MUSICA, CULTI E RITI NELL'OCCIDENTE GRECO

A CURA DI

ANGELA BELLIA

TELESTES

STUDI E RICERCHE DI ARCHEOLOGIA MUSICALE NEL MEDITERRANEO

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ISTITUTI EDITORIALI E POLIGRAFICI INTERNAZIONALI

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SOMMARIO

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THE *AULOS* OF POSEIDŌNIA

STELIOS PSAROUDAKĒS*

INTRODUCTION

AN 'Early' type Hellenic *aulos*[1] made of deer bone[2] is kept at the Paestum Archaeological Museum (FIG. 1), under the inventory number 23068.[3] It was found in 1969[4] in the small cemetery at Tempa del Prete[5] (FIG. 3), 1.5 km[6] to the south of the ruins of Poseidōnia/Paestum,[7] in Grave 21. The cemetery has been dated to the period from the end of the 6th to the 4th c. BC.[8] The date given to the Grave 21 burial is about 480 B.C.[9] The instrument was examined by the present writer on the 16th of January 2012.[10]

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[1] As 'Early' type is described the Hellenic (double) *aulos* of the Archaic and Classical periods, mainly, which has no mechanism for operating on the tone holes; the bare fingers are used for the purpose. The two pipes which comprise an 'Early' *aulos* are of unequal length, and are made either of wood – in two sections (the bulbous mouthpiece and the cylindrical tube), or of bone (usually in four sections).

[2] "Osso di cervo"; Paestum Museum Exhibition Case Card (FIG. 2).

[3] BELLIA 2010, p. 103, n. 10; BELLIA 2012, p. 98, n. 44.

[4] BESCHI 2001, p. 178, n. 14; Exhibition Case Label.

[5] For a description of the Tempa del Prete cemetery see GRECO 1982, pp. 54-56; CIPRIANI 2002, pp. 373-374. See, also, CIPRIANI-PONTRANDOLFO-ROUVERET 2004, pp. 8-11, for a brief but comprehensive outline of the ancient cemeteries in the area.

[6] LEPORE 2010, p. 448, n. 34.

[7] The Hellenic city-state of Poseidōnia was founded in the 6th c. B.C. by the Sybaritai, 10 km to the south of the (ancient) mouth of river Silaros or Silaris (now Sele), Campania. In 410 B.C., it fell to the Lucanians and gradually became Oscanized; its name was then italized to Paistos or Paistom. In 273 B.C., it became a Latin colony under the name Paestum. In the 1st c. A.D., it was known as Flavia. Round about 877 A.D., it was destroyed by the Saracens, and was never to be occupied again (BENVENUTI 1996; LOMAS 1999). On the grounds of its early – 5th c. B.C., perhaps even late 6th – date, the *aulos* could be regarded as a 'Hellenic' instrument. However, there is good evidence that amongst the 20 burials of the Tempa del Prete cemetery some belonged to people of local origin, the 'Tomb of the Diver' being cited as an example (ROBINSON 2011, p. 57). It has been argued that in the first half of the 5th c. B.C. ethnic mixing had occured in the area south of Poseidōnia, since a lot of time had passed from first contact between Hellēnes and nearby local tribes (ROBINSON 2011, p. 66). On the other hand, it does not seem probable that the Tomb of the Diver was made for an Etruscan (ROBINSON 2011, p. 57). For the "hybrid character" of the Tomb of the Diver, contemporary with Grave 21, see PONTRANDOLFO *et alii* 2001, p. 19.

[8] ROBINSON 2011, p. 57.

[9] This is the date given on the Paestum Museum Exhibition Case Card (FIG. 2). Alternative, but close, dates have been given: "end of 6th to early 5th c. B.C." (LEPORE 2010, pp. 448-449, n. 34; BELLIA 2012, p. 98; Paestum Museum Exhibition Case Label); "1st half of 5th c. B.C." (BESCHI 2001, p. 178, n. 14); "5th c. B.C." (BELLIA 2010, p. 103, n. 10).

The "*aulos* fragments" said to have been found in the Sale *Heraion* to the north of the town (5 fragments), and in the South Sanctuary inside the town (unspecified number) – if, indeed, they are *aulos* parts – are not considered in this paper. For references to them see GRECO 1998, p. 57; BELLIA 2010, p. 103 with n. 3; BELLIA 2012, p. 91. Cfr. ROBINSON 2001, p. 57, who reports that in the Tempa del Prete cemetery "musical instruments (the *lyre* and *aulos*) are more common than in other Poseidonian cemeteries", suggesting that besides the *aulos* and *lyre* from the Tempa del Prete Grave 21, other musical instruments have been discovered in the vicinity of Paestum.

[10] I would like to express my sincere thanks to the Director of the Archaeological Museum of Paestum, Dr. Marina Cipriani for granting me permission to examine the *aulos*. I would also like to thank Dr.

Description of parts

The *aulos* survives in good condition, although the upstream ends of the *holmoi* have deteriorated, and the reeds have perished (Figg. 4; 5a-c; 6a-d).[1] The two pipes undoubtedly form a pair, as they are of the same material, form and finish, and were found together *in situ* in an archaeologically controlled excavation.[2] Each pipe consists of four bone sections jointed together by the usual method of spigot and socket. Apart from the mouthpiece sections (A), which have the usual bulbous appearance (Figg. 5a-b; 6a-b), the remaining three sections (B, C, D) of each pipe are cylindrical. Sections B (Figg. 7a-b; 8a-b) are without any holes; sections C (Figg. 9a-b; 10a-b) have four round finger holes: three in line with each other (I, II, III) and one on the other side (T) in between holes I and II, slightly displaced to one side. Sections D (Figg. 11a-b; 12a-b) have two similar aligned holes (IV, V), the lowest being, undoubtedly, a vent hole, since only five holes can be operated upon by the five fingers of the player's hand. Although the pipes have at places been deformed by the deterioration of the bone surfaces, the original mouthpiece sections must have been near identical in shape and size,[3] and so must have been the other three sections as regards their outer diameter, wall thickness, and finger hole diameters. The end sections (D) exibit a gentle bell on the outside, a common feature in both wooden and bone *auloi*.[4] The internal diameter is constant all along the pipes, the predominant measured value at the best surviving places being 1 cm. As the sections have apparently been rearranged a number of times over the years,[5] the correct allocation of the sections to the Long (L) and Short (S) pipes is a significant prerequisite. The sections will thus be presented and discussed singularly, before an attempt is made to join them together.

Mouthpiece section A1 (Fig. 5a-b) could be described as being of the 'bulb with neck' type.[6] The surviving overall length is 6 cm, and the maximum external diameter (1.69 cm) occurs at 4.2 cm from the edge of the neck. The internal diameter at the bulb end (Fig. 5c) – a slightly oval bore now – is 1.15x1.28 cm, while that at the neck end is 0.98 cm (Fig. 5d). The external diameter of the neck is 1.27 cm. Three little holes are located at 1.6 (Fig. 5a), 1.866, and 2.748 cm (Fig. 5b) from the edge of the neck, but only the first one seems to have been purposely opened, the other

Giovanni Avagliano, Caretaker of the Archaeological and Historical Section of the Museum, for his warm reception, as well as the friendly people at the Restoration Laboratory of the Museum who helped me with the practicalities of my study, Ms Cinzia Marino and Mr Pietro Stasi. Special thanks are due to my colleague Angela Bellia, for communicating to me prior to its publication an article of hers containing information on the Poseidōnia *aulos* (now Bellia 2010, p. 103, with n. 10 and fig. 47, and Bellia 2012, pp. 98-99).

[1] Photographs of the Podeidōnia *aulos* have previously appeared in: Bellia 2010, p. 107, fig. 47; Reichlin-Moser 2011; Bellia 2012, p. 99, fig. 96; Psaroudakēs 2013, p. 107, pl. V2c (detail); Italian Wikipedia 2013.

[2] From the same grave, part of a tortoise carapace – undoubtedly a lyre resonator – was retrieved, together with an alabaster *alabastron* (Fig. 1). The Attic black-figure vase, depicting "Dionysos, maenads and satyrs" mentioned in Lepore 2010, pp. 448-449, n. 34, as coming from the same grave, was actually found in Grave 20, and is being exhibited in the same Museum case, but on the shelf above that of the Grave 21 finds.

[3] Compare the mouthpieces of the Pydna *aulos*; Psaroudakēs 2008, p. 208, fig. 6.

[4] See Psaroudakēs 2013, p. 98, with n. 22.

[5] See, eg, photographs in Bellia 2010; Reichlin-Moser 2011; Bellia 2012.

[6] For comparable mouthpieces (Elgin, Perachōra, Ialyssos, Pydna) see photographs in Psaroudakēs 2013, pl. V, 3c-f, 4b.

two being, most probably, breaks. The part receiving the reed, the *holmos*, has been destroyed, and so the original overall length of the section is unknown. There is no sign of a cut out socket for the reed, so it is possible that one did not exist to begin with, on the assumption that not much material has been lost;[1] early *auloi* often have a conical inlet into which the cylindrical stem of the reed is pushed and jammed into position.[2]

Mouthpiece section A2 survives to a length of 6.462 cm (FIGG. 6a-b), and the maximum external diameter (1.7 cm) occurs at a distance of 4.128 cm from the edge of the neck. The internal diameter at the bulb end is 1.144 cm (FIG. 6c-d), while that at the neck is 0.95 cm (FIG. 6e). The external diameter of the neck is 1.236 cm, and the wall thickness at the tip of the neck is 0.128 cm. A small hole, which, however, has the appearence of a fracture (FIG. 6a), and may not have been opened purposefully, is located at a distance of 2.23 cm from the neck end. The original edge of the *holmos* has perished, so, again, we do not have the initial overall length of the section. As with A1, no sign of an internal specially curved socket for the reed is discernible.

'Extension' section B1 has no holes (FIGG. 7a-b). It is the longest of the two B sections. There is a socket at one end and a spigot at the other. Obviously, the socket is located at the upstream end, in order to receive the neck of the mouthpiece section: the internal diameter of the socket (1.236 cm) matches the external diameter of the neck of A2 exactly (1.236 cm) and of A1 closely (1.27 cm). The overall length of the section is 8.16 cm, of which 6.874 cm is its operating length, and 1.256 cm the (measured) length of the downstream spigot. The bore is 1 cm all along. The spigot is slightly conical, with an outer diameter of 1.88 cm at the tip, and one of 1.266 cm at its 'root'. The wall thickness of the spigot is 0.22 cm, while the wall thickness near the centre of the section is 0.32 cm. The depth of the socket is only 0.558 cm, a rather shallow socket, although smaller depths are to be found in the auletic record. This means that only a small amount of the mouthpiece section (A) was inserted into it. It is to wonder how the junction was secured, in the apparent absence of external metal rings.[3]

'Extension' section B2, as has already been said, is the smallest of the two extensions (FIGG. 8a-b). It, too, has no holes, and for the same reasons as with B1, the socket is located at the upstream end and the spigot at the other extreme. The internal diameter of the socket is identical to that of B1 (1.236 cm). The overall length of the section is 5.556 cm, of which 4.25 cm is the operating length of the section, and 1.322 cm the (measured) length of the spigot. The bore diameter is 1.072 cm on the socket side, and 1.044 cm inside the spigot. The outer diameter of the spigot is 1.238 cm, and its wall thickness 0.1 cm. The section has an external diameter of 1.668 cm near its midpoint. The depth of the socket is, again, only 0.53 cm, an even shallower socket than that of B1. The usual depth of sockets in extension sections is of the order of 1 cm.

[1] As will be shown below, the missing portions of the mouthpieces are of the order of 8 mm.

[2] Clear parallels: Perachōra A and B, Ialyssos F; see photographs in PSAROUDAKĒS 2013, pl. v, 3d-f. No doubt, also, the Elgin and Daphnē mouthpieces; see photographs in PSAROUDAKĒS 2013, pl. v, 1b, 3c, 5a-b. The feature is present even in mouthpieces of later date: Korinthos A (MF 9173), dated 300-146 B.C. (PSAROUDAKĒS 1994, II, fig. 113), and Korykeion A (AC 2553, BÉLIS 1984b, p. 177, fig. 1), which, judging from the disposition of its finger holes, must be post classical – compare Dēlos fig. 4 (PSAROUDAKĒS 2012, fig. 45).

[3] The same holds true for B_2; see immediately below.

However, there are smaller values encountered in the auletic record, even smaller than those of the present *aulos*.[1] The wall thickness of the socket is 0.2 cm, and that of the section (measured near the socket) is 0.3 cm.

The 'central' section C1 is the longest of the two C sections (Figg. 9a-b), equipped with socket at one end and spigot at the other. The thumb hole T lies between holes I and II, as is always the case with ancient Hellenic *auloi*. The socket must, therefore, be at the upstream end, which is expected, as both B sections have a spigot at their downstream end. The overall length of the section is 13.10 cm, 12.074 cm of which is the operating length, and 1 cm is the (measured) length of the spigot. The internal diameter of the socket is 1.384 cm, its depth 1.324 cm, and its wall thickness 0.156 cm. The socket has, therefore, enough depth and girth to accommodate both B1 and B2 spigots. The spigot is slightly conical, with an external diameter of 1.2 cm at the tip, and 1.262 cm near its 'root'. The wall thickness of the spigot is 0.1 cm. The bore diameter is 1 cm all along the length of the section. The outer diameter is 1.746 cm, and the wall thickness 0.34 cm near the socket, and 0.299 cm near the spigot. Distances of finger holes (centres) from the upstream end and diameters (d_x along the tube, d_y at right angles to it) (Tab. 1). Thumb hole T is displaced by some degree clockwise from the 'keel' of the section, suggesting that the section belongs to the left-hand pipe.[2] None of the holes have a recession ('seating') around their edge.

Hole	distance (cm)	d_x (↔cm)	d_y (↕ cm)
I	2.800	0.728	0.876
T	5.656	?	0.800
II	8.276	0.748	0.844
III	11.10	0.772	0.830

Tab. 1. Distances of holes from upstream end of C1 and their diameters.

The corresponding 'central' section C2 (Figg. 10a-b), 12.628 cm long overall, is shorter from its counterpart by about half a centimetre. The position of finger hole T, between holes I and II, fixes the orientation of the section here too: socket at the upstream, spigot at the downstream end. The overall length of the section comprises an operating length of 11.6 cm and a spigot of 1 cm. The internal diameter of the socket cannot be measured, as less than half a cylinder survives at this end. The depth of the socket is 1.334 cm, a value large enough to accommodate the spigots of both B1 (1.256 cm) and B2 (1.322 cm). The external diameter of the spigot is 1.272 cm, and its wall thickness varies between 0.1 cm and 1.2 cm. The bore diameter is 1.07 cm at the socket end and 1 cm at the spigot. The external diameter of the section near its mid-length varies from 1.7 cm to 1.6 cm, and the wall thickness of it varies from 0.2 cm to 0.3 cm.

[1] The deepest socket, 1.6 cm, is found on section Agora G (B1 645). Next come: Pydna with 1.03 cm; Perachōra G (A 432), I (A 423), M (A 419) with 1 cm; Perachōra J (A 421+A 422) with 0.8 cm; Perachōra O (A 417) with 0.7 cm; Perachōra K (A 414) with 0.55 cm. Values smaller than those of the present aulos are found in Perachōra L (A 418) and Q (A 412), with 0.4 cm.

[2] It has been argued (Psaroudakēs 2008, p. 202) that a thumb hole displaced clockwise, that is, to the left of the 'keel' of an aulos' pipe, indicates that the pipe was held in the left hand, and, in addition, that the pipe was the longer or the two in a pair. The opposite holds for a thumb hole displaced anti-clockwise.

Distances of finger holes (centres) from the upstream end and diameters (d_x along the tube, d_y at right angles to it) (Tab. 2). Thumb hole T is displaced anti-clockwise by some degree from the 'keel' of the section. None of the holes have a recession ('seating') around their edge.

Hole	distance (cm)	d_x (↔cm)	d_y (↕ cm)
I	2.842	0.774	0.866
T	5.186	0.780	0.800
II	7.936	0.756	0.860
III	10.816	0.786	0.850

Tab. 2. Distances of holes from upstream end of C2 and their diameters.

'Exit' section D1 is 10.9 cm long (Figg. 11a-b), and has a socket at the upstream end, in order to receive the spigot of the previous, 'central' C, section. The internal diameter of the socket is 1.124 cm, its wall thickness 0.176 cm, and its depth 1 cm, the latter being equal to the lengths of both C1 and C2 spigots. There is a gentle rising of the external surface of the bone at the exit, forming thus a superficial bell. The bore diameter is 1 cm all along the section, and the wall thickness near the socket 0.3 cm. At the exit, the bone assumes an oval shape in crossection, with minimun external diameter 1.4 cm and maximum 1.7 cm. Distances of finger holes (centres) from the upstream end and diameters (d_x along the tube, d_y at right angles to it) are as follows (Tab. 3).

Hole	distance (cm)	d_x (↔cm)	d_y (↕ cm)
IV	2.218	?	0.856
V	5.922	0.766	0.854

Tab. 3. distances of holes from upstream end of D1 and their diameters.

'Exit' section D2 is 10.516 cm long (Figg. 12a-b), and has a socket at the upstream end, in order to receive the spigot of the previous, 'central' C, section. The internal diameter of the socket is 1.162 cm, its wall thickness 0.264 cm, and its depth 1.122 cm, enough to receive either of the C1 or C2 spigots. There is a gentle rising of the external surface of the bone at the exit, forming thus a superficial bell. The bore diameter is 1 cm all along the section, and the wall thickness near the socket 0.33 cm. At the exit, the bone assumes an oval shape in crossection, with minimun external diameter 1.374 cm and maximum 1.8 cm, and wall thickness ranging between a minimum of 0.15 cm and a maximum of 0.4 cm. The external diameter of the section varies from 1.5 cm to 1.582 cm. Distances of finger holes (centres) from the upstream end and diameters (d_x along the tube, d_y at right angles to it) are as follows (Tab. 4).

Hole	distance (cm)	d_x (↔cm)	d_y (↕ cm)
IV	2.000	?	0.846
V	4.914	0.75	0.842

Tab. 4. Distances of holes from upstream end of D2 and their diameters.

Assemblage of sections

The best correspondence of holes between the two pipes occurs when the longer sections make up the long pipe (L) and the shorter sections form the short pipe (S), that is: A1-B1-C1-D1 = A_L-B_L-C_L-D_L for the long pipe, and A2-B2-C2-D2 = A_S-B_S-C_S-D_S for the short pipe (Figg. 13, 14, 15).[1] In this arrangement, the distances of the holes from the upstream end of their B sections are as follows (Tab. 5).[2]

	tube	I	T	II	III	IV	V*	exit
L | reed | mouthpiece A1	| B1	o	●	o	o	o	o	|
	o	9.8	12.656	15.25	18.1	21.3	25	30 cm
	| 9.8	| 2.856	| 2.594	| 2.85	| 3.2	| 3.7	| 5	|cm
	tube	I	T	II	III	IV	V*	exit
S | reed | mouthpiece A2	| B2	o	●	o	o	o	o	|
	o	7.2	9.6	12.25	15.2	18.1	21.1	26.5 cm
	| 7.2	| 2.4	| 2.65	| 2.95	| 2.9	| 3	| 5.4	|cm

Tab. 5. Distances of holes from upstream end of tubes.

As can be seen from the above diagram, the correspondence of holes III_L and IV_S is exact (18.1 cm). Next best match is that of holes II_L and III_S, their difference being a mere half millimetre (15.25~15.20 cm). Holes I_L and T_S differ by 2mm, and so do holes IV_L and V_S. The larger difference of 4 mm between holes T_L and II_S may be attributed to an inexact measurement due to the poor condition of the long pipe thumbhole (Fig. 9b). Apart from the perfect match of holes III_L and IV_S, in all other cases, a slight 'upward' shift of the holes of the short pipe is observed; indeed, a look at figures 13-15 testifies to this. A similar upstream shift of the holes of the short pipe with respect to its long counterpart has also been observed on the Pydna *aulos*: after a good match between the hishest pair of holes (I_L-T_S), the shift gets to a maximum of 6.19 mm between the next set (T_L-II_S), and from there it drops to about 2-3 mm in the following pairs (II_L-III_S, III_L-IV_S, IV_L-$V_S^{\star}$).[3] On the Elgin pair of pipes, the shift is very pronounced.[4] Although the excessive values could be attributed to the warping of the long pipe, the fact still remains that the holes of the short pipe are situated nearer to the mouthpiece than the corresponding ones on the long pipe. On the Louvre *aulos*, also, non correspondence of holes between the two pipes has been reported: the holes of the high-hole-1 ('h') pipe (A) – which is equivalent to the short pipe in other pairs – exhibit a varying

[1] Here, again, we have unequivocal evidence that longer sections belong to the long pipe and shorter sections to the short pipe; see '4L Rule' proposed in Psaroudakēs 2008, p. 202. Although it would seem more 'logical' for a leftward displacement of a thumb hole to be an indication of a left-hand pipe, and vice versa, taking into account the relatively short length of the thumbs, by experimenting with aulos replicas, it comes out that the pipes are more securely held in the hands of the player when the tips of the thumbs act as 'pivots' about which the thumbs are flexed downwards when thumb holes are to be opened. In his way, no 'rolling' of the pipes occurs.

[2] With the sections in place, measurements were taken with a long ruler, the upstream ends of the B sections set at zero. Asterisks denote vent holes.

[3] For measurements see Psaroudakēs 2008, p. 204.

[4] *Ibidem*, figg. 33-35.

upstream shift:[1] after a rather good match between the first two corresponding holes (I_l-III_h) of half a millimetre, and a maximum diversion of 8 mm between T_l and IV_h, the remaining hole pairs show a shift of 1.5 (II_l-V_h), 4.1 (III_l-VI_h), and 3.5 mm (IV_l-VII_h). Only in the lowest pair of holes (V_l-$VIII_h$) the shift is negative, that is, the hole on the 'h' pipe is situated further away from the mouthpiece than its counterpart in the 'l' pipe.[2]

Is this shift deliberate, that is, part of the 'design' of the instrument, and if so, why? Could it be that notes of slightly different pitch were to be derived from corresponding holes, in order for beats to be created? Alternatively, and more plausibly, could there be a connection with the reed? Theophrastos, in his description of the manufacture of an *aulos*' reeds (*zeugos*), clearly differentiates between a left and a right reed (*glotta*) to be used on an *aulos*: he associates the slightly harder reed (lower part of *mesogonation*) with the left-hand pipe, and the slightly softer reed (upper part of *mesogonation*) with the right-hand pipe.[3] Questions of this kind might be answered by way of experiment. For this purpose, an exact physical replica of the Poseidōnia *aulos* is presently being constructed, in order to test its acoustic behaviour to parameters such as reed size and hardness.

However, before this becomes possible, the (common, operating) length of the mouthpiece sections must be established. As has already been said,[4] the top lips of both *holmoi* have been destroyed, so the overall lenghts of these sections are not known. The question thus arises, whether there is a way of estimating their original overall (l) and operating (l^o) lengths. As the present instrument is of an early date, and belongs to the 'Early' type, it would be plausible to compare its mouthpieces with other, similar ones. Intact bulbous mouthieces with 'neck' are: Perachōra A (6.6 cm) and B (6.5 cm), Ialyssos F (7.076 cm), and Pydna A_S (7.556 cm).[5] Of the two Poseidōnia mouthpieces, A_S has the greater (surviving) length, 6.462 cm. It has been established[6] that the ratio of bulb length (b) to neck length (n) in these mouthpieces is of little variance (mean value of b/n = 1.2).[7] It can, therefore, be assumed that the Poseidōnia bulb/neck ratio is of the same order. If x be the missing length (of A_S), then x+6.462 (surviving length of A_S) = b+3.262 (mean neck length).[8] By equating, in turn, the b/n ratios of the three mouthpieces refered to above, to the corresponding Poseidōnia ratio (b/3.262), three alternative bulb lengths for Poseidōnia are obtained (Tab. 6). Thus, three alternative overall lengths (l) can be arrived at,[9] and three values for the missing length of A_S (x) can be worked out.[10]

[1] Bélis 1984a, pp. 113, 115. Hagel's correction of 15.65 to 15.55 cm for hole II_a has no bearing on the present argument, as this hole does not have a counterpart in pipe B. Hagel 2004, p. 380, n. 41.

[2] As the two pipes of the Louvre *aulos* are equal in length, the designation 'L' for long and 'S' for short cannot be applied; instead, the symbols 'l' and 'h' are used, with reference to the position of holes I: further away from the mouthpiece or nearer to it, respectively.

[3] Theophrastos, *Enquiry into plants*, iv, 11, 7, p. 372 Hort (1990): συμφωνεῖν δὲ τὰς γλώττας τὰς ἐκ τοῦ αὐτοῦ μεσογονατίου...καὶ τὴν μὲν πρὸς τῇ ῥίζῃ ἀριστερὰν εἶναι, τὴν δὲ πρὸς τοὺς βλαστοὺς δεξιάν. («Tongues made from the same section sound in consonance ... the one from nearer the root goes on the left, and that from nearer the growing-point on the right». Transl. Barker 1984, pp. 188-189, with n. 12).

[4] See descriptions of sections A1 and A2, above.

[5] Figures refer to the overall lenghts (l) of the mouthpieces; see Psaroudakēs 2013, p. 102, fig. 4.

[6] *Ibidem*.

[7] Perachōra A ratio b/n 1.129; Ialyssos F 1.254; Pydna 1.203.

[8] Mean neck length = (neck of A1+neck of A2):2 = (3.124+3.4):2 = 3.262 cm.

[9] Overall length of mouthpiece l = b+n = b+3.262 cm (mean neck value).

[10] Missing length x = (b+n)-6.462 (survivng length).

Mouthpiece	b/n	Poseidōnia b	l	x (cm)
Perachōra A	1.129	3.6829	7.0829	0.6209
Ialyssos F	1.254	4.0910	7.4910	1.0290
Pydna	1.203	3.9258	7.3258	0.8638

Tab. 6. Ratios of bulb to neck lenghts in comparable mouthpieces, and computed corresponding bulb, overall, and missing lengths for the Poseidōnia mouthpieces.

The mean value of the missing length is therefore 0.8379 ≈ 0.8 cm. The overall length (l) of the Poseidōnia mouthpieces is therefore 7.262 cm.[1] The operating length (l°) then becomes: 7.262 (l)-0.544 (mean socket depth of B sections)[2] = 6.718 cm.[3] This, of course, in an approximate length, as mean values have been taken into consideration. Adding this value to the lenghts of tubes L and S, the overall operating lengths of the two pipes become: 36.718 cm for the long pipe, and 33.218 cm for the short pipe. To these operating lengths must be added the operating lengths of the reeds, in order to establish the scale of the instrument.[4] By adding, now, the established operating length of the mouthpieces (6.718 cm) to the measurements given in table 5, a final 'picture' of the Poseidōnia *aulos* is drawn (Tab. 7).

			tube	I	T	II	III	IV	V*	exit	
L	reed	mouthpiece		o	●	o	o	o	o		
	o		6.718	16.518	19.374	21.968	24.818	28.018	31.718	36.718	cm
		6.718	9.8	2.856	2.594	2.85	3.2	3.7	5		cm

			tube	I	T	II	III	IV	V*	exit	
S	reed	mouthpiece		o	●	o	o	o	o		
	o		6.718	13.918	16.318	18.968	21.918	24.818	27.818	33.218	cm
		6.718	7.2	2.4	2.65	2.95	2.9	3	5.4		cm

Tab. 7. Distances of holes from lips of mouthpieces.

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[1] Overall length of mouthpiece (l) = surviving length+mean loss (x) = 6.462+0.8 = 7.262 cm.

[2] Mean socket depth = (socket of B1+socket of B2):2 = (0.558+0.53):2 = 0.544 cm.

[3] Reichlin-Moser 2011 propose a mouthpiece of a much longer operating length, of the order of 8.2 cm. One can arrive at this figure by measuring off their photograph of their reconstruction the operating lengths of the mouthpiece (6 cm) and the long tube (22 cm), and solving for l° in the equation: 22:6 = 30:l°, where 30 cm is the actual length of the long tube.

[4] Operation under investigation at the moment.

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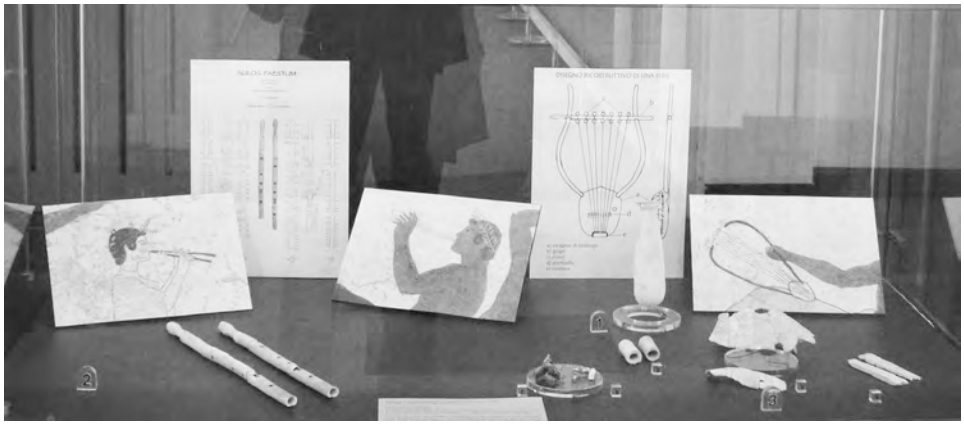

Fig. 1. Paestum Museum, Exhibition Case of Grave 21-Tempa del Prete content (photograph by the author).

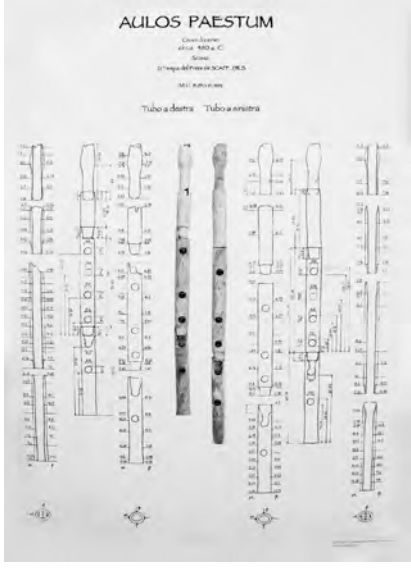

Fig. 2. Paestum Museum, Exhibition Case Card for the *aulos* (photograph by the author).

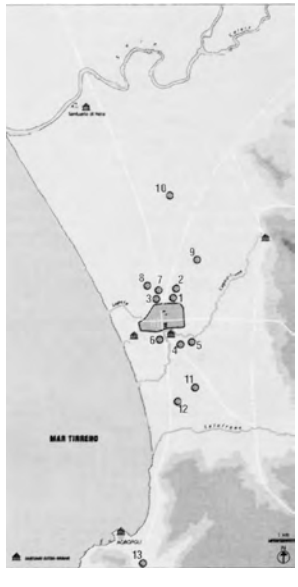

Fig. 3. Map of the Paestum area cemeteries (Pennino-Carpiceci 2011, p. 77).

FIG. 4. The Poseidōnia *aulos* seen from the mouthpiece end (photograph by the author).

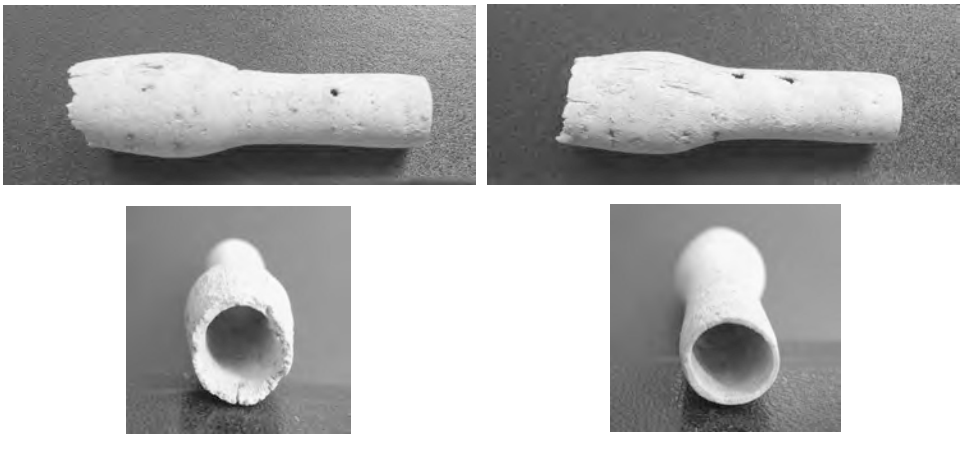

FIG. 5a-d. Poseidōnia *aulos*: mouthpiece A1 (photographs by the author).

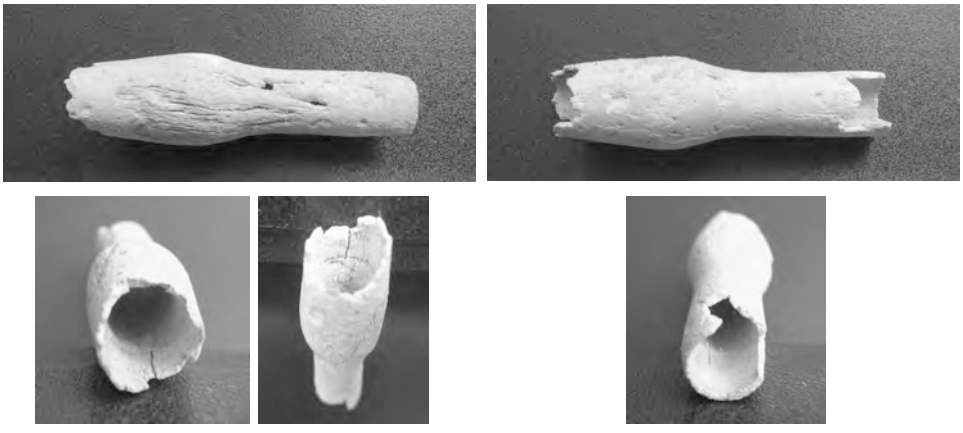

Fig. 6a-d. Poseidōnia *aulos*: mouthpiece A2 (photographs by the author).

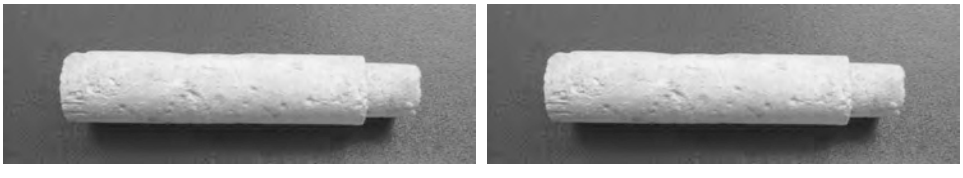

Fig. 7a-b. Poseidōnia *aulos*: section B1 (photographs by the author).

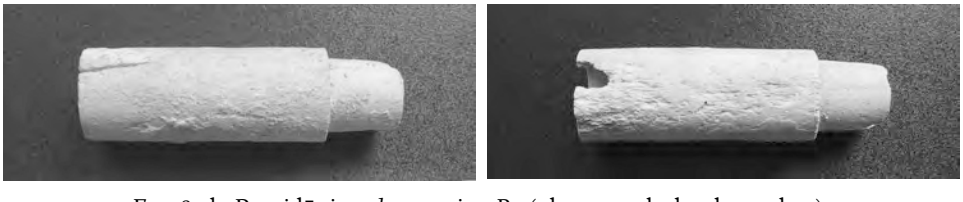

Fig. 8a-b. Poseidōnia *aulos*: section B2 (photographs by the author).

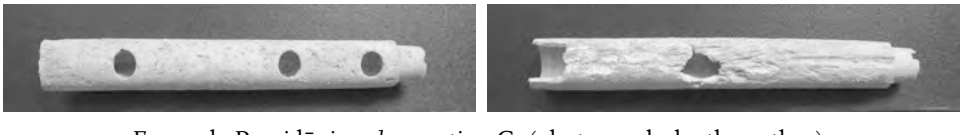

Fig. 9a-b. Poseidōnia *aulos*: section C1 (photographs by the author).

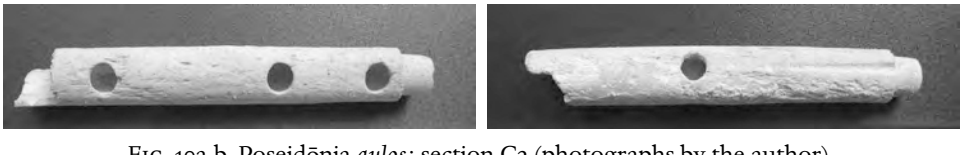

Fig. 10a-b. Poseidōnia *aulos*: section C2 (photographs by the author).

FIG. 11a-b. Poseidōnia *aulos*: section D1 (photographs by the author).

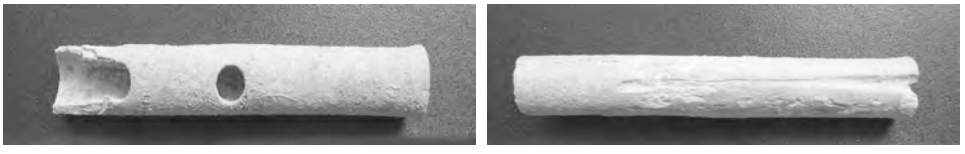

FIG. 12a-b. Poseidōnia *aulos*: section D2 (photographs by the author).

FIG. 13. Poseidōnia *aulos*: the complete instrument in plan view (photograph by the author).

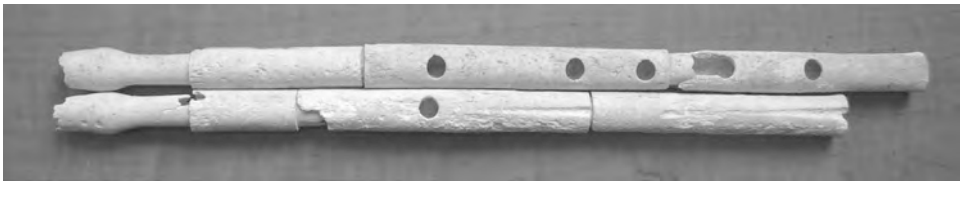

FIG. 14. Poseidōnia *aulos*: correspondence of T_S with I_L (photograph by the author).

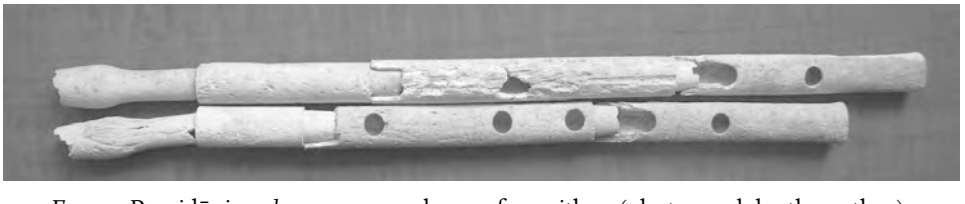

FIG. 15. Poseidōnia *aulos*: correspondence of T_L with II_S (photograph by the author).

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