PELLET BELLS FROM THE AVAR AND THE CAROLINGIAN PERIOD IN THE KESZTHELY REGION (HUNGARY): FUNCTION – SOUNDS – ALLOYS – ADHERING TEXTILES

AVAR ÉS KAROLING KORI CSÖRGŐK A KESZTHELYI RÉGIÓBÓL: FUNKCIÓ – HANGOK – ÖTVÖZETEK – TEXTILMARADVÁNYOK •

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Abstract

The collections of the Balaton Museum in Keszthely and of the Hungarian National Museum contain around 50 pellet bells from the Great Migration period from the Keszthely Region. All originate from cemeteries and were analysed concerning their find position, function, sounds, psychoacoustic parameters, and chemical compositions. Additionally, adhering textiles were investigated. Primarily children wore pellet bells hanging from their tunic. Pellet bell served as amulets and the idea that their sounds and metals protect are still popular today.

Kivonat

A keszthelyi Balaton Múzeum és a Magyar Nemzeti Múzeum gyűjteményei közel ötven, népvándorlás kori csörgőt őriznek a keszthelyi régióból. A leletek temetőkből származnak. A csörgőket megtalálási helyzetük, hangzásuk, pszichoakusztikus paramétereik és kémiai összetételük alapján elemeztük, valamint vizsgáltuk a rajtuk megőrződött textilmaradványokat. Elsősorban a gyerekek viselték a tunikájukról lelógó csörgőket. A csörgőket amulettként használták, a hangjuk és anyaguk védelmező funkciója manapság is népszerű elképzelés.

KEYWORDS: BELLS, PELLET BELLS, AVAR PERIOD, CAROLINGIAN PERIOD, ARCHAEOMUSICOLOGY, ACOUSTICS, PSYCHOACOUSTICS, ARCHAEOMETRY, TEXTILES

KULCSSZAVAK: CSENGŐK, CSÖRGŐK, AVAR KOR, KAROLING KOR, ARCHEOMUZIKOLÓGIA, AKUSZTIKA, PSZICHOAKUSZTIKA, ARCHEOMETRIA, TEXTILEK

Introduction

About 50 pellet bells from the Early Middle Ages and the Carolingian period are known from the Keszthely region in Hungary. They are part of the collections of the Balaton Museum in Keszthely and the Migration Period collection of the Hungarian National Museum in Budapest.

They were investigated within the framework of the research project "Metallic Idiophones between 800 BCE and 800 CE in Central Europe" in terms of their occurrence, functions, chemical compositions, acoustics and psychoacoustics (Pomberger et al. 2021a). Furthermore, textiles adhering to some pellet bells were analysed.

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Keszthely Culture

The Keszthely Culture developed around the late Roman fortification Keszthely-Fenékpuszta located at the Lake Balaton near the western border of the Avar Khaganate during the Early Avar period. *Romani*, different Germanic people and people from the Balkan area lived here and formed an Early Christian community. The early Keszthely Culture lasted from the last third of the 6th century until the early 7th century CE. Around 630 CE, the fortification was destroyed and remained unoccupied for two centuries. The population moved to the Keszthely town area and its surroundings. During the middle of the 7th century, Avars and Slavs settled and mixed with the resident population. They used the same settlements and cemeteries (e.g. Müller 1991; Müller 1996a, Müller 2007; Kiss 2008; Fóthi et al. 2009; Heinrich-Tamáska & Straub 2009; Müller 2018c; Müller 2020).

Cemeteries with pellet bells and bells

Pellet bells appear during the middle of the 7th century in the Avar Khaganate (Pomberger & Stadler 2018, 139, Abb. 4) and this object type probably arrived from the regions of the Black Sea and the Caspian Sea, where for example, pellet bells were found in a woman's burial from a necropolis of the 2nd to 4th century CE in Mingetschevir, Azerbaijan (Ateshi Gadirova 2014, 251). In the region of the Keszthely culture, about 45 pellet bells and bells originate from six cemeteries of the 7th to 9th century, namely from Keszthely-Városi temető (Ált. Iskola, Sörházkert), Keszthely-Dobogó, Gyenesdiás, Lesencetomaj B Piroskereszt, Esztergályhorváti-Alsóbárándpuszta and Zalaszabar–Borjúállás-sziget, so far known to the authors. Only a vanishingly small group of burials contained pellet bells. Therefore, we may say that they were not frequent finds but spread all over the Carpathian Basin during the Avar culture (Pomberger et al. 2021b; Pomberger et al. 2022c).

Keszthely-Városi temető and Keszthely-Dobogó

Excavation of the sites Keszthely-Városi temető and Keszthely-Dobogó started already during the 19th century (Lipp 1885; Hampel 1905). Eight pellet bells can be certainly allocated to Városi temető (see cat. 1–10) and three idiophones to Keszthely-Dobogó (see cat. 11–13) (**Fig. 1.**). Twelve objects (see cat. 14–24) cannot be precisely located, because unfortunately the objects kept in the Hungarian National Museum were mixed by the time of inventorying, some were bought by the museum from Vilmos Lipp, and even in the 1880s and 1870s – when they reached the museum – they were not kept according to grave number nor site but marked as simply "Keszthely". Some of them might correlate to finds mentioned by Kiss, who noted two iron pellet bells from burial 1344 and one iron pellet bell from burial 1354, all excavated in 1882 (Kiss 1997, 121–122). Lipp presents two further pellet bells, one with textile fragments (fig. 1/10) (Lipp 1885, 93/Fig. 14) and one with a chain corroded on the pellet bell (Lipp 1885, 100/Fig. 108).

Gyenesdiás

The cemetery of Gyenesdiás, excavated in the 1960s, 1980s and 1991, was used from the 6th to the 8th/9th century CE and a small noble community buried their deceased here (Müller 1990; Müller 1991; Müller 1992; Müller 1996b; Müller 2008), among them the rich burial of a man of high social status (Müller 1990).We know 14 pellet bells from 11 children's burials and one stray find (see cat. 26–39) (Müller unpublished; Müller 2018). All pellet bells belonged to the children and were positioned mostly near the hips. One was worn around the neck (cat. 26, burial 47) and one lay near the skull of a foal and belonged to a head harness (cat. 36, burial 137) (**Fig. 2.**).

Lesencetomaj B Piroskereszt

The cemetery Lesencetomaj B Piroskereszt, known since 1937 and excavated until 2008 (Müller 1992; Perémi 2000; Perémi 2002; Fóthi et al. 2009, 326–332), contained only two pellet bells, so far known to the authors. They originate from burials 40 and 41 (cat. 40, and 41) (Müller 1992, 272–273, pl. 21/40 and 41), belonging to children who wore them around their neck and on their belt. The burials date to the 8th/9th century CE (see **Fig. 3/1–2**).

Esztergályhorváti-Alsóbárándpuszta

Three burials, 40, 41 and 42, from the cemetery Esztergályhorváti (Szentpéteri 2002, 132) each contained one pellet bell (see cat. 42–44). The cemetery dates to the 9th/10thcentury (Carolingian period) (Szőke 1996, 130–131) (**Fig. 3/3–5**).

Zalaszabar–Borjúállás-sziget

On the island Zalaszabar–Borjúállás in the Kis-Balaton (Small Balaton), a settlement with a manor house, a church and a cemetery fenced with palisades were excavated. The site dates from the second half of the 9th century to the first third of the 10th century (Müller 1996c; Müller 2014).

The burials 193 and 497 each contained one pellet bell without data on the positions in the find contexts (cat. 45, cat. 46) (**Fig. 3/6–7**), according to the information from Balaton Museum, Keszthely.

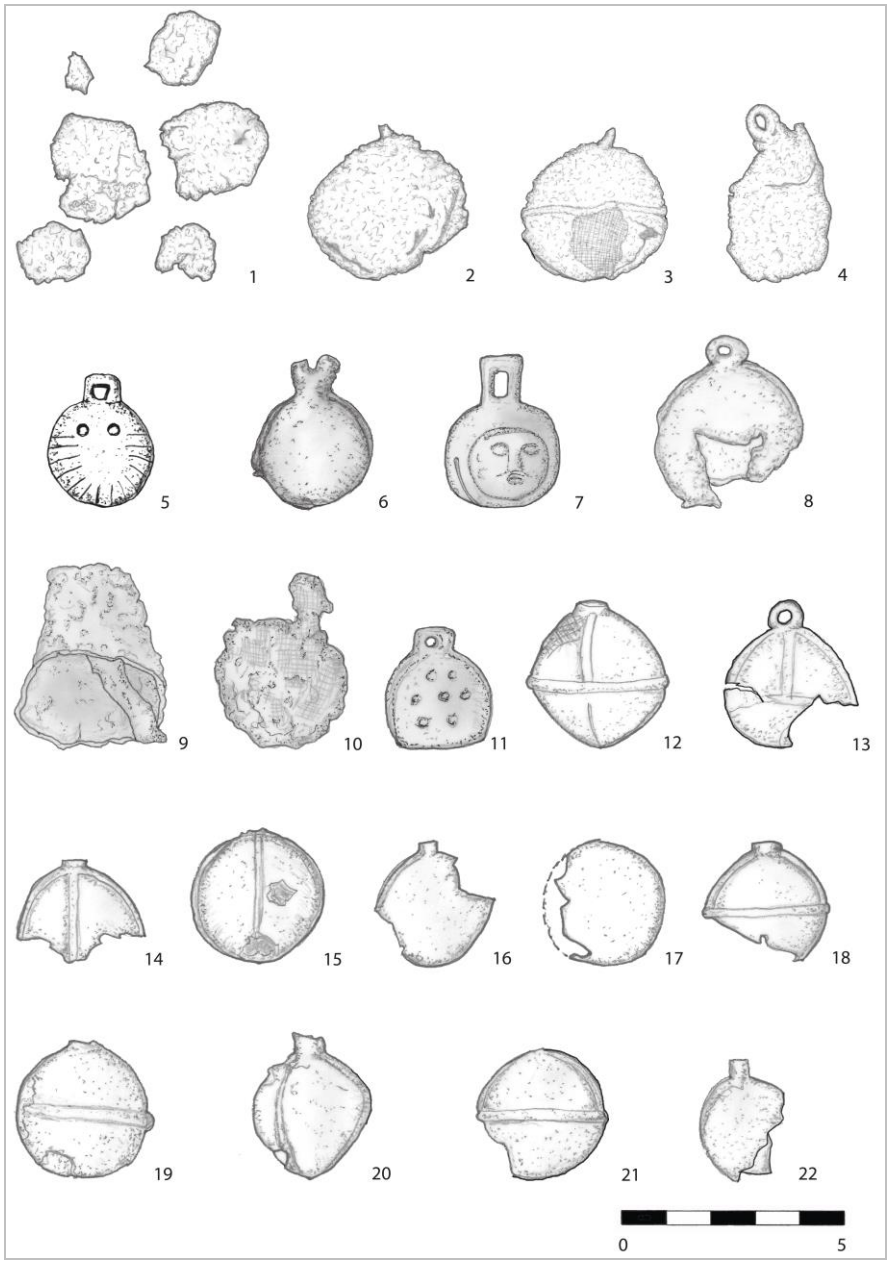

Fig. 1.: Pellet bells from Keszthely-Városi temető (Ált. Iskola): 1 – grave 131; 2 – A grave 134; 3 – B grave 134; 4 – C grave 134; Keszthely-Városi temető (Sörházkert): 5 – grave 52; 6 – MNM 52.96.2; 7 – from a girl's grave, cat. 7 (after Lipp 1885, 116/326), fig. e); Keszthely-Dobogó: 8 – grave 119, cat. 11; 9 – bell grave 119, cat. 12 (after Lipp 1885/16). Keszthely-Városi temető or Dobogó: 10 – with textile fragments, (see note after cat. 13 in catalogue; according Lipp 1885, 93/14); 11 – cat. 25, MNM 157.1880.9 (after Lipp 1885/93/15); 12 – cat. 14, MNM 52.91.1_a; 13 – cat. 15, MNM 52.91.1_b; 14 – cat. 16, MNM 52.91.1_c; 15 – cat. 17, MNM 52.91.1_d; 16 – cat. 18, MNM 52.91.1_e; 17 – cat. 19, MNM 52.91.1_f; 18 – cat. 20, MNM 52.91.1_g; 19 – cat. 20, MNM 52.91.1_h; 20 – cat. 22, MNM 52.91.1_i; 21 – cat. 23, MNM 52.91.1_j; 22 – cat. 24, MNM 52.91.1_k (7, 9 and 10 without scale)(Graphic: B.M. Pomberger).

1. ábra: Csörgők Keszthely-Városi temetőből (Ált. Iskola): 1 – 131. sír; 2 – A 134. sír; 3 – B 134. sír; 4 – C 134. sír; Keszthely-Városi temetőből (Sörházkert): 5 – 52. sír; 6 – MNM 52.96.2; 7 – kislány sírjából, cat. 7 (Lipp 1885, 116/326, fig. e nyomán); Keszthely-Dobogó: 8 – 119. sír, cat. 11; 9 – csengő, 119. sír, cat. 12 (Lipp 1885/16 nyomán). Keszthely-Városi temető vagy Dobogó: 10 – textiltöredékkel (ld. a megjegyzést a cat. 13 után a katalógusban; Lipp 1885, 93/14 szerint); 11 – cat. 25, MNM 157.1880.9 (Lipp 1885/93/15 után); 12 – cat. 14, MNM 52.91.1_a; 13 – cat. 15, MNM 52.91.1_b; 14 – cat. 16, MNM 52.91.1_c; 15 – cat. 17, MNM 52.91.1_d; 16 – cat. 18, MNM 52.91.1_e; 17 – cat. 19, MNM 52.91.1_f; 18 – cat. 20, MNM 52.91.1_g; 19 – cat. 20, MNM 52.91.1_h; 20 – cat. 22, MNM 52.91.1_i; 21 – cat. 23, MNM 52.91.1_j; 22 – cat. 24, MNM 52.91.1_k (7, 9 és 10 méretarány nélkül) (rajz: B. M. Pomberger).

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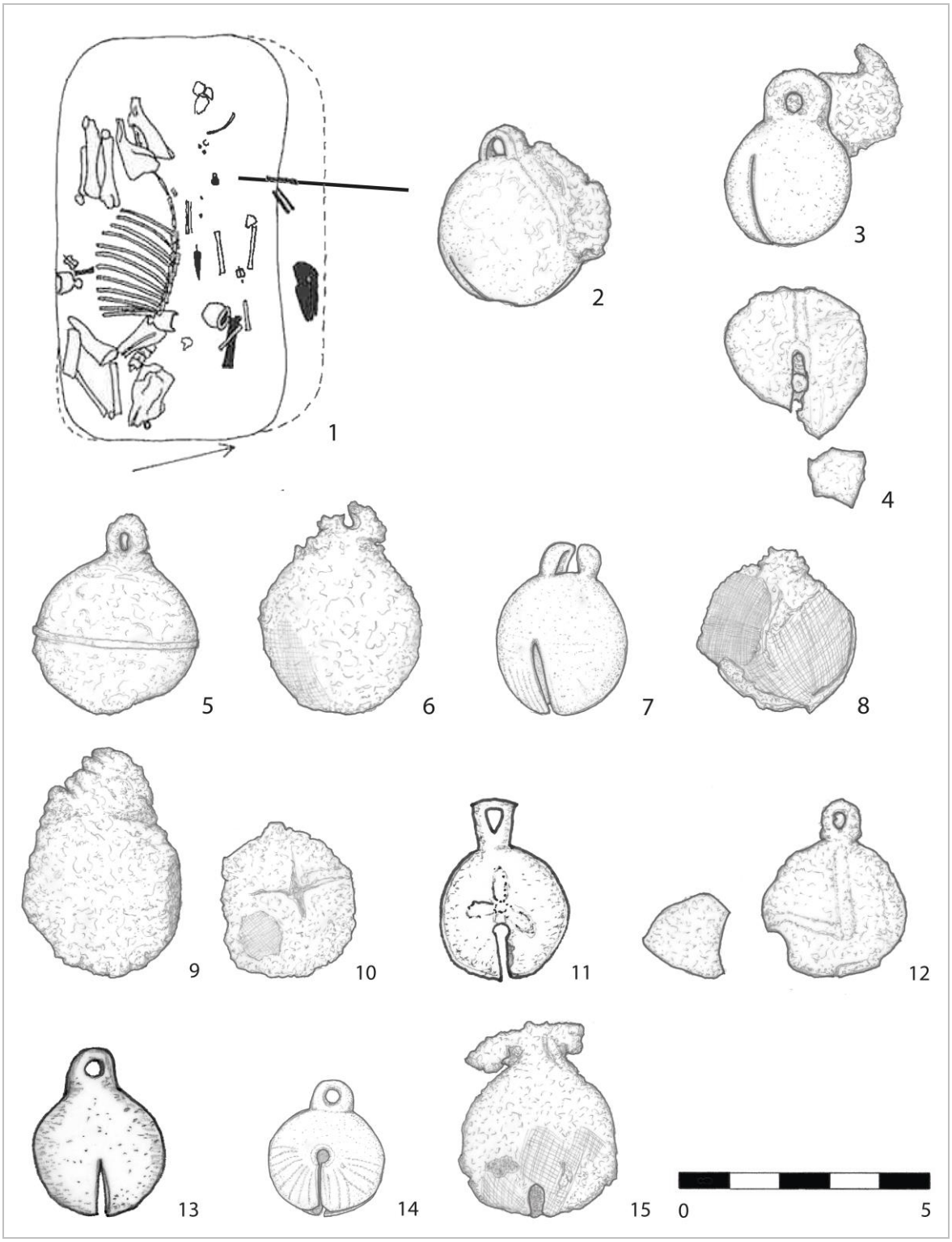

Fig. 2.: Pellet bells from the Gyenesdiás-cemetery: 1 – find situation, grave 47 (after Müller 2018_a, Fig. 1/47); 2 – grave 47; 3 – grave 55/1a; 4 – grave 55/1b; 5 – grave 58; 6 – grave 63; 7 – grave 104; 8 – grave 108/3b; 9 – grave 108/3a; 10 – grave 111; 11 – grave 137 (after Müller 2018_b, Fig. 2/137); 12 – grave 191; 13 – grave 56; 14 – grave 256; 15 – stray find (Graphic: B.M. Pomberger).

2. ábra: Csörgők a gyenesdiási temetőből: 1 – megtalálási pozíció, 47. sír (Müller 2018a, fig. 1/47 nyomán); 2 – 47. sír; 3 – 55/1a. sír; 4 – 55/1b. sír; 5 – 58. sír; 6 – 63. sír; 7 – 104. sír; 8 –108/3b. sír; 9 –108/3a. sír; 10 – 111. sír; 11 – 137. sír (Müller 2018_b, fig. 2/137 nyomán); 12 – 191. sír; 13 – 56. sír; 14 – 256. sír; 15 – szórványlelet (rajz: B.M. Pomberger).

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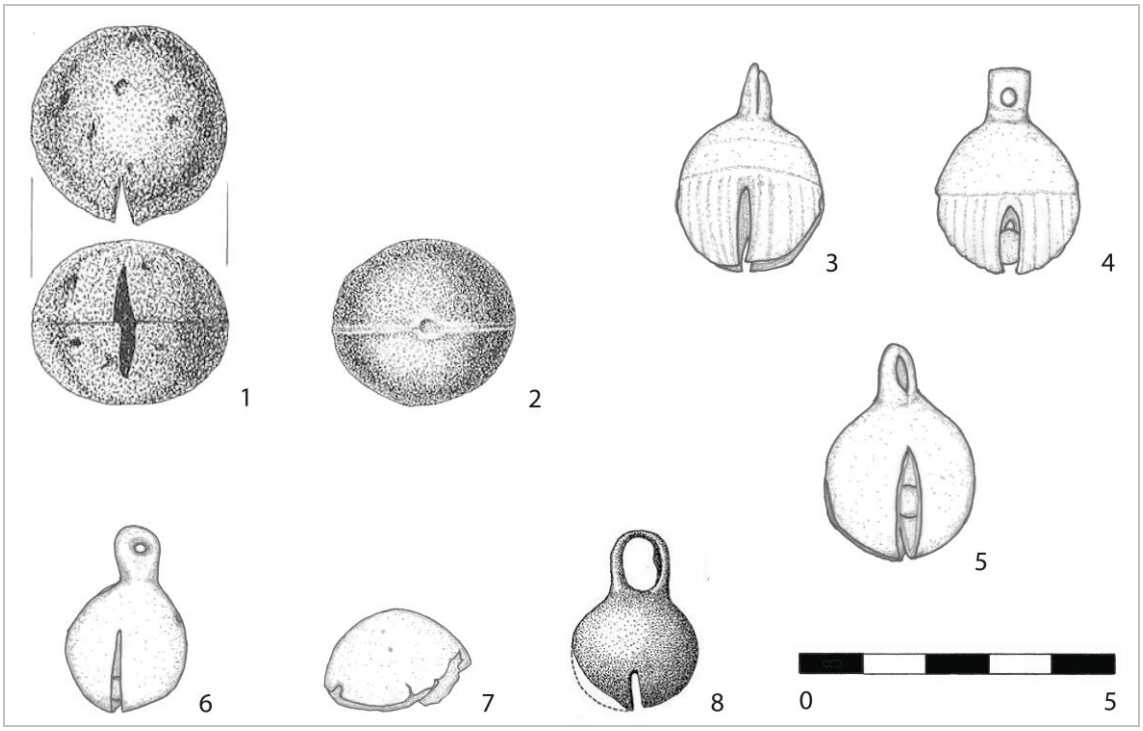

Fig. 3.: Pellet bells from the cemetery Lesencetomaj B: 1 – grave 40; 2 – grave 41 (both after Müller 1992, pl. 21/40 and 41); from the cemetery Esztergályhorváti-Alsóbárándpuszta: 3 – grave 40; 4 – grave 42; 5 – grave 41; from the cemetery Zalaszabar–Borjúállás-sziget: 6 – grave 193; 7 – grave 497; fortification Keszthely-Fenékpuszta south wall, cemetery IV: 8 – grave 1951/15 (after Müller 2010, pl. 21) (Graphic: B.M. Pomberger).

3. ábra: Csörgők a lesencetomaji B temetőből: 1 – 40. sír; 2 – 41. sír (mindkettő Müller 1992, pl. 21/40 és 41 nyomán); az esztergályhorváti-alsóbárándpusztai temetőből: 3 – 40. sír; 4 – 42. sír; 5 – 41. sír; a zalaszabar-borjúállás-szigeti temetőből: 6 – 193. sír; 7 – 497. sír; a keszthely-fenékpusztai erődítményből, déli fal, IV. temető: 8 – 1951/15. sír (Müller 2010, pl. 21 után) (rajz: B.M. Pomberger).

Keszthely-Fenékpuszta south wall

The Carolingian cemetery at the south wall of the fortification Keszthely-Fenékpuszta contained four pellet bells from three burials (1951/15, 1952/50, 1980/13/27) (Müller 2010, 204). A mature man was buried in grave 1951/15. His pellet bell was found near the skull and a stone. It probably contained no grave goods (Sós 1961, 252, pl. LVI/8; Müller 2010, 42, pl. 21). The child (anthropological age infans II) in burial 1952/50 had a pellet bell on an iron chain (Sós 1961, 252, Fig. 4, pl. LXI/7–8; Müller 2010, 45). The pellet bell is lost. And in grave 1980/13/27 a child (infans I) was buried with two pellet bells near the right pelvis. Both pellet bells are not preserved (Müller 2010, 108). The cemetery was used from the middle of the 9th century until the beginning of the 10th century (Müller 2014, 246) (**Fig. 3/8**).

Shapes, sizes, decoration, find positions and function

For classification the pellet bells into types Riita Rainio worked out and proposed a typology of Iron Age pellet bells in Finland (e.g. Rainio 2008). The main author of this article created a typology for Avarian pellet bells, independent from Rainio's typology (Pomberger 2020). This typology is used for all the investigations of our project. Therefore, the Keszthely pellet bells cast in various copper alloys are classified into the Avar base shapes I, II, V and VI. Forged pellet bells show the base shapes II and IV (Pomberger 2020).

The sound slots are shaped cruciform or simple. The sizes of the pellet bells vary between 2.7 cm and 4.3 cm and the weights between 8 g and 28.62 g. Two pellet bells are decorated with masculine faces with mustaches (see cat. 7, cat. 8). This decoration is rather rare (Rácz 2012). The faces probably should either reinforce the "magic power" of the pellet bell (Pomberger et al. 2021b) or simply symbolise cut off heads of enemies (Csuthy 2022), which could also serve as a deterrent. Two Carolingian pellet bells from Esztergályhorváti-Alsóbárándpuszta (see cat. 42, 44) are decorated with vertical grooves. They are similar to finds of burial 34a–b, Rusovce I, Slovakia (Pomberger et al. 2022b). As usual, pellet bell bodies consist of small pebbles, cinder or bronze pellets (Pomberger et al. 2022b). The only

preserved bell (cat. 12) belongs to the Fe type I/var. B (Pomberger & Stadler 2018) and shows no special decoration.

According to the so far documented sources, nearly all pellet bells and bells are grave goods from children's burials. They were detected near the right knees, femurs, pelvis or elbows of the deceased. A few were found on the chests and near the necks of the human skeletons. Pellet bells hanging on chains or perhaps textile strings decorated the belts or ribbons, which held the tunics together. They were also attached to bracelets or ribbons around the wrist or worn on a necklace (Pomberger et al. 2021b). Among the pellet bells from the Keszthely culture, there is only one piece which belonged to the head harness of a foal. It is a small, gilded piece forged from sheet metal and was found in burial 137 from the Gyenesdiás cemetery (cat. 36). Comparable pellet bells are known from Vienna, Csokorgasse, burial 650 (Pomberger et al. 2022a) Radvaň nad Dunajom (former Žitavská Tôň), burials 10 and 31 (Budinsky-Krička 1956, 16–20, 31–35, fig. 5, pl. 18: 8–21, fig. 11, pl. 33: 9) and Pitvaros, burial 51 (Bende 1998).The majority of the pellet bells were forged from sheet iron, which shines silver when polished, whereas pellet bells from copper and copper alloys shine golden.

As we have found out, acoustic (level, fundamental/peak frequency) and psychoacoustic parameters (loudness, brightness, sharpness, tonality) vary greatly between those materials. To be able to control other parameters, like size or shape, one similar pellet bell made of each sheet bronze, sheet iron and sheet copper was reconstructed in an experiment. Sounds of the three pellet bells were recorded and analysed for a multitude of (psycho-) acoustic parameters (Mühlhans et al. 2022).

Pellet bells were both jewellery and amulets. Amulets are believed to have special magic powers and could protect the wearer against illness and evil spirits (Pomberger et al. 2021b, 126–127). Especially metal objects are also believed to have special powers – and pellet bells and bells are made of metal. One explanation is that people believed that the materials, decorations like human faces and sounds could protect humans against evil forces. This imagination was and still is widespread in various societies (e.g., Bächtold-Stäubli & Hoffmann-Krayer 1987b, 207–210; 1987c, 718). From Sámi culture in Lapland, we know small silver balls with rings hanging from the baby cradle. Bronze and silver have protective properties. The shine of the silver and the sound of the beating rings should protect the child from mischief gnomes and goblins (information from the Siida Sámi Museum in Inari, Finland, summer 2022). Esoteric circles are still today trying to persuade people that fairies can be banished with iron and steel and spread their ideas on the internet. A horseshoe on the front door of the house is supposed to offer protection (e.g., https://wicca.ch/Schutzvorfeen.htm, https://snanews.de/20210624/schutz-feen-2607990.html, https://ploetzlichfee.fandom.com/de/wiki/Fee, https://lairbhan.blogspot.com/2016/08/iron-as-protection-against-fairies.html, https://wicca.eu.com/die-metalle-wirkung/, accessed 8.8.2022).

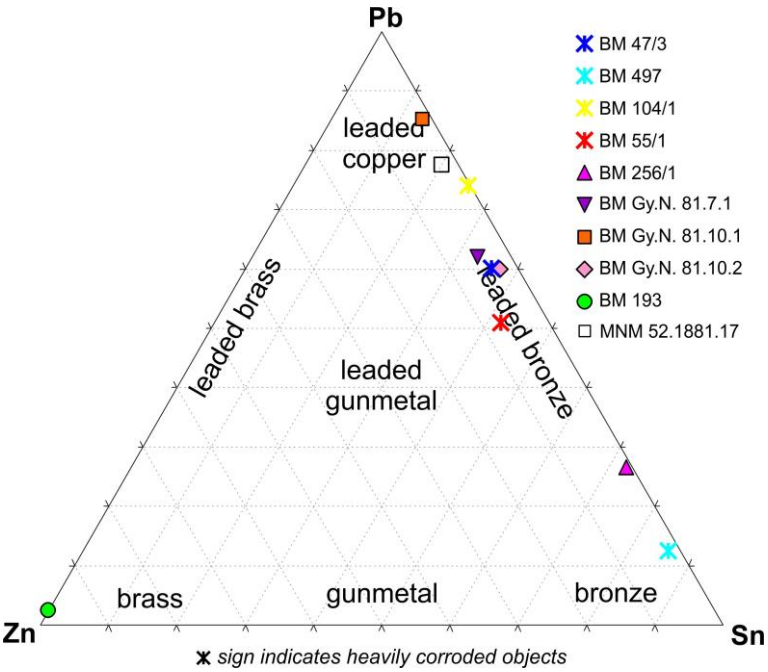

Fig. 4.: Chemical composition of the metallic idiophones from the Keszthely region plotted on the Sn-Pb-Zn ternary diagram (after Bayley 1989). During corrosion processes lead and tin contents increase, whereas zinc content decreases towards the surface (graphic: V. Mozgai).

4. ábra: A keszthelyi régióból származó fémidiofonok kémiai összetétele az Sn-Pb-Zn háromszög-diagramon (Bayley 1989 nyo-mán). Rézötvözettárgyak korróziója során az ólom- és az óntartalom növekszik, míg a cinktartalom csökken a felszín felé (rajz: Mozgai V.).

Table 1.: Chemical compositions of the metallic idiophones from the Keszthely region measured by hXRF. The results are in weight%. LOD = limit of detection. The elevated Fe, Al, Si, P and S content is due to corrosion processes and soil contamination (compiled by V. Mozgai).

1. táblázat: A keszthelyi régióból származó fémidiofonok kézi XRF-fel mért kémiai összetétele. Az adatokat tömeg%-ban adtuk meg. LOD = kimutatási határ. A megnövekedett Fe-, Al-, Si-, P- és S-tartalom a korróziós folyamatok és a talajszennyeződés eredménye (összeállította: Mozgai V.).

Cat. Nr.	Inventory Nr.	Object	Cu	Zn	Sn	Pb	Sb	As	Au	Ag
5	MNM 52.1881.17	pellet bell	69.8	0.7	5.6	21.8	0.2	<LOD	<LOD	<LOD
19	BM 47/3	pellet bell	67.9	1.0	8.2	13.5	<LOD	<LOD	<LOD	<LOD
20	BM 55/1	pellet bell	47.5	3.0	17.7	21.4	0.2	1.2	<LOD	<LOD
24	BM 104/1	pellet bell	53.3	0.2	11.2	32.1	0.3	1.2	0.1	0.1
29	BM 256/1	pellet bell	85.7	0.1	7.4	2.7	2.1	0.9	0.1	0.3
33	BM 81.10.1	pellet bell	86.0	0.1	1.0	6.7	0.1	0.7	0.2	0.2
34	BM 81.10.2	pellet bell	57.9	1.1	13.5	21.7	0.5	0.9	0.3	0.8
35	BM 81.7.1	pellet bell	80.4	0.8	5.1	9.6	0.1	0.4	<LOD	0.2
36	BM 193	pellet bell	69.5	21.8	<LOD	0.6	0.05	1.5	<LOD	<LOD
37	BM 497	pellet bell	93.0	0.05	2.3	0.3	<LOD	0.1	1.1	<LOD
37	BM 497	pellet bell	68.0	<LOD	3.1	<LOD	0.1	0.2	21.1	0.6

Table 1., cont.

Cat. Nr.	Inventory Nr.	Object	Hg	Fe	Al	Si	P	S	alloy
5	MNM 52.1881.17	pellet bell	<LOD	0.1	1.5	0.2	<LOD	<LOD	Cu-Sn-Pb
19	BM 47/3	pellet bell	<LOD	1.4	1.6	0.7	0.6	<LOD	Cu-Sn-Pb
20	BM 55/1	pellet bell	<LOD	0.6	<LOD	1.1	6.8	<LOD	Cu-Sn-Pb-Zn
24	BM 104/1	pellet bell	<LOD	0.1	0.4	<LOD	0.6	<LOD	Cu-Sn-Pb
29	BM 256/1	pellet bell	<LOD	0.1	<LOD	<LOD	0.2	<LOD	Cu-Sn-Pb
33	BM 81.10.1	pellet bell	<LOD	1.1	1.4	1.1	0.1	1.0	Cu-Pb
34	BM 81.10.2	pellet bell	<LOD	0.2	0.7	0.4	1.6	<LOD	Cu-Sn-Pb
35	BM 81.7.1	pellet bell	<LOD	0.2	1.4	0.4	0.6	0.7	Cu-Sn-Pb
36	BM 193	pellet bell	<LOD	0.1	1.0	3.6	0.2	1.6	Cu-Zn
37	BM 497	pellet bell	<LOD	0.1	1.6	0.7	0.6	<LOD	Cu-Sn
37	BM 497	pellet bell	0.3	0.3	<LOD	<LOD	<LOD	<LOD	gilding

Obviously, people have a great tendency towards the supposedly magical and are willing to be manipulated by others (e.g., Charles-Louis de Secondat, Baron de La Brède et de Montesquieu, describes in his Persian Letters how the French king dominates the minds of his subjects. Montesquieu, Persian Letter 24). But metals played an important role in ancient medicine (Yapijakis 2009; e.g., antiseptic effect of silver, discussed by Hippocrates its use in wound care, Dai et al. 2010) and still do in modern times (Yasuyuki et al. 2010; Zhang et al. 2021; Galanski, M. S. 2021) and anthroposophical medicine (Ganz 2013) and also still do in modern medicine (e.g., Universität Wien: 270204 VO Metalle in der Medizin (2021W), https://ufind.univie.ac.at/de/course.html?lv=270204&semester=2021W, accessed 6.12.2022). Pellet bells are rather rare finds in the Avar and Carolingian period and were probably not produced in the regions but imported from neighbouring areas to the east and the steppe.

Chemical analyses

The chemical analyses were carried out non-destructively on 10 copper alloy objects using a handheld XRF spectrometer (SPECTRO xSORT Combi; 15–50 kV; 30–120 µA; Rh anode; SDD detector; 'Alloy Plus' including 'Light Elements' built-in calibration; measurement area 3 mm in diameter; 60 sec measurement time).

The analysed metallic idiophones were manufactured from different types of copper alloys: bronze, leaded bronze, leaded copper and one brass (**Fig. 4.; Table 1.**). The composition of the alloys is very heterogeneous, generally the measured concentration of the alloying elements (Pb, Zn, Sn) is very high. This could be due to corrosion processes (especially in case of Pb and Sn, which can be enriched in the surface layer of the objects) or manufacturing processes (e.g., to enhance sounding). One of the pellet bells (BM 497) was also gilded. In the gilded areas, mercury was also detected indicating the use of fire gilding (**Table 1.**).

Acoustic and psychoacoustic analyses

Pellet bells are clearly classified as metallic vessel rattles according to the classification of musical instruments of Hornbostel and Sachs (system number 112.13) (Hornbostel & Sachs 1914, 566). The sounds of eight objects were recorded in the portable noise absorbing chamber (Pomberger & Mühlhans 2022) at a distance of about 10 cm from the microphone, but the sound of one pellet bell (see cat. 31) could hardly be captured even with a measurement microphone in silent surroundings and might be inaudible with the slightest background noise. No solid data could be obtained for this one recording, so it is not considered in the analyses, the remaining seven data (cat. 28, 32, 38, 42, 43, 44 and 45) were analysed for acoustic and psychoacoustic parameters. All recordings were prepared in the same way, 3 seconds of constant excitation were filtered with a Bessel high-pass of 5^{th} order at a cut-off frequency of 500 Hz, since the lowest partials from the objects range around 1.6 kHz, below that only noise from outside the chamber would be expected to influence the measurements. For the analyses, Adobe Audition (Adobe Inc. 2022), Praat (Boersma & Weenink 2022) and HEAD ArtemiSuite (HEAD 2022) were used, statistical calculations were done in JASP (JASP Team 2022).

General acoustics

The "typical" sound of pellet bells results from a variety of parameters such assize, weight and shape, excitation, material (and state of corrosion) and the fact that struck idiophones create a multitude of oscillations (modes) which emit a lot of partial frequencies that are not integer multiples from one fundamental frequency, as is the case in aerophones or chordophones (Winkler 1988, 119).

Pellet bells are excited by the encapsuled bronze ball or pebble bouncing and hitting the inner wall when shaken. This creates a series of 20–30 single impulses of just a few milliseconds with partials in the range of about 1.6–17 kHz. Pellet bells have no clear pitch, but peak frequencies (strongest partials) and spectral centroids can be measured to compare the "brightness" of the object. A statistical comparison with 31 other pellet bells from various sites all over Central Europe shows that the objects' sounds from Keszthely are on the higher end for peak frequencies, which is explained by the lower end of weight (smaller objects weigh less and have higher peak frequencies) but are quite average in level or loudness. There are certain differences and similarities among the sounds of the objects, i.e. some have a broader and more evenly spaced partial distribution with a peak somewhere in the middle, which might lead to a weaker pitch perception to listeners (see **Fig. 5.**). In others, the distribution is narrower and denser in the lower end with higher peaks. Those sounds are higher in level and loudness and might evoke a stronger pitch to listeners (see **Fig. 6.**).

Levels and audible range

Larger and heavier objects typically create metallic sounds of higher sound pressure levels (SPL), measured in dB re p_0, which is the standard measure for the physical intensity of sound given in decibels according to a reference of 20 µPa (Maling 2014, 1006). The attenuation of airborne sound depends on two effects, decrease of sound energy per area over distance and dissipation. Mathematically, sounds spread spherically, thus sound energy/pressure decreases by 6 dB when doubling the distance to the source (Attenborough 2014, 119), i.e. the sound pressure level of a ringing pellet bell at a distance of 2 m is 6 dB less than at 1 m. This does not exactly match human hearing or perception of loudness, but from a physical perspective (ignoring other effects) the rule of thumb is: twice the distance results in half the level. Dissipation is the dampening of sound in the atmosphere as a result of friction from the molecules in the air. This effect is quite strong for high frequencies.

At a distance of one metre from the ear, the idiophones' sounds emit levels of 48–60 dB SPL, which is well audible even with some background noise, given the fact that human hearing is particularly sensitive in the frequency range between 2 and 5 kHz (ISO 226:2003), where most of the pellet bells have their peak frequencies. How far the sounds of the pellet bells can be heard when excited not only depends on their own emitted sound pressure level, but also the background noise masking the sound of the object, which is commonly higher in a busy place where people talk or work is done, than in a quiet forest or at night. With a given background of about 50 dB, the objects might be audible up to a distance of 5 m maximum, while with 30 dB it would probably be 20 m. Also, it must be assumed that the pellet bells were not corroded at the time of use, thus they rung a bit louder.

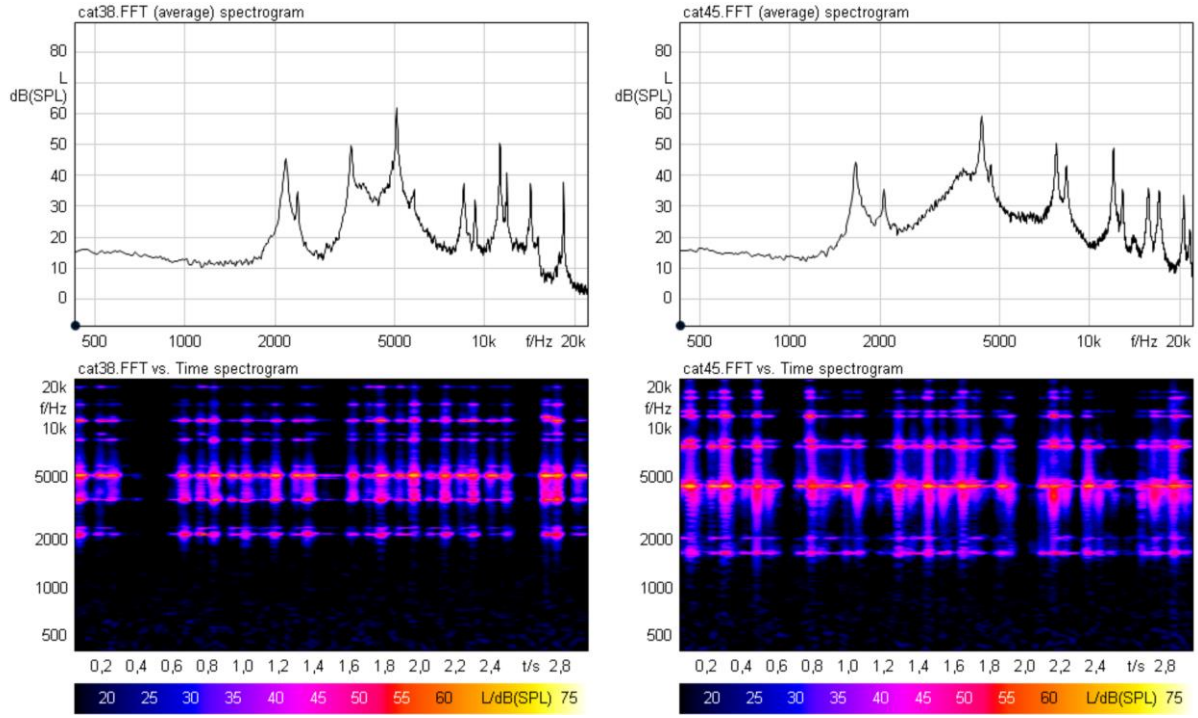

Fig. 5.: Spectrum (top) and spectrogram (bottom) of cat. 38 (left side) and cat. 45 (right side) (Graphic: J. Mühlhans)

5. ábra: A cat. 38 (bal oldal) és cat. 45 (jobb oldal) tárgyak hangspektruma (fent) és frekvenciatartománya (lent) (rajz: J. Mühlhans)

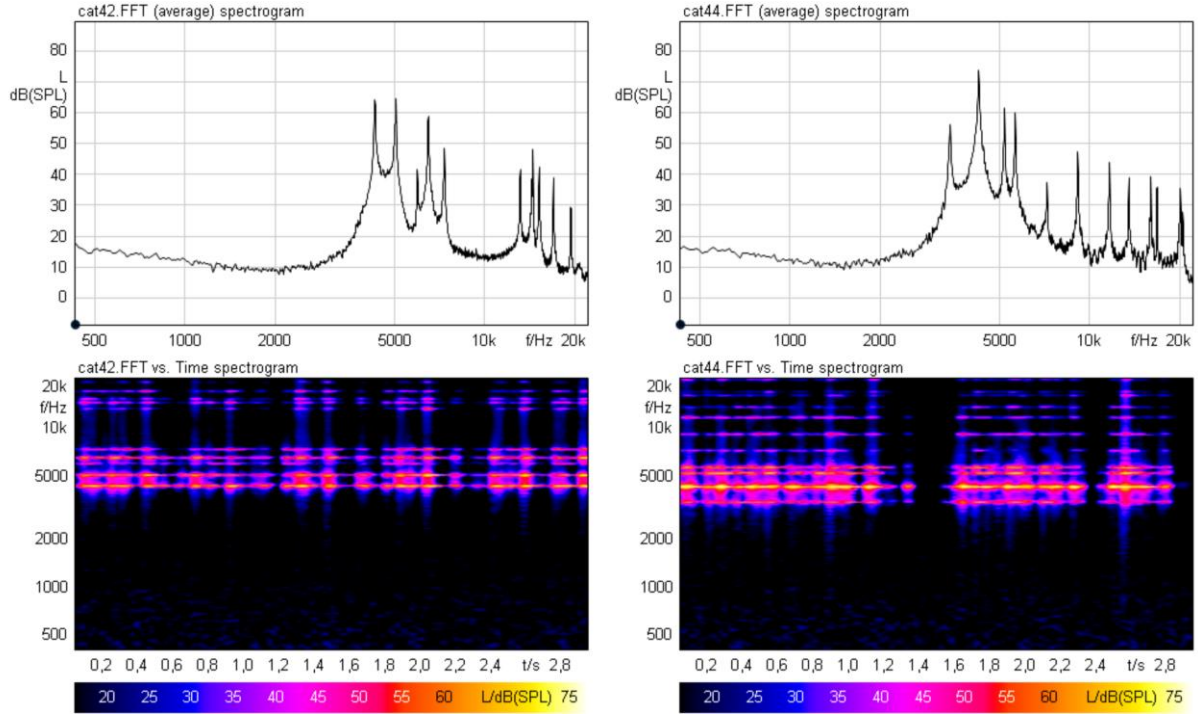

Fig. 6.: Spectrum (top) and spectrogram (bottom) of cat. 42 (left side) and cat. 44 (right side) (Graphic: J. Mühlhans).

6. ábra: A cat. 42 (bal oldal) és cat. 44 (jobb oldal) tárgyak hangspektruma (fent) és frekvenciatartománya (lent) (rajz: J. Mühlhans).

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Psychoacoustic analysis

The field of psychoacoustics aims to objectify human auditory perception by creating computer models with the best possible predictive qualities, taking into account the characteristics of human hearing and auditory processing. The "timbre of sound" is rather difficult to objectively measure, people tend to use adjectives like bright/dark, simple/complex or sharp/dull. Some of these can be represented by the psychoacoustic parameters that are also linked to the concept of "sensory euphony" (Aures 1984, 745).

This includes parameters like loudness, which – unlike level – depends on frequency and can be given in *sone* or *phon*. Loudness is defined as 40 dB SPL at 1 kHz equalling 1 sone or 40 phon (Fastl & Zwicker 2007, 203). With the sone scale, twice the value equals a sound twice as loud, with the phone scale an increment of 10 phon equals a doubling of loudness. Cat. 27, 38, 42 and 45 with loudness values of 12.8–17.2 sone or 76.8–81.1 phon are about half as loud as cat. 44 and 32 with 25.3–30.3 sone or 86.6–89.2 phon (**Table 2**). Usually, heavier objects are louder, which is not the case in this small sample.

Sharpness represents the spectral shape and density of a sound and is strongly linked to the perception of pleasantness. It is measured in *acum* with a 1 kHz critical band wide white noise at 60 dB given as 1 acum (Fastl & Zwicker 2007, 241). Higher values indicate 'sharper' sounds. Sharpness measures range form 3.5–5.1 acum, which can be described as high in overall sharpness, without any object sticking out particularly.

Roughness is a sensation created by the temporal modulation of amplitude, which in idiophones can be a result of partials close to each other in the spectrum. Slow modulations (around 5–15 Hz) create a beat frequency, adding to pleasantness; fast modulations (somewhere between 25–150 Hz) create a sense of roughness, reducing pleasantness. Roughness is measured in *asper* with a 70 Hz amplitude modulation in a 1 kHz sound being defined as the maximum roughness of 1 asper (Fastl & Zwicker 2007, 257). Roughness varies from 0.03–0.09 asper, but with an average value of 0.055 the sounds can be described as not rough at all.

Tonality represents the ratio of tonal components (partial frequencies) to noise, and is given in dB, where 0 dB represent equal amount of tonal and noise components. When tonal components are higher, values are positive and vice versa (Becker et al. 2019, 5820). In most objects, tonal components are about 8–10 times higher than the noise part (TNR of 17.5–22.9 dB), only cat. 27 shows a TNR of just 0.23 dB, indicating tonal and noise components being equally high.

Pellet bells in many cases do not evoke clear pitch perception in humans. This could be shown with an experiment, where 10 musically trained subjects ranked 4 pellet bells from lowest to highest pitch (Pomberger & Mühlhans 2021). Four subjects indicated different orders than the remaining six. This shows that non-harmonic partials lead to different pitch perceptions. Brightness, which rather describes the spectral distribution of energy (as verbally described with dark/bright, low/high) is highly correlated with the spectral centroid, given in Hz (Schubert et al. 2004, 656).

Table 2.: Psychoacoustic data of the pellet bells from the Balaton Museum Keszthely (compiled by J. Mühlhans)
2. táblázat: A keszthelyi Balaton Múzeum csörgőinek pszichoakusztikus adatai (összeállította: J. Mühlhans)

	sound pressure level (dB) @ 10 cm	sound pressure level (dB) @ 1 m	loudness (sone)	loudness (phon)	sharpness (acum)	roughness (asper)	tonality (TNR, dB)	impulsive-ness (iu)	spectral centroid (brightness, Hz)
cat. 27	69.38	49.38	12.8	76.8	3.53	0.0971	0.23	2.66	3706
cat. 31	37.96	17.96	2.53	53.4	2.7	0.0119	n/a	0.487	6159
cat. 32	79.04	59.04	30.3	89.2	5.06	0.0669	17.45	1.93	3869
cat. 38	67.94	47.94	14.9	79	4.23	0.044	18.79	2.29	5478
cat. 42	71.9	51.9	17.2	81.1	5.09	0.0276	18.83	1.15	5161
cat. 43	79.79	59.79	32.1	90	4.51	0.0716	17.72	2.14	3736
cat. 44	77.75	57.75	25.3	86.6	5.09	0.0428	22.88	1.36	4357
cat. 45	67.83	47.83	15.3	79.3	4.15	0.0775	19.16	2.72	5655

Higher values indicate brighter sounds, often a result of high frequency partials with higher amplitudes. Brightness values in the objects range from 3.7–6.2 kHz, which is quite typical for pellet bells of that size.

Peak frequency is positively correlated with brightness ($r=0.84$, $p<0.01$) and negatively with level ($r=-0.9$, $p<0.01$) which on the other hand is correlated positively with sharpness ($r=0.86$, $p<0.01$). Higher peak frequencies lead to higher overall brightness, and objects' sound with a higher loudness are sharper, thus more unpleasant. In summary, the pellet bells are very much in line with the general characteristics of all such pellet bells. Their sounds are very high/bright but not particularly loud, reasonably sharp and hardly rough. The variation in single parameters can be a result of weight, shape, alloy (and corrosion) and material/size/shape of the pellet (excitation).

Textile fragments

Five of the pellet bells (cat. 3, 31, 33, 34, 39) carried fragments of textiles, which were preserved thanks to the toxic metal salts and adhered to the metal in specific environmental conditions in the burial (Chen et al. 1998, 1020). Especially when in close proximity to iron, these textiles can be fully mineralised. Yet the shape of the textile, and also the fibres – *pseudomorphs* – often still remain even without any remaining organic composition (Chen et al. 1998, 1016).

These textiles on the pellet bells in question were analysed using a DinoLite digital microscope, which allows magnifications from x30 to x250, and the corresponding software (DinoCapture 2.0). Hereby it is possible to identify spin directions (s or z), ply, and textile techniques (such as weave type), as well as to measure thread diameters, twist angles, and weave densities. Additionally, the distributions and layers of the textiles as well as the directions of the thread were documented in order to enable possible interpretations and identify further characteristics.

All of the analysed textiles (**Table 3**) are tabby woven using single ply yarn, corresponding with the textile technical characteristics of the Avar period based on previous analyses from eastern Austria (Grömer 2015, 200), eastern Croatia (Grömer & Rapan Papeša 2015), southern Slovakia (Dolejšová 1987; Pomberger et al. 2021b), and Hungary (Pomberger et al. 2022c). The z-spin direction is also typical for this period, which is the case for all textiles analysed here except for textile A on pellet bell cat.39 from Gyenesdiás, with s-twisted threads in both warp and weft. The weave densities of the analysed textiles varied from more open (8 threads per cm) to denser weaves (24 threads per cm), with most being relatively even in warp and weft, except for textile A on the pellet bells cat. 33 and cat. 34, which has roughly double the thread count in one system. In the following, we present the analysed textiles in more detail.

The woven textile on pellet bell cat. 3 was very small and poorly preserved (**Fig. 7a**). On top of the textile, there is an unknown substance with a smooth surface – perhaps leather, though there is no visible structure under the digital microscope. This lack of preservation does not offer many possible interpretations. Considering the microstratigraphy, however, and assuming the substance is leather, one could suggest a textile garment and a leather belt underneath, or a leather pouch lined with fabric containing this pellet bell.

Cat. 31 from Gyenesdiás was almost completely covered by one textile (**Fig. 7b**) on the whole bottom and on all sides, though partly fragmented. Interestingly, all the threads of one system (warp and weft could not be identified) run in the direction of the eyelet (**Fig. 8a**). This indicates that the pellet bell was wrapped in this rather small piece of fabric, whereby the small missing pieces could be the folds that did not directly touch the metal, thus explaining the different thread directions and the large fragment at the bottom. Multiple layers could not be documented. This fabric was probably bound together above the eyelet, forming a pouch that was perhaps attached to the child's belt or as a wrapping specifically for the burial that was laid onto the body. This indicates a spiritual meaning of the pellet bell in this burial, since in this way, the eyelets do not serve a purpose and the bell would not be well audible when covered. Thus, the deposition of the pellet bell – or its wrapping – was likely symbolic. We can assume, however, that the pellet bells were used differently during the child's lifetime, in a manner that would have given the eyelets a function, likely hung from a string and maybe attached to a belt.

In burial 108, textile A on pellet bell cat. 33 bears an indication that the fabric lay directly on the body, namely a small imprint of skin with a well-visible structure directly on textile A (**Fig. 8b**), assuming this is the human skin of the child. This means textile A derived from a burial wrapping on the bare skin or a garment. Alternatively, the fragment might represent animal skin or leather, which might have been part of a belt, yet the grain seems to be too fine for this to be the case. Furthermore, textile A (**Fig. 7c**) displays multiple folds, which are well visible in cross-section (**Fig. 7d**). The folds seem to be too irregular for an intentionally pleated fabric, as is known, for example, from the earlier Lombard period (Saunderson et al. 2022, 99) or 7th century Southern Germany and Switzerland (Grömer & Rast-Eicher 2019, 95). Thus, it is more likely that these folds were created due to widely cut clothing, whereby

the folds could have been enhanced by a belt gathering the fabric. It might have been part of a kaftan, of which there is pictorial evidence on an Avar period antler tool from Nosza, Serbia (Budinský 2016, 86–88), whereby the pellet bells might have been hung from the belt. A further, larger fragment of unknown material is also preserved on top of this textile, which perhaps represents a poorly preserved piece of textile or skin/leather.

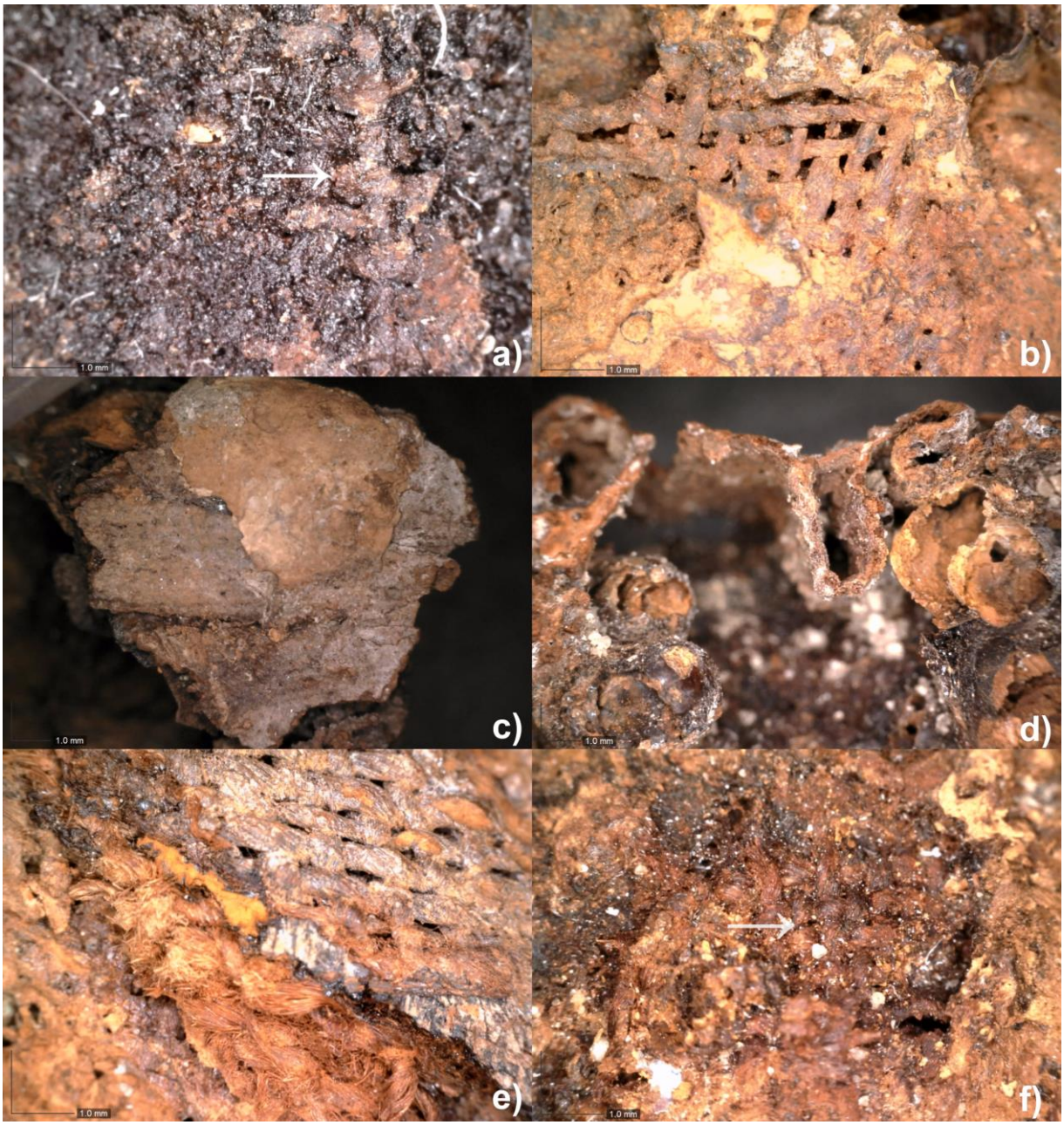

Fig. 7.: Microscope photos of the textiles: a) small remains of a woven textile on cat. 3, 50x magnification; b) the textile on the upper half of cat. 31, 50x magnification; c) folds of textile A and substance on cat. 33, 30x magnification; d) side view of the folds of textile A on cat. 33, 30x magnification; e) multiple layers of textile A on cat. 34, 50x magnification; f) the fine and densely woven textile C on cat. 39, 50x magnification (images: K. Saunderson)

7. ábra: A textilmaradványok mikroszkópos fotói: a) szőtt textil kis maradványai a cat. 3 tárgyon, 50x-os nagyítás; b) a cat. 31 tárgy felső részén megőrződött textil, 50x-os nagyítás; c) az A textil ráncai és anyagmaradvány a cat. 33 tárgyon, 30x-os nagyítás; d) az A textil ráncai oldalnézetben a cat. 33 tárgyon, 30x-os nagyítás; e) az A textil többszörös rétegei a cat. 34 tárgyon, 50x-es nagyítás; f) a finoman és sűrűn szőtt C textil a cat. 39 tárgyon, 50x-es nagyítás (képek: K. Saunderson)

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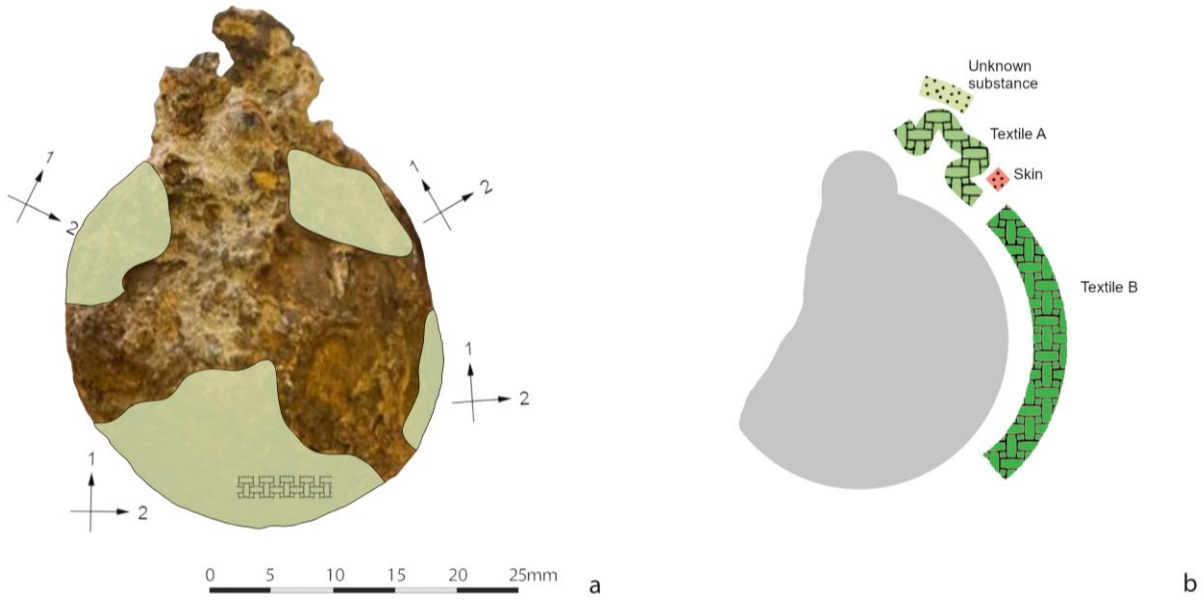

Fig. 8.: Thread alignments and microstratigraphy: a - locations of larger fragments of textile A on cat. 31 with indicated thread orientations; b - schematic cross-section view of the microstratigraphy of organic layers on pellet bell cat. 33 (image: K. Saunderson).

8. ábra: Szálelrendeződés és mikrosztratigráfia: a – az A textil nagyobb maradványainak elhelyezkedése a cat. 31 tárgyon a szálak orientációjának feltüntetésével, b – a szerves rétegek mikrosztratigráfiájának vázlatos keresztmetszeti képe a cat. 33 csörgőn (képek: K. Saunderson).

Table 3.: Analysed features of the seven identified textiles on the Avar period pellet bells (compiled: K. Saunderson).

3. táblázat: Az avar kori csörgőkön azonosított hét textilmaradvány jellemzői (a táblázatot összeállította: K. Saunderson).

cat.	Textile	Ply		Twist direction		Twist angle		Thread diameter (mm)		Weave type	Thread count/cm	
3	A	single	single	z	z	30–40°	30–40°	0.35–0.55	0.35–0.55	tabby	≈13–17	≈16
31	A	single	single	z	z	20°	20°	0.25–0.4	0.25–0.4	tabby	≈20	≈20
33+34	A	single	single	z	z	40°	40°	0.3–0.4	0.3–0.4	tabby	≈12–13	≈23–24
	B	single	single	z	z	30–40°	30–40°	0.45–0.6	0.45–0.6	tabby	≈8–9	≈10
39	A	single	single	s	s	30°	30°	0.2–0.45	0.2–0.45	tabby	≈18	≈16–17
	B	single	single	z	z	30°	20–30°	0.3–0.5	0.4–0.7	tabby	≈13–15	≈16
	C	single	single	z	z	20–30°	20–30°	0.3	0.3	tabby	≈23–24	≈20

This same textile is also attached to the second pellet bell in this grave, cat. 34. Multiple layers of this textile are visible (**Fig. 7e**), perhaps due to being strongly folded – again attesting to this feature of the fabric – though no folds are preserved, or from a wrapping.

Another textile, B, is preserved on both these pellet bells and lies beneath textile A, directly on the pellet bell on the bottom half of both objects. It is woven much more openly than textile A, perhaps representing a pouch or a wrapping for both pellet bells.

Cat. 39 carried three different textiles: textile A on the eyelet, textile B in the bottom area, and textile C in the middle area. None of the textiles touched each other, making the interpretation even more difficult. Textile C, a small fragment of a very fine and dense textile (**Fig. 7f**), is preserved in multiple layers, perhaps again indicating a loosely draped garment, folds or a wrapping. The functions of the other textiles cannot be identified.

Summary

About 50 pellet bells from the Great Migration period were excavated in Keszthely and its surroundings. They are housed in the Balaton Museum in Keszthely and the Migration Period collection of the Hungarian National Museum in Budapest. All idiophones were found in cemeteries, especially in children's burials. The Keszthely cemeteries, Városi temető and Dobogó, contained 23 pellet bells dating to the late 7th–9th centuries. 14 pellet bells come from Gyenesdiás and two from Lesencetomaj B Piroskereszt. Pellet bells dating to the Carolingian period are known from the necropolis of Esztergályhorváti-Alsóbárándpuszta, Zalaszabar–Borjúállás-sziget and Keszthely-Fenékpuszta south wall. Usually, the idiophones were worn on ribbons or chains, hanging from the belt or tunic, considering their find position near the hips. Only two children wore pellet bells around their necks. The foal, buried with a child in burial 137, had one gilded pellet bell serving as decoration of its head gear. The pellet bells cast in copper alloy can be classified into the types I, II, V and VI. The one forged from sheet metal belong to the base shapes II and IV. Most of the pellet bells are undecorated. Two show face-like features and four have grooves on their lower parts. Pellet bells forged from sheet metal, especially from iron sheet, predominate. Eleven analysed metallic idiophones, analysed using a handheld XRF, were manufactured from bronze, leaded bronze, leaded copper and one from brass. The sounds of eight pellet bells were recorded in a portable noise-absorbing chamber, but one could hardly be captured. The partials of the items range between 1.6 and 17 kHz. At a distance of one meter from the ear, the objects emit sound levels of 48–60 dB SPL and might be audible with a given background noise of 50 dB within a distance of 5 m.

The idiophones are very much in line with the general psychoacoustic characteristics of all such pellet bells. Their sounds are very high/bright but not particularly loud, reasonably sharp and hardly rough. The variation in single parameters can be a result of weight, shape, alloy (and corrosion) and material/size/shape of the pellet (excitation).

As the textile fragments on the pellet bells are small and poorly preserved, it is difficult to determine their exact functions. The textile on cat. 31 represents a rare exception, strongly suggesting that the pellet bell was wrapped and tied in a small textile pouch. For the other textiles, garments worn in the burial can be suggested, whereby the pellet bells were perhaps attached to the belt as part of the costume, considering all pellet bells were found in the area of children's hips or thighs. Otherwise, some textiles could have been burial wrappings, linings, or bedding of the grave or coffin.

All in all, pellet bells were not very common among the population at that time. They probably served for a minority both as an amulet and jewellery. Their materials – metal – and sounds as well as additional decorations were believed to protect and banish evil forces – an idea that still exists today among some people and in esoteric circles. But we have to note that metals played an important role in ancient medicine and also still do again in modern medicine. The idea that pellet bells were imports from eastern regions has to be further discussed, traced and investigated.

Contribution of authors

Beate Maria Pomberger Conceptualisation, Investigation, Visualization, Writing – Original Draft, Writing – Review and Editing. **Jörg Mühlhans** Investigation, Visualization. **Kayleigh Saunderson** Investigation, Visualization. **Viktória Mozgai** Investigation, Visualization, Writing – Review and Editing. **Bernadett Bajnóczi** Investigation, Writing – Review and Editing.

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Catalogue

Legend: th. = total height, hwl. = height without handle, l. = length, w. = width, dm. = diameter, wth. = wall thickness, cw. = conserved weight, InvNr. = inventory number,

FNr. = find number

EAP = Early Avar Period, MAP = Middle Avar Period, LAP = Late Avar Period

BM = Balaton Museum Keszthely, MNM = Magyar Nemzeti Múzeum

Literature = Literature used

Locality: Keszthely, Zala County, HU

Site: Keszthely-Városi temető/town cemetery
Feature function: cemetery
Date: Keszthely Culture, around 630 CE – 9th cent. CE
Finds: 4 pellet bells
Literature: Kovrig 1999; Kovrig 1960.

cat. 1: InvNr. BM 67.4.60

Context: tomb 131, child/ infans II, pellet bell near right knee, pellet lost
Date: MAP–LAP
Conservation status: 6 fragments
Base shape: no information
Type: no information
Handle: corroded/lost
Decoration: surface corroded
Measurements: dm.?,wth. 1 mm, cw. 7.81 g
Material: Fe
Frequency range: no sound recordings, no frequency analysis
Fig. 1/1

cat. 2: InvNr. BM 67.4.67_A

Context: tomb 134, child/infans I, near right femur
Date: LAP
Conservation status: slightly deformed, complete
Base shape: shape II
Handle: broken/fragmented
Decoration: smooth, corroded
Sound slot: cruciform
Pellet: corroded inside
Measurements: dm. 2.85 x 3.4 cm, th. 3.5 cm, hwl. 3 cm, cw. 18.02 g
Material: Fe
Frequency range: no sound recordings, no frequency analysis
Fig. 1/2

cat. 3: InvNr. BM 67.4.67_B

Context: tomb 134, child/infans I, near right femur
Date: LAP
Conservation status: complete
Base shape: shape II
Handle: broken/fragmented
Decoration: smooth, corroded, textile fragments
Sound slot: cruciform
Pellet: corroded inside
Measurements: dm. 2.85 x 3.35 cm, th. 3.5 cm, hwl. 3.1 cm, cw. 18.21 g
Material: Fe
Frequency range: no sound recordings, no frequency analysis
Fig. 1/3

cat. 4: InvNr. BM 67.4.67_C

Context: tomb 134, child/infans I, near right femur
Date: LAP
Conservation status: deformed, complete
Base shape: shape II?
Handle: round
Decoration: smooth, corroded
Sound slot: cruciform
Pellet: corroded inside
Measurements: dm. 2 x 2.5 cm, th. 4.05 cm, hwl. 3.35 cm, cw. 14.18 g
Material: Fe
Frequency range: no sound recordings, no frequency analysis
Fig. 1/4

Locality: Keszthely, Zala County, HU

Site: Keszthely-Városi temető/town cemetery (former brewery garden of Venzel Reisch according to V. Lipp 1885)
Feature function: cemetery
Date: MAP–LAP, Late Keszthely Culture
Finds: more than 8 pellet bells, 2 bells
Literature: Lipp 1885; Kiss 1999.

cat. 5: pellet bell InvNr. MNM 52.1881.17 = 52.1881.18

Context: tomb 52, no further information
Date: Late Keszthely Culture, MAP–LAP
Conservation status: complete/small hole
Base shape: round shape I (?)
Handle: rectangular
Decoration: 2 impressions, grooves
Sound slot: simple, 2 sound holes
Pellet: lost
Measurements: dm. 2.8 cm, th. 3.8 cm, hwl. 3 cm, wth. 1–2 mm, cw. 28 g
Material: Cu-Sn-Pb

Frequency range: no sound recordings, no frequency analysis
Fig. 1/5

cat. 6: pellet bell MNM 52.96.2

Context: unknown, no further information
Date: Late Keszthely Culture, MAP–LAP
Conservation status: complete, corroded
Base shape: oval, 2 belts shape II (?)
Handle: round
Decoration: smooth
Sound slot: cruciform
Pellet: no information
Measurements: dm. 3.3 x 2.5 cm, hwl. 3.3 cm, th. 4.3 cm
Material: Fe
Frequency range: no sound recordings, no frequency analysis
Fig. 1/6

cat. 7: pellet bell, no information

Context: burial, child/girl, near left hand
Date: Late Keszthely Culture, MAP–LAP
Conservation status: no information
Base shape: round?
Handle: rectangular
Decoration: man's face
Sound slot: no information
Pellet: no information
Measurements: no information
Material: Cu–alloy
Frequency range: no sound recordings, no frequency analysis
Fig. 1/7

cat. 8: pellet bell, no information

Context: burial, no further information
Date: Late Keszthely Culture, MAP–LAP
Conservation status: no information
Base shape: no information
Handle: no information
Decoration: man's face (?)
Sound slot: no information
Pellet: no information
Measurements: no information
Material: Cu–alloy
Frequency range: no recordings/no analyses
Fig: no drawing

cat. 9: pellet bell, no information

Context: burial, no further information
Date: Late Keszthely Culture, MAP–LAP
Conservation status: no information
Base shape: no information
Handle: no information
Decoration: no information
Sound slot: no information
Pellet: no information
Measurements: no information
Material: Cu–alloy
Frequency range: no sound recordings, no frequency analysis
Fig: no fig.

cat. 10: bell, no information

Context: burial, no further information
Date: Late Keszthely Culture, MAP–LAP
Conservation status: no information
Type: no information
Handle: no information
Decoration: none
Sound slot: no information
Pellet: no information
Measurements: no information
Material: Fe
Frequency range: no sound recordings, no frequency analysis
Fig: no drawing

Locality: Keszthely, Zala County, HU

Site: Keszthely-Dobogó
Feature function: cemetery
Date: EAP–LAP, 6th – 9th cent. CE
Finds: 4 pellet bells, 2 bells
Literature: Lipp 1885; Hampel 1905; Kiss 1997.

cat. 11: pellet bell MNM 119/1882.944

Context: tomb 119 ?, child? no further information
Date: MAP–LAP, 7th– 9th cent. CE
Conservation status: fragmented
Base shape: shape II, 2 belts
Handle: round
Decoration: smooth
Sound slot: simple, 2 sound holes
Pellet: lost
Measurements: dm. 3 x 2.6 cm, hwl. 3 cm, th. 3.9 cm, wth. 2 mm, cw. 8 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/8

cat. 12: bell, MNM 119/1882.943

Context: burial, child?, no further information
Date: MAP–LAP, 7th– 9th cent. CE
Conservation status: nearly complete? corroded, clapper corroded inside
Type: Fe type I/var. B
Handle: lost
Decoration: smooth

Clapper: conserved, corroded on wall
Measurements: h. 3.5 cm
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/9

cat. 13: bell, no information

Context: burial, no further information
Date: MAP – LAP, 7th– 9th cent. CE
Conservation status: no information
Base shape: no information
Handle: no information
Decoration: no information
Clapper: no information
Measurements: no information
Material: Cu–alloy
Frequency range: no recordings, no frequency analyses
Fig: no figure

Note:
Kiss mentions two iron pellet bells from burial 1344 and one iron pellet bells from burial 1354, all excavated in 1882 (Kiss 1997, 121-122). These three iron pellet bells might be among the following list. Lipp presents two further pellet bells, one with textile fragments (fig.1/10) (Lipp 1885, 93/fig. 14) and one with a chain corroded on the pellet bell (Lipp 1885, 100/fig. 108).

Locality: Keszthely, Zala County, HU (uncertain site)

Site: Keszthely-Városi temető or Dobogó
Feature function: cemetery
Date: MAP–LAP
Finds: several pellet bells, exact context unknown
Lit: Lipp 1885; Hampl 1905_2; Kiss 1999.

Note:
Hampel reports about five iron pellet bells, which all originate from men's burials. They probably correlate with the items MNM 52.91.1 (Hampel 1905_2, 82).

cat. 14: pellet bell MNM 52.91.1_a

Context: burial, no further information
Date: MAP–LAP
Conservation status: no information
Base shape: shape II
Handle: broken
Decoration: none, smooth, textile fragments
Sound slot: cruciform
Pellet: lost
Measurements: dm. 3.4 x 3.2 cm, hwl. 3.4 cm, cw. 16 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/12

cat. 15: pellet bell MNM 52.91.1_b

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 60 % preserved
Base shape: shape IV, 3 belts
Handle: round
Decoration: none, smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 3.2 x 2.7 cm, cons. h. 3.4 cm, wth. 1 mm, cw. 8 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/13

cat. 16: pellet bell MNM 52.91.1_c

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 40 % preserved
Base shape: shape IV?, 3 belts
Handle: round
Decoration: none, smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 3 x 2.3 cm, cons. h. 2.3 cm, wth. 1 mm
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/14

cat. 17: pellet bell MNM 52.91.1_d

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 90 % preserved, 3 holes, textile fragments
Base shape: shape II, 2 belts
Handle: round
Decoration: none, smooth
Sound slot: no information
Pellet: pebble
Measurements: dm. 3 x 2.7 cm, whl. 2.3 cm, wth. 1 mm, cw. 7 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/15

cat. 18: pellet bell MNM 52.91.1_e

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 60 % preserved
Base shape: shape I, 2 belts
Handle: round
Decoration: none, smooth
Sound slot: no information
Pellet: lost
Measurements: dm. 2.6 x 2.6 cm, whl. 2.5 cm, th. 3 cm, wth. 1 mm, cw. 5 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/16

cat. 19: pellet bell MNM 52.91.1_f

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 50 % preserved
Base shape: shape I
Handle: lost
Decoration: none, smooth
Sound slot: no information
Pellet: lost
Measurements: dm. 2.9 cm, whl. 2.9 cm, wth. 1 mm, cw. 9 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/17

cat. 20: pellet bell MNM 52.91.1_g

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 60 % preserved
Base shape: shape II
Handle: lost
Decoration: none, smooth
Sound slot: simple?
Pellet: lost
Measurements: dm. 3 x 2.3 cm, whl. 2.9 cm, wth. 1 mm
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/18

cat. 21: pellet bell MNM 52.91.1_h

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 80 % preserved
Base shape: shape I
Handle: broken
Decoration: none, smooth
Sound slot: no information
Pellet: lost
Measurements: dm. 3.2 x 3 cm, whl. 3.2 cm, wth. 1 mm, cw. 9 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/19

cat. 22: pellet bell MNM 52.91.1_i

Context: burial, no further information
Date: MAP–LAP
Conservation status: complete, deformed,
Base shape: shape I?
Handle: broken
Decoration: none, smooth
Sound slot: no information
Pellet: lost
Measurements: dm. 2.8 x 2 cm, whl. 2.5 cm, ch. 3.3 cm, cw. 8 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/20

cat. 23: pellet bell MNM 52.91.1_j

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 70 % preserved
Base shape: shape I
Handle: broken
Decoration: none, smooth
Sound slot: no information
Pellet: lost
Measurements: dm. 2.7 cm, whl. 2.6 cm, wth. 1 mm, cw. 5 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 1/21

cat. 24: pellet bell MNM 52.91.1_k

Context: burial, no further information
Date: MAP–LAP
Conservation status: fragmented, 50 % preserved, deformed
Base shape: shape I
Handle: broken
Decoration: none, smooth
Sound slot: no information
Pellet: pebble
Measurements: dm. 2 cm, whl. 2.2 cm, ch. 2.7 cm, wth. 1 mm, cw. 5 g
Material: Fe
Frequency range: no recordings, no frequency analyses

Fig. 1/22

cat. 25: pellet bell MNM 157/1880.9

Context: burial human and horse? no further information => similar to horse harness pellet bells
Date: MAP–LAP
Conservation status: fragmented, 70 % preserved, impressions
Base shape: shape IV
Handle: round
Decoration: gilded
Sound slot: none
Pellet: lost
Measurements: dm. 2.3 x 0.9 cm, whl. 1.8 cm, th. 2.3 cm, wth. 1 mm, cw. 5 g
Material: Cu–alloy
Frequency range: no recordings, no frequency analyses
Fig. 1/11

Locality: Gyenesdiás, Zala County, HU

Site: Gyenesdiás-Avar vezér utca
Feature function: cemetery
Date: 630 – first third of 9th cent. CE
Finds: 14 pellet bells
Lit: Müller unpublished, Müller 2018b

cat. 26: pellet bell BM FNr. 47/3

Context: tomb 47, child/infans I, with horse/foal, burial disturbed, pellet bell on the chest of the child
Date: LAP / late phase of Keszthely Culture
Conservation status: complete, 1 hole
Base shape: shape II
Handle: round
Decoration: smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 2.65 x 2.9 cm, hwl. 3.05 cm, th. 3.55 cm, cw. 24.52 g
Material: Cu-Sn-Pb-Zn
Frequency range:
Fig. 2/2

cat. 27: pellet bell BM_FNr. 55/1a

Context: tomb 55, child, near right femur
Date: LAP / late phase of Keszthely Culture
Conservation status: complete, 1 hole
Base shape: shape II
Handle: round
Decoration: smooth
Sound slot: cruciform
Pellet: cinder
Measurements: dm. 2,4 x 2.5 cm, hwl. 2.65 cm, th. 3.5 cm, wth. 1–2 mm, cw. 28.07 g
Material: Cu-Sn-Pb-Zn
Frequency range: 3.5–11 kHz
Fig. 2/3

cat. 28: pellet bell BM_FNr. 55/1b

Context: tomb 55, child, near right femur
Date: LAP / late phase of Keszthely Culture
Conservation status: complete, 1 hole, fragmented, corroded on pellet bell 1a
Base shape: shape II?
Handle: lost
Decoration: smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 3.1 cm, ch. 3 cm
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 2/4

cat. 29: pellet bell no information

Context: tomb 56, child?, no information
Date: LAP / late phase of Keszthely Culture
Conservation status: complete, 1 rectangular hole on vertex
Base shape: shape I?
Handle: round
Decoration: smooth
Sound slot: cruciform?
Pellet: no information
Measurements: dm. 2.65 cm, hwl. 2.75 cm, th. 3.75 cm
Material: Cu–alloy
Frequency range: no recordings, no frequency analyses
Fig. 2/13

cat. 30: pellet bell BM_FNr. 58/2

Context: tomb 58, child, near right hip
Date: LAP / late phase of Keszthely Culture
Conservation status: 75% preserved, 1 hole, filled with soil
Base shape: shape II
Handle: round
Decoration: smooth
Sound slot: cruciform
Pellet: pebble
Measurements: dm. 2.75 x 3.3 cm, hwl. 3 cm, th. 3.9 cm, wth. 1–2 mm, cw. 14.6 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 2/5

cat. 31: pellet bell BM_FNr. 63/1

Context: tomb 63, child, near right hip
Date: LAP / late phase of Keszthely Culture
Conservation status: complete, textile fragments
Base shape: shape II
Handle: round
Decoration: smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 2.95 x 3.2 cm, whl. 32.5 cm, th. 4.25 cm, cw. 13.38 g
Material: Fe
Frequency range: 5.2–6.7 kHz (barely audible)
Fig. 2/6

cat. 32: pellet bell BM_FNr. 104/1

Context: tomb 104, child/infans I, near right hip
Date: LAP / late phase of Keszthely Culture
Conservation status: complete, textile fragments, 1 hole
Base shape: shape II
Handle: round
Decoration: grooves on the lower part
Sound slot: cruciform
Pellet: bronze ball
Measurements: dm. 2.45 x 2.65 cm, whl. 2.7 cm, th. 3.45 cm, wth. 1–2 mm, cw. 22.24 g
Material: Cu-Sn-Pb
Frequency range: 2.1–16.5 kHz
Fig. 2/7

cat. 33: pellet bell BM_FNr. 108/3a

Context: tomb 108, child, skeleton passed, near right hip
Date: LAP / late phase of Keszthely Culture
Conservation status: complete, deformed, textile fragments, corroded, textile fragments, skin
Base shape: shape II
Handle: round
Decoration: smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 3.1 cm, th. 4.5 cm
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 2/9

cat. 34: pellet bell BM_FNr. 108/3b

Context: tomb 108, child, skeleton passed, near right hip
Date: LAP / late phase of Keszthely Culture
Conservation status: fragmented, textile fragments, corroded, textile fragments
Base shape: shape II
Handle: lost
Decoration: smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 3.2 cm, whl. 3 cm, th. 3.3 cm
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 2/8

cat. 35: pellet bell BM_FNr. 111

Context: tomb 111, child, skeleton passed, near right hip?
Date: LAP / late phase of Keszthely Culture
Conservation status: 70% preserved, textile fragments
Base shape: shape II
Handle: lost
Decoration: smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 2.9 x 3.15 cm, whl. 2.8 cm, th. 3.3 cm, cw. 10.63 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 2/10

cat. 36: pellet bell BM_FNr. - no information

Context: tomb 137, child/infans I, with horse/foal, near horse skull
Date: LAP / late phase of Keszthely Culture
Conservation status: no information
Base shape: shape I?
Handle: rectangle
Decoration: smooth
Sound slot: cruciform?
Pellet: no information
Measurements: dm. 2.4 cm, wth. 2.5 cm, th. 3.6 cm
Material: Cu–alloy
Frequency range: no recordings, no frequency analyses
Fig. 2/11

cat. 37: pellet bell BM_FNr. 191

Context: tomb 191, child, near right femur
Date: LAP / late phase of Keszthely Culture
Conservation status: fragmented
Base shape: shape II
Handle: lost
Decoration: smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 3.1 cm, whl. 3 cm, th. 4 cm, cw. 10.63 g
Material: Fe

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Frequency range: no recordings, no frequency analyses
Fig. 2/12

cat. 38: pellet bell BM_FNr. 256/1

Context: tomb 256, child, near right hip
Date: LAP / late phase of Keszthely Culture
Conservation status: complete
Base shape: shape VI
Handle: rectangular
Decoration: radial grooves
Sound slot: cruciform, 2 sound holes, 1 rectangular sound hole
Pellet: pebble/bronze ball?
Measurements: dm. 2.05 x 2.25 cm, whl. 2 cm, th. 2.7 cm, cw. 9.76 g
Material: Cu-Sn-Pb
Frequency range: 2.2–18.5 kHz
Fig. 2/14

cat. 39: pellet bell BM_Fnr. 91.10.17

Context: strayfind
Date: LAP / late phase of Keszthely Culture
Conservation status: complete, 2 holes, textile fragments
Base shape: shape II
Handle: round?
Decoration: smooth
Sound slot: cruciform?
Pellet: lost
Measurements: dm. 2.9 x 3.2 cm, hwl. 2.95 cm, th. 3.85 cm, cw. 14.71 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 2/15

Locality: Lesencetomaj, Veszprém County, HU

Site: Lesencetomaj B Piros kereszt (site 14)
Feature function: cemetery
Date: 8th/9th cent. CE, late phase of Keszthely Culture
Finds: 2 pellet bells
Literature: Müller 1992; Perémi 2000; Perémi 2002; Fóthi et al. 2009.

cat. 40: pellet bell BM 88.36.4

Context: tomb 40, child, near chest and right elbow
Date: 8th/9th cent. CE
Conservation status: complete, 1 hole in body
Base shape: shape II
Handle: lost?
Decoration: smooth
Sound slot: cruciform
Pellet: pebble corroded inside
Measurements: dm. 2.55 x 3.25 cm, hwl. 3.2 cm, cw. 11.10 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 3/1

cat. 41: pellet bell BM 88.372

Context: tomb 41, child, near right side of neck
Date: 8th/9th cent. CE
Conservation status: fragmented, 5 pieces
Base shape: shape II
Handle: lost?
Decoration: smooth
Sound slot: cruciform
Pellet: lost
Measurements: dm. 2.55 x 2.9 cm, ch. 1.8 cm, wth. 1 mm, cw. 5.16 g
Material: Fe
Frequency range: no recordings, no frequency analyses
Fig. 3/2

Locality: Esztergályhorváti, Zala County, HU

Site: Esztergályhorváti-Alsóbárándpuszta
Feature function: cemetery
Date: 9th cent., Carolingian Period
Finds: 3 pellet bells
Literature: Szentpéteri 2002; Szőke 1996.

cat. 42: pellet bell BM GyNSz.81.10.1.

Context: tomb 40
Date: 9th cent.
Conservation status: complete
Base shape: shape V
Handle: rectangular
Decoration: vertical grooves on lower part
Sound slot: cruciform
Pellet: pebble
Measurements: dm. 1.85 x 2.25 cm, hwl. 2.35 cm, th. 3.3 cm, cw. 15.5 g
Material: Cu-Pb
Frequency range: 4.3–17.1 kHz
Fig. 3/3

cat. 43: pellet bell BM GyNSz. 81.10.2

Context: tomb 41
Date: 9th cent.
Conservation status: complete
Base shape: shape II
Handle: round
Decoration: smooth
Sound slot: cruciform

Pellet: pebble or bronze ball
Measurements: dm. 2.45 x 2.7 cm, hwl. 2.55 cm, th. 3.4 cm, cw. 28.62 g
Material: Cu-Sn-Pb-Zn
Frequency range: 2.3–11.4 kHz
Fig. 3/5

cat. 44: pellet bell BM GyNSz.81.7.1.

Context: tomb 42
Date: 9th cent.
Conservation status: complete
Base shape: shape II
Handle: rectangular
Decoration: vertical grooves on lower part
Sound slot: cruciform
Pellet: bronze ball
Measurements: dm. 1.8 x 2.3 cm, hwl. 2.3 cm, th. 3.25 cm, cw. 14.9 g
Material: Cu-Sn-Pb
Frequency range: 3.4–11.7 kHz
Fig. 3/4

Locality: Zalaszabar, Zala County, HU

Site: Zalaszabar–Borjúállás-sziget
Feature function: cemetery near the church of the settlement
Date: 9th/10th cent., Carolingian Period
Finds: 2 pellet bells
Literature: Müller 1996c; Müller 2014

cat. 45: pellet bell BM_none

Context: tomb 193
Date: 9th/10th cent., Carolingian Period
Conservation status: complete
Base shape: shape II
Handle:
Decoration: smooth
Sound slot: simple
Pellet: bronze ball
Measurements: dm. 1.7 x 1.95 cm, hwl. 1.9 cm, th. 2.95 cm, cw. 8.34 g
Material: Cu-Zn-Pb
Frequency range: 1.6–12 kHz
Fig. 3/6

cat. 46: pellet bell BM_none

Context: tomb 497
Date: 9th/10th cent., Carolingian Period
Conservation status: complete, deformed
Base shape: shape II
Handle:
Decoration: smooth, gilded
Sound slot: cruciform
Pellet: lost
Measurements: dm. 1.8 x 2.3 cm, cons. h. 1.6 cm, cw. 1.89 g
Material: Cu-Sn
Frequency range: no recordings, no frequency analyses
Fig. 3/7

Locality: Keszthely-Fenékpuszta, Zala County, HU

Site: fortification Keszthely-Fenékpuszta south wall, cemetery IV
Function: cemetery
Date: 9th/10th cent., Carolingian Period
Finds: 4 Pellet bells
Literature: Sós 1961, Müller 2010; Müller 2014.

cat. 47: pellet bell, lost

Context: burial 1952/50, child/infans II, near left hand
Date: 9th/10th cent., Carolingian Period
Conservation status: no information, pellet bell with iron chain, textile and leather fragments,
Base shape: no information
Handle: round
Decoration: grid patterns
Sound slot: cruciform
Pellet: no information
Measurements: no information
Material: Cu–alloy?
Frequency range: no recordings, no frequency analyses
Fig: non

cat. 48: pellet bell burial, BM_?

Context: burial 1951/15, man, near skull, grave good?
Date: 9th/10th cent., Carolingian Period
Conservation status: fragmented, one hole?
Base shape: round?
Handle: round
Decoration: smooth, none
Sound slot: simple?
Pellet: lost?
Measurements: dm: 2 cm, th. 2.6 cm
Material: Cu–alloy
Frequency range: no recordings, no frequency analyses
Fig. 3/8

cat. 49: pellet bell, lost

Context: burial 1980/13/27, child/infans I, near right pelvis
Date: 9th/10th cent., Carolingian Period
Conservation status: no information

Base shape: no information
Handle: no information
Decoration: no information
Sound slot: no information
Pellet: lost
Measurements: no information
Material: Cu–alloy
Frequency range: no recordings, no frequency analyses
Fig: none

cat. 50: pellet bell, lost

Context: burial 1980/13/27, child/infans I, near right pelvis
Date: 9th/10th cent., Carolingian Period
Conservation status: no information
Base shape: no information
Handle: no information
Decoration: no information
Sound slot: no information
Pellet: lost
Measurements: no information
Material: Cu–alloy?
Frequency range: no recordings, no frequency analyses
Fig: none

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