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# Bird Calls from a Middle Neolithic Burial at Ajvide, Gotland? Interpreting Tubular Bird Bone Artefacts by Means of Use-wear, Sound Analysis, and Ethnographic Analogy

Riitta Rainio & Kristiina Mannermaa

**ABSTRACT** **Large tubular bone artefacts were found in a hunter-gatherer burial belonging to the Pitted Ware culture at Ajvide on the western coast of Gotland, Sweden. The artefacts were mainly fashioned from the sawn ulnae and radii of swans, and they can be categorised as broad tubes (D13 mm), narrow tubes (D8 mm), and tubes with three perforations in a row on two opposite sides. Some of the tubes were found inside other tubes, indicating that they formed two-piece artefacts. The original use or function of these unique artefacts is not known. A study of the use-wear revealed that the technology of making the artefacts was uniform and followed the same tradition. The size of the tubes, the two-piece structure, and some of the use-wear marks suggest that the artefacts could have been used for sound production. The perforations, however, are unsuitable to be used as finger holes. The closest parallel to the Ajvide artefacts can be found from the Native Americans, who used a similar two-piece artefact, made of a bird ulna and radius, for imitating a local bird. This instrument was played by sucking, unlike most aerophones.**

**KEYWORDS**

**music archaeology, aerophones, sucked tubes, burial finds, Middle Neolithic, North Europe**

## Introduction

Ajvide is located in the parish of Eksta on the western coast of Gotland, Sweden (**Fig. 1**). Large activity areas with signs of occupation and graves have been excavated during field schools in the 1980s, 1990s, and 2000s (Burenhult 1997b; 2002; Österholm 2008; Norderäng 2008a). Though there are traces of Mesolithic and Bronze Age activity at Ajvide, the most important occupation phase was during the Middle Neolithic. This occupation phase, c. 3100–2300 cal. BC, consists of settlement remains, ritual activity areas, and a burial ground (Burenhult 1997b; Österholm 2008; Norderäng 2008a). Culturally, these people were part of the Scandinavian Pitted Ware tradition, with an economy based on hunting, fishing, and gathering (Storå 2002; Olson *et al.* 2002; Mannermaa & Storå 2006; Olson & Walther 2007). In 2009, when the field school excavations at Ajvide had come to an end, a total of 85 single or multiple graves had been found (Norderäng 2008a). Most graves are richly adorned with animal tooth pendants, pieces of ceramic, stone, and bone artefacts, and unmodified animal bones, such as skulls and teeth, and the skeletal remains are well-preserved (Burenhult

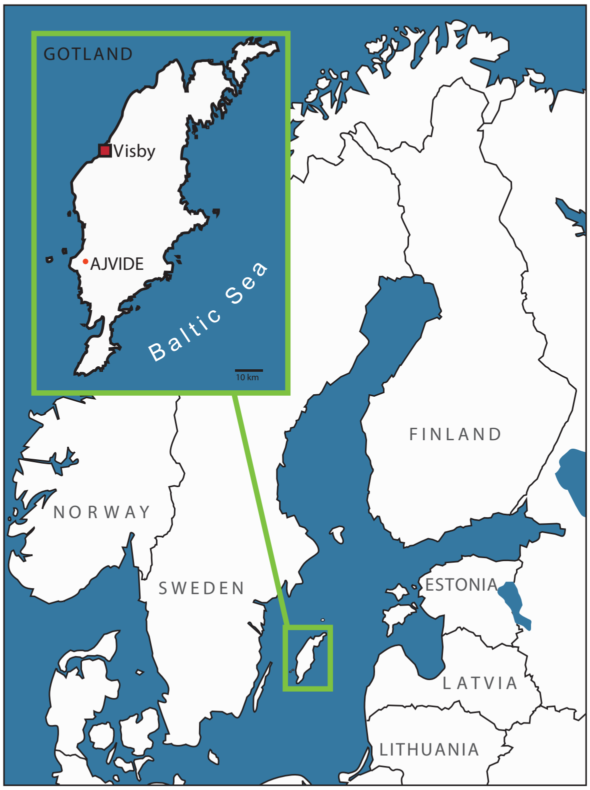


**Figure 1.** Location of the Ajvide site in Gotland, Sweden.

2002). Adult females and males of varying ages, as well as children, have been buried at Ajvide (Molnar 2008).

Grave 62 at Ajvide is very special from the point of view of the grave goods (**Fig. 2**). It not only had an extraordinary amount of grave goods, but it also included a type of artefact that had never before been described on Gotland or in neighbouring areas (Österholm 1998a; 1998b). The deceased is a woman of robust skull structure and relatively tall stature, aged between 25 and 30 years (Molnar 2002:373). She had been placed stretched out on her back, the upper body towards the south, and the head turned slightly towards the east (Burenhult 2002:116). A total of 70 finds were recorded, all of which could be associated with the skeleton in the same find context (Burenhult 2002:116–117). Grave goods are mainly animal bones, tooth pendants, and tools made of stone and bones. Among the unique finds are, for example, a butterfly-

**Figure 2.** Grave 62 at Ajvide. Bone tubes were found in a find concentration near the right arm and around the skull and shoulders. Reconstruction in Gotlands Museum (2006). Photograph by Kristiina Mannermaa.

shaped pendant made of sturgeon (*Acipenser sturio*) backbone plate and 30 worked pieces of mother of pearl (Österholm 1998a; 1998b). In addition to these and the bird bone tubes, the other animal bones in the grave derive from seal (Phocidae), mountain hare (*Lepus timidus*), boar/pig (*Sus scrofa*), hedgehog (*Erinaceus europaeus*), common crane (*Grus grus*), and cyprinid fish (Cyprinidae) (Burenhult 2002:116–117; Mannermaa 2008:208–209). According to the radiocarbon results, the burial took place c. 2500 cal. BC (Norderäng 2008b:Table 2).

In grave 62, a total of 44 bird bone tubes were found in a find concentration near the right arm and around the skull and shoulders (**Fig. 2; 3**) (Burenhult 2002:116–117, Fig. 108). The find concentration, which also contains other artefacts, could be the remains of a bag or other accessory. All these tubes are clearly worked: the epiphyses have been cut off and the ends finished carefully. A total of 23 % of the tubes have been perforated and another 23 % fitted together, thus forming two-piece artefacts. This set of tubular bone artefacts is unique. Similar perforated or two-piece artefacts have not been found in other graves on Gotland or in any other place in Europe. The closest similar artefacts are bone beads, abundant at many Stone Age cemeteries on Gotland and in northern Europe, but they are usually smaller and always unperforated (Nihlén 1927:121–130; Stenberger *et al*. 1943:96; Janzon 1974:67–74; Burenhult 2002). A few larger beads, however, have been found in graves 21, 23, 25, and 52 at Ajvide and at other sites on Gotland. They have been interpreted as possible flutes, whistles or bird calls (Nihlén 1927:121, 126, Fig. 104:9; Janzon 1974:74; Lund 1984:13, 15; Burenhult 1997a:65; 2002:98, 99, 109; Österholm 2008:42–43, 45, 115). Based on the similar size and the finger-hole-like perforations, the tubes of grave 62 were also published as flutes (Österholm 1998a; 1998b; Burenhult 2002:116–117), but their suitability for sound production was not studied systematically.

In this article, we discuss the function of the tubular bone artefacts of grave 62 from the perspective of music archaeology (auditory archaeology) (e.g. Lund 1979; Hickmann 1997). Here, we do not consider possible other lines of interpretation, such as viewing

**Figure 3.** Find concentration in grave 62: bone tubes, tooth pendants, bird tarsometatarsus artefacts, hedgehog (Erinaceus europaeus) mandibles, and a flint knife. Reconstruction in Gotlands Museum (2006). Photograph by Kristiina Mannermaa.

the artefacts as dress ornaments, buttons, needle cases, or textile tools. In an ongoing music-archaeological project at Ajvide, we have documented all artefacts and studied their traces of manufacture or use, with special attention to those that could be related to sound production. Our aim is to reassess the interpretation of the tubes as musical instruments – artefacts intended or used for sound production – but in a different form than previously assumed. We describe why the interpretation as traditional flutes with finger holes is unfeasible, but the interpretation as aerophones still conceivable. In the analysis, we take into consideration all playing techniques or voicing methods found in aerophones, namely: 1) blowing against the sharp edge of a tube (flutes, whistles), 2) blowing through a reed that has been attached to a tube (reed pipes), and 3) blowing or sucking through puckered lips that have been set against a tube (trumpets, sucked tubes). With all these methods, the air column inside the tube starts to vibrate and sets up a sound wave that can be heard as a tone.

## Methods

### Documentation and microscopic analyses

Tubular bone artefacts from grave 62 were studied at Gotlands Museum and Gotland University Department of Archaeology and Osteology in autumn 2011. We identified the bones with the help of a reference bird skeleton collection that was put together at the Finnish Museum of Natural History in Helsinki. The bones were studied with a binocular microscope with a magnification of 10.5 x (Leica Zoom 2000). We documented and studied use-wear marks in order to record all traces of manufacture and use, with special attention to those that could be related to sound production. All specimens were weighed and the width, length, and inner and outer diameter of the ends were measured. A document sheet was filled for every specimen with proper data: osteological and contextual data, measurements, marks as drawings, and a textual description. All specimens were also photographed.

### Copies and experiments

Based on the measurements, photographs, and other documentation, we prepared copies of some of the specimens. The copies represent different size categories, as well as artefact categories: unperforated, perforated, two-piece, and one-piece. The copies were made by using original materials: swan and gull bones as raw material and flint blades, points, and scrapers for working. By using the flint tools, we could explore the original manufacturing techniques, as well as marks emerging on the bones. The copies were tested and recorded both outdoors and at the studio of the University of Helsinki Music Research Laboratory with an Amprobe SM-20 sound level meter, two AKG C 460B condenser microphones, and a Fostex FR-2LE digital recorder. Sound samples were analysed by Sono and Spectutils spectrum analysis tools, which provide graphical representations of audio signals showing their acoustical properties (Lassfolk 2001; Lassfolk & Uimonen 2001). Finally, archaeological and ethnographical parallels for the possible aerophones were sought in literature and on the Internet.

## Results of the osteological and metrical study

### Osteological analysis

Our osteological analysis in 2011 revealed that most tubes in grave 62 are made from swan (*Cygnus* sp.) wing bones: ulna and radius (**Appendix 1**). Other birds used were the cormorant (*Phalacrocorax carbo*), gulls (Laridae), and ducks (Anatidae). Generally it can be said that the ulnae and radii of large and mid-sized water and shore birds were used. These bones are suitable for making tubular artefacts because they are long and straight. In fact, in many areas of the world, these bones have been typical raw material for beads and aerophones throughout the times, swan bones especially for aerophones (Janzon 1974:67–74; Münzel *et al.* 2002:108; Lawson 2004:74, 79, 83; d'Errico & Lawson 2006:44; Morley 2006a:62).

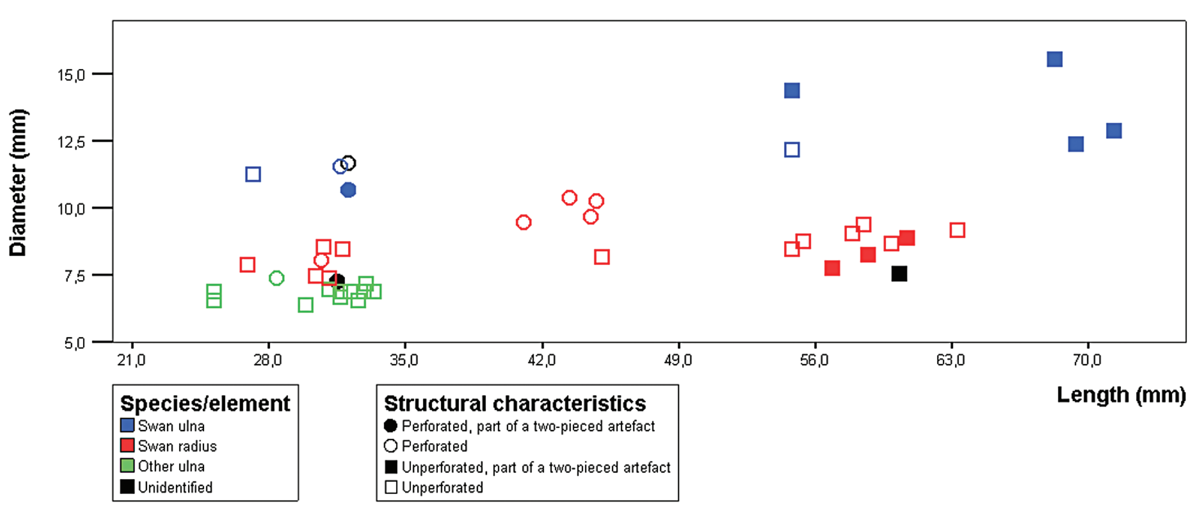


**Figure 4.** Scatter plot showing osteological, metrical, and structural characteristics of the bone tubes in grave 62 at Ajvide.

## Diameter and length of the tubes

The diameter of the tubes varies from 6 to 16 mm (**Fig. 4**). The swan bones are clearly wider than other bones, and the swan ulnae are wider than the swan radii. The diameter of the bore – the possible wind passage – varies from 4 to 10 mm. This means that these artefacts are narrower than most flutes, but still suitable for sound production (cf. Seeberger 1998:31; Münzel *et al.* 2002:108). A narrow bore of this size is even ideal for reed pipes and sucked tubes (cf. McIlhenny 1914:182; Leisiö 1998; Lawson 2004:80). Beads at Ajvide are usually 3–5 mm in outer diameter, at other Gotlandic sites c. 2–10 mm (Stenberger *et al.* 1943:96; Janzon 1974:67, 69; Mannermaa 2008:209–210).

The length of the tubes varies between 25 and 71 mm (**Fig. 4**). The swan bones can be short or long, whereas other bones are always short. Since the original length of the swan bones is c. 250 mm and the gull, cormorant, and duck bones c. 70–160 mm, it is evident that the bones have been cut rather short. This shortness suggests that the potential sound frequencies of the artefacts would have been high, resembling the sounds of whistles or some kind of bird calls (cf. Leisiö 1983:36–39, 65–66, 88–96; Lund 1984:13, 15; 1988:301–302; Radja 1994; Tamboer 2004). Using the acoustical formulae (e.g. Sengpiel 2012), it can be calculated that the fundamental frequencies of these tubes would have ranged from c. 1000 Hz to 5000 Hz, depending on whether the tubes were stopped or open at one end. Interestingly enough, the artefacts can also be arranged in stepwise categories. The categories of 25–32 mm and 41–45 mm consist of both unperforated and perforated artefacts, the categories of 55–63 mm and 68–71 mm only of unperforated artefacts. Most of the tubes forming two-piece artefacts belong to the 55–63 mm and 68–71 mm categories. From the acoustical point of view, these categories could suggest that the makers tried to achieve certain specific frequencies, like for example in pan pipes (cf. Häusler 1960:322–326, T. III:4, V:3; Baczynska & Babel 2007). The use as reed pipes, however, seems unlikely, since adding reeds to such short tubes would be pointless: the reeds themselves could easily provide the necessary tube length. Beads at Ajvide are only 14–30 mm in length, at other Gotlandic sites c. 10–40 mm (Stenberger *et al.* 1943:96; Janzon 1974:67, 69; Mannermaa 2008:209–210). Within the same find context, the beads are also more or less uniform in size (cf. Janzon 1974:Fig. 14c).


**Figure 5.** Two-piece bone artefacts made of the ulna and radius of a swan (Cygnus sp.) from grave 62: ID 34648 (upper) & ID 34649 (lower) . Photograph by Johan Norderäng.

## Two-piece artefacts

There are five two-piece artefacts. The tubes in these artefacts can be unperforated (ID 34647a, 34648a, 34648b, 34649a, 34649b, 34703a, 34703b, 34704b) or perforated (ID 34647b, 34704a) and the joints either loose or tight (**Fig. 5**). In all identifiable cases, the artefacts have been made by inserting a swan radius into a swan ulna by means of sticking one end of the radius in for a length of about 10–30 mm. The total length of the artefacts is 60–100 mm, though the broken artefact ID 34703 may have been a bit longer. The inner tube of the artefact ID 34647 may have slid in accidentally, as it is clearly narrower than the outer tube. The radius and ulna from the second joint of a swan wing seem to fit together almost naturally, without too much trimming. It seems possible, even probable, that some of the tubes that were found separately are actually parts of broken two-piece artefacts. This applies especially to the swan radii ID 34651, 34652, 34700, 34701, and 34711a, which are 55–63 mm long, and all separate swan ulnae. According to our tests, some of these bones actually fit together. A similar two-piece structure can be found in several aerophone categories: end-blown flutes (Rycroft 1984:280–281), slide whistles, and sucked tubes. In slide whistles, the inner tube serves as a piston that changes the pitch (Leisiö 1983:39, 118–119, 154). In


**Figure 6.** Perforated bone tubes from grave 62 (from left: ID 34677b, 34677c, and 34677a). Photograph by Johan Norderäng.

sucked tubes, the inner tube serves as a mouthpiece, while the outer tube affects timbre and volume (Stewart 1985; Williams 1996:167, 181–185). A similar structure cannot be found in beads or in any other archaeological artefact category, as far as we know.

### Perforated artefacts

There are ten perforated tubes. All except the unidentifiable bones ID 34677a and 34705 are swan bones. At first sight, the perforations do look like finger holes (**Fig. 6**), but the measurements taken point to another direction. The diameter of the oval perforations is c. 3 x 5 mm, that is, quite suitable for finger holes. The diameter of the marginal platforms, however, is 5 x 8 mm, which is too narrow for providing an airtight fingertip seal. The perforations are also placed so close together that it is nearly impossible to finger them, even for children. Moreover, the general layout seems awkward for a player. In all artefacts, there are three holes in a row on two opposite sides. Although traditional flutes in France and Spain can have three finger holes and two or three so-called thumb holes (Brown 1984a:763–764; Schechter 1984:766), the holes in these artefacts are always placed in turn, not opposite each other, like here. Therefore, it seems evident that the perforations in the Ajvide artefacts are not finger holes, but something else.

**Figure 7.** A bone tube with bevelled ends (ID 34650, the ulna of a swan Cygnus sp.). Scale 1: 1. Photograph by Johan Norderäng.

## Results of the use-wear and experimental study

### Bevelling of the ends

The first minor detail attracting attention in the Ajvide artefacts is the bevelling, tapering form of the ends, which appears in all tubes (**Fig. 7; 8**). Saw marks and striations perpendicular to the artefact's axis (ID 34650, 34651, 34702) suggest that the form was created by sawing, probably in connection with the initial cut. Bevelling is a common feature in aerophones, especially in end-blown flutes. In these instruments, it facilitates sound production by creating a sharp, even edge at which a player can direct the air flow (Brown 1984b:770, Fig. 1; Lund 1984:13, 15; Münzel *et al.* 2002:108). With the copies of the Ajvide artefacts, whistling sounds with definite pitch can be produced, although the volume of these sounds is not necessarily loud. The copies, which are 71, 57, 48, and 29 mm long, produce the respective fundamental frequencies 1040, 1310, 1550, and 1660 Hz when the lower end is stopped with a finger and the upper end is placed at the smallest possible angle to the lips (Sound sample 1, **Fig. 9**). At a distance of one metre, the A-weighted sound pressure level ranges from 48 to 82 dB. This, however, does not prove that the artefacts were used for sound production, since the bone beads, in Gotland, also have bevelled ends. When cutting the bones for the copies, we noticed that some kind of bevelling resulted automatically from using blunt and thick flint blades. Thus, the resemblance of the Ajvide artefacts to end-blown flutes can be coincidental.

**Figure 8.** A close-up photo of a bevelled end (ID 34677c, the diameter of the end is 10.4 mm). Photograph by Johan Norderäng.

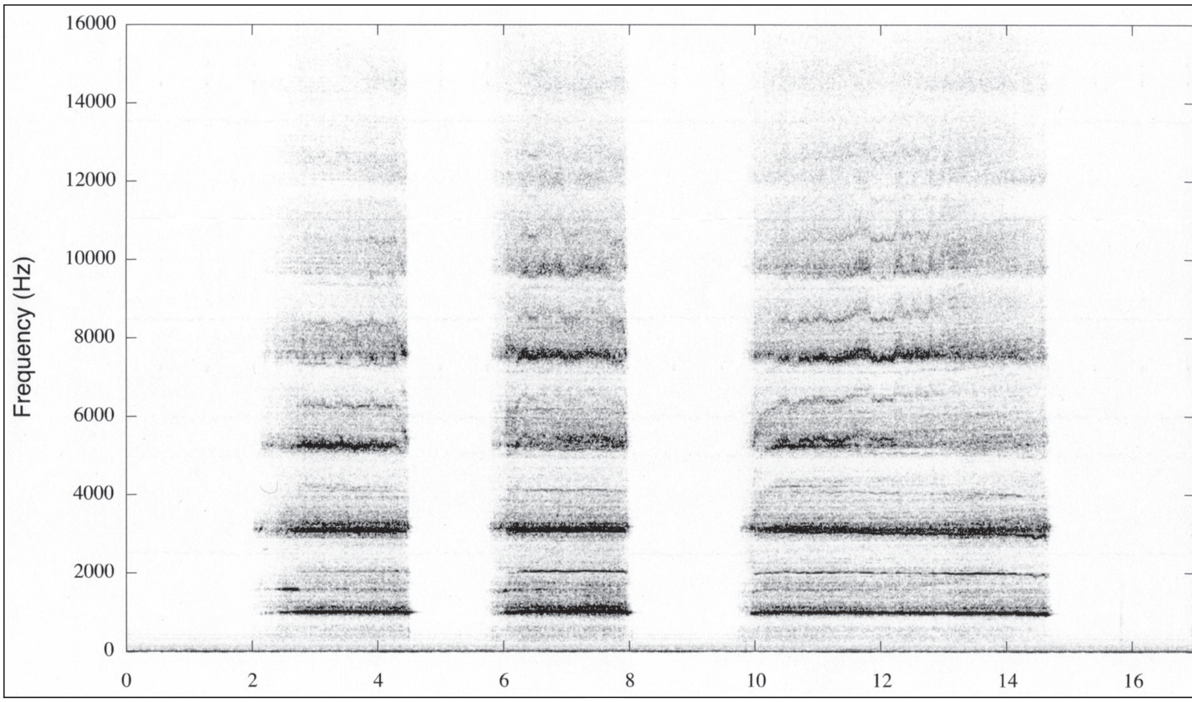


**Figure 9.** Sonogram showing the sound frequencies (kHz) produced by playing the copy of ID 34647a as an end-blown flute. The X axis shows the time in seconds.

## Rounding on the ends

Although bevelled, the ends of the Ajvide tubes also present a more or less rounded form (**Fig. 10**). This rounding appears in almost all artefacts – especially in the swan radii and gull, cormorant, and duck ulnae – on both ends. Outer rims, and in 20 % of the cases also inner rims, are smooth and shiny, as if they had been deliberately ground or handled for a long time. This smoothness is very similar on all these tubes, and we think that natural taphonomic processes are an unlikely cause for this. Short radial striations on the rims of the swan bones ID 34647a, 34649a, 34676, 34677a, 34701, and 34711a suggest that the artefacts could also have been filed after being cut. The perforated tubes ID 34704a, 34706, and 34708 present a less rounded form. Smoothness is essential for all kinds of aerophones: on the mouthpieces of end-blown flutes, reed pipes, and sucked tubes, all rough protrusions and irregularities, which could harm the lips, are sanded down. Also the inner rims and inner surfaces, which house the air column, are cleaned up carefully (e.g. McIlhenny 1914:183; Stewart 1985; Buisson 1994:262; 122; Williams 1996:171, 176–180, 202; Patton 2002:46; Lawson & d'Errico 2004). Although the bone beads in Gotland also have rounded ends, this rounding is more often incomplete, according to our observations. The inner rims of bone beads have not been studied systematically.

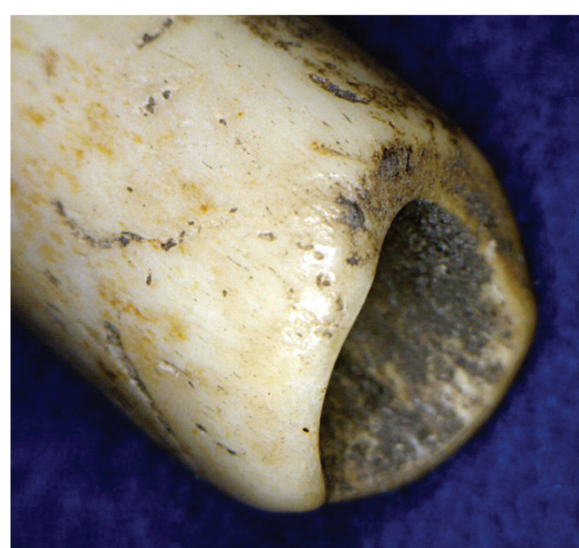

**Figure 10.** A bone tube with a rounded end with a notch (ID 34698, the diameter of the end is 7.9 mm). Photograph by Kristiina Mannermaa.

**Figure 11.** A close-up photo of a notched end (ID 34697, the diameter of the end is 6.9 mm). Photograph by Johan Norderäng.

## Notches on the ends

Notches appear in 30 % of the Ajvide tubes – especially in the swan radii and gull, cormorant, and duck ulnae – on one or two ends (**Fig. 10; 11**). These notches are U-shaped, a couple of millimetres deep, and made by sawing, as the saw marks in the margins indicate. In the artefacts ID 34697 and 34698, one end is cut obliquely from two opposite sides, presenting a pointed profile when viewed from the side. Notches are also common in aerophones. In end-blown flutes, they create a sharp edge at which a player can direct the air flow (Brown 1984b:770, Fig. 1; Seeberger 1998:31). In reed pipes, they provide space for attaching the reed, although the notches in this case should be 1–3 cm deep (cf. Leisiö 1983:231–250; Wyatt 2012:Fig. 5). In sucked tubes, the notches fit comfortably against the sloping edges of the lips, thus helping to create an airtight seal (Schneider 1993:71, 74). The copies of the Ajvide artefacts – notched as well as unnotched – can easily be played as end-blown flutes and sucked tubes. In the case of sucked tubes, the sound can be extremely loud (see page 94). This, again, does not prove that the artefacts have been used for sound production, since the bone beads, in Gotland, can also have notched ends. According to our experiments with flint tools, shallow notches result naturally from sawing the bone from two opposite sides and then snapping it in two. This sawing technique, however, does not explain the deeper notches found, for example, in the artefacts ID 34697 and 34698.

**Figure 12.** A bone tube with a striated shaft (ID 34702, the diameter of the end is 8.2 mm). Photograph by Johan Norderäng.

## Striations on the shafts

The most notable traces on the shafts of the Ajvide tubes are the straight striations along the long axis (**Fig. 12**). These striations appear in 41 % of the artefacts and exclusively in the swan bones. Especially the swan radii ID 34656, 34662, 34675g, and 34702 are entirely striated. According to our experiments with flint tools, these striations may result from some kind of trimming: scraping the bones clean of grease and meat and shaping them into a more cylindrical form, removing crests and ridges. On the artefacts ID 34651 and 34701, the striations clearly appear on the crests, and they seem to make these radii more cylindrical than the unworked ones. Similar straight striations can be found in a few tubular bone artefacts that have been interpreted as aerophones. In the palaeolithic bird bone "flutes" from France and Germany, the striations could be related to shaping and finishing the outward appearance of the instruments (Buisson 1994:262; Münzel *et al*. 2002:108, Fig. 5a; Conard *et al*. 2009:Fig. 1). In the sucked tubes from Tennessee (6500 BC), the striations could be related to the trimming that was meant to make two bones fit together to form two-piece artefacts (Harlan 1994:92–93; Patton 2002:45; Hodges 2012). In the case of slide whistles, theoretically speaking, the striations could result from sliding two bones inside each other, but making feasible – that is, airtight – slide whistles from bone material seems awkward and improbable (cf. Leisiö 1983:39, 118–119, 154). In Gotlandic beads, straight striations along the long axis have not been reported.

### Saw marks around the perforations

Apart from the ends of the Ajvide tubes, saw marks appear in the marginal platforms of the perforations and around them (**Fig. 13**). They indicate that the perforations have been made by sawing perpendicularly to the artefact's axis with a flint blade. This method is contrary to the method used in the palaeolithic bone aerophones, in which the perforations – obvious finger holes – have usually been made by carving parallel to the artefact's axis (Buisson 1994:263; Lawson & d'Errico 2002:123; d'Errico & Lawson 2006:43–44). The latter method provides sufficiently large platforms for fingertips. The saw marks in the marginal platforms of the Ajvide artefacts also indicate that the perforations are in a more or less pristine condition: they are not rounded or polished by use, like the finger holes in palaeolithic and medieval bone aerophones (Buisson 1994:265; Lawson & d'Errico 2002:125, Fig. 4; Tamboer 2004:181). It seems that the perforations in the Ajvide artefacts were hardly handled after the sawing.

**Figure 13.** Saw marks in the marginal platform of the perforation and around it (ID 34677b, the diameter of the perforation is 3.5 x 4.3 mm). Photograph by Johan Norderäng.

**Table 1.** Characteristics of the studied bone tubes and the occurrence of these characteristics in Gotlandic bone beads and aerophones in general.

| Bone tubes in grave 62 | Bone beads | Aerophones |
|---|---|---|
| Bevelled ends | + | + |
| Rounded ends (outer rim) | + | + |
| Rounded ends (inner rim) | ? | + |
| Notches | + | + |
| Scraped shafts | – | + |
| Wingbones | + | + |
| Swan bones | – | + |
| Two-piece structure | – | + |
| Diameter (6–16 mm) | – | + |
| Length (25–71 mm) | – | + |
| Variation of length in a set | – | + |
| Diameter of the perforations (3 x 5 mm) | – | + |
| Diameter of the platforms (5 x 8 mm) | – | – |
| Placement of the perforations (3 + 3) | – | – |

## Discussion

### The tradition of making tubular bone artefacts

The results of this study can be summarised by drawing up a table that shows the characteristics of the studied tubular artefacts and the occurrence of these characteristics in Gotlandic bone beads and aerophones in general (**Table 1**). As can be seen, the bevelled ends, rounded ends, notches, and wing bones are characteristic of both beads and aerophones. As such, they cannot be seen as indicators of acoustical purposes or uses, but they can be seen to represent the "tradition of making tubular bone artefacts".

The scraped shafts, swan bones, two-piece structure, and different size attributes of the artefacts are characteristic of the aerophones, possible for or typical of them. They suggest that the artefacts of Ajvide could have been intended or used for sound production. A counterargument is related to the perforations, which are unique and absolutely unsuitable to be used as finger holes or for some other kind of sound production. Therefore, the evidence in support of the aerophone hypothesis is significant, but mixed.

## Sucked tubes

The playability of the copies, however, can be seen to tilt the balance back in the favour of the hypothesis. When all documentation, experiments, and sources are taken into consideration, the closest match for the Ajvide finds seems to be the instrument category of sucked tubes. Although rare and insufficiently documented, certain archaeological and ethnographical examples of this category seem to share almost all characteristics with the Ajvide artefacts, especially the two-piece ones.

The most frequently used sucked tubes these days are wingbone turkey calls, traditional hunting tools of the Native Americans and modern North American hunters (Harlan 1994:31–35, 71). In their traditional form, these calls are two-piece and made from a turkey (*Meleagris gallopavo*) radius and ulna that have been cut, scraped, filed, and ground to get them to fit together and to create an airtight seal with the help of sinew, thread, or pine resin. Especially the radius, which acts as a mouthpiece, has been trimmed, rounded, and bevelled carefully (Williams 1996:166–185; Patton 2002). An additional cut humerus can act as an end-piece if a three-piece call is preferred. The wingbone calls are played by placing the mouthpiece between puckered lips and sucking in air through the call. While the narrow radius is necessary for creating the sound, the broader ulna and the additional humerus amplify the sound and give it a hollow, more animal-like timbre. This effect is still strengthened by twisting two fingers around the large, open end of the call and making a cone with both palms (Stewart 1985; Williams 1996:181–189, 194–199; Miniter 1998; Patton 2002:47). The sound thus created resembles the vocalisation of a large bird, such as a turkey.

The wingbone calls are used for calling turkeys: luring birds within shooting distance by imitating their sounds. Mating, assembly, and social calls, as well as the cries of immature individuals, can be used for the purpose (McIlhenny 1914:185–197). The tradition of using calls can be traced back to the 19th and 18th centuries, to the Native Americans of Virginia, and even to prehistoric times, as the unearthed two-piece artefacts from Tennessee can be dated to 1000 BC–AD 1000 and 6500 BC (Lewis & Kneberg Lewis 1961:84, Pl. 38, 39; Harlan 1994:31–35, 92–93, 153–154). In Europe, sucked tubes are almost unknown, but in the north-eastern part of Europe and in Siberia, they were used by several peoples: the Permians, Ob-Ugrians, Tunguses, Buryats, Yakuts, Khakas, and other Northern Turkic tribes. Their narrow (0.3–4 cm) and long (60–120 cm) instruments were made of vascular plants, bark, or wood and used for calling deer and playing melodies, thanks to the harmonic partial frequencies of the long tubes (Leisiö 1993; 1998). The name of the Komi instrument, *yus' pöl'an* or 'swan blower', suggests that the partial frequencies were also used for imitating and calling swans (Leisiö 1998:67–68, 76, 84). Some kind of swan calls are even used by modern North American bird watchers and hunters (Mack's Prairie Wings 2012).

## Testing the copies as sucked tubes

As most of the Ajvide artefacts are made of swan bones, this information sets a standard for our experiments with the copies. After the first coughing sucks and smacks, the two-piece copies produced short clucks (Sound sample 2), yelps and finally long trumpeting tones (Sound sample 3, 4). The fundamental frequency of these trumpeting tones moves around 760–930 Hz (**Fig. 14**), which corresponds to the fundamental frequency of natural swan vocalisations (ML Audio 3744; XC27170; XC28927; XC44501; XC45985; XC48094; XC87295). Also the harmonic structure of the partial frequencies – from eight to seventeen in number – corresponds to the harmonic structure of swan vocalisations, meaning that these two sounds appear roughly the same. Another striking feature is that the sound of the copies is extremely loud. At a distance of one metre, the A-weighted sound pressure level ranges from 80–91 dB and the sound easily carries 350–400 m. In several test occasions near the woods, a raven (*Corvus corax*), crow (*Corvus corone*), magpie (*Pica pica*), jay (*Garrulus glandarius*), great spotted woodpecker (*Dendrocopos major*), or great tit (*Parus major*) answered or got close to the player. This means that the two-piece artefacts of Ajvide would have been effective sound-producers, possibly some kind of bird calls or even swan calls, if they had been played with the sucking technique. Individual radii can also be played

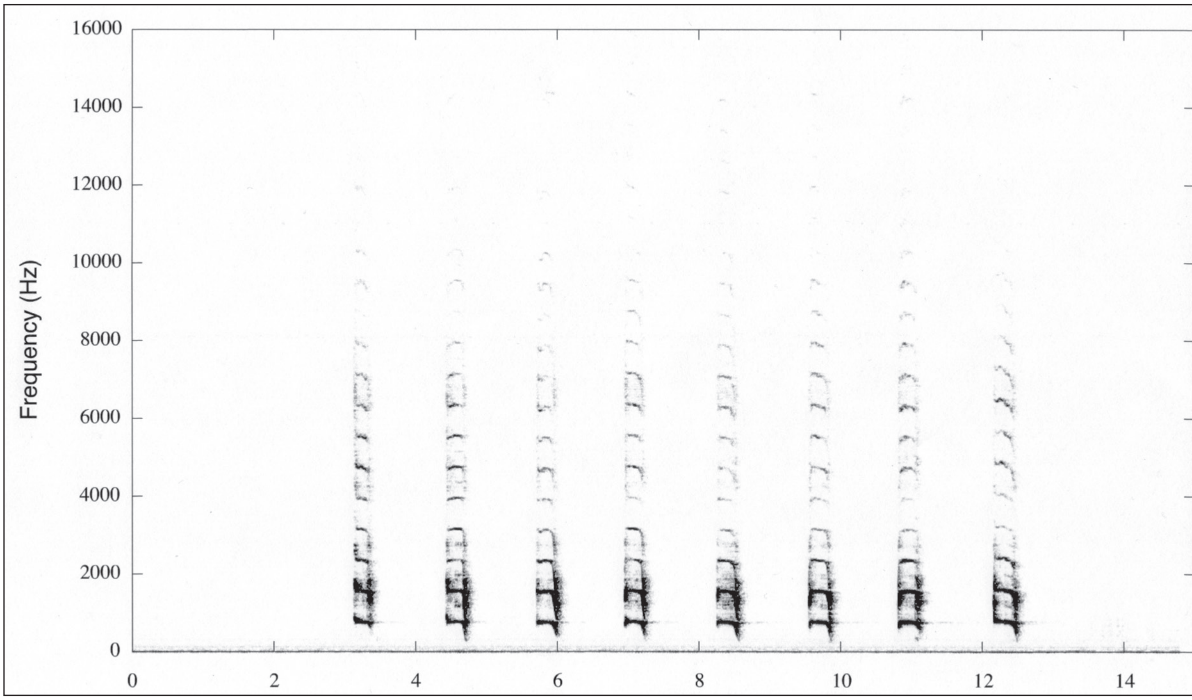


**Figure 14.** Sonogram showing the sound frequencies (kHz) produced by playing the copy of ID 34703 as a sucked tube. The X axis shows the time in seconds.

with this technique, but the sound is then quieter and higher, resembling the vocalisation of a smaller bird or a mouse. Descending hawk- or gull-like cries can be produced by loosening the puckered lips at the end of each sound.

Interpreting the artefacts as sucked tubes would explain most of the characteristics found in the Ajvide artefacts: the two-piece structure, use of radius and ulna, scraped shafts, bevelled, rounded, and notched ends, and the fact that the narrowest bones – possible mouthpieces – are the most heavily worked. This interpretation would not explain the function of the perforated tubes, but it can offer a clue. In the Native American wingbone turkey calls, the discarded extra pieces of the cut bones are often threaded on the neck lanyard of the call, or slipped over the mouthpiece to hold the lanyard in place (Miniter 1998; Patton 2002:47; Young 2012). Having a lanyard is important, since it allows the hunter to use both hands for handling the weapon when needed. Following this lead, the perforated tubes of Ajvide could be interpreted as beads that decorated the mouthpiece (ID 34704) and some kind of carrying strap or neck lanyard. Some of the unperforated short tubes could also have been beads. On the whole, the 44 bone tubes of grave 62 could possibly be interpreted as a set of about ten wingbone bird calls with their appropriate accessories and decorations. According to experienced hunters, a hunter might need several calls of different sizes for luring male, female, and young individuals (Lund 1988:299; Oklahoma Department of Wildlife Conservation 2012).

## Conclusions

Interpreting archaeological artefact finds, let alone possible prehistoric aerophones, is not an easy task. According to earlier studies on prehistoric bone flutes and pipes and our own experiences in this study, it is difficult to find unambiguous evidence of past acoustical purposes or uses and hard to differentiate between possible voicing methods. The voicing methods of many aerophone finds are still disputable (Lawson & d'Errico 2002:122–123; Ringot 2012; Wyatt 2012). The best way to approach this kind of material, in our opinion, is to set wide archaeological, ethnographical, and organological contexts and search for an alternative that explains the material best. According to our analysis, the closest match for the Ajvide artefacts is the instrument category of sucked tubes, more precisely Native American -style wingbone calls. These calls share most of their characteristics with the Ajvide artefacts, most importantly the two-piece structure, which otherwise is almost unknown in the archaeological and ethnographical literature. This interpretation, however, does not offer a fully acceptable explanation for the perforations found on some of the Ajvide finds. The perforated tubes definitely had a significant role in the burial, representing the personal belongings of the woman in grave 62. Perhaps, in the future, a proper use-wear analysis with scanning electron microscope (SEM) could bring additional information about how these artefacts were used.

In this study, we have shown that the copies of the Ajvide artefacts work efficiently as sucked tubes, offering wide possibilities for producing loud and carrying clucks, yelps, tones, and cries. As bird calls, they sound more realistic than end-blown flutes, which is another acoustical explanation for the finds. If the Ajvide artefacts were used for producing bird-like vocalisations, we still cannot say for sure why these sounds were produced. A logical function would be that birds were imitated and called to get them closer to the hunter. The birds could also be imitated for ritual or religious purposes, which is common with the music of recent hunter-gatherers and other archaic societies (Siikala 1978:99, 107, 115, 134–136, 167–170, 333–336; Morley 2006b:96, 101–102). Prehistoric finds of sucked tubes have been unknown in Europe until now, but the instrument category is so rare and – until the 1990s – poorly documented that its representatives have hardly even been sought. Some of the prehistoric representatives may also have been made of vascular plants or bark (Leisiö 1998:84–85, 91–93). In seeking for an acoustical explanation for archaeological tubular bone artefact finds, the category of sucked tubes should be regarded as a relevant alternative, especially if the artefacts are two-piece.

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XC27170=Whooper Swan – Cygnus cygnus, Patrik Åberg, Amperna Sweden, 2008–03–02, xeno-canto, www.xeno-canto.org/27170

XC28927=Whooper Swan – Cygnus cygnus, Ante Strand, Båtfors Sweden, 1992–03–12, xeno-canto, www.xeno-canto.org/28927
XC44501=Whooper Swan – Cygnus cygnus, Matthias Feuersenger, Rethem/Aller Germany, 2010–02–14, xeno-canto, www.xeno-canto.org/44501

XC45985=Whooper Swan – Cygnus cygnus, Nils Krabbe, Yngsjoe Sweden, 2010–03–28, xeno-canto, www.xeno-canto.org/45985

XC48094=Whooper Swan – Cygnus cygnus, Matthias Feuersenger, Huhtilampi Finland, 2010–04–14, xeno-canto, www.xeno-canto.org/48094

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## Sound samples

Sound sample 1. Whistling tones produced by playing the copy of ID 34647a as end-blown flute. Riitta Rainio, University of Helsinki Music Research Laboratory, Finland, 5.11.2012, https://tuhat.halvi.helsinki.fi/portal/eng/person/rrainio.

Sound sample 2. Clucks produced by playing the copy of ID 34703 as sucked tube. Riitta Rainio, University of Helsinki Music Research Laboratory, Finland, 5.11.2012, https://tuhat.halvi.helsinki.fi/portal/eng/person/rrainio.

Sound sample 3. Trumpeting tones produced by playing the copy of ID 34703 as sucked tube. Riitta Rainio, Renko, Finland, 4.11.2012, https://tuhat.halvi.helsinki.fi/portal/eng/person/rrainio.

Sound sample 4. Trumpeting tones produced by playing the copy of ID 34648 as sucked tube. Riitta Rainio, University of Helsinki Music Research Laboratory, Finland, 5.11.2012, https://tuhat.halvi.helsinki.fi/portal/eng/person/rrainio.

**Appendix 1.** Taxonomic and anatomical identifications, measurements, and other characteristics of the bone tubes in grave 62 at Ajvide.

| ID no. | Perforations | I/O | Species | Element | L | OD | ID | B | S1 | S2 | R | N | ST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34646 | Perforated | | *Cygnus* sp. | radius sin. | 35.5 | 9.7 | 5.6 | + | | + | + | | + |
| 34647 | Unperforated | outer | *Cygnus* sp. | ulna sin. | 71.3 | 12.9 | 9.8 | + | + | | + | | + |
| | Perforated | inner | - | - | 31.5 | 7.3 | - | - | - | - | - | - | - |
| 34648 | Unperforated | outer | *Cygnus* sp. | ulna sin. | 54.8 | 14.4 | 8.7 | + | | | + | + | |
| | Unperforated | inner | *Cygnus* sp. | radius sin. | 58.7 | 8.3 | 5.6 | + | | | + | | |
| 34649 | Unperforated | outer | *Cygnus* sp. | ulna sin. | 68.3 | 15.6 | 9.7 | + | + | | + | | + |
| | Unperforated | inner | *Cygnus* sp. | radius sin. | 60.7 | 8.9 | 5.7 | + | | | + | | + |
| 34650 | Unperforated | | *Cygnus* sp. | ulna sin. | 54.8 | 12.2 | 8.7 | + | + | | + | + | |
| 34651 | Unperforated | | *Cygnus* sp. | radius sin. | 63.3 | 9.2 | 6.4 | + | + | | + | + | + |
| 34652 | Unperforated | | *Cygnus* sp. | radius | 58.5 | 9.4 | 5.6 | + | + | | + | + | + |
| 34653 | Unperforated | | Anatidae | ulna | 31.7 | 6.9 | 4.9 | + | + | | + | | |
| 34654 | Unperforated | | *Phalocrocorax carbo*? | ulna | 32.6 | 6.6 | 4.6 | + | + | | ++ | | |
| 34655 | Unperforated | | *Larus* sp. | ulna sin. | 33.0 | 7.2 | 4.7 | + | | | + | ++ | |
| 34656 | Unperforated | | *Cygnus* sp. | radius | 31.1 | 7.4 | 5.9 | + | + | | + | | ++ |
| 34657 | Unperforated | | - | ulna | 25.2 | 6.6 | 4.4 | + | | | ++ | | |
| 34662 | Unperforated | | *Cygnus* sp. | radius sin. | 30.8 | 8.6 | 5.8 | + | + | | ++ | + | ++ |
| 34675a | Unperforated | | *Cygnus* sp. | radius | 31.8 | 8.5 | 5.4 | + | + | | + | ++ | |
| 34675b | Unperforated | | *Phalacrocorax carbo*? | ulna | 29.9 | 6.4 | 4.7 | + | + | | + | ++ | |
| 34675c | Unperforated | | Anatidae | ulna | 32.2 | 6.9 | 4.6 | + | + | | ++ | ++ | |
| 34675d | Unperforated | | *Larus* sp. | ulna sin. | 33.4 | 6.9 | 4.6 | + | + | | + | ++ | |
| 34675e | Unperforated | | *Phalacrocorax carbo*? | ulna | 31.7 | 6.7 | 5.0 | + | + | | + | + | |
| 34675f | Unperforated | | *Larus* sp. | ulna | 32.9 | 6.9 | 4.7 | + | + | | ++ | ++ | |
| 34675g | Unperforated | | *Cygnus* sp. | radius | 30.4 | 7.5 | 5.8 | + | | | ++ | ++ | ++ |
| 34676 | Unperforated | | *Cygnus* sp. | radius dex. | 55.4 | 8.8 | 5.9 | + | + | | + | ++ | + |
| 34677a | Perforated | | - | - | 32.1 | 11.7 | 9.4 | + | + | + | + | + | |
| 34677b | Perforated | | *Cygnus* sp.? | radius? | 44.8 | 10.3 | 7.0 | + | + | + | + | | |
| 34677c | Perforated | | *Cygnus* sp. | radius | 43.4 | 10.4 | 6.8 | + | + | + | + | ++ | |
| 34697 | Unperforated | | *Larus* sp.? | ulna | 25.2 | 6.9 | 4.7 | + | + | | + | + | |
| 34698 | Unperforated | | *Cygnus* sp. | radius dex. | 26.9 | 7.9 | 4.7 | + | | | ++ | ++ | |
| 34699 | Unperforated | | - | - | - | - | - | - | - | - | - | - | - |
| 34700 | Unperforated | | *Cygnus* sp. | radius dex. | 57.9 | 9.1 | 6.0 | + | + | | ++ | ++ | |
| 34701 | Unperforated | | *Cygnus* sp. | radius sin. | 59.9 | 8.7 | 6.5 | + | + | | + | ++ | + |
| 34702 | Unperforated | | *Cygnus* sp. | radius | 45.1 | 8.2 | 4.9 | + | + | | ++ | + | ++ |
| 34703 | Unperforated | outer | *Cygnus* sp. | ulna | 69.4 | 12.4 | - | + | - | - | + | - | - |
| | Unperforated | inner | - | - | 60.3 | 7.6 | - | + | - | - | + | - | - |
| 34704 | Perforated | outer | *Cygnus* sp. | ulna | 32.1 | 10.7 | 7.3 | + | + | | + | | + |
| | Unperforated | inner | *Cygnus* sp. | radius | 56.9 | 7.4 | 5.4 | + | | | + | | + |
| 34705 | Perforated | | - | ulna | 28.4 | 7.4 | 5.0 | + | + | | + | + | |
| 34706 | Perforated | | *Cygnus* sp. | radius | 30.7 | 8.1 | 4.7 | + | + | | + | + | + |
| 34707 | Perforated | | *Cygnus* sp.? | ulna sin. | 31.7 | 11.6 | 8.6 | + | + | + | + | + | |
| 34708 | Perforated | | *Cygnus* sp. | radius dex. | 41.1 | 9.5 | 6.9 | + | + | + | + | ++ | |
| 34709 | Unperforated | | *Cygnus* sp. | ulna | 27.2 | 11.3 | 7.0 | + | + | | ++ | ++ | + |
| 34711a | Unperforated | | *Cygnus* sp. | radius sin. | 54.8 | 8.5 | 5.2 | + | + | | + | | + |
| 34711b | Unperforated | | *Larus* sp. | ulna dex. | 31.1 | 7.0 | 4.7 | + | + | | + | ++ | |

Abbreviations: ID no. = ID number, I/O = inner/outer tube in a two-piece artefact, L = length (mm), OD = largest outer diameter (mm), ID = largest inner diameter / diameter of the bore (mm), B = bevelling on the ends, S1 = saw marks on the ends, S2 = saw marks on the shaft, around the perforations, R = rounding on the ends, N = notch/notches on the ends, ST = longitudinal straight striations on the shaft.