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PELLET BELLS FROM THE AVAR AGE CEMETERIES OF KOMÁRNO

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The pellet bells from 15 graves of the Avar cemeteries Komárno IV, VIII and IX were examined for their position in the graves, their types, their acoustic and psychoacoustic parameters and their metallurgical compositions within the framework of the research project 'Metallic Idiophones between 800 BC and 800 AD in Central Europe'. Based on the results, assumptions could be made about their functions. Burials with pellet bells are only a minority among all the total amount of burials of all three cemeteries together and date from the middle Avar period II onwards. Only five graves belonged to children. These pellet bells can be interpreted as amulets and rather silent signal instruments, fixed on the clothes of the persons. The other ten grave belonged to horsemen and their horses. These pellet bells were part of the horse harness and served as jewellery, warning signal instrument and amulet. Most of the pellet bells were hammered of bronze sheet, and followed by those cast in bronze. But there are also pellet bells hammered of iron, copper and brass sheet. Their main frequencies could be determined between 1.5–4.5 kHz. Acoustic and psychoacoustic parameters can help to identify also similarities and differences between the objects and to get an idea of the actual sound. Especially loudness and level can also be used to draw conclusions about the use of the objects. A video with the original sounds of the pellet bells was created and loaded up on the internet platform Youtube: 'Pellet Bells from the Avar Period in Komárno'.

Keywords: SW Slovakia, Avar Period, pellet bells, music archaeology, acoustics, psychoacoustics, metallurgy, clothing.

INTRODUCTION AND PROJECT

Avar pellet bells have rarely come into focus of extensive scientific research. The research project 'Metallic Idiophones between 800 BC and 800 AD in Central Europe', founded by the Austrian Science Fund (Hertha Firnberg) and supported by the Natural History Museum Vienna, Austria, deals with numerous aspects of metal idiophones. It takes a musical-archaeological approach to studying metal bells, pellet bells and costume jewellery with jingles originating from the Iron Age, the Roman Empire and the Early Middle Ages. The objects' shapes and their positions in the find context allow one to draw conclusions about their use. Extensive metal analyses provide information about the metallurgical composition of the artefacts, which in turn also influences the tonal appearance of the idiophones. Sound recordings of each object – as long as it is playable without being damaged – are carried out in a transportable insulated recording chamber (*Pomberger/Mühlhans, in print*). With the help of analysing software spectral and temporal acoustic parameters such as partial frequencies and their amplitudes, harmonic-to-noise ratio or sound pressure levels etc. and also psychoacoustic parameters such as loudness, brightness, roughness etc. are calculated. Sound emitting objects create an acoustic environment that might unconsciously influence people's behaviour or listening habits. The attempt to study the influence and functionality of sounds in archaeology with (psycho-)acoustic measurements is a novelty and provides interesting new insights. Several of the research objects were discovered in graves located right next to the skeleton. Traces of textiles, still adhering to them, indicate that once they were functioning as sounding components of human clothing. This article focuses on current results of studies directed on pellet bells from the Avar cemeteries of Komárno, Nitra County, Slovakia.

KOMÁRNO AND ITS AVAR SITES

Komárno is located on the left bank of the Danube, which represents the border between Slovakia and Hungary at the point where the Váh enters the Danube. Opposite, on the right bank of the Danube, lies the Hungarian part, Komárom, where the Romans built the legionary camp of Brigetio to guard the Pannonian Limes. The Danube flows more slowly in this section than between Bratislava and Gönyű, where it still shows characteristics of a mountain river. Strategically, the place is of great importance, as on the one hand it allows the monitoring of the great waterway from west to east, and

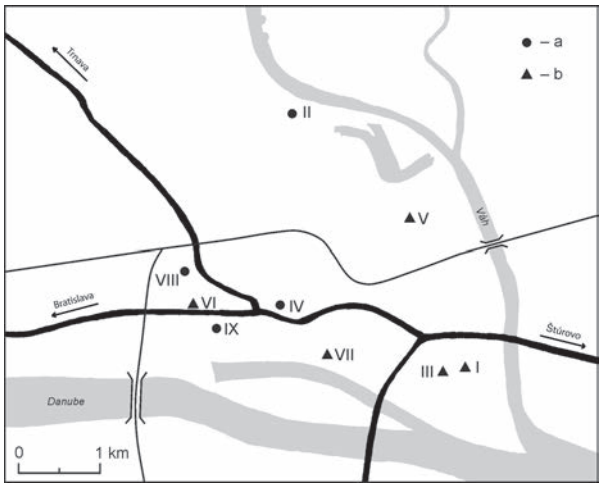

Fig. 1. Map of Komárno with Avar cemeteries. Legend: a – cemetery with pellet bells; b – cemetery without pellet bells (graphic by B. M. Pomberger).

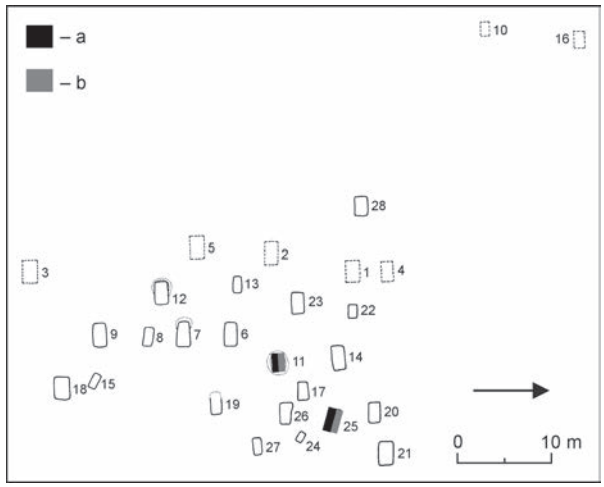

Fig. 2. Cemetery Komárno IV, Váradiho ul. Legend: a – human; b – horse (after *Čilinská 1982*).

on the other hand, through the Váh, it provides a navigable route to the northern region, highly suitable for trade, defence and martial attacks. In the Early Middle Ages, Avars had settled here. Nine burial grounds and six settlements bear witness to their presence in Komárno (Fig. 1; *Zábojník 2009*, 96–99). Graves with pellet bell finds are known from the cemeteries Komárno IV, Váradiho ul., Komárno VIII, Hadovská cesta and Komárno IX, Lodenica. Another pellet bell was possibly discovered in Komárno II, Dunahomok (Nová osada), which was unfortunately lost (*Alapy 1933*, 39, 40; *Zábojník 2009*, 96). The sound objects were found in graves of single individuals as well as those of horsemen with horses.

CATALOGUE OF COMPLEXES AND FINDS[1]

Komárno IV, Váradiho ul. (today Rožná ul.) cemetery (Fig. 2)

Excavations: 1974, 1976, 1978
Graves with pellet bells: 2
Storage: Institute of Archaeology of the Slovak Academy of Sciences Nitra
Literature: *Čilinská 1982*, 349, 351, pl. 2: 5; 9; *Jakab/Vondráková* 1982, 398, 400; *Zábojník 1995*, 299, 300; *2009*, 97.

Grave 11 (Fig. 3: 2)
Contents and condition: individual, horse, undisturbed
Individual: child, masculine?, infans II
Animal: horse
Dating: LAP, 8th c. AD
Finds: one pellet bell
Position in tomb: pellet bell near child's left thigh

Pellet bell (Fig. 3: 1)
Inv. nr.: no information
Conservation status: complete?
Rattle body: no information
Basis shape: oval, circular
Sound slot/sound holes: simple? two sound holes
Decoration: face, vertical grooves
Shape: I
Measures: dm. 40 mm, th. 50 mm, hwl. 40 mm
Material: bronze, no analyses
Frequency range/pitches: no recordings, no frequency analyses

Grave 25 (Fig. 3: 3)
Contents and condition: individual, horse, upper half disturbed
Individual: masculine, adultus II
Animal: horse
Dating: LAP III, 8th c. AD
Finds: one pellet bell
Position in tomb: pellet bell near area of the hip as well as by the lower jaw of the horse

Pellet bell (Fig. 3: 4)
Inv. nr.: no information
Conservation status: complete?
Rattle body: no information
Basis shape: oval
Sound slot/sound holes: none
Decoration: smooth
Shape: VII
Measures: dm. 30 mm, th. 36 mm, hwl. 26 mm
Material: bronze sheet, no analyses
Frequency range/pitches: no recordings, no frequency analyses

[1] Abbreviations: dm = diameter; l = lenght; w = width; th = total height; hwl = height without eyelet; wth = wall thickness; cw = conserved weight, Fn = find number; Inv. nr. = inventory number.

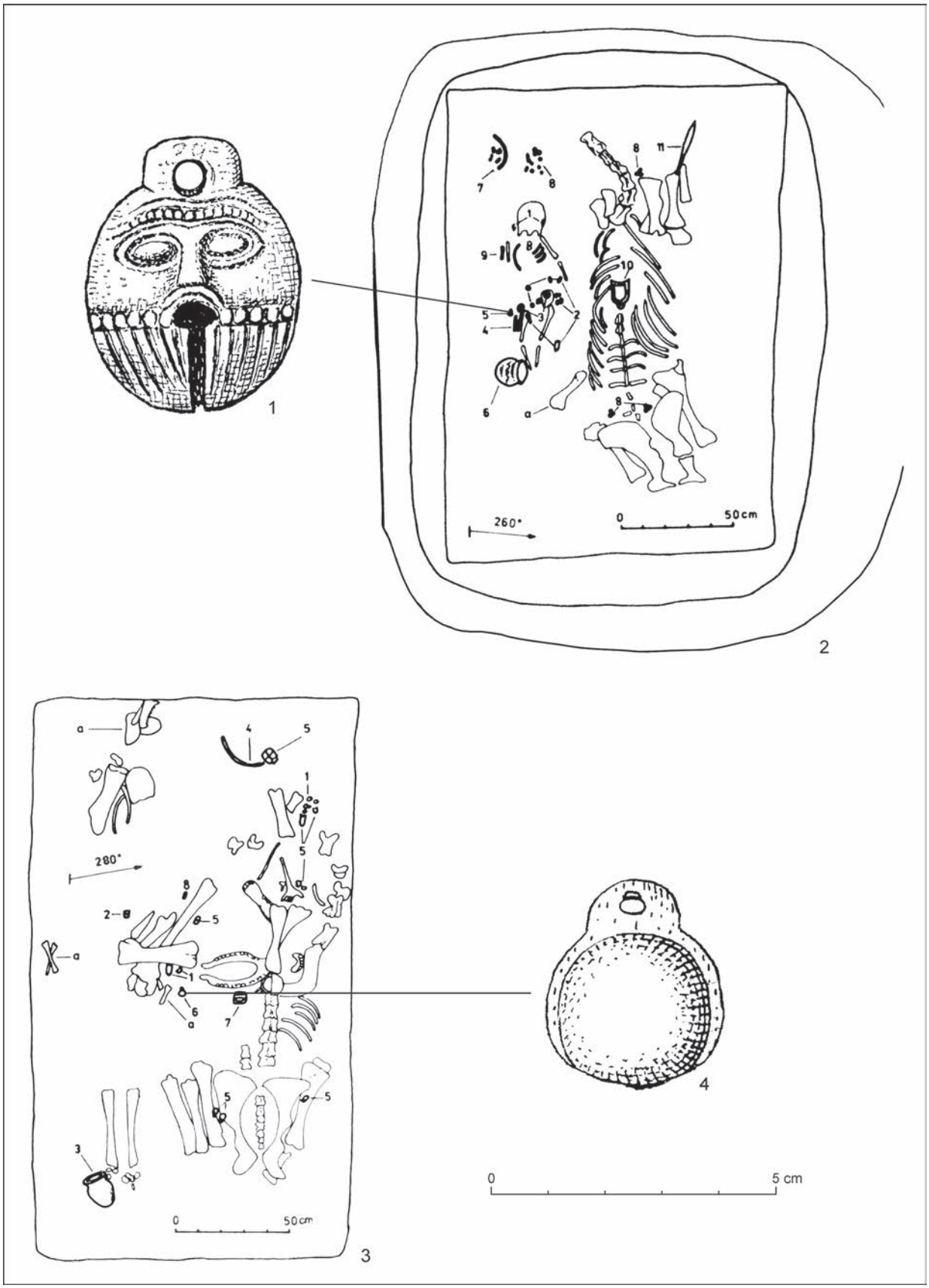

Fig. 3. Komárno IV, Váradiho ul. 1 – pellet bell from the grave 11; 2 – grave 11; 3 – grave 25; 4 – pellet bell from the grave 25 (after *Čilinská 1982*).

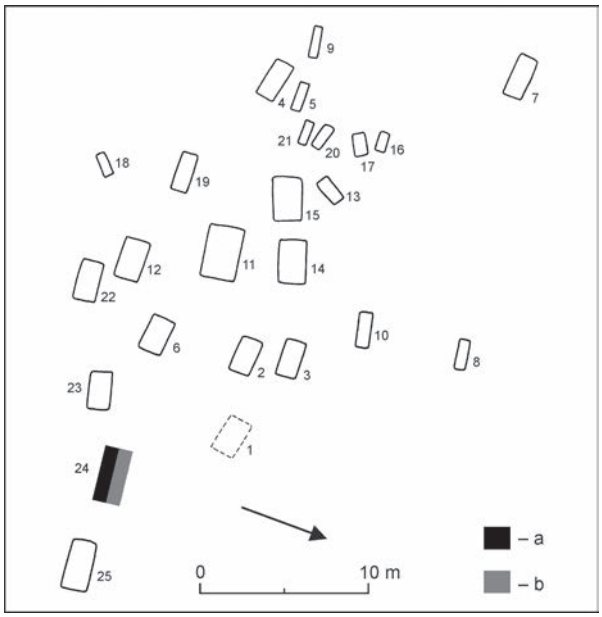

Fig. 4. Cemetery Komárno VIII, Hadovská cesta. Legend: a – human; b – horse (after *Čilinská 1982*).

Komárno VIII, Hadovská cesta cemetery
(Fig. 4)

Excavations: 1977, 1978
Graves with pellet bells: 1
Storage: Institute of Archaeology of the Slovak Academy of Sciences Nitra
Literature: *Čilinská 1982*, 361, pl. 4: 11; *Jakab/Vondráková 1982*, 405, 406; *Zábojník 1995*, 300–303, fig. 7; *2009*, 98.

Grave 24 (Fig. 5: 1)
Contents and condition: individual, horse, undisturbed
Individual: masculine, adultus I
Animal: horse
Dating: LAP IIIb–c, 8th/9th cent.
Finds: one pellet bell
Position in tomb: near spine of the horse

Pellet bell (Fig. 5: 2)
Inv. nr.: no information
Conservation status: complete?
Rattle body: no information
Basis shape: oval
Sound slot/sound holes: none
Decoration: smooth

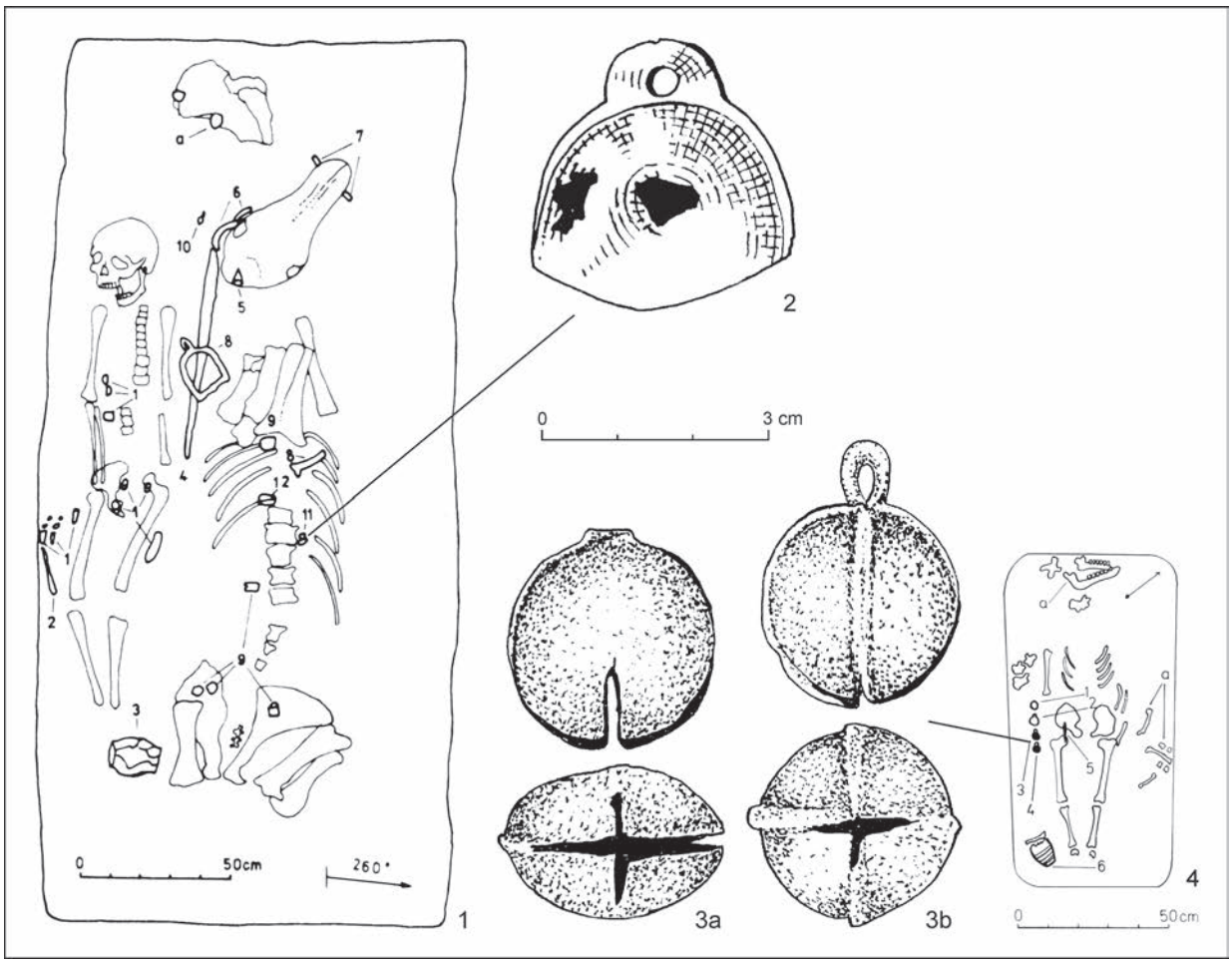

Fig. 5. Komárno VIII, Hadovská cesta: 1 – grave 24; 2 – pellet bell from the grave 24 (after *Čilinská 1982*). Komárno IX, Lodenica; 3 – pellet bells from the grave 65; 4 – grave 65 (after *Trugly 1987*).

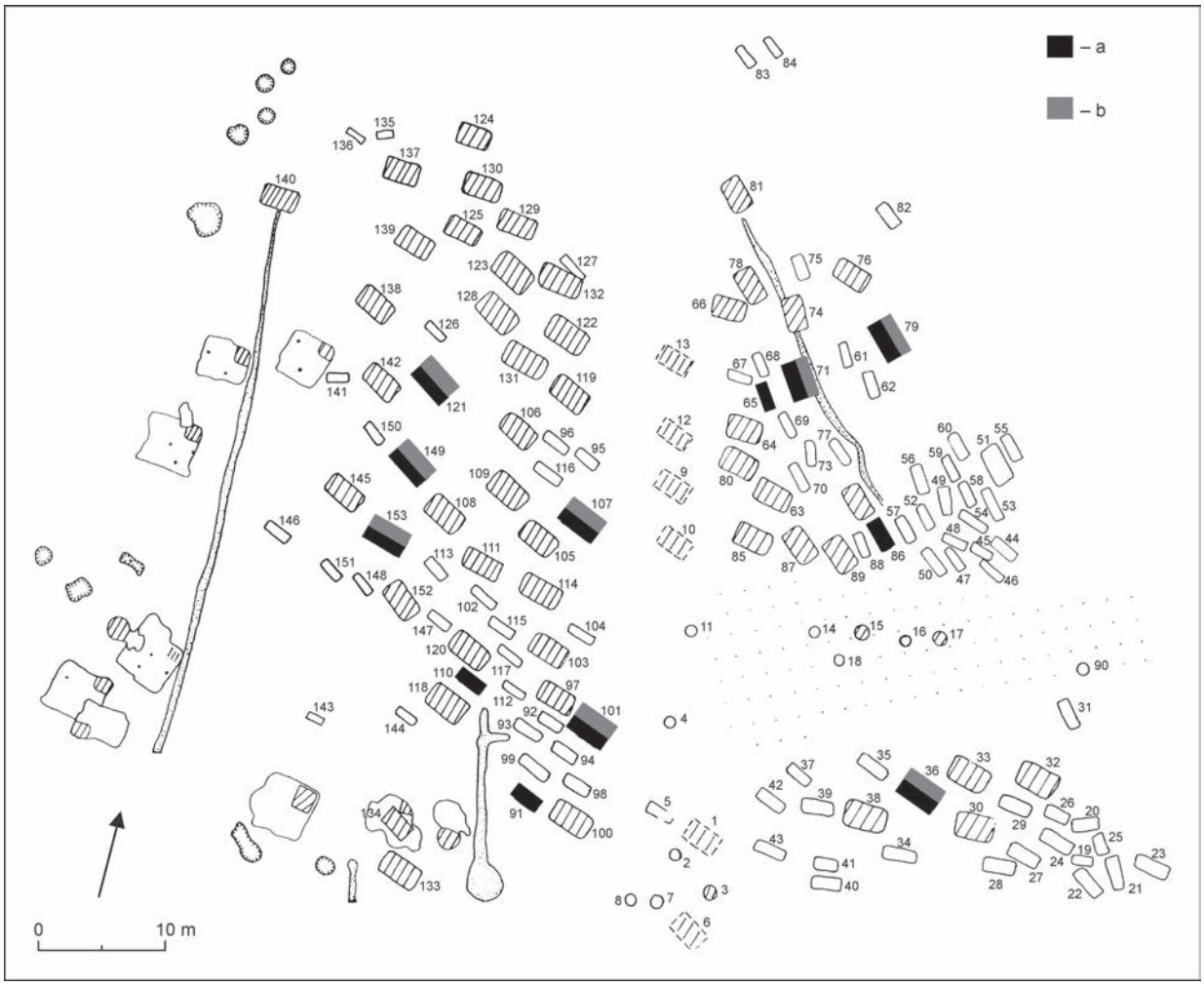

Fig. 6. Cemetery Komárno IX, Lodenica. Legend: a – human; b – horse (after *Trugly 1993*).

Shape: VII
Measures: dm. 40 mm, th. 42 mm, hwl. 36 mm
Material: bronze sheet, no analyses
Frequency range/pitches: no recordings, no frequency analyses

Komárno IX, Lodenica cemetery
(Fig. 6)

Excavations: before 1961, 1979, 1983, 1987–1989
Graves with pellet bells: 12
Storage: Podunajské múzeum in Komárno
Literature: *Ambros 1987*; *Gomolčák/Jakab 1987*; *Jakab 1993*; *Trugly 1987*, 258, 263–265, 268, 270, 272; *1993*, 191, 198, 194, 196, 197, 203, 204, 215, 216; *Zábojník 2009*, 98.

Grave 65 (Fig. 5: 4)
Contents and condition: individual
Individual: child, infans II?
Animal: none
Dating: LAP II, 8th c.
Finds: two pellet bells
Position in tomb: near right hand

Pellet bell a (Fig. 5: 3a)
Inv. nr.: A-5396
Conservation status: complete
Rattle body: pebble
Basis shape: spherical
Sound slot/sound holes: cruciform, no sound holes
Decoration: smooth, two belts
Shape: shape I
Measures: dm. 30 x 30 mm, th. 39 mm, hwl. 30 mm, wth. 1 mm, cw. 13 g
Material: bronze
Frequency range/pitches: 1–12 kHz sound spectrum, peak around 1.5 kHz
Sound pressure level: ~ 55 dB
Loudness: 7 sone
Brightness: 4.6 kHz
Sharpness: 2.7 acum
Roughness: 0.1 asper
Tonality: n/a

Pellet bell b (Fig. 5: 3b)
Inv. nr.: A-5397
Conservation status: complete, eyelet lost
Rattle body: pebble

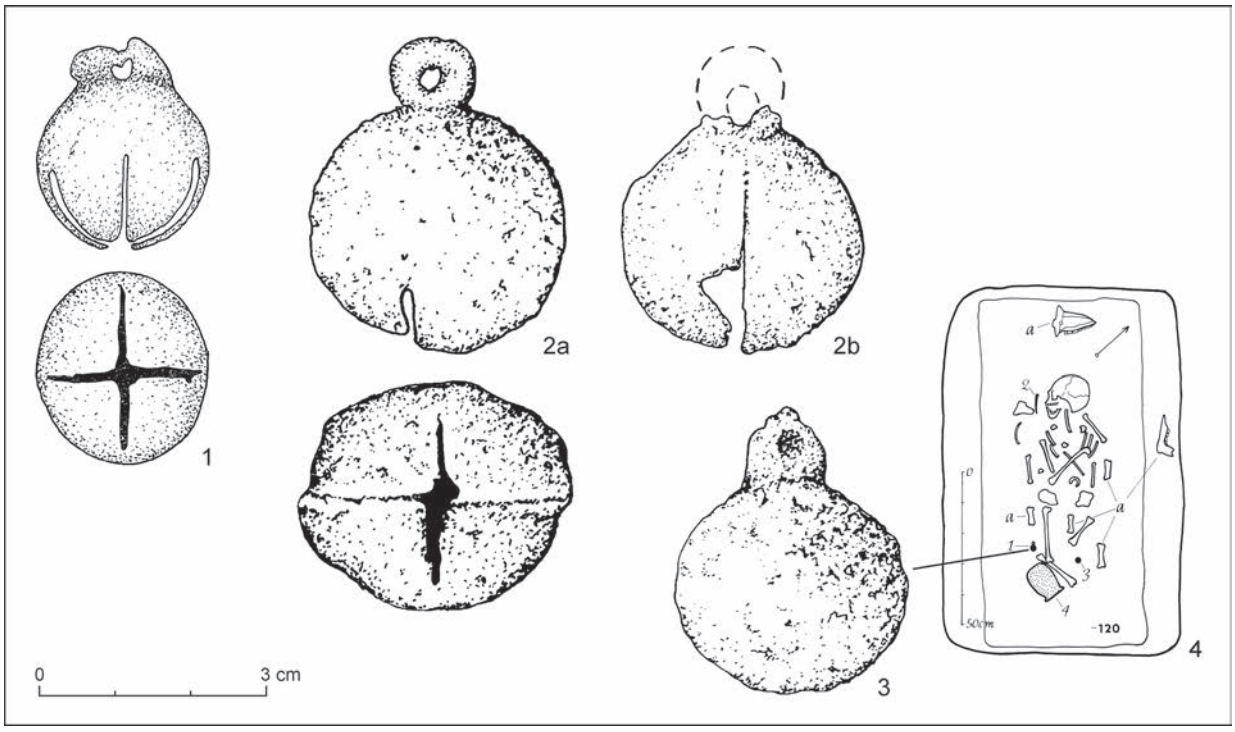

Fig. 7. Komárno IX, Lodenica. 1 – pellet bell from the grave 86; 2 – pellet bells from the grave 91; 3 – pellet bell from the grave 110; 4 – grave 110 (1 after *Trugly 1987*; 2–4 after *Trugly 1993*).

Basis shape: oval
Sound slot/sound holes: cruciform, no sound holes
Decoration: smooth
Shape: shape II
Measures: dm. 30.5 x 23 mm, hwl. 35.5 mm, wth. 1 mm, cw. 13 g
Material: bronze, gilded
Frequency range/pitches: 1.2–10 kHz sound spectrum, peak around 3 kHz
Sound pressure level: ~ 60 dB
Loudness: 9 sone
Brightness: 3.2 kHz
Sharpness: 2.7 acum
Roughness: 0.2 asper
Tonality: n/a

Grave 86
Contents and condition: individual
Individual: child, infans II
Animal: none
Dating: LAP II, 8th c.
Finds: one pellet bell
Position in tomb: between pelvis and right arm

Pellet bell (Fig. 7: 1)
Inv. nr.: A-5638
Conservation status: complete
Rattle body: lumps of bronze
Basis shape: spherical
Sound slot/sound holes: cruciform, no sound holes
Decoration: smooth
Shape: shape I
Measures: dm. 25 x 25 mm, th. 28 mm, hwl. 27 mm, wth. 1 mm, cw. 18 g
Material: bronz
Frequency range/peak: 2–20 kHz, peak at 4.47 kHz
Sound pressure level: 70 dB
Loudness: 16 sone
Brightness: 4.6 kHz
Sharpness: 4.3 acum
Roughness: < 0.1 asper

Grave 91
Contents and condition: individual
Individual: child, infans III
Animal: none
Dating: MA II–LAP I, ca. 655–720 A
Finds: two pellet bells
Position in tomb: near left hand and pelvis

Pellet bell a (Fig. 7: 2a)
Inv. nr.: A-6052
Conservation status: complete
Rattle body: corroded inside
Basis shape: spherical
Sound slot/sound holes: cruciform, no sound holes
Decoration: surface corroded, textile remains
Shape: shape I
Measures: dm. 33 x 32 mm, th. 42 mm, cw. 22 g
Material: iron
Frequency range/pitches: no recording, no analyses

Pellet bell b (Fig. 7: 2b)
Inv. nr.: A-6053
Conservation status: rattle body complete, handle lost
Rattle body: corroded inside
Basis shape: spherical

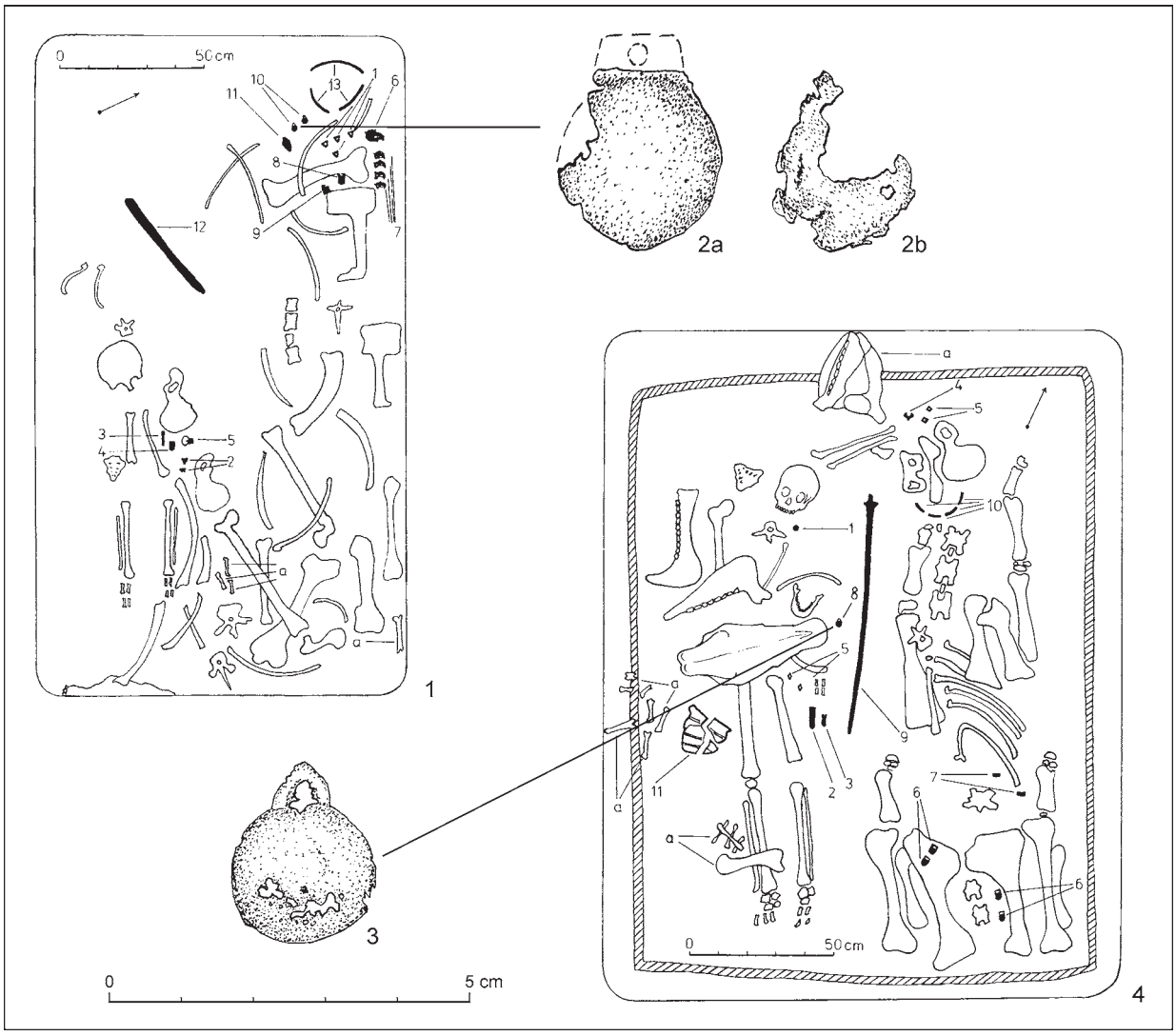

Fig. 8. Komárno IX, Lodenica. 1 – grave 36; 2 – pellet bells from the grave 36; 3 – pellet bell from the grave 71; 4 – grave 71 (after *Trugly 1987*).

Sound slot/sound holes: simple, no sound holes
Decoration: surface corroded, textile remains
Shape: shape I
Measures: dm. 32 x 30.5 mm, hwl. 32 mm, cw. 14 g
Material: iron
Frequency range/pitches: no recording, no analyses

Grave 110 (Fig. 7: 4)
Contents and condition: individual
Individual: child, infans II
Animal: none
Dating: MA II–LAP I, ca. 655–720 AD
Finds: one pellet bell
Position in tomb: near right leg

Pellet bell (Fig. 7: 3)
Inv. nr.: A-6070
Conservation status: complete
Rattle body: pebble?
Basis shape: oval
Sound slot/sound holes: cruciform, no sound holes
Decoration: surface corroded, two belts
Shape: shape II
Measures: dm. 31 x 27 mm, th. 38 mm, hwl. 27, cw. 14 g
Material: iron
Frequency range/pitches: no recording, no analyses

Grave 36 (Fig. 8: 1)
Contents and condition: individual, horse, upper part disturbed
Individual: masculine, senil
Animal: horse, 7–8-year-old stallion
Dating: LAP IIIb, ca. 8th/9th c.
Finds: two pellet bells
Position in tomb: near horse skull

Pellet bell a (Fig. 8: 2a)
Inv. nr.: A-5314_a
Conservation status: two fragments
Rattle body: lost

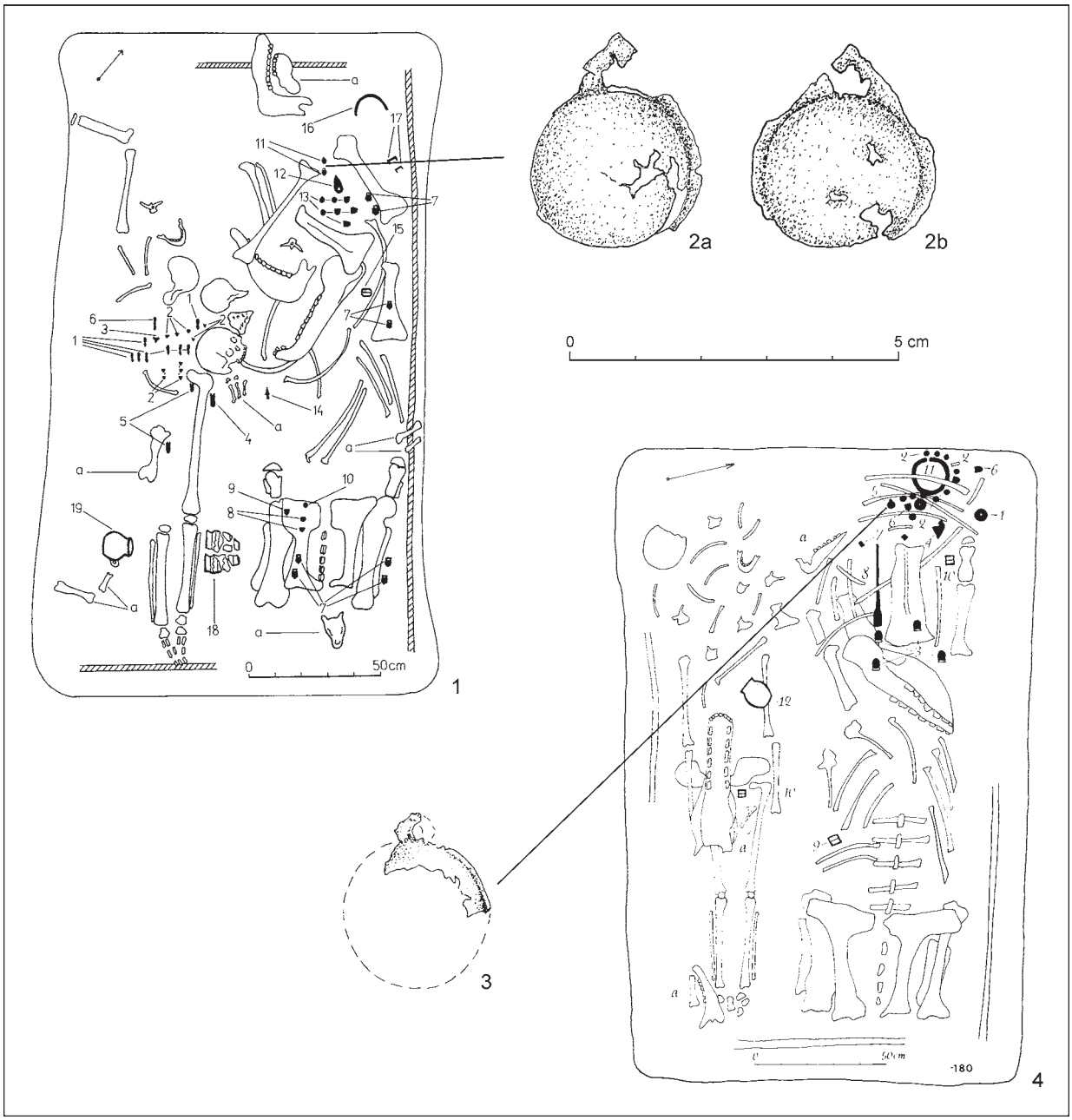

Fig. 9. Komárno IX, Lodenica. 1 – grave 79; 2 – pellet bells from the grave 79; 3 – pellet bell from the grave 101; 4 – grave 101 (1, 2 after *Trugly 1987*; 3, 4 after *Trugly 1993*).

Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: smooth
Shape: shape VII
Measures: dm. 25 mm, rec. th. 30 mm, hwl. 25, wth. 0.5 mm
Material: bronze sheet, gilded
Frequency range/pitches: no recording, no analyses

Pellet bell b (Fig. 8: 2b)
Inv. nr.: A-5314_b
Conservation status: two fragments
Rattle body: lost
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: smooth
Shape: shape VII
Measures: dm. 25 mm, rec. th. 30 mm, hwl. 25, wth. 0.5 mm
Material: bronze sheet, gilded
Frequency range/pitches: no recording, no analyses

Grave 71 (Fig. 8: 4)
Contents and condition: individual, horse, upper part disturbed
Individual: masculine, maturus I
Animal: horse
Dating: LAP IIIa, ca. 760–780 AD

Finds: one pellet bell
Position in tomb: near left pelvis of man and horse skull

Pellet bell (Fig. 8: 3)
Inv. nr.: A-5418-19
Conservation status: four fragments
Rattle body: lost
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: smooth
Shape: shape VII
Measures: dm. 20 mm, rec. th. 25 mm, hwl. 20, wth. 0.5 mm
Material: copper sheet
Frequency range/pitches: no recording, no analyses

Grave 79 (Fig. 9: 1)
Contents and condition: individual, horse, upper part disturbed
Individual: masculine, maturus II
Animal: horse, 6–7-year-old stallion
Dating: LAP IIIb, 8th/9th c.
Finds: two pellet bells
Position in tomb: near horse skull

Pellet bell a (Fig. 9: 2a)
Inv. nr.: A-5490_b
Conservation status: fragmented
Rattle body: lost
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: smooth
Shape: shape VII
Measures: dm. 25 mm, th. 33 mm, hwl. 24 mm, wth. 0.5 mm
Material: bronze sheet
Frequency range/pitches: no recording, no analyses

Pellet bell b (Fig. 9: 2b)
Inv. nr.: A-5490_b
Conservation status: fragmented
Rattle body: lost
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: smooth
Shape: shape VII
Measures: dm. 27 mm, th. 31 mm, hwl. 23 mm, wth. 0.5 mm
Material: bronze sheet
Frequency range/pitches: no recording, no analyses

Grave 101 (Fig. 9: 4)
Contents and condition: individual, horse, upper part disturbed
Individual: masculine, adultus II
Animal: horse
Dating: LAP IIIa, ca. 760–780 AD
Finds: one pellet bell
Position in tomb: near horse skull

Pellet bell (Fig. 9: 3)
Inv. nr.: A-5857-59
Conservation status: fragmented
Rattle body: lost
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: smooth
Shape: shape VII
Measures: rec. dm. 24 mm, conserved th. 18 mm, rec. hwl. 24, wth. 0.5 mm
Material: brass sheet
Frequency range/pitches: no recording, no analyses

Grave 107 (Fig. 10: 1)
Contents and condition: individual, horse, upper part disturbed
Individual: masculine, maturus I
Animal: horse
Dating: LAP I, 7th/8th c.
Finds: four pellet bells
Position in tomb: near horse's spine/breast

Pellet bell a (Fig. 10: 2a)
Inv. nr.: A-5813_a
Conservation status: complete, one hole in body
Rattle body: lump of bronze
Basis shape: oval
Sound slot/sound holes: cruciform, four sound holes
Decoration: face, vertical grooves
Shape: shape II
Measures: dm. 28 x 25 mm, th. 34 mm, hwl. 28, wth. 2 mm, cw. 23 g
Material: bronze
Frequency range/peak: 2–13 kHz, 3.45 kHz
Sound pressure level: 72 dB
Loudness: 24 sone
Brightness: 5.2 kHz
Sharpness: 4.7 acum
Roughness: < 0.1 asper
Tonality: 18.7 dB

Pellet bell b (Fig. 10: 2b)
Inv. nr.: A-5813_b
Conservation status: complete, one hole near eyes
Rattle body: lump of bronze
Basis shape: oval
Sound slot/sound holes: cruciform, four sound holes
Decoration: face, vertical grooves
Shape: shape II
Measures: dm. 30 x 25 mm, th. 35 mm, hwl. 29, wth. 2 mm, cw. 26 g
Material: bronze
Frequency range/peak: 1.7–13.7 kHz, 4.35 kHz
Sound pressure level: 74 dB
Loudness: 22 sone
Brightness: 4 kHz
Sharpness: 4.3 acum
Roughness: < 0.1 asper
Tonality: 18.4 dB

Pellet bell c (Fig. 10: 2c)
Inv. nr.: A-5813_c
Conservation status: complete, one hole near eyes, eyelet lost
Rattle body: lump of bronze
Basis shape: oval
Sound slot/sound holes: cruciform, four sound holes
Decoration: face, vertical grooves
Shape: shape II
Measures: dm. 30 x 27 mm, hwl. 2.5, wth. 2 mm, cw. 28 g
Material: bronze
Frequency range/peak: 2.2–20 kHz, 3.56 kHz
Sound pressure level: 84 dB
Loudness: 45 sone

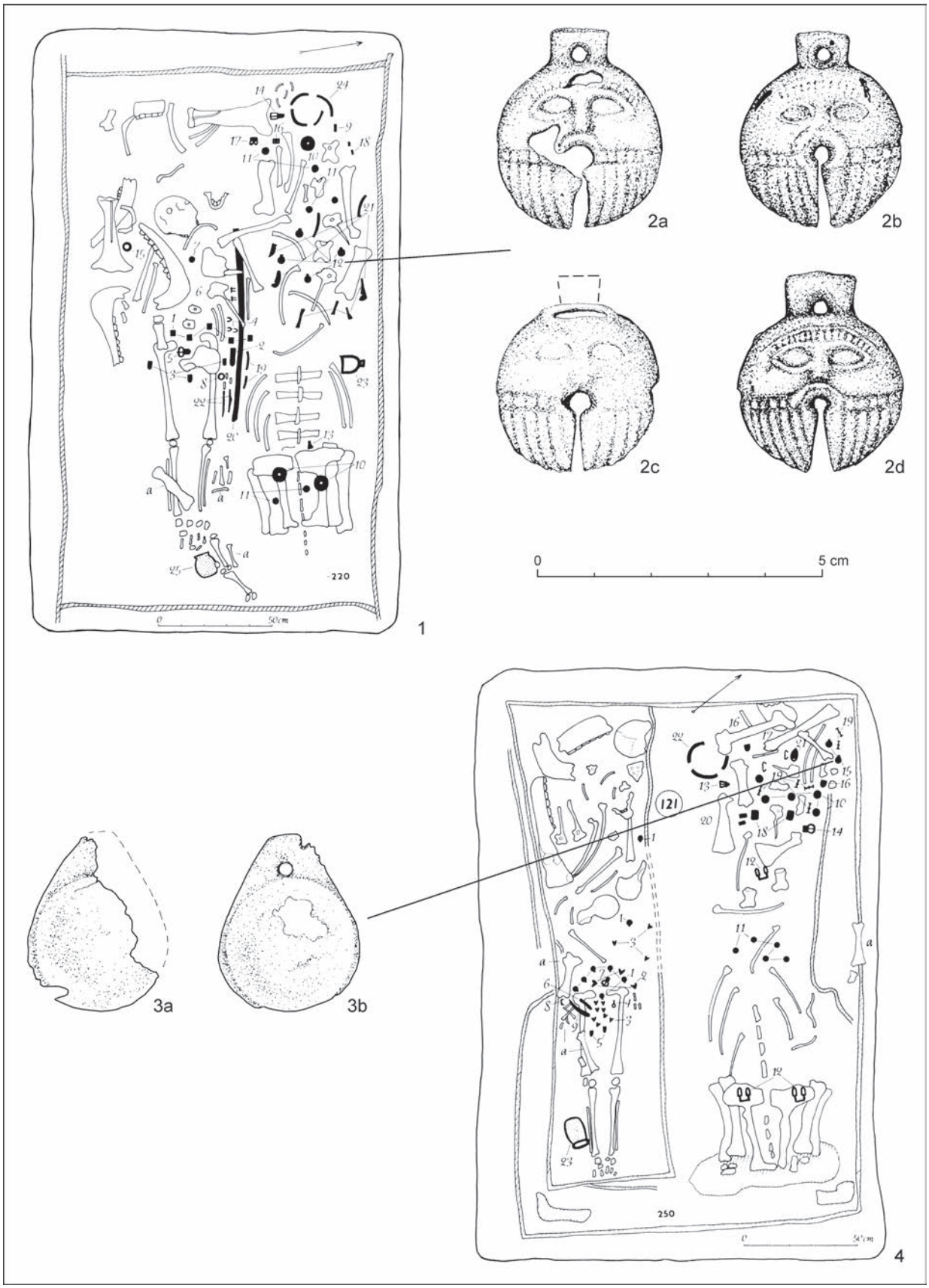

Fig. 10. Komárno IX, Lodenica. 1 – grave 107; 2 – pellet bells from the grave 107; 3 – pellet bells from the grave 121; 4 – grave 121 (after *Trugly 1993*).

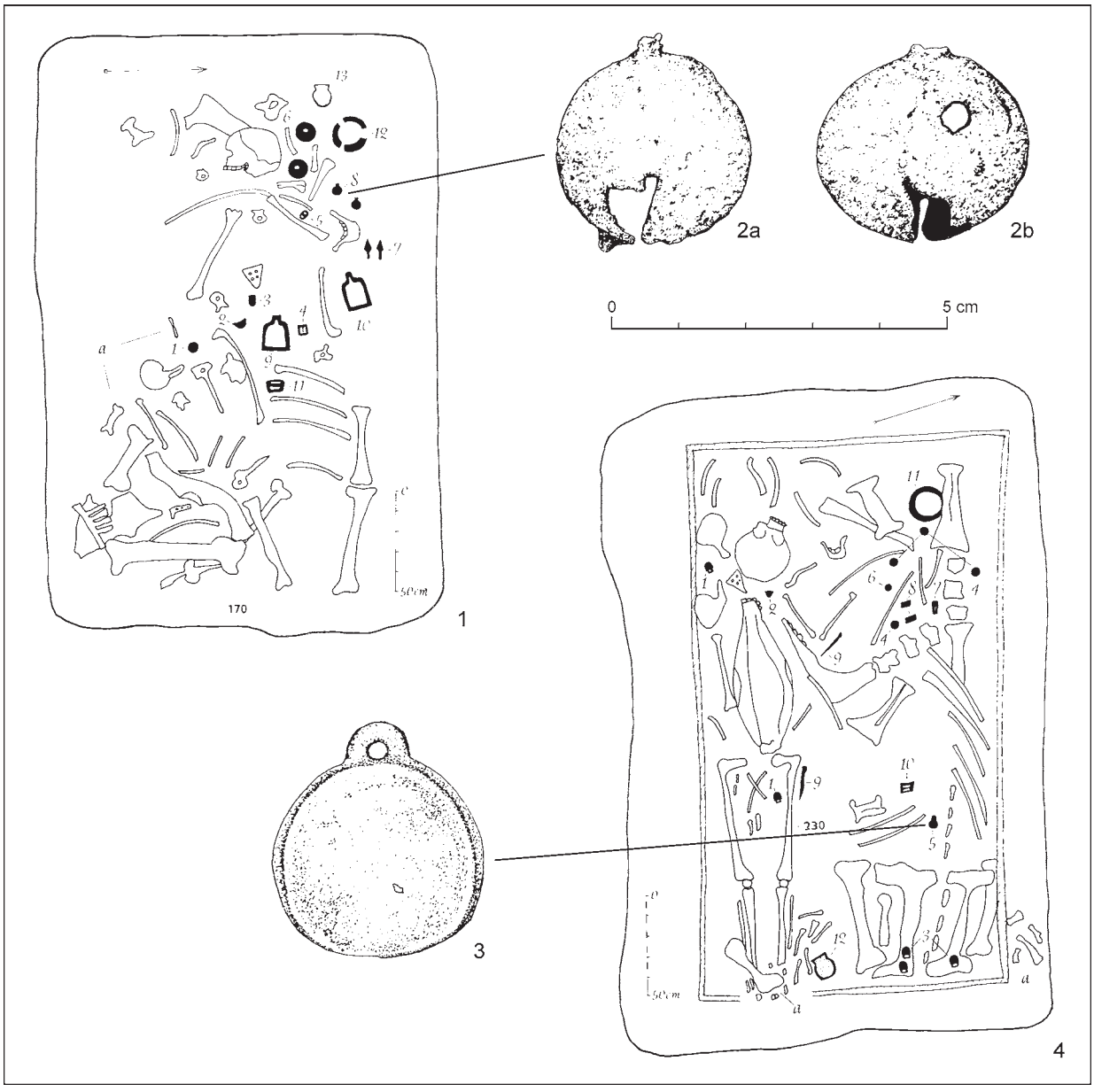

Fig. 11. Komárno IX, Lodenica. 1 – grave 149; 2 – pellet bells from the grave 149; 3 – pellet bell from the grave 153; 4 – grave 153 (after *Trugly 1993*).

Brightness: 3.8 kHz
Sharpness: 6 acum
Roughness: < 0.1 asper
Tonality: 16.8 dB

Pellet bell d (Fig. 10: 2d)
Inv. nr.: A-5813_d
Conservation status: complete
Rattle body: lump of bronze
Basis shape: oval
Sound slot/sound holes: cruciform, four sound holes
Decoration: face, vertical grooves
Shape: shape II
Measures: dm. 29 x 26 mm, th. 36 mm, hwl. 28 mm, wth. 2 mm, cw. 33 g
Material: bronze
Frequency range/peak: 1.8–16 kHz, 3.8 kHz
Sound pressure level: 72 dB
Loudness: 24 sone
Brightness: 4.5 kHz
Sharpness: 4.8 acum
Roughness: < 0.1 asper
Tonality: 14.4 dB

Grave 121 (Fig. 10: 4)
Contents and condition: individual, horse, upper part disturbed
Individual: masculine, maturus II
Animal: horse
Dating: LAP IIIb, 8th/9th c.

Finds: two pellet bells
Position in tomb: near horse skull

Pellet bell a (Fig. 10: 3a)
Inv. nr.: A-5771_a
Conservation status: fragmented
Rattle body: lost
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: smooth
Shape: shape VII
Measures: dm. 24 mm, th. 31 mm, hwl. 24 mm, wth. 0.5 mm
Material: bronze sheet
Frequency range/pitches: no recording, no analyses

Pellet bell b (Fig. 10: 3b)
Inv. nr.: A-5771_b
Conservation status: fragmented
Rattle body: lost
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: smooth
Shape: shape VII
Measures: rec. dm. 24 mm, th. 31 mm, hwl. 24 mm, wth. 0.5 mm
Material: bronze sheet
Frequency range/pitches: no recording, no analyses

Grave 149 (Fig. 11: 1)
Contents and condition: individual, horse, upper part disturbed
Individual: masculine, adult I
Animal: horse
Dating: LAP IIIa, ca. 760–780 AD
Finds: two pellet bells
Position in tomb: near horse skull

Pellet bell a (Fig. 11: 2a)
Inv. nr.: A-6103_a
Conservation status: 90% conserved
Rattle body: corroded inside?
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: corroded
Shape: shape II
Measures: dm. 29 x 25 mm, hwl. 30, cw. 10 g
Material: iron
Frequency range/pitches: no recording, no analyses

Pellet bell b (Fig. 11: 2b)
Inv. nr.: A-6103_b
Conservation status: complete, eyelet lost
Rattle body: corroded inside?
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: corroded
Shape: shape II
Measures: dm. 31 x 24 mm, hwl. 28 mm, w. 1 mm, cw. 10 g
Material: iron
Frequency range/pitches: no recording, no analyses

Grave 153 (Fig. 11: 4)
Contents and condition: individual, horse, upper part disturbed
Individual: masculine, maturus I
Animal: horse
Dating: LAP IIIa, ca. 760–780 AD
Finds: pellet bell
Position in tomb: near horse's spine

Pellet bell (Fig. 11: 3)
Inv. nr.: A-6117-18
Conservation status: complete
Rattle body: lost?
Basis shape: oval
Sound slot/sound holes: none, no sound holes
Decoration: corroded
Shape: shape VII
Measures: dm. 32 x 20 mm, th. 34 mm, hwl. 28 mm, wth. 0.5 mm, cw. 5 g
Material: copper sheet, gilded
Frequency range/pitches: no recording, no analyses

THE PELLET BELLS, THEIR POSITION IN THE GRAVES AND THEIR DISTRIBUTION IN THE CEMETERIES

Pellet bells are idiophones, defined with amusicological approach, i.e. self-sounding musical instruments, shaken idiophones and rhythm instruments. According to the systematics of musical instruments by Hornbostel and Sachs, they are to be classified as metal vessel rattles with the system number 112.13 (*von Hornbostel/Sachs 1914*, 566; *MIMO 2011*, 6). In summary, 20 pellet bells are known from the three cemeteries (Tab. 1). They show two different production methods. One is the casting of bronze in the lost wax technique. The four pellet bells from burial 107 and the one from burial 86, Komárno IX, Lodenica were produced this way as well as the pellet bell from burial 11, Komárno IV, Váradiho ul. The other objects were forged from metal sheets using different dishing blocks. Two halves were hammered and soldered together, as experiments on making spherical earrings have shown (*Čáp et al. 2011*, 66–68, 79–81). Iron pellet bells were detected in burial 91 (two pieces), burial 110 (one piece) and in burial 149 (two pieces). There are two copper pellet bells, one each from grave 153 and 71. One brass sheet idiophone stems from burial 101 and nine made from bronze sheet were found in the burials 36 (one piece), 65 (two pieces), 79 (two pieces), 121 (two pieces) from the cemetery Komárno IX, Lodenica, grave 25 (one piece) from Komárno IV, Váradiho ul. and grave 24 (one piece) from Komárno VIII, Hadovská cesta. Five pellet bells show traces of gilding: the pellet bells from the graves 36, 65, 79, 91 and 153, cemetery Komárno IX, Lodenica. The pellet bells could be classified into three basic types: shape I, shape II and shape VII (Tab. 2; *Pomberger 2020*). All idiophones cast in bronze have

Tab. 1. Pellet bells from Komárno, archaeological datas (graphic by B. M. Pomberger).

Inv. nr.	Locality	Grave	Position in grave	Relativ dating	Type	Sex	Age	Material
A-5813_a	Komárno IX, Lodenica	107	man, horse, near backbones of horse, disturbed	LAP I	shape II	masc.	maturus I	Bz
A-5813_b	Komárno IX, Lodenica	107	man, horse, near backbones of horse, disturbed	LAP I	shape II	masc.	maturus I	Bz
A-5813_c	Komárno IX, Lodenica	107	man, horse, near backbones of horse, disturbed	LAP I	shape II	masc.	maturus I	Bz
A-5813_d	Komárno IX, Lodenica	107	man, horse, near backbones of horse, disturbed	LAP I	shape II	masc.	maturus I	Bz
A-6070	Komárno IX, Lodenica	110	near right leg	MAP II–LAP I	shape II	?	infans II	Fe
A-5396	Komárno IX, Lodenica	65	near right hand	LAP II	shape I	?	infans II?	Bz, gilded?
A-5397	Komárno IX, Lodenica	65	near right hand	LAP II	shape II	?	infans II?	Bz, gilded
A-5638	Komárno IX, Lodenica	86	between pelvis and right arm	LAP II	shape I	?	infans II	Bz
A 6103_a	Komárno IX, Lodenica	149	man, horse, near horse skull	LAP IIIa	shape II	masc.	adultus I	Fe
A 6103_b	Komárno IX, Lodenica	149	man, horse, near horse skull	LAP IIIa	shape II	masc.	adultus I	Fe
A-6117-18	Komárno IX, Lodenica	153	man, horse, near backbones of horse, disturbed	LAP IIIa	shape VII	masc.	maturus I	Cu sheet, gilded
A-6052	Komárno IX, Lodenica	91	near left hand and pelvis	MAP II–LAP I	shape I	?	infans III	Fe
A-6053	Komárno IX, Lodenica	91	near left hand and pelvis	MAP II–LAP I	shape I	?	infans III	Fe, belt gilded?
A-5418-19	Komárno IX, Lodenica	71	man, horse, near left pelvis of man	LAP IIIa	shape VII	masc.	maturus I	Cu sheet
A-5857-59	Komárno IX, Lodenica	101	man, horse, near horse skull, disturbed	LAP IIIa	shape VII?	masc.	adultus II	brass sheet
A-5771_a	Komárno IX, Lodenica	121	man, horse, near horse skull, disturbed	LAP IIIb	shape VII?	masc.	maturus II	BZ sheet
A-5771_b	Komárno IX, Lodenica	121	man, horse, near horse skull, disturbed	LAP IIIb	shape VII?	masc.	maturus II	BZ sheet, gilded
A-5490_a	Komárno IX, Lodenica	79	man, horse, near horse skull	LAP IIIb	shape VII?	masc.	maturus II	Bz sheet
A-5490_b	Komárno IX, Lodenica	79	man, horse, near horse skull	LAP IIIb	shape VII?	masc.	maturus II	Bz sheet, gilded
A-5314_a	Komárno IX, Lodenica	36	man, horse, near horseskull, disturbed	LAP IIIb	shape VII?	masc.	senilis	Bz sheet, gilded
A-5314_b	Komárno IX, Lodenica	36	man, horse, near horseskull, disturbed	LAP IIIb	shape VII?	masc.	senilis	Bz sheet, gilded
	Komárno IV, Váradiho ul.	25	man, horse, on backbones of horse	LPA III	shape VII	masc.	adultus/maturus?	Bz sheet
	Komárno IV, Váradiho ul.	11	child, horse, pellet bell near left femur of child	LPA II	shape I	masc.?	infans	Bz?
	Komárno VIII, Hadovská cesta	24	man, horse, near backbones of horse	LPA IIIb–c	shape VII	masc.	adultus/maturus?	Bz sheet

Tab. 2. Condition and measures of pellet bells from Komárno (graphic by B. M. Pomberger).

Inv. nr.	Locality	Grave	Shape basis	Sound slot	Decoration	Diameter [cm]	Height wihtout loop [cm]	Height + loop [cm]	Wall thikness [mm]	Weight conserved [g]	Condition shape	Rattle body	Textil rests
A-5813_a	Komárno IX, Lodenica	107	oval	cruciform, 4 sound holes	face, vertical grooves	2.8 x 2.5	2.8	3,4	2	23	complete, 1 hole	lump of bronze	none
A-5813_b	Komárno IX, Lodenica	107	oval	cruciform, 4 sound holes	face, vertical grooves	3 x 2.5	2.9	3,5	2	26	complete, 1 hole near eyes, 1 hole at vertex	lump of bronze	none
A-5813_c	Komárno IX, Lodenica	107	oval	cruciform, 4 sound holes	face, vertical grooves	3 x 2.7	2.85	?	2	28	loop lost, complete, 1 hole	lump of bronze	none
A-5813_d	Komárno IX, Lodenica	107	oval	cruciform, 4 sound holes	face, vertical grooves	2.9 x 2.6	2.8	3.6	2	33	complete	lump of bronze	none
A-6070	Komárno IX, Lodenica	110	oval	cruciform?	corroded, 2 belts	3.1 x 2.7	2.7	3.8	?	14	complete	pebble?	none
A-5396	Komárno IX, Lodenica	65	spherical	cruciform	smooth, 2 belts	3 x 3	3	3.9	1	13	complete	pebble?	none
A-5397	Komárno IX, Lodenica	65	oval	cruciform	smooth	3.05 x 2.3	3.55	?	?	13	complete, loop lost	pebble?	none
A-5638	Komárno IX, Lodenica	86	spherical	cruciform	smooth	2.5 x 2.5	2.7	2.8	1	18	complete, loop deformed	lumps of bronze	none
A 6103_a	Komárno IX, Lodenica	149	oval	cruciform?	corroded	2.9 x 2.5	3	?	?	10	90% conserved	corroded inside?	none
A 6103_b	Komárno IX, Lodenica	149	oval	cruciform	corroded	3.1 x 2.4	2.8	?	1	9	complete, loop lost	corroded inside?	none
A-6117-18	Komárno IX, Lodenica	153	oval	none	smooth	3.2 x 2	2.8	3.4	0.5	5	complete	lost/corroded insde	none
A-6052	Komárno IX, Lodenica	91	spherical	cruciform	corroded	3.3 x 3.2		4.2	?	22	complete	corroded inside	textil rests
A-6053	Komárno IX, Lodenica	91	spherical, 1 belt	simple?	corroded	3.2 x 3.05	3.2	?	?	14	complete, loop lost	corroded inside	textil rests
A-5418-19	Komárno IX, Lodenica	71	oval	none	smooth	2	2	2.5	?	?	fragmented	lost	none
A-5857-59	Komárno IX, Lodenica	101	oval	none	smooth	rec. 2.5	rec. 2.5	conserv. 1.8	?	?	fragmented	lost	none
A-5771_a	Komárno IX, Lodenica	121	oval	none	smooth	2.4	2.4	3.1	0.5	?	fragmented	lost	none
A-5771_b	Komárno IX, Lodenica	121	oval	none	smooth	rec. 2.4	2.4	3.1	0.5	?	fragmented	lost	none
A-5490_a	Komárno IX, Lodenica	79	oval	none	smooth	2.5	2.4	3.3	0.5	?	fragmented	lost	none
A-5490_b	Komárno IX, Lodenica	79	oval	none	smooth	2.7	2.3	3.1	0.5	?	fragmented	lost	none
A-5314_a	Komárno IX, Lodenica	36	oval	none	smooth	2.5	2.5	rec. 3	0.5	?	fragmented	lost	none
A-5314_b	Komárno IX, Lodenica	36	oval	none	smooth	2.5	2.5	rec. 3	0.5	?	fragmented	–	none
	Komárno IV, Váradiho ul.	25	oval	none	smooth	3	2.6	3.6	?	?	?	?	none
	Komárno IV, Váradiho ul.	11	oval/ circular?	simple? 2 sound holes?	face, vertical grooves	4	4	5	?	?	complete?	?	none
	Komárno VIII, Hadovská cesta	24	oval	none	smooth	4	3.6	4.2	?	?	?	?	none

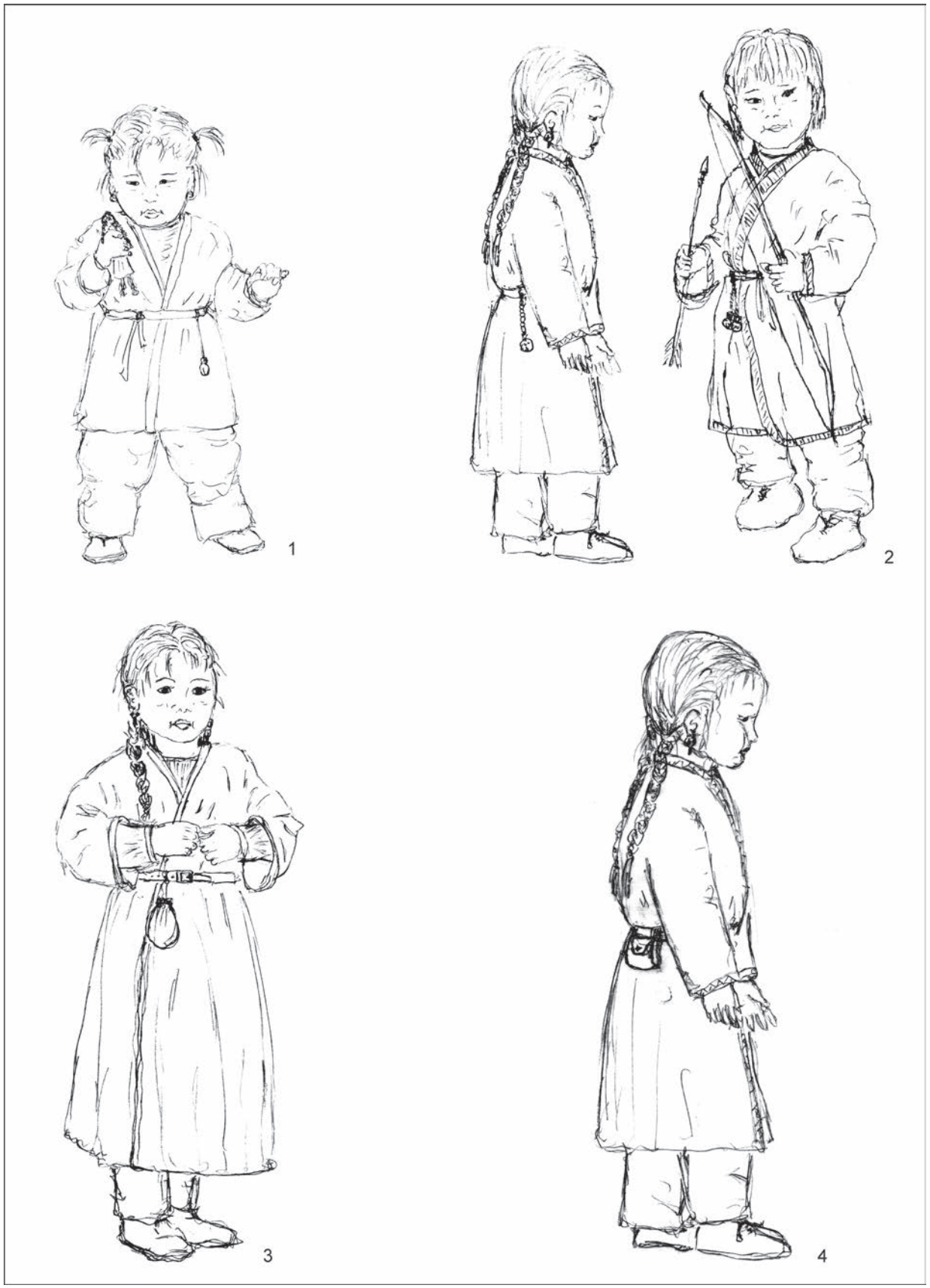

Fig. 12. Possibilities of wearing the pellet bells on the belt. 1 – ribbon; 2 – chain; 3 – small bag; 4 – belt bag (drawn by B. M. Pomberger).

cross-shaped sound slots and some have two or four additional sound holes. The other bells, made of sheet metal, have either cross-shaped sound slots or no sound slots at all. Mostly their surface is smooth. An exception are the pellet bells with faces. On the upper half, the craftsman depicted a face with almond-shaped eyes, bushy eyebrows grown together above them, a short flat nose, an o-shaped open mouth, which also functions as a sound hole, and a moustache curving above it. The lower half is decorated with vertical fluting. Small raised bosses line the belly. In the literature, this kind of pellet bell is referred to as a face bell. Four face pellet bells almost identical to the model, but not identical in casting, are known from grave 107, Komárno IX, Lodenica (Fig. 10: 1; *Pomberger, in print; Trugly 1993*, 196, 197, fig. 12: 15–18). One further, very similar pellet bell was found in burial 11, Komárno IV, Váradiho ul. With total heights of 25 mm to 50 mm, diameters of 20 mm to 40 mm, wall thicknesses of 0.5 mm to 2 mm and conserved weights of 5 g to 33 g, the bells from the cemeteries of Komárno are rather small and lightweight. Inside some of the idiophones, the rattle bodies made of bronze slag and small pebbles could be observed, but mostly they are missing or corroded in more than half of the pellet bells. The two pellet bells from burial 91 show traces of textiles.

In the Komárno cemeteries, pellet bells were found near children's, males' and horses' skeletons. Possibly, there were once even more pellet bells deposited within these cemeteries, but not all graves have been preserved. A large number of the graves have been disturbed in the upper part by graves robbing, but in most cases, the idiophones can be associated with either the deceased or the horse based on their finding position. While the children from graves 86 and 110 of Komárno IX, Lodenica and from grave 11 of Komárno IV, Váradiho ul. were buried with only one bell, those from the graves 65 and 91 of Komárno IX, Lodenica were each fitted with two bells. The pellet bells lay at the right or left thigh, at the right hand, between the pelvis and the right arm or the left arm, between leg and pelvis, i.e. always in the pelvic area. The clothing, be it a tunic or a kaftan, was held together with belts or bands around the middle of the body to give it a better fit. Various items of daily use were often attached to the belt, such as pouches or belt pouches, knives, ornamental jewellery, needle containers, spindle whorls, amulets (*Garam 2011*; *Vida 2018*, 427, fig. 5). The pellet bells were probably worn on a leather or textile strap, on a chain, in a belt pouch or in a small bag (Fig. 12: 1–4; *Pomberger/Stadler 2018*, 126, 129; *Vida/Pásztor 1996*, 344, 345). They also might have been attached to a sleeve or sewn on. It can of course not be excluded that they were not worn but simply laid into the grave.

The pellet bell from grave 25 Komárno IV, Váradiho ul. was found near the man's hips, but the burial was disturbed and the lower jaw of the horse lay on the chest of the man. The idiophone could belong to both man and horse. Since the pellet bell is made of metal sheet, the author is inclined to think that the bell belongs to the horse, because sheet pellet bells mainly derive from horse bridles. On the horse skeletons in graves 36, 79, 101, 121 and 149, Komárno IX, Lodenica, the pellet bells clearly lay in the area of the skull. They very probably adorned the browband or the bridgeband of the bridle (Fig. 13: 1), as is the case in grave 51 of Pitvaros (*Bende 1998*, 224, fig. 14), Radvaň nad Dunajom-Žitava I, graves 10 and 31 (*Budinský-Krička 1956*, 16–20, 31–35), Devínska Nová Ves, graves 79, 147, 401, 765, 796, 804 and 842 (*Eisner 1952*, 24, 47, 48, 91, 92, 161, 162, 168, 170, 181–183), as well as the Wien-Csokorgasse, grave 650 (*Streinz 1977*, 527, 528), and the Vösendorf, grave 715 (*Pomberger/Stadler 2018*, 127, 128). The four facial pellet bells from grave 107, Komárno IX, Lodenica, were located in the chest area of the horse. They may have been attached to the breast collar. The horse of the rider on jar 2 from the Nagyszentmiklós gold hoard, for example, is decorated with a breast-band and ornament (Fig. 13: 2; *Pomberger, in print*). One pellet bell each lay at the back of the horse's spine in grave 153 Komárno IX, Lodenica and in grave 24 Komárno VIII, Hadovská cesta. The pellet bells could have been attached to the back of the saddle (Fig. 13: 3) or to the crupper (Fig. 13: 4).

Since the facial pellet bells from grave 107, Komárno IX, Lodenica and grave 11, Komárno IV, Váradiho ul. are extremely similar and both individuals of male gender belonged to the elite, the question arises whether the boy from grave 11, dating to the Late Avar Period II, is a descendant of the man from grave 107, dating to the Late Avar Period I. A DNA analysis could answer this question. For who else would have a claim to such skilfully cast idiophones? Pellet bells with pronounced human facial features are actually a rarity. Besides the five pieces mentioned earlier, only four other pellet bells are known to the main author – from Szentes-Berekhát, grave 23 (*Meier-Arendt 1985*, 60, fig. 55), Rákóczifalva-Bagi-föld, site 8A, object 808/942, Keszthely-Városi temető (*Rácz 2012*, 427, fig. 13: 7, 9), Nové Zámky, grave 175 (*Čilinská 1966*, 37, pl. 36: 2).

The graves with pellet bells date to the periods Middle Avar II/Late Avar Period I until Late Avar Period III (*Zábojník 1995*, 299, 300; *2009*, 97). This result is in line with previous findings, where pellet bells are dated from the phase Middle Avar Period IIb onwards (*Pomberger/Stadler 2018*, 139).

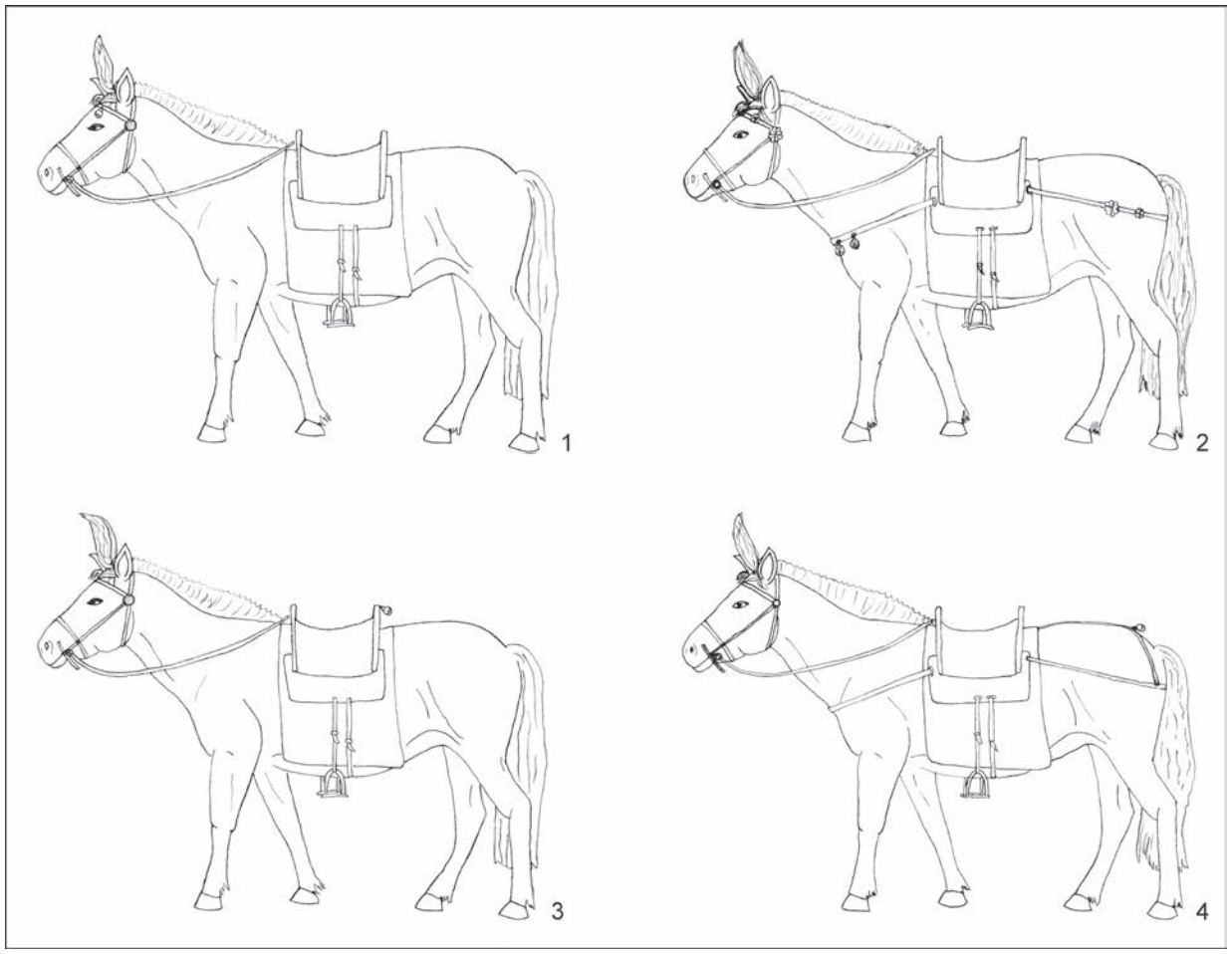

Fig. 13. Possibilities of fixing pellet bells on a horse's harness. 1 – browband; 2 – breast collar; 3 – saddle; 4 – crupper (drawn by B. M. Pomberger).

Distribution of pellet bells in the cemeteries in Komárno

The **Komárno IV, Váradiho ul.** cemetery consists of 28 graves – one child's grave, one boy's grave with a horse, one juvenile individual with a horse, four women's graves, four equestrian women with horses, eight horsemen's graves with horses, five adults of indeterminate sex with horses, three adults of indeterminate sex, and one burial with a child, woman, man and horse. Only the boy with a horse and a man with a horse had pellet bells in the grave, which belonged to the child and the man's horse respectively. Based on his grave equipment, the boy clearly belongs to the elite (*Borzová/Molnárová 2017*). The artistic design of the pellet bell with a face is another indication of the high social position. None of the women from this graveyard carried a pellet bell (Fig. 14: A).

The **Komárno VIII, Hadovská cesta** cemetery is composed of 25 graves, including one child's burial, one double burial of a child and adult, one triple burial with two children, one man together with a horse, three juveniles' burials, three women's graves, four horsewomen with a horse, five men's graves, six horsemen's graves and one undetermined double burial. None of the children's or women's graves contained pellet bells and none of the men carried a pellet bell. The only pellet bell belongs to the horse harness from equestrian grave 24 (Fig. 14: B).

In **Komárno IX, Lodenica** – 44 children's graves, one child's double burial, four children's graves with a horse, two children with a woman, 12 adolescents, 25 women's graves, 13 equestrian women with a horse, one grave with a woman, man and horse, one grave with a woman and man, five men's graves, 31 equestrian graves with a horse, seven individuals

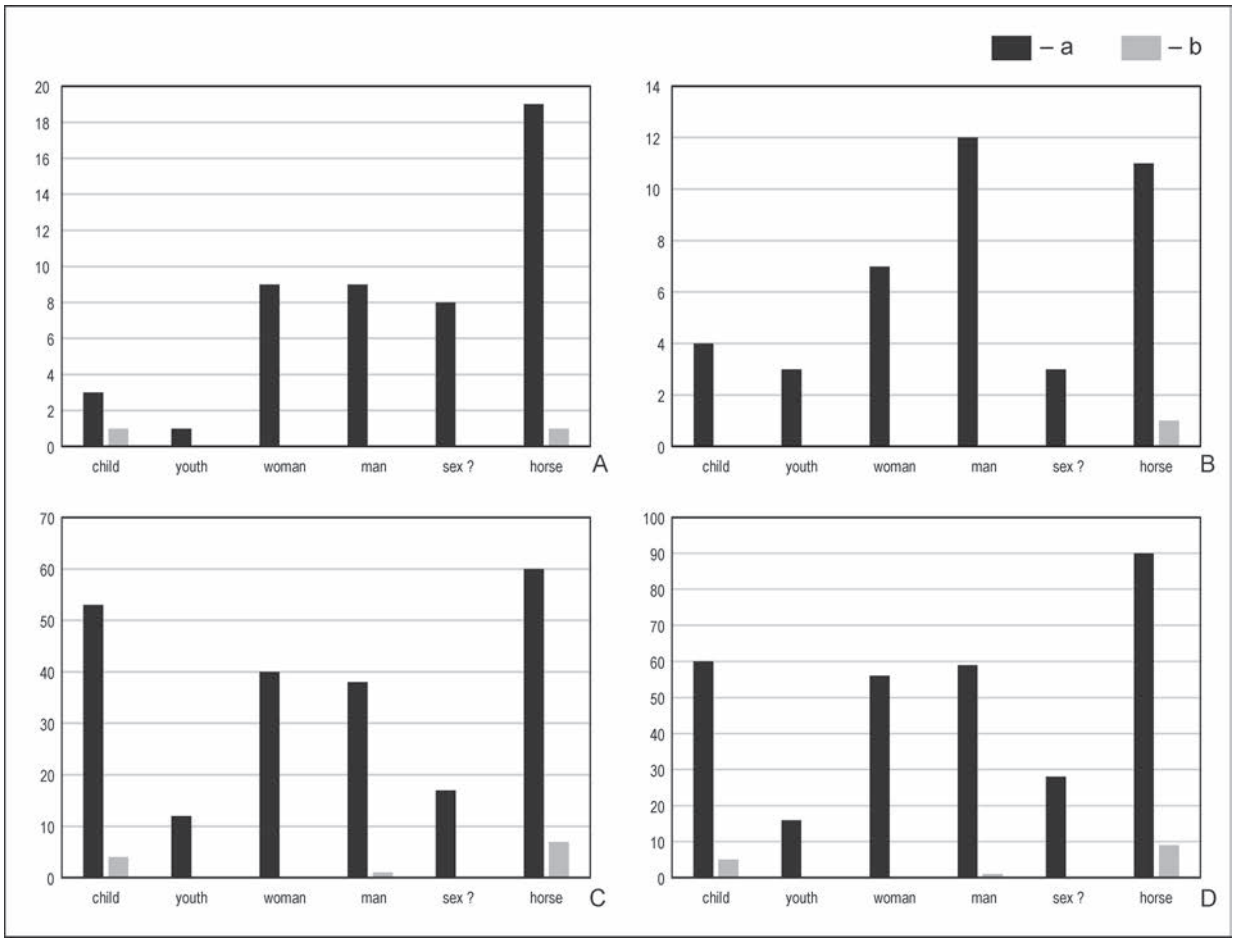

Fig. 14. Distribution of pellet bells in the cemeteries. A – Komárno IV, Váradiho ul.; B – Komárno VIII, Hadovská cesta; C – Komárno IX, Lodenica; D – distribution of pellet bells in all three cemeteries in Komárno. Legend: a – individuals; b – pellet bells (graphic by B. M. Pomberger).

of indeterminate sex and nine individuals of indeterminate sex with a horse were excavated. Pellet bells originate from only four children's graves and eight equestrian graves. In the equestrian graves, seven of these are associated with the horse and only once possibly with the rider. No young person, no woman, no man, no female rider had pellet bells. 48 children also did not have pellet bells (Fig. 14: C).

No other bell finds are known from the other six cemeteries of Komárno. Therefore, it can be concluded that metal rattles were actually only carried by very few children (boys?), hardly any adult men but some horses and were not very common among the Avar population of Komárno. Obviously, here pellet bells were reserved for boys, men and stallions. Girls, women and horsewomen were apparently left empty-handed (Fig. 14: D). In order to support this theory, the sex of all of the co-buried horses would have to be determined as well as – if possible – the sex of the children.

METAL ANALYSIS (X-RAY FLUORESCENCE)

Since we wanted to know which metals and alloys the pellet bells were made from, we subjected them to a non-destructive chemical analysis of their surface. These analyses were carried out by Ján Tirpák[2] with a handheld X-ray fluorescence spectrometer. A total of 22 pellet bells from Komárno and one pellet bell from Gajary, which is also kept in the museum, were examined. There are a total of eight pellet bells cast in bronze. They originate from the graves 107, 65, 86 and from Gajary. All the other idiophones were made of sheet metal. The seven pellet bells from graves 36, 79 and 121 were forged from sheet bronze. Traces of gilding were found on both pellet bells from grave 36 and one pellet bell from grave 79. The two pellet bells from grave 153 were forged from sheet copper, one of which was definitely gilded. Since both pieces decorated the

[2] Univerzita Konštantína Filozofa v Nitre, Fakulta prírodných vied, Gemologické laboratórium.

horse's bridle, it can be assumed that the second pellet bell was originally also gilded. The metal pellet bell from grave 101 is a rarity, because it was made of brass.

'… X-ray fluorescence analysis (ED-XRF) is a method of non-destructive detection of the chemical composition of objects. It is based on the measurement of X-rays aroused by irradiation of an object under investigation. ED-XRF is especially suitable for the analysis of macro elements, or even some trace elements. X-ray fluorescence spectrometry is a relative analytical method because the measured quantity must relate to the composition of the sample by calculations or by comparison with standards. The actual measurement is performed from the surface of the examined object, in which the concentration values (Wt% – weight percent) of individual elements are determined by a spectrometer. Object analyses were performed with a hand-held X-ray fluorescence spectrometer DELTA CLASSIC + from Olympus from the USA, which is intended for non-destructive quantitative analyses of archaeological objects, precious metals and precious metal alloys. The analyser determines the percentage of up to 29 elements (Au, Pd, Ag, Pt, Ir, Rh, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Zr, Nb without leaving traces, Mo, Hf, W, Re, Pb, Sn, Bi and Sb). DELTA CLASSIC + measures only the surface of the examined material and therefore does not guarantee the homogeneity of the chemical composition of the measured material in the whole volume. It provides only information on the composition of the surface layer of the object at the given examined place, while the depth of penetration of the X-ray beam is given by the chemical composition of the material. Therefore, it is very important to choose the place on the studied object where the spectral analysis will be performed. If the material is gold-plated or clad or otherwise surface-treated, possibly with corrosion, then the chemical composition does not correspond to the weight percentages in the whole volume, but to the weight percentages in the measured surface layer at a given measuring point. For objects that have a spherical, resp. the rounded shape can affect the positioning of objects, so it is important to choose the appropriate geometry of such samples. The results of the measurements are presented in the form of tables. Above them is the object, a link to the illustration and location, the grave number and the incremental number of the object. The table shows the name of the object and the average weight percentages of metals (Wt%) measured in the individual artefacts examined. Below the table follows a verbal description of the composition of the investigated alloy determined by ED-XRF analysis…' (*Tirpák, unpublished*). Let us turn to the individual results of the surface measurements. The pellet bell A-5314_a/grave 36 is made of bronze with 83.76% copper and 12.56% tin. Its patina contains metal oxides of iron, zinc, arsenic, silver and gold. Pellet bell A-5314_b is also made of bronze with 91.86% copper and 4.8% tin. The patina contains traces of zinc, arsenic, silver, lead and gold. Two other fragments of the pellet bell have copper contents of 71.22% and 76.92% and tin contents of 18.2% and 18.7%. Iron, zinc, arsenic, silver, lead and gold traces were discovered on their surfaces. Pellet bell A-5396 from grave 65 consists of a copper alloy with 1.62% tin. Its surface was found to contain 93.35% iron, with this corrosion surrounding the bronze body. This iron layer is attributed to iron deposits, e.g. bog iron ore, in the soil. Traces of manganese, arsenic and gold were found in the patina of the pellet bell. For pellet bell A-5397, 62.98% copper and 2.91% tin were discovered, but it too is covered by a corrosion layer of iron. Traces of manganese, zinc, lead and gold were found in its patina. Both pellet bells were gilded. Pellet bell A-5418 from grave 71 is made of copper sheet with a measured proportion of 97.81% copper. The patina contains oxides of tin, silver, zinc and lead. Both bell fragments A-5490_a–b from grave 79 consist of bronze sheet with 90.57% and 90.48% copper and 3.94% and 5.7% tin. Lead, tin, arsenic, silver and gold were also found. The cast pellet bell A-5638 from grave 86 is composed of an alloy of 72.18% copper, 18.1% tin and 7.45% lead. Its patina contains traces of nickel, zinc and arsenic. The corroded pellet bells from grave 91 with inventory numbers A-6052 and A-6053 consist of 96.37% and 92.44% iron respectively. Traces of copper, arsenic and tin are found on their surfaces. A-6053 is encircled by a band of bronze sheet, which may have been gilded. The sheet pellet bells A-5771_a–b, grave 121, have copper contents of 91.29% and 68.09% respectively, and tin contents of 3.92% and 23.16%. While only traces of zinc, silver and lead were discovered on pellet bell a, pellet bell b also contains iron, arsenic and

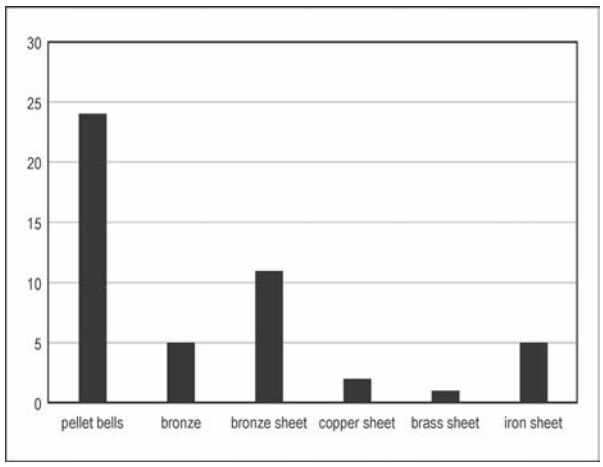

Fig. 15. Distribution of metal and alloys within the pellet bells (graphic by B. M. Pomberger).

Tab. 3. XRF-analyses (after *Tirpák, unpublished*) of pellet bells from Komárno IX, Lodenica cemetery (graphic by B. M. Pomberger).

Artefact	Inv. nr.	Grave	Fe	Cu	Zn	As	Ag	Sn	Au	Pb	Mn	Ni	Sb	Ge	Surface	Result
pellet bell	A-5396	65	93.35	4.22	–	0.2	–	1.63	0.35	–	0.26	–	–	–	–	bronze
pellet bell	A-5397	65	31.89	62.98	1.1	–	–	2.91	0.4	0.81	0.11	–	–	–	gilded	bronze
pellet bell	A-5638	86	–	72.18	0.67	1.44	–	18.1	–	7.45	–	0.16	–	–	–	bronze
pellet bell fragement 1	A-5314_1	36	0.48	83.76	0.87	1.6	0.98	12.56	0.29	–	–	–	–	–	gilded	bronze
pellet bell fragement 2	A-5314_2	36	–	91.85	1.48	0.45	0.61	4.8	0.36	0.45	–	–	–	–	gilded	bronze
pellet bell fragement 3	A-5314_3	36	1.56	71.22	1.1	1.63	0.81	18.2	1.2	4.55	–	–	–	–	–	bronze
pellet bell fragement 4 – rivet	A-5314_4	36	37	76.92	1.7	1.26	1.11	18.7	–	0.39	–	0.18	–	–	–	bronze
pellet bell	A-5418	71	–	97.81	0.71	–	0.57	0.64	–	0.27	–	–	–	–	–	copper
pellet bell fragment a	A-5490_a	79	–	90.57	0.94	–	1.24	3.94	–	3.31	–	–	–	–	–	bronze
pellet bell fragment b	A-5490_b	79	–	90.48	1.12	0.62	1.19	5.7	0.33	0.56	–	–	–	–	gilded	bronze
pellet bell	A-6052	91	96.37	2.8	–	0.26	–	0.57	–	–	–	–	–	–	–	iron
pellet bell	A-6053	91	92.44	5.33	–	–	–	2.23	–	–	–	–	–	–	–	iron
pellet bell – sleeve/belt	A-6053	91	–	75.46	–	0.85	1.5	21.2	0.23	0.64	–	–	0.75	–	gold plating?	bronze
pellet bell fragments	A-5859	101	0.45	90.51	4.47	0.82	–	1.95	–	1.8	–	–	–	–	–	brass
pellet bell	A-6070	110	96.99	2.85	–	0.16	–	–	–	–	–	–	–	–	–	iron
pellet bell	A-5813_a	107	–	90.69	2.59	–	–	4.67	–	2.5	–	–	–	–	–	bronze
pellet bell	A-5813_b	107	–	94.63	0.65	–	2.1	2.6	–	0.57	–	–	–	–	–	bronze
pellet bell	A-5813_c	107	–	92.95	0.58	–	–	4.12	–	2.35	–	–	–	–	–	bronze
pellet bell	A-5813_d	107	–	90.31	0.96	–	0.71	6.37	–	1.65	–	–	–	–	–	bronze
pellet bell fragment	A-5771_a	121	–	91.29	0.7	–	0.37	3.92	–	3.72	–	–	–	–	–	bronze
pellet bell fragment	A-5771_b	121	1.7	68.09	1.46	1.73	2.56	23.16	0.35	1.58	–	–	–	–	–	bronze
pellet bell	A-6103_a	149	94.34	4.54	–	0.21	–	0.91	–	–	–	–	–	–	–	iron
pellet bell	A-6103_b	149	95.38	3.98	–	0.24	–	0.4	–	–	–	–	–	–	–	iron
pellet bell guilded surface	A-6117	153	–	76.01	0.76	–	0.59	–	20.67	0.35	–	–	–	1.63	gilded	copper
pellet bell body	A-6117	153	–	98.75	0.64	0.37	–	–	–	0.24	–	–	–	–	–	copper

gold. Both pellet bells from grave 149, A-6103_a–b, have high proportions of iron – 94.34% and 95.38% respectively – and traces of copper, arsenic and tin in their patina. The gilded pellet bell from grave 153, A-6117, is made of copper sheet – 98.75% copper and very small amounts of zinc, arsenic and lead. Its surface is composed of 76.01% copper, 20.67% gold and portions of zinc, germanium, silver and lead. Furthermore, proportions of iron and zinc were found on its surface. The pellet bell A-5859 from grave 101 was forged from sheet brass containing 90.51% copper and 4.47% zinc. Iron, arsenic, tin and lead components were found on its patina. The iron pellet bell A-6070, grave 110, was found to contain 96.99% iron and traces of copper and arsenic. All four pellet bells from grave 107, A-5813_a–d, have between 90.69% and 94.63% copper and 2.06% to 6.37% tin. Small amounts of zinc, silver and lead were found on their surfaces (Fig. 15; Tab. 3).

'… Based on the results of spectral analysis, individual alloys of objects were identified: bronze and brass alloys, but also objects made of copper and iron. Measurements showed that the bronze objects contained, in addition to the main components (copper and tin), a mixture of lead and zinc. In addition to the main components (copper and zinc), brass objects also contained an admixture of tin and lead. The studied bronze and brass alloys are manifested by the dispersion of the content of zinc, lead and tin, so that they are sometimes difficult to clearly identify as bronze or brass. The presence of silver, arsenic and antimony is related to the fact that copper ores are polymetallic. Oxides of Cu, Pb, Sn, As, Zn, Ag, Ga and Fe often occurred in the patina of individual objects as a result of long-term storage of objects in the ground. When interpreting the results obtained by X-ray fluorescence analysis, it must be considered that they are the product of the current alloy analysis. They therefore provide only qualitative information on the composition of the metals from which the artefact was made and on its surface treatment. In the case of gilded objects, it is assumed that the technology of thermal gilding and plating has been used…' [3]

ACOUSTIC AND PSYCHOACOUSTIC ANALYSES

The 'colour of sound', commonly referred to as 'timbre', is mainly influenced by the temporal and spectral structure of a sound, which is also linked to the majority of subjective perception qualities, often described with contrasting adjective pairs such as bright/dark, full/empty, sharp/dull, simple/complex and many more (*von Bismarck 1974*, 149). The perception of these subjective verbal attributes is strongly linked to objective and thus measurable acoustic parameters like spectral envelope, energy density, impulsiveness and many more. The parameters or 'audio features' can be calculated from the sound pressure function, i.e. the digital audio recording (*Lartillot/Toiviainen/Eerola 2008*). Some of the verbal descriptions have been researched extensively and have been correlated to a variety of single audio features to find out which combination of features delivers the most solid prediction of subjective impressions. These are implemented as algorithms in audio software and form the corpus of objectified psychoacoustic models/parameters. Among the most common ones are loudness, sharpness, brightness, roughness and tonality (*Fastl/Zwicker 2007*). Along with the less complex parameters, like partial frequencies and amplitudes, noise, onsets and so on, large numbers of recorded sounds can easily be classified, categorised and compared to each other in order to find similarities and differences. Generally, psychoacoustics as a discipline within psychophysiology seeks to explore and understand the connection between human audio perception and cognition and the physical properties of sound signals. Of particular interest in connection with archaeological finds is the 'sensory euphony' that can be derived from some of the parameters described below (*Aures 1984*, 735).

Loudness is the subjective sensation of the intensity of sound, not to be mistaken with the (sound pressure) level, which is an objective measurement. It is related to level, but since the human ear is much more sensitive to mid frequencies, especially between 2–5 kHz, sounds in or near this frequency range can be perceived higher in loudness even if they are lower in level compared to e.g. a 100 Hz signal. Loudness level comparisons were introduced by Heinrich Barkhausen in the 1920s (*Fastl/Zwicker 2007*, 203) using the 'phon' scale. 0 phon represents the human hearing threshold, 1 phon is the just noticeable difference. In 1957 Eberhart Zwicker introduced the 'sone' for measuring loudness (*Völz 1999*, 51). Loudness is defined as 40 dB sound pressure level at 1 kHz equals 40 phon or 1 sone. The phon scale steps of 10 phon represent the doubling of the loudness, whereby the sone scale works with doubling the value itself for doubling loudness. Subjective ratings of loudness might differ slightly from calculated values, however, it is safe to say that sounds with higher loudness can be perceived better or over greater distances. The

[3] From J. Tirpáks report on the results of his metal analyses. The pieces date to the 20th c. AD and originate from Egypt, Nubia and Sudan. Among them is a crucifix decorated with bells (*Tirpák, unpublished*).

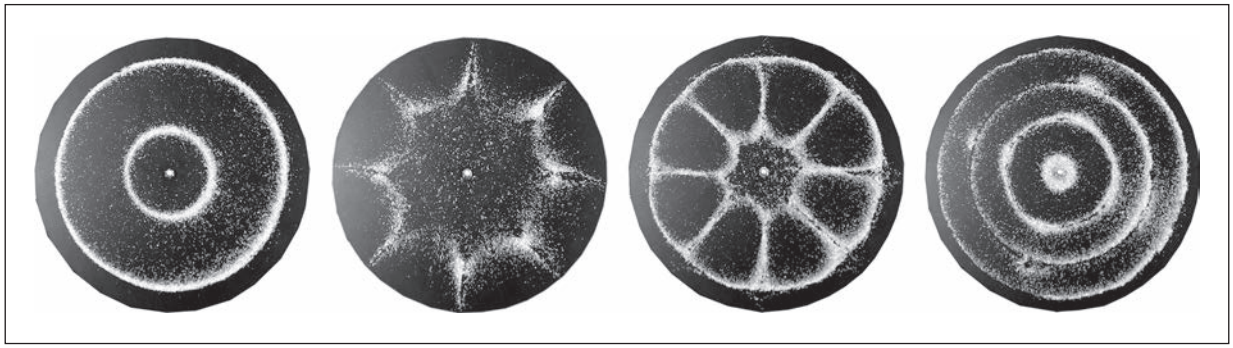

Fig. 16. Different modes created with sand on a round plate by a frequency generator (photo by J. Mühlhans).

measurements carried out in this analysis show the loudness and levels for a distance of roughly 5–10 cm to the source. Sound pressure levels are decrease by 6 dB when the distance to the source is doubled (*Attenborough 2014*, 119).

Brightness is calculated with the spectral centroid (SC), which in simple words is the frequency where the spectral energy of higher and lower frequencies is equal. The parameter does not give any information about the spectral shape but still it is highly correlated with the subjective impression of brightness (*Schubert/Wolfe/Tarnopolsky 2004*, 656). Values are given in Hz, the higher the value, the brighter the sound is perceived.

Sharpness is connected to spectral density and envelope and strongly represents the subjective impression of pleasantness. The frequency range in which the human ear is particularly sensitive (2–5 kHz) plays an essential role. Sharpness is measured in 'acum' and defined as a 1 kHz critical band wide noise of 60 dB being 1 acum (*Fastl/Zwicker 2007*, 241). Higher values indicate higher sharpness, thus higher unpleasantness. The scale is linear.

Roughness in contrast to sharpness, is only influenced by temporal fluctuations i.e. amplitude modulations, but also adds to the impression of pleasantness. Slow amplitude modulations (< 15 Hz) create a beat frequency, higher frequency modulations create the impression of roughness, reaching its maximum at 70 Hz and disappearing at > 150 Hz. Especially in idiophones, two partials in the spectrum can be quite near to each other and create this effect. It is measured in 'asper' being a value between 1 and 0, with a 1 kHz frequency amplitude modulated at 70 Hz being the highest possible roughness (*Fastl/Zwicker 2007*, 257). As with sharpness, higher values lead to a higher impression of unpleasantness.

Tonality in psychoacoustics is still being improved as a model predictor (*Becker/Sottek/Lobato 2019*, 5820) and is represented by the tone-to-noise ratio (TNR) and some other parameters. Since the pellet bells, especially if corroded, are rather noisy compared to larger bells, this parameter is quite interesting to understand the tonal quality of a sound object. The TNR is a simple ratio measured in dB, which means 0 shows an equal distribution of tonal and noise components and positive numbers stand for a higher tonal amount. For the acoustic analysis Adobe Audition CC2018 and for psychoacoustic analysis HEADAcoustics ArtemiSuite 9.3 is used.

PHYSICS OF IDIOPHONE SOUNDS

Sounds from any object are physically spoken complex sounds, which means they consist partly of a number of frequencies, called 'partials' or 'partial frequencies' and partly of noise. The most prominent characteristic of aerophones (wind instruments) and chordophones (string instruments) is overtones being integer multiples of one discrete fundamental frequency. This is not the case for idiophones, where the sound consists of more complex combinations of so called 'modes'. Fig. 16 shows simple modes on a 2-dimensional circular plate, for 3-dimensional objects the modes increase in complexity.

Making use of the 'Fast Fourier Transformation' (FFT), one of the simplest analyses in acoustics, it is possible to visualise all partial frequencies and noise of a sound with their amplitudes in one graph called the (audio) spectrum. The shape of the object, material, wall thickness and so on determine which partial frequencies are formed and how strong they are.

But we have to consider another important factor – aging and especially corrosion might slightly alter all of the parameters described, which has to be taken into consideration when measuring the objects acoustically today.

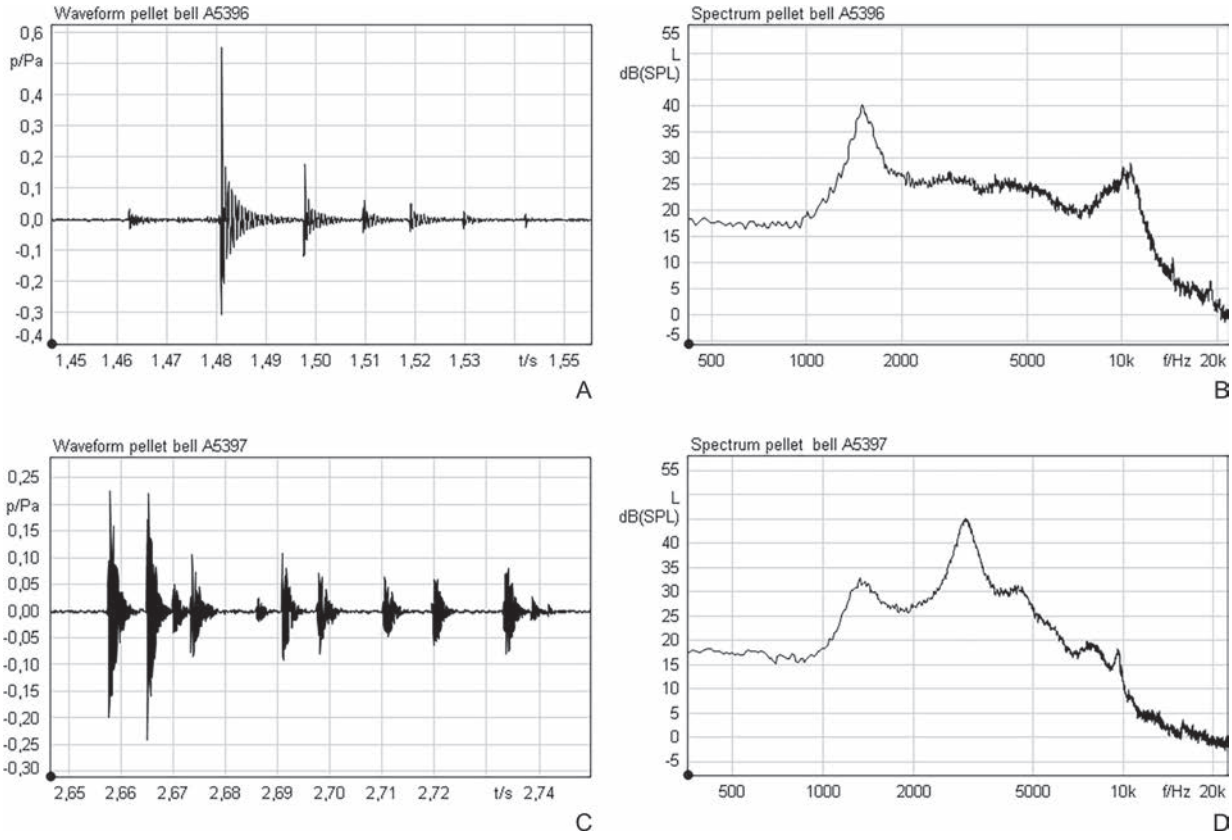

Fig. 17. Komárno IX Lodenica. Waveform and spectrum of the pellet bells from grave 65 – A-5396, A-5397 (graphic by J. Mühlhans).

PITCH PERCEPTION

While pitch perception in aerophones and chordophones is strongly related to the fundamental frequency, this is also not the case for idiophones, since there is no discrete or single fundamental frequency. Not as clearly but still, idiophones evoke pitch perception when played. In some cases, the perceived pitch is also physically present in the spectrum, in other cases, when the pitch frequency is not physically present, it is referred to as 'virtual pitch' or 'harmonic residue'. The phenomenon of the residue or virtual pitch perception, which is created in the brain, has a long history. As early as the 1830s, August Seebeck asserted that the fundamental frequency is not solely involved in pitch perception (*Seebeck 1841*), but also all other parts of the Fourier series. This series, named after its inventor Joseph Fourier, was well known in the early 19th century and is the basis of harmonic analysis up to this day (*Barkowsky 1996*). Almost a century later, Seebeck's assumption was experimentally shown by Jan Frederick Schouten and the 'hypothesis of the residue' was formed (*Schouten 1940*). Some decades later the phenomenon was studied further by Terhardt, Stoll and Seewann and given the name 'virtual-pitch theory' (*Terhardt/Stoll/Seewann 1982*). In further discussion the term residue will be used. Pitch perception is a broad spectrum, it can be weak or strong and, since humans have the ability to focus on certain frequency areas or partials, the perception between subjects might differ greatly. Compared to large bells, pitch perception for pellet bells is generally rather low.

Bronze pellet bells A-5396 and A-5397 from grave 65

The two objects show great similarities in temporal structure. Depending on how the pellet bells are shaken, the pellet bounces against the inner wall creating short impulses in intervals of 5–20 milliseconds (Fig. 17: A, C). No strong partials can be seen, however, the spectral energy created by the periodicity of the impulses is similar to a third octave band filtered noise, creating a rather weak pitch perception. With a centre frequency of roughly 1.5 kHz for pellet bell A-5396 and 3 kHz for pellet bell A-5397, the impression of an octave between

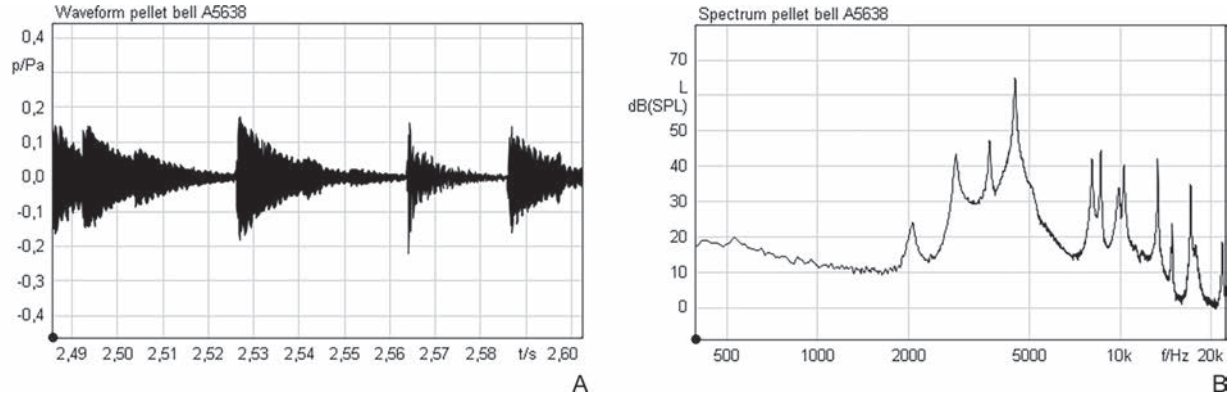

Fig. 18. Komárno IX, Lodenica. Waveform and spectrum of the pellet bell from grave 86 – A-5638 (graphic by J. Mühlhans).

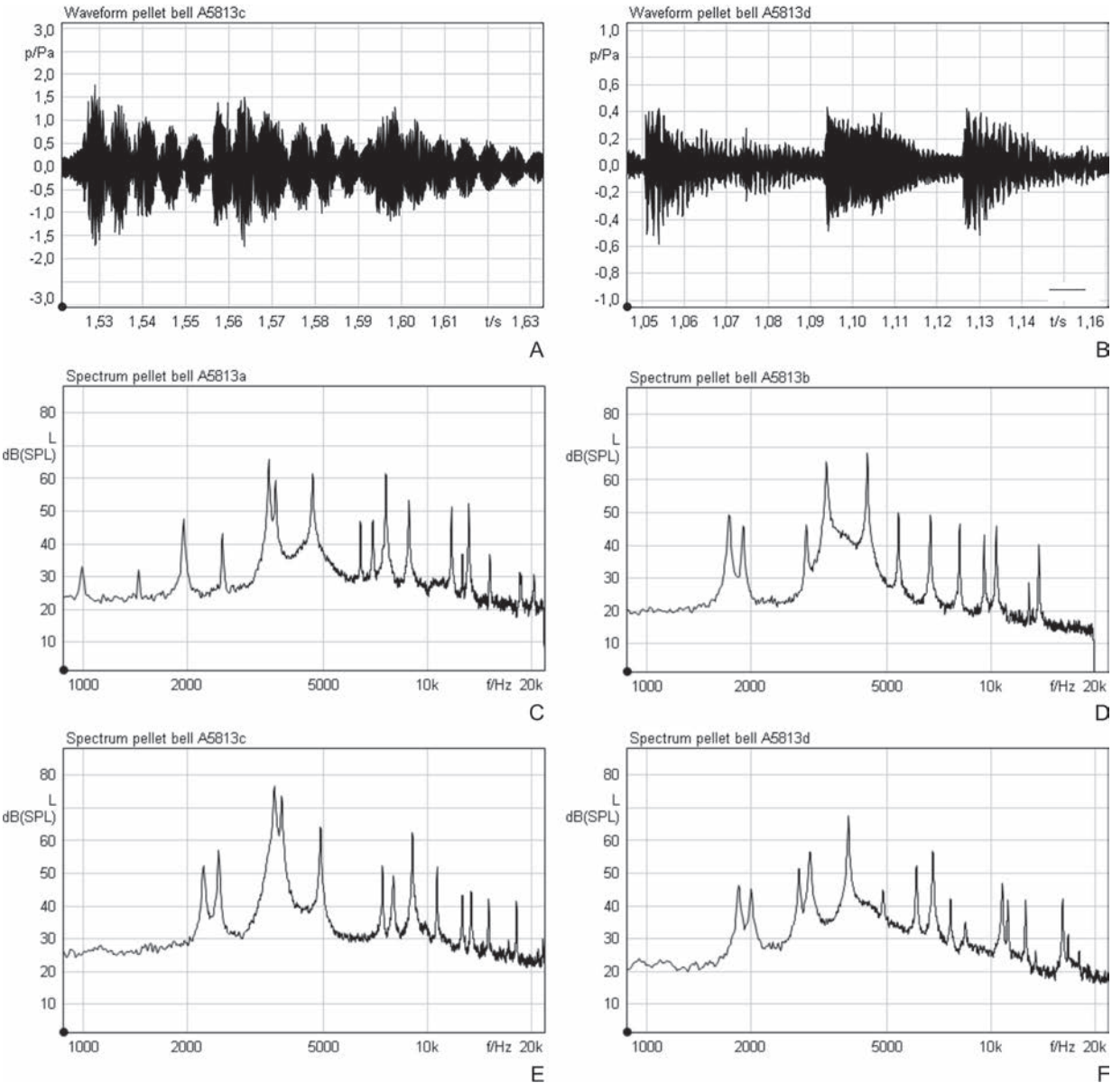

Fig. 19. Komárno IX, Lodenica. Waveform and spectrum of the pellet bells from grave 107–A-5813_a–5813_d (graphic by J. Mühlhans).

Tab. 4. Results of psychoacoustic analyses of the pellet bells from Komárno IX, Lodenica (graphic by J. Mühlhans).

	FFT (average)	Loudness vs. time	Loudness vs. time	Specific loudness	Impulsiveness (hearing model) vs. time	Roughness (hearing model) vs. time	Sharpness vs. time	Specific roughness (hearing model)	Specific tonality (Hearing Model)	Tonality DIN45681	Tonality DIN45681	Tonality DIN45681	Brightness (praat)
	L	N5	N5	N	I	R	S	R	Tonality HMS [0,304–3 s]	TNR	TNR	penalty	Hz (SC)
	dB (SPL)	soneGF	phonGF	soneGF	iu	asper	acum	asper	thHMS	dB	Hz	dB	
A-5396 (0,00–3,00 s)	54.47	7.11	68.3	7.94	2.68	0.126	2.76	0.162	0.122	n/a	n/a	0	4591
A-5397 (0,00–3,00 s)	59.68	9.23	72.1	9.9	3.34	0.232	2.78	0.256	0.175	n/a	n/a	0	3146
A-5683 (0,00–3,00 s)	70.96	15.7	79.7	15.1	2.97	0.0811	4.28	0.114	1.82	18.72	17038	6	4600
A-5813_a (0,00–3,00 s)	72.86	24.3	86	20.9	1.68	0.0483	4.74	0.0786	2.3	17.73	3445	6	5234
A-5813_b (0,00–3,00 s)	73.89	23.4	85.5	20.9	1.69	0.0514	4.28	0.0792	2.35	18.4	4355	6	3996
A-5813_c (0,00–3,00 s)	83.47	44.8	94.9	37.6	1.87	0.0739	6.3	0.109	3.18	16.85	3575	6	3854
A-5813_d (0,00–3,00 s)	72.68	23.5	85.5	21.4	1.79	0.0537	4.83	0.0843	2.43	14.41	3833	6	4471

the two can be heard. Aside from that, the spectral range of pellet bell A-5396 is a bit larger (about 1–12 kHz) with a peak at the low end rendering the sound more 'hollow'. The slightly narrower spectrum of pellet bell A-5397 (about 1.2–10 kHz) with a peak in the middle makes it sound 'dense'. With a spectral centroid of 4.6 kHz, bell A-5396 sounds brighter than A-5397 with 3.15 kHz (Fig. 17: B, D).

With a sound pressure level of 55–60 dB and a loudness of 7–9 sone, the objects are quite similar and the most silent ones. Given the low level, the two bells can only be heard over small distances, probably a radius of 1–5 metres, depending on the present background noise, which can easily mask sounds like this. The lack of partials makes the sound a little rougher than the other objects, but the range of 0.1–0.2 asper is generally not considered as rough. The sharpness is also quite low at 2.7 acum. The tonality is so low that it can't even be detected.

Bronze pellet bell A-5638 from grave 86

This pellet bell differs greatly from the two described above. Strong and clear partials can be found in the spectrum ranging from 2 kHz up to 20 kHz with a peak frequency at 4.5 kHz. Comparing the waveform also shows major differences – not only are the time intervals between the single impulses larger, the amplitude is also higher and a little decay time can be observed, which means the pellet bell rings for a very short amount of time (~ 50 ms). Also, the waveform shows an amplitude modulation of about 80 Hz, though not pronounced enough to evoke a sensation of roughness (Fig. 18).

With a level of 70 dB and a loudness of 16 sone, the bell is about twice as loud as the ones before, thus it can be heard over greater distances, depending on the background, probably in a radius of up to 10 or 12 metres. The peak frequency being in the most sensitive hearing range of the human ear also boosts audibility and adds to the sharpness of 4.3 acum. The timbre is quite different from pellet bell A-5396, but with a spectral centroid of also 4.6 kHz the brightness is about the same. The tonality (TNR) of 18 dB clearly shows more tonal components than noise. Looking at the spectral distribution of tonal components, a stronger signal effect can also be assumed here.

Bronze pellet bells A-5813_a–d from grave 107

The four pellet bells from grave 107 show great similarities to A-5638 and also to each other. The waveform of pellet bell c shows an even more pronounced amplitude modulation (Fig. 19: A) and

Tab. 5. Results of the frequency analyses of the pellet bells from Komárno IX, Lodenica (graphic by B. M. Pomberger).

Inv. nr.	Grave	Partial 1	Partial 2	Partial 3	Partial 4	Partial 5	Partial 6	Partial 7
A-5396	65	1464 Hz	2283 Hz	3187 Hz	3962 Hz	4780 Hz	8699 Hz	–
A-5397	65	1291 Hz	2929 Hz	3101 Hz	4134 Hz	4436 Hz	4737 Hz	9690 Hz
A-5683	86	2842 Hz	3661 Hz	4552 Hz	8096 Hz	8570 Hz	9862 Hz	10250 Hz
A-5813_a	107	1738 Hz	2885 Hz	3310 Hz	4355 Hz	5361 Hz	6637 Hz	8069 Hz
A-5813_b	107	1894 Hz	3456 Hz	3612 Hz	4621 Hz	7595 Hz	–	–
A-5813_c	107	2444 Hz	2465 Hz	3567 Hz	3762 HZ	4877 Hz	9001 Hz	–
A-5813_d	107	1808 Hz	1852 Hz	2777 Hz	3003 Hz	3835 Hz	6050 Hz	6766 Hz

10–12 dB higher amplitudes than bells a, b and d (Fig. 19: B). Short decay times of up to 100 ms can be observed in all of them, making the ringing effect a little more noticeable. They show clear partials in a range between 1 and 20 kHz with peak frequencies around 3.5 kHz (Fig. 19: C–F).

With level around 72 dB and 24 sone on average, bells a, b and d are even a bit louder than the one bell from grave 86. Bell c stands out – with a level 84 dB and 45 sone it is about twice as loud as the other 3. The peak frequencies and stronger tonality (14–18 dB) also lead to higher values in sharpness (4–6 acum), but the roughness (< 0.1 asper) is hardly worth mentioning. Given the slightly higher level, the bells could have been heard over even greater distances, probably up to 20 or 25 metres (Tab. 4).

Moreover, the pitch perception for the bells is interesting. Ten people, mostly musically trained, rated the pitch of the four bells from lowest to highest. In six cases, the ranking was b–d–a–c, four perceived the pitch differently. This shows that pitch perception for small idiophones is not uniform. In brightness (SC) they range from 3.8–5.2 kHz (Tab. 5).

The iron pellet bell A-6070 from grave 110 is one of the very few still functioning iron rattles from the Avar period in which the rattle body is present. Unfortunately, a useful recording for analysis could not be made. A video with the recorded original sounds of the pellet bells was created and loaded up on the internet platform Youtube: 'Pellet Bells from the Avar Period in Komárno'.[4]

AVAR DRESS AND TEXTILES

Textiles found in the area of the Avar Khaganate are usually quite uniform, made of wool and flax, mostly tabby. They are of a quite standardised quality. The fabrics found in Avar graves in, for example, Austria and Hungary also show a very simple range (*Grömer 2010*, 18, 19) – plain tabby dominates, while basket weave and rep are rarely found. Only two of over 120 analysed Avar textiles from Austria e.g. Sommerein, Leobersdorf, Frohsdorf and Zwölfaxing (*Grömer/Müller 2008; Hundt 1984*; *1987*) had been made in twill. The textiles consist of 0.2–0.4 mm (sometimes 0.5 mm) thick yarns, spun in z-twist. Some of the textiles are somewhat denser than the others. This can be seen by a thread count of 20 threads per cm. More open weaves have a thread count of 12 threads per cm, which makes them more elastic. In most cases, fibre analysis was not possible due to the

[4] https://youtu.be/CWybzBXZx4U [11. 1. 2021]

adhering consolidation products. There are rare cases of an identification of wool and plant fibre. Textiles of a similar appearance have been found in graves from the Roman Period Danube Provinces, 4th and 5th c. AD (*Grömer 2014*). However, these Avar textiles differ markedly from the Alamannic and Bayuvarian textiles, 5th to 8th c. AD (e.g. *Bender Jørgensen 1992*, 68–72, 110–113; *Brahter/Krausse 2013*; *Rast-Eicher 2002*), which more frequently feature twill fabrics in different elaborate variants, such as *Rippenköper* or *Kreuzköper*.

AVAR CLOTHING

It is not possible to speak of a single specific Avar costume, particularly since many different cultural influences play a role and are made visible in Avar fashion, which include those of Late Antique, Byzantine, Francian (*Vida 2018*, 421–424), Lombard, Gepid (*Garam 2011*, 73) and Eastern Steppe (*Vida 2018*, 428) origin, though it is important to emphasise that e.g. Byzantine objects are often imports and thus do not necessarily coincide with the bearer's ethnicity (*Stadler 2005*, 132). In the Late Avar Period, the culture seems to somewhat unify (*Stadler 2005*, 133). There is a mention of Avar clothing in written sources. In Maurikios' (582–602 AD) *Strategikon*, it is described how a Byzantine cavalryman should wear wide and fitting clothing, as that of the Avars, which are tunics, made from linen, goat's hide or rough fabric that covers the leg when sitting on the horse (*Dennis/Gamillscheg 1981*, 81). One could also think of a *Klappenrock*, a kind of wrap-over coat, which might be depicted on a presumably Avar antler tool found in Nosa, Serbia, possibly dating to the 6th to 7th century. The carvings depict two horses and three people with long braided hair, long coats and a belt (*Bugarski 2016*, 86–90). From written sources, there is also some information regarding the Avar hairstyle. For example, the 9th century Byzantine chronicler Theophanes describes their hair as long and braided with ribbons, though this is contradictory to other sources (*Stadler 2005*, 87). Clasps behind the skull have been associated with these braids, one of which was found in Komárno IX, Lodenica in grave 114 (*Trugly 1993*, 226), but hairstyles were probably diverse. Archaeological finds from Avar burials can also give us some hints on the clothing that was worn, though the textiles are rarely preserved. Information on clothing is mostly given by metal components, such as buckles, strap ends, etc., on which textile fragments can sometimes be preserved in mineralised form. For men, it was typical to be buried with a knife in the belt area (*Distelberger 2004*, 28), which was also the case for children, for example grave 65 (undefined gender) has a knife in the hip area (*Trugly 1987*, 263). Though it cannot be excluded that the knives were not worn but rather laid on the body during the burial. The double belts are a characteristic of Avar men's clothing. Based on them, the clothing has been suggested to be comprised of a belted undergarment, perhaps trousers, and an overgarment, which is held together by a very decorative belt (*Distelberger 2004*, 29). Belts with such fittings in older children's or juvenile's graves in Komárno could be connected to a higher social standing (*Trugly 1993*, 218). The overgarment could very well be the mentioned *Klappenrock*, that was tailored wider towards the seam, which is especially necessary when mounted. Avar women usually had only one buckle, which has been interpreted as a belt for the undergarments, since it was not excessively decorated, whereas no belt was used for the overgarments (*Distelberger 2004*, 29). However, it could be considered that this belt was used to secure trousers, as has been suggested for the simpler of the two men's belts. Unfortunately, there is no undoubtable proof of women riding horses, but if we assume that they did, considering 23.8% of horse graves in Komárno IX, Lodenica contained women (*Trugly 1993*, 218), trousers would most definitely be more advantageous than only a dress. In Komárno IX, Lodenica (*Trugly 1987, 1993*), as is typical for the later Avar period (*Distelberger 2004*, 39), no buckles were found on women. This might be due to the costumes changing as a whole, e.g. the loss of trousers, though this would not conform with the assumption of the mentioned horsewomen of Komárno. But trousers could also be secured simply with a cord, so this would not be a contradiction. Perhaps belts were still worn but just fastened with a knot (*Distelberger 2004*, 39). The type of overgarment can only be speculated. It could have been a tunic or a dress. For riding, the garment, depending on the length, would have had to have a slit or been wide and/or short enough to be worn when mounted. A pair of clasps (in german *Agraffen*) was found in the grave of woman rider 81 of Komárno IX, Lodenica (*Trugly 1987*, 270), but not in its original position. These clasps are found only in some female burials, mostly dating to the late 7th to early 8th century. They are usually found on the left shoulder and could have fastened a cloak or perhaps a kaftan (*Kürti/Wicker 1991*, 21). Among the textile finds of Komárno IX, Lodenica, linen proved to be the only definable material (*Dolejšová 1987*, 385). These fragments, however, do not necessarily derive from clothing – they could also stem from some kind of burial cloth. One must note that

these graves' contents were quite scattered, so an interpretation of the clothing is difficult (*Dolejšová 1987*, 389). Tabby weaves are generally the most common Avar textiles, though in grave 9 (young individual), a sprang textile was discovered on the horse's harness (*Dolejšová 1987*, 386). Textiles, that have better chances of giving us information on the clothing, are to be found on the belt parts. For example, on the iron buckle from grave 72 there were two different fabrics – a tightly woven tabby, that was mostly on the upper surface of the buckle, and a loosely woven tabby, which lay on top of the other fabric (*Dolejšová 1987*, 387). It could be suggested that the tightly woven fabric was part of the man's clothing, perhaps an overgarment. The loosely woven fabric seems impractical as clothing – perhaps it was a burial shroud. Two more tabby woven possible clothing fragments were also found in grave 87 on bronze belt fittings. Maurikios writes of the Avars being practically fused together with their horses, because they live on them and rarely walk on foot (*Dennis/Gamillscheg 1981*, 365). Due to the fact of horses playing an important role in culture and the clothing being adapted to riding, we can assume that children were well familiar with riding from an early age and that their clothing also reflected this. In Komárno IX, Lodenica graves 9, 64, 109, 118, 119 and 132, young individuals were also buried with horses and their tack (*Trugly 1993*), which suggests that they were their mounts. In Komárno IX, Lodenica, pearl necklaces were generally the most common accessory among children. Pellet bells were also found in children's burials, apart from those of horsemen (*Trugly 1987*; *1993*), probably attached to the horses' harnesses (*Trugly 1987*, 287). Textiles finds might suggest that the children's pellet bells could have been put in a pouch (*Pomberger/Stadler 2018*, 126).

PELLET BELLS AS AMULETS?

Pellet bells and bells may serve as jewellery, protection and as amulets especially for small children (*Wolf 2015*, 74). But, since the silent pellet bells could only be heard over small distances, we may exclude their function as protection against wild animals. Yet we cannot exclude the possibility that louder pellet bells enabled parents to control where their children were at any given time. We believe much more that the idiophones mainly functioned as amulets. Amulets are small objects filled with power, which, according to popular belief, are supposed to protect the wearer from harm. They are worn directly on the body and clothing, hung in dwellings, stables and means of transport, and draped around animals. The 'effect' of the amulet is based on the animistic idea that magical powers affect humans and animals. The amulet is supposed to counteract these invisible forces. '*... Amulets have a suggestive effect, inducing in their wearer the belief that he is immune to harm...*' (*Roberts 1993*, 50). Another explanation is given in the *Handwörterbuch des deutschen Aberglaubens*: '*... since the essential of an amulet is the power dwelling in it, anything can serve as an amulet, which, according to the belief of the wearer, has such power inherent in it...*' (*Bächtold-Stäubli/Hoffmann-Krayer 1987a*, 380), hence also amulets made of metal. For example, objects made of iron and steel are said to be predestined weapons of defence and protection against demons and their negative influences. One of the most plausible reasons may be that bright, sharp weapons were made of metal and therefore the sound of metallic idiophones also might serve as weapons against evil powers (*Bächtold-Stäubli/Hoffmann-Krayer 1987b*, 207–210; *1987c*, 718). But we also have to bear in mind that we do not know whether the Avars believed in this.

A look into the distant past shows that the custom of 'protecting' small children with bells can already be attested in ancient Greece, Rome and Egypt (*Eckardt/Williams 2018*; *Hickmann 1956*; *Ruprechtsberger 1996*; *Ubl 1997*, 300; *Villing 2002*). Bells have also been discovered in graves of warrior women of the 2nd–4th century AD in Azerbaijan (*Ateshi Gadirova 2014*, 251). Slotted bobbles and pellet bells already adorned the costume of rich women during the Early Iron Age Hallstatt culture (*Pomberger et al. 2020*). Clay rattles were buried with the deceased as early as the Early to Middle Bronze Age, namely in the Transdanubian Incrusted Pottery (North Pannonian culture; *Pomberger 2016*, 92–96, 243, 244). This burial custom is also documented in the Late Bronze Age (Urnfield culture and Lusatian culture) and the Early Iron Age (Hallstatt culture; *Pomberger 2016*, 100–141, 247–249, 253–257).

A certain belief in the 'protective power' of metal idiophones extends into more recent times. In 1659 AD, Diego Velásquez painted the little Spanish infant Philip Prosper – the boy is wearing a long girl's dress. Amulets made of coral and a little bell hang from his belt to protect the sickly child. The painting is in the Kunsthistorisches Museum Wien (*Wolf 2015*, 73, 74). The Peter W. Schienerl Collection in the Ethnological Museum Dresden contains numerous amulets made of metal with small bells attached. The pieces date to the 20th century AD and

[5] https://skd-online-collection.skd.museum/Home/Index?page=1&pId=12818534 [7. 1. 2021]

originate from Egypt, Nubia and Sudan. Among them is a crucifix decorated with bells.[5] Let us have a look at Bali, where parents celebrate the Nyambutin ceremony with their 3-month-old babies. The baby gets a necklace and a bracelet and, if the child is a girl, also earrings (*Dewi/Suyasa 2019*). Small pellet bells may decorate the bracelet.[6] The design of the bracelet seems to be a matter of prestige. Apart from their amulet nature, bells and pellet bells are excellent simple musical toys for children (*Deutsch/Walcher 2004*, 129, 130). Thus, the percussive principle in human behaviour can be observed in young children: '*... the manual production of sounds, e.g. by the repeated striking together of objects producing sounds and noises, enables elementary musical experiences...*' (*Stadler Elmer 1997*, 36, 37).

Pellet bells on a horse's harness can function as amulets but also as sounding jewellery. The Assyrians already decorated their horses with bells (*Kramer 2015*, 57). Many a horse in the Hallstatt culture wore pellet bells around its neck (*Pomberger 2016*, 130) and among the Romans there are also isolated references to idiophones as components of the bridle (*Kronberger 2012*, 43).

In the book *Von Zeumen*: gründtlicher Bericht des Zeumens und ordentliche Auszteilung der Mündtstück und Stangen, wie dieselbenn nach eines jedes Pferdts arth und eigenschafft sollenn gebräuchtt werden, first published in 1588 AD, the following is written: '*… Wann die Schellen auff Leder / Adlaß oder Carteken gehefft sein / klingen sie besser / als auff Sammet oder Gewandt / denn dasselbe benimpt ihnen den resonantz...*' – '*... When the bells are attached to leather / atlas or carteken / they sound better / than on velvet or garment / for the latter takes away their resonance...*' (*Deutsch/Walcher 2004*, 124).

The small tin bells on the Avar bridle are probably to be interpreted more as ornaments and decoration than as 'protection' from wild animals due to their quiet sound volume. The louder bronze pellet bells with ranges of 20 to 25 metres might warn wild animals. Nowadays, some 'bear bells' are advertised on the internet to hikers in the forests of Canada, Romania and Slovakia. They are supposed to be attached to the backpack as protection against wild animals, such as bears and wild boars, to warn the animals by ringing and to prevent unpleasant encounters.[7]

CONCLUSION

Pellet bells were found in three Avar cemeteries in Komárno. They stem from the graves of Komárno IX, Lodenica – 36, 65, 71, 79, 86, 91, 101, 107, 110, 121, 149 and 153. From Komárno VIII, Hadovská cesta we know of grave 24 and from Komárno IV, Varádiho ul. there are graves 11 and 25. In total we have 15 graves, among them five children's burials and ten horseman burials with horses and a total of 24 pellet bells. If we add up the number of graves from all three necropolises and compare it with the number of graves with bells, we see that the graves with bell finds are in the minority at 206 : 15. Therefore it can be said that only a small minority of the Avar population used pellet bells. Among the owners are children – whether boys or girls is mostly uncertain – and men, but no women. The owners' ages range from infans II onwards till senilis. It is also interesting that the few zoologically determined horse skeletons are from stallions. Pellet bells appeared from the Middle Avar Period II onwards. In the children's burials the idiophones lay near the hands, the hips and the upper thighs. They could therefore have been attached to ribbons, chains on belts, sewn onto the sleeve or carried in small bags or belt pouches. Avars did not have one single specific costume, which is especially important to note due to the since many different cultural influences. With horses being a large part of the culture, one can assume that the Avar clothing was adapted to be suitable for riding. This could likely already have been reflected in children's clothing. Tunics might have been sewn from linen, wool or hide, a *Klappenrock* and trousers seem to have be the main clothes of the Avars. The bells in equestrian graves were located in the areas of the skull, chest, and spine of the horses. They could therefore have been attached to the browband, the breast collar, the crupper or the saddle. All pellet bells are rather small. Their sizes range from 25 mm to 50 mm and their diameters lie between 20 mm to 40 mm. Their conserved weights range between 5 g and 33 g. In some pellet bells, the rattle bodies made of bronze or pebbles have been preserved. The surfaces of the idiophones are smooth or decorated with grooves and faces. The shapes of the metallic rattles can be classified to the basic shapes I, II and VII. They show simple or cruciform sound

[6] https://www.balilostadventure.com/3-months-balinese-baby-ceremony/ [15. 1. 2021]

[7] https://selbstverteidigung-beherrschen.de/barenglocke/ [11. 1. 2021]
Bears learn very quickly. Once they have experienced that pasture animals – usually wearing bells around their necks – are easy prey, the bears' table seems to be amply set.
https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/HG_Verhalten_im_Baerengebiet_05_06.pdf [11. 1. 2021]
wwf.at_info_verhalten-im-baerengebiet_2018_cpi-1.pdf [11. 1. 2021]
But the German and Austrian WWF therefore explicitly warn hikers: *'... Tying bells to the walking stick or ankle is not advisable in the Alps, as the bear might associate this with livestock and thus potential food...'*

slots, with or without sound holes and some have neither sound slots nor sound holes. Textile remains adhere to the pellet bells in grave 65. XRF-analyses showed that most of the rattles were hammered from sheet bronze, followed by rattles hammered of sheet iron and those cast from bronze. Only very few are made of copper and brass sheet. A few were gilded. The sounds of seven pellet bells were recorded and analysed. Their central frequencies were determined between 1.5–4.5 kHz. The quiet pellet bells from grave 65 with sound pressure levels of 55–60 and a loudness of 7–9 sone can only be heard over a very small distance. The pellet bell from grave 86 is about twice as loud and the four pellet bells from grave 107 with sound pressure levels of 84 dB and 45 sone can be heard over distances of 20 or 25 m. Acoustic and psychoacoustic parameters can help to identify also similarities and differences between the objects and to get an idea of the actual sound. Especially loudness and level can also be used to draw conclusions about the use of the objects. The pellet bells from grave 65 sound hollow and silent. Brighter, shaper and rougher sound the pellet bells from grave 86 and 107. They therefore have signal effects. The silent rattles therefore only could have served as amulets. By wearing louder rattles, parents could hear where their child was. Very loud rattles may have even served as a warning signal and protection against wild animals.

A video with the original sounds of the pellet bells was created and loaded up on the internet platform Youtube.

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Rolničky z avarských pohrebísk v Komárne

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SÚHRN

V štúdii je analyzovaných 24 rolničiek z troch pohrebísk obdobia avarského kaganátu, nachádzajúcich sa v Komárne. Výhodná strategická poloha na sútoku Váhu s Dunajom ovplyvnila, že na začiatku včasného stredoveku sa tu usídlili Avari. Dôkazom ich prítomnosti sú nálezy deviatich avarských pohrebísk a šiestich avarských sídlisk. Skúmané idiofóny pochádzajú z 15 hrobov z nekropol Komárno IV, Váradiho ul., Komárno VIII, Hadovská cesta a Komárno IX, Lodenica. Hroby s rolničkami predstavujú len minoritnú časť z celkového počtu hrobov v rámci jednotlivých pohrebísk, a teda len malá skupina ľudí bola pochovaná s rolničkou. Tie boli súčasťou detských, mužských a jazdeckých hrobov, nie však ženských hrobov. Na pohrebiskách sledujeme rôzne variácie ich uloženia – v blízkosti stehna, pravej ruky, medzi panvou a ramenom nebožtíka, zväčša však v oblasti panvy. Nosené boli pravdepodobne zavesené na koženom alebo textilnom popruhu, retiazke, alebo uložené v malom vrecúšku. V niektorých prípadoch mohli byť prišité, alebo inak pripevnené na odeve. Treba brať do úvahy, že avarský odev nemá jednotnú formu, ovplyvnili ho viaceré kultúrne vplyvy. Dôraz bol kladený na jeho funkčnosť a prispôsobovaný bol predovšetkým na jazdu na koni už od útleho veku. Oblečenie bolo šité z ľanu, vlny alebo kože. Zdá sa, že hlavným prvkom bola tunika alebo *Klappenrock*. V prípade jazdeckých hrobov boli rolničky umiestnené v blízkosti kostry koňa, často pri lebke, hrudníku a chrbtici. Tieto bývali upevnené na konskom postroji.

Rolničky boli vyrábané dvomi rôznymi spôsobmi. Buď odlievaním kovu technikou strateného vosku, alebo boli kované z plechov. Na základe metalografickej analýzy sledovaného súboru vykonanej röntgenovým fluorescenčným spektrometrom bolo zistené, že na pohrebiskách sa vyskytujú železné, medené, bronzové alebo mosadzné rolničky, pričom niektoré z nich boli pozlátené. Ich povrch bol hladký a nachádza sa na ňom zväčša jedna alebo viac zvukových dier. Všetky analyzované rolničky sú menších rozmerov. Ich veľkosti sa pohybujú od 25 mm do 50 mm a ich priemer je medzi 20 mm a 40 mm. Zachovaná hmotnosť sa pohybuje od 5 g do 33 g. V niektorých prípadoch sa zachovalo srdce z bronzu alebo malých kamienkov. Špecifikum predstavujú rolničky s vyobrazením tváre v ich hornej polovici – mandľové oči, zrastené huňaté obočie, malý ploský nos a kruhové ústa s fúzmi. Takýto typ rolničky nachádzajúci sa v hrobovom inventári indikuje vyššie spoločenské postavenie zosnulého jedinca.

Analyzované a zaznamenané boli zvuky siedmich idiofónov z troch hrobov. Ich centrálna frekvencia bola ohraničená medzi 1,5–4,5 kHz. Na základe merania akustického tlaku a hlasitosti je možné hrkálky z hrobu 65 počuť len na malé vzdialenosti, naopak hrkálky z hrobov 86 a 107 sú dvakrát tak hlasné a je ich možné počuť na vzdialenosť až 20–25 m.

Interpretácia funkcie rolničiek nie je jednotná. Na základe analogických prameňov, uloženia v hrobe, písomných prameňov a ikonografie sa interpretujú ako amulet, šperk, alebo ochrana pred divými zvieratami. Pri výklade ich funkcie sú dôležité práve akustické a psychoakustické parametre, ktoré umožňujú získať skutočnú predstavu o pôvodnom zvuku. Hlasné idiofóny, ktoré je možné počuť na väčšiu vzdialenosť využívali rodičia na kontrolu pohybu svojich detí vo voľnom priestranstve a veľmi hlasné rolničky mohli slúžiť ako ochrana pred divými zvieratami. Naopak menšie a tichšie exempláre, ktoré nie je možné počuť na veľkú vzdialenosť, mohli mať len čisto estetickú funkciu. Do úvahy sa berie aj ich funkcia amuletu.

Vtedajšia spoločnosť verila, že amulet dokáže ochrániť svojho nositeľa pred ublížením a zlými silami. Nosené boli priamo na tele na oblečení, viseli v obydliach, stajniach, alebo boli zavesené na zvieratách. Okrem toho sú rolničky výborným príkladom detskej zvukovej hračky.