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Reply to Ben-Dor and Barkai: A low Zn isotope ratio is not equal to a low Zn content

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We are grateful to Miki Ben-Dor and Ran Barkai for their interest in our study (1). We acknowledge that a high-fat diet should have been discussed in our hypothesis as an additional dietary option.

However, we are afraid that there was a misunderstanding in the interpretation of our data. Ben-Dor and Barkai (2) wrote that "One explanation presented in the [our] paper was that Neandertals may have consumed body parts and animals that were relatively poor in zinc, like the liver or deer." This sentence is not reflecting our conclusions: We discussed Zn isotope ratios (i.e., $^{66}Zn/^{64}Zn$ ratio expressed as a $\delta^{66}Zn$ value) and not Zn concentrations. To explain low $\delta^{66}Zn$ values of the Neandertal tooth, we propose that Neandertals ate food items depleted in heavy Zn isotopes (and therefore enriched in light Zn isotopes), but those foods can have variable Zn contents, independent of the Zn isotope composition as such. A large fraction of Zn with low $\delta^{66}Zn$ needs to be ingested with the diet to shift Neandertal enamel mineralizing to low $\delta^{66}Zn$ values. Thus, the proposition of Ben-Dor and Barkai (2) that "a high animal fat consumption with zero zinc content as a probable explanation for the extremely low $\delta^{66}Zn$ in the Gabasa Neandertal" does not work as the zinc content of fat is too low to contribute to the enamel $\delta^{66}Zn$. Furthermore, fat and bone marrow do not even have low $\delta^{66}Zn$ values (3, 4).

To support this statement, we here give an example based on the numbers suggested by Ben-Dor and Barkai (2). Assuming 1) a concentration of Zn in fat of 0.06 mg/100 g and a concentration of Zn in meat (0% fat) of 4 mg/100 g (5), 2) a consumption of 1 kg meat with 20% of protein and 15% of fat per day, 3) Zn isotope compositions of meat ($\delta^{66}Zn$ = 0.15‰) and of fat ($\delta^{66}Zn$ = 0.4‰) (3), 4) and that proteins contribute to 4 kcal/g and fat to 9 kcal/g in the diet (6), we obtain a $\delta^{66}Zn$ of 0.1506‰ (Table 1). Thus, compared with a fat-free meat diet, the $\delta^{66}Zn$ value is only increasing by 0.0006‰, which is two orders of magnitude lower than the analytical error of $\delta^{66}Zn$ measurement (<0.05‰, 1 SD) and therefore not significant.

The consumption of bone grease has been reported in Pyrenean Mousterian sites as described by the work of Costamagno (7, 8) in the nearby location of the Noisetier Cave and Blasco (9) through the exploitation of bone marrow for the very site of Gabasa. Hence, the consumption of fat could potentially be substantial at these sites, but at this stage, zinc isotope ratios do not allow us to quantify it. As shown by our mass balance, a high-fat diet cannot explain the low $\delta^{66}Zn$ values that we observe in the Neandertal tooth of Gabasa as it would have a very small impact on the $\delta^{66}Zn$ bulk value of the diet.

Table 1. Contribution of fat to the Zn isotope composition of 1 kg meat (see text for references)

	Mass in g	Contribution in kcal	% in the diet	Amount of Zn (mg)	$\delta^{66}Zn$ (‰)
Proteins	200	800	37%		
Lipids	150	1,350	63%	0.09	0.4
Meat without fat	850	800	37%	34	0.15
Total amount of meat eaten	1,000	2,150	100%	34.09	0.1506

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The authors declare no competing interest.

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