

INVESTIGATIONS ON SOME PELLET BELLS AND BELLS FROM THE EARLY MIDDLE AGES IN SLOVAKIA

**Nové Zámky I, Radvaň nad Dunajom-Žitavská Tôň (Radvaň I),
Holiare and Skalica**

BEATE MARIA POMBERGER – JÖRG MÜHLHANS –
KAYLEIGH SAUNDERSON

Pellet bells and bells from the Avar period cemeteries Nové Zámky I, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, Holiare and the Slavic cemetery Skalica, housed in the archaeological collections of the Slovak National Museum in Martin and the Archaeological Institute of the Slovak Academy of Sciences were investigated interdisciplinary within the research project ‘Metallic Idiophones between 800 BC and 800 AD in Central Europe’ (funding Austrian Sciences Funds FWF, supporting Natural History Museum Vienna). The aim of the research project was to gain more information about their function, their tonal influence, their material and the textiles corroded on the surface. They sound objects served as sounding-apotropaic amulets for humans and sounding-apotropaic decoration of horse harness. The pellet bells are cast in various copper alloys and forged from metal sheet. Filled with small pebbles or cinder they show oval or ball shaped forms with various decorations on the surfaces. Frequency ranges show partial from 2 kHz up to 20 kHz. The sounds are rather quiet, more noise like, bright, a little bit sharp and very low in roughness. Most of the objects are heavily corroded, which influences the sounds. Apart from decorative and apotropaic uses, a practical test has shown that the horse is much more concentrated and less likely to spook at outside factors when in movement carrying pellet bells.

Keywords: Western Slovakia, Early Middle Ages, music archaeology, acoustics, psychoacoustic, pellet bells, horse bridle.

INTRODUCTION

The project ‘Metallic Idiophones between 800 BC and 800 AD in Central Europe’ (funding Austrian Sciences Funds FWF, supporting Natural History Museum Vienna) investigated metal idiophones, their functional use and their acoustic influence on the daily life of people in Central Europe from 800 BC to 800 CE. An interdisciplinary approach was used for this cross-national project. The investigated metal idiophones were bells, pellet bells and sounding metal jewellery from the Hallstatt period. The aim of the research project was to gain more information about their function, their tonal influence, their material and the textiles corroded on the surface (*Pomberger/Mühlhans/Grömer 2021*).

Therefore, our research questions were: What was the function of the sound objects? Which impact had they on the society? Which frequency ranges and maximum sound pressure level can be produced by the objects? At which distance the sounds can likely been heard and how can the emitted sounds be described with extracted timbral features? Which metals and alloys were used producing the idiophones and what is the composition of the metal alloys in their individual components

like? Which fibers and weaving technics had been used for the textiles?

A few people started to wear pellet bells again in Central Europe in the middle of the 7th c. – probably for apotropaic purposes. Some used them to decorate the bridle of their horses. The archaeological collections of the Slovak National Museum Martin and the Institute of Archaeology of the Slovak Academy of Sciences in Nitra (IA SAS) keep pellet bells and bells from the Avar period cemeteries Holiare, Nové Zámky I, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, and the Slavic cemetery Skalica (Fig. 1). A part of the objects could be investigated within the frame of our project.

SITES, GRAVES AND FIND POSITIONS

Radvaň nad Dunajom-Žitavská Tôň, Radvaň I

Žitava is part of the village Radvaň nad Dunajom in the Nitra Region. 50 graves were excavated during a rescue excavation (*Budinský-Krička 1956*). Another 33 burials came to light during excavations in 1960. A part of the cemetery in the east was destroyed by gravel extraction, so that the total number of original graves is not known

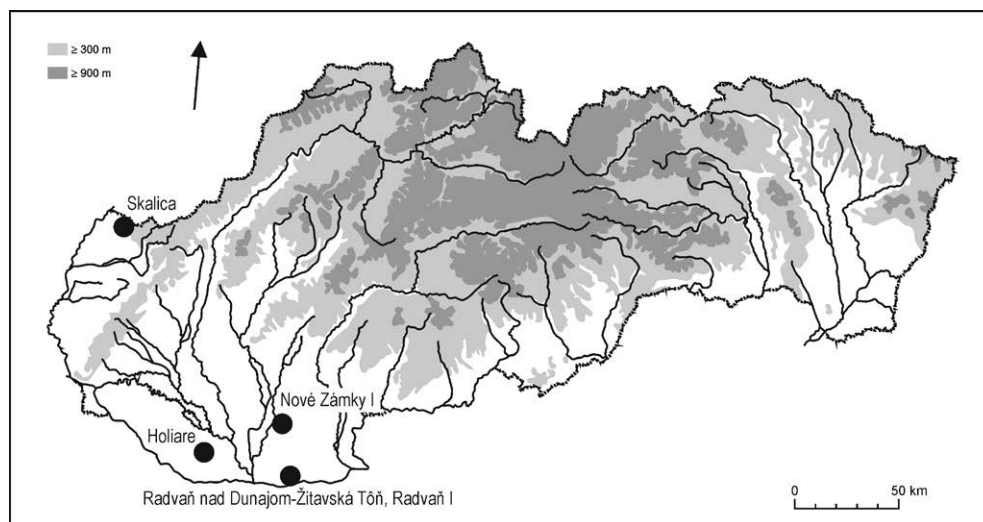


Fig. 1. Map of the sites with pellet bells, discussed in this article. Map background source www.d-maps.com, graphic B. M. Pomberger.

(Čilinská 1963, 87, 107). The cemetery dates to the Late Avar period (Zábojník 1995, 299). Only three graves contained pellet bells. Two graves, 10 and 31, belonged to horsemen/riders and their horses can be dated to SPA III (Csuthy 2020, 161, 162, tab. 4; Zábojník 1995, 315). They are located in the eastern part of the cemetery and are disturbed because of grave robbery. The pellet bells belonged to horses' head bridles. 14 metal sheet pellet bells were found in grave 10 (Cat. nos. 1–14) near the place where usually the horse skull lay. Another four pellet bells made from sheet metal – badly conserved – originate from grave 31 (Cat. nos. 15–18; Budinský-Krička 1956). The pellet bells are composed of the forged vertical halves, filled with a pellet and soldered together. Their surfaces are gilded. One pellet bell, showing a human face, was found in grave 1, excavated in 1960. Three individuals and one horse were buried here. The pellet bell lying near the skull of the animal, probably was part of the horse harness (Cat. no. 19; Fig. 2; Čilinská 1963, 87–89, fig. 2; pl. II: 16).

Holiare

The cemetery in Holiare, Nitra Region, consists of approximately 788 graves.¹ Since the 1930s, a number of graves have been destroyed by exploiting the sand pit. First rescue excavations in 1931 and 1932 were followed by excavations in the years 1952–1955. In only five burials pellet bells were

found (Točík 1968). The graves date to the 2nd half of the 7th to the 8th c. (Točík 1968, 10; Zábojník 2009, 92). Pellet bells were found in the two women's graves 92 (Cat. no. 21) and 146 (Cat. no. 22) and two children's graves, 437 (Cat. no. 23) and 667 (Cat. no. 24). The position of the pellet bells was near the left femur in burial 92, between the skeleton and the left arm in burial 147, between the femurs in grave 437 and near the left hand in grave 667. In grave 782 two pellet bells were found near the left femur of a child's skeleton (Cat. nos. 25; 26; Fig. 3; Točík 1968, 25, 34, 73, 102, 115).

Nové Zámky I

The site is located in the Northwest part of Nové Zámky, Nitra Region. Excavations were carried out in 1958 and from 1961 to 1962, but several graves had been destroyed already before through clay extraction. The cemetery originally consisted of 580 graves approximately² and was occupied from the second half of the 7th c. to the 9th c. (Čilinská 1966, 201–205). Six graves contained pellet bells and one grave a bell. The bell was found in the woman's grave 510 near the femur (Cat. no. 33). In the children's burial 175 (Cat. no. 27) and burial 509 (Cat. no. 32) each one pellet bell was found near the femur respectively in the middle of the grave. In grave 386 three individuals were buried. One was a little child with a pellet bell near the left arm (Cat. no. 30). Grave 438 contained also three

¹ These graves were excavated by the IA SAS and do not represent the whole number of graves from this cemetery. Not all are from the Avar period.

² The disturbed graves are included within this number.

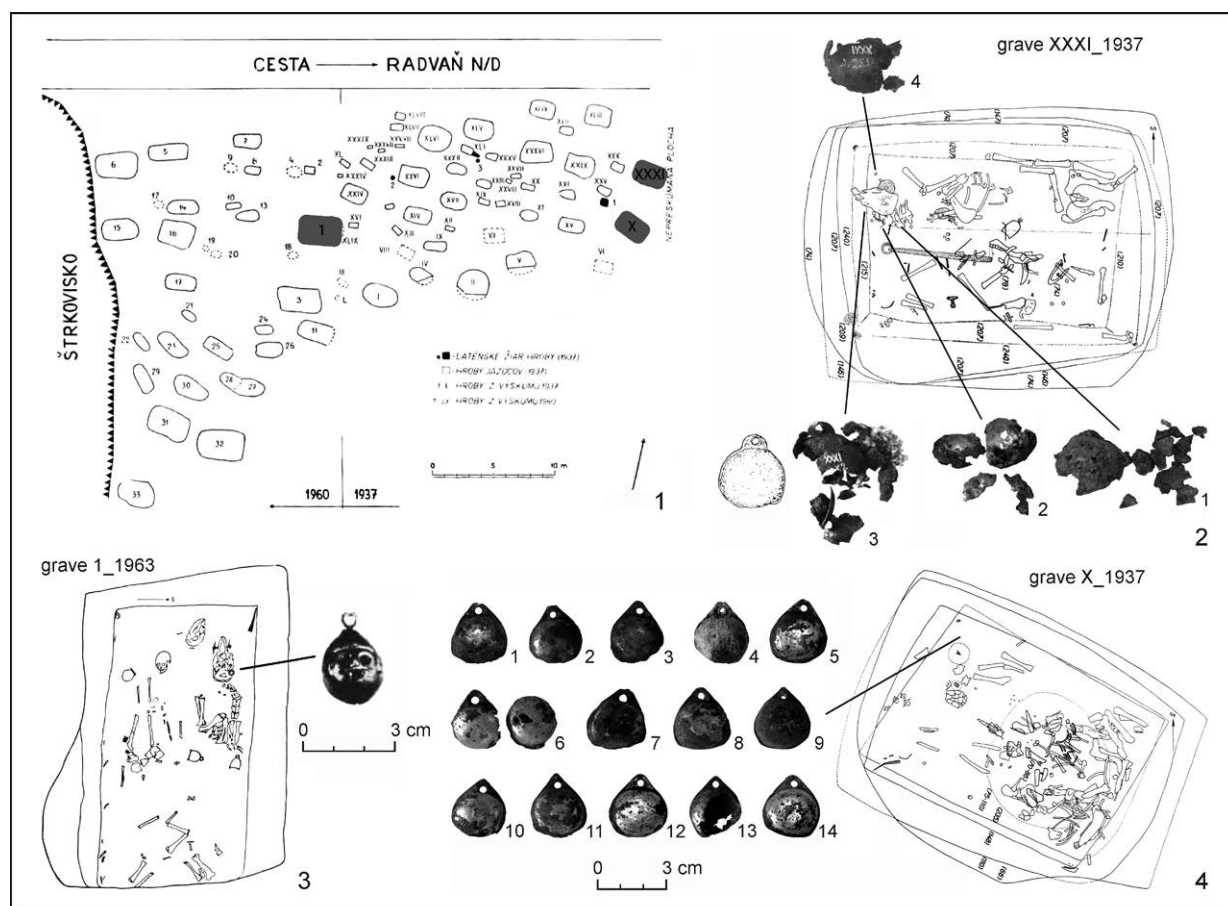


Fig. 2. Cemetery Radvaň nad Dunajom-Žitavská Tôň, Radvaň I. Graves with pellet bells. 1 – position of graves; 2 – grave 31 with four pellet bells; 3 – grave 1_1963; 4 – grave 10 with 14 pellet bells (according Budinský-Krička 1956, 7; Čilinská 1963, 88, fig. 1). Photo, graphic B. M. Pomberger, Slovak National Museum Martin.

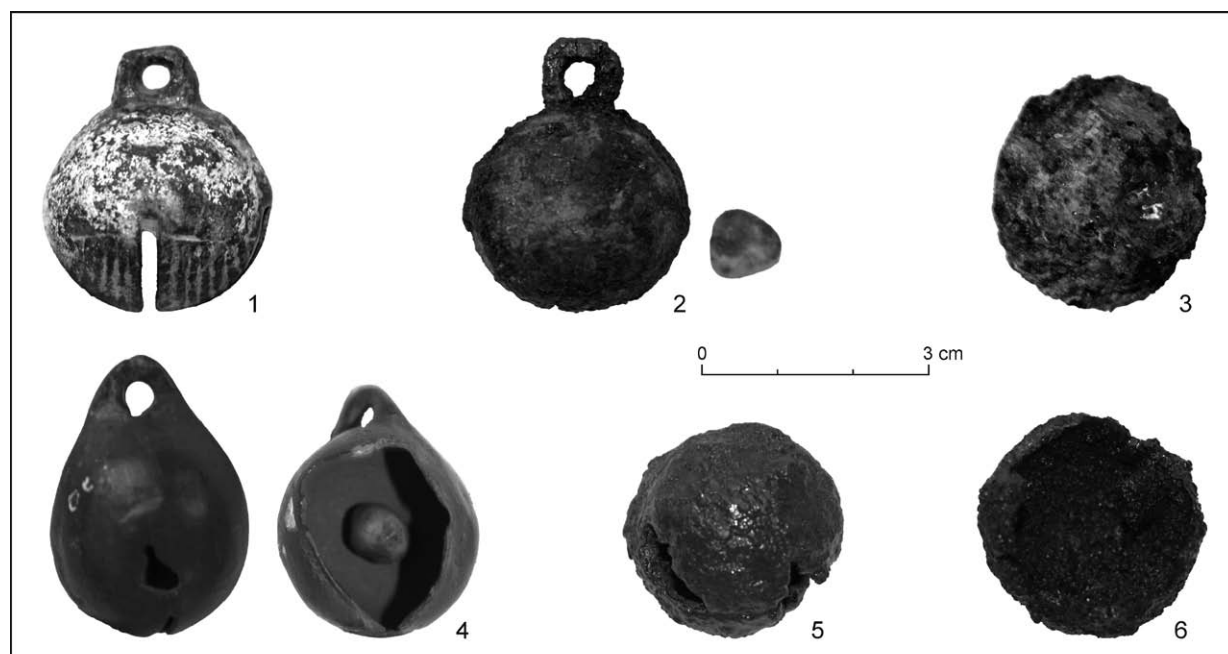


Fig. 3. Cemetery Holiare. Pellet bells. 1 – grave 92; 2 – grave 146; 3 – grave 437; 4 – grave 667; 5, 6 – grave 728. Photo, graphic B. M. Pomberger, IA SAS.

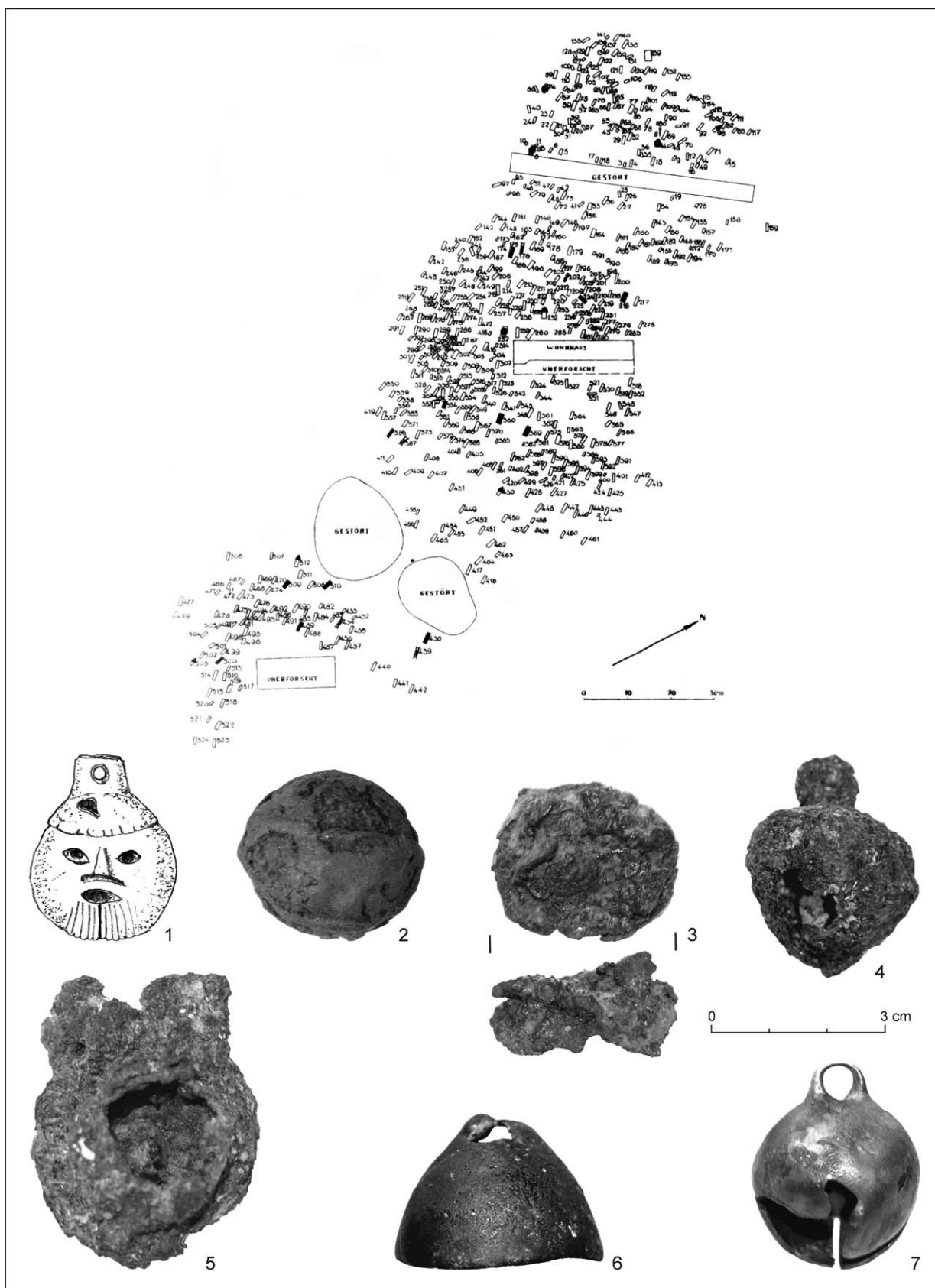


Fig. 4. Cemetery Nové Zámky I. Graves containing pellet bells and the objects. 1 – grave 175; 2 – grave 224; 3 – grave 354; 4 – grave 386; 5 – grave 509; 6 – grave 510; 7 – grave 438 (map according Čilinská 1966, 327). Photo, graphic B. M. Pomberger, IA SAS.

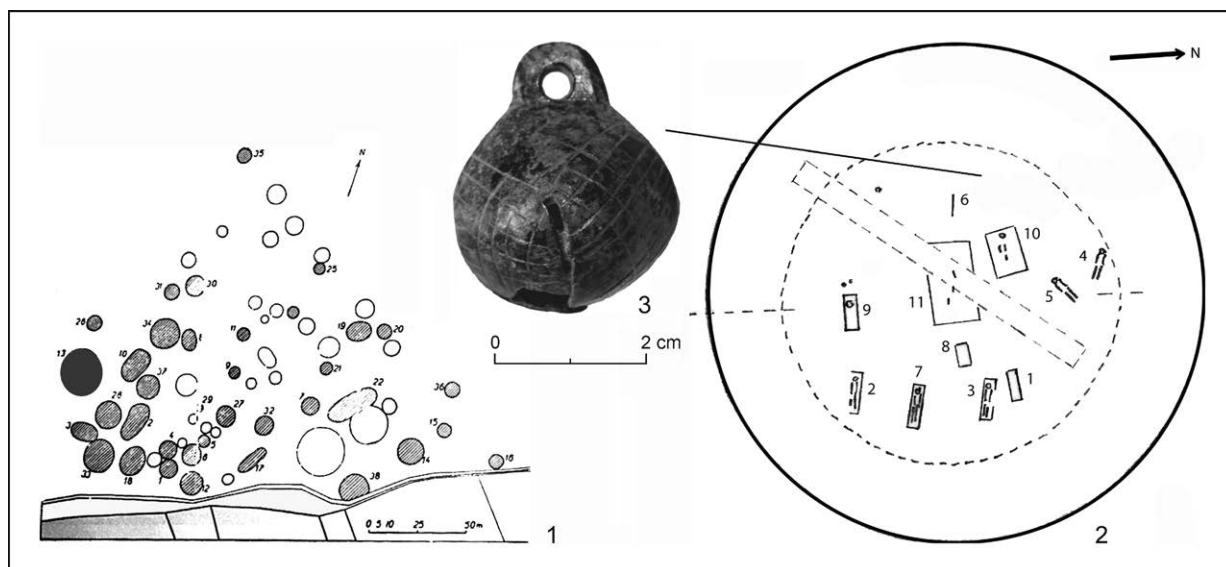


Fig. 5. Cemetery Skalica. Tumulus 13. Pellet bell (according Budinský-Krička 1959, 40, 74, pl. 21: 4). Photo, graphic B. M. Pomberger, Slovak National Museum Martin.

individuals. A pellet bell belonged to a little child, who probably wore it around the neck (Cat. no. 31). The child in grave 354 had two pellet bells near the right femur (Cat. no. 29). The last pellet bell was found in a man's burial 224 near the left foot of the deceased (Cat. no. 28; Fig. 4).

Skalica

The Slavic cemetery in Skalica, Vysoké pole, Trnava Region, contained in total approximately 100 tumuli. First excavations were carried out in 1922 and 1923. During the second world war in 1943–1944 further excavations followed. The cemetery dates to the 9th till 10th c. (Budinský-Krička 1959, 145–149; Kraskovská 1959, 179–182). One complete conserved pellet bell was found in tumulus XIII in a child's grave, burial 6 (Budinský-Krička 1959, 74, pl. 21: 4). It lay near the skull of the skeleton and therefore we can conclude that it was worn around the neck. It is cast in copper alloy, has a size of 3.5 cm and weighs 25.03 g (Cat. no. 20). A small pebble serves as rattle body. The surface is decorated with a network of diagonal lines (Fig. 5).

In all the mentioned cemeteries pellet bells do not play a dominant role. They are rather rare finds and this observation is in accordance with all the observations made in several other contemporary cemeteries, which are for examples the Avar Cemeteries in Slovakia, namely in Bratislava-Devínska Nová Ves, Bratislava-Rusovce (Pri cintoríne), Bratislava-Záhorská Bystrica in Bratislava Region (Pomberger/Mühlhans/Saunderson 2022); as well as

Komárno, Nitra Region (Pomberger et al. 2021a); the Hungarian Avar cemeteries of Szombathely-Kőszegi street and Vasasszonyfa-Gyöp, Vas County (Pomberger et al. 2021b); Cikó and Gerjen Váradmajor, Regöly-Kapuvár-Bozót-dűlő, Váradi, Váradpuszta in Tolna County; Halimba Belátó-domb in Veszprém County; Jánoshida and Jászalsószerbgyörgy in Jász-Nagykun-Szolnok County; Kiskőrös in Bács-Kiskun County; Kölked-Feketekapu A, Szebeny Cemetery I in Baranya County; Mosonszentjános-Kavicsbánya in Győr-Moson-Sopron County; Pilismarót-Basaharc and Pilismarót Öreges-dűlő in Komárom-Esztergom County; Solymár, Szob-Homok-dűlő, Újhartyán in Pest County (Pomberger et al. 2022b); Gyenesdiás, Keszthely-Dobogó, Keszthely-Városi temető, Lesencetomaj B-Piroskereszt in Zala County (Pomberger et al. 2023); Kaposmérő-Agyagbánya, Kaposvár-Toponár-Fészerlak-puszta, Kaposvár 61-es út, Kaposvár-Toponár 40-es őrház, Kereki-Homokbánya, Vörs-Battyáni disznólegelő, Vörs-Papkert B, Zamárdi-Rétiföldek Somogy County (Pomberger et al. 2025). And furthermore, the Austrian cemeteries of Csokorgasse-Wien Simmering, Edelstal (Nemesvölgy), district Neusiedl am See, and Carlberggasse-Liesing Vienna (Pomberger/Mühlhans/Mehofer 2022; 369–377, 388–393).

Only three graves of the known 83 graves in the site Radvaň nad Dunajom-Žitavská Tőň, Radvaň I, four graves out of 788 in Holiare, seven graves of 580 graves in Nové Zámky I and only one burial of 100 tumuli in Skalica contained pellet bells. They appeared during the second half of the 7th c. (Pomberger/Stadler 2018a, 139) and spread across Central Europe. Pellet bells excavated in the four

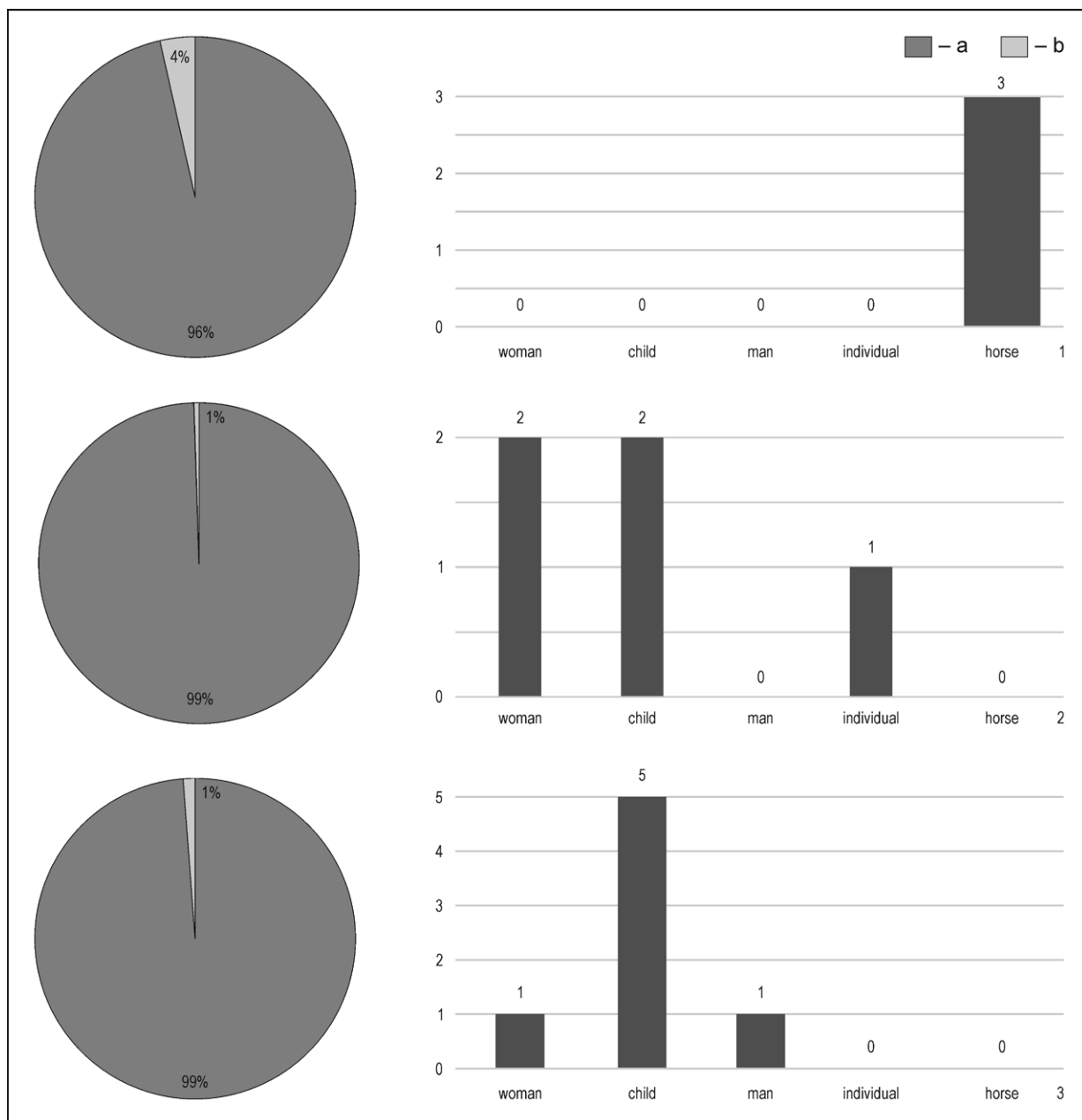


Fig. 6. Statistics on the distribution of pellet bells in the cemeteries and graves. 1 – Radvaň nad Dunajom-Žitavská Tôň, Radvaň I; 2 – Holiare; 3 – Nové Zámky I. Legend: a – graves total; b – graves with pellet bells. Graphic B. M. Pomberger.

cemeteries presented here were mainly worn by children, followed by women (Fig. 6). Horse harness of a few horses, whose owners belonged to the upper social class, was decorated with them (Csuthy 2020).

SHAPES AND TYPES

The pellet bells discussed in this article can be classified into four base shapes (Pomberger 2020). Shape I is probably represented by the pellet bell

from grave 175, Nové Zámky I (Cat. no. 27). Ten pellet bells show shape II. They are the objects from the cemetery in Holiare, grave 92 (Cat. no. 21), grave 437 (Cat. no. 23), grave 667 (Cat. no. 24), grave 782 (Cat. nos. 25; 26), from the cemetery in Nové Zámky II, grave 224 (Cat. no. 28), grave 386 (Cat. no. 30), grave 438 (Cat. no. 31), grave 509 (Cat. no. 32) and from Skalica tumulus 13/grave 6 (Cat. no. 20). All 14 pellet bells from burial 10 (Cat. nos. 1–14) and the four from burial 31 (Cat. nos. 15–18) from the cemetery Radvaň nad Dunajom-Žitavská Tôň, Radvaň I belong to shape VII.

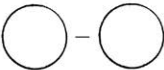
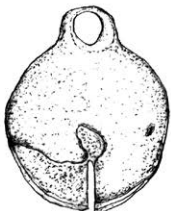
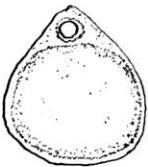
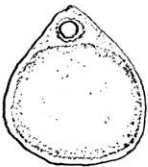
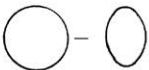
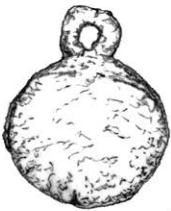
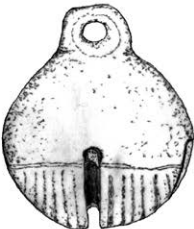
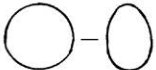
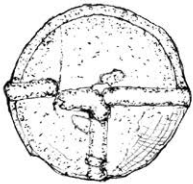
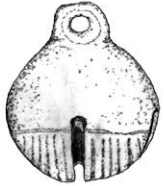
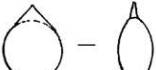
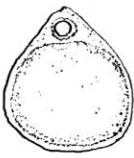
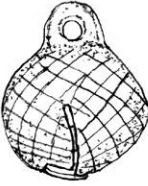
Basic shapes	Production	Sound slot	Decoration
  shape I - circular	 cast	 none	 smooth, gilded
  shape II - oval	 forged	 cruciform	 face
  shape IV	 two horizontal halves		 vertical grooves
  shape VII	 two vertical halves		 network of diagonal grooves

Fig. 7. Shapes of pellet bells. Graphic B. M. Pomberger.

Pellet bells are cast in various copper alloys in the lost wax technique and forged from copper alloy sheets. First, two halves are pressed into moulds, filled with the rattle body and soldered together. Depending on the shape, the halves can be joined vertically and horizontally. Those which are composed of two vertical halves show no sound slot, the others – as far as recognisable – have cruciform sound slots. A great number of the pellet bells have smooth surfaces without any decoration. The ones from grave 10 and 31, cemetery Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, are gilded. The find from grave 92 in Holiare, is decorated with

vertical grooves on its lower body. Masculine faces show the pellet bells from grave 92 in Nové Zámky I and grave 1/1963 in Radvaň nad Dunajom-Žitavská Tôň, Radvaň I. Very rare is the network like ornament on the pellet bell from Skalica (Fig. 7).

The bell from grave 510/Nové Zámky I can be classified to the 'Avar' bell type 1/var. A (Pomberger/Stadler 2018b, fig. 12) which is equivalent to the ancient Roman bell type 5/var. A (Pomberger et al. 2022a).

Pellet bells forged from sheet metal (non-ferrous metal) appear during the last two phases of the Late Avar Period (Csuthy 2020).³

³ This article includes only pellet bells from horse harness.

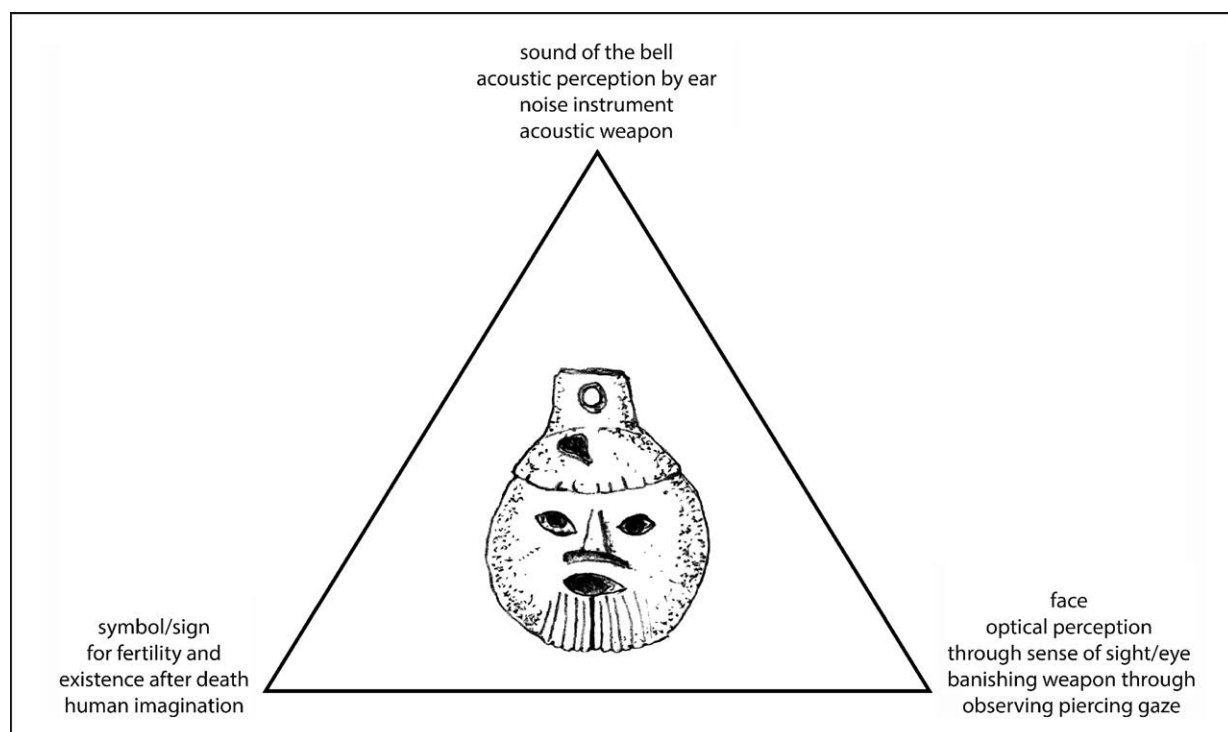


Fig. 8. Interpretation of apotropaic meaning of faced pellet bells. Graphic B. M. Pomberger.

FUNCTION

Pellet bells mainly served for people – especially for children – as apotropaic amulets and were worn on belt straps, bracelets, necklaces, maybe also in belt pouches or small belt bags. In very few cases they were wrapped in textiles (Pomberger et al. 2023, 47–49).

Wearing an amulet requires magic beliefs. Magic thinking is described as an archaic state of mind. Events or objects are attributed a special significance for predicting the future (superstition; *Roubicek-Solms s.d.*). Magic is the attempt to influence fate and the environment in a purely spiritual way. If people believe they perceive animate beings all around them (animism), they also believe they can conjure and influence them and project their spiritual inner world onto the outside world and their environment (Bartheim-Rixen s.d.). An amulet (also fetish, talisman) is defined as a small object often worn around the neck – sometimes in the form of a medallion – which is said to ward off danger and bring luck (Schneider-Ermer s.d.). This object is said to have a kind of ‘magical power’. But this ‘power’ does not come from the ‘magic’ object, but from the feelings and ideas attached to it.

Two of the pellet bells investigated show human faces, namely the ones from grave 175, Nové Zámky I and from grave 1_1963, Radvaň nad Dunajom-

Žitavská Tôň, Radvaň I. The first belonged to a buried child and shows similarities to finds from infants’ burials in Keszthely-Városi temető, grave of a girl (Lipp 1885, 116, 326; Pomberger et al. 2023), a child’s burial in Jánoshida (grave 107; Erdély 1958, pl. 61; Pomberger et al. 2022b, fig 1: 7) and a boy’s grave from Komárno IV, Váradiho street (grave 11; Čilinská 1982, 358, tab. 4: 39; Pomberger et al. 2021a, fig. 3: 1). The second one of the above-mentioned pellet bells – Radvaň nad Dunajom-Žitavská Tôň, Radvaň I – was found near the skeleton of a horse and reminds on the four pellet bells belonging to the bridle of the horse in burial 107 from Komárno IX (Trugly 1993, 197, tab. 12: 15–18). The interpretations of the meaning of faced pellet bells range from apotropaic amulet (Rácz 2012, 429, 435) via decorations on horse harness (Csuthy 2019, 354) till decollated heads of enemies (Csuthy 2022). The author of this article prefers to plead for apotropaic amulets and tries to explain this interpretation.

Pellet bells with smooth surface or other decorations include two ideas: sound and the imitation of a vascular fruit with its symbols. Pellet bells with faces additionally have a third aspects, which are said to give them enhanced ‘apotropaic powers’: protective power intensified by the optical sense.

Imitating vascular fruits with many seeds pellet bells are symbols of fertility, prosperity, long life and life after death (Fig. 8; Grömer/Pomberger 2024,

60). They are also noise instruments that produce sound by being shaken. The rattle bodies inside the rattles hit against the rattle wall and thus create acoustic waves. The wearer of the pellet bell draws attention to himself through the sound, i.e., he is heard, perceived acoustically. Animals as well as humans try to shout over each other, to shout the other down. Noise was and is used as an acoustic weapon to disturb other living beings, to terrorise them psychologically and acoustically and, in some cases, to drive them crazy. People now believe that these methods are also effective against evil, illness and evil spirits. The third aspect is the face of a man (warrior) with closely observing eyes. Here the effect is said to work via the visual sense. A piercing, cold and stern gaze can stop attacking creatures and keep them at a distance. On the other hand, every hunter (animal or human) focusses his prey with an extremely concentrated gaze before attacking. And also, emotions can often be read in the eyes of the other person (Fig. 8).

The three Gorgons, terrifying creatures with snake hair, whose gaze turns anyone who looks at them to stone, are known from Greek mythology (*Bremmer/Welwei 2006*). This subject, especially which of the decapitated Gorgon Medusa, has been taken up and depicted by numerous artists. The goddess Athena for examples carries a shield with a Gorgoneion (*Roscher 1884, 1695–1721*). Furthermore, the idea of the evil eye is a widespread phenomenon (*Tuczay 2024*). Bells with faces are known from the Graeco-Roman period of ancient Egypt. Very often they show the face of God Bes, who was dedicated to women and children (*British Museum s.d., Roman Period/*Object number EA6374; *Metropolitan Museum of Art s.d., Ptolemaic Period/*Object number 1985.73; *EgyptCentre, Ptolemaic Period/*Object WK44). ‘Magic’ bells from Meroë, Sudan, dating to the 1st c. CE, show images of war, capture and torture of the enemies and the fear-inducing depiction of the griffin. These depictions are intended to reinforce the cruel desires of the Meroan rulers and turn the bells into effective weapons of protection (*Hermann 1966*).

Pellet bells in connection with buried horses appear during the middle Avar period II – around 650 CE (*Csuthy 2019, 355; 2020, 170; Pomberger/Stadler 2018a, 139*). Mostly they are part of the head horse harness, but also could be fastened on the breast strap, on a back strap and on the saddle (*Pomberger et al. 2021a*). Pellet bells forged from two sheet metal halves (vertically assembled) became common during the second half of the Late Avar period (*Csuthy 2020*). Mainly they are

gilded and are fixed on the head harness. Objects are known from Kaposvár-Toponár 40-es őrház, Komárno IV, Komárno IX, Lukácsháza-Hegyalja dűlő 8, Pitvaros-Víztározó (*Csuthy 2020, 170*), Wien-Csokorgasse (*Pomberger/Mühlhans/Mehofer 2022*) and Vösendorf-Laxenburgerstraße (*Pomberger/Stadler 2018a*). Vertically assembled sheet pellet bells are only found in connection with horse skeletons. Therefore the one find from Dobogó or Keszthely-Városi temető (*Lipp 1885, 93, fig. 13; Pomberger et al. 2023, fig 1: 11*) has to be mentioned here.⁴ Since the sounds of all these pellet bells are rather weak and high, as the analyses of the pellet bell from grave 650, Wien-Csokorgasse proves (*Pomberger/Mühlhans/Mehofer 2022*) it could be perceived by the horse but possibly did not disturb the animal.

EXPERIENCES AND USES OF PELLET BELLS ON HORSE TACK

A practical test was conducted by attaching four modern pellet bells – two beneath each ear – to a horse’s bridle. This cannot be seen as an experiment, as it was only tested on one case and there is an abundance of variables and factors that can hardly be measured regarding a horse’s psychology. Rather, it applied in order to gain some insights into using pellet bells on horses and how it might influence the practical test. The tested horse, a 23-year-old Camargue gelding, and rider in this case have been regularly working together for 15 years.

At first, before the bells were attached (Fig. 9), the horse was somewhat wary of the sound of the pellet bells, which is not surprising as a flight animal. As soon as they were attached to the bridle and sounded with every movement of the horse, it no longer paid attention to them. During riding in the countryside with a lot of factors that could spook the horse (agricultural machines, wild animals, wind), the horse seemed much more concentrated than usual and did not spook as easily at sounds, most likely due to the constant sound of the pellet bells driving its hearing towards them instead of the outside. This could have likely also been the reason for using pellet bells on horses during the Avar period. This use can also be observed during the Late Medieval and Early Modern period, from the late 15th to the 16th c., where in most depictions of jousts, the horses wear a strap with many large pellet bells behind their ears. Furthermore, the horses are also (at least partially)

⁴ Magyar Nemzeti Múzeum, Inv. nr. 157.1880.9.



Fig. 9. Pellet bells attached to the horse's harness near the ear. Photo K. Saunderson

blinded by fabric covering their eyes. This most definitely served a practical purpose, since in this martial game, two horses and riders charge at each other with lances, which is highly likely to spook or at least drive away a horse that is aware of this. Thus, when the horse is not able to see (by

the blinding fabric) and hear (by the loud sounds of the pellet bells) this situation, it will concentrate on its rider's aids, charging very closely towards the other combatant. Earlier depictions, such as a late 12th c. fresco from the Church of Lyngby (Denmark) also showing a joust (*Meyer 2017, 54*), suggest a similar use of bells and pellet bells attached to the horses' breast plates. From Sassanid Persia, there is another interesting example from Taq-e Bostan: A heavily armoured warrior, probably Khosrow II (ruling from 591 to 628 CE; *Daim 2021, 302, 303*), and horse are shown in a stone relief with a lance. The chest, neck, and head of the horse are armoured and are covered in many pellet bells. It is quite likely that these served the same purpose as those used in Medieval and Early Modern jousts. The sounding element might have been especially necessary for close combat rather than mounted archery, i.e., with lances, where it is vital that the horse follows the rider's aids and does not shy away. This might indicate the use of pellet bells for in the Avar period.

Frequency ranges of the pellet bells mostly are between 1000 and 10,000 Hz. The horse's hearing threshold shows a clear kink in this range (Fig. 10). This probably means that the horse does not perceive the pellet bells as well as humans or dogs (*Pomberger/Mühlhans/Mehofer 2022, 378, fig. 16: 2–4*). However, as flight animals, horses should hear twice as well as humans, namely up to 32 kHz/40 kHz (*Pollmann s.d.; Schay-Beneke s.d.*).

But there are also more possibilities. They could have served an acoustic decorative purpose, as the sound of the pellet bells in rhythm with the horse's gaits can be considered as appealing. Apart from

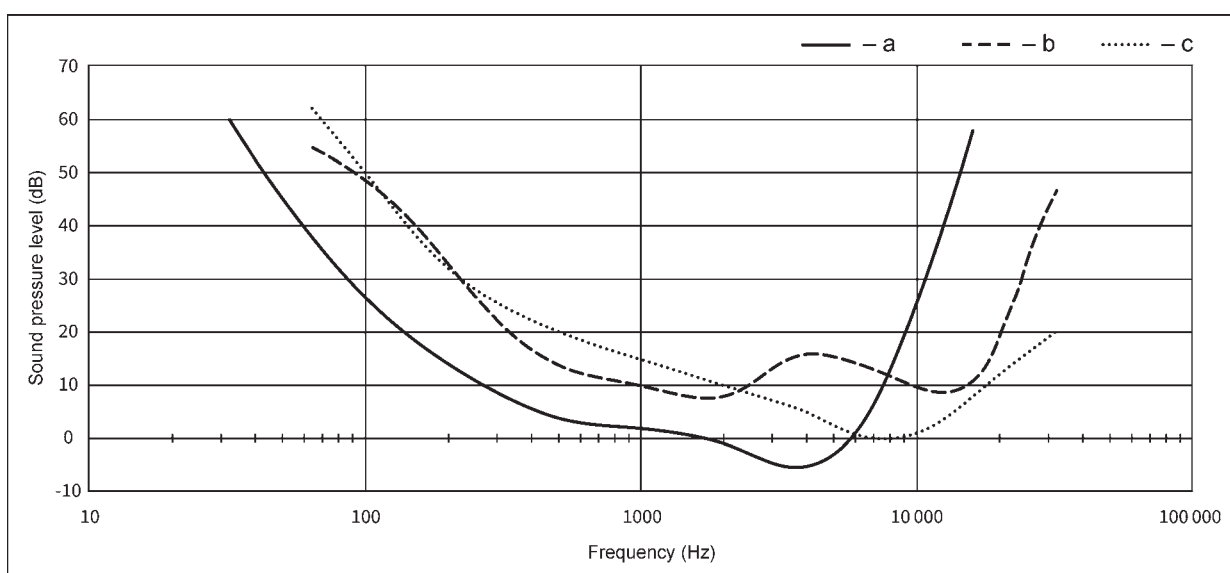


Fig. 10. Threshold of hearing. Legend: a – humans; b – horses; c – dogs. Graphic J. Mühlhans.

also maybe being connected to apotropaic beliefs protecting the horse, the sounds could also have a practical function. The sound created during movement could have warned nearby people of a horse and rider coming closer, alerting them in time to move out of the way. The speed can also be determined by the rhythm of the sounds. Thus, this might have been a safety measure for other people. Two videos were recorded and are available on the repository of the Natural History Museum Vienna (*Saunderson/Saunderson/Dupper 2024*).⁵

THE (PSYCHO-) ACOUSTICS OF IDIOPHONES

The acoustics of idiophones is very complex and influenced by numerous factors, primarily related to the object's physical characteristics such as material/alloy, weight, size, shape, and wall thickness. Additionally, the mode of excitation is crucial. The sound and timbre of pellet bells arise from a series of individual excitations over time, caused by a smaller encapsulated object striking the inner walls, prompting the bell's mantle to oscillate. When continuously excited (e.g., by shaking), these idiophones typically generate up to 25 single impacts per second. Each impact has a short decay time of approximately 20–150 milliseconds, depending on the level of corrosion (*Pomberger et al. 2021a*, 124).

The oscillation duration of an idiophone primarily depends on its physical properties. If an object is solid and minimally dampens oscillation, numerous modes can form. In idiophones (and membranophones), the sound comprises a complex combination of single oscillations (modes) creating various partial frequencies or overtones, unlike aerophones and chordophones, where overtones are integer multiples of a fundamental frequency (f_0 ; *Hall 1980*, 156–168).

Instruments excited impulsively have a very short attack time, just a few milliseconds, within which the maximum amplitude is reached, and the oscillation begins to decay. The moment of impact is rich in spectral energy, and partial frequencies become visible within a few milliseconds. On a spectrogram, the impact appears as a vertical line with dense colouring, and the decay of partials appears as horizontal lines. Decay time varies for all partials, but typically low-frequency oscillations are less dampened (*Hall 1980*, 168), resulting in a longer decay time than higher frequencies. Fig. 11 illustrates the typical pattern of excitation in the

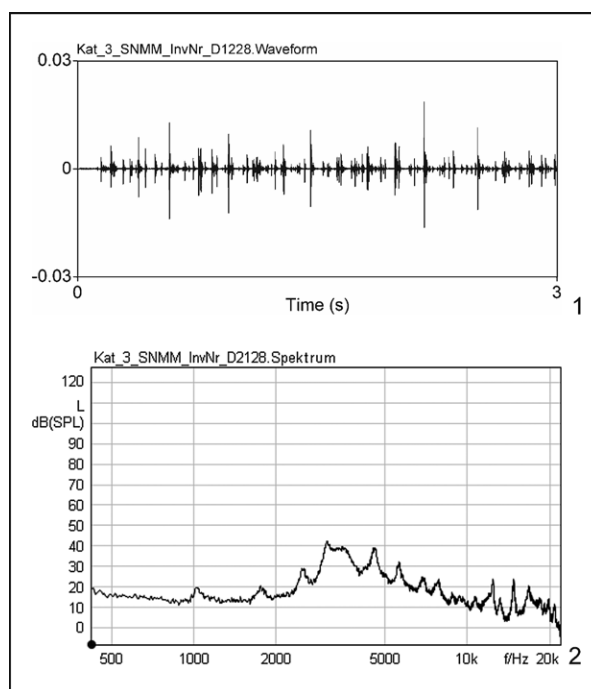


Fig. 11. 1 – waveform of pellet bell Cat. no. 3 (burial 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I), that shows the single impulses during a 3^s period of constant excitation; 2 – resulting spectrum shows the partial frequencies and the spectral distribution of energy. Graphic J. Mühlhans.

waveform (1) and the resulting spectrum (2) from one of the objects.

The given example in Fig. 11 is quite representative for the examined pellet bells, some are a little bit more tonal, others are slightly noisier. Compared to small bells, that were quite common in later ages, pellet bells sound is generally noisier, which leads to less pitch perception (*Schneider 2000*).

A crucial acoustic parameter is the sound pressure level (SPL) of the objects, given in dB re p_0 ($= 0.00002$ Pa), calculated from the root mean square (RMS) value of the calibrated recordings. Since SPL decreases by 6 dB per doubling of the distance from the source (*Attenborough 2014*, 119), the maximum audible distance for a sound object can be determined for a given background noise. Another key parameter is the frequency range, from the lowest ($f_{\min}$) to the highest ($f_{\max}$) partial frequency. Although the overall SPL of small idiophones is not high, their frequency range typically overlaps with the most sensitive area of human hearing, roughly between 1.5–6 kHz (*Moore 2008*, 55–57). Often, one of the partial frequencies has a particularly high amplitude, known as the 'peak frequency', which matches the

⁵ Horse_wearing_eight_pellet_bells_in_canter.mp4; Horse_wearing_eight_pellet_bells_in_trot.mp4

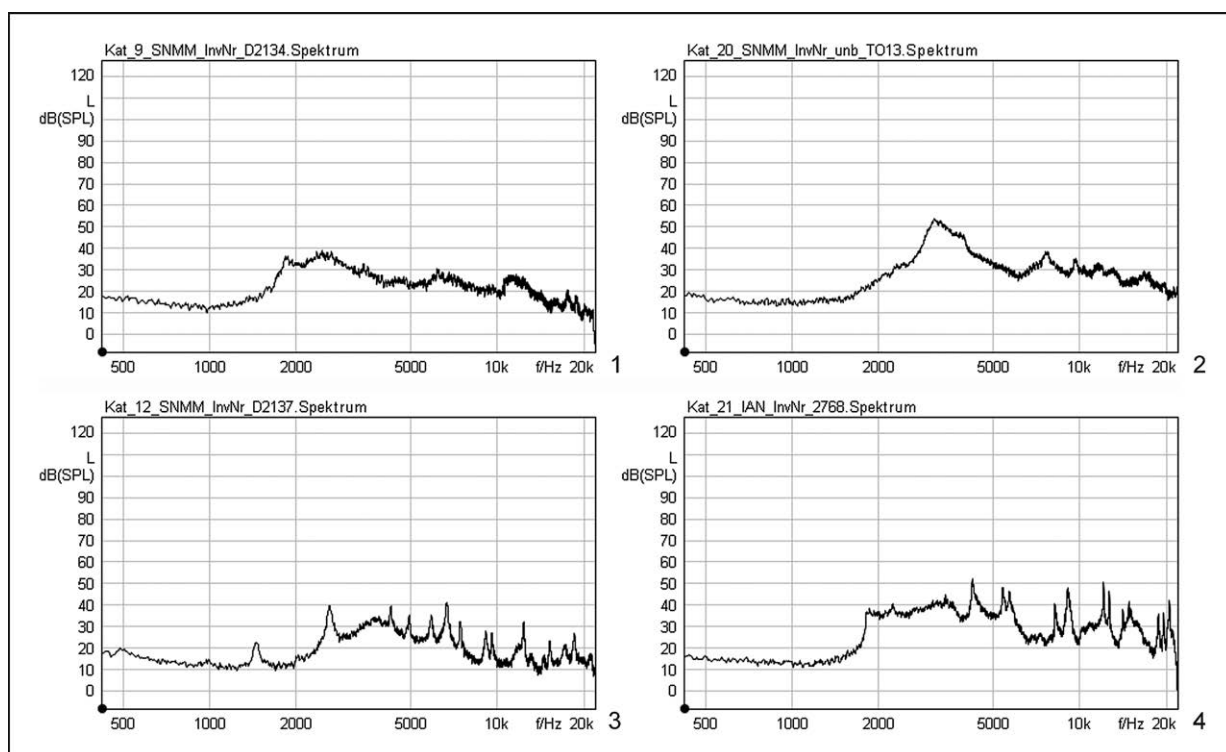


Fig. 12. Spectra of pellet bells, that lack pronounced partials and only have specific frequency ranges with increased spectral energy (rather noisy objects). 1 – Cat. no. 9 (burial 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I); 2 – Cat. no. 20 (tumulus 13, burial 6, Skalica). Spectra of pellet bells that have at least more than ten clearly visible partials/peaks. 3 – Cat. no. 12 (burial 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I); 4 – Cat. no. 21 (burial 92, Holiare). Graphic J. Mühlhans.

idiophone's 'eigenfrequency' and plays a significant role in pitch perception.

Psychoacoustic parameters provide a different approach to describing sounds, focusing on subjective human perception rather than physical properties. Psychoacoustics, a branch of psychophysics, seeks to correlate the physical qualities of a sound with its perception. In psychoacoustics, loudness measures the intensity sensation and is expressed in 'phon' or 'sone'. A reference sound of 1 kHz at 40 dB SPL equals 40 phon or 1 sone (Fastl/Zwicker 2007, 203, 204). Phon is interval-scaled, while sone is ratio-scaled, meaning 50 phon is twice as loud as 40, and 2 sone is twice as loud as 1. Sharpness, measured in 'acum', describes a sensation resulting from the spectral shape and density, with a critical band wide noise at 60 dB centred at 1 kHz (Fastl/Zwicker 2007, 241). Roughness, caused by amplitude modulation (AM), peaks around a 15 Hz modulation frequency, reaching its maximum at 70 Hz, and decreases above 150 Hz. It is measured in 'asper', ranging from 0 (not rough) to 1 (maximum roughness at 70 Hz AM at 1 kHz; Fastl/Zwicker 2007, 257). Tonality is represented by the tone-noise-ratio (TNR), given in dB, comparing the tonal part of a sound to the noise part based on a human hearing model (Becker/Sottek/Lobato 2019, 5820). These four parameters of-

ten quantify the concept of 'sensory pleasantness' of sound (Fastl/Zwicker 2007, 243).

Common adjectives for describing timbral brightness include high/low or dark/brilliant. This parameter can be estimated using the spectral centre of gravity or 'spectral centroid' (SC) in Hz (Saitis/Siedenburg 2020, 2256). Finally, impulsiveness measures the degree of impulsive content perceived in a sound, often described as 'rattles' or 'clicks' (Willemsen/Rao 2010, 2), in the non-standardized 'impulsiveness unit' (iu).

The aforementioned (psycho-) acoustic parameters have been calculated using Audition CC (Adobe Audio Team), ArtemiS Suite 9.3 (HEAD Acoustics), and Praat (Boersma/Weenink 2022). The number of examined objects in this study is not large enough for additional statistical calculations.

(Psycho-) Acoustic Analyses

Nine objects in total could be recorded and analysed for their (psycho-) acoustical parameters. Recordings were made in the portable sound absorbing chamber built for the project to avoid any external noise (Pomberger/Mühlhans 2022) at the distance of about 10 cm to the measurement

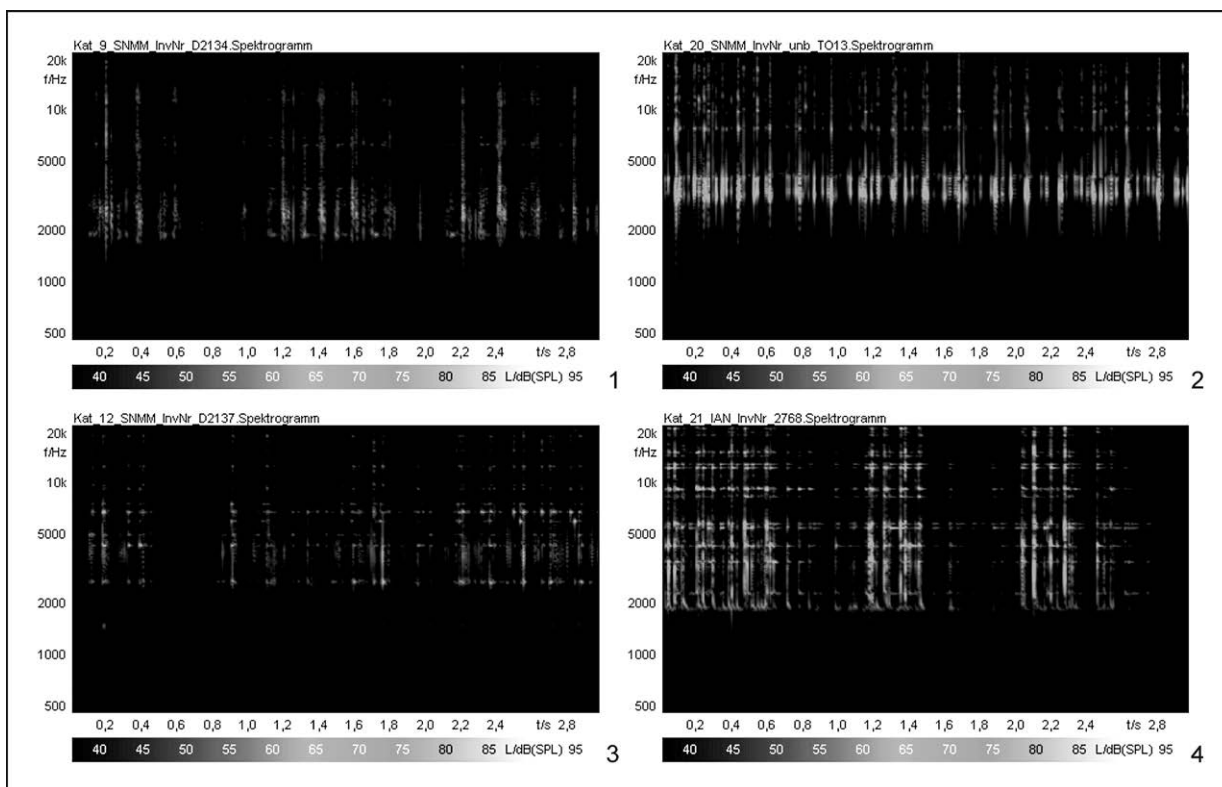


Fig. 13. Spectrograms of pellet bells. 1 – Cat. no. 9 (burial 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I); 2 – Cat. no. 20 (tumulus 13, burial 6, Skalica); 3 – Cat. no. 12 (burial 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I); 4 – Cat. no. 21 (burial 92, Holiare). Both pellet bells from burial 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I (1, 3), show significantly lower amounts of spectral energy (colouring). Find from tumulus 13, burial 6, Skalica (2) has more energy in a narrow band of roughly 3–4 kHz and the last one from burial 92, Holiare, has its higher energy more evenly distributed between 2–20 kHz. Graphic J. Mühlhans.

microphone (Presonus PRM 1). In SPL, they vary between 56–72 dB with an average of 62 dB. These values have to be reduced by 20 dB to evaluate the SPL at a distance of 1 m. Given those values, we can estimate that the pellet bells on average, with their actual status of corrosion today, are audible at distances of 2–16 m maximum, even in a quiet surrounding. However, practical tests with replicates have shown that corroded original finds made from copper alloys are not necessarily lower in SPL than the replicas (Mühlhans/Pomberger 2023). The loudness ranges from 6.8–18.6 sone, so the loudest object (Cat. no. 21; pellet bell Inv. nr. 2760_Holiare, burial 92) is about 4 times as loud as the least loud one (Cat. no. 25; pellet bell Inv. nr. 2405a_Holiare, burial 782).

In terms of sharpness and roughness, the pellet bells from Nové Zámky I, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, Holiare and Skalica line up quite well with similar objects from other locations that have been studied during the project. With an average sharpness of 3.3 acum and roughness of 0.11 asper, the pellet bells can be described as quite sharp, but not rough overall, which is typical

for pellet bells. The rather high sharpness for the generally low SPLs is a result of the objects having their peak frequencies and overall high spectral energy in the human's sensitive hearing area of roughly 1.5–6 kHz, even for the ones without pronounced partials. In bells, for comparison, the partials' peaks are up to 60 dB higher than the noise floor, in pellet bells this value is rather 30 dB at best. Also, the number of visible partials in the spectrum is quite low in comparison to bells, in some cases only frequencies areas are 10–20 dB above the noise floor without any visible partials (Fig. 12).

Despite the similarities in the spectral range, Cat. no. 9 (pellet bell Inv. nr. D 2134, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, burial 10) and Cat. no. 20 (pellet bell, Skalica, tumulus 13_tomb 6) do not sound as similar as one might expect, and neither do Cat. no. 12 (pellet bell Inv. nr. D 2137, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, burial 10) and 21 (pellet bell Inv. nr. 2760_Holiare, AI SAS). If one considers the time range, as shown in Fig. 13, a different picture emerges. There seems to be a greater similarity between Cat. no. 9 (pellet

bell Inv. nr. D 2134, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, burial 10) and 12 (pellet bell Inv. nr. D 2137, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, burial 10) and also between Cat. no. 20 (pellet bell, Skalica, tumulus 13_tomb 6) and 21 (pellet bell Inv. nr. 2760_Holiare, AI SAS), but this is not confirmed by the auditory impression either. This should only be mentioned to clarify that auditory impressions cannot be satisfactorily clarified by analytical visualizations, at best individual tonal characteristics that contribute to the overall impression. The differences in the other parameters analysed contribute significantly to this.

The general sound impression of most objects (Cat. no. 2, pellet bell Inv. nr. D 2127; Cat. no. 3, pellet bell Inv. nr. D 2128; Cat. no. 8, pellet bell Inv. nr. D 2133; Cat. no. 9, pellet bell Inv. nr. D 2134; Cat. no. 12, pellet bell Inv. nr. D 2137, all from Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, burial 10; Cat. no. 25, pellet bell Inv. nr. 2405a_Holiare, burial 782) is muffled and noisy but quiet. They are in the range of 6.8–11.4 sone loudness. The same sound impression, but with a significantly higher loudness of 16.9 sone, is created by Cat. no. 20 (pellet bell, Skalica, tumulus 13_tomb 6). The remaining two objects differed significantly in timbre. Cat. no. 13 (pellet bell Inv. nr. D 2138, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, burial 10) is lower than Cat. no. 20 (pellet bell, Skalica, tumulus 13_tomb 6) at 11.7 sone but has the highest value for tonality at 13.8 dB TNR. Cat. no. 21 (pellet bell Inv. nr. 2760_Holiare, burial 92) is comparable in terms of sound, although its tonality is significantly lower at 8.7 dB TNR, but this compensates for the high loudness of 18.6 sone.

Due to the spectral density and envelope curve, all objects have a high sharpness of 2.3–4.2 acum and a very low roughness of 0.006–0.1 asper. There are clearer differences in brightness, which is also reflected in the auditory impression. The objects range in the spectral centre frequency between 2.8–7.8 kHz, whereby again Cat. no. 13 (pellet bell Inv. nr. D 2138, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I, burial 10) and Cat. no. 21 (pellet bell Inv. nr. 2760_Holiare, burial 92) are located at the upper edge.

The recordings of the original pellet bells are available on the repository of the Natural History Museum Vienna.

SUMMARY

Pellet bells appear in the middle of the 7th c. in the Avar domain. They probably were imported from Eastern regions like the Caucasus and Black Sea area. Only 1% of all the burials contained pellet bells. They were worn by a few children and women and decorated the bridle of a few horses. For the former they had the function of apotropaic amulets, for the latter they were probably status objects. In three graves of the cemetery Radvaň nad Dunajom-Žitavská Tôň, Radvaň I pellet bells were found, all decorating the horse harness. Four burials of the Holiare cemetery contained pellet bells, namely two children's graves and two women's graves. The cemetery Nové Zámky I included five children's and one man's grave with pellet bells. A Roman period bell originates from a woman's burial. And from tumulus XIII/grave 6 one pellet bell is known. The pellet bells are cast in various copper alloys or forged from iron or copper alloy sheet metal. Small pebbles or lumps of bronze/cinder serve as pellets. The sizes of the pellet bells vary in height from 2.4 cm to 4.2 cm and weight from 0.67 g to 25 g. Their shapes are spherical or oval. The surfaces either carry no decoration or are adorned by vertical grooves, networks of lines and human faces. The find positions show that pellet bells were worn around the neck and on the wrist, but mostly on the belt or belt straps of the garment. From an acoustic point of view, the objects fit seamlessly into the previous analyses of bells. They are quiet and not very tonal, yet bright and somewhat sharp, but their roughness is very low. These characteristics are generally typical for pellet bells, with the exception that non-corroded objects are significantly higher, especially in loudness and tonality. In summary, one could say that most of the objects are quite typical of heavily corroded jingles in both aural impression and analytical findings. For the use of pellet bells on horses, multiple purposes come into question. Apart from decorative and apotropaic uses, a practical test has shown that the horse is much more concentrated and less likely to spook at outside factors when in movement carrying pellet bells. This was utilised during jousts in the Late Medieval and Early Modern period and likely also earlier.

CATALOGUE⁶

**Archaeological collection
of the Slovak National Museum in Martin**

**Cemetery Radvaň nad Dunajom-Žitavská Tôň,
Radvaň I, Nitra Region**

Excavations: 1937

Graves with pellet bells: 2 (Fig. 2)

Storage: Slovak National Museum Martin

Dating: LAP, last third 7th–9th c.

References: *Budinský-Krička 1956*

Burial 10

Contents and condition: individual, horse, disturbed

Individual: *masculine, maturus*

Animal: horse

Dating: LAP; LPh III

Finds: 14 pellet bells

Inv. nr.: D 2126–D 2139

Position in grave: the north-western part of the grave, where the horse's skull usually is located

References: *Pomberger/Stadler 2018a*, 139, fig. 4; *Zábojník 1995*, 315

• Cat. 1 pellet bell Inv. nr. D 2126 (Fig. 2: 4: 1)
Conservation status: complete, 2 halves
Rattle body: corroded inside
Basis shape: oval, shape VII
Sound slot/sound holes: none
Decoration: smooth, gilded
Measures: dm. 2.5×1.3 cm; h. 2.7 cm, wth. 0.5 mm; cons. wgt. 2.44 g
Material: copper-alloy-sheet
Surface/decoration: gilded, no analyses
Frequency range/pitches: no recordings, no frequency analyses

• Cat. 2 pellet bell Inv. nr. D 2127 (Fig. 2: 4: 2)
Conservation status: complete, two halves
Rattle body: 1–2 pebbles
Base shape: oval, shape VII
Sound slot/sound holes: none
Decoration: smooth, gilded
Measures: dm. 2.5×1.3 cm; h. 2.7 cm, wth. 0.5 mm; cons. wgt. 2.89 g
Material: copper-alloy-sheet, gilded
Frequency range/pitches: 1 kHz–21 kHz

• Cat. 3 pellet bell Inv. nr. D 2128 (Fig. 2: 4: 3)
Conservation status: complete, two halves
Rattle body: pebble
Base shape: oval, shape VII
Sound slot/sound holes: none
Decoration: smooth, gilded
Measures: dm. 2.4×1.3 cm; h. 2.8 cm, wth. 0.5 mm; cons. wgt. 2.08 g
Material: copper-alloy-sheet, gilded
Frequency range/pitches: 0.8 kHz–21 kHz

• Cat. 4 pellet bell Inv. nr. D 2129 (Fig. 2: 4: 4)
Conservation status: complete, two halves
Rattle body: pebble
Base shape: oval, shape VII
Decoration: smooth, gilded
Measures: dm. 2.5×1.3 cm; h. 2.7 cm, wth. 0.5 mm; cons. wgt. 3.27 g
Material: copper-alloy (?), gilded, no analyses
Frequency range/pitches: no recordings, no frequency analyses

• Cat. 5 pellet bell Inv. nr. D 2130 (Fig. 2: 4: 5)
Conservation status: complete, two halves, soldering open
Rattle body: lost (?), corroded (?)
Base shape: oval, shape VII
Sound slot/sound holes: none
Decoration: smooth, gilded
Measures: dm. 2.5×1.3 cm; h. 2.8 cm, wth. 0.5 mm; cons. wgt. 3.08 g
Material: copper-alloy-sheet
Frequency range/pitches: no recordings, no frequency analyses

• Cat. 6 pellet bell Inv. nr. D 2131 (Fig. 2: 4: 6)
Conservation status: complete, two halves, two holes in body, fragmented
Rattle body: lost (?), corroded (?)
Base shape: oval, shape VII
Sound slot/sound holes: none
Decoration: smooth, gilded
Measures: dm. 2.5×1.3 cm; h. 2.7 cm, wth. 0.5 mm; cons. wgt. 2.29 g
Material: copper-alloy-sheet
Frequency range/pitches: no recordings, no frequency analyses

• Cat. 7 pellet bell Inv. nr. D 2132 (Fig. 2: 4: 7)
Conservation status: complete, two halves, deformed
Rattle body: lost (?), corroded (?)
Base shape: oval, shape VII
Decoration: smooth, gilded
Measures: dm. 2.5×1.3 cm; h. 2.7 cm, wth. 0.5 mm; cons. wgt. 2.38 g
Material: copper-alloy-sheet
Frequency range/pitches: no recordings, no frequency analyses

• Cat. 8 pellet bell Inv. nr. D 2133 (Fig. 2: 4: 8)
Conservation status: complete, two halves
Rattle body: pebble
Base shape: oval, shape VII
Sound slot/sound holes: none
Decoration: smooth, gilded
Measures: dm. 2.5×1.3 cm; h. 2.7 cm, wth. 0.5 mm; cons. wgt. 2.92 g
Material: copper-alloy-sheet
Frequency range/pitches: 0.8 kHz–21 kHz

• Cat. 9 pellet bell Inv. nr. D 2134 (Fig. 2: 4: 9)
Conservation status: complete, two halves
Rattle body: pebbles

⁶ Legend: dm. – diameter; h. – height; hwh. – height without handle; wth. – wall thickness; cons. wgt. – conserved weight.

Base shape: oval, shape VII
 Decoration: smooth, gilde
 Measures: dm. 2.5×1.3 cm; h. 2.7 cm, with. 0.5 mm; cons.
 wgt. 3.62 g
 Material: copper-alloy-sheet
 Frequency range/pitches: 0.8 kHz–18.5 kHz

- Cat. 10 pellet bell Inv. nr. D 2135 (Fig. 2: 4: 10)
 Conservation status: complete, two halves, one hole
 Rattle body: lost (?), corroded (?)
 Base shape: oval, shape VII
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: dm. 2.4×1.2 cm; h. 2.6 cm, with. 0.5 mm; cons.
 wgt. 2.22 g
 Material: copper-alloy-sheet
 Frequency range/pitches: no recordings, no frequency analyses

- Cat. 11 pellet bell Inv. nr. D 2136 (Fig. 2: 4: 11)
 Conservation status: complete, two halves
 Rattle body: lost (?), corroded
 Base shape: oval, shape VII
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: dm. 2.5×1.4 cm; h. 2.9 cm, with. 0.5 mm; cons.
 wgt. 3.06 g
 Material: copper-alloy-sheet
 Frequency range/pitches: no recordings, no frequency analyses

- Cat. 12 pellet bell Inv. nr. D 2137 (Fig. 2: 4: 12)
 Conservation status: complete, two halves
 Rattle body: lost (?), corroded (?)
 Base shape: oval, shape VII
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: dm. 2.5×1.3 cm; h. 2.9 cm, with. 0.5 mm; cons.
 wgt. 1.5 g
 Material: copper-alloy-sheet
 Frequency range/pitches: 1.5 kHz–20 kHz

- Cat. 13 pellet bell Inv. nr. D 2138 (Fig. 2: 4: 13)
 Conservation status: two halves, fragmented
 Rattle body: pebble
 Base shape: oval, shape VII
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: dm. 2.5×1.3 cm; h. 2.9 cm, with. 0.5 mm; cons.
 wgt. 1.75 g
 Material: copper-alloy-sheet
 Frequency range/pitches: 1.5 kHz–21 kHz

- Cat. 14 pellet bell Inv. nr. D 2139 (Fig. 2: 4: 14)
 Conservation status: two halves, fragmented
 Rattle body: lost
 Base shape: oval, shape VII
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: dm. 2.45×1.3 cm; h. 2.9 cm, with. 0.5 mm; cons.
 wgt. 1.62 g
 Material: copper-alloy-sheet
 Frequency range/pitches: no recordings, no frequency analyses

Burial 31

Contents and condition: individual, horse, disturbed

Individual: *masculine* (?), adult (*maturus*?)

Animal: horse

Dating: LAP 680–822 CE; LPh III

Finds: four pellet bells (Fig. 2: 2)

Inv. nr.: 2495, 2500, 2507, 2517

Position in grave: pellet bell near horse's skull

References: *Pomberger/Stadler 2018a*, 139, fig. 4; *Zábojník 1995*, 315

- Cat. 15 pellet bell Inv. nr. D 2495 (Fig. 2: 2: 1)
 Conservation status: two halves (?), fragmented, many pieces
 Rattle body: lost
 Base shape: oval/circular (?)
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: h. ca. 3.3 cm; dm. ca. 3 cm; with. 0.5 mm; cons.
 wgt. 3.66 g
 Material: copper-alloy or bronze, gilded
 Frequency range/pitches: no recordings, no frequency analyses

- Cat. 16 pellet bell Inv. nr. D 2500 (Fig. 2: 2: 2)
 Conservation status: two halves (?), fragmented, many pieces
 Rattle body: lost
 Base shape: oval/circular (?)
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: h. ca. 3.3 cm; dm. ca. 3.3 cm; with. 0.5 mm; cons.
 wgt. 1.31 g
 Material: copper-alloy or bronze, gilded
 Frequency range/pitches: no recordings, no frequency analyses

- Cat. 17 pellet bell Inv. nr. D 2507 (Fig. 2: 2: 3)
 Conservation status: two halves (?), fragmented, many pieces
 Rattle body: lump of bronze
 Base shape: oval/circular (?)
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: h. ca. 3.3 cm; dm. ca. 3.3 cm; with. 0.5 mm; cons.
 wgt. 4.71 g
 Material: copper-alloy or bronze, gilded
 Frequency range/pitches: no recordings, no frequency analyses

- Cat. 18 pellet bell Inv. nr. D 2517 (Fig. 2: 2: 4)
 Conservation status: two halves (?), fragmented, many pieces
 Rattle body: lump of bronze
 Base shape: oval/circular (?)
 Sound slot/sound holes: none
 Decoration: smooth, gilded
 Measures: h. ca. 3.3 cm; dm. ca. 3.3 cm; with. 0.5 mm; cons.
 wgt. 0.67 g
 Material: copper-alloy or bronze, gilded
 Frequency range/pitches: no recordings, no frequency analyses

Burial 1/1960

Contents and condition: three individuals, one horse

Individual: two adults (?), one child

Dating: LAP; LPh III

Finds: one pellet bell

Inv. nr.: no information

Position in grave: near skull of horse

References: Čilinská 1963, 87, 88, fig. 2: grave 89; pl. II

- Cat. 19 pellet bell Inv. nr. unknown (Fig. 2: 3)
Conservation status: complete (?)
Rattle body: no information
Base shape: shape I
Sound slot: cruciform
Decoration: human face
Measures: h. 3.2 cm
Material: copper-alloy
Frequency range/pitches: no recordings, no frequency analysis

Cemetery Skalica-Vysoké pole, Trnava Region

Excavations: 1922/1923, 1943/1944

Graves with pellet bells: one (Fig. 5)

Dating: 9th–10th c.

References: Budinský-Krička 1959

Burial in tumulus 13/tomb 6

Contents and condition: individual

Individual: child

Dating: Slavic, end of Moravian Empire, at 900 CE

Finds: 1 pellet bell

Inv. nr.: no information

Position in grave: near skull

- Cat. 20. pellet bell Inv. nr. unknown (Fig. 5: 3)
Conservation status: complete, two holes
Rattle body: small pebble
Base shape: shape II
Sound slot/sound holes: cruciform
Decoration: crossing diagonal lines
Measures: h. ca. 3.5 cm; hwh. 2.4 cm; dm. 2.7 × 2.35 cm; wth. 1–2 mm; cons. wgt. 25.03 g
Material: copper-alloy
Frequency range/pitches: 1–22 kHz

Collection of the Institute of Archaeology Slovak Academy of Sciences, Nitra

Cemetery Holiare, Nitra Region

Excavations: 1931/1932; 1952–1955

Graves with pellet bells: four (Fig. 3)

Dating: MAP–LAP, second half of the 7th to the 8th c.

Storage: Collection of the IA SAS, Nitra

References: Točík 1968; Zábajník 2009

Burial 92

Contents and condition: individual, undisturbed

Individual: woman

Dating: second half of 7th c. to 8th c.

Finds: one pellet bell

Inv. nr.: 2760_Holiare

Position in grave: pellet bell near left femur

- Cat. 21 pellet bell Inv. nr. 2760_Holiare (Fig. 3: 1)
Conservation status: complete
Rattle body: conserved, small pebble
Base shape: shape II

Sound slot/sound holes: cruciform

Decoration: vertical grooves on lower part of body

Measures: h. ca. 3.6 cm; hwh. 3 cm; dm. 3.2 × 2.7 cm; wth. 1 mm

Material: copper-alloy

Frequency range/pitches: 1.7 kHz–21.3 kHz

Burial 146

Contents and condition: individual

Individual: woman

Dating: second half of 7th c. to 8th c.

Finds: one pellet bell

Inv. nr.: 505_Holiare

Position in grave: pellet bell between skeleton and left arm

- Cat. 22 pellet bell Inv. nr. 505_Holiare (Fig. 3: 2)
Conservation status: nearly complete, one small piece broken out, corroded
Rattle body: conserved, small pebble
Base shape: shape IV
Sound slot/sound holes: cruciform
Decoration: none
Measures: h. 3.7 cm; hwh. 2.75 cm; dm. 3.1 × 2.8 cm; wth. 2 mm; cons. wgt. 12.6 g
Material: iron sheet
Frequency range/pitches: no recordings, no frequency analyses

Burial 437

Contents and condition: individual

Individual: child

Dating: second half of 7th c. to 8th c.

Finds: one pellet bell

Inv. nr.: 1414_Holiare

Position in grave: pellet bell between femurs

- Cat. 23 pellet bell Inv. nr. 1414_Holiare (Fig. 3: 3)
Conservation status: complete, corroded, textiles corroded on surface
Rattle body: conserved, corroded inside
Base shape: shape II
Sound slot/sound holes: no information because of corrosion
Decoration: none
Measures: hwh. 2.8 cm; dm. 3.1 × 2.9 cm; cons. wgt. 13.68 g
Material: iron sheet
Frequency range/pitches: no recordings, no frequency analyses

Burial 667

Contents and condition: individual

Individual: no information

Dating: second half of 7th c. to 8th c.

Finds: one pellet bell

Inv. nr.: 2034_Holiare

Position in grave: pellet bell near left hand

- Cat. 24 pellet bell Inv. nr. 2034_Holiare (Fig. 3: 4)
Conservation status: one piece broken out
Rattle body: conserved, small pebble
Base shape: shape II
Sound slot/sound holes: cruciform, one hole on vertex
Decoration: none
Measures: h. 3.9 cm; hwh. 3 cm; dm. 2.9 × 2.8 cm; wth. 0.5–1 mm; cons. wgt. 23.91 g
Material: copper-alloy
Frequency range/pitches: no recordings, no frequency analyses

Burial 782

Contents and condition: individual

Individual: child

Dating: second half of 7th c. to 8th c.

Finds: two pellet bells

Inv. nr.: 2405a_Holiare, 2405b_Holiare

Position in grave: pellet bells near left femur

- Cat. 25 pellet bell Inv. nr. 2405a_Holiare (Fig. 3: 5)

Conservation status: two holes in body, handle is lost

Rattle body: conserved, small pebble

Base shape: shape II

Sound slot/sound holes: cruciform

Decoration: none

Measures: hwh. 3 cm; dm. 3 × 3.2 cm; cons. wgt. 14.75 g

Material: iron sheet

Frequency range/pitches: 3.2 kHz–11 kHz

- Cat. 26 pellet bell Inv. nr. 2405b_Holiare (Fig. 3: 6)

Conservation status: fragmented

Rattle body: lost

Base shape: shape II

Sound slot/sound holes: simple sound slot

Decoration: none

Measures: hwh. 3 cm; dm. 2.9 cm; cons. wgt. 7.06 g

Material: iron sheet

Frequency range/pitches: no recordings, no frequency analyses

Cemetery Nové Zámky I, Nitra Region

Excavations: 1958, 1961–1962

Graves with pellet bells: 7 (Fig. 4)

Dating: MAP–LAP, 7th c.–9th c. CE

Storage: Collection of the IA SAS, Nitra

References: *Čilinská 1966*

Burial 175

Contents and condition: individual, undisturbed

Individual: child

Dating: LAP, 8th c. CE

Finds: one pellet bell

Inv. nr.: no information

Position in grave: near right femur

- Cat. 27 pellet bell Inv. nr. unknown (Fig. 4: 1)

Conservation status: complete

Rattle body: no information

Base shape: shape I or II

Sound slot/sound holes: cruciform

Decoration: face

Measures: dm. 2.5 cm

Material: copper-alloy

Frequency range/pitches: no recordings, no frequency analyses

Burial 224

Contents and condition: individual

Individual: man, *adultus/maturus*

Dating: LAP, 8th c.

Finds: one pellet bell

Inv. nr.: 83_Nové Zámky I

Position in grave: near left foot

- Cat. 28 pellet bell Inv. nr. 83_Nové Zámky I (Fig. 4: 2)

Conservation status: complete, inside filled with material (?), textile fragments on surface (?)

Rattle body: no information

Base shape: shape II

Sound slot/sound holes: no information

Decoration: smooth, two circular belts

Measures: hwh. 3.4 cm; dm. 3.25 × 3.05 cm; cons. wgt. 19.71 g

Material: iron sheet (?)

Frequency range/pitches: no recordings, no frequency analyses

Burial 354

Contents and condition: individual

Individual: *infans*

Dating: LAP, 8th c.

Finds: two pellet bells

Inv. nr.: 213_Nové Zámky I

Position in grave: near right femur

- Cat. 29 two pellet bells Inv. nr. 213_Nové Zámky I (Fig. 4: 3)

Conservation status: deformed, flat, corroded together

Rattle body: no information

Base shape: no information

Sound slot/sound holes: no information

Decoration: no information, corroded

Measures: length. 4.2 cm, wth. 3.5 cm; cons. wgt. 22.47 g

Material: iron sheet

Frequency range/pitches: no recordings, no frequency analyses

Burial 386

Contents and condition: three individuals

Individual: one woman/adult and two children, *infans* and *infans I*

Dating: LAP

Finds: one pellet bell

Inv. nr.: 245/62_Nové Zámky I

Position in grave: near left arm of one child

- Cat. 30 pellet bell Inv. nr. 245/62_Nové Zámky I (Fig. 4: 4)

Conservation status: deformed, textiles fragments on surface

Rattle body: pebble

Base shape: shape II (?)

Sound slot/sound holes: no information

Decoration: no information, corroded

Measures: h. 3.8 cm, hwh. 2.56 cm; dm. 3.1 × 2.5 cm; cons. wgt. 12 g

Material: iron sheet

Frequency range/pitches: no recordings, no frequency analyses

Burial 438

Contents and condition: 3 individuals

Individual: one woman and unknown sex; *senilis*, *adultus*, *infans*

Dating: LAP, 8th c.

Finds: one pellet bell

Inv. nr.: 297_Nové Zámky I

Position in grave: near left arm of senile person and teeth of child

- Cat. 31 pellet bell Inv. nr. 297_Nové Zámky I (Fig. 4: 7)
Conservation status: fragmented, 75% conserved
Rattle body: lost
Base shape: shape II
Sound slot/sound holes: cruciform, two sound holes
Decoration: vertical grooves on lower part
Measures: h. 3.5 cm; hwh. 2.8 cm; dm. 2.8 × 2.55 cm; wth. 2 mm, cons. wgt. 13.34 g
Material: copper-alloy
Frequency range/pitches: no recordings, no frequency analyses

Burial 509

Contents and condition: individual, disturbed
Individual: child, *infans*
Dating: LAP, 8th c.
Finds: one pellet bell
Inv. nr.: 509_Nové Zámky I
Position in grave: in the middle of the grave

- Cat. 32 pellet bell Inv. nr. 509_Nové Zámky I (Fig. 4: 5)
Conservation status: deformed, compressed, 60% conserved, broken, corroded on a ring with two further rings, textile fragments
Rattle body: pebble
Base shape: shape II
Sound slot/sound holes: no information

Decoration: corroded
Measures: h. ca. 3 cm; length 5 cm; wth. 4 cm; wth. 0.1 cm, cons. wgt. 23.1 g
Material: iron sheet
Frequency range/pitches: no recordings, no frequency analyses

Burial 510

Contents and condition: individual
Individual: woman, *adultus* (?)
Dating: MAP, 7th c.
Finds: one bell
Inv. nr.: 369_Nové Zámky I
Position in grave: near left femur

- Cat. 33 bell Inv. nr. 369_Nové Zámky I (Fig. 4: 6)
Conservation status: 75% conserved, two holes in body, one hole on vertex
Clapper: lost
Type: type 1/var. A
Sound slot/sound holes: no information
Decoration: smooth
Measures: hwh. 2.7 cm; dm. 3.85 × 3.7 cm; wth. 1 mm, cons. wgt. 15.98 g
Material: copper-alloy
Frequency range/pitches: no recordings, no frequency analyses

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Súhrn preložila Kristína Sedliaček

Mag. Dr. Beate Maria Pomberger
Naturhistorisches Museum Wien
Prähistorische Abteilung
Burgring 7
A – 1010 Wien
beate.pomberger@NHM.at
<https://orcid.org/0000-0002-3366-0924>

Dr. Jörg Mühlhans, B.a. M.a.
Universität Wien
Medialab der Philologisch-Kulturwissenschaftlichen Fakultät
Althanstraße 14
Rotunde, Stiege H, Ebene I
A – 1090 Wien
joerg.muehlhans@univie.ac.at
<https://orcid.org/0000-0001-9720-7355>

Kayleigh Sanderson B.A.
Universität Wien
Institut für Urgeschichte und historische Archäologie
Franz Kleingasse 1
A – 1190 Wien
kayleigh@saunderson.at
<https://orcid.org/0000-0002-8561-6204>

Analýza rolničiek a zvončekov z včasného stredoveku na Slovensku

Nové Zámky I, Radvaň nad Dunajom-Žitavská Tôň (Radvaň I), Holiare a Skalica

Beate Maria Pomberger – Jörg Mühlhans –
Kayleigh Sanderson

SÚHRN

Nálezy rolničiek sa na území avarského kaganátu objavujú od polovice 7. stor. Pravdepodobne boli importované z východných oblastí Kaukazu a Čiernomoria. Iba 1 % z celkového počtu hrobov na pohrebiskách obsahovalo v rámci hrobového inventáru tento nález. Nosené tak boli len zopár ženami a deťmi a rovnako slúžili ako ozdoba konského postroja. Ich funkcia bola rôzna – pre niekoho predstavovali apotropaický amulet, neskôr boli pravdepodobne symbolom spoločenského postavenia.

Na pohrebisku Radvaň nad Dunajom-Žitavská Tôň, Radvaň I sa našli rolničky v troch hroboch a všetky boli súčasťou konského postroja. Na pohrebisku Holiare boli objavené štyri hroby s rolničkami, konkrétne dva detské a dva ženské hroby. Podobne aj pohrebisko Nové Zámky I obsahovalo päť detských a jeden mužský hrob s týmto typom artefaktu. Rolnička datovaná do obdobia rímskej ríše pochádza zo ženského hrobu a ďalšia sa našla v mohyle XIII/hrob 6.

Rolničky sa vyrábali odlievaním z rôznych zliatin medi alebo kovaním zo železného plechu, poprípade medenej zliatiny. V ich vnútri bol umiestnený voľne sa pohybujúci drobný kamienok, hrudka bronzu alebo trosky. Veľkosť nálezov sa pohybuje okolo 2,4–4,2 cm a váha 0,67–25 g. Tvar je spravidla oválny alebo guľovitý. Ich povrch je buď

bez výzdoby, alebo nesú stopy po vertikálnych ryhách, zväzky čiar a tiež na nich boli zobrazované ľudské tváre. Na základe umiestnenia nálezov v hrobe sa zdá, že boli nosené na krku alebo na zápästí, avšak najčastejšie boli upevňované na opasku a na bočných remeňoch opasku.

Z hľadiska akustiky zodpovedajú analyzované nálezy podobným nálezom rolničiek. Ich zvuk je málo intenzívny a slabo tonálny, avšak jasný a čiastočne ostrý, spektrálna drsnosť je pritom veľmi nízka. Táto charakteristika je vo všeobecnosti platná, avšak s výnimkou nekorodovaných exemplárov, ktoré vykazujú výrazne vyššie hodnoty, predovšetkým v hlasitosti a tonálnosti. Je možné konštatovať, že väčšina skúmaných exemplárov je z hľadiska zvukového dojmu, rovnako aj výsledkov analýz, pomerne typická pre silne skorodované rolničky.

Čo sa týka upevnenia rolničiek na konský postroj, je možné uvažovať o viacerých funkčných účeloch. Odhliadnuc od ich dekoratívneho a apotropického využitia, praktický test dokázal, že kôň je vďaka ich zvuku viac sústredený a menej náchylný na rušenie vonkajšími vplyvmi. Na túto funkciu sa prihliadalo predovšetkým počas dobových turnajov v období neskorého stredoveku a raného novoveku a pravdepodobne aj v predchádzajúcich dejinných obdobiach.

Obr. 1. Mapa s vyznačenými lokalitami s nálezmi rolničiek. Zdroj mapového podkladu www.d-maps.com, grafika B. M. Pomberger.

Obr. 2. Pohrebisko Radvaň nad Dunajom-Žitavská Tôň, Radvaň I. Hroby s nálezmi rolničiek. 1 – poloha hrobov; 2 – hrob 31 so štyrmi rolničkami; 3 – hrob 1_1963; 4 – hrob 10 so 14 rolničkami (podľa Budinský-Krička 1956, 7; Čilinská 1963, 88, obr. 1). Foto, grafika B. M. Pomberger, Slovenské národné múzeum v Martine.

Obr. 3. Pohrebisko Holiare. Nálezy rolničiek. 1 – hrob 92; 2 – hrob 146; 3 – hrob 437; 4a, b – hrob 667; 5, 6 – hrob 728. Foto, grafika B. M. Pomberger, AÚ SAV, v. v. i.

Obr. 4. Pohrebisko Nové Zámky I. Hroby s nálezmi rolničiek a inými predmetmi. 1 – hrob 175; 2 – hrob 224; 3 – hrob 354; 4 – hrob 386; 5 – hrob 509; 6 – hrob 510; 7 – hrob 438 (mapa podľa Čilinská 1966, 327). Foto, grafika B. M. Pomberger, AÚ SAV, v. v. i.

Obr. 5. Pohrebisko Skalica. Mohyla 13. Nález rolničky (podľa Budinský-Krička 1959, 40, 74, tab. 21: 4). Foto,

grafika B. M. Pomberger, Slovenské národné múzeum v Martine.

Obr. 6. Štatistické znázornenie distribúcie rolničiek na pohrebiskách a v hroboch. 1 – Radvaň nad Dunajom-Žitavská Tôň, Radvaň I; 2 – Holiare; 3 – Nové Zámky I. Legenda: a – hrobov spolu; b – hroby s guľôčkovými zvončekmi. Grafika B. M. Pomberger.

Obr. 7. Tvary rolničiek. Grafika B. M. Pomberger.

Obr. 8. Interpretácia apotropaického významu rolničiek s vyobrazením ľudskej tváre. Grafika B. M. Pomberger.

Obr. 9. Rolničky pripevnené ku konskému postroju v blízkosti ucha zvierťa. Foto K. Sanderson.

Obr. 10. Prah počutia. Legenda: a – ľudia; b – kone; c – psy. Grafika J. Mühlhans.

Obr. 11. 1 – vlnový priebeh zvuku rolničky Cat. 2 (hrob 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I), zobrazujúci jednotlivé impulzy počas 3-sekundovej konštantnej excitácie; 2 – výsledné spektrum zobrazujúce čiastkové

frekvencie a spektrálne rozloženie energie. Grafika J. Mühlhans.

Obr. 12. Spektrá rolničiek, ktorým chýbajú výrazné čiastkové tóny a majú zvýšenú spektrálnu energiu iba v určitých frekvenčných pásmach (skôr hlučné objekty). 1 – kat. č. 9 (hrob 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I); 2 – kat. č. 20 (mohyla 13, hrob 6, Skalica). Rozsah rolničiek, ktoré majú aspoň desať zreteľne viditeľných čiastkových tónov/pikov. 3 – kat. č. 12 (hrob 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I); 4 – kat. č. 21 (hrob 92, Holiare). Grafika J. Mühlhans.

Obr. 13. Spektogramy rolničiek. 1 – kat. č. 9 (hrob 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I); 2 – kat. č. 20 (mohyla 13, hrob 6, Skalica); 3 – kat. č. 12 (hrob 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I); 4 – kat. č. 21 (hrob 92, Holiare). Obe rolničky z hrobu 10, Radvaň nad Dunajom-Žitavská Tôň, Radvaň I (1, 3), ukazujú výrazne nižšie množstvo spektrálnej energie (sfarbenie). Nález z mohyly 13, hrob 6, Skalica (2) má viac energie v úzkom frekvenčnom pásme 3–4 kHz a nález z hrobu 92, Holiare, má vyššiu energiu rovnomernejšie rozloženú v pásme medzi 2–20 kHz. Grafika J. Mühlhans.

