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NEW AMS ^{14}C DATES FOR HUMAN REMAINS FROM STONE AGE SITES IN THE IRON GATES REACH OF THE DANUBE, SOUTHEAST EUROPE

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ABSTRACT. Archaeological investigations in the Iron Gates reach of the Lower Danube Valley between 1964 and 1984 revealed an important concentration of Stone Age sites, which together provide the most detailed record of Mesolithic and Early Neolithic settlement from any area of southeastern Europe. Over 425 human burials were excavated from 15 sites. Of these, less than one-fifth have been directly dated. This article presents 37 new AMS dates on human bone from five sites in the Iron Gates, together with the corresponding δ^{13}C and δ^{15}N values. They include the first dates on human bone from two sites, Icoana and Velesnica. The results are important for the chronology of Stone Age mortuary practices in the Iron Gates and the timing of the Mesolithic–Neolithic transition in the region.

INTRODUCTION

Accelerator mass spectrometry (AMS) radiocarbon dating has revolutionized the chronology of prehistoric settlement in the Iron Gates reach of the Lower Danube Valley where, previously, dating relied on archaeostratigraphy and architectural typology, together with a small series of radiometric ^{14}C measurements on bulk samples of charcoal, soil organic matter, or burnt bone.

The majority of the Mesolithic and Neolithic sites known from the Iron Gates (Figure 1) were investigated between 1964–1971 and 1977–1984 during construction of the Iron Gates I and II dams across the Danube, which resulted in flooding (and in many instances complete submergence) of the sites. Up until 2014, 198 single-entity AMS dates had been published for mainly Stone Age contexts at 13 sites in the Iron Gates: 125 on animal bone, 72 on human bone, and 1 on carbonized plant material (Bonsall 2008; Borić 2011). This article reports a further 37 dates on human bone collagen from five sites, including two sites for which dates on human remains were previously unavailable.

METHODS

All AMS ^{14}C dates and stable isotope ratios reported here were measured at the Oxford Radiocarbon Accelerator Unit (ORAU) between 2008 and 2013. Samples typically comprised a minimum of 0.5 g of cortical bone removed from the diaphysis (shaft) of a long bone (femur, tibia, humerus, etc.) with a Dremel or Minicraft rotary tool fitted with a diamond cutting disk. Where long bones were not available, rib, skull, or scapula fragments of appropriate size/weight were selected for analysis.

The bone samples were prepared for AMS ^{14}C dating and for stable isotope analysis at ORAU using its standard pretreatment procedure, which includes ultrafiltration (Brock et al. 2010). The collagen extracts were combusted using a Roboprep CHN sample converter unit and analyzed using a Europa Scientific 20-20 mass spectrometer operating in continuous flow mode. Graphite was prepared using routine methods (Bronk Ramsey and Hedges 1997). Collagen integrity was assessed from the yield relative to the total sample weight and the C:N atomic ratio. All samples yielded collagen with C:N

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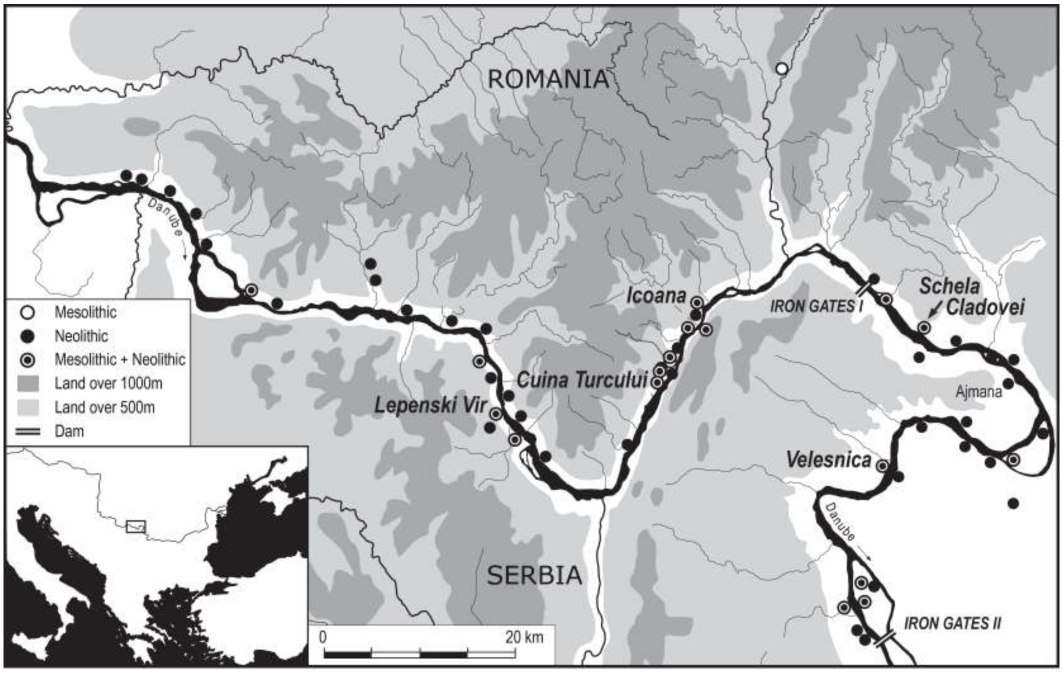

Figure 1 Stone Age sites in the Iron Gates. Named sites were dated within the project.

ratios within the acceptable range of 2.9–3.6 (DeNiro 1985). In all cases, the percentage weight collagen was above the minimum acceptance threshold (1 wt.%) for dating at ORAU (van Klinken 1999). C and N isotope analyses were performed in triplicate with analytical precision of ±0.2‰.

The calibrated age ranges in Tables 2 and 3 are quoted with endpoints rounded outwards to 5 yr, following Mook (1986). The ranges have been calculated using the maximum intercept method (Stuiver and Reimer 1986), the IntCal13 calibration curve (Reimer et al. 2013), and the computer program OxCal v 4.2.3 (Bronk Ramsey 2009).

It was previously established that ^{14}C dates on human bone collagen from the Stone Age sites in the Iron Gates carry a reservoir offset owing to large inputs of fish into the diet. Cook et al. (2001) calculated the size of this offset for Late Mesolithic burials at the site of Schela Cladovei, and proposed a correction procedure based on the δ^{15}N value of bulk collagen, as follows: A number of the burials had well associated projectile points of red deer bone. ^{14}C analysis of the human remains and associated projectile points indicated a significant age offset between the paired materials. Three of the human bone collagen samples had δ^{15}N values close to +15‰ (average 15.1‰) and the weighted mean age offset between the human and red deer bone collagen was 425 ± 25 ^{14}C yr. The correction assumes a linear relationship between δ^{15}N and the percent contribution of fish to dietary protein. δ^{15}N endmembers of +8.0‰ (100% terrestrial) and +17.0‰ (100% freshwater) were used to calculate the "percent aquatic diet" for a value of +15.1‰. This equates to 79% and from this, 100% aquatic diet was determined to be 540 ± 70 ^{14}C yr. The value of +8.3‰ now employed as the endmember for 100% terrestrial diet is an average from analyses of the human burials from Ajdovska Cave, Slovenia. The burials have been assigned to the Late Neolithic Alpine Lengyel culture, and this is broadly confirmed by radiometric ^{14}C ages on charred plant material from the same archaeological horizon. The stable isotope data and archaeological remains indicate a mixed diet based on C_3 plant and animal food (Bonsall et al. 2007). The value of +17.0‰ adopted as the aquatic endmember is that used in Cook et al. (2001). The full 100% freshwater reservoir effect (FRE) correction, using the latter endmembers, is 545 ± 70 ^{14}C yr and is applied prior to calibration. While the resulting calibrated age range for the corrected age is broader, it is a more accurate estimate of the true age.

SITES AND SAMPLES

The locations of the sites are shown in Figure 1. Accounts of the excavations and principal archaeological findings can be found in Srejović (1972), Radovanović (1996), V. Boroneanț (2000), Vasić (2008), A. Boroneanț (2012), and A. Boroneanț and Bonsall (2013, in press).

Lepenski Vir (44°33′24″N, 22°01′38″E), the most famous of the Iron Gates sites, was situated on the right bank of the Danube, 15 km upriver from the town of Donji Milanovac. Excavations in 1965–71 exposed an area of >2500 m^2 to a maximum depth of 3.5 m. The abundant archaeological finds, including "pit houses" with trapezoidal ground plans, burials (some inserted through the floors of trapezoidal structures), stone, bone, and ceramic artifacts, and faunal remains, were attributed mainly to three phases of Mesolithic and two phases of Early Neolithic occupation. According to Roksandic (2008), 134 formal burials were uncovered at Lepenski Vir containing the remains of 190 individuals. The majority were single inhumations, but 33 comprising bones from two or more individuals were classed as "multiple" burials. ^{14}C dating has confirmed the presence of Mesolithic and Early Neolithic occupations at Lepenski Vir, but does not support the finer stratigraphic divisions proposed by the excavator (Srejović 1969) and is not always in accord with the chronological attributions of individual features.

Cuina Turcului (44°35′30″N, 22°15′33″E), a rockshelter site on the left bank of the Danube ~32 km downriver from Lepenski Vir, is one of a number of cave and open-air sites situated in the narrow, canyon-like section of the Iron Gates Gorge known as The Cauldrons. Excavated in 1964–9, a complex stratigraphic sequence was described in which three Epipaleolithic ("Tardigravettian") horizons (I, IIa, and IIb) were succeeded by three Early Neolithic (Starčevo-Criș culture) levels, in turn overlain by deposits belonging to more recent periods. Human remains (*minimum number of individuals* = 6) were recovered from the Epipaleolithic and Early Neolithic parts of the sequence. They occurred as scattered bones or clusters of disarticulated bones in several different locations within the rockshelter, although the excavator did not rule out the possibility that they represent disturbed burials. Epipaleolithic horizon I was dated by three radiometric ^{14}C measurements on pine charcoal ranging between 12,600 ± 120 and 11,960 ± 60 BP, while a radiometric date of 10,125 ± 200 BP was obtained on a mixed sample of charcoal and burnt bone fragments from Epipaleolithic horizon IIa (Păunescu 1970, 1978, 2000).

Icoana (44°39′06″N, 22°18′02″E) is an open-air site situated on the left bank of the Danube within The Cauldrons, ~6–7 km downriver from the Cuina Turcului rockshelter. An area of ~90 m^2 was excavated in 1967–9 and remains of Mesolithic, Early Neolithic, and later occupations identified. AMS dates on bones of wild boar (Dinu et al. 2007) indicate at least two phases of Mesolithic occupation of the site. Human bones were found in various locations across the site, but only three formal burials were identified, represented by two articulated skeletons and an isolated skull, all of which apparently had been interred through the floor of a trapezoidal "pit house."

Schela Cladovei (44°37′34″N, 22°36′21″E) is a large open-air site on the left bank of the Danube in the area downriver from the Iron Gates Gorge and ~6 km below the Iron Gates I dam (Boroneanț and Bonsall 2013). Excavations in 1965, 1967–8, 1982–97, 2001–2, and 2007–14 have uncovered remains of Late Mesolithic, Early Neolithic, and later occupations, including over 90 inhumation burials. Published dates for 16 of the burials all fall in the Late Mesolithic period between ~7000 and 6600 cal BC (Bonsall 2008).

Velesnica (44°32′03″N, 22°33′32″E) is a large, multiperiod site on the right bank of the Danube, ~40 km downriver from Schela Cladovei. Excavations in 1980–2 and 1984 uncovered evidence of settlement at various times between the Mesolithic and Medieval periods. Two Early Neolithic (Starčevo culture) occupation horizons were distinguished. Three graves containing in total the remains of nine individuals were found. Graves 1 and 3 were assigned to the later Starčevo horizon, whereas Grave 2 was considered to represent an initial phase of Neolithic activity at the site, predating the main Starčevo occupation phases. Graves 1 and 3 each contained a single crouched or tightly flexed inhumation—a child in Grave 1 and an adult female in Grave 3. Grave 2 contained the remains of seven individuals (adults and children), comprising five articulated skeletons and disarticulated bones from two other individuals (Vasić 1986, 2008). The human remains were originally studied by Živanović (1986) but subsequently re-assessed by Roksandic (2008). No ^{14}C dates were previously obtained for Velesnica.

RESULTS AND DISCUSSION

The new dates on human bone collagen from Lepenski Vir are presented in Table 1, and those for Cuina Turcului, Icoana, Schela Cladovei, and Velesnica in Table 2.

Lepenski Vir

The Lepenski Vir samples were originally dated at the Oxford Radiocarbon Accelerator Unit in 2002. However, they fell within the series of samples (OxA-9361 to OxA-11851 and OxA-12214 to OxA-12236) that subsequently were found to have been affected by a problem with the ultrafiltration protocol used at Oxford between 2000 and 2002. This led to some samples becoming contaminated by glycerol (containing older carbon) from the ultrafiltration membranes, resulting in ^{14}C age measurements that were artificially old (for discussion, see Bronk Ramsey et al. 2004; Bayliss et al. 2007). Subsequently, the Lepenski Vir samples were redated using ORAU's revised protocol (Bronk Ramsey et al. 2004). The redating was done either by reprocessing stored collagen from the original analyses (n = 15) or by dating new samples of bone (n = 5). Redissolving and re-ultrafiltering the collagen should have removed any glycerol.

The 1σ errors on the new measurements are significantly smaller, reflecting improvements in measurement precision since 2002. Figure 2 shows the offsets between the original ages quoted for the samples and the new measurements. The offsets range from –47 to +219 ^{14}C yr, and there is one outlier where the offset is –500 yr (OxA-25092, Burial 60). However, for 10 out of the 20 samples the differences between the old and new measurements are not statistically significant at the 68% confidence level, and in only three cases (OxA-11693/25206, OxA-11698/25211, and OxA-11715/25092) is there a significant difference at the 95% confidence level. In most cases, the offsets are positive, i.e. the new measurements have "younger" ages as expected. The two instances of negative offsets (Burials 8 and 60) suggest contamination with modern carbon during the original ultrafiltration procedure, perhaps exacerbated in the case of Burial 60 by low collagen yield (2.6 wt.%).

The original series of measurements were presented and discussed in two papers by Bonsall et al. (2004, 2008). The main impacts of the new measurements are to shift the date for Burial 60 much nearer to the beginning of the Holocene, and to bring the ages of Burials 8 and 9 (House 24) into closer agreement (the dates are now statistically indistinguishable at the 68% confidence level). Indeed, the placement of the two skeletons within "house 24" (Srejović 1972:plate 63) suggests the burials were broadly contemporaneous.

Table 1 AMS ^{14}C ages and stable isotope values for human burials from Lepenski Vir. Body position: Es – extended supine; Dd – dorsal decubitus; C – crouched; D – disarticulated; ? – uncertain.

Lab ID	Sample details	Context	Body position	^{14}C age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N	Corrected age BP	Calibrated age (95% confidence)	Remarks
OxA-25092	Adult, male?, 25–40 yr, R femur	Burial 60	Es	9970 ± 45	–19.1	15.5	3.2	9519 ± 73	9175–8635 cal BC	Replaces OxA-11715: 9470 ± 55 BP
OxA-25215	Adult, male?, >40 yr, L femur	Burial 69	Dd	9089 ± 38	–19.3	14.6	3.2	8694 ± 63	7940–7590 cal BC	Replaces OxA-11703: 9180 ± 50 BP
OxA-25214	Adult, male, 20–25 yr, L femur	Burial 45b (House 61)	D	7759 ± 33	–18.9	15.8	3.2	7289 ± 69	6355–6015 cal BC	Replaces OxA-11701: 7805 ± 50 BP
OxA-25213	Adult, L femur (“loose bone”)	Burial 54d (House 65)	D	7717 ± 35	–18.1	15.2	3.2	7285 ± 66	6340–6015 cal BC	Replaces OxA-11700: 7785 ± 45 BP
OxA-25090	Adult, female?, >40 yr, R femur	Burial 14	Es	7701 ± 37	–18.9	15.7	3.2	7237 ± 70	6235–5990 cal BC	Replaces OxA-11704: 7830 ± 45 BP
OxA-25204	Adult, male?, >40 yr, R femur	Burial 7/I (House 21)	Es	7710 ± 35	–18.3	16.1	3.2	—	—	Replaces OxA-11692: 7710 ± 50 BP. Burial also dated by AA-57779: 7368 ± 74 BP, $\delta^{13}C$ –18.9‰, $\delta^{15}N$ 11.5‰ (Borić 2011).
OxA-25205	Adult, male?, >40 yr, R femur	Burial 7/I (House 21)	Es	7689 ± 37	–18.1	16.1	3.2	—	—	Replaces OxA-11692: 7710 ± 50 BP. Burial also dated by AA-57779: 7368 ± 74 BP, $\delta^{13}C$ –18.9‰, $\delta^{15}N$ 11.5‰ (Borić 2011).
				7700 ± 25	*–18.2*	*16.1*	*3.2*	*7211 ± 68*	*6230–5985 cal BC*	*Weighted mean of OxA-25204/25205*
OxA-25209	Adult, female, >40 yr, L femur	Burial 54c (House 36)	Es	7461 ± 35	–19.9	12.4	3.2	7204 ± 48	6215–5995 cal BC	Replaces OxA-11696: 7610 ± 45 BP
OxA-25211	Child, 2–6 yr, R femur	Burial 61 (House 40)	Es	7670 ± 35	–19.0	16.1	3.2	7181 ± 72	6225–5915 cal BC	Replaces OxA-11698: 7860 ± 50 BP
OxA-25210	Adult, female, 25–40 yr, L femur	Burial 54e (House 65)	Es	7474 ± 35	–19.4	13.0	3.2	7180 ± 52	6210–5930 cal BC	Replaces OxA-11697: 7550 ± 45 BP
OxA-25091	Adult, male?, 25–40 yr, scapula	Burial 79a	D	7605 ± 38	–18.7	15.8	3.2	7135 ± 71	6210–5850 cal BC	Replaces OxA-11705: 7780 ± 50 BP
OxA-25206	Adult, male?, 25–40yr, R femur	Burial 26 (House 34)	Es	7161 ± 34	–20.3	9.6	3.2	7080 ± 36	6025–5890 cal BC	Replaces OxA-11693: 7380 ± 45 BP. Burial also dated by AA-57782: 7112 ± 55 BP, $\delta^{13}C$ –26.5‰, $\delta^{15}N$ 11.5‰ (Borić 2011).

Table 1 AMS ^{14}C ages and stable isotope values for human burials from Lepenski Vir. Body position: Es – extended supine; Dd – dorsal decubitus; C – crouched; D – disarticulated; ? – uncertain.

Lab ID	Sample details	Context	Body position	^{14}C age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N	Corrected age BP	Calibrated age (95% confidence)	Remarks
OxA-25089	Adult, >25 yr, tibia	Burial 89a	D?	7521 ± 36	–18.4	15.7	3.2	7057 ± 70	6060–5780 cal BC	Replaces OxA-11702: 7595 ± 45 BP
OxA-25207	Adult, female, >40 yr, L femur	Burial 8 (House 24)	C	7097 ± 36	–19.9	9.8	3.2	7003 ± 38	5990–5790 cal BC	Replaces OxA-11694: 7050 ± 45 BP. Burial also dated by AA-58319: 6825 ± 51 BP, $\delta^{13}C$ –21.2‰, $\delta^{15}N$ 10.2‰ (Borić 2011).
OxA-25208	Adult, female, >25 yr, L femur	Burial 9 (House 24)	C	7120 ± 34	–19.6	10.8	3.2	6963 ± 40	5980–5740 cal BC	Replaces OxA-11695: 7150 ± 45 BP
OxA-25093	Adult, 25–40 yr, R femur	Burial 2	C	5337 ± 32	–19.5	10.6	3.2	5193 ± 37	4225–3945 cal BC	Replaces OxA-11719: 5425 ± 50 BP
OxA-25217	Adult, >40 yr, L ulna	Burial 18	?	1825 ± 25	–18.6	10.5	3.2	—	cal AD 125–255	Replaces OxA-11716: 1874 ± 40 BP
OxA-25218	Adult, R humerus	Burial 30	Es	427 ± 23	–18.7	10.3	3.2	—	cal AD 1430–1490	Replaces OxA-11717: 477 ± 34 BP
OxA-25216	Adult, male?, 25–40 yr, L femur	Burial 29	Es	426 ± 23	–18.6	9.4	3.2	—	cal AD 1430–1610	Replaces OxA-11706: 445 ± 31 BP
OxA-25212	Adult, male, 25–40 yr, L fibula	"Burial 4"	?	421 ± 23	–18.5	9.2	3.2	—	cal AD 1435–1610	Replaces OxA-11699: 485 ± 31 BP
OxA-25219	Adult, male?, 20–25 yr, R femur	Burial 62	Es	389 ± 23	–18.8	9.3	3.2	—	cal AD 1440–1625	Replaces OxA-11718: 445 ± 63 BP

Table 2 AMS ^{14}C dates and stable isotope values for human remains from Cuina Turcului, Icoana, Schela Cladovei, and Velesnica. Abbreviations: Es – extended supine; Dd – dorsal decubitus; C – crouched or tightly flexed; D – disarticulated; Sk – skull burial; ? – uncertain. Context: sq – grid square; ▴ – elevation (m) asl.; ▾ – level (m) below site datum.

Lab ID	Sample details	Context	Body position	^{14}C age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N	Corrected age BP	Calibrated age (95% confidence)
Cuina Turcului									
OxA-19203	"Individual 1," adult, female, L humerus	Trench M, "Tardigravettian" level II	?	10,435 ± 45	–19.4	15.2	3.3	10,003 ± 71	9845–9295 cal BC
OxA-19202	"Individual 2" (687), adult, male?, 25–35 yr, L ulna	Trench B, "Tardigravettian" level II	?	10,350 ± 45	–19.3	15.2	3.3	9918 ± 71	9745–9255 cal BC
OxA-19205	Baby, rib shaft	Trench M, "Criş" level I	?	7650 ± 36	–19.1	17.1	3.3	7099 ± 79	6205–5780 cal BC
OxA-19204	Child, <12yr, L tibia	Trench D, "Criş" level III, ▾2.05 m	?	7324 ± 39	–19.4	13.9	3.1	6973 ± 60	5985–5735 cal BC

Table 2 AMS ^{14}C dates and stable isotope values for human remains from Cuina Turcului, Icoana, Schela Cladovei, and Velesnica. Abbreviations: Es – extended supine; Dd – dorsal decubitus; C – crouched or tightly flexed; D – disarticulated; Sk – skull burial; ? – uncertain. Context: sq – grid square; ▴ – elevation (m) asl.; ▾ – level (m) below site datum.

Lab ID	Sample details	Context	Body position	^{14}C age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N	Corrected age BP	Calibrated age (95% confidence)
Icoana									
OxA-25140	Adult, female?, cranial fragment	Burial M1, Trench II, sq 3, ▾0.45–0.50 m	Sk	7688 ± 38	–19.3	16.1	3.2	7199 ± 73	6230–5920 cal BC
OxA-29022	Adult, male? (35–45), L zygomatic	Burial M2, Trench II, sq 4, ▾0.45–0.50 m	Es	7758 ± 38	–19.5	15.9	3.5	7282 ± 72	6355–6005 cal BC
Schela Cladovei									
OxA-19088	Adult, female, L tibia	M6, Trench VI, sq 9–10, ▾0.50–0.55	Es	583 ± 25	–17.6	9.0	3.1	—	cal AD 1300–1415
OxA-19089	Adult, female, L tibia	M6, Trench VI, sq 9–10, ▾0.50–0.55	Es	570 ± 25	–17.5	9.2	3.2	—	cal AD 1305–1420
				576 ± 18[a]	–17.6	9.1	—	—	cal AD 1310–1415
OxA-19090	Adult, male, ~21 yr, metacarpal	M17, Trench VI sq. 17–18, ▾0.40–0.45	Es	176 ± 25[b]	–19.0	11.9	3.2	—	cal AD 1660–1920
Velesnica									
OxA-19190	Child (3–7 yr)	Burial 1, Cutting 8, ▴36.10 m	C	7166 ± 38	–19.8	9.9	3.2	7066 ± 40	6020–5845 cal BC
OxA-19192	Adult, female	Burial 2B/2F, Cutting 7, ▴35.30 m	C	7385 ± 39	–19.3	10.7	3.2	7235 ± 44	6215–6020 cal BC
OxA-19209	Child (7–11 yr)	Burial 2C, Cutting 7, ▴35.13 m	C	7245 ± 39	–19.2	9.9	3.2	7145 ± 45	6080–5920 cal BC
OxA-19191	Adult, female (mature)	Burial 2A/2E, Cutting 7, ▴35.10 m	C	7409 ± 38	–19.4	11.7	3.2	7196 ± 47	6210–5990 cal BC
OxA-19210	Adult, female (mature-senile)	Burial 2D, Cutting 7, ▴35.09 m	C	7327 ± 38	–19.2	10.6	3.2	7183 ± 42	6205–5985 cal BC
OxA-19211	Child (5–9 yr)	Burial 2G, Cutting 7, ▴34.84 m	Dd	7291 ± 38	–19.3	10.1	3.2	7178 ± 41	6205–5935 cal BC
OxA-19212	Neonate	Burial 2G-1, Cutting 7	D	8735 ± 40	–19.3	14.7	3.2	8334 ± 65	7530–7185 cal BC

[a]Weighted mean of OxA-19088 and OxA-19099.
[b]Calibrated using CALIBomb, IntCal13, and the NHZ1 bomb curve extension (http://calib.qub.ac.uk/CALIBomb/).

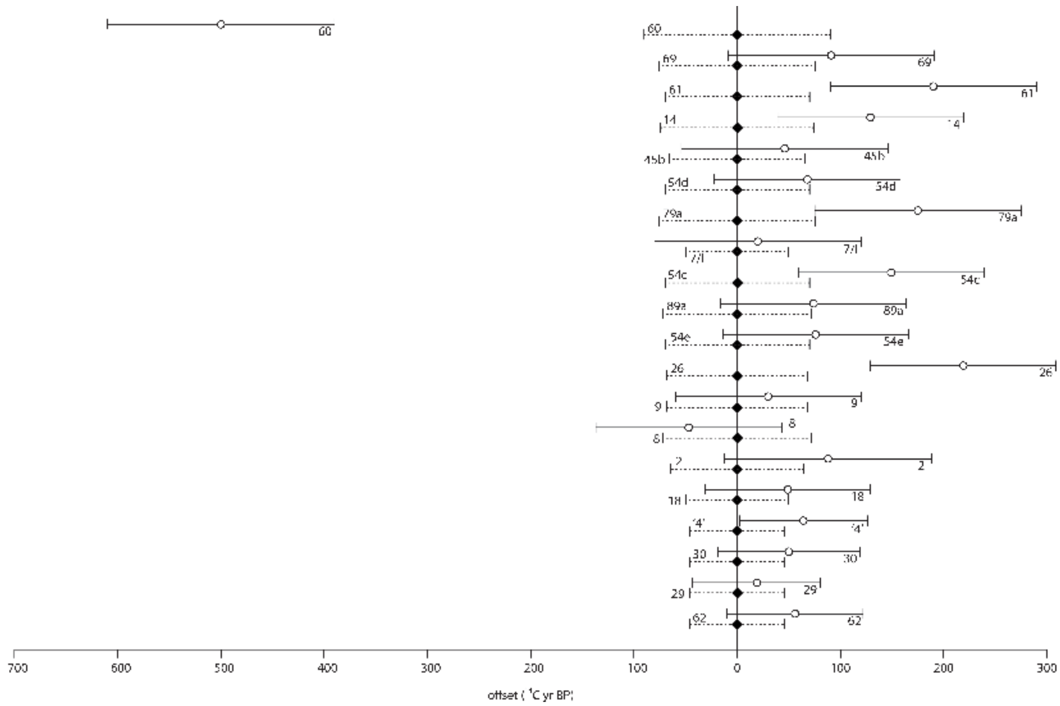

Figure 2 Offsets between ^{14}C results for Lepenski Vir burials produced with the ultrafiltration protocols used at ORAU in 2000–2002 (solid lines) and since 2002 (dashed lines).

Three burials (7/I, 8 and 26) in our series were also dated at the Arizona AMS Laboratory (Table 3). The Arizona and Oxford dates for Burial 8 are statistically distinct, although both fall into the expected (Early Neolithic) time range based on the crouched burial position and the relatively light C and N isotope values. The ^{14}C ages for Burial 26 obtained by the two laboratories are similar. However, because the $\delta^{15}N$ value of the Arizona sample is heavier, the difference between the ages increases when FRE corrections are applied to both dates. Nevertheless, the 2σ calibrated ranges of the corrected age measurements overlap. There is a difference of 332 yr between the ^{14}C ages of a rib fragment dated at Arizona and a femur shaft fragment dated at Oxford from Burial 7/I, and a difference in the $\delta^{15}N$ values of the samples of ~4.6‰. It is generally assumed that collagen turnover in ribs occurs at a much higher rate than in some other bones of the skeleton, including cortical bone of the femur shaft (e.g. Tsutaya and Yoneda 2013). Assuming the two bone samples *are* from the same skeleton (but see discussion in Bonsall et al. 2008:179–80), then one explanation of the data could be that the individual underwent a significant change in diet in the period prior to death. When FRE corrections are applied to the Oxford and Arizona results using the respective $\delta^{15}N$ values, the adjusted ages are in very close agreement. Substantial dietary change is reflected in human bone collagen stable isotope data from the Iron Gates for the period ~6200–5900 cal BC, and is thought to reflect the shift from a Mesolithic fishing economy to a Neolithic farming and fishing food producing strategy (Bonsall et al. 1997). Burial 7/I from Lepenski Vir is potentially the first evidence of this change in a single individual dating to the Mesolithic–Neolithic transition period in the Iron Gates and highlights the importance of obtaining stable isotope data from different bones of a skeleton, rather than the single measurements that hitherto have been the norm in paleodietary studies.

Table 3 AMS ^{14}C dates and stable isotope values for burials 7/I, 8 and 26 from Lepenski Vir, dated at the NFS-Arizona AMS Laboratory (after Borić 2011:Appendix 1). Reservoir-corrected ages obtained by Method 1 of Cook et al. (2002). C – crouched or tightly flexed.

Lab ID	Sample details	Context	^{14}C age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	Corrected age BP	Calibrated age (95% confidence)
AA-57779	Human rib	Burial 7/I	7368 ± 74	–18.9	11.5	7168 ± 78	6220–5900 cal BC
AA-57782	Human mandible	Burial 26	7112 ± 55	–26.5	11.5	6912 ± 61	5975–5670 cal BC
AA-58319	Human skull	Burial 8	6825 ± 51	–21.2	10.2	6706 ± 53	5716–5535 cal BC

Cuina Turcului

The two adult individuals from the "Tardigravettian II" horizon (OxA-19203 and OxA-19202) have similar ^{14}C ages and almost identical C and N isotope values, consistent with an Epipaleolithic context, although the reservoir-corrected ages suggest a date at the beginning of the Holocene rather than in the Late Glacial.

The two other samples dated were bones of young children whose presence was thought by the excavator to be related to Early Neolithic use of the rockshelter. Only rough estimates of age-at-death are available, which leaves open the possibility of ^{15}N enrichment due to breastfeeding resulting in $\delta^{15}N$ values higher than those of older members of the same population. Arguably, this is more likely in the case of the baby than the older child. If the $\delta^{15}N$ values do include a breastfeeding component, then the reservoir-corrected ages shown in Table 2 will be too young. A study by Tsutaya and Yoneda (2013) found average $\delta^{15}N$ breastfeeding enrichment in archaeological populations of 2.44 ± 0.9‰, with $\delta^{15}N$ values returning to adult levels after weaning. Since our FRE correction for the Iron Gates predicts a change in ^{14}C age of ~63 yr for every 1‰ change in $\delta^{15}N$, subtracting 2.44‰ from the $\delta^{15}N$ values of both children from Cuina Turcului would have the effect of increasing the reservoir-corrected ages by over 150 ^{14}C yr, while smaller reductions in $\delta^{15}N$ would produce correspondingly smaller increases in the reservoir-corrected ^{14}C ages. Allowing for the uncertainty over diet-derived offsets, the ^{14}C and stable isotope data suggest both individuals belong to the period ~6200–5800 cal BC when the shift from a Mesolithic fishing to a Neolithic fishing and farming economy took place in the Iron Gates. The measured $\delta^{15}N$ values of the two children from Cuina Turcului (+17.1‰ and +13.9‰) fall within the range of *Late Mesolithic* populations from the Iron Gates (Bonsall 2008: Figure 10.3). A hypothetical reduction of 2.44‰ in $\delta^{15}N$ to account for breastfeeding enrichment would still leave the younger child in the Late Mesolithic range, but would put the older child into the local Early Neolithic range (Bonsall 2008: Figure 10.3). Thus, the infant most likely was a member of a Mesolithic fishing community, whereas the older child could have belonged to either a fisher or a farmer-fisher community.

Icoana

The dated samples are from a cluster of three single inhumation burials that were uncovered in the most elevated part of the site. Only two of the burials were available for sampling, one represented by an articulated skeleton in the extended supine position and oriented parallel to the Danube with the head downstream (M2) and the other an isolated skull (M1). Skull burials and extended (parallel) inhumations are a common feature of Late Mesolithic mortuary practice in the Iron Gates, and especially the final phase between 6200 and 5950 cal BC. The relatively heavy C and N isotope values of the two dated skeletons are within the range obtained for other Late Mesolithic individuals from the Iron Gates, and the reservoir-corrected ^{14}C ages are a good fit with the Final Mesolithic time range.

Schela Cladovei

The dates reported here are for extended inhumations that are reminiscent of Late Mesolithic mortuary practice at the site but were buried in unusually shallow graves (<0.75 m deep), suggesting they could be of post-Mesolithic date. Mesolithic graves at Schela Cladovei are typically over a meter deep.

The results confirm the relatively recent origin of the burials. The weighted mean of two measurements on Burial M6 is 576 ± 18 BP, which indicates that the individual probably died sometime in cal AD 1310–1415. We would not normally apply a freshwater reservoir correction to samples of this age from the Iron Gates, because we have no independent archaeological or historical evidence of the foods consumed and no information on the size of the Danube reservoir effect in the historical period. Moreover, the mean $\delta^{15}N$ value of 9.1‰ for Burial M6 indicates a diet dependent on terrestrial food sources, while the unusually heavy $\delta^{13}C$ value is better explained in terms of direct or indirect consumption of millet (a C_4 plant) rather than fish. Proso millet (*Panicum miliaceum*) was grown extensively in Europe, including Romania, during the Middle Ages, being gradually replaced by wheat during the 19th century (Krishna 2014:113).

The date for skeleton M17 indicates an even more recent burial. With no reservoir correction, the ^{14}C age of 176 ± 25 BP calibrates to cal AD 1660–1955 (95% confidence). ^{14}C dates between the mid-1600s AD and AD 1950 lead to ambiguous calendar age ranges owing to strongly changing ^{14}C production and the effect of fossil fuel burning. However, the C and N isotope data suggest this individual regularly obtained some of their dietary protein from fish and/or shellfish. Applying our standard reservoir correction yields a corrected ^{14}C age of –50 ± 38 BP, which calibrates to cal AD 1705–1960 (95% confidence). This result, however, should be treated with caution because of uncertainty over the FRE during the period in question.

Velesnica

Dates were obtained on bones of seven individuals recovered from Graves 1 and 2 at Velesnica; the skeletal remains from Grave 3 were not available for sampling. The numbering of the burials in Table 2 follows Roksandic (2008).

Vasić (1986, 2008) attributed all three graves to the Early Neolithic based on stratigraphic evidence, the crouched/tightly flexed body position of many of the skeletons, and the presence of Starčevo pottery in Grave 2. With one exception (OxA-19212), the ^{14}C results are consistent with this interpretation and the range of the associated $\delta^{15}N$ values (9.9–11.7‰) corresponds with that for Early Neolithic crouched burials from other Iron Gates sites (Bonsall 2008; Borić 2011). The stable isotope data also indicate that Early Neolithic people living along the Danube regularly consumed fish, though to a lesser extent than their Mesolithic predecessors, and the archaeofaunal record from Velesnica and elsewhere in the Iron Gates supports this interpretation. From this, it follows that a reservoir correction should be applied to the ^{14}C ages.

Grave 2 is unusual in the context of the Iron Gates Early Neolithic in containing the remains of a large number of burials. Živanović (1986) put forward the hypothesis that it was a mass grave of people who died at about the same time, as a result of some natural disaster, possibly epidemic disease. However, given the careful placement of the bodies and the presence of burial goods (pottery), it is perhaps more likely to have been a collective tomb of people, possibly members of a descent group, who were buried at intervals over an extended period of time—years or decades.

A Bayesian approach, which allows for the combination of the ^{14}C dates and the archaeological information (Buck et al. 1996), was used to investigate the chronology of the five *in situ* burials in Grave 2 (Figure 3). The results of the Bayesian modeling, the *posterior density estimates*, are interpretative estimates that can and will change as further data become available and as other researchers choose to model the existing data from different perspectives. Furthermore, they are given in italics to separate them from the results of simple calibration. The modeling was undertaken using OxCal v 4.2 (Bronk Ramsey 1995, 1998, 2001, 2009) and the terrestrial calibration curve of Reimer et al. (2013). Figure 3A shows the results of a model that treats the deposition of the burials within the grave as a single short-lived event (*Phase model*), while in Figure 3B the assumption is made that the burials were added to the grave one by one over a period of time and that the elevation of the skeletons represents the order in which the individuals were interred, beginning with Burial 2G and ending with Burial 2B/F (*Sequence model*). Both models show good agreement between the ^{14}C dates and the archaeological data (*Phase model*: A_{model} = 146; *Sequence model*: A_{model} = 131). Using the *Last* command in OxCal to provide the probability for the latest event in the group for the *Phase model*, we estimate that the burials all took place in *6065–5995 cal BC* (*95% probability*; Figure 3A; *burials in Grave 2*), and probably in *6050–6010 cal BC* (*68% probability*). The *Sequence model* assumes burial over a period of time. It estimates that the first individual buried (Burial 2G) died in *6085–6020 cal BC* (*95% probability*; Figure 3B; *OxA-19211*), and probably in *6070–6035 cal BC* (*68% probability*). The last individual buried (Burial 2B/2F) died in *6065–6005 cal BC* (*95% probability*; Figure 3B; OxA-19192), and probably in *6050–6015 cal BC* (*68% probability*).

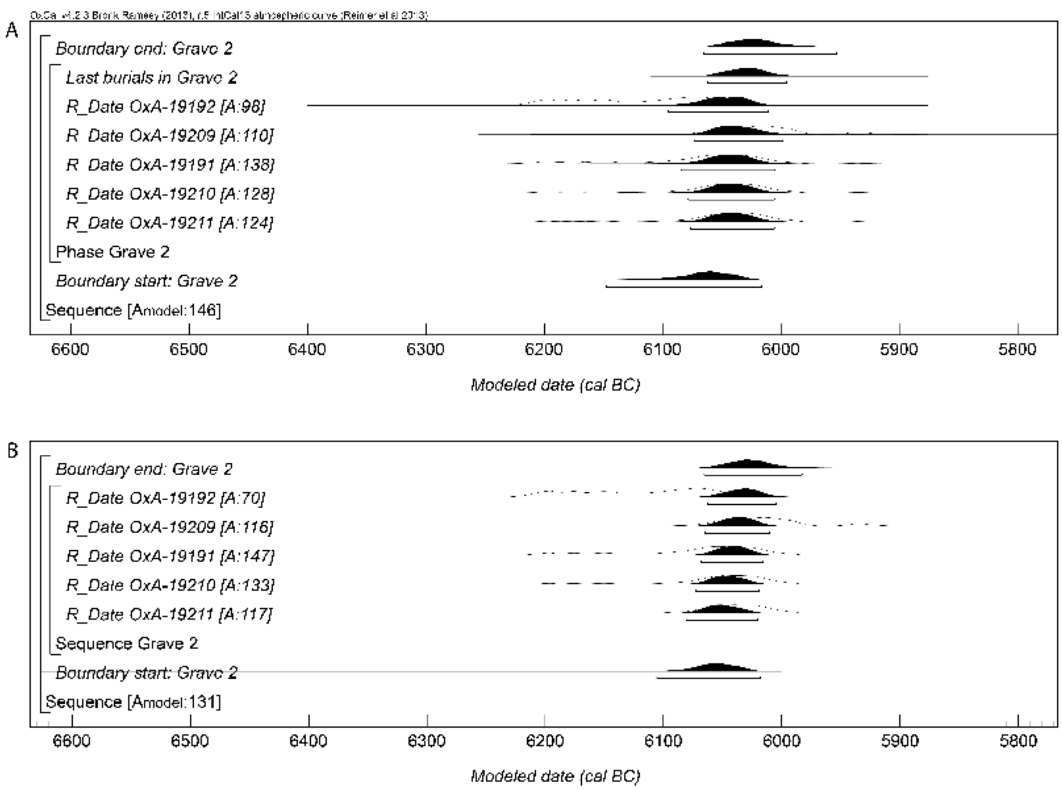

Figure 3 Bayesian chronological models of Grave 2 at Velesnica implemented in OxCal v 4.2.3 (Bronk Ramsey 2009). (A) Modeled as a single event (phase). (B) Modeled as a sequence of individual burials. Probability distributions of the calibrated dates are shown in outline. Solid distributions are posterior density estimates of the dates of samples included in the OxCal models, and of the beginning and end of grave construction (OxCal Boundary).

In each model, the probability ranges of the samples from Grave 2 suggest the burials took place between *6100 and 6000 cal BC*. This is an important finding because it represents the strongest evidence to date for Early Neolithic settlement of the Lower Danube Valley before 6000 cal BC. One sample (2G-1) from Grave 2 produced a ^{14}C age (OxA-19212: 8735 ± 40 BP) that links it with a much earlier, Mesolithic occupation phase. This was one of three bones of a neonate recovered from the grave pit. These bones could have been accidental inclusions in the grave fill, or a case of deliberate reburial of bones from an older, disturbed grave.

Comparison of the Velesnica dates with those from Lepenski Vir implies that the Neolithic burial rite appeared earlier in the "downstream area" of the Iron Gates than in the Iron Gates Gorge, where crouched burials are dated after 6000 cal BC (Table 1; see also Bonsall 2008; Borić 2011). All this has implications for the timing of Neolithization in the Iron Gates region and southeast Europe in general.

The single crouched inhumation from Grave 1 at Velesnica was also included in our dating program. According to Vasić (2008), Grave 1 should be assigned to a later phase of the Neolithic than Grave 2 (see above). The ^{14}C evidence supports this interpretation and indicates that Early Neolithic occupation of Velesnica continued after 6000 cal BC.

Within the Iron Gates region, the closest parallel for Velesnica Grave 2 is from the site of Ajmana 30 km upriver, where a pit containing 17 skeletons in mainly crouched/tightly flexed positions was found (Stalio 1986). Only two of the skeletons have been dated directly (Table 4), and on the basis of these dates Borić and Price (2013) suggested that Ajmana was one of the first farming settlements to be established in the downstream area. However, the reservoir-corrected ages of Burials 6 and 7 from Ajmana correspond better with the date for the later of the two Early Neolithic graves (Grave 1) at Velesnica (Figure 4).

Table 4 AMS ^{14}C dates and stable isotope values for human remains from Ajmana, dated at the NFS-Arizona AMS Laboratory (after Borić 2011:Appendix 1). Reservoir-corrected ages obtained by Method 1 of Cook et al. (2002). C – crouched or tightly flexed.

Lab ID	Sample details	Context	Body position	^{14}C age (BP)	δ^{13}C (‰)	δ^{15}N (‰)	Corrected age BP	Calibrated age (95% confidence)
AA-58322	Skull	Burial 7	C	7219 ± 51	–20.0	10.0	7113 ± 53	6075–5885 cal BC
AA-58323	Skull	Burial 6	C	7065 ± 48	–20.0	10.5	6927 ± 51	5975–5715 cal BC

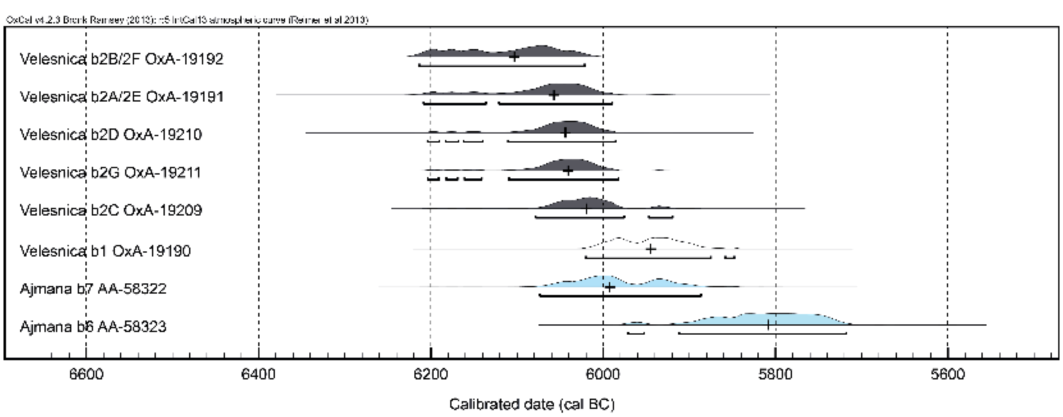

Figure 4 Calibrated probability distributions of reservoir-corrected ^{14}C ages for Early Neolithic burials from Velesnica and Ajmana.

The foregoing comments should be regarded as provisional. Ultimately, the accuracy of reservoir-corrected dates for human remains from the Iron Gates rests on whether the reservoir offset established for the 7000–6600 cal BC period at Schela Cladovei is applicable to the Iron Gates as a whole and constant during at least the last 1500 yr of the Mesolithic–Early Neolithic time range. The timing of the Neolithic transition in the Iron Gates region generally, and between the gorge and the downstream area, is a crucial issue. The suggested pre-6000 cal BC date for the earliest Neolithic occupation of the Lower Danube Valley requires confirmation from high-precision, single-entity dating of associated terrestrial materials, such as domestic livestock or crop remains.

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