Archeologia e Calcolatori
34.1, 2023, 289-298
doi 10.19282/ac.34.1.2023.31

ROMAN LAND USE AND ITS IMPACT ON THE PANNONIAN LANDSCAPE

1. Introduction

Contrary to the Mediterranean, indirect, unbuilt traces of Roman occupation and settlement in the Northern provinces are difficult to detect. Not only the detection of former villa buildings or settlement traces, but also the identification of traces of Roman land use can be problematic. The Northern provinces, such as Pannonia, came under Roman rule in the early imperial period, when they began to be pacified. In these areas the military presence can be traced from the 1st century AD. The process began with the building of military camps and then, as the camps were abandoned, colonies and other civilian settlements have arisen on their place. This is currently the main schematic picture of the early development of Pannonia. The first Roman colony of Pannonia was Savaria (Fig. 1), the birthplace of St. Martin of Tours. Despite what has been described above, no earlier legionary camp has yet been identified in Savaria. But around the settlement, which was founded around present-day Szombathely (Hungary) in ca. AD 50, during the reign of Roman emperor Claudius, the land was probably given to the veterans of the *XV legio Apollinaris*. The veterans who were settled were allocated parcels of land. So the surrounding area was determined by the regular system of land occupation established by the *centuriatio*. There are now solid archaeological arguments in favour of the Pannonian design of this parcel system.

2. Research history of the *centuriatio* in Savaria

During the 1960s and 1970s, when the *centuriatio* research started in Western and Southern Europe (Caillemer, Chevallier 1954; Bradford 1957), the use of aerial photographs was highly restricted and forbidden in Hungary. Even topographic maps were secret and of limited use. In the absence of aerial photographs, A. Mócsy (1965) attempted to reconstruct the traces of land division from the early period of the Roman empire in Pannonia and present-day Hungary based on topographic maps. In doing so, he has mainly investigated and documented the existing perpendicular network of roads, which can be identified on Gauss-Krueger topographic map sections at a scale of 1:50.000. Mócsy proposed a *centuria* system with a 67-68° (+n×90°) bearing angle (Gauss-Krueger projection) and a size of 16×25 *actus* (568×887.5 m). Since his publication, apart from E. Tóth's territorial reconstruction (Tóth 1977) and the article by Lajos Négyesi on the network of villa buildings, there has been no substantial contribution to the interpretation of the *centuriatio*

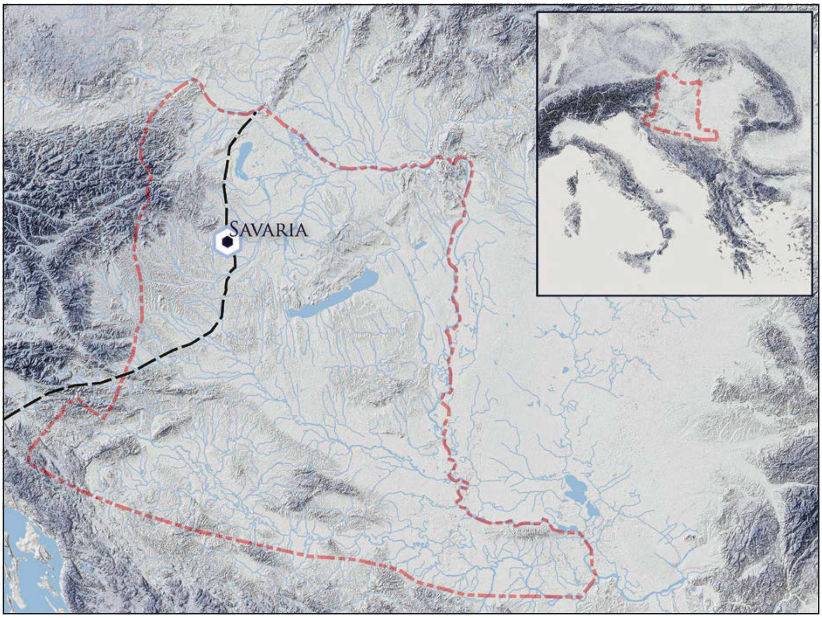

Fig. 1 – Pannonia and Savaria.

surrounding Savaria. However, A. Mócsy (1990) has already drawn attention to the fact that research in this direction is essential, both around Savaria and in the province. However this research had been remained practically abandoned for four decades, until a fortunate coincidence, in one of the pre-excavations of a road construction project in the late 1990s, a Roman dirt road crossing was discovered. Geospatial analysis showed that not only the roads at the cross-roads were parallel or perpendicular to the 25 km of arrow-straight Roman road published in the 1970s (Tóth 1977), but that they were regularly spaced at 1 Roman mile from it (Bödőcs 2008, 2013). By building a preliminary *centuriatio* model based on these values, we began to document various traces in the aerial photographs that corresponded to the model, and re-evaluated previous excavation data by using the model.

3. *Centuria* grid sizes

Based on the position of the archaeological sites, we searched for the best model to fit each known coordinate in order to reconstruct the most appropriate orientation and *centuria* dimensions. Since both the Hungarian topographic projection and the Roman division of land employ rectangular coordinate systems, the modern coordinate data were compared with the *centuria* values in a similar way to the Helmert transformation. Based on the differences of the x-y coordinate pairs and α degree rotation the relative *centuria* "coordinates"of the right-angled system were calculated using the following formula (Peterson 1993):

$$((X1-X2)\times\cos\alpha)-(Y1-Y2)\times\sin\alpha) \text{ and } ((X1-X2)\times\sin\alpha)-(Y1-Y2)\times\cos\alpha)$$

In fact, this can be considered as a relative Roman *centuriatio*-coordinate system. By using the relative coordinates of the sites, or the distance in Roman foot (*pedes*) and *actus*, it was also possible to calculate the possible side length – *modulus* – of a *centuria* unit.

According to ancient descriptions, the ideal *centuria* side-length was 2400 *pedes* (20 *actus*) and had a regular square shape, although ancient authors described other designs. By continuously varying the value of the angle α in the formula described above, it was possible to obtain a value which resulted in a rectangular grid with an orientation which, for all the known study points, showed the smallest deviation from the ideal (0) value. Based on these results, a regular square shaped *centuria* of approximately 707.5×707.5 m side length could be determined. The average value of the orientation angle α was 81.7°(+ n×90°) measured in the Hungarian projection (this is about 80° (+ n×90°) for the WGS84 projection). Thus, compared to the 16×25 *actus* grid proposed in the previous reconstruction, we were able to define *centuria* units with a base area of 20×20 *actus*, which was also considered as ideal by the authors of the *Corpus Agrimensorum*, with an orientation of 80° (+ n×90°) instead of the previously proposed orientation of 67-68°(+ n×90°).

4. Control data

Hundreds of military images, taken between the 1950s and 1980s, were reviewed and other available satellite images (e.g. Google Earth) were analysed using the newly defined parameters. New excavation data was inserted into the system as control data. Furthermore aerial recognition was carried out to locate possible road crossings based on our model. In many cases, we were able to document or recognise the significance of phenomena that we would have missed without the model. There was usually a very small difference (<10-15 m) between the theoretical coordinates and the documented traces, which shows the astonishing accuracy of ancient surveyors.

During this process we could found the westward branch (Fig. 2, left) of the Roman road that was mapped E of the town in the 1970s (Tóth 1977). They were practically connected along a line (Bödőcs 2013). This road is most probably the main axis, the *decumanus maximus*, of the *centuriatio*. We also tried to confirm the model by geophysical research (Fig. 2). The results

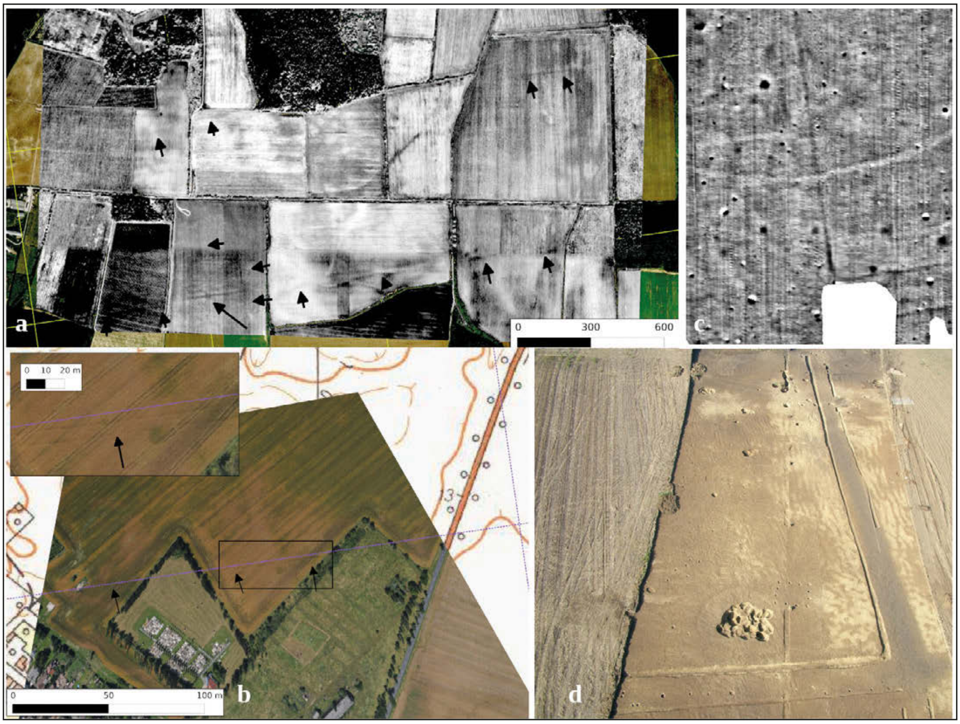

Fig. 2 – The visible traces (left to right) of the *centuriatio* of Savaria on a) archive photos; b) recent oblique photo; c) on geophysical suryey, and d) the excavated surface of Roman *centuriatio*'s road crossing.

showed that the *centuriatio* model is correct and working. We collected data continuously since then.

Surprisingly, not just a single section of formerly roads, but coherent (ca. 10-12 neighbouring) *centuria*-divisions could be documented in the late spring and late autumn images (e.g. Google Earth) since years 2018-2022. Based on this, we have launched new research that now aims to conduct a geophysical survey of the entire surface of the known *centuriae*, in order to get an image of possible parcels within a single *centuria*, thus detecting veteran estates. The results of this study are expected by 2023-2024.

5. The relationship between *centuriatio* and landscape

One of the most striking things we observed was how precisely Roman engineers could work. The observed phenomena hardly deviated from the theoretical, computer-designed network, which shows their geodetic skill. At the same time, this raised several questions which indirectly led to a kind

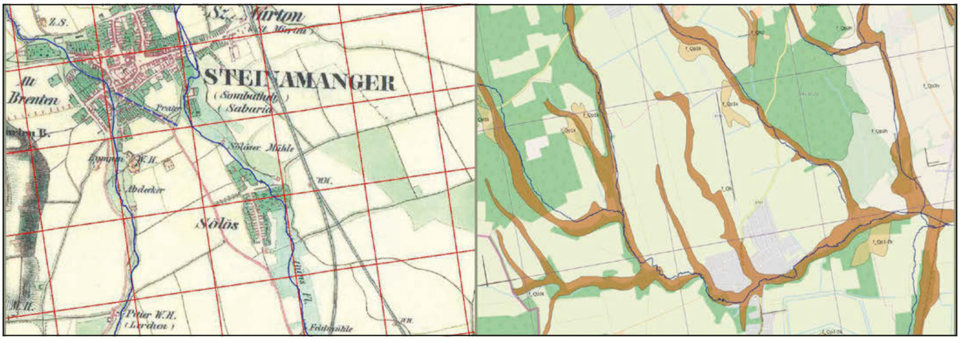

Fig. 3 – The Habsburg military survey showing the 19th watercourses S from the Roman colony with the *centuriatio* grid (left); the sediment map of the Ják-Sorok region shows the alluvial soil corresponding to the *centuriatio* grid (right).

of environmental reconstruction questions and answers. The research has long adopted the words of ancient geographers describing Pannonia as a topos-like contiguous forested area. The image of the *glandifera Pannonia* (acorn-bearing) suggested that there were extensive woodlands here, where the new veterans arrived at and, like the medieval hospices, cleared forests to acquire land. Even charcoal layers found in late Iron Age strata during soil drilling were attributed to this. This was clearly not the case, given the extensive geodetic work. The available *centuriatio* traces suggest the formation of a large land division grid, which was already in use at the time when the first *veterani* arrived after the foundation of the town. If they had been arrived to contiguous woodlands, this could hardly have been done in a short time. This is not an insignificant point since a few decades earlier there had been a rebellion over the lands of the resettled veterans. Whoever staked out a straight line in a forest have experienced that it is almost impossible to stake out a large area quickly in this way. For this reason, it can be assumed that the Romans were greeted by a landscape similar we have today.

Another interesting point is that a comparison of the *centuriatio* grid and the geographical (mainly hydrological) environment reveals the extent to which there is a correspondence between the Roman division and the hydrography (Fig. 3). The hydrographic data from maps of Habsburg military surveys show the situation before the great water regulations in Hungary in the second half of the 19th century (Kovács 2010) and a lot of similarities with the *centuriatio*. Some of the watercourses, instead of flowing downstream in the area, take a sharp, sometimes 90° bend and flow in a different direction according to the orientation of the *ceturiatio*. Although of course we cannot exclude the possibility of coincidences, it is striking that these phenomena often run unusually, and also unjustifiably, like based on the Roman pattern.

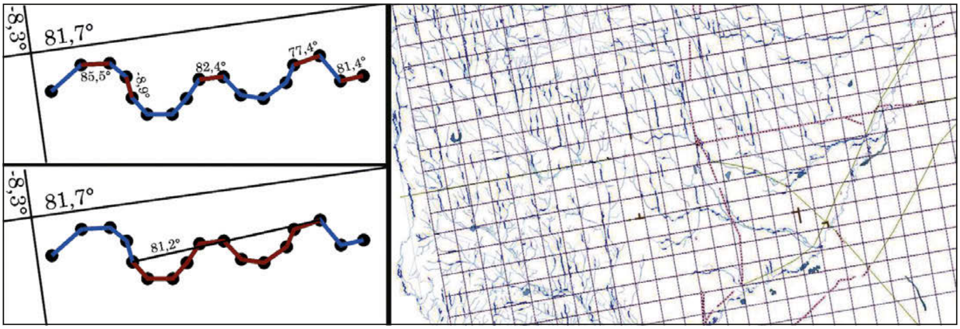

Fig. 4 – The methods and the results of the hydrological vector layer analysis.

The *centuriatio* model has not only opened new possibilities to hypothesize and locate former roads or sites along roads (such as burials), but also to investigate Roman attempts to transform the natural environment. The large-scale parcelling out of the land may have involved the construction of irrigation and drainage channels (Chouquer, Favory 1991, 103). The borders of the *centuriae* were often formed by artificial elements (roads, ditches, canals, possibly tree-lined streets), whose directions coincided with those of the rectangular system. The reason for this is that the boundaries of the estates may have been formed not only by field roads but also by common drainage or irrigation channels. This could not only involve the digging of smaller canals, but also the diversion of prehistoric (ancient) watercourses into new channels, altering the natural environment. Traces of this can be found in some sections of watercourses, which have been analysed using GIS tools to find a correspondence between the course of the water system and the direction of the land allotment system (*centuriatio*).

These channels have now become the natural beds of watercourses. The artificial transformation of watercourses is already attested. In fact in Szombathely, S of the former *colonia*, an earlier branch of the Perint stream, not documented in the maps of 19th and 20th centuries (Fig. 3, dotted line), has already been identified during archaeological excavations (Mladoniczki, Sosztarits 2009; Bödőcs, Kovács, Anderkó 2014). This is a branch that corresponds more to a natural flow direction, while the still active bed of the Perint stream in this section turns sharply southwards and follows the orientation of the *centuriatio* for almost 1.5 km. The established property boundaries (roads, canals) may have survived somehow until the Middle Ages, and sometimes until the modern era.

Although the GIS analyses have identified several areas where the current picture of the hydrological environment differs slightly from the “expected”

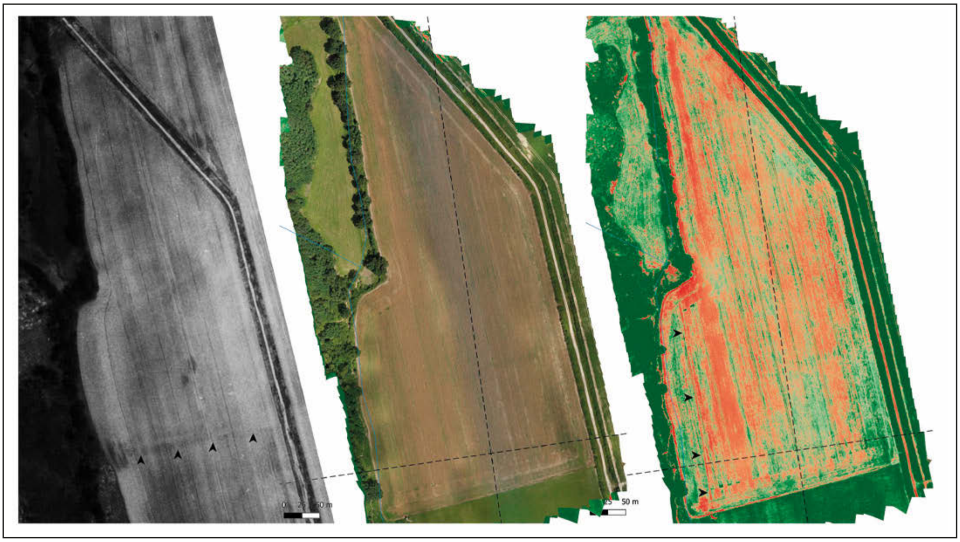

Fig. 5 – Details of the Ják-Sorok region (left). Aerial photo from 1993 showing the *centuria* border, and the result of the UAV surveys in visible spectral range (middle) and NDVI composite (right).

flow direction based on topographic conditions, the results are not yet available. In this modelling exercise, a preliminary study produced from a current digital surface model (SRTM) was used to delineate zones defined by comparing the recent hydrographic environment with the modelled runoff. In these zones, "unexpected" changes in flow direction, not fully explained by topographic conditions, were observed in many cases (Kovács 2013). Another geospatial analysis method was used to investigate the digitized trajectories of current river flows.

Based on the assumption that, although an artificial canal was once constructed with the same orientation as the *centuriatio*, the former artificial beds may have gone wild after regular maintenance ceased, becoming active watercourses with natural meanders along the course of the riverbed. Therefore, map analysis was used to compare the different sections of each watercourse. The digitized hydrographic layer was divided into edges and vertices and so one edge's orientation by one, or "in blocks", i.e., 10 sections' average orientation was analysed together at the same time (Fig. 4, left). Thus, a distribution map (Fig. 4, right) was produced for the hydrography of the area, on which the watercourse sections that could be correlated with the *centuriatio* orientation were marked (Bödőcs, Kovács, Anderkó 2014).

It should be noted that, unlike man-made artificial features (e.g. roads), in the case of watercourses the course is not expected to be perfectly straight, since the energy of the watercourse has been able to shape its bed since Roman times, i.e., it only maintains the main course of the river. In the case of a stream with a higher water flow, the flow direction in the area is usually broken, briefly taking the direction marked by the grid and then returning to its previous natural direction.

When mentioning the modification of the water system around Savaria, we should also note the recently excavated riverbed (Mladoniczki, Sosztarics 2009, fig. 1), which existed in the Roman times and has since then been filled in, and which may have connected the waters of the present-day Perint and Gyöngyös creeks. If we assume that this section could be an original riverbed, we must also consider the section of the Perint creek S of the town to be artificial (Fig. 3, left). The stream, after flowing NW-SE direction, turns sharply and flows S for 2 *centuriae*, whereas the natural flow would be in a SE direction. A branch is still marked here on a map from the 18th century, and we even know from early modern descriptions that it was fenced by a palisade (Horváth 1993, 15-16). Excavation has indeed revealed traces of this palisade and of a former water basin. However, the branch that still exists today runs southwards for about 1 Roman mile, according to the *centuria* borders.

In this region, we have noticed several places where the streams run in a surprisingly straight line (Fig. 3, right) following the orientation of the *centuriatio*. So, we started to investigate sections that change direction sharply at confluence. We are currently trying to detect an earlier buried streambed by using remote sensing. From 2022 onwards, the research has continued with multispectral UAV imagery in addition to the analysis of available imagery. Multispectral UAVs were chosen because the infrared resolution of the available satellite data is not fine enough to detect smaller channels. Although the resolution of multispectral UAV cameras is around 2 mP (DJI Phantom 4 multispectral with RTK module), a field resolution of centimetres can be achieved by choosing the appropriate flight altitude.

Although the surveys have only recently begun, some of the recordings have already shown interesting results (Fig. 5). In the pictures taken in the NIR and RedEdge infrared range, an interesting channel(?)-like phenomenon was documented along the Ják-Sorok stream, whose sections fit well with the orientation of the *centuriatio*, which constitutes a straight continuation after the right-angled break in the stream bed. By verifying these and similar phenomena with geophysical research, we hope to obtain a more detailed picture to support the theory of the landscape transformation effect of *centuriatio*.

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Acknowledgments

The present research is partly realized in the frames of János Bolyai postdoctoral scholarship of MHAS (BO_115_12), the UAV and geophysical observations were supported by the grant of NKFI OTKA FK 138707.

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ABSTRACT

The Roman colony of Savaria was the first founded town in Pannonia (*Colonia Claudia Savaria*). Some inscriptions attest the so-called *deductio*, the settlement of veterans. After the first reconstruction of the *centuriatio* of Savaria no substantial archaeological attempt has been made in the last 40 years to verify the theory. In the last decade, research into the existence of the Savarian *centuriatio* has been pursued by using GIS methods, thanks to which we have managed to build a predictive model-network for the *centuriatio*, which is completely different from the previous reconstructions. The model has been continuously refined and validated by archaeological fieldwork and geophysical survey. The new reconstruction has led to new possibilities for interpreting the sites excavated in recent decades and the previously known Roman roads and aqueducts. Another interesting relationship between the watercourses running through the former *colonia* and the Roman *centuriatio* was also detected: the impact of Roman agriculture on the landscape transformation that has survived to the present day. Our pilot project, launched this year, plans to verify these effects using multispectral UAV surveys and geophysical measurements to show whether there were former streams along the presumed Roman channels that could provide evidence to support this hypothesis.