

Supplementary Material 1. Description of the cultural, historical and natural values of the studied mounds

Kálvária-domb (*‘Calvary Mound’; Hungarian name*) in Szentes, Hungary

Coordinates: 46.643917, 20.272332

Other names: Vigyázó-halom, Vigyázó (*‘Sentinel Mound’; Hungarian name*), Őr-halom (*‘Guard Mound’; Hungarian name*), Szántó-halom (*‘Plougher Mound’; Hungarian name*), Temető-halom (*‘Cemetery Mound’; Hungarian name*), Kálvária-halom, Kálvária (*‘Calvary Mound’; Hungarian name*)

History

The Kálvária-domb (*‘Calvary Mound’*) is situated in the outskirts of Szentes town in Hungary. It was built in the late Copper Age by the Yamnaya Culture. Originally it was built for burial purposes, but in subsequent times it was used as a sentinel mound. This function was first reported from 1566, when the region was occupied by the Ottoman Empire (Balogh, 1887). The sentinel function was reflected in the name of the mound: Vigyázó-halom (*‘Sentinel Mound’*; in 1566, Balogh, 1887), *‘Őr-halom’* (*‘Guard Mound’*; in 1864, Szendrey, 1929). The sentinel guards were always local citizens, and this important task was generally inherited to the next generations of the same local family (Zsíros, 1990). Later, the mound was used again for burial purposes. In 1709, during the plague, the German military also used the mound and the neighbouring areas for burying the several hundred soldiers who passed due to the disease (Balogh, 1887). Since 1817, the area of the mound has been officially used as a Catholic cemetery, in which also a calvary, a crucifix, and a belfry were built (Balogh, 1887). Currently, the mound is still used by local people, and both the calvary and the old graves are maintained by the local population. The mound serves as a central place for the annual calvary procession during Lent.



Mown dry grassland among the graves (photo by Kristóf Süveges)



Calvary procession during Lent (photo by Ádám Bede)



Erodium ciconium, a rare arable weed on the kurgan (photo by Kristóf Süveges)



Invasion of planted and adventive species can suppress dry grassland vegetation in the abandoned parts of the kurgans (photo by Kristóf Süveges)

Landscape changes

In the 18th century, both the mound and the neighbouring areas were covered by dry grasslands according to the 1st military survey of the Habsburg Empire. At that time the name of the mound

was Szántó-halom ('Plougher Mound'), but this name likely reflected the name of a person (Szántó is a Hungarian surname), not the land use. From the 19th century the mound became isolated, as many of the surrounding grasslands were ploughed or were transformed to urban areas and graveyards.

Vegetation

Although a considerable part of the mound is covered by graves and ornamental shrubs, presently the small continuously mown parts of the mound provide safe haven for species typical to loess grasslands such as *Bromus inermis*, *Carex praecox*, and *Salvia nemorosa*. The mound also holds the population of the protected grassland-related *Ornithogalum brevistylum* and rare weed species (*Erodium ciconium*). The graves are overgrown by several adventive woody species that most probably were planted for ornamental purposes. The graves also hold several planted herbaceous ornamental plants such as *Sedum* spp., *Paeonia* spp. and *Senecio cineraria*. Probably the most interesting planted ornamental species is the *Amygdalus nana* that is a protected and red-listed species.

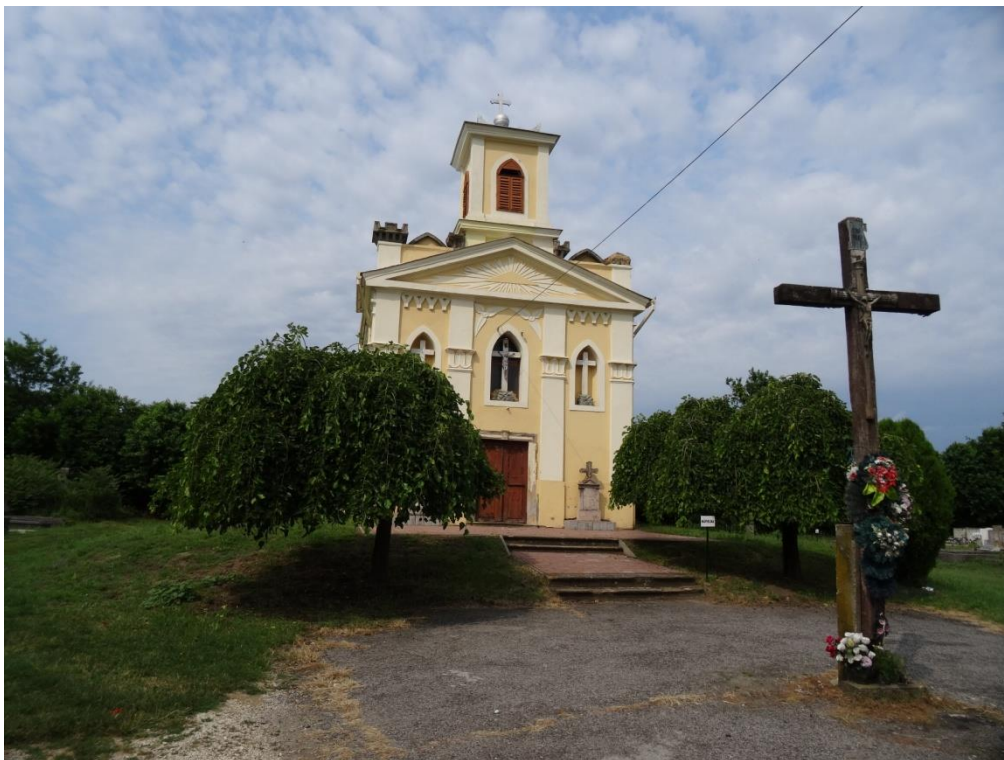
Akasztó-halom ('Hanger Mound') in Békés, Hungary

Coordinates: 46.7655224, 21.112406

Other names: NA

History

The Akasztó-halom ('Hanger Mound') originally formed a twin kurgan within the urban area of Békés town. The relatively flat mounds were built by the Yamnaya Culture. They had been the execution place in the city before the 19th century. Unfortunately, one mound was destroyed in the second half of the 19th century for mineral extraction. In the middle of the 19th century, a Catholic cemetery and a crypt were established on the other mound; they remained until present and are still used. However, the structure of the kurgan was damaged during the establishment of the cemetery and the crypt. Soil was removed from the top of the kurgan and the originally circular shape of the mound was formed into a square. In 1855, a road leading to the crypt was built on the mound. The road is lined by the stations of a calvary (Szelekovszky, 2002).



The crypt that was built in 1855 is surrounded by grasslands on the mound (photo by Kristóf Süveges)



Populations of typical grassland species *Salvia nemorosa* and *Thymus glabrescens* in the mown grassland of the kurgan (photo by Kristóf Süveges)



Species-rich dry grassland (photo by Kristóf Süveges)

Landscape changes

Even at the end of the 18th century, the twin mounds were covered with grassland vegetation. After losing its original function (execution place), one of the mounds was ploughed, then used for excavating soil, which destroyed the mound. Later an urban area was established next to the mound. The other mound was ploughed in the 19th century, but after the establishment of the cemetery, the grassland vegetation was able to spontaneously regenerate.

Vegetation

The mound is covered by a frequently mown recovering grassland that holds many species typical of dry grasslands (such as *Festuca rupicola*, *Thymus glabrescens*, and *Salvia* spp.). The kurgan also holds many generalist and weed species. The frequent mowing hinders the spontaneous establishment of woody species, which are mostly represented by planted ornamental species such as *Thuja orientalis* and *Morus alba*.

Temető-halom ('Cemetery Mound') in Iratoșu, Romania

Coordinates: 46.314990, 21.192134

Other names: NA

History

The Temető-halom that was probably built by the Yamnaya Culture is located in the outskirts of Iratoșu, Romania. Formerly it was situated in the border of Iratoșu (Nagyiratos) village and Vizes puszta (former administrative area); thus, functioned as a border mound. As a part of this function the mound held a border mark and a border ditch. The latter is still visible, and crosses the mound. The Catholic cemetery on the mound is still actively used was established in the 19th century. There is a wooden cross on the top of the mound. On the northern slope of the mound a chapel and several graves are situated.



Diverse grassland with *Salvia nemorosa*, *Silene bupleuroides* and *Stachys recta* (photo by Kristóf Süveges)



Frequent mowing could maintain several grassland species (photo by Kristóf Süveges)



Unmanaged, disturbed parts of the mound are invaded by *Ailanthus altissima* and ruderal weeds (photo by Kristóf Süveges)

Landscape changes

Both the kurgan and the neighbouring landscape were covered by grasslands in the 18th century. In the middle of the 19th century maps show that most of the grassland area had been ploughed in the vicinity of the kurgan, and there were apparent signs of urbanisation east of the kurgan. The first documented mention of the cemetery is also dated in this period. From the 19th century until present, the settlement developed further, and the proportion of grasslands remaining are negligible. Presently, the kurgan does not have a functional connection with other grasslands.

Vegetation

The east-facing slope and part of the north- and south-facing slopes of the kurgan are covered by a species-rich loess grassland holding many specialist species such as *Asperula cynanchica*, *Carex praecox*, *Festuca pseudovina*, *F. rupicola*, *Salvia* spp., *Teucrium chamaedrys* and *Thymus glabrescens*. The conservation of the grassland is supported by regular mowing around the graves and the wooden crucifix. The west-facing slope and part of the north- and south-facing slopes are heavily prone to the encroachment of adventive woody species such *Ailanthus altissima*, *Robinia pseudoacacia*, and *Lycium barbarum*. There is a high diversity of weeds (39 species) on the mound, including rare weed species as *Ajuga chamaepitys* and *Anagallis foemina*.

Cinci Movile ('Five Mounds'; Romanian name) in Vladimirescu, Romania

Coordinates: 46.160176, 21.420709

Other names: Öt-halmok, Öt-halom ('Five Mounds'; Hungarian name)

History

This kurgan group is located on the easternmost part of the Maros–Körös Interfluvium region (Vladimirescu village, Arad County; Romania). The group of five mounds was built by the Sarmatians during the Roman Ages. The original function of the mounds was related to burials, but the mounds also had a functional connection with an ancient linear rampart system (Csörsz-árok – 'Csörsz Ditch'). The ramparts were also built by Sarmatians and stretch for 1260 km along the lowland areas of the Carpathian Basin (Garam *et al.*, 2003). Documents from the 17th century mention the kurgans as strategic sentinel mounds (Márki, 1895). Given their unique configuration, as they are placed along a north-south ordered line, there are many legends connected to the mounds. Since the region has been inhabited both by Hungarian and Romanian people, both nations have their own tales about the construction of the mounds, which are still well-known by the local people. The legends involve stories about rovers piling the mud from their boots in five hills, giants who aimed to build fortresses, and people creating graves for sons who tried to assassinate their father (Márki, 1892). The origin of the mounds is also associated with the folklore of historical wars. There is a tale that the mounds are graves of the Dacian warriors of King Decebalus who were killed in the war against the Roman armies led by the Roman emperor Traianus (Fábián, 1835). Other tales say that the mounds were built for soldiers fallen during the Mongolian invasion (13th century) (Parecz, 1871), or for 68 Hungarian nobleman who were killed in the 'diet' (political meeting for noblemen) in 1331 because they took part in a treason leading to the blinding of the King 'Vak' ('Blind') Béla (1131–1141) (Márki, 1891).

Theories linking mounds with certain events were likely due to the archaeological artifacts (human bones and weapons) found during raiding the mounds in previous centuries. In 1852, a crypt was built into the southern mound. The southern mound also holds a calvary with 14 stations and there are also three crucifixes dating back to 1783. These objects likely contributed to the preservation of the grassland vegetation on the mound, since in this period all plain fertile grasslands had been ploughed in the landscape. Although these religious objects had been respected in the past, they are currently abandoned. This has led to an increasing negative human influence by placing lamp pillars, construction debris and garbage on the mounds.



Three crosses on Cinci Movable (photo by Kristóf Süveges)



Three out of the five mounds; only the one on the right holding cultural values is mown
(photo by Kristóf Süveges)



Weed encroachment in the unmown parts (photo by Kristóf Süveges)

Landscape changes

Based on the military maps, although the mounds have been covered by grasslands since their construction, the adjacent areas were predominantly used as arable lands. Until the end of the 19th century there was a grassland area situated south of the mounds, but disappeared in the 20th century. At present the kurgans do not have a functional connection with other grasslands.

Vegetation

The diverse grasslands on the mounds are loess grasslands typical to the forest steppes. Due to the vicinity of the Bihar Mountains, they also hold some floristic elements typical to foothill steppe vegetation (Molnár and Demeter, 2020). The vicinity of the crucifixes is regularly mown supporting the preservation of grassland specialist species such as *Filipendula vulgaris*, *Galium verum*, *Linaria biebersteinii*, *Ornithogalum brevistylum*, *Rosa gallica*, *Salvia pratensis*, and *Thalictrum minus*. Although the grasslands on the mound hold outstanding species richness, they also harbour many weed species and the northern slope is particularly threatened by the encroachment of woody species. We found a rare weed species (*Rumex pulcher*) on the mound.

Humka Kalvarija ('Calvary Mound') in Kanjiža, Serbia

Coordinates: 45.364396, 20.169803

Other names: Kálvária-domb ('Calvary Mound'; *Hungarian name*)

History

The kurgan is situated next to the fork of the River Körös-ér and was built by the Yamnaya Culture. The mounds hold a calvary dating back to the 18th century. Originally the stations of the calvary were placed east of the mound, but they were replaced to the north (as shown by maps from 1860). Before WWII, every year during Easter the local Hungarian Catholic population processioned to the mound crossing the whole settlement. Klamár (2007) reported that the Catholic calvary was renovated several times before 2007 and based on our field survey changes have been made then (e.g., local families have renovated the calvary in 2009). There are three baroque crosses made of sandstone on the top of the kurgan (the one in the middle represents Jesus, the ones on the two sides represent the thieves who were crucified together with Jesus).



Grassland with a high conservation value holding populations of *Seseli varium* and *Allium sphaerocephalon* (photo by Kristóf Süveges)



Diverse grassland around the crosses (photo by Kristóf Süveges)



The mound provides safe haven for grassland species despite being surrounded by orchards and arable lands for more than a century (photo by Kristóf Süveges)

Landscape changes

Even in the 18th century the mound was surrounded by arable lands; however, in that time an extended grassland area was situated east of the mound. Over the 19th century the settlement near the kurgan expanded and reached the mound, which led to the loss of primary grassland areas in the landscape. However, some of the arable lands have been abandoned resulting in the formation of secondary grasslands north of the mound that still exist.

Vegetation

The Humka Kalvariija held the highest cover of grassland species of our studied sites. probably due to the fact that this mound was the only one that was surrounded by grasslands. Also, the whole area of the kurgan was frequently mown. Like the Kamenita umka it also holds a large population of *Stipa capillata* and the protected *Agropyron pectinatum*. Also, the protected *Astragalus austriacus* has a stable population on the mound. Further grassland specialist species with high cover values were *Asperula cynanchica*, *Centaurea scabiosa*, *Euphorbia cyparissias*, *Festuca rupicola*, *Salvia nemorosa*, *Seseli varium* and *Thalictrum minus*. Weeds had a low species richness and cover, and were largely represented by rare weed species such as *Calepina irregularis*, *Camelina microcarpa*, *Glaucium corniculatum*, and *Valerianella dentata*. Woody species were not present on the kurgans at this site.

Kamenita umka (Stony Mound) in Žabalj, Serbia

Coordinates: 45.364396, 20.169803

Other names: Jurišina kosa ('Yuri's Hair'; *Serbian name*), Jurišina humka ('Yuri's Mound'; *Serbian name*), Žabalj (*Serbian name*), Zsablya-halom ('Zsablya Mound'; Zsablya is the *Hungarian name* of the settlement near to the mound), Kő-halom ('Stone Mound'; *Hungarian name*)

History

This mound was built by the Yamnayas and is situated in an elevated ground surrounded by the forks of the River Tisza (Koledin *et al.*, 2020; Jarosz *et al.*, 2021a, 2021b). During the 'Árpád Ages' (11–14th century) they built a stone temple on the mound that was surrounded by a cemetery. The temple was abandoned in later times, but the ruins (pieces of stone and brick) are still present on the surface of the mound. Although the graves are not visible today, human remains can be seen at the base of the mound, where the agricultural activity impacted the site. Besides two modern ones, there is an old carved stone geodetic point dating back to the 19th century.

The mound has several Serbian and Hungarian names. The name 'Stony Mound' reflects the ruins of the temple. The names Frog mound, Yuri's hair, Yuri's Mound is connected to an old family name, and the name Zsablya reflects upon the location as Zsablya is the Hungarian name of the settlement, where the kurgan is located.



The locally protected mound is surrounded by intensively used agricultural fields (photo by Kristóf Süveges)



The isolated mound holds the population of two rare steppe grass species (*Stipa capillata* and the protected *Agropyron cristatum*) (photo by Kristóf Süveges)



Adonis vernalis a strictly protected dry grassland species (photo by Kristóf Süveges)

Landscape history

The kurgan was surrounded by vast grasslands in the end of the 18th century. As the number of farms increased over the 19th century, grassland areas decreased considerably as former grasslands were ploughed and the kurgan became isolated. This pattern of landscape change persists to the present day.

Vegetation

Despite the fact that the mound was unmanaged, the entire mound was covered by a species-rich loess grassland holding a very high number and cover of grassland specialist species such as *Centaurea scabiosa*, *Euphorbia glareosa*, *E. cyparissias*, *F. rupicola*, *Salvia nemorosa*, and *Thalictrum minus*. *Agropyron pectinatum* (protected) and *Stipa capillata* that are typical but rare steppe species in the region were present with a cover of 20% and 25% respectively. The kurgan also held populations of several red-listed species such as *Adonis vernalis*, *Allium paniculatum*, and *Hypericum perforatum*. Although there was only a small proportion of woody species on the kurgan, the number of weeds was high. Among the weed species there were many rare ones such as *Calepina irregularis*, *Camelina microcarpa*, *Erodium ciconium*, and *Nigella arvensis*. Due to the high conservation value of the kurgan it was declared as a locally protected area (Stojšić and Kovačev, 2011).

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