In the Beetle's Black Home

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A pair of great capricorn beetles mating on an oak trunk.

Bog oaks, dating from around 6000 BC up to 1000 AD, have been discovered in various regions of Europe and have long been a source of knowledge about the paleoenvironment. Much less is known about the Holocene history of the great capricorn beetle (*Cerambyx cerdo* L.) due to the scarcity of any fossil or subfossil (an intermediate stage between fossil and modern) remains. In the Raba River sediments, however, subfossil bog-oaks trunks were found along with well-preserved areas affected by the great capricorn beetle, including subfossil larvae, pupae and adult forms. These trunks probably belonged to the pedunculate oak species (*Quercus robur* L.).

Five samples (one consisting of a great capricorn beetle larva and four consisting of oak wood) have been examined with the radiocarbon dating method; they date back to the period between 45 BC and 554 AD. Subsequent dendrochronological dating of the wood samples indicates two periods of their growth, namely 799–700 BC and 378–558 AD. Earlier

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An important discovery has been made at Targowisko in southern Poland, where ancient bog-oak trunks with well-preserved remains of great capricorn beetle galleries were found in old sediments of the Raba River. Traces of these insects in fossilized or partially fossilized wood provide valuable information, helping us interpret the ancient environment and climate.

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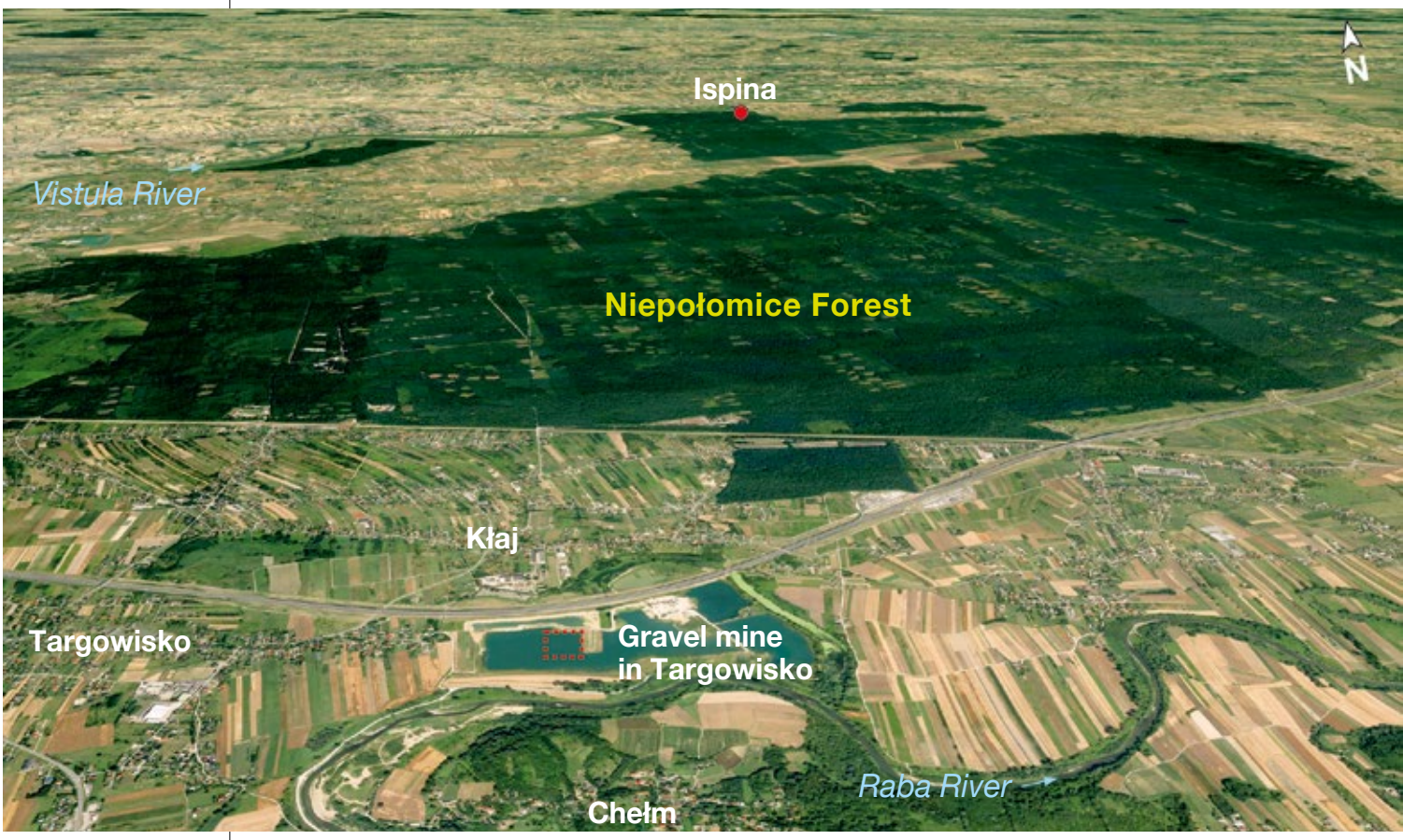

The location of black oaks with subfossil remains of a great capricorn beetle from the Roman Warm Period (red dotted line). The red spot in the Ispina region indicates the current habitat of the beetle in the Niepołomice Forest. Image from Google Earth.

discoveries of subfossil great capricorn beetle remains were limited to five locations only in Western Europe. The oldest of them, from the early Holocene (around 9000–10,000 BC), comes from northern France, the youngest (2351–1871 BC) from England. Our discovery at Targowisko, the sixth in Europe and the first in its central part, is the youngest (dating back to 799–558 BC) subfossil proof of the occurrence of the great capricorn beetle in the late Holocene. This find sheds new light on environmental, climatic and anthropogenic conditions.

Past and present

Subfossil oak – often called bog oak, fossil oak, or black oak due to its dark coloring – is the wood of various oak species that has been preserved in whole or in part in the ground or under water for at least a few hundred years. The preservation status of the tree-trunks depends mainly on the conditions in which they were buried, on the sediment chemistry and on their not being repeatedly relocated. Trunks of ancient trees that fell into rivers, swamps or peat bogs, then were quickly covered over with sediment, often remain preserved in very good condition. Rapid burial cuts off the oxygen supply and prevents or delays the decomposition of organic matter. The dark coloring itself is caused by the interaction of tannins in the oak wood with soluble iron salts present in the water. In consequence, over time the wood changes its color from the fresh, grey-yellow hues typical of oak to various brown and black shades.

The excellent condition of the beetles in the Raba River discovery indicates that the oaks were covered over rapidly, together with living insects. Especially the mummification of the beetle's larvae points to the trunks being covered by sediments quickly, as well as to a cut-off oxygen supply and a highly acidic environment maintained by oak tannins. Such conditions halted any decay processes.

The great capricorn beetle is the species belonging to the family of Cerambycidae (order: Coleoptera). It inhabits almost all of Europe, from southern Scandinavia to the Mediterranean area; it also occurs in northern Africa, Asia Minor and the Caucasus. It is more often found in the south, and less often in the

Sampling of a bog oak with galleries formed by the great capricorn beetle.

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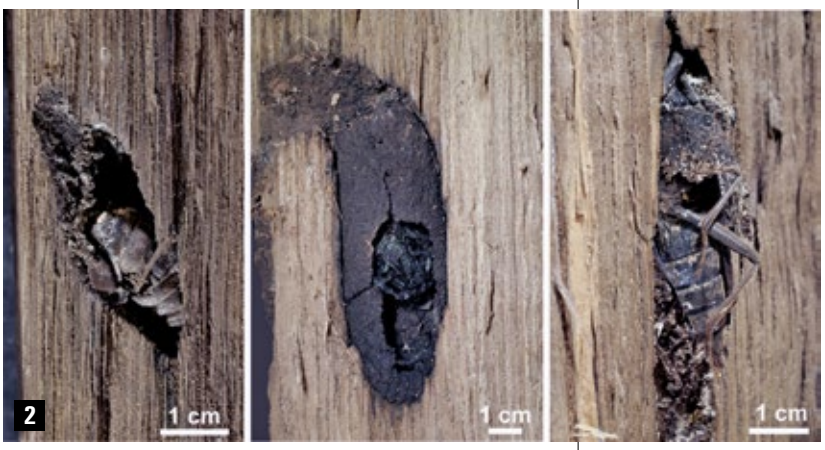


Fig. 1.
CT scanning of a black oak trunk at the John Paul II Hospital in Kraków. The recorded signal of the examined specimen and complex mathematical calculations (known as reconstruction) yield a three-dimensional image of the object.

Fig. 2.
Development stages of the subfossil great capricorn beetle: a larva (left) in its feeding tunnel, a pupa (middle) and an adult (right) in a pupal chamber.

central and northern regions of its geographical range. The species occurs in deciduous forests and larger forest city parks, as well as in smaller tree clusters. It definitely has a preference for oaks (genus *Quercus*), and in Central Europe it exclusively inhabits these trees; however, in southern regions it has been also observed on other deciduous tree species.

Adults live 3–5 weeks and are visible only during their short flying period. They are usually found on host trees from mid-May to early September, and most often in June and early July, at dusk, when they are most active during mating or feeding. In Poland, their entire life-cycle from egg to adult form takes 3–5 years, depending on the wood quality, habitat and climate conditions at the site.

The original habitats of the great capricorn beetle in Poland included forests with a large proportion of pedunculate oak, without a dense undergrowth, with dry soil, and alluvial habitats in river valleys and riverbank zones. Currently, the beetle occurs mainly in habitats of anthropogenic origin, e.g. single, old oak trees or their small clusters in parks and along roadside alleys and dikes.

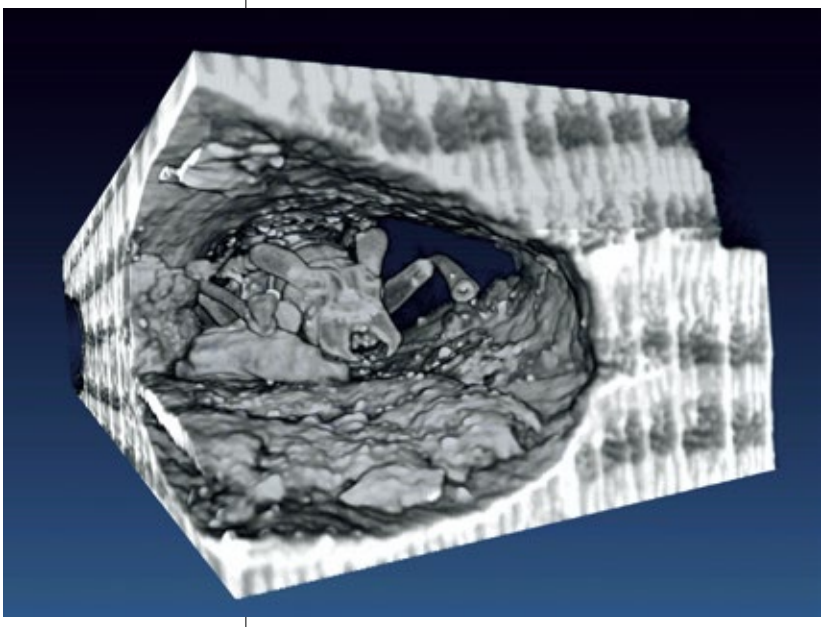
The earliest mention of the occurrence of the great capricorn beetle in Poland dates back to the second half of the nineteenth century. Over the last two centuries, the species has been registered many times, throughout the country. From 1930, a gradual decrease in its population numbers has been recorded in Poland. Despite the strict protection established in 1952, the decline in populations east of the Vistula River has intensified in the last 30 years. Currently, it is no longer present in the Białowieża Forest and in the Polish part of the Carpathians, and its occurrence at several other sites still requires confirmation. Its largest populations occur in the basins of the Warta and Oder and in the Warsaw region, where they are monitored.

The beetle was first registered in the Niepołomice Forest in 1954, and in 1973 it was found at two other sites. These three places, located in the north-eastern part of the Niepołomice Forest, consisted of old (300- to 500-year-old) pedunculate oaks well exposed to sunlight. Unfortunately, two of these sites have been eliminated when the oaks were felled; now the village of Ispina is the only known and confirmed site of the great capricorn beetle. It consists of a single, 200-year-old oak tree, growing in an alluvial forest habitat. The site was observed by Professors Ryszard Laskowski and Jerzy Starzyk from 1983 to 2015. In 1983, a few old oaks were growing there, and up to 50 individuals of the great capricorn beetle were found on the site. In 2010 and 2011 only five adult beetles were observed on the sole surviving old oak. In 2015, only two adults were observed. The current population of the great capricorn beetle in the Niepołomice Forest is therefore on the verge of extinction and depends on the last still-standing trunk of pedunculate oak – or to be more precise, on the people who decide about forest-cutting.

At present, the range and population of the great capricorn beetle is shrinking considerably, mainly due to adverse environmental changes, and especially the decrease in the number of old oaks, its hosts. The beetle is on the verge of extinction in Europe, therefore it is protected by law and red-listed in many European countries. It is also protected by the Habitat Directive

Life-cycle of the great capricorn beetle

The life-cycle of the new generation starts from the moment of fertilization. After mating, the female lays eggs one by one in slits within the thick bark on trunks of living old oaks. The larvae hatch after 10–14 days and start tunneling through the bark, where they overwinter. For the next two years larvae continue to feed deep within the tree. In the middle of the third year, its bore into the wood, forming tunnels which form an arc towards the outer surface of the trunk, where, at the end of the feeding gallery, a hooked pupal chambers, in which larvae pupates, are created. The entire length of the larva feeding gallery can reaches about 1 m. At the end of development in the wood (28 months on average), the larvae transform into pupae in pupal chambers. Pupation takes place at the end of July or at the beginning of August. However, the adults overwinter in pupal chambers, remaining dormant for the next 7 months until spring or early summer the following year, when they finally go outside to mate.



A three-dimensional image of a female great capricorn beetle found in a pupal chamber, obtained by segmentation of the microtomographic image. The age of the trunk: 344–536 AD.

of the European Commission and the International Union for Conservation of Nature, which has recognized the great capricorn beetle as a species globally threatened with extinction. Despite its general decline, the insect is still widespread, though, in some areas where intact oak forests still grow.

Native or foreign?

The site at Targowisko is located approximately 2 km south of the Niepołomice Forest, which is a remnant of the extensive lowland forest that once covered the western part of the Sandomierz Basin. Oaks grew there under generally favorable environmental conditions. These conditions deteriorated significantly only during floods, when the roots, growing in a shallow layer of soil, were deprived of oxygen, which might have adversely impacted the speed of tree growth. Those weakened oaks were then a good target for colonies of the great capricorn beetle. Well-preserved larvae, pupae and adult specimens found in the boring galleries in the studied oaks suggest that these huge trunks, colonized by several generations of this beetle, were knocked down suddenly (probably between September and April) and quickly filled over with sediments, preventing them from rotting under aerobic conditions or from decomposition.

The body length of contemporary great capricorn beetle adults is about 28–55 mm. Individuals living in the southern part of its range are generally larger, while those in the northern regions are smaller. The body length of the subfossil great capricorn beetles discovered by us varies from 46 to 52 mm. Although their number is too small for a statistical comparison, they are generally slightly larger than the individuals of the modern-day population in this region. Both the range and the number of great capricorn beetles in the studied area were probably greater and more compact than at present. This is confirmed by the relatively large number of galleries found in the many black oaks at Targowisko.

The accumulation of these black oaks in river sediments was synchronous with the warmer period known as the Roman Warm Period, occurring between late antiquity and the Dark Ages, from around 250 BC until 400 AD. This warming is known mainly from evidence in the North Atlantic area (Europe, North America). At the beginning of the Dark Ages, the climate cooled down, triggering the migration of peoples in Europe.

The Roman Warm Period was just one of numerous warm periods of this kind in the Holocene. Its end is correlated with enormous accumulation of fallen oak trunks found in the sediments of various river valleys of the Carpathians dating to 450–570 AD. As the results of our research indicate, the Roman Warm Period was the most favorable for the great capricorn beetle.

The accumulation of black oaks trunks in Targowisko can be associated with the wetter phases of the Vistula basin. One of the studied oaks fell around 700 BC, when this area was often flooded. The younger trunks probably represent two phases of falling. The trunks dated around 45 BC – 136 AD seem related to a phase when falling prevailed over sowing. Two samples dating from 344–536 AD and 403–554 AD, as well as three other trunks dated around 370–550 AD, might be associated with processes responsible for the massive accumulations of fallen trunks in the Carpathian region and in the Dniester basin, dating back to the years 450–570 AD. These events coincide with the beginning of the cold period of the Dark Ages, marked by floods and episodes of intense rainfall. A simultaneous accumulation of black oaks trunks has been noted in the area of Kraków and some other sites in the Carpathian foothills. After the Roman Warm Period, the environmental conditions for the great capricorn beetle deteriorated due to the cooling of the climate during the Dark Ages, as well as due to the continuous harvesting in forests and the decline of its habitats. In the Niepołomice Forest, deforestation was limited due to the protection of this area initiated by Polish kings.

The question remains as to whether the great capricorn beetle population of the Roman Warm Period survived the cold period of the dark ages, especially the Little Ice Age (a period of cooling from 1570 to 1900 AD) in small refuges, or became extinct, and the current population consists of immigrants from the south.

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Further reading:

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