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THE COMMON HAMSTER AS A SYNURBIST: A HISTORY OF SETTLEMENT IN EUROPEAN CITIES

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Abstract: Following the expansion of agriculture in the Neolithic period, the common hamster has spread throughout Europe, and occurred abundantly until the recent past. However, in the last 45 years, populations declined markedly, partly attributable to urbanization and to major changes in agricultural practices. As a result, the species has been considered endangered at international levels as well as in most European countries. At the same time, the species has established populations in large Central and Eastern-European cities such as Vienna (Austria), Simferopol (Ukraine) and Nalchik (Russia), where it inhabits green spaces such as parks, gardens, embankments and buffer strips. In an attempt to reveal factors enabling hamsters to cope with urban environments, we reviewed historical data and habitat conditions of several urban hamster populations. We suggest that supplemental food resources and reduced predation pressure were the main factors promoting urban occurrence of common hamsters in the last 30 years. Its notable adaptability may be associated with higher stress resilience, ecological opportunism, polyphagy and higher fertility compared to species

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relying on non-urban habitats. The phenomenon of synurbization implies coexistence of wildlife and our urban civilization, but at the same time conflicting interests in conservation and urban development. Thus, the common hamster might serve as a model species for efficient mitigation and compensation concepts in urbanism and spatial planning.

Keywords: *Cricetus cricetus*, urbanization, adaptation, urban population

INTRODUCTION

The fundamental aim of ecology is to increase understanding of how organisms interact with the biotic and abiotic environment rather than address a particular societal, conservational or economical problem. From this point of view, Sutherland *et al*. (2013) highlighted 100 fundamental ecological questions including: "what determines whether species adapt, shift their ranges or go extinct?" Urbanization is a unique and evolutionarily new phenomenon and it has no natural analogues. Many bird and mammal populations have colonized cities, and some of them are much more successful in urban conditions than in their native natural habitats (Luniak 2004). Among mammals, rodents in particular have adapted well to live in cities, for example the brown rat (*Rattus norvegicus*) and mice (*Apodemus* spp., *Mus musculus*). These rodents proved successful by taking advantage of their synanthropic existence, which allowed them to expand their habitats over most parts of the world (Kucheruk 1988). This phenomenon was termed "synurbization" (e.g., Andrzejewski *et al.*1978, Babińska-Werka *et al.* 1979, Babińska-Werka and Malinowska 2008), denoting the adjustment of wild animal populations to specific conditions of urban environments (Luniak 2004). In some cases, animals seem to be attracted by abundant resources such as food or nest sites available in urbanized areas. On the other hand, they may subsequently suffer increased mortality rates due to anthropogenic impacts or novel diseases (e.g., Luniak 2004, Rutz 2008). Evans *et al.* (2010) described three stages of the urban colonization process: arrival in the urban areas, adjustment to the urban environment and spreading within urban areas and to neighboring towns and cities. Adaptation to urban ecological niches requires changes in the behavior and ecology of synurbic populations in comparison with rural ones (e.g., Luniak 2004, Babińska-Werka and Malinowska 2008, Surov and Tovpinetz 2008, Surov and Bogomolov 2013).

The common hamster (*Cricetus cricetus*) primarily inhabits fertile steppe and open grassland habitats, and was wide-spread from Belgium across Central Europe, Western Siberia, and North Kazakhstan to the upper Yenisei and Altai region and North Western China (Wilson and Reeder 2005, Smith *et al.* 2008). As a classical synanthrope species („Kulturfolger" *sensu* Povolný and Šustek 1982), it has successfully spread into a variety of anthropogenic habitats including meadows, croplands (especially cereals), field edges, road verges and scrubby fallow areas on farms. In the eastern part of its range, it frequently occurs in gardens and orchards, in close proximity to human habitation, and is more abundant in these man-made habitats than in its native grasslands. Its diet mainly consists of the green parts of plants and seeds, supplemented by invertebrates and, occasionally, small vertebrates. At high densities, it has been considered an agricultural pest (Kryštufek et al. 2008, Nechay 2000), as described by Hanák Ker (1853): „… in 1769 they reached such a high number that they were killed in hundreds in the fields. The village Cseged gave up about 1,500 furs to Kassa" (now Košice, Slovakia; cited in Nechay 2000).

In the last 45 years, common hamster abundance has declined markedly throughout its range (Neumann et al. 2005). At the same time, numbers increased in several urban agglomerations from Russia to Germany (e.g., Čanády 2013, Franceschini-Zink and Millesi 2008, Schmelzer and Millesi 2008, Telitsina *et al.* 1994, Tovpinetz *et al.* 2006, Vohralík 2011). During the past decades, common hamsters have settled in gardens, cemeteries, parks and even buildings, and eventually established high-density and stable populations. On the other hand, peripheral hamster populations declined or even disappeared as a consequence of habitat destruction due to urban sprawl (Hoffmann 2011, Telitsina *et al.* 1994; V. Vohralík, personal communication).

Ground-dwelling rodents are generally classic subjects for research on population dynamics and population ecology (e.g., Boonstra 1994, Franceschini-Zink and Millesi 2008, Sinclair 1989), in particular while facing habitat alterations (e.g., Andrzejewski *et al.* 1978, Babińska-Werka et al. 1979, Babińska-Werka and Malinowska 2008, Kucheruk 1988, Surov and Bogomolov 2013). In the common hamster, the degree of interaction with human environments goes beyond that previously described for other endangered rodents (Banaszek and Ziomek 2010, Čanády 2013, Hoffmann 2011, Surov and Tovpinetz 2008, Telitsina *et al.* 1994, Tovpinetz *et al.* 2006). For this reason, research on urban populations of this species could provide substantial information about how synurbic mammals cope with the constraints imposed by altered environmental conditions.

Synurbic populations show ecological and behavioral differences as compared with populations of the same species living in their natural, non-urban habitats. In this paper, we aim to review the temporal occurrence of common hamsters in European cities from Russia to Germany and discuss some of the most typical features of synurbization according to Luniak (2004): high population density, altered circadian activity, adaptations of diet to supplemental food resources, tolerance toward anthropogenic structures and genetic modifications. Concluding, we outline possible costs and benefits associated with settling in novel types of environment.

MATERIAL AND METHODS

We examined data on the historical and recent occurrence of common hamsters close to human habitations from published papers, secondary sources, conference proceedings, online sources, reports, theses, our own unpublished data and personal communications. We compiled data gathered and published between 1977 and 2013, aiming to outline a review on the formation of synurbic common hamster populations in Europe as extensive as possible, proceeding from the East to the West.

RESULTS AND DISCUSSION

Urban occurrence of common hamsters

Russia

The first records of common hamsters in Moscow (Table 1) date back to the end of the 19th century (Karaseva *et al.* 1999), referring mainly to river banks, ravine slopes with bushy vegetation and other semi natural habitat. The largest colonies in the region were found in the south-east of Moscow, in the Lyublino and Lyubertsy sewage treatment fields. Wastewater accumulated in the ponds, separated by earthen ramparts 10-12 m wide and 2 m high. Due to high humidity, these banks were covered with bushes and grass and hence were favorable habitats for many rodents and common hamsters in particular. The Moscow Rodent Control Service surveyed this rodent population from 1963 to 1993 by trapping animals twice a year (autumn and spring). In 1985, the treatment plant was closed, and housing blocks were densely built on the area in the 1990s (Telitsina *et al.* 1994). Hence, these large hamster colonies in Moscow have diminished or disappeared. At present, the common hamster has survived only in the southern part of Moscow where it has been confined to the valleys of small tributaries of the Moscow River. The actual number of animals in the city is unknown. Until 2013, the species was included in the Red Book of Moscow City (2001), but was excluded from the latest edition (2013) (Moscow city government regulation #79 February, 19, 2013). As the landscape around Moscow currently does not contain habitat suitable for hamsters, the nearest recent occurrence of the species is located in the Ryazan region, 200 km to the South. Molecular genetic analysis revealed that Moscow haplotypes match with matrilines from that region (Feoktistova *et al.* 2013), indicating connectivity in the past.

There is evidence that the species has been common in Nalchik (Table 1), the capital of Kabardino-Balkaria, since the 1960s. According to sightings and the presence of inhabited burrows, unknown numbers still are widespread, mostly dwelling in private fruit and vegetable gardens throughout the city, in the large city park and around multistory buildings surrounded by shrubs and flower beds (F. Tembotova, personal communication).

Ukraine

While the common hamster had become rare in natural habitats in Crimea by 2000, it was recorded in eight cities and six towns of the Crimean peninsula in 2000-2004 (Tovpinetz *et al.* 2006). Over the subsequent eight years, it became even more widespread in human settlements and has been observed in 18 cities and 42 towns of the Crimean peninsula (Feoktistova *et al.* 2013) including its

Table.1. Geographic location, demographic and climatic attributes, and characteristics of common hamster habitats (location within city, anthropogenic exposure, area types) of six European cities. All cities have humid continental climate and are located in the same vegetation zone (temperate broadleaf and mixed forest; latitudes <46° 00' + temperate steppe).

		Moscow	**Nalchik**	**Simferopol**	**Lublin**	**Košice**	**Vienna**
Latitude / longitude		55° 45' / 37° 37'	43°29' / 43°37'	44° 57' / 34° 06'	51°14' / 22°34'	48°41' / 21°15'	48°13' /
Elevation (m a.s.l.)		156	490	250	200	208	170
Hamster habitat	Location / distribution	peripheral, patchy	area-wide	area-wide	peripheral patch - central	peripheral - central patch	peripher locally a
	Alteration	semi natural	anthropogenic - strongly altered	anthropogenic - strongly altered	anthropogenic	strongly altered	nearly na strongly
	Description	bank slopes	gardens, city park, urban green space	parks, gardens, street verges	grain fields, urban green space	cemetery	green be cemeter urban gr
Surface area (km^2)		2511	67	107	147	243	415
Urban (km around city centre)		15-20	4-6	6-7	6-7	5	10
Metropolitan (km around city limits)		75	15-18	15	10	12	20
Human population	Metro area	7,000,000	200,000	150,000	100,000	100,000	500,000
	City	12,000,000	240,000	360,000	350,000	240,000	1,700,0C
Precipitation (mm)		707	531	514	538	650	649
Mean temperature (°C)	January	-6.5	-2.5	0.1	-2.8	-2.7	0.1
	July	19.2	21.4	23.2	19.1	19.5	21.0
	Annual	5.8	9.6	11.2	8.2	9.0	10.7

capital Simferopol (Table 1), where its presence has been reported since the late 1970s (Tovpinetz and Alexeev 1992). Persistent colonies of hamsters not only occur on the periphery, but also in the center of Simferopol: During a survey in 2000, they were found in 13 localities within the city. Average burrow density around one of the central streets (Sevastopolskaya) was 36 per hectare in 2000 (corresponding to approx. 12 individuals per hectare when abandoned burrows were excluded) and 26 burrows per hectare in another survey conducted in 2012. Whereas burrow entrances occasionally lead into basements and underground public utilities of houses, the majority of burrows, however, were found under trees and shrubs (Feoktistova *et al.* 2013).

Poland

In 2005, common hamsters were localized in the grain fields of an experimental station of the Agricultural University of Lublin (Table 1) in the district Felin. Banaszek and Ziomek (2010) reported 73 active burrows and a population density of approximately 2.8 individuals per hectare between 2005 and 2008. The species' presence in urban parts of Lublin has been confirmed thereafter (Łopucki and Szeląg 2011).

Slovakia

In 1971-1972, the common hamster was found in 192 Slovakian villages, suburbs and even the centers of cities such as Sobrance, Mihalovtse, Trebišov, Velke Kapushany and Košice, as long as there were no pest control activities (Grulich 1977). Since 2009, the common hamster has recurred in the southern part of Košice (East Slovakia) after cessation of pest control in the 24 ha Public Cemetery (Čanády 2013). In 2012, a total of 15 individuals and 33 burrow systems were observed in the park-like cemetery area (Čanády 2013).

Austria

The largest populations of the common hamster in Central Europe inhabit Vienna (Table 1). They are virtually relics and have been investigated since 1995 (Schmelzer and Millesi 2008). After having maintained low densities for decades (personal observation), the population south of the Danube started to grow and thrive in the 1980s, coinciding with the termination of excessive application of rodenticides. In 2010, around 3,000 individuals dwelled in the outer green belt, cemeteries, parks and gardens down to embankments and street verges, and average density was 2.2 burrows per hectare (Hoffmann 2011). While Viennese „city-hamsters" rely on urban green patches in the order of 1000 m˛ and thus mathematically achieve population densities of 20/ha, the largest continuous habitats comprise 360 ha of the southeastern green belt with ca 250 burrows, and the 253 ha main cemetery with a projected 965 burrows. Another extreme is a renaturalized area along the S1 highway, where two dozen individuals could be found locally on less than one hectare (Hoffmann 2011). It should be noted, however, that these figures present solely a snapshot, since populations may fluctuate even within one season (natality, dispersal), and mortality in severe winters apparently strongly exceeds that of mild ones (Franceschini-Zink and Millesi 2008).

Czechia

In 1976-1982, the common hamster occurred in Brno. While it was not abundant in the urban area, larger numbers were found in the unwooded, open countryside southeast of the town (Pelikán et al. 1983). During the 20th century, hamsters were common in fields with heavy layers of loess soils at the north-eastern periphery of Prague. Spacious housing estates composed by blocks of high panel-buildings were erected in the 1970s, leaving large grassy plots in between. At present, this so called Severní Město (= North Town) has ca 100,000 inhabitants. Common hamsters survived there, mostly in ruderal plots as well as in grassy areas, where the vegetation is cut (Vohralík 2011). The species is also present in the western and southeastern suburbs where it inhabits abandoned fields, gardens and grassy plots in housing estates (V. Vohralík, personal communication).

Germany

Niethammer (1982) first mentioned records of common hamsters in lawns of cemeteries, gardens and parks of urban agglomerations in Germany. Currently, populations are known from the suburbs and peripheries of a few major cities such as Mainz, Mannheim, Hanover, Frankfurt, Göttingen and Braunschweig, where it occurs in the western parts with an estimated density of 0.3-3.0 burrows per hectare (Endres and Weber 1999, Kupfernagel 2003, Thorns 1998).

Potential factors facilitating synurbism

All of the above mentioned cities are situated within the historic range of the species (Kryštufek *et al.* 2008); with formerly only small populations in the Moscow area on the northern edge of the distribution range (Weinhold 1999). Despite the fact that some of them are considerably remote from each other (e.g., linear distance Moscow - Göttingen: 1,900 km) they have a similar, more or less continental, climate (Table 1), warm and humid with mild winters. The only exception is Moscow, where the climate is notably colder.

The common hamster inhabits fertile steppe and forest-steppe habitats, as well as in agricultural clearings in and near forest. Hence, its current range generally coincides with agricultural areas. In cities, it occurs in green spaces such as parks, cemeteries, gardens, embankments and buffer strips (Surov *et al.* 2013), which are often planted with adventive shrubs and trees. Hamsters are more or less polyphagous and thus forage on a variety of food species and types. In natural habitats in Poland, the diet mainly consisted of green parts and seeds of wheat and poppy (45%), clover, rape, beet, maize, lucerne and occasionally invertebrates (6.2%; Górecki and Grygielska 1975). In cities, ornamental plants and fruit trees provide supplemental high quality food such as blossoms, fruits and seeds of chestnut, sycamore, plum, honey locust, oak, walnut, filbert, rowan, arrow-wood, pear, apple and cherry (Surov *et al.* 2013), and vegetables (e.g., potatoes, corn and beans; Tovpinetz *at al*. 2006). Field observations confirmed that common hamsters foraged on seeds and parts of *Setaria* spp., *Tilia platyphyllos*, *T. cordata* and, most likely, *Thuja occidentalis* (Pelikán *et al.* 1983), and when available, females preferably cached fruits of apple, chestnut and cherry (Hufnagl *et al*. 2011). In cities, trees and bushes are often watered, which may increase food resources during drought, while garbage, dumps and human stores may be available for hamsters *ad libitum*. For example, discarded leftovers were frequently found in urban areas of the Viennese district with the highest hamster population densities, which could explain their accumulation just there (Hoffmann 2011).

Substrate with preferably heavy layers of loam and loess (Weinhold 1999) are a prerequisite for burrowing activities of hamsters. High population densities and abundance in Simferopol, Vienna and Prague may have been promoted by an optimal substrate, increasing the availability of numerous and stable burrow systems.

Due to the permanent presence of humans, urban hamsters are rarely exposed to potential predators such as kestrels (*Falco tinnunculus*), owls (e.g., *Bubo bubo*; Spitzenberger and Bauer 2001), red foxes (*Vulpes vulpes*), and its main mammalian predators (Niethammer 1982), various mustelids (*Mustela eversmanii, M. putorius, M. erminea, Vormela peregusna, Martes foina*; Siutz and Millesi 2012). However, dogs and cats locally substituted for the original predators: In Simferopol, we observed stray dogs to prey upon hamsters (unpublished data) whereas in Vienna, dogs are kept as more or less restrained pets and thus rarely cause harm**.** Cats may also pose a danger, mainly for juveniles and subadults. The brown rat (*Rattus norvegicus*) is a potential competitor, but may also be a predator of the hamster. Franceschini and Millesi (2007) observed rats attacking hamsters (mostly young ones) and competing for food, both most probably resulting from an elevated stress response.

Behavioral adaptations to urban environments

Although the common hamster is typically nocturnal (Niethammer 1982), it exhibited diurnal surface activity in Vienna (Schmelzer and Millesi 2003) as well as in Simferopol (Tovpinetz *et al.* 2006). As hamster burrows were located close to the main street of Simferopol, animals did not seem to avoid disturbance by traffic and illumination.

In the Altay foothills, a natural habitat, fierce male-male fights were recorded from May to June (Karaseva 1962). Information about aggression of the common hamster in urban areas is mainly available for Vienna (e.g., Franceschini *et al*. 2007), where most aggressive interactions between males occur in April and May, the peak mating period. Thereafter, almost no intra-sexual interactions were observed (Franceschini *et al.* 2007). The situation after male reproduction season compares to Simferopol, where males sniffed each other and separated peacefully, or even entered the same burrow. However, reduced agonistic behavior in Simferopol was observed in August, after the end of the mating period

(Lebl and Millesi 2008). Females did not seem aggressive in August as well, and they were more active than males, foraging to accumulate sufficient fat reserves and caches. Females were obviously less fat and some had pups, both of which might have stimulated their foraging behavior. Their average run per day was seven times larger than in males, which spent more time grooming and burrowing. Neither the number of litters per female nor litter size differed significantly from populations in agricultural areas (Kayser and Stubbe 2003).

Genetics

The question concerning possible genetic differences between synurbic and non-urban populations has no clear answer so far (Luniak 2004). Interestingly, hamster populations in the cities we reviewed belong to at least three different genetic lineages ("Pannonia", „East", and "West"; cf. Neumann et al. 2005), all of which obviously inhere the potential for synurbism. Thus, adaptations to urban environments rather seem due to the phenotypic plasticity of the species. Still, genetic differences should be kept in mind when preparing and conducting reintroductions.

Agricultural pest vs endangered species

Well into the 20th century, the common hamster was locally so abundant in Europe that rural communities offered rewards for killed specimens (e.g., Wick 1934 in Spitzenberger 2001), and the fur trade flourished until the 1980s (Franke and Kroll 1989). Today, the species is considered endangered on international as well as on most national levels. However, responses of the public to its presence are still ambiguous, urban hamsters are often confused with rats and/or fell victim to deratizations. The increasing abundance of urban hamsters after pest control reduction (Čanády 2013, Grulich 1977, Hoffmann 2011) indicates that nonspecific applications of rodenticides locally has led to low population densities near to extinction. On the other hand, population peaks in urban environments, with hamsters foraging and burrowing in gardens and orchards, may produce conflicts between conservation concerns and land users (Hoffmann 2011). Informed public relations and mediation between conflicting interests of ecology and the general public is thus essential for efficient, practicable and publicly acceptable conservation measures.

CONCLUSION

Given that basic requirements are fulfilled, common hamsters apparently benefit from proximity to human habitations in general and synurbism in particular. In urban agglomerations, they have access to supplemental food and are less exposed to predators, thus facilitating the establishment of persistent high density populations. We assume that the species' ecological opportunism, polyphagy and higher fertility as compared to other hibernators have been crucial for the ability to settle in urban environments. However, among the cities reviewed, hamsters occur synurbic *sensu stricto* only in parts of Nalchik, Simferopol, Lublin and Vienna, in that they successfully dispersed into urban areas where they had not been recorded previously. All other populations mentioned inhabit suitable patches at the periphery or in suburbs, the latter of which had been natural or agricultural hamster habitat until the recent past (e.g., Moskow: TELITSINA *et al.* 1994; Prague: VOHRALÍK 2011). Even in Vienna, the largest continuous populations have been found to dwell at the periphery (HOFFMANN 2011). Adaptability to different degrees of urbanization on a scale from nearly natural (e.g., outer green belts) to strongly altered (e.g., verges of main streets) and its genetic potential remain yet to be investigated.

The exposure to human impact is a substantial factor influencing the existence of wildlife in the urban landscape. On the other hand, artificially shaped areas might offer the opportunity to supply refuge areas and to manage the persistence of natural communities, provided that efficient conservation plans are implemented.

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CHOMIK EUROPEJSKI JAKO PRZYKŁAD SYNURBIZACJI: HISTORIA ZASIEDLANIA MIAST EUROPEJSKICH

STRESZCZENIE

Chomik europejski rozprzestrzenił się w Europie w następstwie rozwoju rolnictwa w Neolicie i do niedawna występował bardzo licznie. Jednak w ciągu ostatnich 45 lat, liczebność populacji wyraźnie spadła częściowo ze względu na urbanizację i znaczące zmiany w rolnictwie. W efekcie gatunek jest obecnie uważany za zagrożony zarówno na poziomie międzynarodowym, jak i w poszczególnych państwach europejskich. Jednocześnie jednak powstały populacje w dużych miastach Europy Centralnej i Wschodniej, na przykład w Wiedniu (Austria), Symferopolu (Ukraina) i Nalchiku (Rosja), gdzie chomik zamieszkuje tereny zielone takie jak parki, ogrody na nabrzeżach rzek i pasy buforowe. W celu ustalenia czynników umożliwiających chomikom dostosowanie do warunków zurbanizowanych, stworzyliśmy przegląd danych historycznych i warunków siedliskowych w kilku miejskich populacjach chomika. Sugerujemy, że dodatkowe źródła pokarmu i zmniejszony nacisk drapieżników były głównymi czynnikami sprzyjającymi występowaniu chomika europejskiego w miastach w ciągu ostatnich 30 lat. Szczególna adaptacyjność chomika może być związana z wyższą odpornością na stres, ekologicznym oportunizmem, wszystkożernością i wyższą płodnością w porównaniu do gatunków polegających na niezurbanizowanych siedliskach.

Fenomen synurbizacji zakłada współistnienie przyrody i naszej miejskiej cywilizacji, ale w tym samym czasie przeciwstawne interesy ochrony i rozwoju urbanistycznego. Tak więc chomik europejski może posłużyć za gatunek modelowy dla idei skutecznego łagodzenia konfliktów i wyrównywania strat w urbanistyce i planowaniu przestrzennym.

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