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Recent evidence for food storing in European ground squirrel (*Spermophilus citellus*)

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Abstract
Whereas European ground squirrels (*Spermophilus citellus*) do not utilize food caches during hibernation, it has occasionally been reported that they store food during the active season. Recent evidence for *S. citellus* maintaining food stores in summer arose during the long-term ecological supervision of a construction project in Vienna, Austria. From the onset of the project in 2012, ground squirrels were observed to forage on tubers of the tuberous vetchling (*Lathyrus tuberosus*). During the preparation of a building plot in July 2016, a cavity containing 380g of tubers of *L. tuberosus* was excavated by a digger when removing the upper 30 cm soil layer. When the construction area was expanded in July 2017, a ground squirrel repeatedly inspected a burrow on a future building plot, once carrying a tuber to the burrow. To examine if the burrow was vacant, it was stripped by layer, revealing a cache of 290g tubers in a blind-ending tunnel at a depth of about 90 cm. The structure consisted of one chamber without nesting material, and one tunnel containing the cache. We conclude that the burrow may have served as a hideout facilitating food intake while avoiding predation and other adverse external conditions.
Keywords: food caching, foraging, *Lathyrus tuberosus,* Sciuridae

Introduction

The European ground squirrel (*Spermophilus citellus*) is a medium-sized ground-dwelling sciurid endemic to Central and South-Eastern Europe. It lives in loosely structured colonies in grasslands on a range from natural to distinctly anthropogenic (Ramos-Lara et al., 2014). Because of the species' critical conservation status (Hegyeli, 2020, Ramos-Lara et al., 2014), interference with its habitat requires special permits by the competent authorities involving

mitigation and compensation measures. In Vienna (Austria), such interference has to be accompanied by a person in charge of so-called ecological supervision.

S. citellus constructs and maintains burrows up to 2 m deep (Brinkmann, 1951, Ružić, 1978) where it hides, rests, reproduces, and hibernates (Kachamakova et al., 2019). Permanent burrow systems typically consist of a 16- to 25-cm-wide nesting chamber. If present, a second chamber is used as a latrine (Ružić, 1978). It has been a common doctrine among ground-squirrel researchers that European ground squirrels do not maintain food caches for hibernation (e.g., Millesi et al., 1999, Németh, 2010). However, the presence of expandable inner cheek pouches (Zherebtsova, 2005) confirms their basic ability to collect or even hoard food. Indeed, the cheek pouches of European ground squirrels in Romania have been reported to retain up to 100 g grains of wheat (Calinescu, 1934). Nonetheless, the existence and nature of caches has been controversial, and records outdated: Müller and Müller (1882) reported lateral tunnels ("Nebenröhren") serving to store collected food that the squirrels consume before and shortly after hibernation. Some decades later, a popular scientific publication mentioned that the European ground squirrel carries stores collected in its pouches into its burrow (Floericke, 1932). Calinescu (1934) stated that *S. citellus* caches collected grains in its burrow, where a second chamber serves as a granary, containing seeds, leaves, insect remains and other stored food items. He also mentioned a ground squirrel foraging on a dead *Natrix natrix* and trying to pull it into its burrow. In Upper Silesia (nowadays south and north of the Czech-Polish border), European ground squirrels have been reported to cause damage in the 1930ies and 1940ies by foraging crops and carrying them into their burrows (Brinkmann, 1951). In September, about 3 handfuls of buckwheat grains were stored in the nesting chamber and in its afferent tunnel ("im Gange davor"). Unlike in Common hamsters, Brinkmann (1951) could not find specific chambers with large stockpiles in any of the burrows he excavated. From the relatively small amount of stocks found, he concluded that European ground squirrels harvest on easy-to-grasp crops only for a few days, and perhaps also for the first early spring days after the offset of hibernation. *Spermophilus suslicus* sparely collected stocks such as grass, grain, and tubers during summer (Ognev, 1947 cit. Niethammer, 1978). In 63 burrows excavated in 1950, no caches were found (Ružić, 1978). Grulich (1960) suggested that parts of plants sometimes found in burrows have likely been gathered by other rodent species. Herzig-Straschil (1976) observed European ground squirrels to carry food items into their burrows during the whole active season. She suggested that collected food is probably soon consumed; in any case, no caches were found during excavations of some burrows. Accordingly, Ružić (1978) stated that *S. citellus* may carry food

into the burrow for their offspring, but do not establish caches. Lagaria and Youlatos (2006) discussed the potential of a burrow being used for food caching but did not provide any further details. Since the 1970ies, research on the hoarding behavior of European ground squirrels and the structure of their burrow systems seems to have gotten out of scientific focus. In view of the outdated data availability, the present paper is the only one providing recent evidence for the species utilizing or even maintaining food caches.

Material and Methods

Since 2012, a mitigation and compensation project accompanying a building development has been going on in the Viennese north (16°25,3 E/ 48°17,7' N, 163 m a.s.l.). The site is inhabited by a population of European ground squirrels that have been monitored by continuous burrow mapping, capture-mark-recapture, and observations during the active seasons. Details of the capture technique appear in Hoffmann et al. (2008).

To divert the ground-squirrel population from the future construction site, maintenance of the habitat edges in the West and North was deferred successively. In 2015 and 2017, the Viennese environmental protection authority issued special permits to first remove the sod to deteriorate the western edges of the habitat, and then the upper 30 cm soil layer of the same area. These measures aimed at inducing the remaining ground squirrels to abandon their burrows and prepare the future building plots in evacuating them. Burrows present in the area concerned were stripped by layer with a mini-digger to verify their vacantness. The allotted measures were implemented in July 2016 and, on a further building plot, in 2017.

Results

Since May 2012, we observed ground squirrels feeding on tubers of a vetchling, the earthnut pea *Lathyrus tuberosus*, and we often found remains of tuber peels at burrow openings. Consumption of tubers became even more frequent after they were excavated when removing the sod and the soil. During the removal of the upper 30 cm soil layer of the building plot on 27.07.16, we discovered a chamber with more than 50 stored tubers of *L. tuberosus* about 30cm under the surface, corresponding to 380g. No tunnels were visible, and according to our mapping results, there had been a burrow in the area of the store until September 2014.

While supervising the expansion of the construction site in 2017, we observed a ground squirrel ever and ever again inspecting a burrow in the area concerned, even after the sod and the upper 30 cm soil layer had been removed. At one time it carried a tuber of *L. tuberosus* to one of the burrow's openings. To this, we found remains of tuber peels at the burrow openings every day. On 25.07.17, the burrow was stripped by layer to ensure its being unoccupied. In about 90cm depth, we came up to a cache of 290g tubers stored in a blind-ending tunnel (Fig.

1). The burrow consisted of one chamber without any nesting material and the tunnel containing the cache.

Figure 1: Excavating the cache on 25.07.17. a) a chamber and a tunnel stripped by layer with a digger. b) chamber and tunnel excavated by hand. c) emptying the cache in about 90cm depth. d) 290g tubers of *L. tuberosus* were found in the cache.

Discussion

There is consensus that European ground squirrels occasionally collect abundant food and carry it into their burrows (Brinkmann, 1951; Calinescu, 1934; Floericke, 1932; Herzig-Straschil, 1976; Müller & Müller, 1882, Ružić, 1978). This is confirmed by our own observations on a free-ranging population of marked *S. citellus* in the 1990ies in the Northwest of Vienna, where an animal lover fed the squirrels on a daily basis. At one time we observed that a male ground squirrel came from his burrow about 50 m away, stuffed his pouches with as many carrot pieces and sunflower seeds as possible, ran to his burrow, and returned a couple of minutes later with empty pouches to repeat the whole procedure several times (pers. obs. I.E. Hoffmann). If his pouches could retain up to 100 g of food (Calinescu, 1934), the male would have collected up to 0.5 kg of food after running to and fro 5 times.

Obviously, he must have stored carrots and/or sunflower seeds at least for a short time period in his burrow, even if he would have eaten some of the food immediately.

The main factor for the existence of food caches is the availability of storable food. Consequently, it might be a phenomenon restricted to areas with a high abundance of storable food, as applies to the earthnut pea on the project site (pers. obs. I.E. Hoffmann). *L. tuberosus* is a Fabacea developing edible tubers functioning for vegetative propagation and as stores of starch, sugar, protein, and fat (Hegi, 1975), which represent items ideal for caching also for longer periods.

As the diet composition of *S. citellus* depends on biotope, microrelief, age and sex (Dănilă, 1984), the same might apply to caches and their maintenance. The ground squirrel we had observed inspecting the burrow most likely was a male that we captured several times adjacent to the building plot after the burrow had been stripped. As it was the only specimen involved, no further conclusions are possible.

Caching might also depend on location and seasonal patterns, not to exclude tradition and imitation: the behaviour to consume unexpectedly abundant food seems to spread within a colony, as observed with freshly hatched summer chafers (*Amphimallon solstitiale*) in the 1990ies in the aforementioned colony (pers. obs. I.E. Hoffmann). Similarly, juveniles often start to carry nesting material into the burrow when their mother does so (pers. obs. I.E. Hoffmann).

Food caching has also been observed in North-American ground-dwelling sciurids: A Golden-mantled ground squirrel (*Callospermophilus lateralis*) having found more food than it can consume, caches the food to move it to a more secure location. There, the food can be stored for later consumption or consumed by family members (Breed, 2002). California ground squirrels (*Otospermophilus beecheyi*) utilize their cheek pouches while they are foraging to collect more food than would otherwise be possible in one sitting. The cache or store food for future use (Lima, 2003). Among adult Arctic ground squirrels (*Urocitellus parryii*), females carried food for immediate use, whereas males did so for caching; the latter rely on food caches for the energy they need to compete for mates in spring (Gillis et al., 2005). Similarly, the hibernaculum of adult male Columbian ground squirrels (*Urocitellus columbianus*) often includes a cache of food (Elliott & Flinders, 1991). A food cache may permit them to emerge earlier, and thus may yield reproductive advantages.

Conclusions

We presume that structures like the cache we excavated serve as temporary shelter enabling food intake while avoiding unfavourable conditions (e.g., predation and/or inclement

weather). Similarly, Breed (2002) hypothesized that by hoarding food, the ground squirrel protects itself from starvation during times of food shortage. We resume that European ground squirrels may establish and utilize caches when adequate food items are abundant. The detailed conditions under which food caching may occur in *S. citellus*, e.g. local and temporal prerequisites, remain to be investigated.

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