The Auloi of Pydna

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ZUSAMMENFASSUNG

Der Doppelaulos von Pydna wurde als einziges Instrument seiner Art bei der dokumentierten Ausgrabung einer ungestörten Begräbnisstätte gefunden. Er ist in einem so gut erhaltenen Zustand, dass zu seiner Vollständigkeit nur die Rohrblätter fehlen. Alle erhaltenen Doppelauloi sind bisher ohne Provenienz und ohne Kontext überliefert, wir wissen nicht einmal, ob sie überhaupt paarweise aufgefunden wurden (einen vergleichbaren Fund bildet nur das ausgegrabene Rohrpaar von Akanthos, wobei dieses, was den Erhaltungszustand betrifft, nicht vergleichbar ist). Das Rohrpaar von Pydna hat eine kurze und eine lange knöcherne Pfeife, die jeweils aus fünf Einzelteilen besteht: Becher am Anblasende, Birne, Verlängerung, daran ein Mittelteil mit vier Grifflöchern, ein Ende mit zwei Löchern, das unterste jeweils ein Windloch. Allem Anschein nach hielt der Spieler das längere Rohr, mit dem Daumenloch mit Drehung im Uhrzeigersinn, in der linken Hand und brachte darauf den tiefsten Ton der kombinierten Skala hervor. Auf dem kurzen Rohr, mit Daumenlochdrehung entgegengesetzt des Uhrzeigersinns, war der höchste Ton zu erzielen. Die jeweils vier anderen Klänge waren die gleichen, die Löcher sind in fast genau übereinstimmender Position angebracht.

1 INTRODUCTION

What has been established so far in our knowledge of the ancient Hellenic double aulos, from an organological point of view, can be summarized as follows:

- The aulos comprises a pair of cylindrical pipes having circular, more or less, finger holes, and cylindrical bores throughout that are either in one piece when made of wood¹, or in several sections when made of bone².
- The pipes are operated by cane reeds, most probably of the double kind, although the single kind has not as yet been excluded from the argument³.

• The pipes are not bound together in any way but are physically independent of each other, and their reeds are placed together inside the player's mouth, each hand of the player operating on the holes of only one pipe⁴.

These are the basic established facts. However, there are important questions, which have not as yet been satisfactorily answered, and which have to do both with the comparative physical aspects of the pipes in the pair, and the comparative acoustic behaviour of the two pipes played in conjunction with each other.

From a physical point of view the pertinent questions are:

• Are the two pipes equal or unequal in overall length? Several depictions of the instrument while being played suggest unequal lengths: the left pipe is drawn longer than the right one (e.g. Fig. 20). In frontal view, the left pipe is defi-

Athens-Daphnē (Psaroudakēs, publication in preparation), Elgin (Schlesinger 1939, 411-420, Pl. 17), Louvre (Bélis 1984a), Egypt (Behn 1954, Pl. 27; Psaroudakēs 1994 Vol. 1, 271 with Vol. 2, Fig. 94). The Ephesos pipe (Hogarth 1908, 194, Pl. 37.12; Psaroudakēs 1994, Vol. 1, 287, Vol. 2, 106) is the only aulos made out of one piece of bone. It is, however, much too small, possibly a child's instrument.

² Athens-Agora (Boulter 1953; Landels 1964) and Athens-Akropolis (Psaroudakēs 1994 Vol. 1, 261 with Vol. 2, Figs. 84–85; Psaroudakēs 2002, 357, Pl. 19), Akanthos (Κοψαχείλης 1992, 93–95; Psaroudakēs, this paper), Aphaia (Furtwängler 1906, 429, Fig. 337), Argithea (Psaroudakēs 2002), Argos (Psaroudakēs 1994, Vol. 1, 267, Vol. 2, Fig. 89), Brauron (Landels 1963), Dēlos (Deonna 1938; Bovon 1970, 233, Pl. 38), Delphoi (Psaroudakēs 2002, 362, Pl. 21), København (Olsen 1968), Korinthos (Broneer 1947, 241, Fig. 21, Pl. 61; Davidson 1952; Psaroudakēs 2002, 358–361, Pl. 20), Korykeion Antron (Bélis 1984b), Lindos (Blinkenberg 1931), Lokroi Epizephyrioi (Orsi 1917), Perachōra (Dunbabin 1962), Rhodos and Ialissos (Psaroudakēs 2002, 356, Pl. 18), Sparta (Dawkins 1929), Taras (Psaroudakēs 1994, Vol. 1, 313, Vol. 2, Figs. 128–129).

³ West 1992, 83. For a good assessment of the relevant evidence see Landels 1999, 28–31.

⁴ See, e.g., bell crater New York 25.78.66 of ca. 420 B.C. (West 1992, Pl. 16), and amphora London E 271 of ca. 440 B.C. (West 1992, Pl. 21).

nitely longer than the right one in a painting a century earlier than the previous representation (Fig. $21)^5$.

- Are respective holes of the two pipes in a pair equidistant from the mouth? In other words, are the hole patterns the same and at the same place along the two pipes (adjacent to each other)?
- Are the two reeds physically equal in all respects? Theophrastos⁶ seems to imply reeds of a different form for the two pipes.
- Is one pipe in a pair intended to be the 'left' and the other the 'right'? And if their lengths are unequal, on which side should the longer/ shorter pipe be held? Some written evidence and a large number of vase paintings seem to point in that direction.

Of course, physical differences between the pipes would cause different acoustic behaviors. If, indeed, the overall lengths of the pipes were different, and the reeds were not exactly the same, and, on top of that, the hole patterns were different and at different places along the pipes, what would then be the combined acoustic effect? The next question concerns what kind of technique should have been employed by the player, in order to affect the intended acoustic behavior?

Although answers to these questions have been attempted, what makes our evidence shaky is the fact that auloi found in excavations are fragmentary to such an extent, that they do not afford the necessary evidence in order for us to tackle problems of the kind just mentioned. Even in the case of pairs of pipes brought to light, because these are products of illicit excavations, we cannot be sure that the two pipes belong together, that they are actually members of the same pair⁷: the Elgin pipes, said to have been found in Attica, on the way from Peiraieus to Eleusis, surfaced in the late 19th century in the British Museum, together with all the other items of the Elgin Collection⁸; the København pipes, said to come from Athens, surfaced in the National Museum of København in 1961, with their sections obviously reassembled in the wrong way9; as to the Louvre pipes, their multiplicity of holes have rendered them suspect as forming a pair¹⁰. So, unless a complete instrument is found in a proper, controlled excavation, the questions posed above will not receive satisfactory answers.

2 THE AULOS PAIR OF PYDNA

It is very fortunate, then, that such a pair of auloi was brought to light in 1996, during excavations in

one of the cemeteries of Pydna (dated to the first half of the 4th century B.C.)¹¹. Pydna was a large harbor city in the kingdom of the Makedonai, a strategic point on the coast of Pieria, in the Aegean, which flourished in the 5th century B.C.¹²

In the Northern Cemetery of the city, Grave 324 (Field 951) contained a full skeleton and an aulos pair; no other grave offering was found (Fig. 1). The excavator was the archaeologist Manthos Besios, of the 16th Ephorate of Prehistoric and Classical Antiquities. The orientation of the skeleton was from East to West, with the skull to the East. The skull lay sideways, towards the right shoulder. The upper ends of the auloi were placed near the mouth, and the pipes ran parallel over the bones of the right upper arm and shoulder of the skeleton. The left hand lay on the ground and ran parallel to the body. Undoubtedly, the iron nails found at different levels in the grave belonged to the wooden coffin, inside which the deceased had been placed, and which has now disintegrated.

The instrument is kept in the Archaeological Museum of Thessalonikē (No. Pydna 100).

3 REFERENCES TO THE PYDNA AULOI THUS FAR

The instrument was presented for the first time by the archaeologist Ourania Banou at the '1st International Conference on Ancient Hellenic Technol-

- ⁶ Enquiry into plants 4.11.7, Hort 1990, Vol. 1, 372; Barker 1984, 189, Note 12; Hagel 2004, 382, Note 61.
- ⁷ So Landels 1999, 42.
- ⁸ Schlesinger 1939, 411–420, Pl. 17.
- ⁹ Olsen 1968.
- ¹⁰ Adherents of the pair theory are: Bélis 1984a; West 1992, 100; Hagel 2004, 379–380, 385. Landels (1999, 279, Notes 19, 30), however, puts forward a strong case for the two pipes being single pipes (*monauloi*): the holes of the Louvre pipes, particularly the thumbholes, "show signs of shaping", which "suggests that they did not have keywork".
- ¹¹ For an aerial view of the site of Pydna see Μπέσιος/Παππά n.d., 7. The date of the cemetery is given in Μπάνου 1997, 519.
- ¹² For an archaeological map of Northern Pieria see Μπέσιος/Παππά n.d., 4.

⁵ However, in a number of Sicilian terracottas (from Fontana Calda, Selinunte, Mozia, Mussomeli, Kamarina, Morgantina, Adrano) dated to the 6th-3rd centuries B.C., depicting women playing the double aulos amongst other musical instruments, it is the right hand pipe which is often shown longer (Bellia 2005, 62, Fig. 11, cover Fig. Also, Bellia 2006, cover Fig.). According to Bellia (private correspondence), about 50 % of these aulos-playing statuettes have the right hand pipe longer, while in others the pipes are shown as being equal (e.g. Bellia 2005, 59, Fig. 2). The fact that statistics so largely diverge from either of the positions, namely, longer pipe in the right or left hand, allows us, I believe, to disregard the evidence of this particular material. It is unlikely, on the other hand, that both types of aulos existed (in Sikelia or anywhere else in the Hellenic world), one with the long pipe in the right hand and another with the opposite combination.

ogy' in Thessalonikē in 1997, and a preliminary report appeared in the published Transactions¹³, together with a photograph of the pipes in situ (Fig. 1), and a photograph of the pipes after retrieval from the grave¹⁴. The pipes were among the items in the exhibition 'Gifts of the Muses: Music and Dance in ancient Hellas', set up by the Hellenic Ministry of Culture in Bruxelles in 2003. A brief description and a photograph of the instrument (Fig. 2) appeared in the pages of the Exhibition Catalogue¹⁵. In the same year (2003), in a report about the exhibition in the Hellenic popular archaeological magazine *Corpus*, a picture of the pipes was again published¹⁶.

4 PRESENT INVESTIGATION

The instrument was studied afresh by the present writer in March 2006¹⁷. Let it be said at this point that, because the auloi were methodically excavated and photographed in place by the archaeologist, there is no doubt that the sections are in the right order. Even if they were not in the order in which they were when the pipes were being played, at least they are the way they were when the pipes were placed next to the body. In other words, we can be sure that no rearrangement of the sections took place after the pipes had been buried in the ground. It is also highly probable that the sections are in the right organological order, but this, of course, has to be proven. It must also be said at the outset that the two pipes must have formed a pair in antiquity, not only because they were found together and are of similar construction and finish, but also because the thumb holes in the 'central' sections (Figs. 18-19) are displaced with respect to the upper series of holes in opposite directions, as we shall see later.

By just looking at them as exhibited in the Museum (Fig. 2), the pipes are obviously unequal in length and have corresponding holes at different distances from the mouth end. A closer look reveals that corresponding distances between holes are also not the same in the two pipes. Thus, one is left with the impression that this particular aulos, at least, comprises unequal pipes of different holepatterns and at different distances from the mouth end. However, as will be shown below, a closer examination of the individual sections will draw a somewhat different picture of this aulos' form. For the sake of convenience, let us call the two pipes L and S that is, 'long' and 'short', respectively.

As is always the case with earlier finds, so with the present aulos, the two pipes comprise five sections connected to each other by the spigot-andsocket method (Fig. 3): first comes a conical 'cup' at the mouth end that received the reed; then the 'bulb' section, immediately after without any holes, and with the characteristic external bulge; then the 'extension', a piece of tube without any holes then the 'central' section with the first four holes, including the thumbhole underneath as the second hole; and finally the 'exit' section, with the remaining two holes. The two pipes will here be examined in parallel, one section type at a time.

4.1 THE 'CUPS' (SECTIONS TYPE 'A')

Cup a^S (Fig. 4 top and Fig. 9 top left) survives in its original length, thus providing us with the initial length of the section (3.146 cm), and also with the original depth of the socket receiving the reed (socket depth 1.668 cm). Cup a^L (Fig. 5 and Fig. 9 bottom left) has lost part of its entry length (surviving length 2.580 cm). If we assume that the two cups were equal in both effective¹⁸ length and socket depth, then the missing length and the missing depth of the socket of cup a^L can be calculated (missing length 0.566 cm; missing depth 0.604 cm). Engraved into the outer surface of the spigot of cup a^S are about nine parallel lines (Fig. 4), most probably for the purpose of joining together cup to bulb, perhaps with the use of thread¹⁹. Similar indentations were not, however, observed on the spigot of cup a^L (Fig. 5), but two parallel lines inscribed on its periphery and near to the broken-off end were clearly visible under the microscope.

4.2 THE 'BULBS' (SECTIONS TYPE 'B')

The bulbs are the sections adjacent to the cups (Fig. 6 and Fig. 9 middle). They survive in their

- ¹⁴ Μπάνου 1997, 522, Fig. 2.
- ¹⁵ 'Ανδρίκου et al. 2003, 177.
- ¹⁶ Anonymous 2003, 83.
- ¹⁷ I would like to thank wholeheartedly the former Director of the Ephorate, Ms Polyxenē Adam-Velenē, the former Director of the Archaeological Museum of Thessalonikē, Mr Dēmētrios Grammenos, and last but not least, the excavator, Mr Manthos Besios, for, not only was I allowed to examine and publish the find, but was also offered access to the Excavation Diary and to the Restoration Laboratory of the Thessalonikē Museum and its facilities. During my stay in the Museum, I had the chance to discuss the find with archaeologists Eleonora Melliou, Eutychia Kephalidou, and Zoē Kotitsa, and restorer Sonia Athanasiadou. I would like to thank them all, for sharing with me their knowledge, inner thoughts, and enthusiasm.
- ¹⁸ By 'effective' length is here meant the length of tube seen by the eye when the sections are joined together. Thus, the spigot length is not included in the 'effective' length.
- ¹⁹ Landels (1999, 33) doubts the use of thread in joining the sections together; he is inclined to think that the sections were permanently glued together.

¹³ Μπάνου 1997.

original lengths (5.3 cm bulb b^{S} , 5.82 cm bulb b^{L}). They are not exactly equal in length, which is noticeable. It could be that as both bulb sections were found in bits and glued together during restoration, their original overall lengths have been slightly altered, although the matches between the bits seem correct. However, the fact remains that the two sections differ now by just over half a centimetre (0.52 cm), a fact that should not perhaps be disregarded for the time being. The bulb sections have sockets at their upstream ends, into which the cups are inserted (Fig. 7).

Externally, very fine incised lines are clearly seen on bulb b^{L} (Fig. 6 bottom) at two places: two together on the bulb side and one on its own on the other, tubular, side. Similar lines can be seen on bulb b^{S} (Fig. 6 top), too, although not as clearly, undoubtedly due to its eroded surface²⁰. Here it is proposed, rather hesitantly, that these lines, albeit too fine to be distinguished from a distance, had a decorative purpose²¹.

The maximum external diameter of bulb b^L (1.66 cm) is only just over a millimetre larger than the external diameter of the remaining cylindrical part (1.55 cm), and similarly for pipe S. This means that the bulbs, at least in the case of the Pydna pipes, cannot "have served to protect the reed[s] when the aulos was laid down on a flat surface"²². They must have played a different role.

As with the Akanthos, Athens-Daphnē (most probably), Berlin²³, Elgin, København, Megara²⁴, Pompeii²⁵, Reading²⁶ and Taras pipes, and the Pergamon model²⁷, so the Pydna pair possesses only one bulb per aulos. This now makes us think that there never actually existed any auloi with two bulbs per pipe, as some vase paintings seemed to indicate²⁸. Undoubtedly, what looks in iconography like a "second bulb" near the mouth is simply the combined curve of the stem of the reed and the cup.

4.3 THE 'EXTENSIONS' (SECTIONS TYPE 'C')

Next in order come the extensions, cylindrical pieces with sockets and spigots but without any holes (Fig. 8 and Fig. 9 right). A close examination of extension c^{S} (Fig. 8 top) under the microscope reveals a fracture at the entrance end: the remains of a socket (surviving depth 0.33 cm) and an external recession (surviving length 0.1 cm) are evident. Obviously, part of the tube at entry is missing. The question arises as to whether the missing length can be established, and thus whether the overall length of the section be calculated. The question will be tackled after an examination of the corresponding extension c^{L} .

Extension c^L (Fig. 8 bottom and Fig. 9 midright) survives in all of its significant details, thus its initial shape can be confidently restored. There are spigots at both ends. The upstream spigot is embraced by another section, a 'ring' or 'band' of bone, 1.536 cm long (Fig. 8 and Fig. 9 bottom right, r^L). Part of the cylindrical surface of this ring is missing, allowing us to see inside and to get a good picture of the junction of the two sections. The ring 'sits' on the upstream spigot, so that its external surface is level with that of its host and extends beyond the spigot by just under a centimetre (0.948 cm), therefore, together with the spigot underneath, forming a socket of that depth (0.948 cm in depth). On its external surface, near its entry, and all around its circumference, the ring has a shallow depression (0.444 cm wide).

This geometric feature reminds us of similar constructions in other known auloi: the Elgin pipes (Fig. 10) and the Athens-Daphne pipe (Fig. 11), both wooden, and in one piece; the Athens-Agora G fragment (Fig. 12); the Lindos F fragment (the only example with a hole I in it) (Fig. 13); the Perachora G and H fragments (Fig. 14); the Perachora I and J fragments (Fig. 15), all, undoubtedly, extension sections. In these 'troughs', at the points where the bulbs are inserted into the extensions, metal or leather bands might have been inserted (although no trace of any material is left on any such section), in order to prevent the bone from splitting but also securing a better grip of the bulbous sections. Very importantly, the widths of these troughs are equal to those of the two Elgin pipes (Fig. 10), the only pair with this feature on it - assuming, of course, that the two pipes do form a pair²⁹.

One could safely, I believe, take it from there and generalize that in a pair of pipes these portions

²⁴ Psaroudakēs 1994, Vol. 1, 301–302, Vol. 2, Fig. 118.

- ²⁶ Landels 1968, Pl. 5.
- ²⁷ Behn 1954, Pl. 58.
- ²⁸ Landels 1999, 27, 32, Figs. 2a.3, 2a.9.

²⁰ Similar incised lines have been observed on the bone 'bulb' Fragment A from Athens-Agora (Landels 1964, 394). In the same group of aulos fragments, incised lines appear on Fragment B (Landels 1964, 395); Fragment E (Landels 1964, 398); Fragment H (Landels 1964, 400).

²¹ Landels (1999, 34) also speaks of bone sections turned in a lathe and "decorated with incised lines".

²² Landels (1999, 33), one of three suggestions made on the function of the bulbs in auloi (the other two being decoration and ballast).

²³ Behn 1954, Pl. 27.

²⁵ Behn 1954, Pl. 58.

²⁹ West (1992, 100, Note 84) is sceptical about the Elgin pipes being a pair; compare Landels (1999, 279, Note 30): "The Elgin auloi may have been a pair [...]". However, the comparison made between the Elgin pipes and the Pydna pipes below will strongly, almost conclusively, support the pair theory.

of the extensions were of the same geometry, at least when seen from the outside. If so, and since the bottom part of the socket and the beginning of the depression on extension c^{S} survive, the missing length of extension c^{S} can be calculated (missing length x = 0.544 - 0.1 = 0.444 cm; Fig. 16). The ring, therefore, is not really an independent member of the pipe, but rather an 'elongation' of its extension section. The effective lengths of the two extensions are now known (3.50 + 0.544 = 4.044 cm for extension c^{S} , 4.792 + 1.536 = 6.328 cm for extension c^{L}), their difference being 2.284 cm, a significant amount; this, then, is responsible for the non-correspondence of the first holes (I) of the pipes.

It is not apparent why the aulos maker constructed the two extensions in a different manner, one with and another without a ring. Possibly, extension c^L already existed, and, in order to make use of it rather than discard it, he thought it easier and, perhaps, more economical to supplement it with a ring rather than to make a whole new section from scratch. Or, alternatively, the ring was introduced at a later stage, during repair work: the initial c^L was broken and was replaced by another c^L section, which was readily available but not long enough; thus a ring was made to supplement it. Let it be said that this feature in unique to this aulos and is not found on any other surviving extensions.

4.4 THE 'CENTRAL' PARTS (SECTIONS TYPE 'D')

These sections are cylindrical and have a set of four holes in them (here called I, T, II, III): three (I, II, III) on the same side and in line with each other (Fig. 17), and one on its own (T) on the other side (Fig. 18), not exactly diametrically opposite to the set of three holes. Numerous such sections have been reported in the relevant bibliography³⁰. Both section d^S and section d^L have a socket at the upstream end and a spigot on the other side.

The sections are of unequal length: d^S overall 12.660/effective 11.952 cm; d^L overall 13.65 cm/ effective 12.856 cm³¹ (Fig. 19). The spigot of section d^S has obviously lost part of its material: not only its edge seems to have worn off (surviving length 0.638 cm), but also it is shorter by about 2 mm than the receiving socket of the next section (0.806 cm). The difference in the effective lengths of the two sections is just under a centimetre (0.904 cm), not an insignificant amount. Obviously, the reason why section d^L is longer than d^S is because more space was needed in order to accommodate the larger distances of the holes in section d^L .

On both sections the upper holes (I) and their respective thumb holes (T), as has already been

said, are not diametrically opposite (Figs. 18–19). The thumb holes are shifted slightly to the side, counter-clockwise (as one is looking down, along the stream direction) in the case of section d^S, and clockwise in the case of section d^L. Central sections with displaced thumb holes are reported in literature³², where the feature has been interpreted as an indication of right or left pipe³³. By trying out fingering these sections, I am inclined to think that a clockwise shift indicates a left hand pipe and a counter-clockwise shift a right hand pipe. There is good evidence for that, as will become apparent immediately below:

• The evidence of iconography. Very interestingly, in iconography showing auloi while being played, the pipe held in the left hand is nearly always drawn longer than the other one³⁴. In Paquette's iconographic collection³⁵ the longer pipe is held in the left hand fifteen times (A4, A3, A7³⁶, A8, A10³⁷, A14, A16, A23, A27, A34, A36, A37, A43, A52, A54) and only twice in

- ³² Brauron (Landels 1963, 117–118); Elgin-Long clockwise T, Elgin-Short anticlockwise T (Psaroudakës 1994, Vol. 2, pocket, Fig. 105); Korinthos G+H clockwise T (Psaroudakës 1994, Vol. 2, Fig. 113G+H); Perachōra T clockwise T (Psaroudakës 1994, Vol. 2, Fig. 121T); Perachōra U anticlockwise T (Psaroudakës 1994, Vol. 2, Fig. 121U).
- ³³ For example, in the case of the Brauron aulos, the clockwise rotation of the thumb hole has been thought of as an indication of a right hand pipe, although the elliptical recessings on holes IV and V are in line with the fourth and little fingers of the left hand: "two contradictory items of evidence" (Landels 1963, 117–118).
- ³⁴ For an exception to this 'rule' see No. 5, above (Sicilian terracottas).
- ³⁵ Paquette 1984, 39–61, Pl. II; 21, Fig. 21B.
- ³⁶ Reproduced here as Fig. 20.
- ³⁷ Reproduced here as Fig. 21.

³⁰ Athens-Agora C, D, E (Landels 1964, 393, Fig. 1 A, C, D); Athens-Akropolis A, B (Psaroudakēs 2002, 357, Pl. 19 A, B; Argithea D (Psaroudakēs 2002, 344, Pl. 7 D); Brauron (Landels 1963, 116, Fig. 2, Section AB); København (Psaroudakēs 2002, 364, Pl. 24); Korinthos F (Psaroudakēs 2002, 359, Pl. 20.2 F); Korinthos G (Psaroudakēs 2002, 360, Pl. 20.3 G); Lokroi Epizeuphyrioi (Psaroudakēs 1994, Vol. 2, pocket, Fig. 116); Perachōra T, U, V, X, I' (Psaroudakēs 1994, Vol. 2, Pl. 121 T, U, V, X, I'); Sparta D, E, F (Psaroudakēs 1994, Vol. 2, Fig. 126 D).

³¹ Landels (1999, 33) mentions that the sheep or deer tibia bones were most suitable for making aulos sections, and that these were usually not longer than 9 cm. However, the central and exit sections here of both pipes exceed this size. Similarly, the København pair comprises central sections of overall lengths 11.1 and 12.6 cm, and exit sections of 9.9 and 10.1 cm, all larger than 9 cm. Also, longer than 9 cm are the sections: Athens-Akropolis A (14.5 cm), B (over 13 cm); Argithea A, D, E (10.25, 10.78, 9.5 cm, respectively); Brauron (13.1, 10.8 cm); Ephesos 13.4 cm; Korinthos C, F, I, H, G, L (14.65, over 12.7, over 10, 10.6, 14.07, 12.2 cm respectively); Korykeion Antron B (11.1 cm); Lokroi Epizeuphyrioi (over 16.4, 13.6 cm); Perachōra T, B', C', D', E', I' (over 12.3, 12.4, 11.1, 10.9, 10.3, 19.2 cm resp.); Sparta I (9.37 cm) - see, collectively, Psaroudakes 1994.

the right hand³⁸. It has been suggested that the apparent difference in the lengths of the two pipes in iconography should be interpreted as the painter's attempt to show depth of field: "One [pipe] may appear to project further than the other, but this is almost invariably the artist's way of trying to indicate that it is nearer to the viewer"³⁹. This is true, of course, in the case of auletes facing to the left, whence the left, longer pipe *is* closer to the viewer⁴⁰, but does not hold true in the cases of pipers facing to the right, in which case the pipe closer to the viewer, the right one, is drawn shorter⁴¹. There is no doubt that the painters knew that the pipes were unequal⁴², and in most cases they tried to indicate this feature in their work.

The evidence of the Akanthos pair. The Pydna pipes are comparable to another pair of auloi, found some years earlier (1988) in a grave (Burial 4769) in one of the cemeteries of Akanthos (Field 165), another Macedonian town in Chalkidikē on the Aegean coast⁴³. These pipes, alas not as well preserved, afford strong evidence of the argument presented here, namely, that a clockwise thumb hole belongs to a left hand pipe and vice-versa: there are marks like 'eyebrows' on the mouth end side of the thumb holes, cut into the bone and orientated in opposite directions to each other, which, no doubt, indicate whether the respective holes were operated by the left or the right thumb (Fig. 22). If one places one's fingers on the sections, one discovers that the hole with the clockwise shift and the 'acute' mark fits the left hand (Fig. 23), while the hole with the counterclockwise shift and the 'grave' mark fits the right hand (Fig. 24): marks and thumbs have the same direction.

Furthermore, the section with the 'acute' mark is the longer of the two Akanthos 'central' sections (Fig. 25), indicating that, by analogy with Pydna section d^L, it belonged to the longer pipe of the pair. Unfortunately, the Akanthos pipes do not survive in their entirety, so the argument that the longer 'central' section belongs to the longer pipe of the pair cannot be proved for this particular instrument. However, as with the Pydna pair, so with the Akanthos pair, the exit sections are not exactly equal in length (10.494 cm and 9.880 cm). Of the two exit sections it is the longer one that is connected to the longer 'central' section, indicating that the longer sections (d and e) belong to the longer pipe in the pair (Fig. 25). Thus it can, with little hesitation, be suggested that, in general: longer sections belong to the longer pipe in a pair, which is held in the *left* hand.

In the case of the Elgin pipes, too, the thumb hole with the clockwise shift appears on the longer pipe, an indication that this was the left pipe (Fig. 26). Interestingly, the longer Elgin pipe is of a lower register than the short one. This is in accord with the Pydna pair, where the lower register pipe *is* the left hand pipe. Thus, the above observation can now become a general rule (the '4L Rule'):

Longer sections belong to the Longer pipe in a pair, which is held in the Left hand and is of Lower register⁴⁴.

All four holes on both central sections of the Pydna aulos, d^S and d^L , have a 'dip' around the periphery of the holes, that is, the edges of the holes are not 'square' but have been gently smoothed out (Figs. 17–18). This is especially evident in section d^S around holes III and T, less so around I and II, as these latter holes are not in a good state of preservation, due to corrosion of the surface around them. On section d^L all four holes have the recession. Similar recessions have been observed on many extant aulos fragments and have been thought of as having provided a better 'seating' for the fingers⁴⁵, for better air sealing.

- ⁴⁰ E.g. Paquette 1984, 39, 41, 43, 47, 51, Figs. A5, A7, A14, A16, A25, A27, A34.
- ⁴¹ E.g. Paquette 1984, 39, 40, 45, 47, 53, 57, 59, Figs. A3, A4, A6, A8, A23, A24, A37, A52, A54.
- ⁴² See, especially, Paquette (1984, 49, Fig. A31), where the two, definitely unequal pipes are clasped in one hand by the musician, and there is no question of perspective.
- I would like to thank the Director of the 16th Ephorate of Prehistoric and Classical Antiquities, Thessalonike, Ms Lilian Acheilara, for granting me permission to examine the Akanthos auloi, and the archaeologist in charge of the excavation, Ms Helenē Trakosopoulou, for consenting to it. I am indebted to Mr Michael Larentzakes-Laskaris, restorer at the Ephorate, for his friendly reception and our illuminating discussions during my weekly visit to the Laboratories of the Ephorate. Special thanks are also due to Ms Athanasia Raïsē and Svetlana Vivtenko, restorers, for their help with microscopic examination of certain details and their good will to share with me their knowledge on material decay. The aulos pair is kept today in the Archaeological Museum of Polygyros, Chalkidike (Inventory Number I 165.28 = Ierisos, Field 165, Item 28). A preliminary report on the instrument, with photograph, is given in Κοψαχείλης 1992, 93-95.
- ⁴⁴ In the case of the Louvre pipes, Bélis (1984a, 113) reports that only pipe 'A' [the 'high register' pipe] exhibits a thumb hole shift, although the direction of this shift is not specified. Of pipe 'B', ['low register'], it is said that all holes are absolutely aligned ("ici, les trous sont rigoureusement alignés"). The absence of opposite shifts of the thumb holes in the Louvre pipes may now be thought of as further, perhaps not very strong, evidence against the argument of them forming a pair. See footnote 10, above.
- ⁴⁵ Landels 1999, 34.

³⁸ Paquette 1984, 21, Pl. II, Fig. B; 53, Fig. A38.

³⁹ Landels 1999, 42.

4.5 THE 'EXIT' SECTIONS (SECTIONS TYPE 'E')

The last sections of the pipes are cylindrical, unequal in length, and have in them two holes each $(IV, V^*)^{46}$ on the same side (Fig. 27). There are no holes on the lower side (Fig. 28). At the upstream end, both sections, e^S and e^L, have a socket (Fig. 29). As regards finger 'seating', this can be found on holes IV, but it is certainly absent from holes V* (Fig. 27). Similar absence of 'seating' around the last hole of several aulos exit fragments is reported in literature, and it has been interpreted as an indication that these holes were not fingered; they were mere vent-holes⁴⁷. Indeed, as each hand of the aulos player has only five fingers, with the thumb fixed in place, a sixth hole cannot be handled without the use of some remote control device.

The Auloi of Pydna 203

4.6 ASSEMBLING THE PARTS

When the individual sections as they survive today are joined together in the order cup-bulb-extension-central part-exit part (a-b-c-d-e), two pipes are formed of unequal length (S, L) and non-corresponding holes (Fig. 2). With the proposed reconstruction of the extension c^{S} the difference in length of the two pipes increases, and a much better correspondence of the tone holes is afforded: correspondence of upper holes (Fig. 30); correspondence (approximate) of thumb hole T^{L} with hole II^S (Fig. 31); correspondence of thumb hole T^{S} with hole I^L (Fig. 32).

So, there seems to be a logic behind the placing of the hole patterns in the two pipes, as shown schematically below⁴⁸:

This correspondence pattern is very much like that of the Elgin pair: correspondence of upper holes (Fig. 33); correspondence (approximate) of thumb hole T^L with hole II^S (Fig. 34); correspondence (approximate) of thumb hole T^S with hole I^L (Fig. 35), as shown schematically below⁴⁹:

L	I→	T→	II→	III→	IV→	V^*
S	Ι	Т	II	III	IV	V*

Interestingly, the difference in the lengths of the pipes at these hole correspondences are: 3.138 cm for the Pydna pair and 3.2 cm for the Elgin pair⁵⁰ (Fig. 36), practically the same length difference. The effective lengths of the Pydna sections are tabulated below, together with the overall effective lengths of the pipes and the difference between them (in cm):

• (Mπ	άνου 1997 ⁵¹))					
	a b		с	d	e	overall effective length	pipe difference
L	6.7		6.4	12.9	11	37.0	2.8
S	8.0		3.5	11.7	11	34.2	
• (Psa	roudakēs ⁵²)						
L	<2.256>	4.872	6.328	12.856	11.040	0 37.352	3.138
S	2.256	<4.872>	4.044	11.952	11.090	0 34.214	

The most noticeable difference between the figures in the above table is that in the sizes of section c^{L} : 3.5 cm (surviving) and 4.044 cm (restored). This is a very important point, for the extra 0.544 cm added to

have become so badly distorted that measurements are unreliable".

⁴⁶ The asterisk indicates a vent-hole.

⁴⁷ Landels 1999, 34: "The vent-hole [...] can be distinguished by its sharp outer edge, not shaped for the player's fingers".

⁴⁸ The diacritic \rightarrow means that the hole which bears it is located a little further down from its counterpart (e.g. $T^{L} \rightarrow$ is a little lower than II^S). Absence of the diacritic indicates good correspondence of holes.

⁴⁹ It must be remembered that the long pipe in the Elgin pair is quite deformed, being exceedingly curved, which makes it difficult to take reliable measurements; compare Landels (1999, 279, Note 30): "They [the Elgin auloi]

⁶⁰ The Elgin pipes are 31.2 and 34.4 cm long (excluding the problematic bulb sections); see Psaroudakēs (1994, Vol. 1, 282), where it is argued that the bulbs are wrongly placed on the pipes.

⁵¹ Μπάνου (1997) does not give measurements for cups and bulbs separately.

⁵² The diacritic <...> indicates that the enclosed figures are derived from the other pipe of the pair, assuming equality of the corresponding sections.

pipe S brings its holes in better alignment with those of pipe L (Fig. 30). The diameters of the holes are as follows (in cm)⁵³:

 I
 T
 II
 III
 IV
 V*

 L
 0.9x0.9
 0.884x0.846
 0.854x0.894
 0.876x0.856
 0.848x0.886
 0.912x0.872

 S
 0.746x0.84
 0.922x0.922
 0.862x0.894
 0.894x0.880
 0.804x0.90
 0.824x0.912

The distances of the (centres of the) holes from the mouth end are tabulated below (in cm):

	cup	Ι	Т	II	III	IV	V*	exit
L	0	16.456	19.576	22.189	25.204	28.502	33.23	37.352
S	0	13.879	16.391	18.961	21.983	24.872	28.236	34.214

The degree of correspondence of the holes between the two pipes can be discerned from the following table⁵⁴:

		16.456	19.576	22.189	25.204	28.502	33.23	37.352
L	_	I^L	T^{L}	II^{L}	III^{L}	IV^L	V^{L*}	$exit^L$
S	I^S	TS	IIS	III ^S	IV ^S	V^{S*}	_	exit ^S
	13.87	9 16.391	18.961	21.983	24.872	28.236		34.214
\mathbf{X}^{I}	–X ^S	0.065	0.619	0.206	0.329	0.266		

The table shows that the distances of the holes from the cup end in the long pipe are in every case a little larger than those of the corresponding holes in the shorter pipe ($X^{L}-X^{S}$ values). Although a good match between the couple I^L and T^S is afforded, T^L and II^S show a maximun diversion, which is then reduced in the remaining hole couples. One could, therefore, say that, apart form the couple I^L-T^S, the rest of the hole couples are almost perfectly aligned. However, a different picture is given by the Elgin pair, where there is a distinct and uniform shift of the L and S sets of holes.

A set of questions, therefore, arises: is the shift observed in the Elgin pipes deliberate, or is it due to the distortion of the pipes, especially the long one? Are the Pydna pipes closer to reality as regards the respective placement of the holes? In other words, should we think of the L and S sets of holes as corresponding, more or less, with each other, or are we to allow for a deliberate displacement of the two sets at the stage of manufacture? In the case of the Pydna pipes, does the close correspondence of the holes in the two pipes suggest (near or exact) identity of notes produced by these holes? Obviously, answers to these questions can only be given after an experimental study carried out on a replica of the instrument, in an attempt to establish notes and scales, and investigate possible heterophonic use of the pipes⁵⁵.

5 CONCLUSIONS

• The short Pydna aulos was longer in antiquity than what it is today by about half a centimetre (0.444 cm).

- The two pipes of the Pydna pair were unequal in length, differing by 3.138 cm.
- The longer sections belonged to the long pipe.
- The short pipe was held in the right hand and the long pipe in the left hand.
- The left, longer, pipe was of a lower register than the right, shorter, one.
- The highest note of the pair was produced by (opening) the top hole of the short pipe alone (I^S), while the lowest note of the pair was produced by (closing) the lowest tone hole of the long pipe alone (IV^L).

⁵³ The first figure gives the diameter reading along the axis of the pipe, and the second that at right angles to it.

⁵⁴ By X^L-X^S is marked the difference between the distances along the two pipes of corresponding holes from the cup ends to their centres.

Hagel (2004, 380-385, Diagrams 1-4, Tab. 1-3) reports to have developed a computer programme, which calculates the pitches of the notes produced by the holes of any metal-wrapped aulos pair (i.e. with rotating metallic 'sleeves' over the holes, 2.5 mm thick). The programme is applied to the Louvre pipes - on the belief that they formed a pair and were operated by rotating 'sleeves' - and the results are presented and assessed. With mouthpiece extrusions of certain values (4.23 cm for the 'high' pipe A, and 4.58 cm for the 'low' pipe B) the lowest notes of the pipes were near identical (177.9 Hz for A, and 177.8 Hz for B), while corresponding holes on the two pipes produced nearequal notes, differing by as low as 0.5 Hz (couple V^h-II^l), to as high as 7.6 Hz (couple $IV^{h}-T^{l}$). Interestingly, it is the 'h' holes (pipe A) in the couples which are a little higher than the 'l' ones (pipe B), apart from couple VIII^h-V^l, where note VIII^h is lower than V¹ (by 2.4 Hz). Note VI¹ of pipe B (203.8 Hz) has no 'h' counterpart in pipe A. The software is not presented in the publication, so it cannot be assessed here.

- The patterns of holes in the two pipes correspond well between them in general, although the long pipe set seems to be displaced a little lower down with respect to the short pipe set.
- The same kind of correspondence (vii) seems to exist between the sets of holes in the two Elgin pipes, although there the set of holes of the long pipe is clearly lower than that of the short pipe (unless, of course, the discrepancy has

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been caused by an excessive distortion of the wood).

• Although the bulbous sections of the Elgin pair are not in a good state of preservation, it is evident from the rest of the pipes that the Pydna pair and the Elgin pair were instruments of the same kind, but perhaps of a different pitch level, the Pydna aulos being of lower register.

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Fig. 1 Part of the skeleton in situ with aulos (after $M\pi \acute{\alpha} vo\upsilon$ 1997, 522, Fig. 1).



Fig. 2 The Pydna aulos as exhibited in the Archaeological Museum of Thessalonikē (after Ἀνδοίπου *et al.* 2003, 177, Fig. 67).



Fig. 3 Pydna pipe S: the five sections a–e. Photograph by the author.



Fig. 4 Pydna pipe S: 'cup' (a^S). Photograph by the author.



Fig. 5 Pydna pipe L: 'cup' (a^L). Photograph by the author.



Fig. 6 Pydna aulos: 'bulbs' S (b^S, top) and L (b^L, bottom). Photograph by the author.



Fig. 7 Pydna pipe L: socket of the bulb section (b^L). Photograph by the author.



Fig. 8 Pydna aulos: 'extensions' S (c^S, top) and L (c^L, bottom). Photograph by the author.







Fig. 10 The Elgin pipes: detail of the mouthpiece end. Photograph by the author.



Fig. 11 The Athens-Daphnē aulos: detail. Photograph by the author.



F 1.1 5.3 1.4 1.3

Fig. 12 The Athens-Agora G aulos fragment. Drawing by the author (scale: 1 : 1.5 cm).

Fig. 13 The Lindos F fragment. Drawing by the author (scale: 1 : 1.5 cm).



Fig. 14 The Perachōra G and H aulos fragments. Drawing by the author (scale: 1 : 0.7 cm).



Fig. 15 The Perachōra I and J aulos fragments. Drawing by the author (scale: 1 : 0.7 cm).



Fig. 16 Pydna sections c (extensions): c^L (right) and reconstructed c^S (left). Sketch, not to scale: by the author.



Fig. 17 Pydna aulos: sections d ('central') seen from above, with holes I, II, III: d^S (top) and d^L (bottom). Photograph by the author.



Fig. 18 Pydna aulos: sections d ('central') seen from below, with holes T: d^S (top) and d^L (bottom). Photograph by the author.



Fig. 19 Pydna aulos: sections d ('central') showing positions of thumb holes. Drawing by the author (scale: 1:0.7 cm).



Fig. 20 Tarento Inv. 4358, ca. 410 B.C. Crater. Aulētris (after Paquette 1984, 41, Fig. A7).



Fig. 21 Paris, Cabinet des Médailles No. 258, ca. 520 B.C. Oinochoē. Aulete (after Paquette 1984, 41, Fig. A10).



Fig. 22 Akanthos aulos: the 'central' sections seen from below, with slant cuts over the thumb holes. Photograph by the author.



Fig. 23 Akanthos aulos: the 'left' central section held in the left hand. Photograph by the author.



Fig. 24 Akanthos aulos: the 'right' section held in the right hand. Photograph by the author.



Fig. 25 Akanthos aulos: central and exit sections of left (top) and right (bottom) pipes. Photograph by the author.



Fig. 26 Elgin aulos: detail of mouthpiece ends, showing positions of thumb holes. Drawing by the author (scale: 1 : 0.7 cm).



Fig. 27 Pydna aulos: sections e ('exit') seen from above, with holes IV and V*: e^{S} (top) and e^{L} (bottom). Photograph by the author.



Fig. 28 Pydna aulos: sections e ('exit') seen from below: e^{S} (top) and e^{L} (bottom). Photograph by the author.



Fig. 29 Pydna aulos: the exit sections. Drawing by the author (scale: 1:0.7 cm).



Fig. 30 Replica in paper of the Pydna aulos seen from above: pipe S with reconstructed 'extension' (lighter colour); correspondence of holes. Construction by the author.



Fig. 31 Replica in paper of the Pydna aulos: correspondence of hole T^L with II^S. Construction by the author.



Fig. 32 Replica in paper of the Pydna aulos: correspondence of hole T^S with I^L . Construction by the author.



Fig. 33 Replica in cane of the Elgin aulos seen from above: correspondence of holes. Construction by the author.



Fig. 34 Replica in cane of the Elgin aulos: correspondence of hole T^L with II^S. Construction by the author.



Fig. 35 Replica in cane of the Elgin aulos: correspondence of hole T^S with I^L . Construction by the author.



Fig. 36 Replicas of the Pydna (in paper, top) and Elgin (in cane, bottom) auloi seen from above: a comparison of their sets of holes. Constructions by the author.