding pond is often strongly skewed towards males (as it was in both study sites), the ASR in green toads is close to equal (Ciechańska 2008, Juszczyk 1987, Staufer et al. 2023). In addition, our methodology—catching individuals on the mating site—does not consider non-breeding juveniles, so the total population size is even larger.

The two studied populations clearly differed in their estimated size, which was at least partially due to methodological issues (different times between capture and recapture sessions – see below). We estimated that the PR population was much smaller than the PC population, estimated at approximately 600 individuals (range 582–601), seems to be a large (but not exceptional) urban population of the species. Unfortunately, our results have a wide confidence interval of 336 for the PC population and 58 for the PR population. Therefore, conclusions must be drawn carefully from our data. Notably, it is generally accepted that an effective population of 500 adults is necessary to ensure that not too many alleles are lost due to genetic drift (Lehmkuhl 1984, but see McCartney-Melstad & Shaffer 2015). So, the estimated size of the PR population is not numerous enough. Nevertheless, it is comparable to one of the populations from Vienna – estimated to be 137 individuals (Sistani et al. 2021) – and to the Pergola site in Wroclaw (SW Poland), which was 159 individuals according to the total population captured during translocation (Ciechańska 2008). On the other hand, another Viennese population investigated by Staufer et al. (2023) in the city's southern outskirts was estimated at 1631 adult toads, all captured within a relatively small area, 300 m from the nearest breeding site. The values mentioned above came from articles using various methods to estimate population size, a comparison of which is beyond the scope of our article and is presented only to provide a broader perspective on our results. Therefore, based on the above information, we consider it sufficient to maintain the current population management at the PC site. In contrast, we recommend taking further conservation actions at the PR site and implementing management strategies that consider the requirements of this species to achieve an adequate adult population size in the long term. However, we cannot rule out the possibility that the past site management with a greatly restricted breeding habitat (only temporary pools) may have also affected PR population size (see below).

The different time between the two capturing sessions leads to a drawback of our study: the longer interval between trapping sessions in the PC site resulted in fewer recaptured individuals, which translated to a larger estimated population size. For a more reliable comparison, the two populations should have been sampled using the same time intervals between capture sessions, preferably in the same year (we sampled the two populations one year apart). However, the mating activity of amphibians depends strictly on weather conditions, especially air temperature, precipitation, and water temperature; therefore, maintaining a constant time between inspections is not always possible, nor is it necessarily optimal (Saare & Rannap 2021), especially in species such as green toads, which are prolonged breeders (Kaczmarski et al. 2019, Kovács & Sas 2010, Vargová et al. 2023). In general, the interval between capture sessions varies significantly between studies. For example, one study of the green toad population in Vienna (Austria) using photo-identification lasted from April to July, with 30 capture sessions several days apart (Sistani et al. 2021). In another study, ten trapping sessions in Camphausen (Germany) were conducted from the beginning to the end of the breeding season, which lasted from March to June (Wagner et al. 2011). In contrast, monitoring the yellow-bellied toad *Bombina variegata* metapopulation in central Switzerland occurred over five years, where trapping was carried out two to four times a year (Cayuela et al. 2019). With just two capture sessions, our approach provides a snapshot of the whole picture and is limited relative to the 'superpopulation approach' (Wagner et al. 2011). However, while increasing the number of capturing sessions would provide a more accurate estimation of population size, it could also negatively affect the course of mating (e.g., via disruption of calls, the pairing process, and egg deposition) and induce stress in repeatedly caught individuals (Roberts et al. 2021). It would also increase the cost of monitoring, which can be particularly important when conducting research over a large area or working with large populations with limited financial resources.

Individuals from the PC site had higher condition values than those from the PR site. Furthermore, toads from the PC site had the highest mean SMI value (females: 29.4 g; males: 30.9 g) compared to 17 other populations studied in European cities by Landler et al. (2023). In contrast, individuals from the PR site reached SMI values (females: 24.4 g; males: 21.0 g) that were similar to the mean (21.7 g) across European populations (Landler et al. 2023). The stable conditions (with numerous hiding places) or better habitat quality at the PC site probably enabled higher condition values due to good feeding opportunities, not necessarily good health or high fitness per se (Landler et al. 2023). The body condition of the green toad (and other amphibian species) can be affected by environmental conditions in previous years and may vary annually (Mazgajska & Mazgajski 2020). Thus, comparing results for the two populations collected in different years may be error-prone and require careful interpretation.

Individuals from the second capture at the PC site had higher condition values than in the first, but we did not find such a difference in the PR site. The apparent reason is that the timespan between the two capturing sessions in the PR site was only two days, while in the PC site, it was 12 days. As a consequence, the individuals that arrived at the breeding site later are the ones that could have had more time to forage before entering the pond. In anurans, even explosive breeders may forage on the way to the breeding reservoirs (Kolenda et al. 2019), and prolonged breeders – like the green toad – are even more likely to do so (Covaciu-Marcov et al. 2010, Juszczyk 1987). Alternatively, the effect may be caused by the varying conditions and fitness of animals arriving at the pond at various times. However, in such a case, the opposite effect might be expected: in natterjack toads, older (presumably larger) individuals enter the breeding area earlier than younger ones (Saare & Rannap 2021).

In the two populations we studied, differences in population size and individual size (SVL) may reflect the sites' recent history and current management. Land use at PR sites has changed dramatically in recent years. Initially, the population lived on post-industrial wastelands that provided attractive land habitats but low-quality and unpredictable breeding sites. At that time, toads reproduced only in highly ephemeral puddles, and their reproductive output was strongly limited by water availability (cf. Kaczmarski et al. 2019). However, it is worth noting that such conditions—relatively harsh habitats—seem similar to those initially occupied by green toads (*sensu lato*), a group of pioneer species (Dufresnes et al. 2019). Consequently, the lower body sizes and a smaller estimated population at the PR site might reflect potential habitat transition and mortality due to park construction the year before our study. In contrast, the PC site is a mature green area with more than 50 years of stable management. The area has not been significantly transformed since the park's creation, and suitable habitat quality has been established. Due to its age, the infrastructure of this park is partly damaged in some places, with numerous hiding places in crevices and cracks and the remains of a fortress. Therefore, based on the latest research, such spaces have great importance for green toads in urbanized areas (Vargová et al. 2024). However, additional research is needed to determine whether the larger body sizes in the PC population (compared to the PR population and other cited studies) are related to habitat quality or some life history traits, such as the survival rate or age structure. Long-term research using CMR or skeletochronology studies is required to evaluate this relationship (Altunişik et al. 2021, Sinsch et al. 2007).

In conclusion, using simple data collection schemes might be an important first step in community-based urban conservation initiatives for green toads (or any other focal species of amphibian) that often lack data on the population size. Even very preliminary data should be made public for educational purposes, which include creating a positive relationship between city inhabitants and animals using urban green spaces as their habitat. Public involvement in managing protected species is necessary in the face of the growing pressure on urban green areas due to the ever-increasing human population. Our experience clearly shows that the conservation of amphibians in cities is possible; new breeding ponds for green toads were created at the PR site, and the pond used by toads for breeding is regularly cleared of fish at the PC site. Information on population size can support this process because it indicates the relative value of a given population. In the case of the populations discussed here, scientists and conservationists working in the city were able to create public interest in amphibian conservation matters (our unpublished data). In response, the site manager constructed new breeding ponds for green toads at the PR site, placed educational materials in both parks, changed the mowing regime near ponds at both sites and implemented regular removal of fish, which threaten amphibian larvae, from the toad breeding pond at the PC site. Scientific experience in managing urban green toad populations adds to public discussion about biodiversity-friendly habitat management in cities (Ensabella et al. 2003, Kaczmarski et al. 2023, Sistani et al. 2021, Vargová et al. 2023, 2024). In the face of the great extinction of amphibians, preparing conservation strategies and proactively managing amphibians, including green toads, based on field data and knowledge is necessary (Sterrett et al. 2019).

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