

**Supplementary Information: Multi-isotope analysis of bone collagen from Les Cottés, France, reveals niche partitioning and behavioural plasticity in Late Pleistocene ungulates**

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**Table S1** (see Excel File 'SI\_Table S1'):  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$  data of *Bison*, *Equus* and *Rangifer* bone collagen samples from Les Cottés archaeological site.

This excel file includes all repeat  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$  measurements of bone collagen samples from Les Cottés, measured at both the Max Planck Institute for Evolutionary Anthropology, Leipzig, (MPI) and the Scottish Universities Environmental Research Centre (SUERC). Includes %C, %N, %S, C:N, C:S and N:S, along with calculated means from duplicate, triplicate or quadruplicate measurements.

**Table S2:** Difference in  $\delta^{13}\text{C}$  between species (*Bison*, *Equus* and *Rangifer*) and between species by levels at Les Cottés, estimated with mixed linear models. *Bison* is the reference category for species and US02 for the site level. Significant effects (95% CI excluding 0) are indicated in bold.

Variables	Estimate	SE	t-value	95% CI	
				Lower	Upper
Model : $\delta^{13}\text{C} \sim \text{Species}$					
(Intercept)	-20.40	0.076	-268.39	-20.55	-20.25
<i>Equus</i>	<b>-0.25</b>	<b>0.106</b>	<b>-2.35</b>	<b>-0.46</b>	<b>-0.04</b>
<i>Rangifer</i>	<b>0.83</b>	<b>0.092</b>	<b>9.04</b>	<b>0.65</b>	<b>1.01</b>
Model : $\delta^{13}\text{C} \sim \text{Species} * \text{Levels}$					
(Intercept)	-20.19	0.211	-95.79	-20.60	-19.77
<i>Equus</i>	-0.56	0.327	-1.72	-1.21	0.08
<i>Rangifer</i>	0.43	0.227	1.88	-0.02	0.87
US04 (upper)	0.31	0.293	1.07	-0.27	0.89
US04 (lower)	-0.39	0.243	-1.59	-0.87	0.09
US06	-0.21	0.267	-0.79	-0.74	0.32
US08	-0.29	0.242	-1.21	-0.77	0.18
<i>Equus</i> :US04 (upper)	-0.01	0.405	-0.04	-0.81	0.79
<i>Rangifer</i> :US04 (upper)	0.08	0.324	0.24	-0.56	0.72
<i>Equus</i> :US04 (lower)	0.46	0.366	1.25	-0.27	1.18
<b><i>Rangifer</i>:US04 (lower)</b>	<b>0.75</b>	<b>0.273</b>	<b>2.74</b>	<b>0.21</b>	<b>1.29</b>
<i>Equus</i> :US06	0.21	0.426	0.49	-0.63	1.05
<b><i>Rangifer</i>:US06</b>	<b>0.61</b>	<b>0.310</b>	<b>1.97</b>	<b>0.00</b>	<b>1.23</b>
<i>Equus</i> :US08	0.27	0.373	0.72	-0.47	1.01
<i>Rangifer</i> :US08	0.22	0.277	0.79	-0.33	0.77

**Table S3:** Difference in  $\delta^{15}\text{N}$  between species (*Bison*, *Equus* and *Rangifer*) and between species by levels at Les Cottés, estimated with mixed linear models. *Bison* is the reference category for species and US02 for the site level. Significant effects (95% CI excluding 0) are indicated in bold.

Variables	Estimate	SE	t-value	95% CI	
				Lower	Upper
Model : $\delta^{15}\text{N} \sim \text{Species}$					
(Intercept)	6.40	0.225	28.50	5.96	6.85
<i>Equus</i>	-0.61	0.315	-1.94	-1.23	0.01
<b><i>Rangifer</i></b>	<b>0.97</b>	<b>0.272</b>	<b>3.56</b>	<b>0.43</b>	<b>1.50</b>
Model : $\delta^{15}\text{N} \sim \text{Species} * \text{Levels}$					
(Intercept)	7.38	0.651	11.34	6.10	8.67
<i>Equus</i>	-0.44	1.027	-0.43	-2.46	1.59
<i>Rangifer</i>	0.29	0.703	0.41	-1.10	1.67
US04 (upper)	-1.34	0.919	-1.46	-3.16	0.47
US04 (lower)	-1.09	0.752	-1.45	-2.58	0.39
US06	-0.35	0.824	-0.42	-1.97	1.28
US08	-1.43	0.751	-1.90	-2.91	0.06
<i>Equus</i> :US04 (upper)	0.52	1.277	0.41	-2.00	3.04
<i>Rangifer</i> :US04 (upper)	0.48	1.015	0.48	-1.52	2.49
<i>Equus</i> :US04 (lower)	-0.72	1.149	-0.63	-2.99	1.55
<i>Rangifer</i> :US04 (lower)	0.50	0.848	0.59	-1.18	2.17
<i>Equus</i> :US06	-1.02	1.318	-0.77	-3.62	1.58
<i>Rangifer</i> :US06	0.23	0.964	0.24	-1.68	2.13
<i>Equus</i> :US08	0.59	1.172	0.51	-1.72	2.91
<i>Rangifer</i> :US08	1.48	0.865	1.71	-0.23	3.19

**Table S4:** Difference in  $\delta^{34}\text{S}$  between species (*Bison*, *Equus* and *Rangifer*) and between species by levels at Les Cottés, estimated with mixed linear models. *Bison* is the reference category for species and US02 for the site level. Significant effects (95% CI excluding 0) are indicated in bold.

Variables	Estimate	SE	t-value	95% CI	
				Lower	Upper
Model : $\delta^{34}\text{S} \sim \text{Species}$					
(Intercept)	11.99	0.451	26.60	11.10	12.88
<i>Equus</i>	-0.81	0.632	-1.29	-2.06	0.44
<b><i>Rangifer</i></b>	<b>-2.29</b>	<b>0.550</b>	<b>-4.16</b>	<b>-3.38</b>	<b>-1.20</b>
Model : $\delta^{34}\text{S} \sim \text{Species} * \text{Levels}$					
(Intercept)	11.24	1.281	8.77	8.70	13.77
<i>Equus</i>	-3.14	2.025	-1.55	-7.14	0.87
<i>Rangifer</i>	-2.06	1.403	-1.47	-4.83	0.71
US04 (upper)	-1.14	1.812	-0.63	-4.72	2.45
US04 (lower)	0.35	1.502	0.23	-2.62	3.32
US06	-0.14	1.621	-0.09	-3.34	3.06
US08	2.48	1.479	1.68	-0.44	5.40
<i>Equus</i> :US04 (upper)	4.22	2.521	1.68	-0.76	9.21
<i>Rangifer</i> :US04 (upper)	2.57	2.039	1.26	-1.46	6.60
<i>Equus</i> :US04 (lower)	2.42	2.282	1.06	-2.09	6.93
<i>Rangifer</i> :US04 (lower)	0.05	1.707	0.03	-3.32	3.43
<i>Equus</i> :US06	3.94	2.594	1.52	-1.19	9.07
<i>Rangifer</i> :US06	0.51	1.912	0.27	-3.27	4.29
<i>Equus</i> :US08	1.75	2.338	0.75	-2.88	6.37
<i>Rangifer</i> :US08	-1.75	1.722	-1.02	-5.15	1.66

1 **Table S5:** Pairwise comparison of the estimates from the mixed linear models testing the differences in  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$  between species considering all  
2 levels together (All Levels model : isotope value ~ species) and between species by level (isotope value ~ species \* levels). Significant differences are indicated  
3 in bold.

Units	Contrast	$\delta^{13}\text{C}$					$\delta^{15}\text{N}$					$\delta^{34}\text{S}$				
		estimate	SE	df	t-ratio	p-value	estimate	SE	df	t-ratio	p-value	estimate	SE	df	t-ratio	p-value
All Levels	<i>Bison - Equus</i>	0.25	0.108	125	2.32	0.06	0.61	0.319	124	1.91	0.14	0.81	0.640	117	1.27	0.42
	<i>Bison - Rangifer</i>	<b>-0.83</b>	<b>0.093</b>	<b>125</b>	<b>-8.92</b>	<b>&lt;0.001</b>	<b>-0.97</b>	<b>0.275</b>	<b>124</b>	<b>-3.51</b>	<b>&lt;0.01</b>	<b>2.29</b>	<b>0.558</b>	<b>117</b>	<b>4.11</b>	<b>&lt;0.001</b>
	<i>Equus - Rangifer</i>	<b>-1.08</b>	<b>0.091</b>	<b>123</b>	<b>-11.80</b>	<b>&lt;0.001</b>	<b>-1.58</b>	<b>0.272</b>	<b>124</b>	<b>-5.79</b>	<b>&lt;0.001</b>	<b>1.48</b>	<b>0.551</b>	<b>117</b>	<b>2.68</b>	<b>0.02</b>
US02	<i>Bison - Equus</i>	0.56	0.349	139	1.61	0.25	0.44	1.097	138	0.40	0.92	3.14	2.173	131	1.44	0.32
	<i>Bison - Rangifer</i>	-0.43	0.242	145	-1.76	0.19	-0.29	0.751	139	-0.38	0.92	2.06	1.506	131	1.37	0.36
	<i>Equus - Rangifer</i>	<b>-0.99</b>	<b>0.282</b>	<b>134</b>	<b>-3.50</b>	<b>&lt;0.001</b>	-0.72	0.894	138	-0.81	0.70	-1.08	1.792	131	-0.60	0.82
US04 (upper)	<i>Bison - Equus</i>	0.58	0.256	134	2.25	0.07	-0.08	0.812	137	-0.10	0.99	-1.09	1.612	131	-0.67	0.78
	<i>Bison - Rangifer</i>	-0.51	0.247	135	-2.05	0.11	-0.77	0.782	138	-0.99	0.59	-0.51	1.587	131	-0.32	0.94
	<i>Equus - Rangifer</i>	<b>-1.08</b>	<b>0.177</b>	<b>137</b>	<b>-6.12</b>	<b>&lt;0.001</b>	-0.69	0.558	138	-1.23	0.44	0.58	1.157	131	0.50	0.87
US04 (lower)	<i>Bison - Equus</i>	0.11	0.176	140	0.60	0.82	1.16	0.552	138	2.10	0.09	0.72	1.130	131	0.63	0.80
	<i>Bison - Rangifer</i>	<b>-1.18</b>	<b>0.162</b>	<b>142</b>	<b>-7.24</b>	<b>&lt;0.001</b>	-0.78	0.507	139	-1.55	0.27	2.01	1.043	131	1.92	0.14
	<i>Equus - Rangifer</i>	<b>-1.28</b>	<b>0.155</b>	<b>134</b>	<b>-8.29</b>	<b>&lt;0.001</b>	<b>-1.94</b>	<b>0.490</b>	<b>137</b>	<b>-3.97</b>	<b>&lt;0.001</b>	1.29	0.972	131	1.33	0.38
US06	<i>Bison - Equus</i>	0.35	0.290	156	1.21	0.45	1.45	0.882	141	1.65	0.23	-0.80	1.740	131	-0.46	0.89
	<i>Bison - Rangifer</i>	<b>-1.04</b>	<b>0.226</b>	<b>142</b>	<b>-4.60</b>	<b>&lt;0.001</b>	-0.51	0.704	139	-0.73	0.75	1.55	1.394	131	1.11	0.51
	<i>Equus - Rangifer</i>	<b>-1.39</b>	<b>0.272</b>	<b>153</b>	<b>-5.11</b>	<b>&lt;0.001</b>	<b>-1.97</b>	<b>0.832</b>	<b>140</b>	<b>-2.36</b>	<b>0.05</b>	2.35	1.644	131	1.43	0.33
US08	<i>Bison - Equus</i>	0.29	0.192	137	1.53	0.28	-0.16	0.605	138	-0.26	0.96	1.39	1.255	131	1.11	0.51
	<i>Bison - Rangifer</i>	<b>-0.64</b>	<b>0.170</b>	<b>134</b>	<b>-3.79</b>	<b>&lt;0.001</b>	<b>-1.76</b>	<b>0.539</b>	<b>137</b>	<b>-3.27</b>	<b>&lt;0.001</b>	<b>3.81</b>	<b>1.071</b>	<b>131</b>	<b>3.55</b>	<b>0.00</b>
	<i>Equus - Rangifer</i>	<b>-0.94</b>	<b>0.184</b>	<b>137</b>	<b>-5.09</b>	<b>&lt;0.001</b>	<b>-1.61</b>	<b>0.580</b>	<b>138</b>	<b>-2.77</b>	<b>0.02</b>	2.42	1.209	131	2.00	0.12

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6 **Table S6:** Changes over time in  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$  for *Bison*. Linear and quadratic effects of the median  
7 age of the level were estimated using mixed linear models. Best models are indicated in bold with their  
8 AICc, as well as significant effects.

model	AICc	variable	estimate	se	t-value	95% CI	
						lower	upper
<b><math>\delta^{13}\text{C} \sim \text{age}</math></b>	<b>-1.3</b>	intercept	-18.93	1.059	-17.88	-21.07	-16.78
		age	0.04	0.026	1.39	-0.02	0.09
$\delta^{13}\text{C} \sim \text{age} + \text{age}^2$	-0.1	intercept	0.03	18.079	0.00	-36.47	36.65
		age	0.98	0.894	1.09	-0.83	2.79
		age <sup>2</sup>	0.01	0.011	1.05	-0.01	0.03
<b><math>\delta^{15}\text{N} \sim \text{age}</math></b>	<b>87.6</b>	intercept	10.04	3.623	2.77	2.70	17.39
		age	0.09	0.089	1.01	-0.09	0.27
$\delta^{15}\text{N} \sim \text{age} + \text{age}^2$	89.9	intercept	17.90	62.002	0.29	-107.81	143.48
		age	0.48	3.068	0.16	-5.74	6.69
		age <sup>2</sup>	0.00	0.038	0.13	-0.07	0.08
<b><math>\delta^{34}\text{S} \sim \text{age}</math></b>	<b>148.4</b>	intercept	-3.03	7.477	-0.41	-18.21	12.14
		<b>age</b>	<b>-0.37</b>	<b>0.183</b>	<b>-2.01</b>	<b>-0.74</b>	<b>0.00</b>
$\delta^{34}\text{S} \sim \text{age} + \text{age}^2$	150.2	intercept	125.10	126.335	0.99	-131.26	381.46
		age	5.98	6.255	0.96	-6.71	18.68
		age <sup>2</sup>	0.08	0.077	1.02	-0.08	0.23

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10 **Table S7:** Changes over time in  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$  for *Equus*. Linear and quadratic effects of the median  
11 age of the level were estimated using mixed linear models. Best models are indicated in bold with their  
12 AICc, as well as significant effects.

model	AICc	variable	estimate	se	t-value	95% CI	
						lower	upper
<b><math>\delta^{13}\text{C} \sim \text{age}</math></b>	<b>-27.2</b>	intercept	-19.38	1.060	-18.28	-21.53	-17.24
		age	0.03	0.026	1.19	-0.02	0.09
$\delta^{13}\text{C} \sim \text{age} + \text{age}^2$	-24.9	intercept	-22.67	20.281	-1.12	-63.74	18.39
		age	-0.13	1.001	-0.13	-2.16	1.90
		age <sup>2</sup>	0.00	0.012	-0.16	-0.03	0.02
$\delta^{15}\text{N} \sim \text{age}$	-6.3	intercept	6.15	3.242	1.90	-0.42	12.71
		age	0.01	0.081	0.11	-0.15	0.17
<b><math>\delta^{15}\text{N} \sim \text{age} + \text{age}^2</math></b>	<b>-10.3</b>	intercept	153.08	55.895	2.74	39.92	266.23
		<b>age</b>	<b>7.27</b>	<b>2.759</b>	<b>2.64</b>	<b>1.68</b>	<b>12.85</b>
		<b>age<sup>2</sup></b>	<b>0.09</b>	<b>0.034</b>	<b>2.63</b>	<b>0.02</b>	<b>0.16</b>
<b><math>\delta^{34}\text{S} \sim \text{age}</math></b>	<b>113.0</b>	intercept	-1.53	4.344	-0.35	-10.33	7.28
		<b>age</b>	<b>-0.32</b>	<b>0.109</b>	<b>-2.93</b>	<b>-0.54</b>	<b>-0.10</b>
$\delta^{34}\text{S} \sim \text{age} + \text{age}^2$	114.4	intercept	-93.77	78.678	-1.19	-253.24	65.71
		age	-4.88	3.887	-1.26	-12.76	3.00
		age <sup>2</sup>	-0.06	0.048	-1.17	-0.15	0.04

13 **Table S8:** Changes over time in  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$  for *Rangifer*. Linear and quadratic effects of the  
 14 median age of the level were estimated using mixed linear models. Best models are indicated in bold  
 15 with their AICc, as well as significant effects.

model	AICc	variable	estimate	se	t-value	95% CI	
						lower	upper
$\delta^{13}\text{C} \sim \text{age}$	35.6	intercept	-19.35	0.734	-26.36	-20.81	-17.89
		age	0.01	0.019	0.30	-0.03	0.04
<b><math>\delta^{13}\text{C} \sim \text{age} + \text{age}^2</math></b>	<b>22.1</b>	intercept	-64.94	10.780	-6.02	-86.40	-43.47
		<b>age</b>	<b>-2.29</b>	<b>0.542</b>	<b>-4.22</b>	<b>-3.37</b>	<b>-1.21</b>
		<b>age<sup>2</sup></b>	<b>-0.03</b>	<b>0.007</b>	<b>-4.24</b>	<b>-0.04</b>	<b>-0.02</b>
$\delta^{15}\text{N} \sim \text{age}$	158.1	intercept	6.35	2.042	3.11	2.28	10.41
		age	-0.03	0.052	-0.50	-0.13	0.08
<b><math>\delta^{15}\text{N} \sim \text{age} + \text{age}^2</math></b>	<b>156.5</b>	intercept	71.31	33.138	2.15	5.35	137.28
		age	3.24	1.666	1.95	-0.07	6.56
		<b>age<sup>2</sup></b>	<b>0.04</b>	<b>0.021</b>	<b>1.96</b>	<b>0.00</b>	<b>0.08</b>
$\delta^{34}\text{S} \sim \text{age}$	<b>283.4</b>	intercept	7.84	4.396	1.78	-0.92	16.60
		age	-0.05	0.111	-0.42	-0.27	0.17
$\delta^{34}\text{S} \sim \text{age} + \text{age}^2$	285.6	intercept	-21.08	72.837	-0.29	-166.25	124.14
		age	-1.50	3.656	-0.41	-8.79	5.79
		age <sup>2</sup>	-0.02	0.046	-0.40	-0.11	0.07

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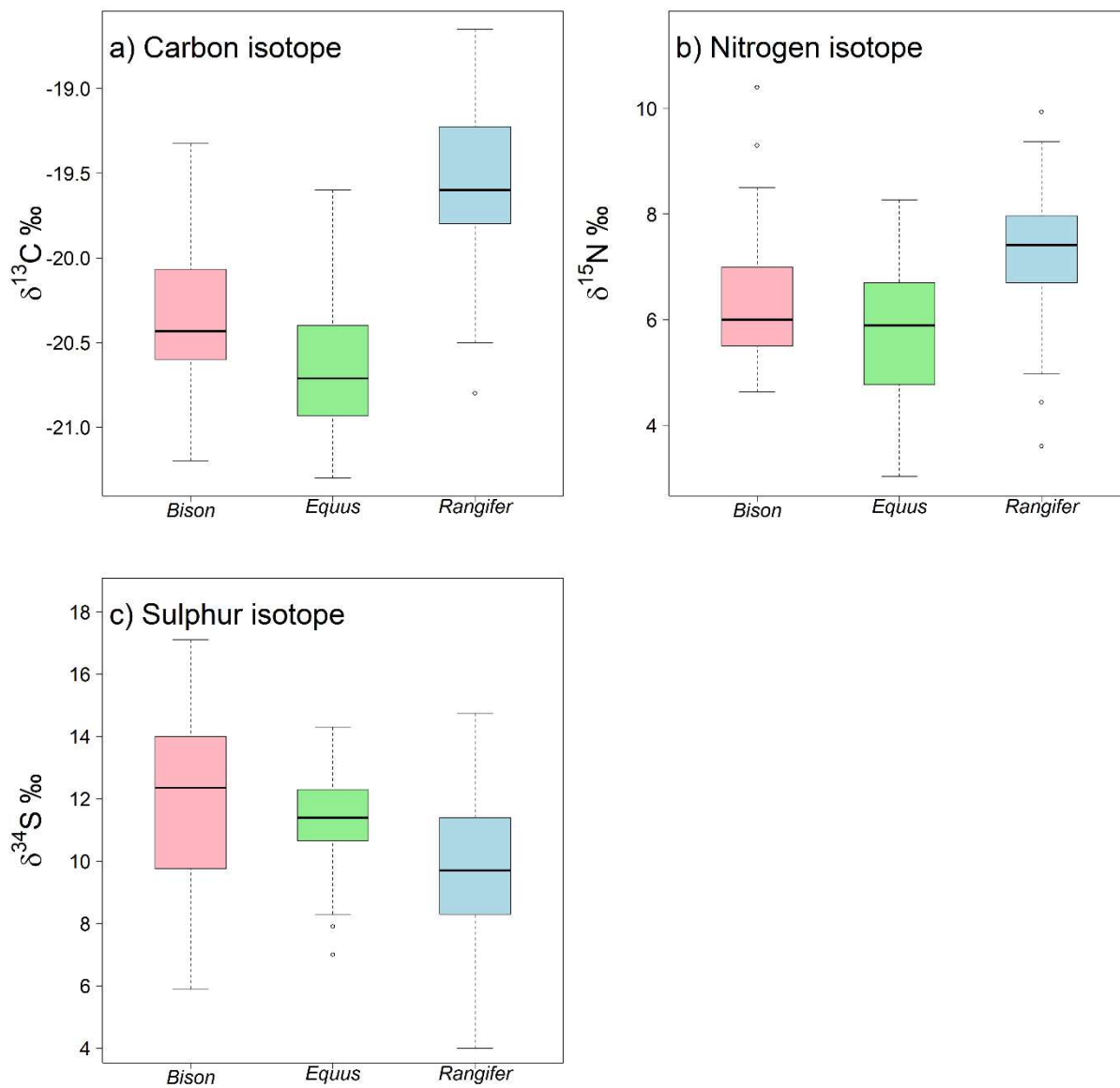
17 **Table S9:** Percentage of overlap between the isotopic niches of *Rangifer*, *Bison* and *Equus* defined  
 18 within the  $\delta^{13}\text{C} - \delta^{15}\text{N}$  isotopic space. TA (Total Area) corresponds to the convex hull area encompassing  
 19 all the data of a given species. SEAc (Standard Ellipse Area corrected for small sample size) refers the  
 20 core niche area. Low overlap (<30%) is indicated in italic, and high overlap (>60%) in bold.

Unit	Species 1	Species 2	% of TA overlap		% of SEAc overlap	
			sp.1 by sp.2	sp.2 by sp.1	sp.1 by sp.2	sp.2 by sp.1
All Levels	<i>Rangifer</i>	<i>Bison</i>	48.3	<b>67.9</b>	0	0
	<i>Rangifer</i>	<i>Equus</i>	26.5	46.7	0	0
	<i>Bison</i>	<i>Equus</i>	51.2	<b>64.2</b>	48.6	55.9
US02	<i>Rangifer</i>	<i>Bison</i>	<i>1.0</i>	<i>1.6</i>	<i>2.4</i>	<i>0.4</i>
US04 (upper)	<i>Rangifer</i>	<i>Bison</i>	12.3	23.3	47.6	11.5
	<i>Rangifer</i>	<i>Equus</i>	12.9	8.8	0	0
	<i>Bison</i>	<i>Equus</i>	53.8	19.5	37.3	<b>76.1</b>
US04 (lower)	<i>Rangifer</i>	<i>Bison</i>	0	0	0	0
	<i>Rangifer</i>	<i>Equus</i>	0	0	0	0
	<i>Bison</i>	<i>Equus</i>	<b>64.7</b>	33.6	37.3	24.5
US06	<i>Rangifer</i>	<i>Bison</i>	0	0	0	0
	<i>Rangifer</i>	<i>Equus</i>	0	0	0	0
	<i>Bison</i>	<i>Equus</i>	<i>6.0</i>	<i>11.4</i>	44.2	33.2
US08	<i>Rangifer</i>	<i>Bison</i>	30.1	<b>69.5</b>	9.1	20.3
	<i>Rangifer</i>	<i>Equus</i>	5.7	22.9	0	0
	<i>Bison</i>	<i>Equus</i>	41.6	<b>72.8</b>	41.9	50.6

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23 **Figure S1:** Differences in a)  $\delta^{13}\text{C}$ , b)  $\delta^{15}\text{N}$ , c)  $\delta^{34}\text{S}$  between species (*Bison*, *Equus*, *Rangifer*) at Les  
24 Cottés.



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27 **Figure S2:** Box plots of a) carbon and c) nitrogen data from ungulate bone collagen generated at the  
 28 Max Planck Institute, Leipzig (MPI) and b) carbon and d) nitrogen data generated at the Scottish  
 29 Universities Research Centre (SUERC) from the same bone samples. Box plots show the median isotope  
 30 values, quartiles and outliers for each species by level.

