In Discussion with the Past

Archaeological studies presented to W.A. van Es

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ROB

Foundation for Promoting Archaeology in co-operation with
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Roman Panpipes from Uitgeest, the Netherlands

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Introduction

'The clear tones of Roman panpipes, cut from one piece, sound through the evening. In a small settlement near Uitgeest someone is sitting on the edge of a well, playing the instrument he bought from a Roman trader some time before. One of the onlookers offers him a drink. The player makes a clumsy movement, and the panpipes disappear into the well. Time goes on, and the settlement perishes in the game of wind and water. Some eighteen hundred years later the hamlet comes to life again under the digging hands of archaeologists'

With this romantic story, the journalist Kees Roos starts an interview with Professor W.A. van Es in the science column *Kleintje Wetenschap* of the newspaper De Telegraaf of 28 August 1982 about the special archaeological finds from that year which, according to the interviewee, was *'a golden year for Dutch archaeology'*.[1] The panpipes from the excavations in Uitgeest constituted one of these unique finds, about which hardly anything has been published so far.[2] The panpipes were on display in the National Museum for Antiquities in Leiden for some time in 1988-89 as part of the exhibition *Nederland Onderste Boven* (The Netherlands Bottom Up), which was organised on the occasion of the 40th anniversary of the ROB. It seemed to me that the 65th birthday of Wim van Es was a good opportunity to put this musical instrument in the limelight once again.[3]

Archaeological context

The panpipes were found in 1982, during excavations carried out by the ROB at a future industrial park on the northern edge of the North Holland village of Uitgeest (the site is known as Uitgeest-Dorregeest, fig. 1). This research continued from November 1980 to March 1983 and covered an area of more than 2.5 ha where many settlement traces from the Roman period and the Early and Late Middle Ages were found. Research into imported pottery and metal from this site[4] has recently confirmed the existing suspicion about continuous occupation from the Roman period until the Early Middle Ages.[5]

The panpipes were among the many settlement finds dating from the Roman period; they were found in a shallow pit, not in a well. We cannot yet say very much about this pit's location in comparison with other contemporary traces. The excavated site was used for centuries, starting from the 1st century BC; not only as a dwelling place, but also for agricultural purposes. This has resulted in a maze of soil traces cutting through one another in which many phases can be distinguished and whose definitive analysis - if it is ever carried out at all - will certainly not take place in the near future.

Fig. 2 shows the site's location in what is more or less the contemporary landscape: the eastern edge of the wide Oer-IJ basin. This estuary, where the sea penetrated far into the land, silted up in the course of the Roman period. A landscape of tidal flats developed, which changed later into a salt marsh landscape, the higher parts of which were suitable for the permanent establishment of farmsteads. The excavated settlement was situated on such a high area: partly on a dune, and partly on the sandy filling of a broad, sedimented channel, in the bend of a narrow fossil channel. Initially water still flowed through this narrow channel, coming from the vast peat moors in the east. In the course of habitation, it became filled with sediment, drift sand and waste from the settlement. The location of the panpipes within the excavated area is shown in fig. 3, which also shows the situation of a number of farmhouses and wells dating certainly or probably from the Roman period, and provides a picture of the geological situation.

The many well-preserved (as yet hardly analysed) plant and animal remains give us a good insight into the inhabitants' mixed agrarian subsistence economy. This was based on the cultivation of barley, emmer, oat, linseed (flax) and tickbeans, and the breeding of cattle, horses, sheep, goats, pigs and chickens. Cattle played an important role here.[6]

The Roman products found in the settlement show that the inhabitants maintained contacts with the Roman Empire, the northern frontier of which was less than 50 km to the south as the crow flies, mainly in the period AD 150-250. The goods that ended up in Uitgeest via bartering (perhaps for cattle and cattle produce), certain services or the exchange of gifts, include various kinds of thrown pottery, bronze ware, fibulae, coins (including a hoard of 1302 denarii),[7] and also the panpipes which are the subject of this contribution. We cannot say very much yet about the precise date of the instrument; it is probably of the same date as most of the Roman imports: the second half of the 2nd or the first half of the 3rd century AD.

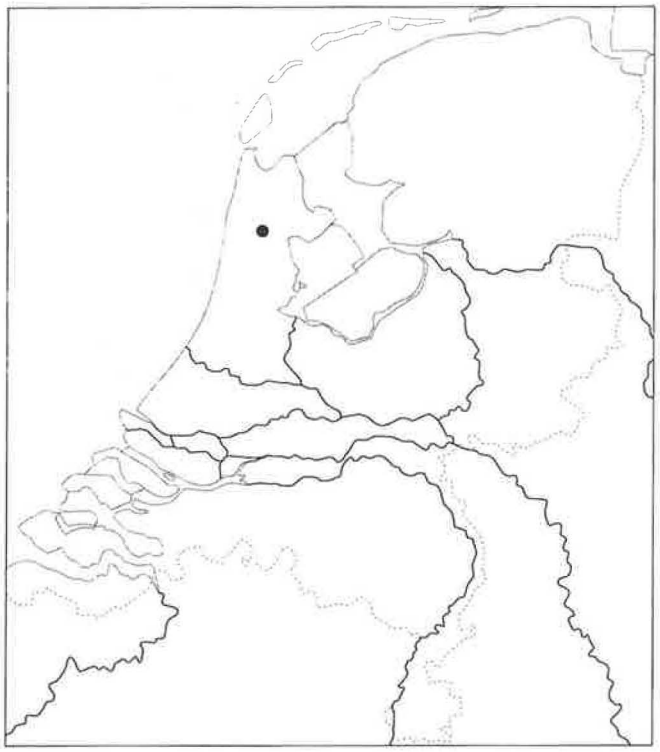


Figure 1 The Netherlands: location of Uitgeest..

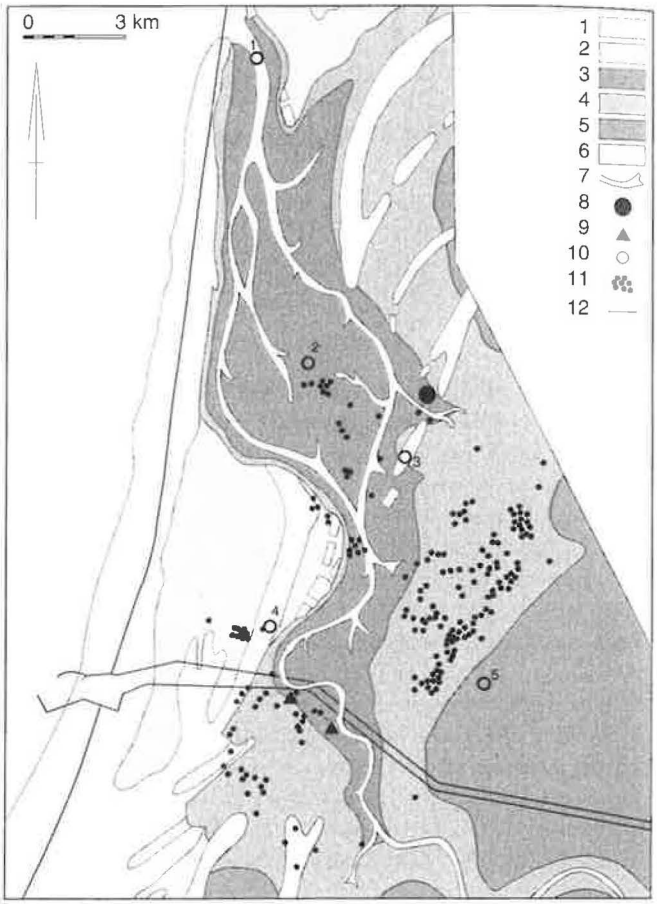


Figure 2 Location of Uitgeest in the Oer-IJ estuary. The geographical background shows the situation at the end of the Iron Age, when the tidal channels were still active. Most of the old settlements shown on the map, including that near Uitgeest, date from a slightly later phase (the Roman period), when the estuary had largely silted up and become suitable for habitation. Legend: 1 beach barriers and older dunes (identified and assumed); 2 beach plains, with peat vegetation in the low-lying parts; 3 tidal flats; 4 high salt marshes; 5 peat bogs; 6 sea; 7 tidal channels of the Oer-IJ; 8 the native settlement excavated near Uitgeest; 9 Roman military forts from the beginning of the 1st century AD; 10 the present-day villages of Egmond (1), Castricum (2), Uitgeest (3), Beverwijk (4) and Assendelft (5); 11 native settlements from the Late Iron Age - Roman period; 12 current coastline and the North Sea Canal. After Van Es, Sarfatij & Woltering 1988.

Find circumstances

The panpipes were discovered in excavation trench 19 when the work on the deepest level (level 7) was being completed. This work consisted of cutting and drawing the traces still visible at this level (postholes, pits, ditches), scanning with a metal detector, taking soil samples from a selection of traces for archaeobotanical and archaeozoological research, and digging up all the traces with spade and trowel, with a view to collecting finds - almost exclusively pottery. The panpipes were discovered when a bit was cut off them while a pit was being dug out. When it became clear that this was a special object, the soil that had already been thrown aside was searched intensively for the missing fragment, but this has not been found. During the recovery process the soft, waterlogged wood broke into two (lengthwise through the shortest pipe but one, see fig. 4). The panpipes were registered under find number 19.7.45.[8] The wood had been preserved in the soil because of the constantly high groundwater level.

Wood determination, conservation and documentation

Shortly after the discovery, the wood was determined to be box (*Buxus sempervirens*).[9] The piece of wood from which the panpipes were made contains about 60 year-rings and comes from a tree-trunk of a size that only occurs naturally in the Mediterranean. Because of this the panpipes, or at least the wood that has been used, were most probably imported from Italy or southern France.

The panpipes were conserved in the ROB laboratory in 1982, using a variant of the polyethylene-glycol method.[10] This conservation method involves driving out the water present in the wood by means of alcohol, after which the alcohol is replaced and all the hollows occurring in the wood are filled with the synthetic resin polyethylene-glycol. Before this process, an analysis was carried out of the substance used at the time to repair a crack in the panpipes (see fig. 4). This turned out to be natural resin from a type of tree which has not been deter-

mined. This resin dissolved in the alcohol during the conservation process. The conservation may generally be regarded as successful. Only in the width of the grain did some shrinkage occur: *c.* 4 mm, measured where the bevelled edge starts in the bottom left corner (see the description in the next section), while at the top, on the side of the shortest pipes, there are a few deformations (compare fig. 4 with fig. 5).
Prior to the conservation, when it was still in a waterlogged condition, the panpipes were photographed (fig. 4) and drawn (fig. 6). The X-ray (fig. 5) was not taken until well after the conservation (in 1997). Only on the basis of this X-ray was it possible to determine exactly the shape and position of the pipes. The original drawing of the longitudinal section of the panpipes has been adjusted as regards these aspects on the basis of the X-ray. Because the conservation did not lead to shrinkage in the longitudinal direction of the wood, this correction could be carried out without any problems.
Also before conservation, an attempt was made to detect the basic tuning of the undamaged pipes by blowing them. The tones produced were recorded on a cassette tape, after which the pitch levels were determined by means of a digital tuning instrument.[11] It appears that, as is usual for panpipes, the pitch of each pipe varies considerably, depending on the position of the lips and the method of blowing. The average pitch levels arrived at are shown in table 2. It was not possible to blow up to the next octave on the waterlogged instrument.

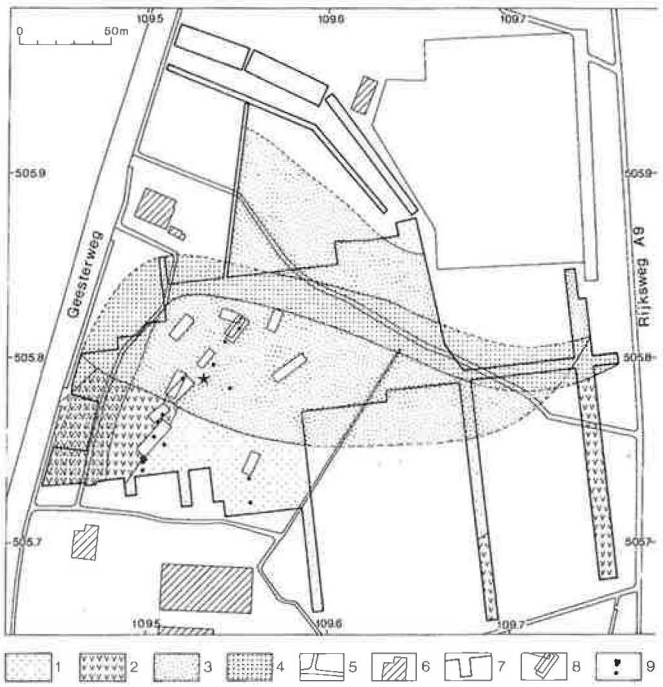
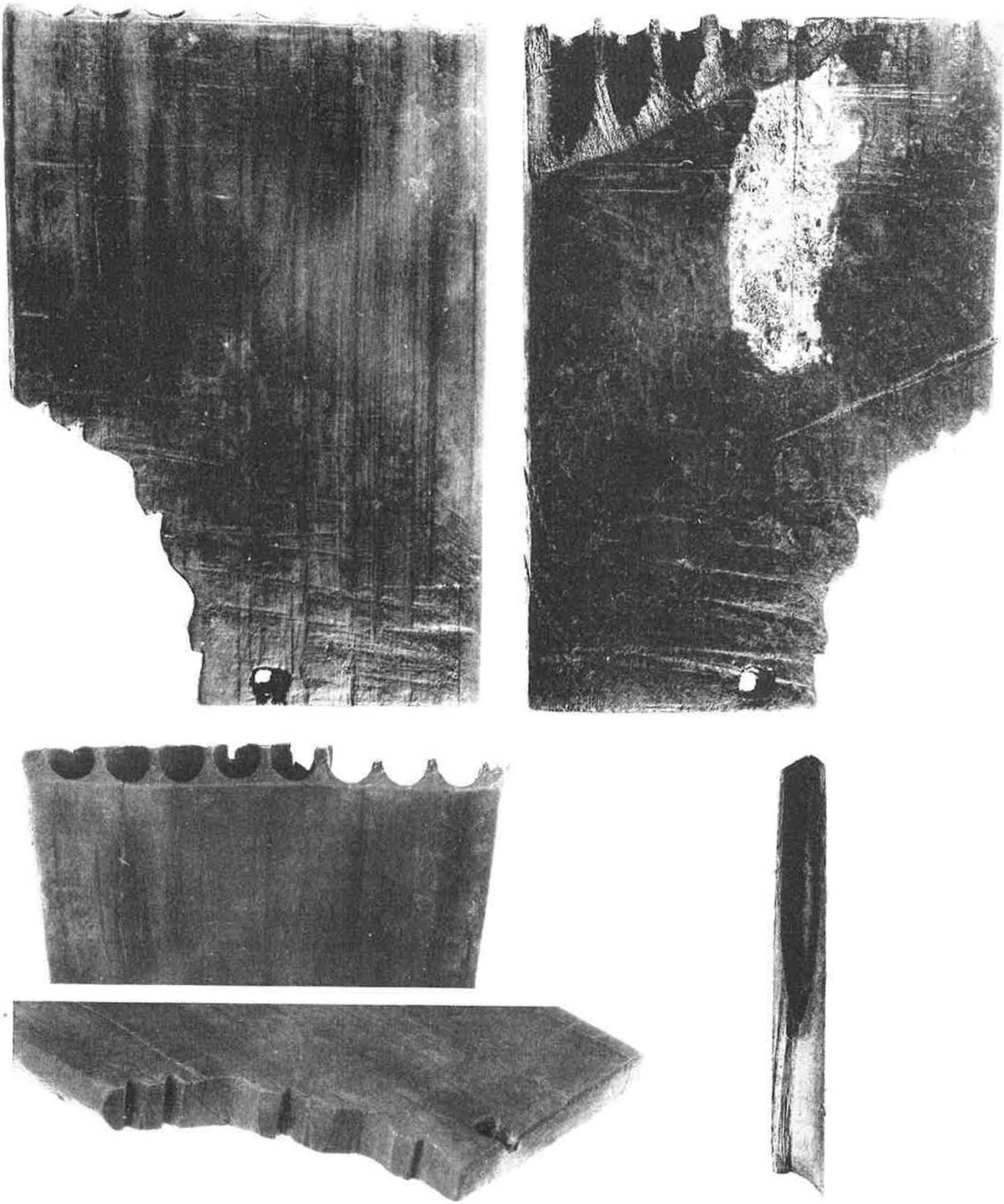


Figure 3 Uitgeest. The geological situation of the site, the position of the panpipes and a few traces from the Roman period within the excavated area. Legend: 1 beach sediment (Calais IV); 2 peat; 3 channel sediments (Dunkirk I); 4 fossil channel; 5 recent parcelling; 6 recent building; 7 boundary of excavated area; 8 house plans, Roman period (and probable Roman period); 9 wells, Roman period (and probable Roman period). The findspot of the panpipes is indicated by a star. After Woltering 1982.

Description

Today's panpipers usually hold their instruments in such a way that the longest pipe (with the lowest tone) is on the player's right-hand side, and the shortest is on the left-hand side. This was probably also normal practice in the Roman period,[12] although some depictions suggest that there was no fixed rule.[13]
The way in which the top of the Uitgeest panpipes has been finished shows that these pipes were also played with the longest pipe to the right. This description and the sections below are based on the player's perspective: left and right refers to what is left and right to the player; the side facing the player is called the front, and the opposite side, which faces the listeners, is referred to as the back. The pipes are numbered from long to short. All the sizes refer to the panpipes in their non-conserved, waterlogged condition.
The panpipes have the shape of a virtually rectangular flat piece of wood, with more height than width, which has been bevelled in one corner (bottom left): not straight, but according to an irregular pattern of concave and convex undulations, alternated with notches. The bevelling is at the side of the shortest pipes, and therefore reminds us of the archetype of panpipes: a series of interlinked individual pipes of gradually increasing lengths. The way in which this corner has been finished may also have had a functional purpose: the fingers of the right hand must have had a better grip on the instrument because of this.
Widthways, the piece of wood is slightly bent, with the hollow side facing the player (fig. 6). This concave looks like the result of a functional design. Nevertheless, it seems likely that this is an unintended deformation, which did not occur until after the instrument was produced, and possibly as a consequence of its location in the ground. This warping may have partly been the result of the ornamentation of vertical grooves applied at the front.
At the top, the panpipes have a width of 99 mm, further down (where the bevelling starts), this is 98 mm, and the bottom has a width of 58 mm. The height is 140 mm on the right-hand side, 80 mm on the left-hand side, and 143 mm measured along the place where the bevelling starts at the bottom. The thickness is 12 mm at the top, increasing to 13 mm in the middle; at the bottom the instrument has a thickness of 10 mm. The piece of wood is not entirely rectangular. The angle between the bottom and the right-hand side is 90.5°, the angle between the top and the right-hand side is 91.5°, and between the top and the left-hand side there is an angle of 87°. Close to the bottom, slightly to the right of the middle, a hole has been drilled from both ends. The careless way in which this has been done suggests that this hole with a 4 mm diameter was drilled by the user rather than by the manufac-



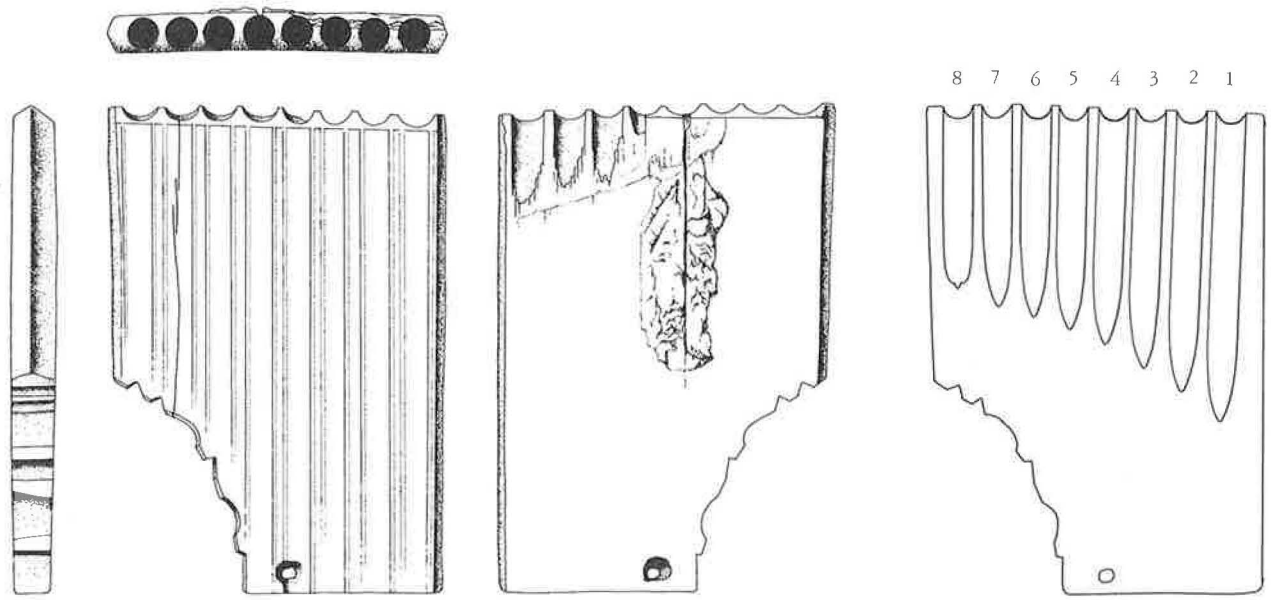


Figure 6 The Uitgeest panpipes. The drawing was produced prior to conservation; the pipes' shape and position were adjusted at a later stage, on the basis of the X-ray (see fig. 5) taken after the conservation. Scale 1:2.

The length of the pipes, measured from the top of the instrument, increases from 53 mm to 90 mm; the outer edge is 1.5 to 2 mm, and the inner edge is 3 to 4 mm lower. The exact measurements are shown in table 1.

Parallels

Within the scope of this article, we cannot dwell upon the history and worldwide distribution of panpipes and the variety of models and materials used. There are indications that panpipes made from the long bones of birds were used as early as in the French Aurignacien and Magdalenien,[18] while the oldest evidence for panpipes - also made of bird bones - appears to date from the Late Neolithic.[19] Later prehistorical finds include panpipes from the long bones of sheep from a Late Bronze Age cemetery in Poland[20] and the imprint of panpipes, consisting of five reed pipes of increasing length, held together by a piece of resin, in a Late La Tène cemetery in Germany.[21] Literary tradition (the earliest of which is Homer's Iliad) and many iconographic depictions show that panpipes were a very much appreciated, frequently used musical instrument in classical civilisation.[22]

Two counterparts of the Uitgeest panpipes are known: a virtually complete instrument from Alise-Sainte-Reine (Alesia; Côte-d'Or), France[23] and a fragment (about half) of an instrument from Barbing-Kreuzhof (Regensburg, Bavaria), Germany.[24] Both examples show many similarities with the Uitgeest panpipes. In addition to these three wooden instruments, there is an earthenware example of a similar shape from Wilcote, Oxfordshire, England.[25]

The literature also contains information - in general fairly incomplete and not always consistent - about a number of Roman panpipes which deviate considerably from the ones mentioned above in terms of shape, material and construction. These are:

A fragment of panpipes made out of one piece of marble with ten pipes from Rouhling (Moselle), France. The design copies the appearance of classical panpipes, which consist of a series of loose pipes tied together. The pipes might date from the end of the third to the beginning of the 4th century AD.[26]

A fragment of bronze panpipes from Bon-Encontre (Lot-et-Garonne), France, consisting of six (originally at least seven) cylindrical pipes, welded together, of increasing lengths.[27]

Earthenware panpipes consisting of eight pipes, provided with a mouthpiece, from an unknown findspot in the German

pipe	depth from top of the instrument	inner edge	outer edge
1	90	86.5	(88.5)
2	83	79.5	(81.5)
3	77	73.5	(75.5)
4	71	67.5	69.5
5	66	63	64.5
6	62	58	60
7	59	55	57
8	53	50	51.5

Table 1 Uitgeest panpipes. The depth of the pipes, measured from the top of the instrument and from the inner and outer edge of the upper orifice. The depths of damaged pipes 1, 2 and 3 have been reconstructed in terms of the measurement from the outer edge.

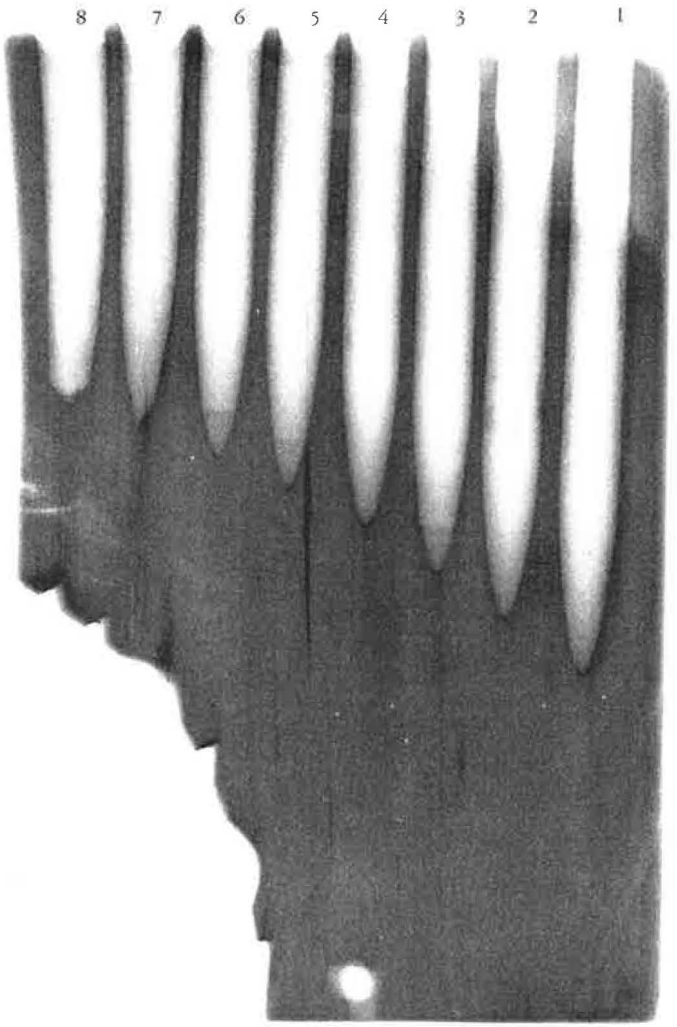


Figure 5 The Uitgeest panpipes. X-ray after conservation. Scale 1:1.

turer. It must have served to enable the user to hang the panpipes around his neck on a piece of string or leather.
The piece of wood has roof-shaped bevelling on both sides and at the top. At the top of the panpipes, this operation resulted automatically in a double-sided crescent-shaped hollow in each pipe, giving a characteristic notched rim. The bevelling is not symmetrical; as a result, the upper orifice of the pipes is at the front (where the lower lip would rest), *c.* 2 mm lower than on the back (where the airstream would be aimed at while playing). The bevelled top has shallow grooves on both sides, running more or less diagonally, from which we may conclude that this operation was carried out by means of a fine-toothed saw. The front of the panpipes has been decorated with very shallow, parallel vertical groove lines, which appear to be related to the position of the drilled pipes; they may have been intended as a reminder of the original collection of reed pipes. Although the surface of the decorated front has a better finish than that of the undecorated back, both sides show traces of sawing which have not been entirely sanded or polished away.[14]

Figure 4 The Uitgeest panpipes, before conservation. Front and back, longitudinal section via the break through the seventh pipe, the top with the blow holes, and the bevelled and worked bottom left corner. Scale 1:1.

The panpipes contain eight pipes, drilled with great accuracy, the details of which are shown most clearly in the X-ray of fig. 5. The pipes are more or less at right angles to the top, as a result of which their position diverges from the right-hand side. All the pipes have a diameter of 8.5 mm at the top (pipes 7 and 8 were deformed during the conservation process). There is no more than 2 to 3 mm of wood between the individual pipes; the top of pipes 1 and 8 is 5 mm from the instrument's sides; the minimum thickness of the wood at the front and the back varies from 1.5 to 2.5 mm.
The shape of the pipes shows that they were drilled in two phases. This is most clearly visible in pipes 3, 5 and 6 and also, but less clearly, in pipe 2. When we have a closer look at, for instance, pipe 6, we see that first a cylindrical hole was drilled, tapering slightly towards the bottom, with a depth of 55 mm (measured from the top), and probably a slightly rounded bottom. A spoon drill was most probably used for this purpose.[15] After this, the hole was drilled further with a pointed type of drill, most likely a twist drill,[16] to a depth of 62 mm. The dividing line between the two drilling holes is clearly visible.
Pipes 7 and 8 are slightly different from the others. In the case of pipe 7, the situation only seems to be different; in fact the difference is caused by the way in which the break that occurred in the panpipes during the excavation manifests itself in the X-ray (see fig. 4 where, as a result of this break, pipe 7 can be shown in a longitudinal section). Pipe 8 differs not only because of the deformation that occurred during conservation, but also in terms of the original shape. It can clearly be seen that here the first drilling went deeper in comparison with the other pipes. The second drilling, that was to bring pipe 8 to a depth established in advance, goes barely 1 mm deeper than the first one. As a result, pipe 8 did not get the same nicely pointed end as the other pipes. Because of the deviating shape, pipe 8 does not sound any higher, but rather slightly lower than pipe 7, in spite of its lesser depth. This might be due to a production fault. In modern panpipes, the smallest pipe always has a slightly larger diameter than the other pipes for reasons of acoustics.[17] Such a difference was not noticed in pipe 8 before the restoration, nor does it ap-pear from the photographs that were taken at the time. It is quite conceivable, however, that increasing the volume in pipe 8 by means of the continuation of the first drilling was done specifically for this purpose.
As early as the Roman period, a crack occurred at the back of the instrument, lengthwise in pipe 5, which made it impossible to elicit the desired tone from this pipe any longer. The fact that this crack was repaired with resin shows that the owner really played the instrument.

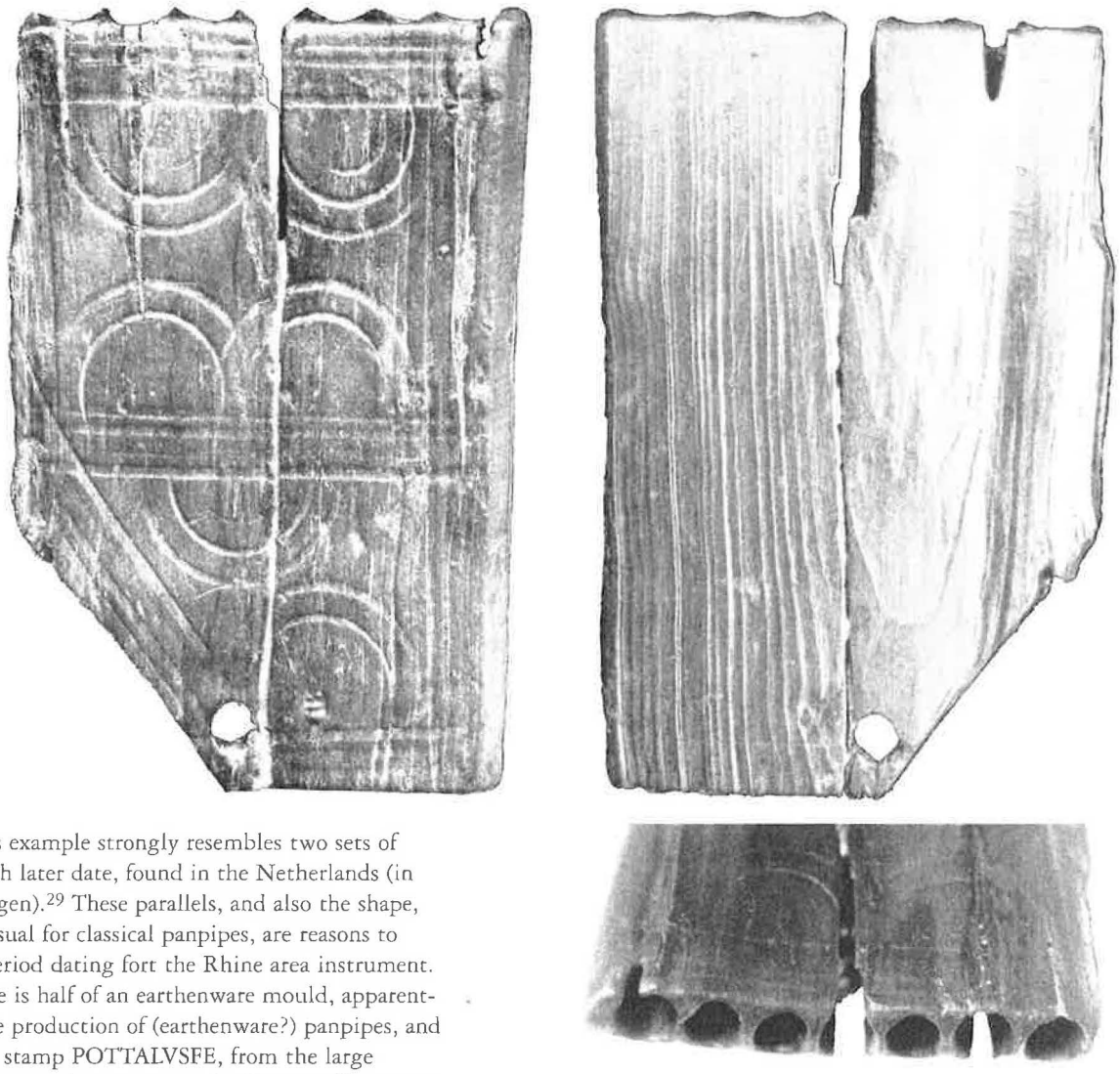


Figure 7 Front and back of the boxwood panpipes from Alesia (Alise-Sainte-Reine, France). Scale 1:1.

Rhine area.[28] This example strongly resembles two sets of panpipes of a much later date, found in the Netherlands (in Cothen and Albergen).[29] These parallels, and also the shape, which is very unusual for classical panpipes, are reasons to doubt a Roman period dating fort the Rhine area instrument. Furthermore, there is half of an earthenware mould, apparently intended for the production of (earthenware?) panpipes, and provided with the stamp POTTALVSFE, from the large Rheinzabern pottery production centre in Germany.[30] We can barely determine what the end product might have looked like from the photograph in Ludowici. Presumably, the maximum height was 90 mm and the width was 72 mm. There were thirteen pipes in total, varying in length from *c.* 53 to 86 mm.[31]

I will discuss the features of the wooden panpipes from Alesia and Barbing-Kreuzhof and those of the earthenware example from Wilcote in more detail here, partly because of the similarities with the Uitgeest panpipes (Alesia, Barbing-Kreuzhof, and in terms of shape also Wilcote), and partly because the information provided in the literature contains details that are interesting from a musicological point of view. What is said below about these panpipes is derived from the literature, and is therefore not based on new observations regarding the instruments themselves.

Alise-Sainte-Pierre (Côte-d'Or, France) (fig. 7). Found in a well in 1906 during excavations in the Roman settlement in the former Celtic oppidum Alesia on Mont Auxois. On the basis of other finds from the same well, the panpipes have been dated to the end phase of the 2nd or the start of the 3rd century AD.[32] The wood was initially thought to be probably oak,[33] but later it was identified as most probably box.[34] The instrument has seven complete pipes, and in the short left-hand side, where some wood has disappeared, there are traces of an eighth pipe. It is unclear whether the measurements supplied by Reinach are based on the pipes in their non-conserved (waterlogged) state, or whether they were taken after conservation. The latter is probably the case, which means that, as is the case with the Uitgeest panpipes, we will have to take into account shrinkage in the width. Reinach gives a height of 115 mm, maximum and minimum widths of 77 and 43 mm, and a thickness varying from 11 mm (at the top) to 6 mm (at the

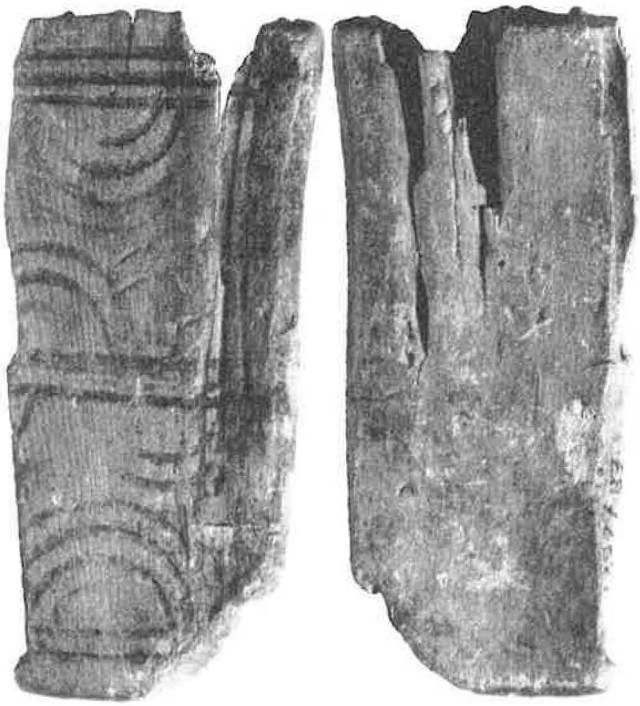


Figure 8 Front and back of the fragment of the boxwood panpipes from Barbing-Kreuzhof (Regensburg, Germany). Scale 1:1.

bottom).[35]
The pipes are at a distance of about 2 mm from each other, and there is 5 mm of wood between pipe 1 and the undamaged right-hand side. From these figures we may conclude that the pipes, like the Uitgeest panpipes, have a diameter 8.5 mm. The width of the complete instrument in its conserved state may be estimated at 92 mm. If we take into account a shrinkage in the width of, for instance, 4 mm (as is the case with the Uitgeest panpipes), we arrive at an original width of *c.* 96 mm. As is the case with the instrument from Uitgeest, the side facing the player has a decoration, consisting in this case of a combination of shallow horizontal and vertical parallel lines and upright and hanging half concentric circles. The bottom left corner of the instrument has been sawn off slantwise. In the angle with the bottom resulting from this (*c.* 130°), close to the edge, there is a suspension hole with a width of 6 mm. The top has roof-shaped bevelling, which gives this instrument too a characteristic notched rim.
Reinach established the shape of the pipes by means of '*sondage*' and on the basis of the remainder of pipe 8, describing it as largely cylindrical, but ending more or less in a point towards the bottom (*'comme un crayon taillé'*).[36] We may conclude from this that the pipes are of the same shape as the Uitgeest pipes.[37] The seven pipes that have been preserved have a depth of 71, 63, 55, 50.5, 43.5, 39 and 35.5 mm; the depth of the incomplete pipe has been reconstructed at 31.5 mm. It is not clear whether these measurements have been taken from the top of the instrument, or from the inner or outer orifice of the blow holes. On the basis of Reinach's calculation of the 'theoretical' pitch levels, we may conclude that the latter should be the case. The pipes were blown by four renowned flute players; this yielded the tone sequence shown in table 2.[38]

Barbing-Kreuzhof, Regensburg (Bavaria, Germany) (fig. 8). A fragment of boxwood panpipes of the same type as the instruments found in Uitgeest and Alesia. Discovered in a well, during excavations in the remains of a Roman building. On the basis of other finds from this well, the piece has been dated to the end of the 2nd or the start of the 3rd century AD. The fragment is 100 mm high, 40 to 45 mm wide and has a thickness varying from 10 mm (at the top) to 6 mm (at the bottom). Four partly damaged pipes have been preserved. Again, if the longest pipe was held to the right, the decorated side (with a pattern of superficially burnt-in parallel lines and concentric half standing and hanging circles) would have faced the player. There are so many similarities with the panpipes from Alesia that Ulbert considers it very likely that the two instruments were produced in the same workshop, in spite of the fact that the latter instrument is less high and its pipes are less deep.[39] The instrument was broken off at the fourth pipe from the right. The break goes through a suspension hole located close to the bottom. From the position of this hole and incompleteness of the decoration of the front - in comparison with the pattern on the panpipes from Alesia - we may conclude that the left-hand side of the instrument, with another four pipes, is missing. The original width will not have differed very much from that of the panpipes from Uitgeest and Alesia. It is not known whether the bottom left corner was bevelled. The bottom right corner is damaged.
The diameter and shape of the pipes are identical to those of the instruments from Uitgeest and Alesia. They are largely cylindrical with a diameter of 8.5 mm, and have a pointed end. The depths (measured from the top of the instrument) are 65, 57, 51 and 47 mm. Due to the roof-shaped bevelling of the top, this instrument also has a notched rim. The front and back of the blow holes' orifices are *c.* 2 mm below the top. When the pipes were blown, a tone could be produced only on pipe 3 (see table 2).

Wilcote (Oxfordshire, England) (fig. 9). Found between 1965 and 1971 during excavations at Shakenoak Farm, in the debris of building C, most probably a bath-house. Dated to the end of the 2nd century AD. These earthenware panpipes are interesting within the context of this article because of the similarities in shape in comparison with the wooden panpipes from Uitgeest, Alesia and Barbing-Kreuzhof: rectangular with a (concave) bevelled bottom left corner and suspension hole, and provided with seven cylindrical, pointed pipes. At the side of the shortest pipes a fragment is missing, as a result of which two pipes have been damaged; it is also very likely that there was an eighth pipe, which has disappeared. The longest pipe,

on the right-hand side, is also damaged. An inscription has been scratched into two sides: CATAVACVS at the bottom, and BELLICIN[in the hollow bevelling of the bottom left corner.
The instrument has a height of 124 mm, a maximum surviving width of 96 mm, and a maximum thickness of 12 mm. The original width must have been approximately 105 mm. The pipes have a diameter of 7-8 mm at the top and are 3-5 mm apart. The top of the instrument has rounded sides, but it does not have any bevelling, which means that it does not have the notched rim characteristic of the wooden panpipes. The original depths of the preserved pipes were 105, 102, 87, 86, 84, 71 and 67 mm. Only undamaged pipes 2, 3, 4 and 5 yielded a tone when they were blown. The results are shown in table 2.[40]

Production of the wooden panpipes

The precision with which the pipes of the wooden panpipes were drilled, at very short distances from each other (2-3 mm) and in exactly the same plane, makes it seem very likely that this was done by means of a fixed drilling set-up. The literature I have consulted does not mention any such facility; it is assumed that during the Roman period drilling was always done by hand, using *Fiedelbogenantrieb* (bow drive) or *Seilantrieb* (rope drive).[41]
It does not seem very likely that during the production process a piece of wood more or less the size of the end product was sawn first, and that the eight pipes of different depths were drilled into it afterwards. It is more likely that a block of wood from which several instruments could be made was the starting point, and that a kind of serial production took place based on standardised sizes. The measurements of the instruments and the diameter and depths of the pipes that were drilled into them are an indication of this.
The measurements that were used should be compared with the length of the foot common in the Roman Empire, which was divided into 4 *palmi*, 12 *unciae*, or 16 *digiti*. The literature gives information about several foot measures: the *pes Romanus* of 292.2 mm (on average), the Punic foot of 294.1 mm and the Vindonissa foot of 292.5 mm.[42] At *digitus*, *uncia* and *palmus* level the (rounded-off) differences vary from 0.1 to 1 mm, which is so little that it does not really matter which foot measure is used. The southern origin of the boxwood used (Italy or southern France) and the fact that the workshops were therefore probably also located in this area, might be a reason to choose the *pes Romanus* rather than one of the other foot measures, which may have been of a local nature. This would give us the following measures, rounded of to 0.5 mm: *pes Romanus*, 296 mm; *palmus*, 74 mm; *uncia*, 24.5 mm; and *digitus*, 18.5 mm.
A comparison of these measures with the measurements of the Uitgeest panpipes yields the following. The length and width

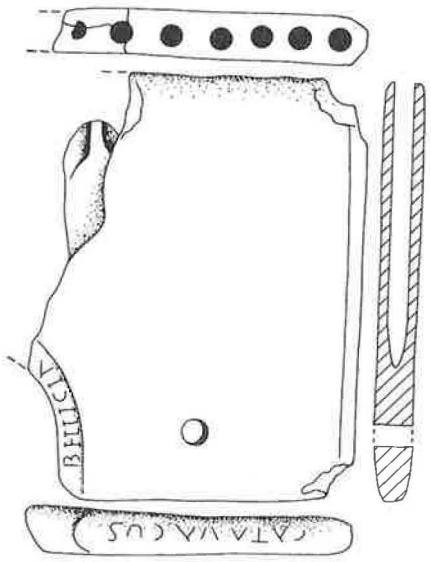


Figure 9 The earthenware panpipes from Wilcote (England), redrawn from fig. 23 in Brodribb, Hands & Walker 1973. Scale 1:2.

of a piece of wood in which these panpipes fit (144 mm high, 99 mm wide) correspond to 2 *palmi* (148 mm) and 4 *unciae* (98.5 mm). The thickness of the instrument must have been determined mainly by the diameter of the pipes. If several instruments were sawn from one block of wood, *c.* 2 mm should be added for each saw-cut for a maximum thickness of 13 mm. This means that *c.* 15 mm of wood was need-ed for one instrument, and that from a piece of wood with a thickness of 1 *palmus* five sets of panpipes could be cut.
The panpipes from Alesia (117 mm high and originally *c.* 96 mm wide) fit into a piece of wood of 5 by 4 *unciae*; the ones from Barbing-Kreuzhof (100 mm high and originally with more or less the same width as the other two wooden instruments) fit into a piece of wood of 4 by 4 *unciae*.
The three wooden instruments have striking similarities, not only in terms of the pointed shape of the pipes, but also in the original number of pipes (8), their diameter (8.5 mm) and the distance between them (2-3 mm). The number, diameter and distance between the pipes were certainly not arbitrary, but rather based on musical traditions (octave), acoustic principles (volume of the pipe), and the requirements imposed by playing practice (the pipes should not be too close together or too far apart). These factors determined the uniform width of the instruments (between 95 and 100 mm). They partly also apply to the earthenware panpipes from Wilcote, which are best regarded as a somewhat primitive local copy of the wooden panpipes. The pipes (originally there were probably 8) have a narrower diameter, but measured from centre to centre they are more or less as far apart (11-12 mm) as the pipes from the wooden instruments.
If the wooden panpipes were manufactured in serial production, we may assume that all the pipes were drilled first in a prepared piece of wood (sawn in a rectangular shape) intended

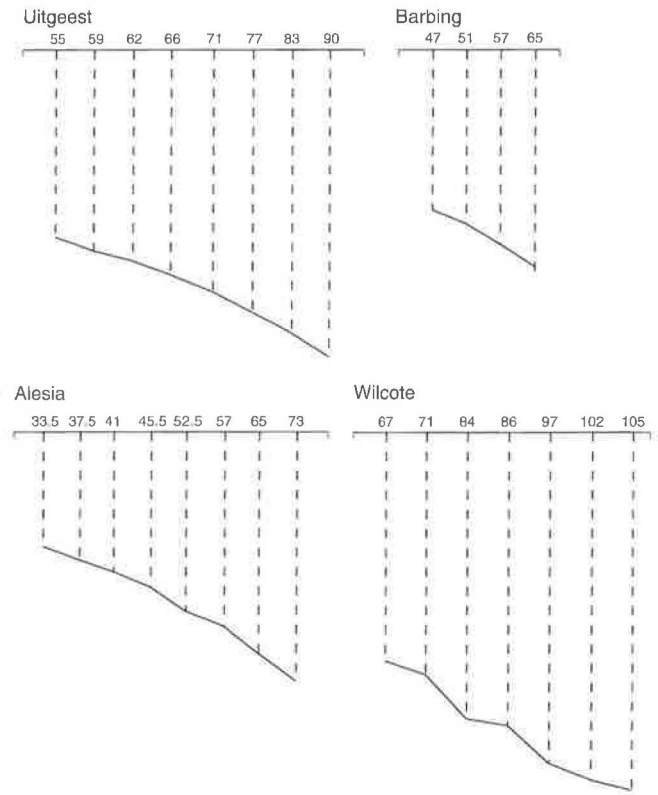


Figure 10 The pipe depths in mm of the panpipes from Uitgeest, Alesia, Barbing-Kreuzhof, and Wilcote. Scale 1:2.

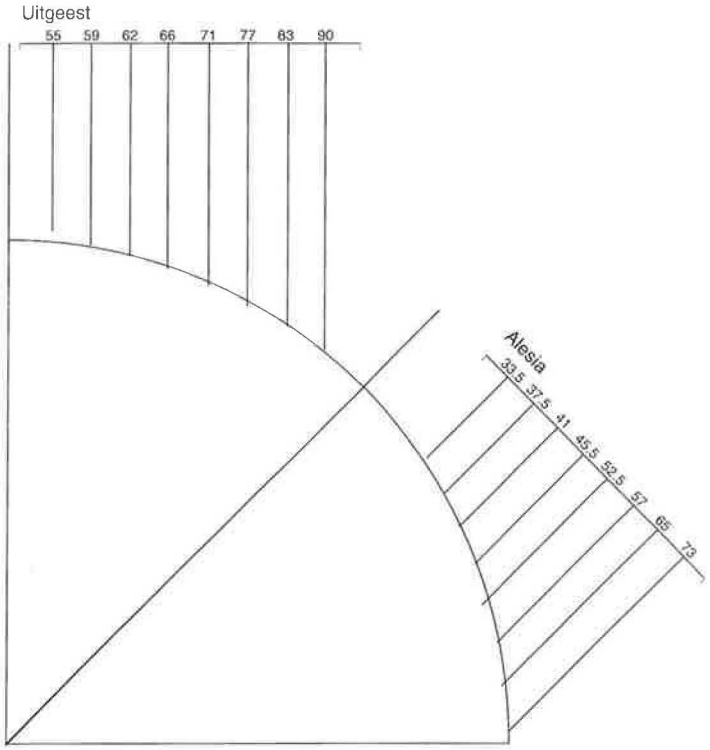


Figure 11 The pipe depths of the panpipes from Uitgeest and Alesia, projected on a quarter of a circle with a diameter of 1 pes Romanus (296 mm). Scale 1:2.

for several instruments. It seems unlikely that, following this, eight holes of unequal depths where then drilled for each individual instrument. The most practical method would have been to drill the pipes intended for several instruments in series of equal depths. The question is, at what stage of the production process the second drilling, established in the Uitgeest panpipes, was carried out. Perhaps the pipes of each individual instrument were not drilled to their final depth until a later stage in the production process, in which case this drilling work may have been carried out by hand. The fact that the second drilling is always exactly centred in comparison with the first one, and joins onto it virtually seamlessly, contradicts this and makes it seem likely that the second drilling phase was also carried out in a fixed set-up and preceded the sawing off of the individual instruments.
Again we might ask whether drilling phases 1 and 2 of each pipe followed each other immediately, or whether phase 1 was carried out first in all the pipes of equal depth, and phase 2 followed after this. Due to centring problems that might occur in the latter case, the first method seems to be the more probable one. This does, however, imply a change of drill during the drilling of each individual pipe, and also suggests that not only the depths of the first drilling phase, but also those of the second drilling phase had been standardised.
The aim was to manufacture pipes that could produce a tone sequence that goes up (or down) more or less evenly. For this purpose, the bottoms had to follow an exponential curve. This is clearly visible in the X-ray of the Uitgeest panpipes, and also applies to the panpipes from Alesia and Barbing-Kreuzhof. The earthenware panpipes from Wilcote show a very different picture in this respect: the depths of the pipes follow a very irregular, broken line (fig. 10).
The pipes of the wooden instruments were clearly drilled according to a specific diagram. The depths of the two drilling phases were fixed, and because of this the drills that were used will have had a stopper or mark. The absolute depths (and the resulting pitch levels) were less important, and accordingly in this respect the different instruments vary considerably. This also explains why there is more variety in the lengths of the instruments (from 100 to 143 mm) than in their widths. The question is, how the required drilling depth sequences were established in the workshops. The projection of the pipe bottoms on part of a circle may have been an adequate practical geometrical aid.[43] Fig. 11 shows that the curves on which the pipe bottoms of the instruments from Uitgeest and Alesia rest could easily be plotted, without any omplicated calculations, by projection onto a circle of 296 mm (*pes Romanus*).

Uitgeest			Alesia			Barbing-Kr.			Wilcote		
pipe	pitch		pipe	pitch		pipe	pitch		pipe	pitch	
	A	B		A	B		A	B		A	B
1	-	>b flat"	1	>d"'	<e flat"'	1	-	e"'	1	-	<a flat"
2	-	c"'	2	e"'	<f"'	2	-	<g"'	2	b flat"	>a flat"
3	-	d flat"'	3	g flat"'	g"'	3	g"'	<a"'	3	c"'	>a"
4	<e flat"'	<e flat"'	4	>g"'	a-a flat"'	4	-	>b flat"'	4	<d flat"'	>b"
5	<e"'	e"'	5	>b flat"'	b"'	5	-	-	5	d flat"'	<c"'
6	<f"'	>f"'	6	<c""	d flat""	6	-	-	6	-	<e flat"'
7	>g flat"'	>g flat"'	7	<d""	<e flat""	7	-	-	7	-	<e"'
8	<g flat"'	a flat"'	8	-	<f""	8	-	-	8	-	-

Table 2 The scales of the four non-tuned Roman sets of panpipes discussed in the text. The pipes are numbered from long to short. The table shows the - approximate - tones produced by blowing the pipes (A), and the tones calculated on the basis of the pipe depths (B; formula n=c/4l, based on a' = c. 440 Hz. See note 48). < = clearly lower than the pitch mentioned, > = clearly higher.

Some musicological aspects

Most authors seem to think that panpipes were used mainly by shepherds, goat herds and children, and can hardly be considered a proper musical instrument.[44] Reinach, however, mentions a number of other situations where panpipes played a prominent role in classical antiquity: at '*danses populaires*', '*processions très anciennes*', '*pompes dionysiaques*' and other traditional festive events.[45] We may also conclude that classical panpipes were used for making real music from the characteristic playing poses of the musicians depicted.[46]

The characteristic shape of the pipes of the Roman panpipes discussed in this publication could be a further indication of this. The wooden panpipes from Uitgeest, Alesia and Barbing-Kreuzhof and the earthenware example from Wilcote have in common the remarkable fact that the pipes do not have a flat or rounded bottom,[47] but have a pointed end. The investigation of the Uitgeest panpipes has shown that this shape was not the unintended result of a certain production process, but was consciously aimed for by means of a twofold drilling, carried out with different types of drill. The fact that the earthenware panpipes from Wilcote, which were produced in a completely different way, have the same pipes with pointed ends, confirms this.

The question is now what the purpose of the pointed pipe ends was. This shape appears clearly to affect the pitch. Pipes with a pointed end sound higher than pipes with an equal diameter and length with a flat bottom. Even simply because of this effect, there is little point in calculating the 'theoretical' tuning of the pipes on the basis of their depths.[48] However, such calculations does tell us something about the intervals (see table 2).

The pointed pipe ends cause irregular air swirling at the bottom of the pipes, resulting in off-key pitch levels, and certainly did not have any musical significance.[49] They must be accounted for as a possibly standard tuning facility in this type of panpipes in the Roman period. The drilled depth of the pipes was approximate. As was said above, it was important that a gradually rising (or falling) tone sequence could be produced on the panpipes. The same still applies to panpipes used today. The instruments were (and are) tuned by slightly raising the bottom of the pipes. Nowadays, beeswax, resin or plugs of wood or cork fixed with wax are used for this purpose. Sometimes loose material is used for fine-tuning: sand, grains of rice, small metal or glass balls.[50] Such loose filling material has the advantage that the tuning can easily be adjusted, if necessary during a performance. Pipes with a pointed end are easier to tune than pipes with a flat bottom, and the pointed ends also keep the filling material better in place. As far as is known, this ingenious facility is not (or is no longer) used anywhere by contemporary panpipers.[51]

The generally common practice of fine-tuning enables the player to compile tone sequences according to his own liking. Blowing tests on non-tuned panpipes yield a result that says little or nothing about the tone sequences that were played on them in the past. Moreover, while playing, one can bring the pitch up and down by at least a semitone depending on the way the pipe is blown. To illustrate the above, table 2 shows the tone sequences that were produced by blowing the five panpipes discussed together with the outcome of the calculations on the basis of the pipe depths. From the fact that these panpipes could play a sequence of eight tones, we might conclude that there was a preference for a range of an octave. Such a range would be quite convenient from a musical point of view, but it would not be strictly necessary. In any case, the octave is one of the few universals in music.[52] It is interesting to note that the instruments vary considerably in terms of absolute pitch.

The intervals as shown in table 2 are usually a semitone or a full tone. Intervals of a tone and a half or less than a semitone are exceptions. The excessively deep first drilling in pipe 8 in

the Uitgeest panpipes has led to such an exception, as a consequence of which pipe 8 sounds slightly lower than pipe 7. On the basis of the intervals we can make the general statement about the four sets of panpipes that, after fine-tuning, several diatonic major and minor modes could be played on them. These included not only the modes common in the Roman or Gallo-Roman world,[53] but also those from free Germania. This takes us back to our starting point: the farming settlement excavated near Uitgeest in North Holland, in the Oer-IJ estuary. The panpipes that were found there were definitely used as a musical instrument. What melodies were elicited from the pipes and by whom - outdoors on the extensive pastures or indoors near the fireplace - cannot be deduced from the archaeological data.

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Notes

1. Roos 1982
2. The excavations were carried out by the State Service for Archaeological Investigations (ROB); see Woltering 1982 and 1983.
3. Wim van Es will understand that this subject has not been chosen completely at random. I would like to take this opportunity to mention our long-term musical collaboration: I learnt from an old diary that our attempts to play sonaras for flute and piano began on 30 March 1977, at pm 9.30 .
4. Carried out by J. de Koning in 1997-98 as part of the Frisia Project.
5. See Besteman 1990, 98.
6. Van Es, Sarfatij & Woltering 1988, 162-4.
7. Vons 1987.
8. The pit in question did not yield any other Roman imports, but some native pottery was found (find numbers 19.7.5 and 19.7.48). Two soil samples were taken for archaeobotanical research (find numbers 19.7.46 and 19.7.47), which have not yet been analysed.
9. By Dr. W. Casparie, then of the Biologisch-Archaeologisch Instituut (BAI), University of Groningen.
10. By H.F. Wijnman.
11. Seiko Chromatic Auto-Tuner ST1000; a=440 Hz.
12. See Reinach 1907, *Planche* XXII; 1969, figs. 6706, 6707.
13. See Homo-Lechner & Vendries 1993, no. 71.
14. The back also has a few recent deep grooves, which occurred during the digging that preceded the discovery.
15. See Gaitzsch 1980, 28-33.
16. See Gaitzsch 1980, 33-4.
17. Personal communication by Dr. E.L. Heins, University of Amsterdam.
18. Häusler 1960, 153.
19. Burial finds in Mariupol (Dnepr-Donets Culture), Ukraine, and Skarovka (*Ockergrabkultur*), Russia: Häusler 1960, 153-60.
20. Przeczyce: Coles 1975, 164, fig. 37.
21. Klein-Kühnau, Kr. Dessau: Behn 1912-13, 286; 1954, 147, *Abb.* 195. Brodribb, Hands & Walker (1973, 44) mention *'a fragmentary bronze syrinx'* from Klein-Kühnau, but they appear to confuse it with the panpipes from Bon-Encontre, France, mentioned below.
22. See for instance the overview in Reinach 1969 and the examples in Behn 1954.
23. Reinach 1907; Homo-Lechner & Vendries 1993, no. 118.
24. Ulbert 1961, 56-9, Taf. 1.
25. Brodribb, Hands & Walker 1973, 44-6.
26. Homo 1987; Homo-Lechner & Vendries 1993, no. 117.
27. Homo-Lechner & Vendries 1993, no. 116. The instrument is also mentioned by Reinach 1969, 1597 (with a reference, note 4, to Reinach 1907 where, however, the pipes are not mentioned), by Behn (1954, 147), and by Brodribb, Hands & Walker (1974): see note 21.
28. Unclear picture in Niessen 1911, no. 3231; described and better depicted in Behn 1912-13.
29. Cothen: Van Tent 1976, fig. 10, dated to the 15th or 16th century AD; Albergen: Hesselink - v.d. Riet & Verlinde 1980, 212-4, dated to the 16th-17th century.
30. Ludowici 1901-04, 137, no. 11; Behn 1954, 111.
31. They do not have a length of 20 to 55 mm as is assumed by Brodribb, Hands & Walker (1973, 46).
32. Reinach 1907, 161; see also Ulbert 1961, 58.
33. Reinach 1907, 163.
34. Ulbert 1961, 57, note 26a.
35. Homo-Lechner & Vendries (1993, no. 118) give measurements, some of which differ slightly, derived from the conserved panpipes: a height of 117 mm, a maximum width of 77 mm and a thickness of 8 to 13 mm.
36. Reinach 1907, 164.
37. Reinach (1907, 164) assumes that the pipes were made by means of a red-hot pointed rod, *'sans aucune torsion, et d'une main très sûre'*, but given the hardness of the wood, the depth of the pipes and the small distance between them and the front and the back of the instrument, this does not seem very likely.
38. Reinach 1907, 182.
39. Ulbert 1961, 58.
40. *'... as closely as can be determined without reckoning quarter-tones ...'*, Brodribb, Hands & Walker 1973, 46.
41. Gaitzsch 1980.
42. Heinz 1991.
43. This or a related idea had been developed before (in 1982), but not written down, by A. Bruijn (ROB).
44. E.g. Behn (1954, 111): *'Ein eigentliches Kunstinstrument ist die Syrinx nie gewesen...'*).
45. Reinach 1969, 1599.
46. Personal communication by W.F.K. Mann (Bussum).
47. As is the case with, for instance, boxwood panpipes from Early Medieval York: Hall 1984, 116.
48. See Reinach 1907, 182-3, in his account of the panpipes from Alesia. An additional complication is that the formula to be used for this purpose ($n=c/4l$, in which n stands for the number of vibrations per sec., c for sonic speed in mm per sec., and l for pipe length in mm) only applies when the length of the pipes is at least 12x their diameter (Reinach 1907, 183). A larger diameter lowers the tone; this certainly applies to the three wooden instruments. The similarity between the tones acquired by blowing the panpipes from Alesia and the calculated pitch levels is therefore based entirely on coincidence.

49. Personal communication by Dr. E.L. Heins (University of Amsterdam).
50. Personal communication by Dr. E.L. Heins (University of Amsterdam) and W.F.K. Mann (Bussum). Contemporary Peruvian panpipers use pieces of maize grains for this purpose: noticed by Dr. J.A. Brongers (ROB) during a performance by buskers in Amersfoort city centre.
51. Personal communication by Dr. E.L. Heins (University of Amsterdam), and W.F.K. Mann, (Bussum).
52. According to Dr. E.L. Heins (University of Amsterdam), personal communication.
53. See for instance Walcker-Mayer 1972, 77-9.

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