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Great capricorn beetle-created corridors as refuges for lizards

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Abstract

Ecosystem engineering is among the most important factors shaping ecosystems; however, it remains largely unstudied. Here, we present observations on three lizard species, the common lizard *Zootoca vivipara*, the sand lizard *Lacerta agilis*, and the slow worm *Anguis fragilis*, which use habitats created by the great capricorn beetle, *Cerambyx cerdo*. These galleries are heavily used by the common lizards and young sand lizards. We discuss the possible advantages of such beetle-created habitats for reptiles: antipredator refuges, hibernation sites, thermoregulatory behaviour, and preying activities. Since previous studies have reported numerous invertebrate species as well as vertebrates (including bats and snakes) in these refugia, we find the great capricorn beetle-inhabited oaks as potentially important microhabitats for a variety of animals.

Key Words

Anguis fragilis, *Cerambyx cerdo*, conservation, ecosystem engineers, *Lacerta agilis*, niche, *Zootoca vivipara*

Understanding the relationship between organisms can significantly help in managing the environment, restoring ecosystems to their proper condition, and taking appropriate measures to protect biodiversity (Wright et al. 2006; Calderón-Cortés et al. 2011).

Ecosystem engineers are characterised as species that modify or create habitats in a way that other species inadvertently can benefit from. Their activities are key for the existence of other species or for their increased survival rate. Examples of ecosystem engineers are earthworms, woodpeckers, crocodylians, turtles and beavers (Wright et al. 2002; Cockle et al. 2011; Regnery 2013a; Ojha and Devkota 2014; de Miranda 2017; Somaweera et al. 2020; Brazier et al. 2021). However, the interactions between ecosystem engineers and other species, although important for the function of ecosystems, are still poorly recognised and not fully understood.

The great capricorn beetle, *Cerambyx cerdo* Linnaeus, 1758 (Coleoptera, Cerambycidae), is a large (up to 56 mm length) saproxylic beetle. It develops under the bark and in the wood of old oaks. It prefers oaks (*Quercus robur* Linnaeus, 1753) with sun-exposed trunks and diameters more than 60 cm. The great capricorn beetle attacks trees, in which physiological processes have been disturbed. Its larval stage may last from 3 to 5 years. The larvae galleries are approximately 3.5 cm in diameter and up to 40 cm in length and often end with an approximately 10 cm wide oval cell (Kadej et al. 2017; Zan et al. 2017). These galleries are very durable and can persist for decades (Buse et al. 2007). Moreover, the deep corridors of the great capricorn beetle provide stable conditions inside the gallery which may be important for thermoregulation behaviour (O'Connell and Kepperll 2016). These galleries often serve as a refuge for many organisms and thus positively influence local biodiversity. It has already been reported that these microhabitats are used by several other beetle species (Buse et al. 2008), small bat species (Regnery 2013b; Gottfried et al. 2019a), and young grass snakes *Natrix natrix* (Gottfried et al. 2019b).

We describe the first recorded use of *C. cerdo* galleries by sand lizards *Lacerta agilis* Linneaus, 1758 (Squamata, Lacertidae), common lizards *Zootoca vivipara* (Lichtenstein, 1823) (Squamata, Lacertidae), and slow worms *Anguis fragilis* Linneaus, 1758 (Squamata, Anguidae).

Observations of lizards using galleries were conducted on two sites distanced approximately 15 km from each other: the forest meadow in the 'Las Rędziński' area in Wroclaw suburbs (site 1) and an oak alley on the Widawa River embankment in Wroclaw–Zgorzelisko district (site 2). The 'Las Rędziński' is a part of a protected area included in the Natura 2000 network ('Dolina Widawy', PLH 020036). The meadow in 'Las Rędziński' is a place where tree logs with confirmed great capricorn beetle galleries are stored. In 2020, 58 tree logs were stored in the meadow (Fig. 1), under a part of the programme dedicated to active protection of *Cerambyx cerdo*. Oak trees from Wroclaw and surroundings areas that must be cut down and are confirmed with *C. cerdo* larvae are stored in that meadow to protect and allow the larvae to complete development, in accordance with the recommended conservation action for this species. The average height of those tree logs was 1.78 m (60–425 cm) and the average circumference was 2.3 m (123–456 cm).

The old oak alley is located along the Widawa River embankment (51°07'47"N, 17°07'49"E). The oaks are old trees (mostly >80 years), and many of them are hosts for saproxylic beetle larvae. In 2019, after a storm and strong winds, one of the trees fell down, and was subsequently set on fire (an act of vandalism) and later cut into shorter pieces to unblock the alley. It was an already dead tree with numerous galleries, but the beetles had left this tree 2–3 years before.

Observations of lizards using the galleries at site 1 were conducted in May and June 2020 and March and April 2021. The observations were made independently during compensation action (RU) and other research and teaching field classes for biology students (BB, IG). The surveys were performed irregularly at different times of

Figure 1. A, B. An adult great capricorn beetle (*Cerambyx cerdo*); **C, D, E.** Larvae galleries in the oak logs stored on the meadow. Photographs by Iwona Gottfried (**A**), Bartosz Borczyk (**B, C, D**), Radosław Urban (**E**).

the day. Ten surveys were carried out in 2020 and five in 2021. Lizards were detected by observation of the tree logs from a distance of 2–4 metres. When a lizard was detected, the observer slowly approached the tree log and noted if the animal escaped on the ground or hid inside the corridor. Observations at site 2 (JK) were made on 16 June 2021.

Unfortunately, we do not have data on the density of the populations of both lizard species, as well as the distribution on the studied meadow (these studies are in progress), thus any statistical comparisons of those species would not be correct.

We observed several specimens of common lizards (<100 observations), sand lizards (>30 observations), and one slow worm occupying the tree-logs with confirmed great capricorn beetle corridors (Figs 1, 2). The common lizards were observed during each control at both sites (1–20 individuals per control), and the sand lizards were observed only at site 1 (1–10 individuals per control). The number of lizards on the tree log depended on the air temperature. When it was more than 30 °C, only a few individuals were observed (1–9). When the temperature was about 20 °C, more individuals occupied the tree logs with the great capricorn beetle corridors (19 individuals). The slow worm was observed on a single occasion (site 2).

We observed adult and young individuals of the common lizards and the sand lizards. In the case of sand lizards, most individuals observed on the tree log and in the tree holes were hatchlings and subadults, although some adult lizards were also observed using these refuges (Fig. 2A). Most individuals of both lizard species on the tree log hid inside the corridors at the moment when the observer slowly approached the tree log. Only a few animals (1 out of 21 observed individuals during 4 controls) escaped on the ground.

The slow worm was observed on one occasion. It was an adult individual. It emerged from the corridor and remained for some time on the log surface. Subsequently, it moved onto the ground undisturbed and crawled away into vegetation.

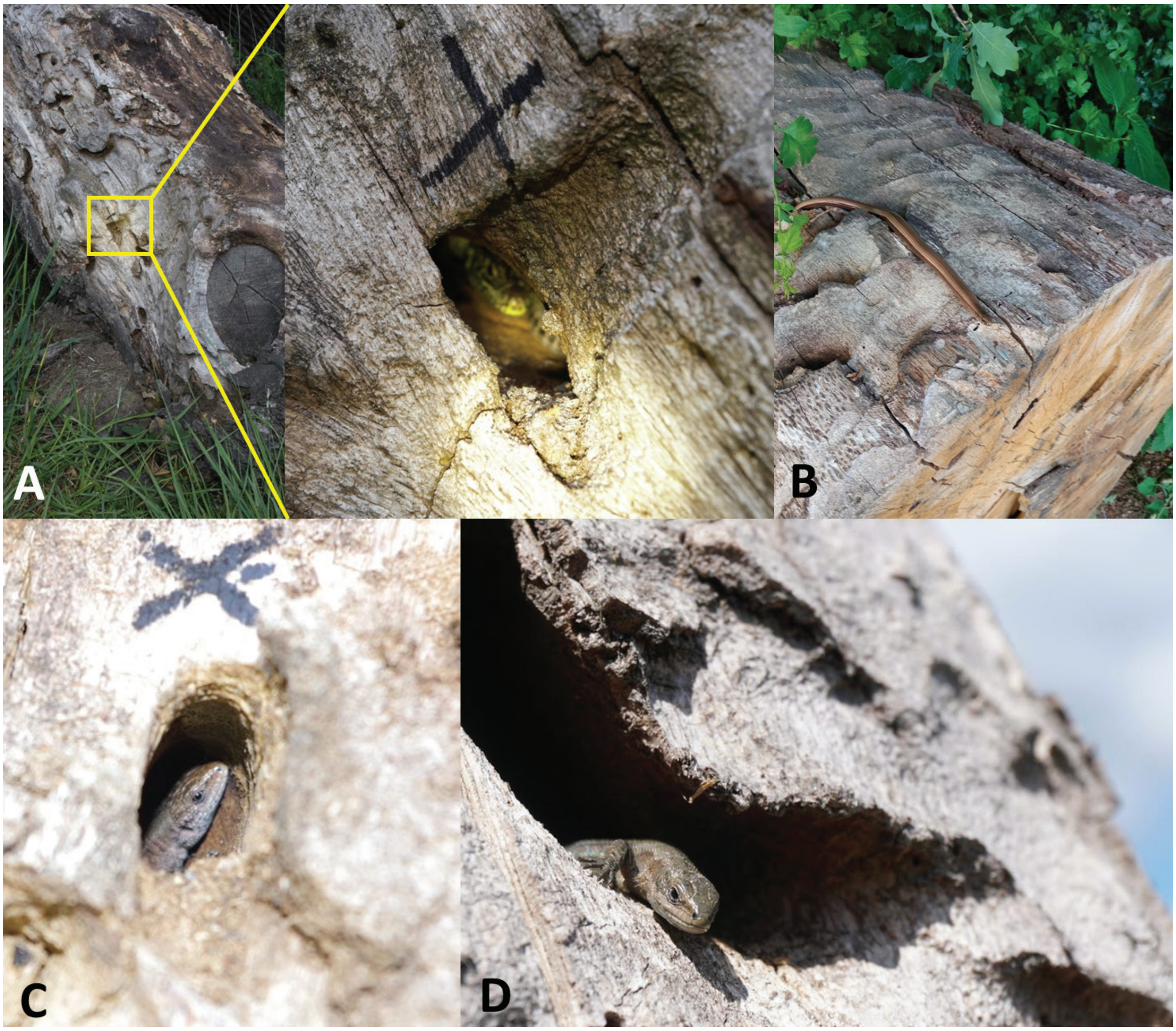

Figure 2. The sand lizard *Lacerta agilis* (**A**), the slow worm *Anguis fragilis* (**B**), and the common lizards *Zootoca vivipara* (**C, D**) in the great capricorn beetle larvae galleries. Photographs by Iwona Gottfried (**A, C**), Marta Mazurkiewicz-Kania (**B**), Radosław Urban (**D**).

In 2021 (28.03.2021), three common lizard adult males were observed emerging within a few minutes from the same corridor (site 1). That was the first observation of the lizards in this season.

There may be several reasons, not mutually exclusive, for the use of the great capricorn beetle galleries by lizards. First, individuals may use them as refuges when under attack (antipredator behaviour). The deep galleries may also provide stable thermal conditions (O'Connell and Keppel 2016) and thus may play an important role for thermoregulation, providing a shelter from overheating or hypothermia. Also, these corridors are often used by invertebrates (Buse et al. 2008), and lizards may simply penetrate holes when hunting. Finally, very early observations (the first emergence in the season) of common lizard males emerging from the same opening may suggest that lizards hibernate in these galleries.

The common lizards were more often observed on the logs than sand lizards, and younger sand lizards were more common than adult ones. This reflects the differences in microhabitat preferences between the species and within the species (sand lizard) and the differences in habitat use between hatchlings, subadults, and adults. This latter case may result from the higher tree-climbing capability of smaller, lighter lizards versus larger, heavier, and insufficiently agile individuals (see also Borczyk 2001). It may also be the way to reduce the risk of predation by larger lizards, as sand lizards are known to prey on the same species of hatchlings (e.g., Bury and Kolanek 2020). The air temperature also influences the number of observed lizards (Kolanek and Bury 2021). When it is too hot or cold, reptiles limit their activity or exposure to the sun. Therefore, the number of observed individuals depends on weather conditions, and this should be taken into account when planning regular research.

The meadow habitat was dominated by larger, more aggressive sand lizards, whereas the log piles were inhabited by the common lizard. This shows that storing the logs with the great capricorn beetle larvae galleries increases the heterogeneity of the environment and provides conditions for competing species to coexist in a relatively small area.

The slow worm was only noticed once. Likely, it may use the galleries as shelter only if the tree log has fallen on the ground or the gallery opening is near ground level, as this legless lizard is a ground dwelling and burrowing species. However, this species is often found under stones, pieces of wood, and similar objects, thus the presence of such deeply perforated logs may enrich its environment.

The translocation and storage of the tree logs with confirmed beetle corridors, enabling larval development, is an effective tool for conservation of those endangered species. It may also provide a positive environmental enrichment for local populations of lizards and other species by creating additional refuges, basking sites, and possibly hibernation sites. However, when the logs are transported, it may lead to unintentional relocation of animals and thus alter the interpopulation diversity. We do not advocate against the log storage and translocation as a conservation tool (we strongly support it), but we stress the need for careful examination of the logs for possible stowaways.

Conclusion

Our observations show that oak logs with the great capricorn beetle corridors are frequently used by common lizards and subadult sand lizards (this study) as well as grass snakes (Gottfried et al. 2019b). It is a clear example that the great capricorn beetle larva corridors seem to be an important microhabitat for small vertebrates. Numerous species may use them, and active protection of invertebrate species may have a positive impact on other fauna members.

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