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Big City Life: Investigating the population of European green toads (*Bufotes viridis*) at the Rudolf-Bednar-Park (Vienna, Austria)

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Abstract

The European green toad (*Bufotes viridis*) is classified as endangered in Austria and as critically endangered in Vienna. An investigation in 2012 showed that the man-made basins in the Rudolf-Bednar-Park in the north of Vienna are the spawning site of at least 54 individuals. The future of this population is uncertain, because construction work on the nearby ruderal site may threaten land habitat and wintering sites of the toads. Therefore, more detailed investigations of the population are necessary. In this study over two years we attempted to record the total population in the Rudolf-Bednar-Park and surrounding areas with capture-recapture methods. Furthermore, morphological data, spatial distribution of toads, amplectant pairs and spawn as well as temporal activity patterns of the toads were recorded. The captured 200 adult individuals show that the population size exceeds the previous estimate by far, but a population estimation suggests that at least 247 toads reproduce in the basins of the Rudolf-Bednar-Park. Taking into consideration that toads from the rest of the park, the ruderal site and the near community gardens were left out of the estimation, the overall population is probably considerably larger. Toad activity peaked in both years in April, however in 2016, activity reached its highest peak in July. The start of mating season is not synchronized between all individuals and the duration of mating season varies in both sexes. In spite of previous assumptions, female toads were observed in amplexus at the spawning site several times in one year. Body condition indices (Fulton’s index) were calculated from morphometric data of captured toads to provide a basis for a long-term monitoring of the population. This will be useful to assess the impact of the building activity on the site of the former railway station on the health of the toads.

Introduction

On the red list of threatened species, the European green toad (*Bufotes viridis*) is classified as 'vulnerable' throughout Austria (Gollmann 2007) and as 'critically endangered' in Vienna (Tiedemann & Häupl 1994). Additionally, it is listed in Annex IV of the EC Habitats and Species Directive (COUNCIL DIRECTIVE 92/43/EEC on the conservation of natural habitats and of wild fauna and flora). This species is characterised by a pattern of greenish blotches on the dorsal side, which differs between individuals and can be used to identify them (Grosse & König 2005). The dorsal pattern can also be used to distinguish between the sexes. Females usually have a more contrasting pattern with black borders around the blotches, while the pattern of males is often blurrier and may even give the animal the appearance of uniform colouration. During the breeding season, males can also be identified by their bulkier front legs

and black nuptial pads on their thumbs (Speybroeck et al. 2016). As in 90% of anuran species, females are larger than males on average (Shine 1979). Adult toads mostly feed on invertebrates, while tadpoles consume detritus and algae. The reproductive period lasts from February to July, but varies according to the geographical location of populations, as does the hibernation period (Cabela et al. 2001).

The site of the former northern railway station ("Nordbahnhof") in Vienna offers a wide area of ruderal and uncultivated land (ruderal site, RS), and a permanent spawning opportunity in the form of ornamental water basins at the Rudolf-Bednar-Park (RBP), which is located in close vicinity to the RS. The area hosts a population of at least 50 adult European green toads, which have their main spawning site in the basins in the RBP that provide the only permanent breeding opportunities throughout the mating season. Current and future construction work at the RS may pose a serious threat for the toad population (Csarmann 2012). However, temporary puddles which form on the RS after heavy rainfall are also used (pers. observation). Therefore, research on the green toad population at the RS and the RBP is necessary to make a statement about the status and the size of the population. The gathered information will help to determine whether this population of European green toads needs specific protection. In the previous study on the same population by Csarmann (2012), the number of different tadpole stages per basin was used as an indicator for the number of sexually mature females in the population; the total population size was then estimated based on the assumption that there is a sex ratio of 1:1. However, the author did not record the actual number of toads in the park.

The present study utilizes the capture-recapture method and body condition indices to estimate size and health of the population of the European green toad in the RBP. Our data also provides the ground work for a long-term monitoring project by future students of the field course "Populationsbiologie heimischer Amphibien".

Furthermore, we aim to assess the suitability of the RBP as a habitat of the European green toad and determine shortcomings in the design of the spawning site and dangers for the toads in the RBP and surroundings. Based on the results of the present study, suggestions for improvement of the habitat can be developed in order to preserve this population of the European green toad at the RBP and the RS.

Material and methods

Study area

The study area (48° 13’ 34.126’’ N, 16° 23’ 48.317’’ E (WSG 84), 161 m a.s.l.) is located in the second district of Vienna, in the north of the transportation hub “Praterstern” at the site of the former northern railway station (“Nordbahnhof”) and has a total size of 75 hectares. Infrastructural and housing projects are being developed in this area since 2000. Our research focused on the remaining ruderal site (RS) of the former railway station, the parking lot adjacent to the RS, the nearby Rudolf-Bednar-Park (RBP), and the community gardens (CG) situated in the Ernst-Melchior-Gasse in front of the Bildungscampus Getrude Fröhlich-Sandner (Fig. 1). The park measures 31.000 m² and is surrounded by large residential buildings. Thirteen artificial water basins, which are about 10 cm deep and densely planted with reed and bulrushes, are located in the centre of the park (Fig. 2). These basins are situated between asphalted lanes leading through the park from northwest to southeast.

Monitoring

Data for the present study were collected from 25 March 2015 to 17 August 2015 and from 29 March 2016 to 31 July 2016, up to four times per week in the evening hours between 19:30 and 02:00. On a total of 84 days (40 in 2015, 44 in 2016) during this period, between one and six people searched for European green toads in the RBP, the CG, the parking lot adjacent to the RS, and the area in the southwest of the RS.

After capture, toads were weighed in grams with digital scales (On Balance Notebook Scale NBS-2000 & BL scale TUF-1000) correct to one decimal place and their snout-urostyle-length (SUL) was measured in millimetres with a plastic calliper or a triangle ruler correct to one decimal place.

Sex was determined by morphological and behavioural criteria. Males were identified by their thicker front legs and black nuptial pads, as well as their calling behaviour.

The dorsal patterns of the toads were photographed for individual identification before release. We also recorded location, date and time. The capture site was defined by numbering the basins consecutively from one to 13 and dividing them into sections (Fig. 2). If the toads were not captured at the basins, the capture site was described as precisely as possible (street names, conspicuous landmarks). We logged and photographed each encountered amplectant pair without capturing them.

Toads which were captured in or near the basins in the RBP were also assigned a site preference for each year, according to the basin group they visited most (Northwest, middle or southeast; Fig. 2).

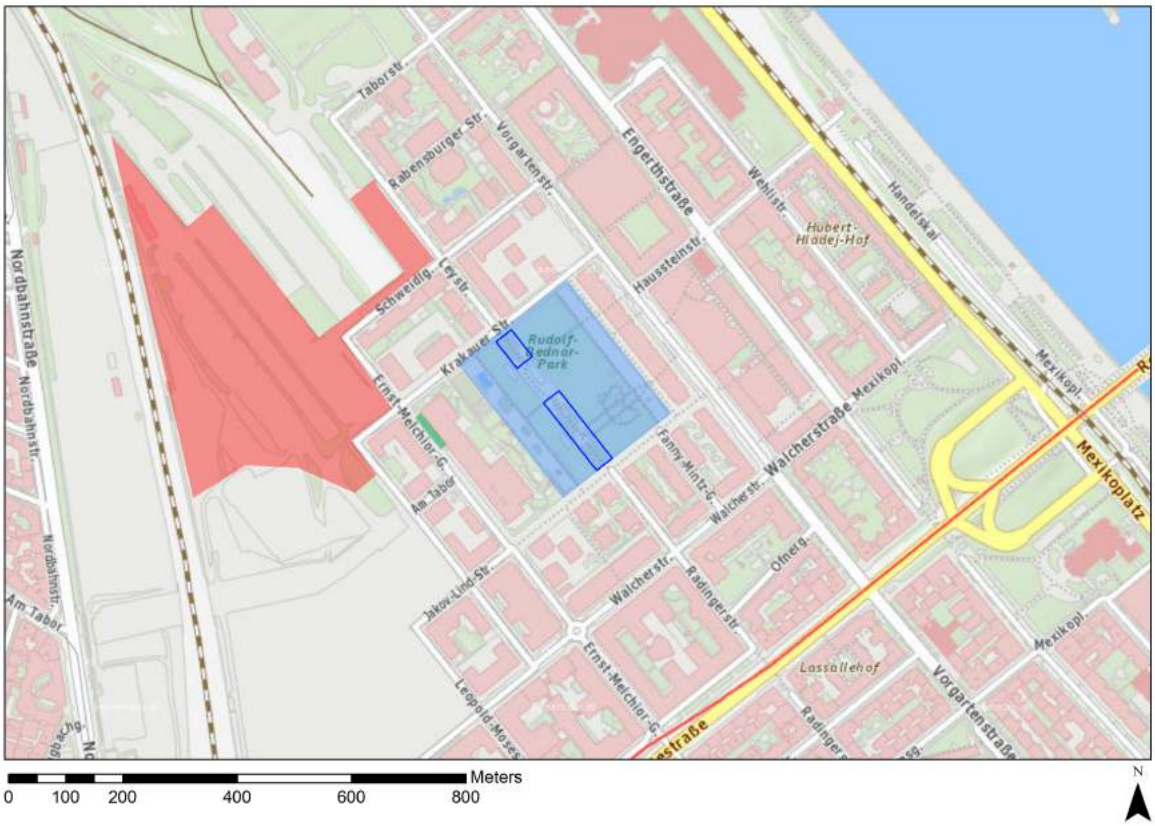

Figure 1. Map showing Rudolf-Bednar-Park (RBP, light blue), basins (dark blue), community gardens (CG, green) and ruderal site (RS, red).

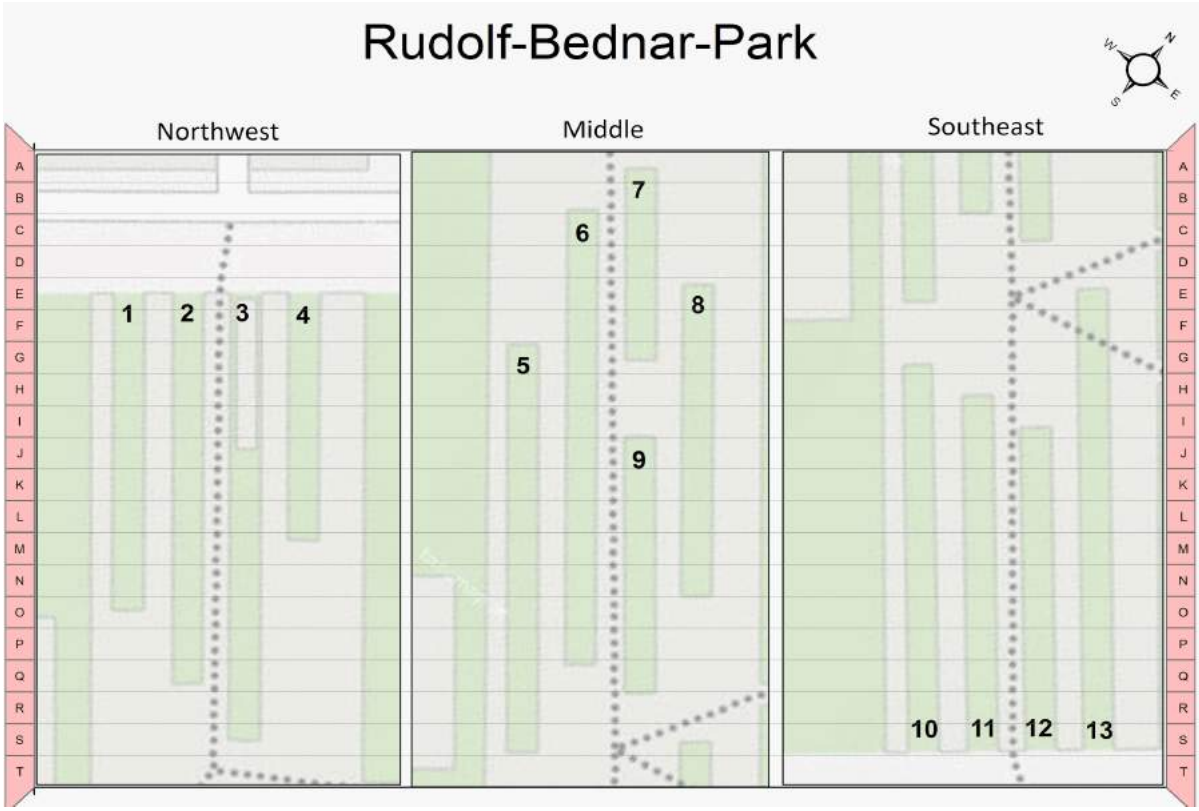

Figure 2. Map of the numbered basins 1 - 13 at the Rudolf-Bednar-Park.

Data analysis

Software

Program R (R Core Team 2016) was used for statistics. Graphs were created with SigmaPlot 11 (Systat Software, Chicago, IL).

Individual identification

Pictures of captured toads were visually inspected to confirm the identity of a given toad. A database of all individuals was created, containing ID number, sex, date of first and last capture, date of first and last capture at the mating sites, average body mass and SUL.

Population size

The population size was estimated with the Lincoln-Peterson estimator (Lincoln 1930), 2015 and 2016 were each treated as single capture events and the population was considered closed due to geographical isolation. Population size was calculated separately for both sexes because the Lincoln-Petersen estimator assumes that all animals have the same probability of being caught. This was not the case for male and female toads because males are at the basins for longer periods of time, and calling males are also more conspicuous than silent females.

Only toads which had been captured inside the basins of the RBP or on the concrete paths next to them at least once were used for the calculation. This was because the basins of the RBP were the only area which was regularly visited during the survey in 2015. Juveniles, dead toads and individuals where the sex could not be determined were excluded from the analysis.

Morphometric survey

For analysis of snout-urostyle-length (SUL) and body mass (BM), an average of all measurements during the observation period was calculated for each individual for each year, if caught multiple times. Fulton's index (Băncilă et al. 2010) was calculated separately for each individual toad with the formula $K = \frac{BM}{SUL^3} * 10^5$ (BM = body mass in g; SUL = snout-urostyle-length in mm) to assess body condition of individuals.

SUL and BM in both years were compared between sexes, as was the individual difference in BM between the years.

Fulton's index was compared between the years in both sexes. Normally distributed and not normally distributed variables were analysed with the Mann-Whitney U test and the t-Test, respectively.

Duration of mating period

The duration of the mating period for an individual was defined as the period between the first and last time we found the individual in or next to the basins. Because of small sample size for females, we did not test for differences between the sexes.

Spawn

Because data were collected by different researchers on different days in 2015, it is possible that the same spawn was recorded multiple times. Therefore, spawn recorded less than seven days apart from the last spawn in the same location in 2015 was excluded from the analysis. In 2016, every spawn was recorded each time it was encountered. For analysis each spawn was only counted once.

Results

General

2015

We captured 112 European green toads (74 males, 21 females, 14 juveniles and three adults of unknown sex, sex ratio = 3.52:1) a total of 281 times on 45 days in the field (Tab. 1). No toads were captured on eight days. Four toads were found dead, two of which had previously been captured alive during this study. Seventy-two individual toads were captured in or on the concrete paths directly next to the basins in the Rudolf-Bednar Park (RBP). Four individual toads were captured at temporary puddles on the parking lot near the ruderal site (RS), but none of them were recaptured. The remaining toads were caught in the park and/or at the edge of the RS. Twenty-four amplectant pairs were encountered, one of them in the temporary puddles on the parking lot near the RS, and twenty-three in the basins of the RBP. Of these 24 amplectant pairs, 11 males and 16 females could not be identified. Three males and one female were recorded as part of an amplectant pair twice, and one female was observed in amplexus three times (twice in the basins, once in the RBP away from the basins). A total of 26 clutches were found in the basins in the park, as well as an additional three in the temporary puddles on the parking lot near the RS. The body mass and the SUL of two males and three females were not recorded.

2016

A total of 179 toads (84 males, 48 females, 48 juveniles, three adults of unknown sex; sex ratio = 1.75:1) were captured a total of 397 times on 40 days in the field (Tab. 1). On three days, no toads were captured. Twenty-two male and seven female toads were recaptured from 2015. One hundred toads (74 males, 26 females) were captured in or in or on the concrete paths directly next to the basins in the RBP. Two of them had already previously been captured at the RS in November 2015 in a telemetry study (Leeb et al. 2015). Seven individual toads were captured in the RS, and four at the parking lot near the RS. One of the toads captured at the parking lot was previously captured at the basins in the RBP. The remaining toads were captured in the community gardens and the RBP. Twenty-six amplectant pairs were recorded in the RBP. Two males and one female were twice recorded as part of an amplectant pair. Both times the female was recorded in an amplexus in the basins. Two dead toads were encountered, one of which we had previously captured alive. Sixty-three clutches of spawn were found: four

in the parking lot near the RS and fifty-nine in the basins of the RBP. The body mass and SUL of four males, seventeen females and one adult of unknown sex were not recorded.

Table 1. Number of field days, duration of field season (days), captured individual toads (male, female, unknown sex, juvenile), amplectant pairs, spawn, captured individual toads in and near the basins, and total captures in 2015, 2016 and 2015-2016.

	2015	2016	2015 - 2016
Field days	45	40	85
Duration of field season (days)	146	125	271
Captures	281	397	678
Amplectant pairs	24	26	50
Spawn	29	63	92
Individual toads	112	179	258
Individual males	74	84	136
Individual females	21	48	59
Sex ratio	3.52:1	1.75:1	2.31:1
Individuals of unknown sex	3	3	5
Individual juveniles	14	44	58
Individuals in & near basins	72	95	143

Population size estimation

Using the Lincoln-Petersen estimator, we calculated a total number of 212 male and 35 female (sex ratio 6.06:1) toads that reproduce in the basins of the RBP (Tab. 2).

Table 2. Number of captured male and female individuals in 2015 and 2016, recaptured individuals and the results of the Lincoln-Petersen estimator.

	Male	Female
Captured individuals (2015)	64	10
Captured individuals (2016)	73	25
Recaptured individuals	22	7
Lincoln-Petersen estimator	212	35

Morphometric data

Normal distribution

The Mann-Whitney U test was used for the analysis of SUL, as it was distributed normally in females (Shapiro-Wilk, $W = 0.980$, $p = 0.950$) but not in males (Shapiro-Wilk, $W = 0.963$, $p < 0.05$) in 2015, and followed normal distribution in males (Shapiro-Wilk, $W = 0.984$, $p = 0.405$) but not in females (Shapiro-Wilk, $W = 0.928$, $p < 0.05$) in 2016.

Body mass was analysed with the t-Test because it was normally distributed in 2015 (males: Shapiro-Wilk, W = 0.988, p = 0.752; females: Shapiro-Wilk, W = 0.984, p = 0.983) and 2016 (males: Shapiro-Wilk, W = 0.985, p = 0.457; females: Shapiro-Wilk, W = 0.968, p = 0.459).
Fulton's index was normally distributed in females in both years (2015: Shapiro-Wilk, W = 0.929, p = 0.187; 2016: Shapiro-Wilk, W = 0.979, p = 0.815) and in 2016 (Shapiro-Wilk, W = 0.976, p = 0.139) but not in 2015 (Shapiro-Wilk, W = 0.921, p < 0.001) in males. It was therefore analysed with the Mann-Whitney U test in males and the t-Test in females.
Differences in mass of individual toads between 2015 and 2016 followed a normal distribution in both sexes (males: W = 0.953, p = 0.394; females: Shapiro-Wilk, W = 0.967, p = 0.873) and were therefore analysed with the t-Test.

Analysis

Male and female toads had an average SUL of 66.32 mm (n = 72) and 71.70 mm (n = 18) in 2015, and 64.92 mm (n = 80) and 68.83 mm (n = 31) in 2016, respectively (Fig. 3). SUL differed significantly between sexes in 2015 (Mann-Whitney, W = 300.5, p < 0.001) and 2016 (Mann-Whitney U, W = 785, p < 0.01).
The average body mass was 32.55 g for male and 40.94 g for female toads in 2015, and 29.81 g for males and 37.31 g for females in 2016 (Fig. 3). There was also a significant difference in body mass between sexes in 2015 (t-Test, t = -3.549, df = 21.325, p < 0.01) and 2016 (t-Test, t = -3.29, df = 38.024, p < 0.01).
The average Fulton's index was 11.12 for males (n = 72) and 11.03 for females (n = 18) in 2015 and 10.78 for males (n = 80) and 11.12 for females (n = 31) in 2016 (Fig. 3).
There was no significant difference in Fulton's index between the years 2015 and 2016 in males (Mann-Whitney U, W = 3020.5, p = 0.512) or females (t-Test, t = -0.183, df = 34.315, p = 0.856).
The average body mass difference of individual toads between the years 2015 and 2016 was +2.85 g for males (n = 21) and +8.73 g for females (n = 7). The differences between the sexes were not significant (t-Test, t = -1.681, df = 7.063, p = 0.136; Fig. 3).

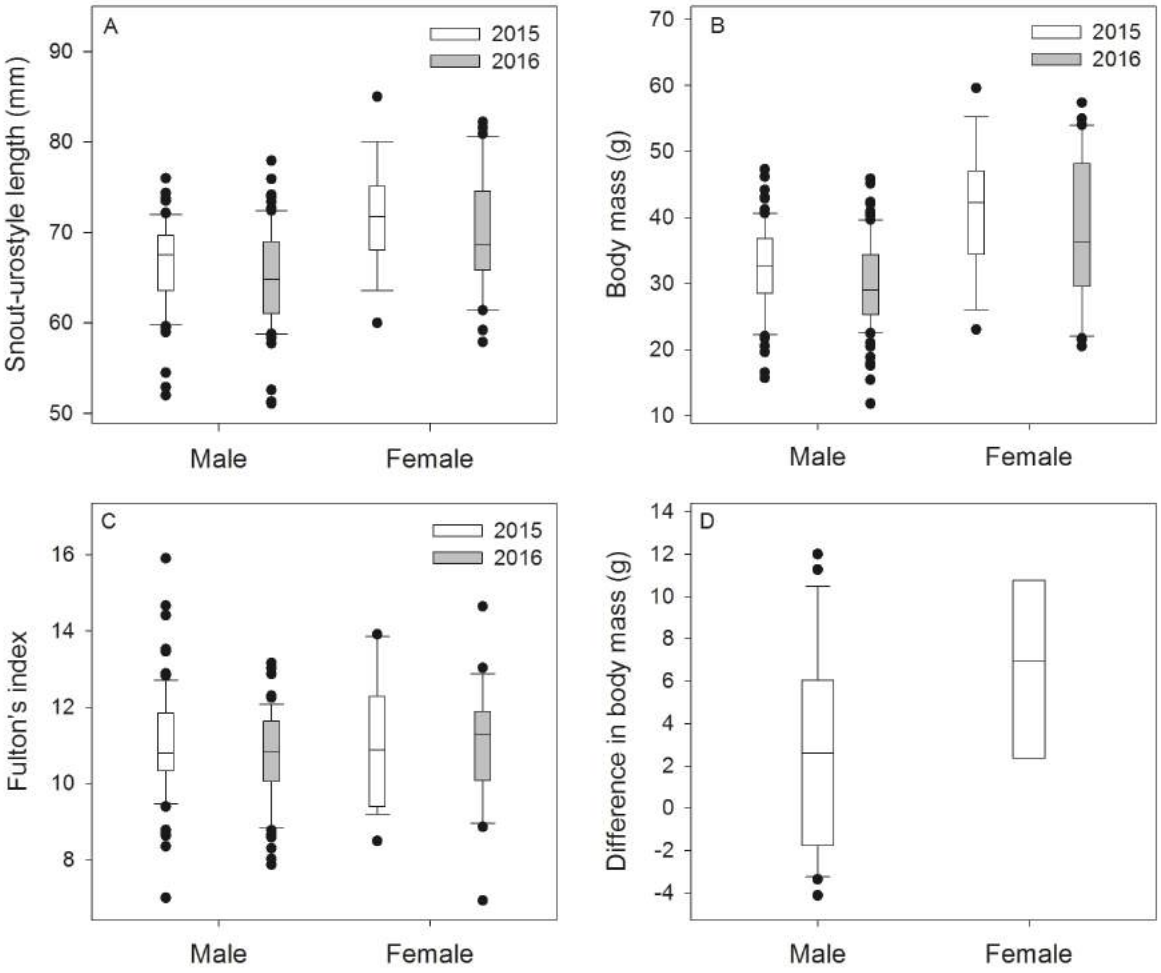

Figure 3. A: Snout-urostyle length (SUL) of male (2015: n = 72; 2016: n = 80), and female (2015: n = 18; 2016: n = 31) toads in 2015 and 2016. B: Body mass of male (2015: n = 72; 2016: n = 80) and female (2015: n = 18; 2016: n = 31) toads in 2015 and 2016. C: Fulton's index of male (2015: n = 72; 2016: n = 80) and female (2015: n = 18; 2016: n = 31) toads in 2015 and 2016. D: Difference in body mass for individual male (n = 21) and female (n = 7) toads between the years 2015 and 2016.

Number of captures at the spawning site

The number of captures at the basins in the RBP in males followed normal distribution in 2015 (Shapiro-Wilk, W = 0.915, $p < 0.001$) and 2016 (Shapiro-Wilk, W = 0.853, $p < 0.001$). In females, it followed normal distribution in 2015 (Shapiro-Wilk, W = 0.856, p = 0.139) but not in 2016 (W = 0.436, $p < 0.001$).

On average, males were captured 3.33 times in 2015 (n = 64) and 3.35 times in 2016 (n = 74), and females 2.00 times in 2015 (n = 7) and 1.15 times in 2016 (n =26; Fig. 4).

Males were captured at the basins significantly more often than females in 2016 (Mann Whitney U, W = 1594, $p < 0.001$) but there was no difference between the sexes in 2015 (Mann-Whitney U, W = 312.5, p = 0.085).

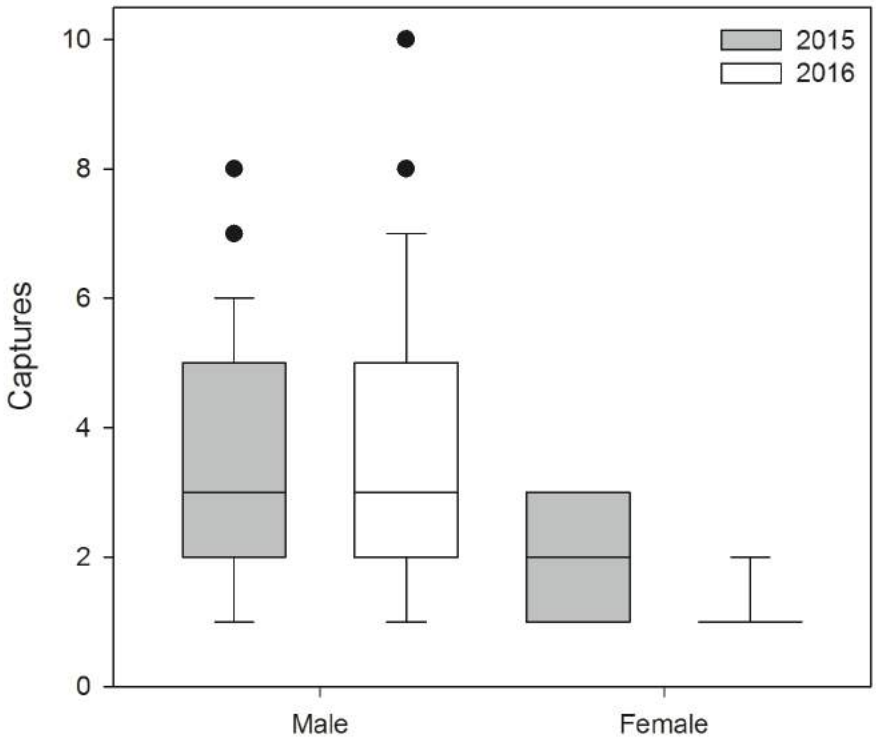

Figure 4. Number of captures of male and female toads at the basins in the Rudolf-Bednar-Park in 2015 (males: n = 64; females: n = 7) and 2016 (males: n = 74; females: n = 26).

Duration of mating season

On average, the mating season, defined as period between first and last capture of an individual at the spawning site in the RBP, lasted 27.64 days for male (n = 64) and 36.86 days for female toads (n = 7) in 2015. In 2016, the mating season lasted 34.11 days for male (n = 74) and 11.35 days for female (n = 26) toads.

Temporal distribution of toads, amplectant pairs and spawn

Toad activity was not distributed evenly throughout the survey period (Fig. 5). In 2015, there was a peak in activity between 11 and 15 April. Over 20 % of total captured toads in 2015 were captured in three days during this period (Fig. 5). Toad activity increased again on 05 July and stayed high until the end of data collection on 17 August.

In 2016, there were two major peaks in toad activity, one from 30 March to 17 April and the other from 13 July until the end of data collection on 31 July (Fig. 5).

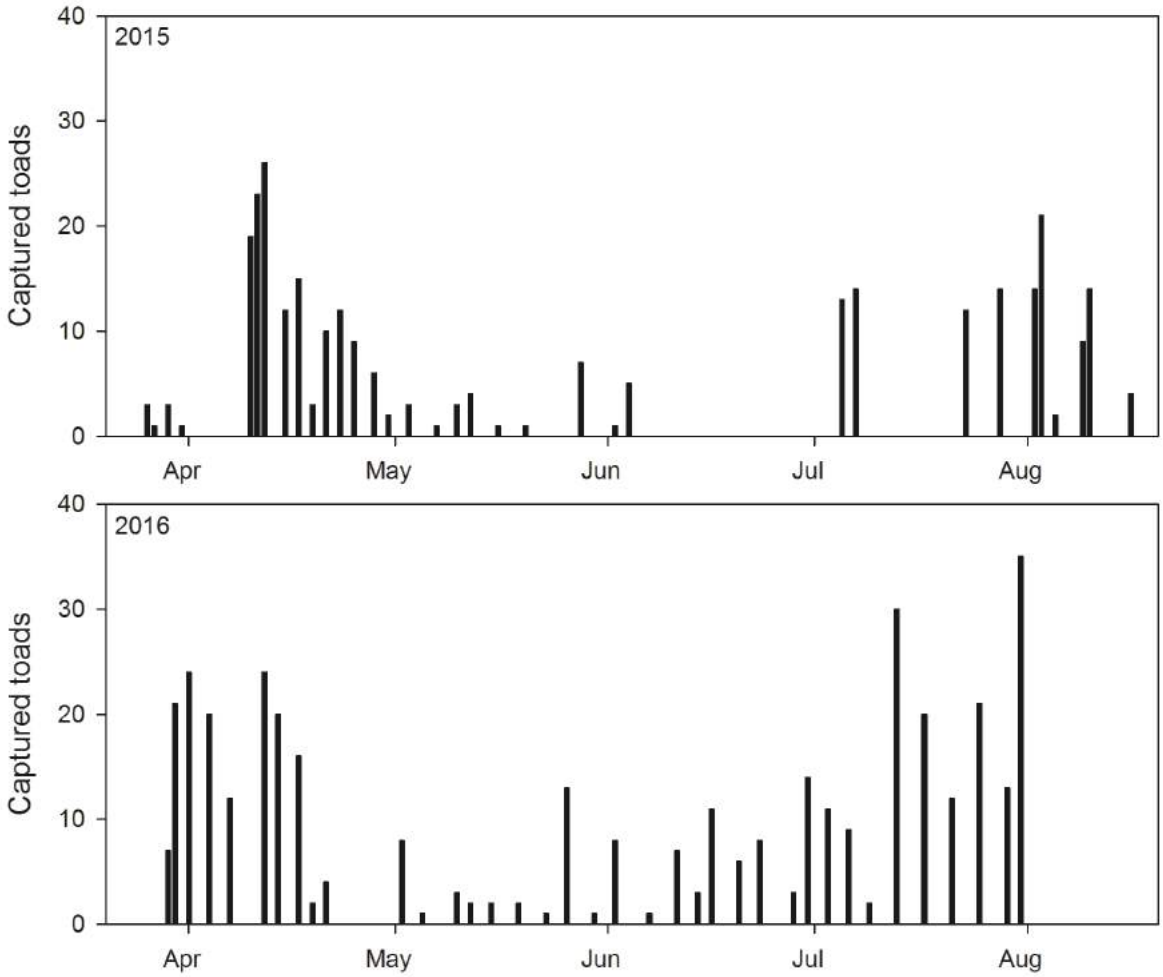

Figure 5. Temporal distribution of captured toads in 2015 (n = 281) and 2016 (n = 397).

Temporal distribution of amplectant toad pairs and spawn followed a similar pattern to the temporal distribution of captured toads in 2015, with the highest peak between 11 and 15 April 2015, and lower activity throughout the season (Fig. 6; Fig. 7). In 2016, the highest numbers of amplectant pairs and spawn were found between 01 and 17 April.

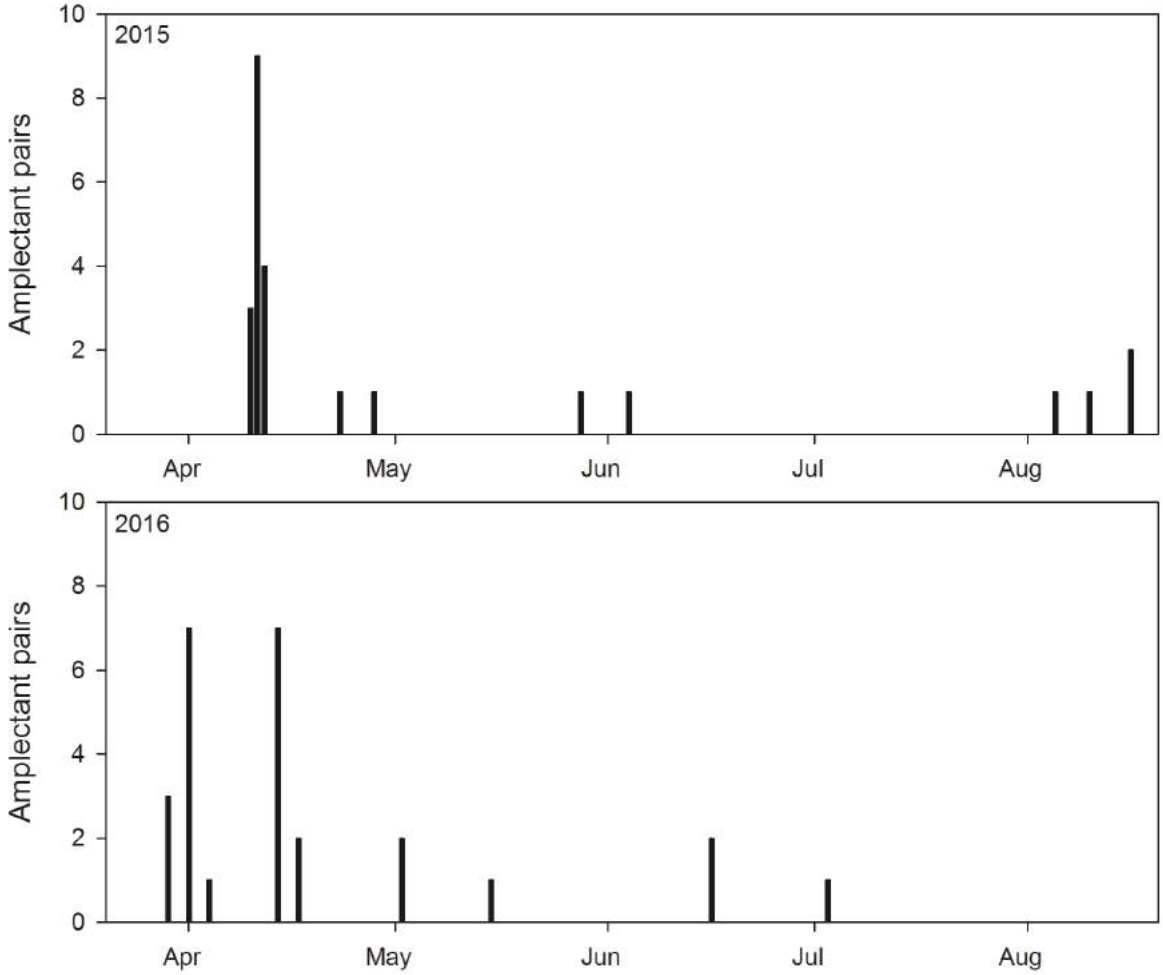

Figure 6. Temporal distribution of amplectant toad pairs in 2015 (n = 24) and 2016 (n = 26).

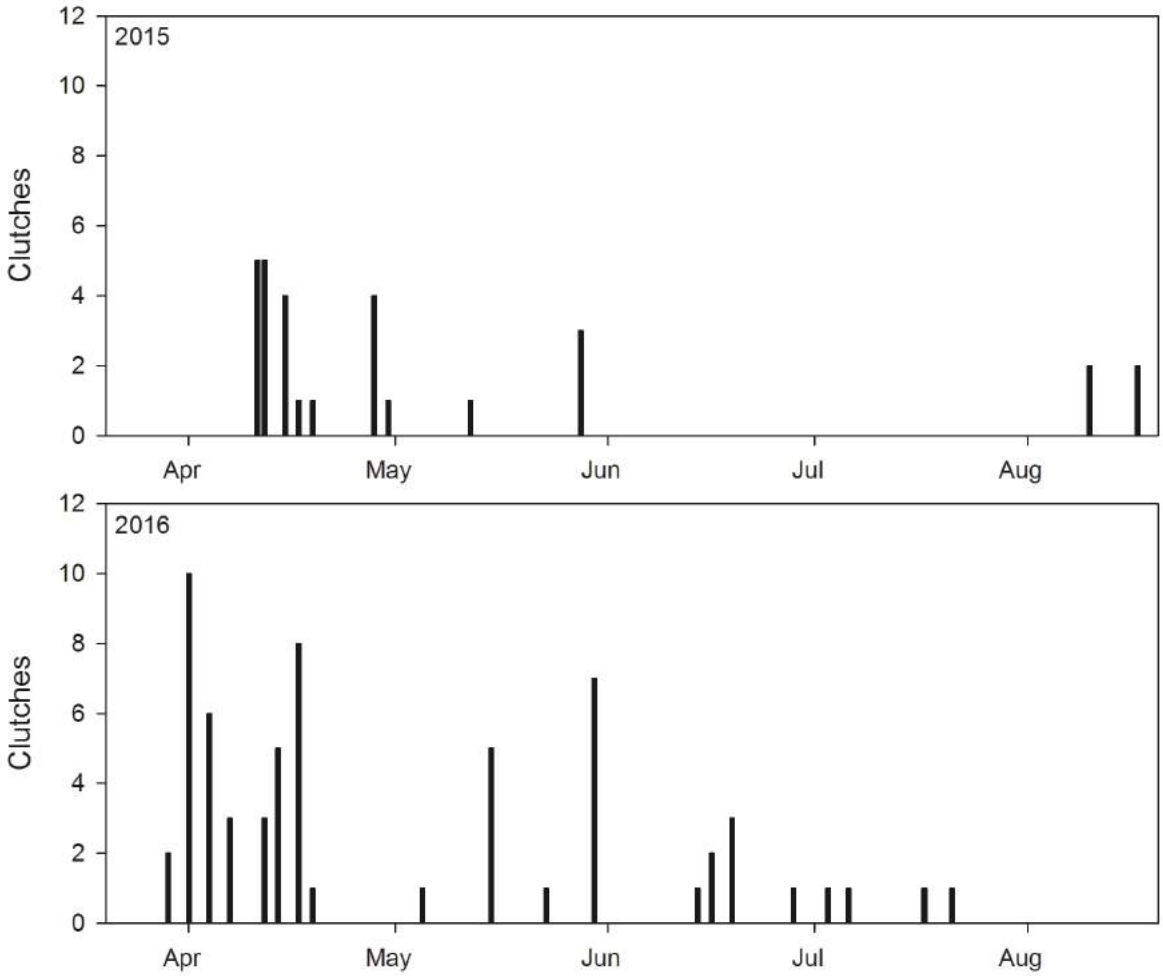

Figure 7. Temporal distribution of clutches in 2015 (n = 29) and 2016 (n = 63).

Spatial distribution of toads, amplectant pairs and spawn

Basins were placed into one of three groups according to their geographic location (Fig. 2). In 2015, the largest number of toads as well as amplectant pairs were found in the basins in the middle of the park. However, the basins in the northwest contained the largest number of clutches (Fig. 8). In 2016, the southeast basins contained the largest number of toads, but the amplectant pairs and spawn were most numerous in the basins in the middle of the park.

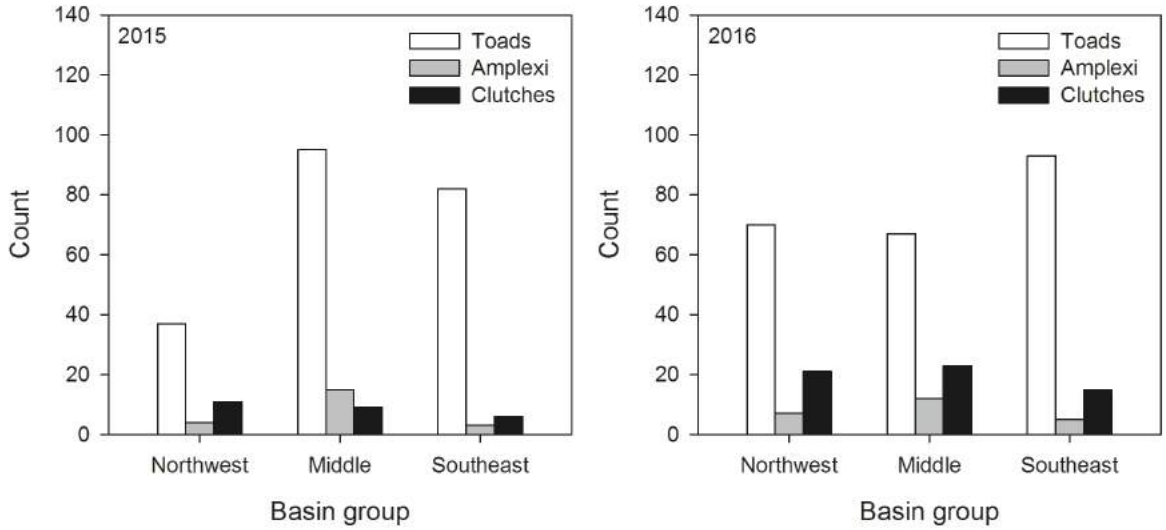

Figure 8. The distribution of adult toads (2015: n = 210; 2016: n = 230), amplectant pairs (2015: n = 22; 2016: n = 24) and clutches (2015: n = 26; 2016: n = 59) between northwest, middle and southeast basins in the Rudolf-Bednar-Park in 2015 and 2016. Multiple captures of individual toads on different days included.

Site fidelity

Of the male toads captured at the basins, 88.9 % in 2015 (n = 72) and 87.00 % in 2016 (n = 100) showed a preference for one of the three geographically separate basin groups (north-west, middle and south-east). 75 % of toads captured at the basins in 2015 and 2016 showed a preference for a basin group in both years (n = 24). Of these 18, 77.78 % had the same preference in both years.

Other Results

No other amphibian species were encountered during this survey. However, invertebrate aquatic life was abundant in the basins. We encountered snails (Physidae & Planorbidae), diving beetles (Dytiscidae), pond skaters (Gerridae), backswimmers (Notonectidae), diving bell spiders (*Argyroneta aquatica*), as well as the larvae of soldier flies (Stratiomyidae), dragonflies (Anisoptera) and damselflies (Zygoptera).

Discussion

Our results show that the population of European green toads living in the Rudolf-Bednar-Park (RBP), the nearby community gardens (CG) and ruderal site (RS) is much larger than previously thought. Morphological measurements showed a significant difference in snout-urostyle-length (SUL) and body mass (BM) between the sexes in both years. The temporal distribution of captured individuals was uneven, indicating distinct peaks in toad activity.

Recorded amplectant pairs follow a similar temporal distribution in 2015 but not in 2016. In contrast, spatial distribution of toads, pairs and spawn among the basins in the RBP followed different patterns.

The Lincoln-Petersen-Index could only be used to estimate the number of toads in and next to the basins of the RBP, because this was the only site which was consistently monitored throughout both field seasons. The calculated population size of 247 adult toads is almost five times the size of the estimate of Csarmann (2012), but since individuals from the RS and the CG were not included, the actual number of toads is certainly even larger. Recapture rates fluctuate depending on the whereabouts of the toads: individuals at the spawning site are much more conspicuous to the observer and have a higher recapture probability. Additionally, the seven individuals of unknown sex, which were left out of the analysis, could further influence these results. Therefore, data monitoring must continue for a definitive statement about the population size.

Even going by the captured 258 individuals, the population is far bigger than estimated by Csarmann (2012), who estimated a minimum population size of 54 adult individuals using the number of different tadpole stages. According to Kühnel and Krone (2003), the population at the RBP can therefore be classified as large.

Csarmann (2012) assumed an equal sex ratio of 1:1, whereas the captured individuals in this study yielded a skewed sex ratio of 2.31:1 for males, and calculations with the Lincoln-Petersen estimator calculated a more highly skewed sex ratio of 6.06:1 for males. Assuming a sex ratio of 1:1 and taking only captured male toads into account, the population would consist of at least 272 adult individuals. While the sex ratio of European green toads at two sites suffering from anthropogenic pollution is fairly close to equal with a slight skew towards females (Zhelev et al. 2014), sex ratios are usually highly skewed towards males in the common toad, *Bufo bufo* (Brede & Beebee 2006; Davies & Halliday 1979; Gittins et al. 1980; Hels & Buchwald 2001; Reading 2001). This is considered the result of females maturing later than males (Brede & Beebee 2006) and/or females not reproducing every year (Gittins et al. 1980). It is certainly possible that the former also applies to the European green toad. However, it does not seem likely that the majority of females reproduce less than once a year, because seven out of ten females captured at the basins in 2015 were also captured there in 2016, and three females were seen in amplexus multiple times in one season. The difference between the sexes in capture rates at the basins demonstrates that male toads spend more time at the spawning sites than females. Since toads are more easily captured at the spawning sites, this is certainly a relevant

factor for the estimated population size using only the toads captured in or near the basins. Additionally, calling males are more conspicuous than the silent females.

Interestingly, there has been an increase in feminisation in anthropogenically influenced amphibian populations (Lambert et al. 2015). The probable cause is contamination with estrogens or heavy metals (Lambert et al. 2015; Zhelev et al. 2014). This process does not seem to influence the population at the RBP yet. There probably still is a surplus of male individuals in the overall breeding population, as found in other amphibians (Elmberg 1990; von Bülow 2001).

Females are larger than males in 90 % of anuran species (Shine 1979). Since there is a strong correlation between age and size dimorphism in many anuran species (Monnet & Cherry 2002), a stronger dimorphism may indicate that individuals survive and reproduce longer. Without comparative data from populations living under more natural conditions it is not possible to make a definitive statement.

Fulton's index is a method of assessing the health of a population. We found no comparative data on body condition indices of the European green toad in literature and therefore cannot say if the Fulton's indices of the population in the RBP are at a healthy range. The comparison of Fulton's indices between years suggests that the population's health has stayed constant despite construction activities. However, the major part of construction on the RS is yet to come. Further monitoring in the coming years is necessary to show the effect on the toads. A comparison with populations living under more natural conditions would also help.

No toads were captured at the RS in 2015, and only seven toads in 2016. Nevertheless, on ten days in 2016 we could hear one to four males calling from a fenced area directly next to the construction site. Unfortunately, we had no access to the fenced area and could not record these toads. Therefore, we assume that more toads than recorded are reproducing at the RS. Additionally, it is alarming that the toads are so close to the construction work which is constantly going on, so that the animals are in danger of being run over by construction vehicles and buried under piles of rubble.

Six toads in 2015 and four toads in 2016 were captured at the parking lot near the RS. One of these individuals had previously been captured at the basins at the RBP. Two toads which were captured at the RS in 2015 during a telemetry study (Leeb et al. 2015) have been recaptured at the basins in the RBP in 2016. This demonstrates that at least some of the toads use not only the temporary puddles at the parking lot and the RS for reproduction, but move to the RBP for mating and possibly use the RS as hibernation site (Leeb et al. 2015).

We used the time between the first and last capture of a specimen in or near the basins as an approximation for the duration of the mating season. Both male and female toads were seen returning to the basins late in the season despite having already visited earlier. For males, this is to be expected because male anurans are generally capable of siring multiple clutches (Wells 2010). However, females returning to the spawning site multiple times in one year is surprising, because female European green toads are known to produce only one clutch per mating season (Castellano & Giacoma 1998), or even less (Gittins et al. 1980). Since we did not witness the actual spawning act in these cases, we cannot be certain that the females did indeed spawn multiple times in one year. As the basins and their immediate vicinity do not seem to provide adequate food for adult toads, and female individuals were not regularly captured in or near the basins, it does seem likely that the females visited the basins for reproductive activity. This interpretation is further supported by the three female toads which were found in amplexus in the basins twice in one year. Chances are that the mating females were disturbed by dogs or people and therefore had to come back again on a later occasion.

Males with a longer lasting reproductive season may mate more often because they spend more time at the spawning site, but it is also possible that they stay because they have not yet reproduced. Since only five males were actually observed mating twice in this study, and two of these were observed on consecutive days, it is not possible to determine what is the case. A study using genetic methods to determine paternity of spawn could provide valuable insight into this.

There was a spike in toad activity in April 2015, where we obtained more than one fifth of total captures in 2015 in only three days, and the number of amplectant pairs follows a similar distribution. In 2016, there was a peak in toad activity around the same time, but the peak in July was even higher than in April. The temporal distribution of amplectant pairs in 2016 peaked in April, but not in July. It is possible that we missed the second peak of amplectant pairs in 2016 because data collection ended on 31 July. Nevertheless, reproduction evidently continued throughout the season in both years.

Despite the similar structure of the basins in the RBP (with one exception: basin 7 lacked vegetation), the European green toads did not distribute evenly in 2015. The basins in the northwest were frequented less than those in the middle and southeast of the park. Even though the basins in the middle of the park hosted the highest number of individual toads as well as amplectant pairs in 2015, we found the highest number of clutches in the basins in the north-west of the RBP. A possible explanation is that in most anurans species where the males call from a calling site in the water, male territories are only used for mating, but not for oviposition.

Once a male enters amplexus, it is carried to a suitable oviposition site by the female (Höglund & Alatalo 1995 quoted by Wells, 2010; pers. observation). Because fieldwork was not regularly conducted past midnight, we were unable to observe the distribution of amplectant pairs among the basins in the morning hours. It is also possible we either missed disproportionately many clutches in the middle of the park, or they were destroyed at a disproportional rate.

At first glance, the perilous conditions in and around the basins seem to make successful reproduction difficult for the toads. Spawn and tadpoles are threatened by ducks, dogs and children, as well as numerous invertebrate predators. Those who survive until metamorphosis then face difficulties leaving the spawning basins, because the walls are smooth and concrete ramps designed to aid them are few and far between. Additionally, many of the ramps leave a gap to the edge of the basin, which the toadlets can fall into. Further problems arise once they have left the water, many of which are man-made and preventable. The basins are surrounded by paved roads, which heat up during the day and where numerous toadlets dry out before reaching the grass (pers. observation). Street grates in the vicinity of the basins are death traps for small toads, and even larger specimens were observed falling into grates in front of the Bildungscampus Gertrude Fröhlich-Sandner (BGFS) in the Ernst-Melchior-Gasse. Another trap for the toads are deep holes at the parking lot next to the RS where animals fall into and cannot find their way out anymore (pers. observation). Moreover, dead toads have been found in the cellar of the BGFS (janitor of the BGFS, pers. comment). With these problems it is uncertain if enough offspring can survive until sexual maturity to keep the population stable.

However, since we found multiple juvenile toads (one of which we captured as a juvenile in 2015 and as adult in 2016), at least some toadlets are able to survive their first year. This as well as the unexpectedly large population size means that it is likely that the population is healthy and self-sustaining. Nevertheless, action is required to minimise casualties and assure long-term survival of the population. Ramps to help toads get out could be placed below the grates in the RBP, and the meshes of the grates in the Ernst-Melchior-Gasse should be made smaller, so that at least large toads can no longer fall victim to them.

To confirm long-term stability of the population, assess effectiveness of any measures taken to aid the population, and to compare the average Fulton’s index with populations occurring in a more natural environment, long-term monitoring is necessary. The use of genetic methods could clarify the possible isolation of this population.

It is difficult to manage conservation projects in urban regions without the involvement of the public. While collecting data for the present study, we were frequently (often multiple times per evening) approached by curious passers-by inquiring about the nature of our work.

Although the responses were overwhelmingly positive, it is worrying that many people were not aware that the toads were in need of protection. The current signs near the basins indicating that the toads are a protected species are small, inconspicuous and heavily damaged (see Appendix, Fig. A2). Bigger and more informative signs may help curb the influx of children taking spawn and tadpoles from the pools as well as dogs displacing spawn.

Animals other than the toads should also be considered when planning the long-term future of the RBP. According to Csarmann (2012), no other amphibians inhabit the park, and macroscopic life-forms other than the toads and their tadpoles are exceedingly rare in the basins. The European green toad was indeed the only amphibian we found in the park and surrounding areas. This can be attributed to the relative isolation of the basins from other permanent bodies of water, and the barren environment both in and around the basins, which favours pioneer species such as the European green toad. However, we found numerous aquatic invertebrates, predominantly insects and snails, in the basins, showing that the toads are not the only species which depend on the basins. Aquatic life-forms are potentially threatened by the removal of algae from the basins (seen August 2015), which is especially damaging to fully aquatic organisms or those with multi-year larval stages. The diving bell spider (*Argyroneta aquatica*) was encountered in the basins in both years, which, to the best of our knowledge, is the first record for the RBP. This species is widely distributed in the Palaearctic, but few records for Austria exist in literature (Walder 1995). Although it can be found at various sites throughout Vienna (Gross, MA22, pers. comment), no data exists on population size and stability. In 1998, seven species of dragonfly belonging to the category threatened or higher were found in the Tritonwasser, located 2.7 km from the RBP (Chovanec & Raab 2001). A species survey is recommended to determine if some of these species also occur in the RBP. Last but not least, the fate of late-hatching tadpoles in the basins remains unknown. As spawn was encountered as late in the year as 17 August 2015 and 21 July 2016, tadpoles and/or freshly metamorphosed toads may still be in the basins when algae removal takes place. We recommend that future studies conduct further investigations into this matter.

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Appendix

Figure A1. Water basins in the Rudolf-Bednar-Park.

Figure A2. Sign informing visitors of the Rudolf-Bednar-Park about the European green toads.

Figure A3. Rudolf-Bednar-Park.

Figure A4. Ruderal site at the former railway station.

Figure A5. Construction site at the former railway station.

Figure A6. Construction site at the former railway station.