CHAPTER XXVIII-3

THE SPINAL BONES (THE SACRUM AND ONE LUMBAR VERTEBRA)

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Abstract

The partial sacrum discovered in 1886 at Spy as well as an adult lumbar vertebra found at the very end of the 20th century on the slope leading to the cave are discussed in this chapter. Both fossils could well be Neandertals and associated with the original specimens found in 1886 in front of the cave. Even if the features analysed on the sacrum prevent absolute taxonomic distinction from modern human sacra, the fossil exhibits an association of characteristics rarely observed in modern humans but common in Neandertals, such as a relatively wide sacral plateau with, at least partially, a posterior convexity, a slightly concave shape of the upper border of the right auricular surface in upper view, and a narrow ala. Some details of the morphology of the vertebra are very close to Neandertals, notably its extreme ventral wedging; in addition, a direct ^{14}C AMS date of 36,250 ± 500 BP is compatible with those obtained from the other Spy Neandertal remains.

INTRODUCTION

In 1886, the cave site of Spy yielded the first Neandertal spinal bones ever discovered. In their inventory, Fraipont & Lohest (1887: 603-604) mention the presence of seven remains belonging to the vertebral column: the seventh cervical vertebra, the first, second and fourth thoracic vertebrae, an undetermined thoracic vertebra, a possible lumbar vertebra and a partial sacrum. All of these remains have been lost except for the sacrum. At the end of the 20th century, a local resident (Philippe Pirson) discovered a fragmentary lumbar vertebra on the slope between the cave and the Orneau stream. The direct dating of this new fossil (36,250 ± 500 BP; Toussaint & Pirson, 2006) makes it compatible with the dates obtained from the Spy Neandertal specimens (Semal *et al.*, 2009, volume 1: chapter XVI).

In this chapter, we describe the sacrum (Figure 1) found at Spy in 1886 and the lumbar vertebra (Figure 2) found recently, which add to a still rare Neandertal fossil record of the vertebral column and contribute to the debate regarding whether or not the vertebral column presents significant differences between Neandertals and modern humans.

Out of the 183 recently reviewed sites which yielded Neandertal remains (Serangeli & Bolus, 2008), less than four percent yielded adult sacra, either well preserved or not (nine bones from seven sites including Spy). While this has recently increased with the findings from Sima de las Palomas (Walker *et al.*, 2011a, 2011b), this number is still low compared to other infracranial elements such as limb bones. Regarding the number of adult lumbar vertebrae, the picture is similar, being restricted to a few individuals.

Although generally robust, Neandertal sacra are often considered quite similar to those of modern humans in size and morphology (Vandermeersch, 1981: 190; Trinkaus, 1983: 205; Rak, 1991: 151; Pap *et al.*, 1996: 246) and the same observation has traditionally been made about Neandertal lumbar vertebrae (Trinkaus, 1983: 197; Arensburg, 1991: 144). However, recent studies have demonstrated that the latter do show significant differences with those of modern humans, especially in the orientation of the transverse processes and in the wedging of the vertebral body. The latter is related to a less lordotic lumbar spine in Neandertals, which is also reflected in a more horizontal sacral endplate and was probably already present in their Middle Pleistocene ancestors (Been, 2005; Gómez-Olivencia, 2009; Been *et al.*, 2010, 2012; Bonmatí *et al.*, 2010).

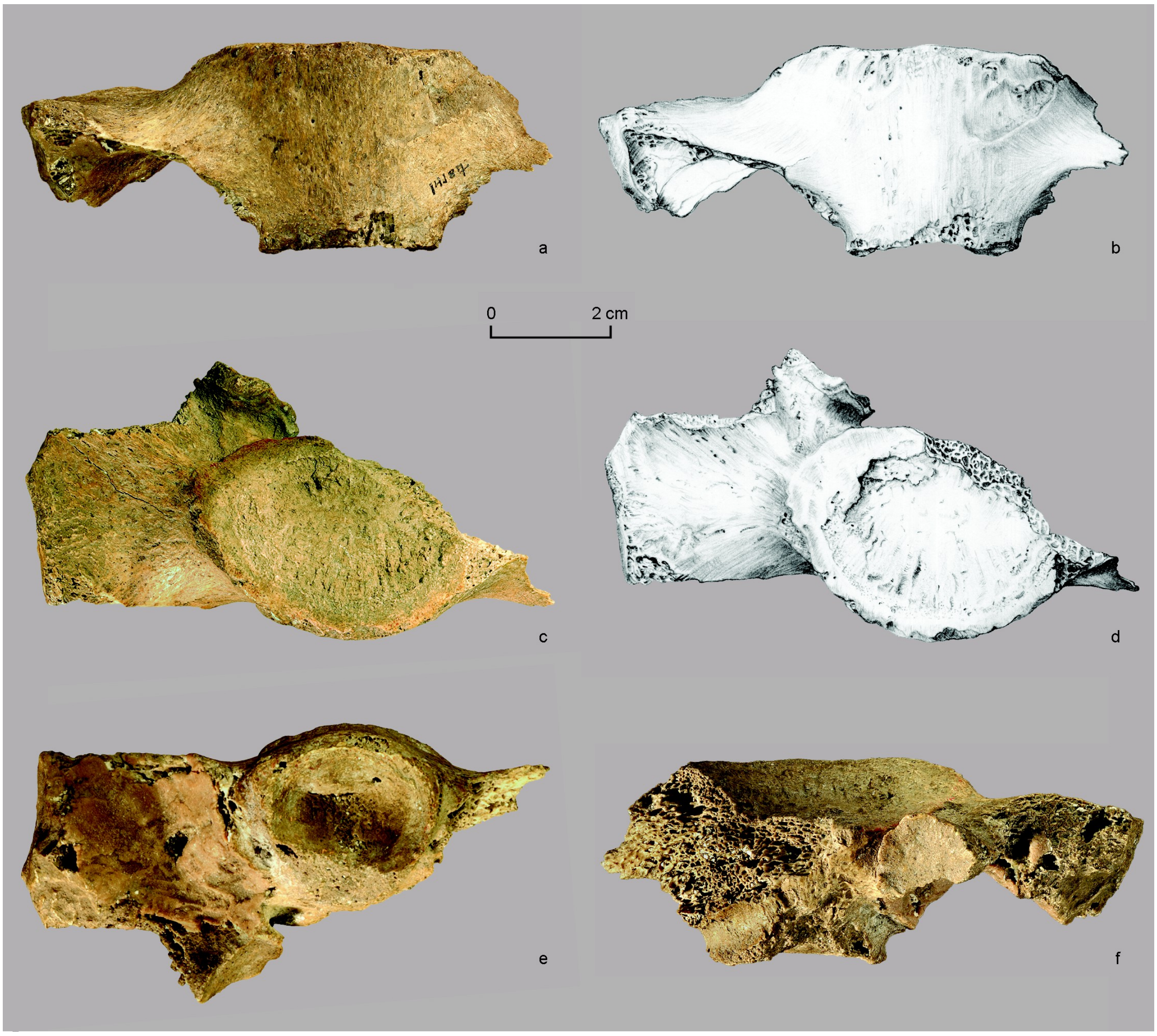

Figure 1. Partial sacrum Spy 574a. a, b: anterior view; c, d: upper view; e: lower view; f: dorsal view.

SACRUM

Early descriptions

The partial sacrum discovered in 1886 at Spy was the first ever to be attributed to a Neandertal. Neither the somewhat isolated Neandertal remains from the caves of Engis (1829-1830), Gibraltar (1848) and La Naulette (1866), nor even the partial skeleton of the eponymous site in 1856, included a complete or fragmentary sacrum.

In the monograph published one year after the discovery of the skeletons of Spy, Julien Fraipont mentions the sacrum only briefly: "[…] relatively narrow, judging by the volume of the first vertebra of the one we have. *This one was not yet fused to the following one* […]. We know that this fusion happens between the ages of 25 and 30 years at the latest in our current races. We therefore tend to attribute it to skeleton no. 2, which was undeniably younger than the skeleton no. 1 […]"[1] (Fraipont & Lohest, 1887: 650).

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[1] Original text in French: "*[...] relativement étroit, si on en juge par le volume de la première vertèbre de celui que nous possédons.* Celle-ci n'était pas encore soudée à la suivante *[...] On sait que cette soudure s'accomplit entre 25 et 30 ans au plus tard chez nos races actuelles. Nous la rapportons donc avec doute au squelette n° 2, qui incontestablement était plus jeune que le squelette n° 1 [...].*"

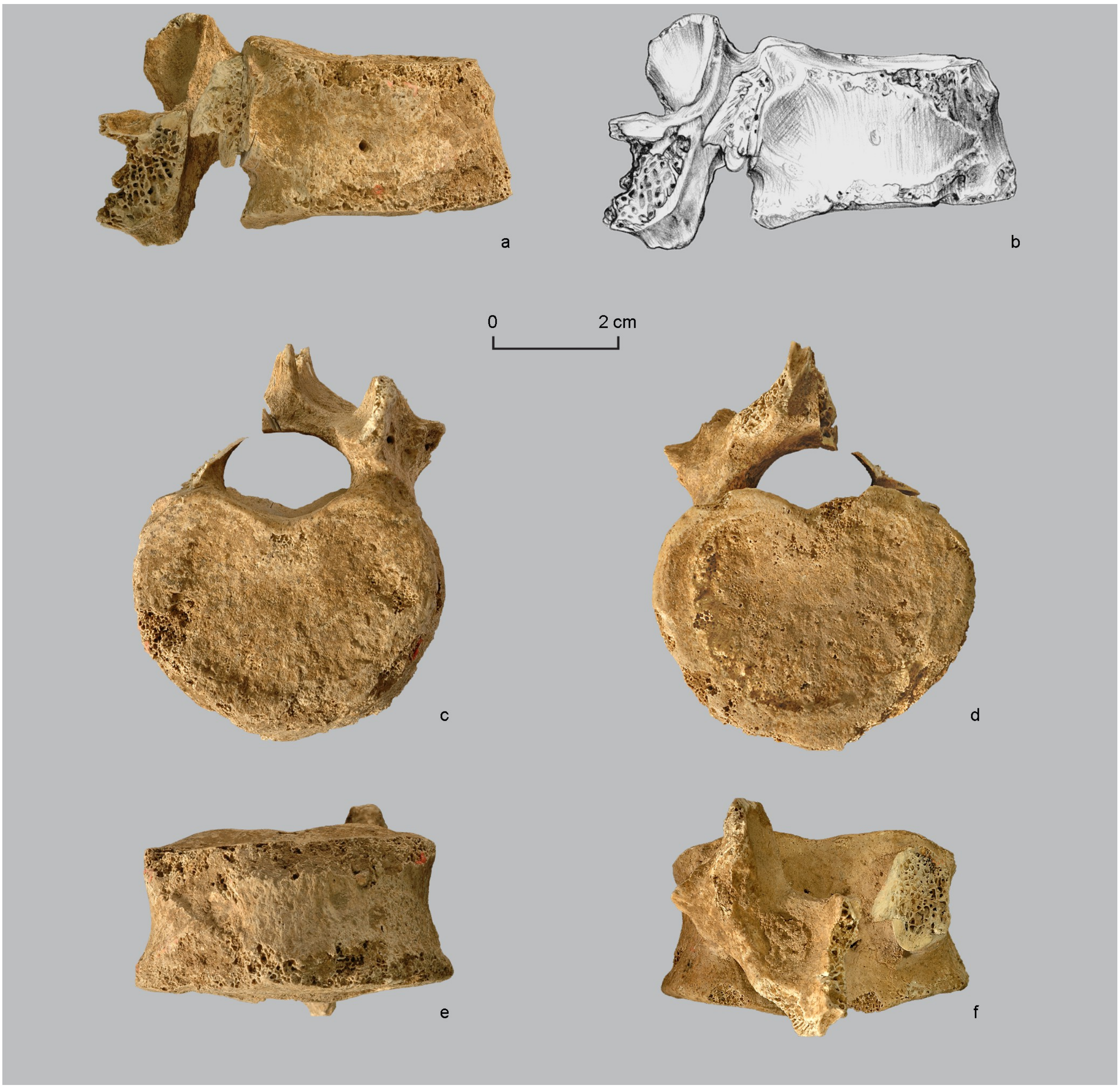

Figure 2. Lumbar vertebra Spy 737a.
a, b: right lateral view; c: upper view; d: lower view; e: anterior view; f: posterior view.

Forty years later, Charles Fraipont (1927: 194-195) briefly described the partial sacrum. He misidentified the sides of the ala and the auricular surface; contrary to what he wrote, the partial ala is the right one and not the left. He then proposed some interesting attempts – though debatable in view of the current state of knowledge – at differentiating between Neandertals and modern humans, based on the sacral plateau.

A few years later, Hrdlička (1930: 202) simply mentioned that the uppermost segment of the sacrum "does not appear to have been as yet fully united with the rest of the bone" and has "nothing very distinctive".

Material and methods

While most of the Spy remains are conserved in the Section of Anthropology and Prehistory of the Royal Belgian Institute of Natural Sciences in Brussels, the sacrum studied in this chapter belongs to the collections of the *Université de Liège* along with fragments of two scapulae dug up at the same time. It is housed at the Department of Geology, Service of Animal and Human Palaeontology. On the left inferior part of the anterior surface of its body, the former identification number 14187 marked in Indian ink is still legible. In the updated inventory of the Spy collections, the sacrum has been identified as Spy 574a (see Rougier *et al.*, this volume: chapter XIX).

The comparative material is composed of data from the literature on Neandertal sacra and, secondly, measurements and morphological traits of a sample of sacra from the Middle Ages (N = 32), Neolithic (N = 5) and Early Mesolithic (N = 3) found in the Belgian Meuse River Basin (Table 1; ST1).

During the 127 years following the discovery of the Spy remains, only a few other Neandertal adult sacra have been discovered:

- 1908: La Chapelle-aux-Saints 1 (France), partial sacrum consisting only of the body of S1 and S2 (the anterior face of which is missing), the articular facets, the median crest and a portion of the left ala (Boule, 1912: 96-97; Trinkaus, 2011; Gómez-Olivencia, 2013a);
- 1909: La Ferrassie 1 (France), crushed partial sacrum composed of four fragments (Heim, 1976: 319-321);

		Spy 574a	*Neandertal*			*Early Mesolithic & Recent Neolithic*			*Middle Ages*		
			N	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
Sacral breadth M-5 (mm)		102.2	7	110.76	8.42	8	108.59	6.16	32	115.92	7.75
Body	ant.-post. M-18 (mm)	(35.0)	4	33.23	1.32	7	29.20	2.12	32	30.15	2.79
	transv. M-19 (mm)	(48.0)	6	52.33	4.60	8	45.53	5.19	32	47.18	5.43
Right ala breadth (mm)		29.0	6	28.54	2.95	8	31.28	2.99	32	33.96	3.48
Sacral plateau	posterior shape	(convex)	-			50 % convex, 37.5 % transverse, 12.5 % concave (N = 8)			25 % convex, 56.2 % transverse, 18.8 % concave (N = 32)		
	anterior shape	convex	-			100 % convex (N = 8)			90.6 % convex, 9.4 % nearly flat (N = 32)		
S1 anterior height (mm)		32.8	4	29.53	2.19	8	29.85	2.01	25	29.65	2.30
Promontory angle (°)		66	3	70.33	1.53	6	57.83	4.54	28	56.50	5.74
Right superior articular facet	length (mm)	18.0	-			7	17.17	1.33	25	17.30	1.76
	depth (mm)	2.2	-			7	1.66	0.95	25	1.81	1.37
	angle on transv. axis (°)	35	2	41.50	16.26	6	40.67	6.09	29	40.45	10.12
Type of upper edge of auricular surface in upper view	shape	concave	-			57.1 % concave, 42.9 % long concave (N = 7)			72 % concave, 16 % flat, 8 % long concave, 4 % long convex (N = 25)		
	right	1 or 7	-			1: 33.3 %, 2: 33.3 %, 6: 33.3 % (N = 6)			1: 12.5 %, 2: 50.0 %, 4: 4.2 %, 5: 8.3 %, 6: 16.7 %, 7: 8.3 % (N = 24)		
	left	-	-			1: 83.3 %, 6: 16.7 % (N = 6)			1: 18.2 %, 2: 36.4 %, 3: 4.5 %, 4: 4.5 %, 5: 13.6 %, 6: 18.2 %, 7: 4.5 % (N = 22)		

Table 1. Dimensions of the partial sacrum Spy 574a compared to those of the comparative samples. M-5, M-18 and M-19 are after Martin (Bräuer, 1988). For individual values of the comparative samples, see ST1.

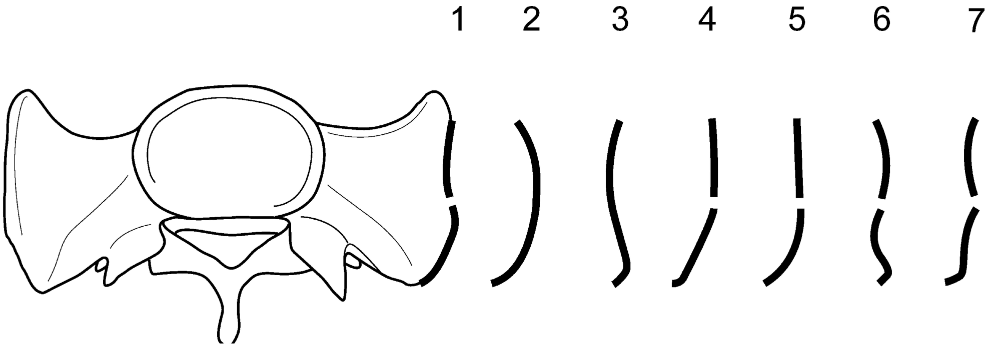

Figure 3. Sacrum: the seven types of shape of the upper border of the auricular surface in upper view.

- 1910: La Ferrassie 2 (France), partial and pathological sacrum representing the first sacral vertebra;
- 1932: Subalyuk 1 (Hungary), fully fused S1 to S3 (Bartucz, 1940; Pap *et al.*, 1996);
- 1957: Shanidar 1 (Irak), mostly complete sacrum with most of S1-S5, and Shanidar 3, quite complete sacrum found in two portions (S1 and part of S2; most of S3 to S5) that have been joined with filler (Trinkaus, 1983: 198-205);
- 1960: Shanidar 4 (Irak), partial sacrum consisting of the bodies of S2-S5 and vertebral canal moderately complete (Trinkaus, 1983: 198-205);
- 1957-1962: Regourdou 1 (France), bodies of S1, S2 and partially S3 as well as portions of the two alae (Piveteau, 1966: 172; Meyer *et al.*, 2011);
- 1983: Kebara 2 (Israel), quite complete albeit crushed sacrum (Duday & Arensburg, 1991: 184-185; Rak, 1991: 151-152);
- 2005-2006: Sima de las Palomas (Spain): Palomas 92, partial sacrum (92ss) (S1-S3) embedded in breccia, and Palomas 96, quite complete sacrum (96u) with all the five sacral vertebrae represented but unfused (Walker *et al.*, 2011a, 2011b).

Several sacra of juvenile Neandertals were also found during the same period but are not relevant for comparisons with the Spy sacrum.

The following description of the Spy sacrum attempts to identify diagnostic morphological features, if any. Particular attention was paid to the shape and dimensions of the sacral plateau, the promontory angle (angle between the superior articular surface of S1 and the ventral slope of the body), the shape of the upper border of the auricular surface in upper view, the sacrum ala width versus the sacrum endplate width, as well as the orientation, length and depth of the superior articular facet. To study the morphological variability of the upper border of the auricular surface, different types have been established by dividing the upper border into posterior and anterior parts (Figure 3; Table 2). Univariate comparisons were conducted using plot histograms. Bivariate biometric comparisons used the well-known technique of equiprobable ellipses (Defrise-Gussenhoven, 1955); 95 % confidence ellipses were plotted using the statistical software package PAST (v. 2.16; Hammer, 2012).

		Type							*Total*
		1	*2*	*3*	*4*	*5*	*6*	*7*	
Right	N	5	14	0	1	2	6	2	30
	%	16.7	46.7	0	3.3	6.7	20.0	6.7	
Left	N	9	8	1	1	3	5	1	28
	%	32.1	28.6	3.6	3.6	10.7	17.9	3.6	
Total	N	14	22	1	2	5	11	3	58
	%	24.1	37.9	1.7	3.4	8.6	19.0	5.2	

Table 2. Sacrum: shape of the upper border of the auricular surface of Belgian modern specimens.

State of preservation

The Spy 574a sacrum is incomplete due to postmortem damage and is slightly fossilised. It consists only of most of the first sacral vertebra (Figure 1). In detail, the body of S1 is strongly eroded in the left postero-lateral area. The anterior surface of the body is complete except for some erosion of the inferior and superior borders. The posterior face of the body is largely damaged. The left superior articular facet is missing and only the cranial part of the right one is present. The promontory is well preserved. The inferior face of the body is nearly complete except for some erosion of its right posterior area.

In superior view, the right ala (or wing) seems to be quite well preserved except for its postero-lateral angle. However, the inferior part of the wing is missing as seen in anterior or inferior views. Only the uppermost part of the right auricular surface is present. The left wing is almost completely missing.

Description

The shape of the sacral plateau (or base) draws a transversal oval whose anterior edge forms a regular convexity. The remainder of the posterior edge is convex before the pedicle, then slightly oblique on the medial side of the pedicle. The sacral plateau shows a slight concavity in its posterior half, particularly in its right posterior area. Its dimensions are imprecise but slightly over 48 x 34/35 mm (Table 1; ST1).

The body of S1 is not fused with S2, as previously mentioned (Fraipont & Lohest, 1887; Fraipont, 1927). The fossil is much higher anteriorly than posteriorly with a ventral height of 32.8 mm versus an estimated dorsal height of less than 25 mm. The angle between the upper and lower articular surfaces of S1 is 25.5° (26° in Fraipont, 1927).

In anterior and posterior views, the left and right sacral foramina are about the same size and therefore show no asymmetry. The medial walls of the canal joining the anterior and posterior sacral foramina are preserved at the inferior parts of both lateral faces of the body.

The inferior articular surface of S1 is deep (ca. 7 mm). Its anterior border is slightly convex and is separated from the two lateral sides by rounded but well-marked and nearly straight angles. The posterior border of the surface is almost completely eroded.

The Spy sacrum is hypobasal (*sensu* Radlauer, 1908); in other words, the superior face of the wing lies below the level of the upper face of the body of the vertebra. This is also the case in Regourdou 1 (Meyer *et al.*, 2011) and Subalyuk 1; on the contrary, Kebara 2 and Shanidar 3 are homobasal (Been, pers. obs.). The breadth of the ala, i.e. the distance between the lateral part of the sacral plateau and the most lateral part of the wing along the transversal axis of the plateau, is 29 mm.

The periphery of the sacral canal is missing since the neural arch is destroyed. However, according to Fraipont (1927), this sacral canal would have been quite flat as the preserved part of the posterior border of the sacral plateau is convex; this can be sustained only as an assumption since most of the median crest is missing. As in La Chapelle-aux-Saints 1 (Boule, 1912: 112), the promontory of Spy 574a is not strongly developed. Its angle is 66°.

The right superior articular process, or facet, is slightly coronally (or frontally) orientated. Its angle with the transverse axis of the sacral plateau is 35°. In other Neandertals, this angle is: 30° for Kebara 2 right and 51° for Kebara 2 left, 53° for Subalyuk 1 right and 39° for Subalyuk 1 left. Both these specimens show tropism (differences in articular processes angle). The articular process of Spy 574a is slightly concave along its transversal longitudinal axis (chord of 2.2 mm for a length of 18 mm) as well as along its supero-inferior axis. The medial border of the superior articular facet exhibits some osteophytes.

The right auricular surface is only preserved on its superior part (18 mm in height). Posterior to it, the upper part of the sacral tuberosity (*tuberositas sacralis*), the site of ligamentous attachment, exhibits a small fossa (9.5 mm vertically). In superior view, the upper border of the right auricular surface appears to be slightly concave in its anterior part.

Finally, very faint traces of radiating channels are still present on the superior and anterior surfaces of the S1, giving it a billowed appearance.

LUMBAR VERTEBRA

Material and methods

In the updated inventory of the Spy collections, the lumbar vertebra (Figure 2) found at the end of the 20th century has been identified as Spy 737a (see Rougier *et al.*, this volume: chapter XIX).

Only a limited number of adult Neandertal lumbar vertebrae have been found and can be used as comparative material. Among them are:

- 1899-1905: Krapina (Croatia), several incomplete lumbar vertebrae, i.e. 10 or 11 fragments from L1 to L5 (according to Smith, 1976: 290, but see Radovčić *et al.*, 1988);
- 1908: La Chapelle-aux-Saints 1 (France), four slightly damaged lumbar vertebrae, which are L1, L2, L4 and L5 according to Boule (1911-13) or L1, L3-L5 according to Gómez-Olivencia (2013a);
- 1909: La Ferrassie 1 (France), five badly damaged lumbar vertebrae (Heim, 1976: 318-319; Gómez-Olivencia, 2013b);
- 1957: Regourdou 1 (France), nearly complete first lumbar vertebra (Piveteau, 1966) together with other fragments of at least another three lumbar vertebrae (Gómez-Olivencia *et al.*, 2013);
- 1957-1960: Shanidar (Irak); Shanidar 1, portions of L1 to L5; Shanidar 2, portions of L1 to L4; Shanidar 3, nearly complete L1 to L5; Shanidar 4, portions of L1 to L5; and Shanidar 6, portions of L1 to L4 (Trinkaus, 1983);
- 1961: Amud 1 (Israel), body, probably from the first lumbar vertebra, as well as a fossil representing the neural arches of three lumbar vertebrae in articulation (Endo & Kimura, 1970: 233);
- 1963: Hortus XIX (France), first lumbar vertebra with missing parts of the body and of the spinous process as well as missing transverse processes (de Lumley, 1973: 548-49);
- 1983: Kebara 2 (Israel), well-preserved L1 to L5 (Arensburg, 1991);
- 2007: Palomas 96 (Spain), L5 (96t) (Walker *et al.*, 2011b).

According to the state of preservation of the Spy 737a lumbar vertebra, ten standard measurements were taken (see Trinkaus, 1983; Bräuer, 1988). The wedging of the vertebral body was calculated based on DiGiovanni *et al.* (1989).

State of preservation

The body of the vertebra is almost complete. However, on the anterior margin, both the superior and inferior borders are eroded. The vertebral arch is well preserved on the left side (pedicle and lamina) and partially so on the right one (damaged pedicle, no lamina), and the shape of the vertebral foramen is preserved. Only one of the four articular facets, i.e. the superior left one, is present. Both transverse processes are missing. The spinous process is very incomplete except for a small part of its root. In 2001, most of this vertebra was destroyed to obtain a ^{14}C AMS date (36,250 ± 500 uncal BP, OxA-10560; Toussaint & Pirson, 2006), which is compatible with other dates on the Spy Neandertal remains (Semal *et al.*, 2009, volume 1: chapter XVI).

Description

In upper view, the body of the Spy 737a lumbar vertebra has a reniform outline due to the angled anterior part of the vertebral canal (Figure 2). The vertebral foramen is quite hexagonal; two well-defined edges form the posterior upper border of the body, two are formed by the pedicles, and the last two by the laminae. The root of the spinous process, the only preserved part of this structure, is horizontal at its superior border and slightly concave at its inferior border. The width of the pedicle of Spy 737a is 10.6 mm on the left side. The height of its main (vertical) axis is 16.6 mm. The laminar length is 9.5 mm. The left superior articular facet is slightly concave, but has the same angle and similar dimensions as in modern human populations.

Tables 3 and 4 provide the preserved dimensions of the Spy lumbar vertebra compared to other Neandertals and to a modern human sample. It appears that the Spy 737a vertebra is extremely kyphotic (body dorsal height is much longer than body ventral height). Its amount of kyphotic wedging exceeds that found in modern humans, similar to what Weber & Pusch (2008) described for Kebara 2 and Shanidar 3.

Variable	*Spy 737a*	*Kebara 2*	*La Chapelle-aux-Saints 1*	*Regourdou 1*	*Shanidar 2*	*Shanidar 3*	*Modern Euroamerican and European male sample*				
							Mean	*SD*	*Min*	*Max*	*N*
Canal dorso-ventral diameter (M-10)	14.3**	18.0	16.8	17.3		18.1	17.44	1.13	13.5	19.4	58
Canal transverse diameter (M-11)	22.3	19.8	22.4	23.3	19.9	20.2	21.94	1.54	19.3	27.3	58
Body cranio-caudal ventral diameter (height) (M-1)	22.9	24.4	23.4	25.8		23.4†	25.60	1.77	21.5	29.1	52
Body cranio-caudal dorsal diameter (height) (M-2)	28.3	27.5	28.2	(28.4)		28.5	27.28	1.40	22.2	31.5	57
Body superior dorso-ventral diameter (M-4)	(32.0)	31.9	(35.0)	(32.4)		34.6†/(32.5)	30.76	2.02	26.7	35.4	56
Body inferior dorso-ventral diameter (M-5)	37.5**	34.8		34.6		34.9†/(34.4)	31.22	2.06	26.5	36.1	56
Body superior transverse diameter (M-7)	46.6	42.0		45.5		49.5†/(47.0)	44.13	2.80	39.1	52.1	57
Body inferior transverse diameter (M-8)	50.9	45.3		(48.0)		55.1†/(48.0)	46.96	2.99	41.6	55.7	56
Vertebral wedging (after DiGiovanni *et al.*, 1989)	9.65**	5.56	7.85	4.60		8.97†	3.27	2.56	-3.39	9.03	51
Pedicles: maximum diameter (cranio-caudal) (PedMaxDi)	-/16.6	18.1*/17.4	14.3/15.3	16.5/17.3	15.2/15.9	17.2/16.2	15.55	1.19	12.9	20.3	58
Pedicles: minimum diameter (thickness) (PedMinDi)	-/10.6	7.4/7.3	10.5/10.7	8.8/10.3	6.1/6.6	9.0/9.6	7.61	1.76	4.6	11.2	57

Measurements noted M-xx are after Martin (Bräuer, 1988).
The dimensions of Regourdou 1 are from Gómez-Olivencia *et al.* (2013) and those of Shanidar 2 from Trinkaus (1983).
Values in parentheses are estimated; values followed by † are affected by pathology.
Values underlined are outside the range of the modern human comparative sample; values that are significantly different from the modern male sample in the z-score analysis are followed by * ($p < 0.05$) or ** ($p < 0.01$).
Cells that contain two entries are for the right and left sides (right/left); only the right side was measured for modern humans.

Table 3. Raw dimensions (in mm) of the Spy 737a L1 or L2 vertebra compared to L1s of other Neandertals and to our modern sample.

Variable	*Spy 737a*	*Kebara 2*	*Shanidr 3*	*Modern Euroamerican and European male sample*				
				Mean	SD	Min	Max	N
Canal dorso-ventral diameter (M-10)	14.3**	16.9		16.48	1.18	13.0	18.6	59
Canal transverse diameter (M-11)	22.3	20.7		21.93	1.48	19.2	26.9	59
Body cranio-caudal ventral diameter (height) (M-1)	22.9	23.8	24.8†	26.92	1.74	23.2	30.7	56
Body cranio-caudal dorsal diameter (height) (M-2)	28.3	27.9	(29.5)	27.61	1.56	24.5	31.1	58
Body superior dorso-ventral diameter (M-4)	(32.0)	34.6	37.0†/(34.3)	31.69	2.10	26.5	36.5	55
Body inferior dorso-ventral diameter (M-5)	37.5*	36.2	(33.0)	32.13	2.09	28.2	37.3	55
Body superior transverse diameter (M-7)	46.6	44.2	(50.6)	45.68	2.94	40.9	54.3	56
Body inferior transverse diameter (M-8)	50.9	46.8	55.5†/(51.7)	48.97	3.26	44.0	59.4	56
Vertebral wedging (after Digiovanni *et al.*, 1989)	9.65**	6.78*	7.84**	1.19	2.33	-4.24	5.64	55
Pedicles: maximum diameter (cranio-caudal) (PedMaxDi)	-/16.6	18.1/16.4	16.1/-	15.07	1.32	12.0	18.6	59
Pedicles: minimum diameter (thickness) (PedMinDi)	-/10.6	8.4/9.0	7.3/-	7.85	1.52	3.8	10.7	59

Measurements noted M-xx are after Martin (Bräuer, 1988).
Values in parentheses are estimated; values followed by † are affected by pathology.
Values underlined are outside the range of the modern human comparative sample; values that are significantly different from the modern male sample in the z-score analysis are followed by * ($p < 0.05$) or ** ($p < 0.01$).
Cells that contain two entries are for the right and left sides (right/left); only the right side was measured for modern humans.

Table 4. Raw dimensions (in mm) of the Spy 737a L1 or L2 vertebra compared to L2s of other Neandertals and to our modern sample.

Anatomical identification

The lumbar vertebra from Spy belongs to an adult as both its annular epiphyses are fused. Its anatomical identification should however be viewed as tentative because of its incompleteness. As a first approach, we used Fawcett's (1932) method of the four-sided figures. In the case of Spy 737a, the reconstructed angular figure of Fawcett has a vertical axis. The outline seems to be that of a trapezium hence the vertebra is more likely an L1 or L2 than an L3.

The vertebral canal of the Spy lumbar vertebra is quite similar to the L1s of La Chapelle-aux-Saints 1 and Regourdou 1. It is also similar to that of Kebara 2's second lumbar vertebra and quite distinct from that of the first lumbar vertebra of Kebara 2 (Arensburg, 1991); however, the vertebral canal of the L1 of Kebara 2 is quite unique. In addition, the overall metric dimensions of Spy 737a are similar to the L1s of La Chapelle-aux-Saint 1, Regourdou 1 and Shanidar 3 (Tables 3 & 4).

In conclusion, the Spy 737a lumbar vertebra is one of the first two vertebrae, more probably the L1 than the L2.

DISCUSSION

Does the Spy partial sacrum exhibit taxonomical particularities?

Charles Fraipont (1927: 194) stated that "the superior articular surface of the vertebra is shorter in the transversal axis and wider in the antero-posterior direction than in *Homo sapiens*. The oval is more rounded. While in modern humans this surface is rather reniform and presents at the back a flattening and even an inversion of curvature which becomes concave […], in *Homo neanderthalensis* the curve is as convex at the rear as it is at the front [...]"[2].

An analysis of the other Neandertal sacra actually shows that the observations of Fraipont, based on the examination of the fossil of Spy alone, possess hardly any taxonomic value. It appears that the antero-posterior and transverse diameters of the sacral plateau of Neandertals are in the range of Belgian modern humans (Table 1; ST1; Figure 4), though at its upper limit. In addition, in superior view, the posterior border of the sacral plateau of La Chapelle-aux-Saints 1 is transversally sub-rectilinear and that of Kebara 2 is almost slightly concave (Figure 5). As for Spy 574a, the right part of the posterior edge is very convex, then slightly oblique and linear; its central and left parts are lost. This feature is thus indisputably variable in Neandertals. In addition, it is true that in modern humans, represented by a Belgian sample, the posterior edge is more frequently linear and transverse (52.5 %) or even slightly concave (17.5 %), but nearly a third (30.0 %) exhibit a slightly convex shape.

Ch. Fraipont (1927) also considers that the slightly concave shape of the anterior part of

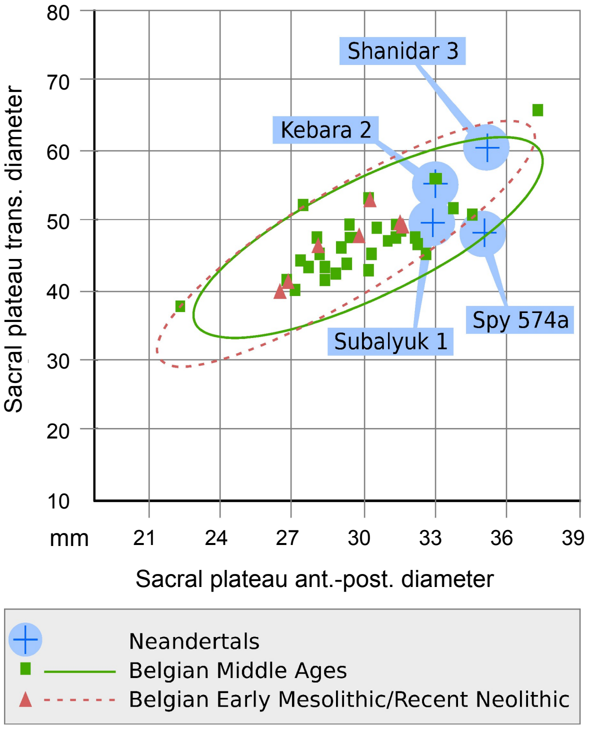

Figure 4. Sacrum, statistical comparisons: bivariate plot of transverse vs. antero-posterior diameters of the sacral plateau, with 95 % confidence ellipses of 32 Middle Ages sacra and 7 Mesolithic/Neolithic sacra from Belgium.

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[2] Original text in French: "*La surface articulaire supérieure de la vertèbre est moins longue dans le sens transversal et plus large dans le sens antéro-postérieur que chez* Homo sapiens. *L'ovale est plus arrondi. Alors que chez l'homme actuel, cette surface est plutôt réniforme et présente en arrière un aplatissement et même une inversion de la courbure qui devient concave [...], chez* Homo neanderthalensis *la courbe est, en arrière, aussi convexe qu'en avant [...].*"

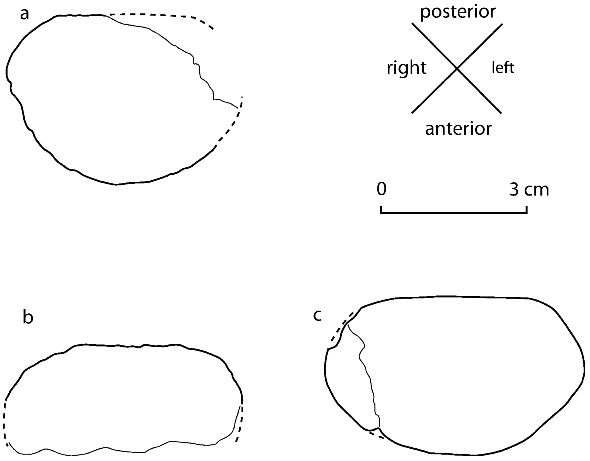

Figure 5. Partial sacrum of Spy, comparisons of the outline of the sacral plateau. a: Spy 574a; b: La Chapelle-aux-Saints 1; c: Kebara 2.

the upper border of the auricular surface in upper view is distinctive of Neandertals and that this surface is convex in modern humans. Is this true? On La Chapelle-aux-Saints 1 and on the right side of Kebara 2, this border is clearly convex rather than concave. This feature is therefore variable in Neandertals, as was the previous one. In addition, while studying 40 Belgian modern sacra (Table 2), a wide variability in the morphology of the upper border of the auricular surface became even clearer. Referring to the different shapes of the upper border of the auricular surface (Figure 3), it appears that 52 % of the 25 comparative modern sacra having both sides preserved exhibit the same shape on the left and right sides; therefore, 48 % of them have morphological differences between their sides. Type 2, in which the anterior and posterior parts of the upper border are convex, is the most frequent, both sides combined, making up over a third (37.9 %) of the total. However, types 1, 3, 6 and 7, which all have at least one concave segment, represent 50 %. Our results thus do not support Fraipont's assertion. The so-called Neandertal shape is actually within the range of modern humans and the Spy sacrum, with a concave anterior part, is not very different from our types 1 and 7, even if it is not possible to determine which precise type Spy 574a belongs to as its postero-lateral angle is damaged.

Fraipont (1927) also stated that the shape of the inferior articular surface of S1 is elliptically triangular in *Homo sapiens* and transversally rectangular with rounded edges in Neandertals. Again, this statement was issued after studying the Spy sacrum alone; furthermore, the right posterior area of that surface is badly damaged.

As in the initial description of La Chapelle-aux-Saints 1 by Boule (1912: 112), Fraipont (1927) wrote that the ala breadth of the Spy sacrum, i.e. the distance between the auricular surface and the upper articular surface of the body of S1, is quite small. But does it mean anything? Discussing this observation, Rak (1991: 151) states that in Kebara 2: "The body width constitutes the same ratio to the general sacral width as in a modern male sample". Comparing the sacral plateau breadth with the ala breadth of our sample of Belgian modern humans (Table 1; ST1), it appears that the Neandertal sacra for which these dimensions are available fall within the range of modern humans (Figure 6). However, the Neandertal ala breadth is clearly in the lowest part of the modern distribution and the difference is statistically significant ($p < 0.01$) using a Wilcoxon rank test. With an ala breadth of 29 mm, Spy 574a is close to other Neandertals.

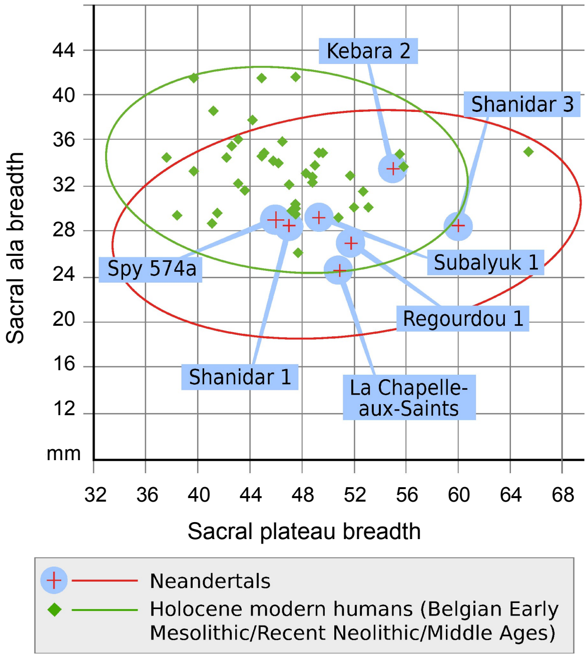

Figure 6. Sacrum, statistical comparisons: bivariate plot of ala breadth vs. sacral plateau breadth, with 95 % confidence ellipses of Neandertals and 40 modern sacra from Belgium (Middle Ages, Mesolithic and Neolithic).

Vandermeersch (1981: 190) considers that the superior articular facets of the sacrum (*processus articulares superiores*) are flat on Neandertals and concave on modern humans, but such a distinction is not always evident. First, it appears that both superior articular processes of any sacrum may sometimes be unequal in size and inclination, as in Kebara 2 (Rak, 1991: 151) and in the Belgian modern sample. Second, on the basis of the comparative sample (Table 1), no real differences in orientation (Figure 7), dimensions, or maximal length and depth are obvious between Neandertals and modern humans.

On Spy 574a, the maximum length of the right superior articular facet is 18 mm, for a depth of 2.2 mm and an angle of 35° (Table 1).

The promontory angle does not allow a real distinction between modern humans and Neandertals either, even if the Neandertal fossils on which this angle has been measured are in the upper range of recent *Homo* (41°-75° according to De Beer Kaufman, 1975; 47.5°-72° in the present study with a set of Belgian Middle Ages, Early Mesolithic and Recent Neolithic specimens): Subalyuk 1 (cast): 69°, Kebara 2: 70°, and Shanidar 3: 72° (Figure 8). With an angle of 66°, Spy 574a is in the Neandertal range.

In conclusion, none of the features analysed on the S1 of Spy would allow on its own a clear taxonomic distinction from modern human sacra, as already mentioned for other Neandertal specimens (Vandermeersch, 1981: 190; Trinkaus, 1983: 205; Rak, 1991: 151; Pap *et al.*, 1996: 246). Nevertheless, the partial sacrum Spy 574a exhibits an association of characteristics not frequently found in modern humans, such as a sacral plateau with, at least partially, a posterior convexity, a slightly concave shape of the upper border of the right auricular surface in upper view, and relatively narrow alae.

Is it possible to make a taxonomical attribution of the lumbar vertebra?

While previous studies suggested that Neandertal lumbar vertebrae were similar to those of modern humans (Heim, 1976; Trinkaus, 1983; Arensburg, 1991), recent re-analyses of Neandertal lumbar vertebrae have detected significant differences along the spine in the wedging of the vertebral body (L1-L4), the orientation of

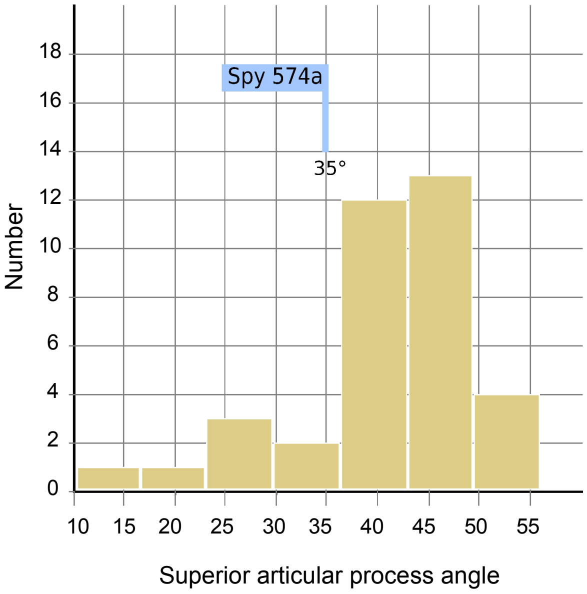

Figure 7. Sacrum: angle of the right superior articular process with the transverse axis of the sacral plateau. The modern human sample comprises 30 Middle Ages and 6 Mesolithic/Neolithic sacra from Belgium.

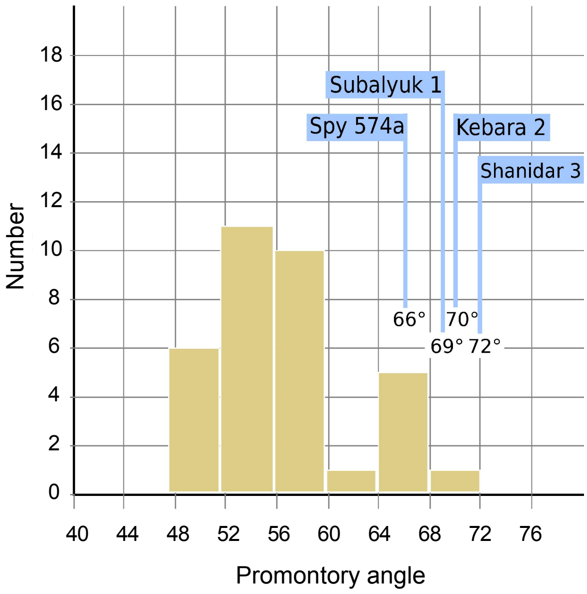

Figure 8. Sacrum: angle of the promontory, i.e. angle between the superior articular surface of S1 and the ventral slope of the body. The modern human sample comprises 28 Middle Ages and 6 Mesolithic/Neolithic sacra from Belgium.

the articular facets (L2-L3), the length and orientation of the transverse processes (L2-L4) and the length and orientation of the laminae (L5) (Been, 2005; Gómez-Olivencia, 2009; Been *et al.*, 2010). The differences in the wedging of the vertebral body are related to a lumbar spine with less lordosis (Been *et al.*, 2012), which was likely already present in the Middle Pleistocene humans from Sima de los Huesos (Gómez-Olivencia, 2009; Bonmatí *et al.*, 2010).

There are two facts that make the taxonomic assessment of the Spy 737a lumbar vertebra extremely difficult: first, its incompleteness, and second, that the segment to which it belongs (L1-L2) displays fewer morphological differences between Neandertals and modern humans than the more caudal lumbar segment (L3-L5). However, there is one anatomical feature that would suggest that Spy 737a is Neandertal: its extreme ventral wedging (kyphotic condition), which is outside the range of variation of our modern male sample and slightly above the individual Shanidar 3. When compared to modern humans, Neandertals tend to show more differences in vertebral wedging in the L1-L4 segment and especially in the L2-L4 segment (Gómez-Olivencia, 2009; Gómez-Olivencia *et al.*, 2013).

If Spy 737a is an L1, the width of its pedicle (10.6 mm) is well over the mean of modern humans (7.61 ± 1.76 mm; Table 3; Been *et al.*, 2010) and inside the Neandertal distribution – above Shanidar 2 (right - left mean = 6.35 mm) and Kebara 2 (right - left mean = 7.35 mm), and similar to La Chapelle-aux-Saints 1 (right = 10.5 mm, left = 10.7 mm).

In summary and even if it is risky to perform a taxonomical assessment based on this partially preserved fossil, some morphological details suggest that it is indeed Neandertal. Its direct dating which is consistent with other dates obtained from indisputable Neandertal fossils from Spy reinforces this hypothesis.

Is it possible to attribute the sacrum and the lumbar vertebra to a precise skeleton?

There are two adult Neandertal skeletons in the Spy collection. Spy I belongs to a mature adult, possibly female (Thoma, 1975), represented by the calvaria and portions of the mandible and maxillae, as well as a few infracranial bones, mainly a partial humerus. Spy II is a young adult, possibly male (Thoma, 1975), much more complete, with the calvaria, the maxillae, the mandible, and many infracranial bones, notably both partial humeri, the partial left and right ulnae and radii, the complete right femur, partial left femur, left tibia, left talus and calcaneus as well as some smaller bones, notably metacarpals and phalanges (see Rougier *et al.*, this volume: chapter XIX).

Julien Fraipont wisely stated that the sacrum of Spy cannot be attributed with certainty to either one of the two adult skeletons (Fraipont & Lohest, 1887: 604). However, in the course of his study (Fraipont & Lohest, 1887: 650) and since S1 is not fused to S2, he attributes it with hesitation to skeleton no. 2, which was younger than Spy I. In his short description, Charles Fraipont (1927) did not take this problem into consideration. Hrdlička (1930: 202) wrote that the sacrum belongs undoubtedly to Spy II. This is also the opinion of Trinkaus (2011).

Since in modern humans the ossification between the bodies of S1 and S2 occurs at around 25 years of age or later (Scheuer & Black, 2004: 209) and since very faint traces of radiating channels are still present on the superior and anterior surfaces of the S1 body, the Spy 574a sacrum could well belong to the youngest adult of the site and Julien Fraipont's assessment seems realistic. Some growth lines are indeed still visible on the micro-CT scans of the lower limb bones of Spy II, who is supposed to be a young adult (Rougier *et al.*, this volume: chapter XIX). However, it should be kept in mind that some hominin fossils – for example the sacrum from pelvis 1 at Sima de los Huesos, which is one of the oldest or maybe even the oldest individual in the Atapuerca sample – do not show fusion between S1 and S2 (Bonmatí *et al.*, 2010).

Contrary to the sacrum, it is much more difficult, or even impossible, to attribute with certainty the Spy 737a lumbar vertebra to either Spy II or Spy I. The fossil does not present any traces of billowed appearance. Using modern standards, the age-at-death would be well over

25 years, so the fossil would have belonged to a middle-aged or old individual, like La Ferrassie 1, Shanidar 3 and La Chapelle-aux-Saints 1, rather than to a young adult individual like Regourdou 1. In this hypothesis – and since the assumption that there could be a third adult Neandertal at Spy, only represented by the Spy 737a vertebra, has little chance to be supported by the current collection – the fossil would not belong to Spy II, the youngest of the two Spy adults, but rather to Spy I, which is older than Spy II. However, the fusion of the annular epiphyses does not always occur at the same time in all vertebrae of the same individual, so that these considerations should be regarded with caution.

Another approach is to compare the relative robustness of both fossils. The Spy 737a vertebra is quite large and similar in size to other male Neandertal individuals such as La Chapelle-aux-Saints 1 and Shanidar 3 (Boule, 1911, 1912, 1913; Trinkaus, 1983), and larger than female individuals such as La Ferrassie 2; however, a male attribution has to be kept as a hypothesis as other Neandertal individuals with similar vertebral size, such as Regourdou 1, have not been confidently sexed (Vandermeersch & Trinkaus, 1995) even if they preserve pelvic elements (Meyer *et al.*, 2011). Nevertheless, on the basis of its robustness, the Spy 737a lumbar vertebra, being more robust than the sacrum, could belong to the possibly male Spy II skeleton.

In conclusion, according to the adopted approach, the results are somewhat contradictory and it is best not to try to attribute the vertebra with any certainty to a specific adult Neandertal found at Spy.

CONCLUSION

The partial sacrum found at Spy in 1886 exhibits an association of characteristics unusual in modern humans but common in Neandertals, such as a sacral plateau with a posterior convexity, relatively narrow alae and a high promontory angle. The Spy lumbar vertebra shows a morphology consistent with a Neandertal attribution, notably its extreme ventral wedging. In addition, its direct dating (36,250 ± 500 uncal BP) is similar to that of other Neandertal fossils found at the site (Semal *et al.*, 2009, volume 1: chapter XVI).

The sacrum most probably belongs to Spy II, as already suggested by various authors. It is extremely difficult to attribute the lumbar vertebra to one of the two Spy adult skeletons insofar as there are no decisive arguments one way or the other.

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