

Exploring the Mesolithic and Neolithic transition in Croatia through isotopic investigations

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(<http://antiquity.ac.uk/ant/085/ant0850073.htm>). Here we publish supplementary material.

The generalised picture of Mesolithic marine diet giving way to a Neolithic terrestrial diet, as derived from isotope measurements, has been both championed and challenged in this journal. Here new results from the Balkans offer a preliminary picture of a diversity of food strategy, both before and after the great transition.

Keywords: Balkans, Croatia, Mesolithic, Neolithic, diet

The paper shows that the Mesolithic–Neolithic transition cannot be seen as a simple dichotomy between people who used aquatic resources and people who did not. Naturally, some Neolithic coastal dwellers did exploit the sea. There is a growing consensus that we must go beyond the oppositional views of foragers *versus* farmers across the Mesolithic–Neolithic transition, since the archaeological evidence is showing diversity in patterns of behaviour related to material culture within and between regions. Isotopic studies are now showing a similar range in patterns of behaviour related to subsistence and diet. The study emphasises how crucial it is to examine the patterns derived from different lines of evidence in order to understand more fully this important process in human history.

This online supplement contains data methods of analysis, the sites examined (Appendix 1), statistical tests (Appendix 2), and animal and human samples (Appendices 3 and 4).

Method

For the majority of samples, collagen was extracted following the method described in Privat *et al.* (2002) with some modifications, but two samples were extracted at the Oxford Radiocarbon Accelerator Unit for radiocarbon dating (ELFL67 and ELFL68). All collagen samples were analysed in triplicate using a Costech elemental analyser coupled in continuous-flow mode to a Finnigan MAT253 mass spectrometer. Carbon and nitrogen isotopic ratios were measured on the delta scale, in comparison to international standards, VPDB and AIR respectively, in units of 'permil' (Hoefs 2004). Repeated measurements on international and in-house standards showed that the analytical error was <0.2‰ for both carbon and nitrogen.

Measured collagen is deemed to be of good quality if it fulfils the following criteria: an atomic C:N ratio of 2.9 to 3.4 (De Niro 1985); a 'collagen' yield of >1% by mass; final carbon yields of >13%; and final nitrogen yields of >4.8% (Ambrose 1990). All of the human samples produced results deemed to be of good quality. Nine of the animal samples analysed here failed to produce reliable results and are thus excluded from the following analyses and discussions.

Statistical analyses were performed using SPSS 13.0 for Windows, and results were investigated using Student's t-tests. All statistical data are given in Appendix 2.

Appendix 1. Table showing site information.

Site	Location	Period	Radiocarbon date	Sample number	Reference
Vela Luka-Vela Spilja	Coastal (Island)	Mesolithic	Two humans directly dated, publication forthcoming	5	Čečuk & Radić 2005; Forenbaher & Miracle forthcoming
		Neolithic		1	
Pupićina	Coastal (Istria)	Mesolithic		2 (+4; Paine <i>et al.</i> 2009)	Miracle & Forenbaher 2006
		Neolithic		3	
Crno Vrlo	Coastal (Dalmatia)	Early Neolithic		1	Marijanović 2003
Kargadur	Coastal (Istria)	Middle Neolithic		3	Miracle <i>pers. comm.</i>
Vela Spilja Lošinj	Coastal (Island)	Neolithic		1	Miracle <i>pers. comm.</i>
Grapčeva	Coastal (Dalmatia)	Late Neolithic	One human directly dated, publication forthcoming	3	Borojević <i>et al.</i> 2008; Forenbaher & Miracle forthcoming
Metaljka	Coastal (Dalmatia)	Eneolithic		3	Periša <i>pers. comm.</i>
Belišće-Staro Valpovo	Inland (Pannonia)	Early Neolithic	6400–5000 cal BC	4	Šimić 2007
		Late Neolithic		1	
Vukovar-Gimnazium	Inland (Pannonia)	Early Neolithic		5	Šlaus 2002
Osijek	Inland (Pannonia)	Late Neolithic	4590–4350 cal BC	1	Šimić 1999
Radovanci	Inland (Pannonia)	Late Neolithic		1	
Vučedol	Inland (Pannonia)	Eneolithic	3077–2703 cal BC	9	Durman & Obelić 1989

Appendix 2. Table summarising statistical data.

Comparison	Test	n	$\delta^{13}\text{C}$			$\delta^{15}\text{N}$		
			df	t	P	df	t	P
Mesolithic terrestrial vs marine fauna	t-test	32, 5	35	-12.484	<0.001	4.484	-1.458	0.045
Neolithic sheep/goat, cow and deer vs pigs	t-test	25, 6	39	-1.501	0.144	29	-2.257	0.032
Neolithic terrestrial vs marine fauna	t-test	39, 6	43	-16.586	<0.001	43	-4.470	<0.001
Mesolithic vs Neolithic humans	t-test	10, 36	44	4.340	<0.001	44	0.472	0.639
Mesolithic vs Coastal Neolithic vs Inland Neolithic humans	ANOVA	10, 15, 21	2, 43, 45	20.607	<0.001	2, 43, 45	4.448	0.018
Coastal vs inland Neolithic humans	t-test	15, 21	34	3.904	<0.001	34	-2.893	0.007

Appendix 3. Table summarising the Mesolithic faunal results.

Sample code	Site	Species	Element	Period	%C	%N	C:N	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
VSF001	Vela Spilja-Vela Luka (Korcula)	Erinaceus	Femur	Mesolithic	42.5	15.4	3.22	-19.5	7.7
VSF002	Vela Spilja-Vela Luka (Korcula)	Erinaceus		Mesolithic	43.9	16.0	3.20	-19.7	8.8
VSF003	Vela Spilja-Vela Luka (Korcula)	Erinaceus	Humerus	Mesolithic	41.0	14.9	3.22	-19.7	8.1
VSF004	Vela Spilja-Vela Luka (Korcula)	Erinaceus		Mesolithic	40.7	14.8	3.20	-19.3	8.0

VSF005	Vela Spilja-Vela Luka (Korcula)	Capreolus	Metapodial	Mesolithic	42.4	15.5	3.18	-20.7	6.3
VSF006	Vela Spilja-Vela Luka (Korcula)	Capreolus	Metapodial	Mesolithic	41.6	14.9	3.25	-21.5	7.5
VSF007	Vela Spilja-Vela Luka (Korcula)	Capreolus	Metapodial	Mesolithic	41.4	15.1	3.21	-20.2	6.2
VSF008	Vela Spilja-Vela Luka (Korcula)	Capreolus	Metapodial	Mesolithic	42.9	15.6	3.20	-20.7	6.0
VSF009	Vela Spilja-Vela Luka (Korcula)	Cervus	Metapodial	Mesolithic	38.1	13.9	3.19	-20.4	5.6
VSF010	Vela Spilja-Vela Luka (Korcula)	Cervus	Phalanx	Mesolithic	n/a	n/a	n/a	n/a	n/a
VSF011	Vela Spilja-Vela Luka (Korcula)	Cervus	Phalanx	Mesolithic	41.4	14.7	3.28	-20.0	4.9
VSF012	Vela Spilja-Vela Luka (Korcula)	Cervus	Ulna	Mesolithic	37.8	13.8	3.20	-20.3	5.4
VSF013	Vela Spilja-Vela Luka (Korcula)	Martes		Mesolithic	47.0	17.2	3.18	-18.7	8.6
VSF014	Vela Spilja-Vela Luka (Korcula)	Martes	Tibia	Mesolithic	n/a	n/a	n/a	n/a	n/a
VSF015	Vela Spilja-Vela Luka (Korcula)	Martes	Tibia	Mesolithic	43.1	15.7	3.21	-19.1	9.3

VSF016	Vela Spilja-Vela Luka (Korcula)	Martes	Vertebrae	Mesolithic	43.5	15.9	3.19	-19.1	9.0
VSF017	Vela Spilja-Vela Luka (Korcula)	Martes	Ilium	Mesolithic	n/a	n/a	n/a	n/a	n/a
VSF018	Vela Spilja-Vela Luka (Korcula)	Felis		Mesolithic	37.3	13.5	3.23	-19.5	6.9
VSF019	Vela Spilja-Vela Luka (Korcula)	Felis	Metatarsal/ Metacarpal	Mesolithic	42.7	15.6	3.19	-19.6	7.1
VSF020	Vela Spilja-Vela Luka (Korcula)	Felis		Mesolithic	43.7	15.9	3.21	-19.0	6.9
VSF021	Vela Spilja-Vela Luka (Korcula)	Fish	Vertebra	Mesolithic	n/a	n/a	n/a	n/a	n/a
VSF022	Vela Spilja-Vela Luka (Korcula)	Fish	Vertebra	Mesolithic	n/a	n/a	n/a	n/a	n/a
VSF023	Vela Spilja-Vela Luka (Korcula)	Fish	Vertebra	Mesolithic	n/a	n/a	n/a	n/a	n/a
VSF024	Vela Spilja-Vela Luka (Korcula)	Fish	Vertebra	Mesolithic	n/a	n/a	n/a	n/a	n/a
VSF025	Vela Spilja-Vela Luka (Korcula)	Fish	Vertebra	Mesolithic	40.8	15.0	3.17	-14.7	5.6
VSF026	Vela Spilja-Vela Luka (Korcula)	Fish	Vertebra	Mesolithic	36.0	13.0	3.23	-15.1	5.9

VSF027	Vela Spilja-Vela Luka (Korcula)	Vulpes	Tibia	Mesolithic	42.1	15.4	3.19	-19.4	7.4
VSF028	Vela Spilja-Vela Luka (Korcula)	Vulpes	Radius	Mesolithic	43.1	15.8	3.19	-18.9	6.7
VSF029	Vela Spilja-Vela Luka (Korcula)	Vulpes	Ulna	Mesolithic	43.4	15.7	3.22	-19.2	7.0
VSF030	Vela Spilja-Vela Luka (Korcula)	Vulpes	Tibia	Mesolithic	43.1	15.7	3.20	-19.2	7.0
VSF031	Vela Spilja-Vela Luka (Korcula)	Lepus		Mesolithic	39.9	14.3	3.26	-19.3	4.2
VSF032	Vela Spilja-Vela Luka (Korcula)	Lepus		Mesolithic	33.9	12.3	3.23	-16.2	6.6
VSF033	Vela Spilja-Vela Luka (Korcula)	Lepus		Mesolithic	38.6	13.9	3.23	-20.1	4.7
VSF034	Vela Spilja-Vela Luka (Korcula)	Lepus	Metatarsal	Mesolithic	45.3	16.0	3.31	-22.1	2.7
VSF035	Vela Spilja-Vela Luka (Korcula)	Dolphin	Vertebrae	Mesolithic	41.2	15.1	3.18	-13.2	10.6
VSF036	Vela Spilja-Vela Luka (Korcula)	Dolphin	Vertebrae	Mesolithic	44.2	16.1	3.21	-13.4	11.5
VSF037	Vela Spilja-Vela Luka (Korcula)	Sus	Cranium	Mesolithic	38.3	13.9	3.22	-19.4	5.9

VSF038	Vela Spilja-Vela Luka (Korcula)	Sus	Radius	Mesolithic	34.5	12.5	3.22	-20.1	5.0
VSF039	Vela Spilja-Vela Luka (Korcula)	Sus	Vertebrae	Mesolithic	44.0	15.8	3.25	-20.5	5.5
VSF040	Vela Spilja-Vela Luka (Korcula)	Sus	Femur	Mesolithic	36.1	13.1	3.22	-19.7	4.2
BB10	Karagadur	Cervus	Phalanx	Early Neolithic	n/a	n/a	n/a	n/a	n/a
BB11	Karagadur	Cervus	Phalanx	Early Neolithic	44.1	16.0	3.11	-20.6	4.2
BB12	Karagadur	Cervus	Metacarpal	Early Neolithic	31.0	11.6	3.14	-20.6	4.7
BB13	Karagadur	Sheep/goat	Radius	Early Neolithic	37.1	13.6	3.18	-20.9	7.1
BB14	Karagadur	Sheep	Radius	Early Neolithic	39.3	14.8	3.10	-16.8	8.6
BB15	Karagadur	Sheep?	Phalanx	Early Neolithic	n/a	n/a	n/a	n/a	n/a
BB16	Karagadur	Sheep	Metapodial	Early Neolithic	34.6	12.7	3.18	-20.8	5.6
BB17	Karagadur	Sheep/goat	Radius	Early Neolithic	35.0	13.1	3.11	-20.7	6.6

BB18	Karagadur	Sheep/goat	Metapodial	Early Neolithic	39.8	15.0	3.09	-20.5	6.8
BB20	Karagadur	Cervus	Navicular	Early Neolithic	38.4	14.5	3.05	-21.2	6.3
BB21	Karagadur	Fish	Dentary	Middle Neolithic	20.3	7.1	3.32	-13.6	9.7
BB22	Karagadur	Fish	Dentary	Middle Neolithic	18.4	6.1	3.49	-14.8	8.9
BB23	Karagadur	Fish	Dentary	Middle Neolithic	24.0	8.8	3.19	-13.7	9.0
BB24	Karagadur	Fish	Dentary	Middle Neolithic	26.9	9.5	3.30	-14.3	8.9
BB25	Vela Spilja Losinj	Fox	Radius	Early Neolithic	29.4	11.3	3.07	-19.3	8.6
BB26	Vela Spilja Losinj	Pig	Radius	Early Neolithic	39.8	15.1	3.06	-20.5	6.8
BB27	Vela Spilja Losinj	Hare	Ilium	Early Neolithic	38.8	14.8	3.04	-21.0	5.9
BB28	Vela Spilja Losinj	Hare	Metatarsal	Early Neolithic	29.2	11.2	3.04	-21.0	7.1
BB29	Vela Spilja Losinj	Sheep/goat	Radius	Early Neolithic	35.6	13.7	3.06	-19.2	6.5

BB30	Vela Spilja Losinj	Sheep/goat	Radius	Early Neolithic	34.3	13.1	3.06	-21.2	5.9
BB31	Vela Spilja Losinj	Fox	Metatarsal	Early Neolithic	38.7	14.8	3.07	-19.2	8.0
BB32	Vela Spilja Losinj	Roe deer	Metatarsal	Early Neolithic	39.6	15.1	3.10	-20.8	7.5
BB33	Vela Spilja Losinj	Roe deer	Redius	Early Neolithic	28.7	10.8	3.06	-19.5	7.2
BB34	Vela Spilja Losinj	Sheep/goat	Metacarpal	Early Neolithic	44.7	17.0	3.06	-20.2	6.1
BB35	Vela Spilja Losinj	Fox	Femur	Early Neolithic	40.3	15.5	3.06	-19.4	8.4
BB36	Vela Spilja Losinj	Sheep/goat	Radius	Early Neolithic	38.5	14.7	3.05	-21.5	8.7
BB37	Vela Spilja Losinj	Hare	Phalanx	Early Neolithic	44.4	17.0	3.07	-20.3	6.8
BB38	Vela Spilja Losinj	Roe deer	Metatarsal	Early Neolithic	31.2	11.9	3.06	-19.9	5.3
BB39	Vela Spilja Losinj	Sheep/goat	Radius	Early Neolithic	41.0	15.6	3.07	-20.1	9.6
BB40	Vela Spilja Losinj	Roe deer	Metatarsal	Early Neolithic	39.4	15.0	3.08	-20.1	6.9

BB41	Vela Spilja Losinj	Hare	Metatarsal	Early Neolithic	37.9	14.4	3.06	-20.8	5.0
BB42	Vela Spilja Losinj	Hare?	Humerus	Early Neolithic	40.4	15.5	3.20	-21.7	7.4
BB43	Vela Spilja Losinj	Fish	Dentary	Early Neolithic	28.5	10.6	3.15	-12.1	7.4
BB44	Vela Spilja Losinj	Fish	Vertebra	Early Neolithic	37.6	14.0	3.13	-14.0	8.1
BB45	Vela Spilja Losinj	Pig	Mandible	Mesolithic	18.5	6.7	3.07	-20.4	5.7
BB47	Vela Spilja Losinj	Roe deer	Metatarsal	Mesolithic	37.6	14.3	3.04	-20.0	6.7
BB48	Vela Spilja Losinj	Hare	Innominate	Mesolithic	32.2	12.4	3.02	-20.6	2.6
BB49	Vela Spilja Losinj	Fish	Dentary	Mesolithic	20.3	7.4	3.18	-12.9	7.4
BB50	Pupicina	Sheep	Metacarpal	Middle Neolithic	40.0	15.5	3.02	-20.3	5.1
BB51	Pupicina	Sheep	Metacarpal	Middle Neolithic	37.3	13.3	3.14	-20.1	5.1
BB52	Pupicina	Sheep	Metacarpal	Middle Neolithic	41.2	15.9	3.03	-20.3	5.2
BB53	Pupicina	Sheep	Metacarpal	Middle Neolithic	43.3	16.7	3.04	-20.3	5.6
BB54	Pupicina	Sheep	Metacarpal	Middle Neolithic	43.4	16.7	3.03	-20.1	5.5

BB55	Pupicina	Goat	Astragalus	Middle Neolithic	40.2	15.5	3.02	-19.0	5.8
BB56	Pupicina	Goat	Astragalus	Middle Neolithic	28.0	10.6	3.10	-20.9	4.8
BB57	Pupicina	Bos	Metacarpal	Middle Neolithic	41.9	15.0	3.15	-21.1	4.8
BB58	Pupicina	Bos	Metacarpal	Middle Neolithic	43.8	16.6	3.07	-20.0	5.2
BB59	Pupicina	Bos	Metacarpal	Middle Neolithic	26.5	10.0	3.09	-20.5	5.0
BB60	Pupicina	Cervus	Phalanx	Middle Neolithic	38.0	14.4	3.08	-20.7	4.5
BB61	Pupicina	Cervus	Carpal	Middle Neolithic	45.4	16.7	3.17	-20.7	3.7
BB62	Pupicina	Pig	Tibia	Middle Neolithic	42.1	16.1	3.07	-19.6	7.1
BB63	Pupicina	Pig	Phalanx	Middle Neolithic	39.2	14.9	3.08	-19.9	7.0
BB64	Pupicina	Pig	Phalanx	Middle Neolithic	41.2	15.9	3.03	-19.2	7.8
BB65	Pupicina	Pig	Phalanx	Middle Neolithic	27.2	9.9	3.20	-19.3	4.8
BB66	Pupicina	Pig	Scapula	Middle Neolithic	41.3	15.8	3.05	-19.2	7.9

Appendix 4. Table showing human results.

Sample	Site	Sex	Age (years)	Period	Element	%C	%N	C:N	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
ELFL01	Vela Spilja-Vela Luka	J	0.5–1	Neolithic	Rib	40.2	14.7	3.19	-20.4	9.2
ELFL02	Vela Spilja-Vela Luka	M	45–50	Mesolithic	Rib	41.7	15.1	3.23	-19.2	9.0
ELFL03	Vela Spilja-Vela Luka	J	0–0.5	Mesolithic	Rib	43.6	16.0	3.18	-17.9	10.7
ELFL04	Vela Spilja-Vela Luka	J	2.5–3.5	Mesolithic	Rib	40.7	15.1	3.16	-18.8	8.7
ELFL05	Vela Spilja-Vela Luka	M	35–45	Mesolithic	Rib	40.7	15.0	3.16	-18.3	8.5
ELFL06	Osijek-Filipovica	F	25–30	Neolithic	Rib	41.7	15.5	3.15	-20.5	10.1
ELFL07	Crno Vrilo	F	35–40	Neolithic	Rib	39.6	14.2	3.25	-20.1	9.6
ELFL08	Radovanci	F	25–30	Neolithic	Rib	43.1	15.7	3.20	-20.2	9.3
ELFL09	Belišće St Valpovo	F?	25–35	Neolithic	Rib	38.1	13.7	3.24	-20.8	10.1
ELFL10	Belišće St Valpovo	J	4.5–5.5	Neolithic	Rib	39.6	14.5	3.19	-20.9	10.8
ELFL11	Belišće St Valpovo	M	35–45	Neolithic	Rib	36.1	13.1	3.21	-20.4	10.0
ELFL12	Belišće St Valpovo	F?	20–25	Neolithic	Rib	46.5	16.9	3.20	-20.6	10.0
ELFL13	Belišće St Valpovo	F?	20–25	Neolithic	Cranium	36.9	13.2	3.25	-20.9	10.4
ELFL14	Vukovar-Gimnazija	J	12.5–13.5	Neolithic	Rib	48.0	17.7	3.17	-20.3	9.6
ELFL15	Vukovar-Gimnazija	F	40–45	Neolithic	Femur	38.4	14.0	3.20	-20.2	9.8
ELFL16	Vukovar-Gimnazija	J	0–0.5	Neolithic	Rib	43.6	16.0	3.19	-19.3	14.1
ELFL17	Vukovar-Gimnazija	J	11.5–12.5	Neolithic	Rib	42.0	15.6	3.14	-19.9	9.8
ELFL18	Vukovar-Gimnazija	M	35–40	Neolithic	Rib	37.9	13.9	3.17	-19.6	10.3
ELFL24	Vučedol	M	50–55	Neolithic	Rib	45.9	16.9	3.18	-20.0	10.1

ELFL25	Vučedol	F	30–35	Neolithic	Rib	42.5	15.8	3.14	-20.2	10.1
ELFL26	Vučedol	F	45–50	Neolithic	Rib	43.1	15.9	3.16	-20.2	10.6
ELFL27	Vučedol	F	20–25	Neolithic	Rib	42.8	15.5	3.22	-20.1	9.8
ELFL28	Vučedol	F	15–20	Neolithic	Rib	42.1	15.3	3.20	-20.2	10.4
ELFL29	Vučedol	M	15.5–16.5	Neolithic	Rib	41.1	15.2	3.15	-21.1	10.0
ELFL30	Vučedol	F	40–45	Neolithic	Rib	43.4	16.0	3.16	-20.1	11.0
ELFL31	Vučedol	M	20–25	Neolithic	Rib	36.9	13.5	3.18	-21.4	9.2
ELFL32	Vučedol	J	9.5–10.5	Neolithic	Rib	43.4	16.1	3.15	-20.1	10.2
ELFL41	Metaljka	M?	20–30	Neolithic	Long Bone	41.4	15.1	3.20	-18.0	8.2
ELFL42	Metaljka	M	40–50	Neolithic	Long Bone	41.8	15.1	3.23	-18.6	9.5
ELFL43	Metaljka	F?	20–40	Neolithic	Long Bone	40.4	14.7	3.20	-19.6	8.7
ELFL66	Grapčeva			Neolithic	Vertebra	46.3	16.8	3.22	-19.0	8.8
ELFL67	Grapčeva			Neolithic	Clavicle	46.3	17.0	3.18	-19.8	8.3
ELFL68	Grapčeva			Neolithic	Humerus	45.9	16.8	3.19	-19.7	8.2
BB01	Karagadur		child	Neolithic	Rib	29.3	10.7	3.19	-19.8	10.2
BB02	Karagadur		adult	Neolithic	Rib	31.5	11.9	3.09	-20.0	9.9
BB03	Karagadur		child	Neolithic	Rib	40.9	15.5	3.08	-19.0	10.3
BB04	Pupićina		adult	Neolithic	Metatarsal	34.6	13.2	3.06	-20.2	9.0
BB05	Pupićina		young adult	Neolithic	Metatarsal	38.0	14.7	3.02	-20.1	8.9
BB06	Pupićina		young adult	Neolithic	Metacarpal	44.0	17.0	3.03	-20.1	8.9

BB07	Pupićina		adult	Mesolithic	Metacarpal	40.3	15.4	3.05	-19.2	10.3
BB08	Pupićina			Mesolithic	Navicular	45.0	16.8	3.13	-19.1	10.7
BB09	Vela Spilja Lošinj			Neolithic	Cranium	23.9	8.9	3.14	-18.9	12.0

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