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Short Note

## In the footsteps of city foxes: evidence for a rise of urban badger populations in Switzerland

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### Abstract

Single observations of badgers in urban areas have been interpreted as relicts of formerly rural populations that have merely survived urban encroachment. However, decades after the rise of urban fox populations in continental Europe, there is evidence from Switzerland which suggests that badgers may be following a similar trend. We present long-term traffic casualty data, a comparison over time of camera trap studies, and incidental observations collected in a Swiss citizen science project which indicate both an increase of badgers at the national scale as well as a range expansion into urban areas. Their rather delayed and slow increase, compared to foxes, might be based on slower reproduction and less flexible behavioural adaptations. Our data, however, suggest that badgers are recovering delayed from a population depression following the rabies epizootic of the 1960s and 70s and may be starting to expand their range through the colonisation of urban habitats, similar as foxes did during the 20<sup>th</sup> century.

Urban areas worldwide are increasing in size (United Nations, 2014) and wildlife is increasingly confronted with the urban environment (Gaston, 2010). While the urban environment constitutes a serious threat to many species, others take advantage of its resources (Ineichen et al., 2012). One species thriving in anthropogenic habitats is the red fox *Vulpes vulpes*. In Switzerland, it is well documented how fox populations drastically increased after the passing of the rabies epizootic from 1967–1996 (e.g., Gloor et al., 2001; Fig. 1), a recovery trend which was also reported in other parts of Europe (e.g., Chautan et al., 2000). In the wake of this population increase, foxes became common and abundant in urban areas throughout Europe, a phenomenon previously known only in British cities (Harris and Smith, 1987).

In contrast to foxes, European badgers *Meles meles* found in cities were generally considered to be relict populations stranded following urban encroachment (Harris, 1984). Although badgers are known to occur in urban areas e.g., in England (e.g., Harris, 1984; Scott et al., 2018) and Norway (Bjerke et al., 2003), burrows are generally restricted to the edges of cities (Harris, 1984). This pattern did not appear to change, even decades after the rise of urban fox populations, although there is some evidence for active colonization of urban areas by badgers and an increase of urban badger populations in the UK (Davison et al., 2008; Huck et al., 2008; Delahay et al., 2009; for a review see Bateman and Fleming, 2012). However, recent and regular observations of

badgers roaming urban areas of Switzerland have begun to be reported. In this study, we evaluate the evidence for both a general population increase and the spread of badgers into cities.

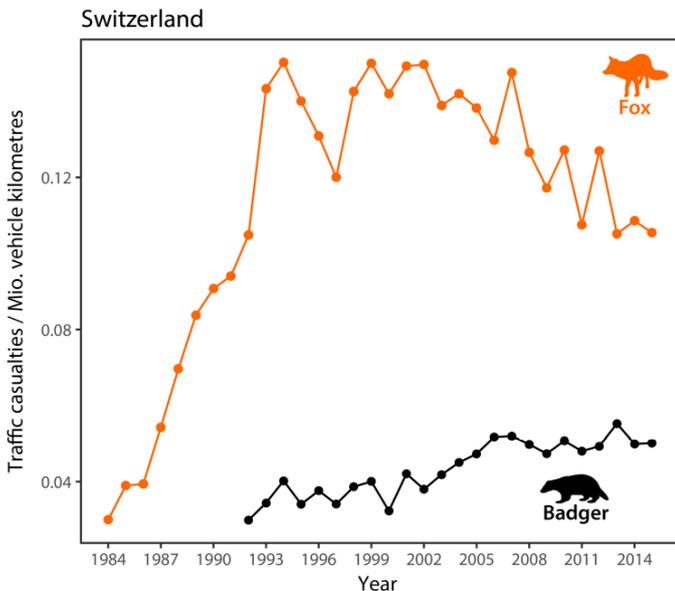
To investigate temporal changes in badger densities, we used three main approaches: first, official records of badger traffic casualties over the last three decades were collected and used to estimate changes in population density in Switzerland and in Zurich, the largest Swiss city (401000 inhabitants, 92 km<sup>2</sup>). Second, results from camera trap studies, conducted in the cities of Zurich and St. Gallen (79000 inhabitants, 39 km<sup>2</sup>), were analysed and occupancies of badgers were compared between years. Third, incidental sightings of badgers collected by game wardens and citizen scientists in the city of Zurich were evaluated. It should be noted that the names of Zurich and St. Gallen in this article will refer to the cities themselves (and not to the Cantons of the same names).

Counts of traffic casualties have been proposed as a suitable estimate for the abundance of a species in an area (Baker et al., 2004). Data on traffic casualties were obtained (1) for Switzerland from the hunting statistics of the Federal Office for the Environment (road traffic casualties from 1992 – 2015) and (2) for Zurich from the database of the local game sanctuary (road and train traffic casualties from 1996–2017). In Switzerland, the law requires deadly accidents with large wild mammals to be reported to gamekeepers. If traffic casualty counts are used as an estimate for wildlife abundance, traffic volume, and other traffic characteristics should be taken into account (Baker et al., 2004). Thus, the number of traffic casualties in Switzerland was corrected for an increasing vehicle number by dividing the number of casualties by the

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**Figure 1** – Trend of annual badger and fox traffic casualties in Switzerland. The mortality indicator “dead by traffic accident” was corrected for the sum of travelled kilometres per year in Switzerland. There are no data on badger traffic casualties prior to 1992.

sum of vehicle kilometres in each year (data from the Federal Statistical Office). Traffic casualty data from Zurich were not corrected for traffic related variables as the data were unavailable. However, the moderate human population and vehicle number increase from 1996 to 2016 (Statistical Office Canton of Zurich) and widespread introduction of zones with reduced driving speed give evidence that traffic risk for wildlife in Zurich increased only moderately, if at all. Spearman’s rank correlations were used to investigate the correlation between year and traffic casualties in Switzerland. In the city of Zurich, no data on traffic casualties were available for 2005–2008. Therefore, traffic casualties in the first (1997–2005) and the second (2009–2017) time interval were compared using a non-parametric Wilcoxon rank sum test.

In the years 1997 and 2014 camera traps were placed throughout Zurich to evaluate the occurrence of wild animals in the course of several research projects (Tab. 1). We compared badger data between these years only in cases where the camera traps had been positioned in similar habitats, as evaluated by calculating habitat class composition using GIS layers (Braaker et al., 2014) for each area where a camera trap had been placed in 1997. In St. Gallen, camera trap studies were conducted in 2008 and 2016 and camera traps were distributed evenly throughout the city in both years (Tab. 1). Observed occupancy, an indicator of occurrence, was calculated as the proportion of camera trap localities with badgers to the total number of camera trap localities in the study (Rovero and Spitale, 2016). To statistically evaluate if the occurrence of badgers has increased over the investigated time periods, camera trap data of Zurich and St. Gallen were summarised and a binary logistic regression was computed with absence (0) and presence (1) of badgers at a camera trap location as dependent variable. The independent variables were city with the categories Zurich (0) and St. Gallen (1) and time period with the categories “early time period” (0: 1997 in Zurich and 2008 in St. Gallen) and “late time period” (1: 2014 in Zurich and 2016 in St. Gallen). The interaction between city and time period was not significant and therefore excluded in the final model.

Observations of wild animals (by lay people and experts) in Zurich were collected in a database by the city administration Grün Stadt Zürich from 1986–1995. From 2013 onwards, incidental observations of wild animals by citizens have been registered in the online-database of the citizen science project StadtWildTiere [www.stadtwildtiere.ch](http://www.stadtwildtiere.ch). These were combined with traffic casualty data from 2008 onwards. Subsequently, badger observations from 1986 to 1995 were compared to data from 2008–2017. All reported analyses were conducted using Microsoft Excel 2010, R version 3.4.0, SPSS 25 and QGIS 2.18.2.

Across Switzerland, badger traffic casualties have increased more than twofold in absolute numbers between 1992 and 2015 (from 1349 to 2872 per year). Corrections of these numbers for vehicle kilometres revealed a significant positive correlation with time ( $\rho=0.863$ ,  $S=316$ ,  $p<0.001$ , Fig. 1). In Zurich, there was a significant increase in annual badger traffic casualties between the time interval 1997–2005 (median=4, range=3–9) and 2009–2017 (median=11.5, range=5–15;  $W=7$ ,  $p=0.017$ ). Evaluation of camera trap data from the two cities showed that the observed occupancy of badgers has increased more than threefold in Zurich between 1997 and 2014 and in St. Gallen between 2008 and 2016, even though the trapping effort per camera was lower in the later phases (Tab. 1). The period of observation (early or late) had a significant effect on the probability that a badger was captured on a camera trap, with a higher probability of capturing a badger in the late period ( $p<0.05$ ; OR 4.1; 95%-CI: 1.2–14.6). Additionally, the number of localities where a badger was captured on more than one night increased in Zurich from 0 in 1997 to 19 in 2014 (data not shown). Further, the probability of a badger observation was higher in St. Gallen than in Zürich ( $p<0.05$ ; OR 2.7; 95%-CI: 1.0–7.3).

The citizen-science-databases with incidental observations show that while badgers have been rare within Zurich from 1986–1995, observations of badgers were widespread throughout the entire city (not just in suburban areas and city edges but also in the core areas) from 2008–2017 (Fig. 2). Similar findings have been reported from other Swiss cities (Winterthur, St. Gallen; data not shown, see [www.stadtwildtiere.ch](http://www.stadtwildtiere.ch)).

Our data from multiple sources consistently indicate an increase in badger density in Switzerland and a range expansion into urban areas in the course of the last decades. While foxes in Switzerland started their population recovery and range expansion in the late 1980s (Fig. 1), traffic casualties of badgers indicate a delayed start and a slower population growth compared to foxes. The possible explanation arises that the observed, so far moderate, population increase of badgers marks the beginning of a similar urban colonization success story as occurred in foxes.

But why has the entire process been faster and possibly earlier in foxes? Or in other words, why have foxes, so far, been more successful in colonising an urban environment? Badgers and foxes are both medium sized carnivorans that exhibit great dietary flexibility (Harris, 1984; Contesse et al., 2004). However, later first reproduction (Pacifi ci et al., 2013) and smaller litter size (Jones et al., 2009) in badgers may lead to lower population growth compared to foxes. Furthermore, a higher dependency on the home den as well as more limited dispersal from it (Niethammer and Krapp, 1993) might render badgers less flexible in responding to the fast changing urban environment than foxes. This limitation may be compounded by the home den itself being restricted to certain habitats (e.g., wasteland, allotment; Huck et al., 2008).

**Table 1** – Details of camera trap studies conducted in the Swiss cities Zurich and St. Gallen. Observed occupancy is calculated as the number of camera trap localities with animal records divided by the total number of camera trap localities in the study. Superscripts denote used camera trap types (see footnotes).

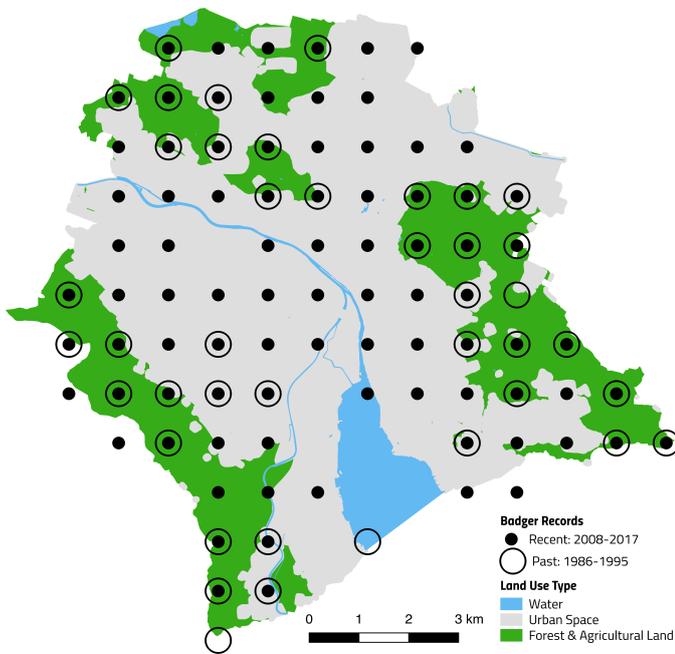
City & year of study	Zurich		St. Gallen	
	1997	2014	2008	2016
Number of camera trap localities	40 <sup>1</sup>	45 <sup>2</sup>	25 <sup>3</sup>	73 <sup>4</sup>
Trap-nights per locality	7.23	5.94	20.12	10.82
Localities with badgers	1	5	2	18
Observed occupancy badger	0.03	0.11	0.08	0.25
Localities with foxes	24	34	21	29
Observed occupancy fox	0.60	0.76	0.84	0.40

<sup>1</sup> compact cameras, BRAUN Trend DX AF 3 and AF-C;

<sup>2</sup> digital camera traps, Moultrie M80 GameSpy, Cuddeback Long-Range IR C2, and Reconyx PC800 HyperFire;

<sup>3</sup> analog camera traps, Camtrakker;

<sup>4</sup> digital camera traps, Cuddeback Long-Range IR C2.



**Figure 2** – Incidental observations of badgers recorded in the city of Zurich. Observations from 1986–1995 are compared with 2008–2017. Circles and points denote the presence of at least one badger observation per 1 km<sup>2</sup> grid cell in these time intervals, respectively.

Further research is needed to determine why badgers are in the process of expanding into cities. The current increase of badgers in cities might be the result of only recently occurring behavioural adaptations (Harris, 1982). In foxes, the adoption of “urban tameness” has been suggested as important factor for the colonisation of cities (Hegglin et al., 2015). Badgers appear to exhibit high flexibility in terms of diet, territorial behaviour, dispersal, home range size and overlap, and social organisation, attributes which might render them well pre-adapted for the urban environment once “tame” enough to colonize it (for a review see Bateman and Fleming, 2012).

It remains open if cities constitute sinks into which badgers from growing rural populations are migrating or isolated “islands” with more or less spatially and behaviourally isolated and adapted badger populations. The current strong population increase in cities suggests that urban areas are not simply spill-over sinks for rural badgers. Urban badger populations may even partially be isolated from rural population as was found in foxes (Gloor et al., 2001; Wandeler et al., 2003), although subadult individuals might still get into cities during dispersal. In any event, the consequences of a high urban badger density may be multi-layered. As relatively large mammals, badgers and foxes are charismatic “flagship” species that can help raise public interest in nature, which is a prerequisite for its conservation and of increasing importance regarding the trend towards disconnection from nature in urban citizens (Miller, 2005). Furthermore, urban wildlife has a potentially positive effect on ecosystem processes and human wellbeing (Soulsbury and White, 2015). On the other hand, badgers and their burrowing activity can cause damage to garden facilities and an increased density might thus be a nuisance for citizens (Bontadina et al., 2001; Huck et al., 2008; Delahay et al., 2009). Additionally, badgers may be a disease reservoir, e.g., for bovine tuberculosis, and while culling is one option for dealing with increased disease risk due to increased badger numbers, it may also make the situation worse by increasing the movement of rural animals which carry diseases into cities (Meylan, 2013; Hegglin et al., 2015). Additionally, increased badger densities in urban areas will likely have a knock-on effect on other sympatric species. While the digging activity of badgers will provide more possible den sites for foxes (Mori et al., 2015), increased badger density could result in increased competition over various resources between the two species, which share a similar diet in urban habitats (for a review see Bateman and Fleming, 2012). Moreover, badgers prey on European hedgehogs *Erinaceus europaeus*, and increased badger dens-

ities in urban areas therefore might have a negative effect on hedgehog densities (Doncaster, 1992).

To conclude, so far foxes have been more successful in colonising anthropogenic environments than badgers, possibly due to their faster reproduction and more flexible behavioural adaptation (see above). However, our data suggest that the badger is recovering from a population depression and might expand its range and colonise the urban habitat more extensively than previously thought, although with a temporal delay and at a slower rate than foxes. This pattern in badgers might not be confined to Switzerland, but become a European phenomenon as well. 🐾

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