**Sex Determination and Stable Isotope Analysis of the Nivåfjord Mesolithic Burials, Zealand, Denmark**

Kurt J. Gron1, Harry K. Robson1,2,7, Nicolas A. Stewart3, T. Rowan McLaughlin4, Chris Meiklejohn5, Peter Rowley-Conwy1, Ole Lass Jensen6 and Janet Montgomery1

1Department of Archaeology, Durham University, South Road, Durham, DH1 3LE, UK

2BioArCh, Department of Archaeology, University of York, York YO10 5DD, United Kingdom

3School of Applied Sciences, University of Brighton, Brighton, BN2 4AT, UK

4Hamilton Institute, Maynooth University, Maynooth, Co. Kildare, Ireland

5University of Winnipeg, Winnipeg, MB, R3B 2E9 Canada

6Museum Nordsjælland, Frederiksgade 9, 3400 Hillerød, Denmark

7Corresponding author (hkrobson@hotmail.co.uk)

Email addresses: Kurt J. Gron (k.j.gron@durham.ac.uk), Harry K. Robson (hkrobson@hotmail.co.uk), Nicolas A. Stewart (n.stewart@brighton.ac.uk), T. Rowan Mclaughlin (rowan.mclaughlin@mu.ie), Chris Meiklejohn (c.meiklejohn@uwinnipeg.ca), Peter Rowley-Conwy (p.a.rowley-conwy@durham.ac.uk), Ole Lass Jensen (olj@museumns.dk) and Janet Montgomery (janet.montgomery@durham.ac.uk)

ORCiDs: Kurt J. Gron (<https://orcid.org/0000-0002-0415-2891>), Harry K. Robson (<https://orcid.org/0000-0002-4850-692X>), Nicolas A. Stewart (<https://orcid.org/0000-0002-8969-4242>), T. Rowan Mclaughlin (<https://orcid.org/0000-0003-4923-1339>), Chris Meiklejohn (<https://orcid.org/0000-0002-1324-1976>), Peter Rowley-Conwy (<https://orcid.org/0000-0002-9494-3151>) and Janet Montgomery (<https://orcid.org/0000-0001-6729-3088>)

**ABSTRACT**

Since 1992 the prehistoric Nivåfjord in northeast Zealand, Denmark, has yielded an appreciable number of inhumation burials and cremations dating to the Mesolithic, especially the sites of Nivå 10 and Nivågård. Unfortunately, the micro-region is characterised by poor organic preservation, restricting the successful application of biomolecular techniques to human remains, including large-scale radiocarbon dating programmes as well as both stable isotope and ancient DNA analyses. Here, we apply an alternative technique, an acid etch peptide-based method, to determine the sex of eight individuals from Nivå 10 as well as the Nivågård child. Moreover, we revisit the utility of stable carbon (δ13C), nitrogen (δ15N) and sulfur (δ34S) isotope analysis of human tissues to reconstruct the life histories and diets of 10 individuals from Nivå 10 as well as the Nivågård child. To contextualise further, we sampled 14 *Capreolus capreolus* and three *Sus scrofa* from the Nivågård site for stable isotope analysis. We demonstrate that sex can successfully be determined from contexts susceptible to poor organic preservation, and show that the Nivågård child spent a proportion of its life outside a sea spray-influenced environment, and consumed significant quantities of marine protein as demonstrated by its δ13C and δ34S values. By applying novel analytical methods, a wealth of information can both be gleaned from older collections as well as from sites with poorer conditions for organic preservation.

**KEYWORDS**

Denmark; Middle Mesolithic; Late Mesolithic; Proteomic analysis; Stable isotope analysis; Human remains

**OxCal CQL code for Figure 3.**

Plot()

{

 Curve("Intcal20","intcal20.14c");

 Curve("Marine","marine20.14c");

 Delta\_R("Baltic",-234,61);

 Sequence("Burials at Niva")

 {

 Boundary("Start burial activity");

 Phase("Niva 10 dates")

 {

 Mix\_Curves("Curve AAR-14934", "Intcal20", "Baltic", 40,10);

 R\_Date("Human, Grave A129 AAR-14934", 7265, 38);

 Mix\_Curves("Curve AAR-14936", "Intcal20", "Baltic", 50,50);

 R\_Date("Cremated human, Grave A128 AAR-14936", 7035, 35);

 Mix\_Curves("Curve AAR-7058", "Intcal20", "Baltic", 30,10);

 R\_Date("Human, Grave A41 AAR-7058", 6900, 90);

 Mix\_Curves("Curve AAR-10147", "Intcal20", "Baltic", 60,10);

 R\_Date("Loose human humerus, Dwelling 2 AAR-10147", 6868, 46);

 Curve("IntCal20","intcal20.14c");

 R\_Date("Charred hazel, Grave A162 AAR-16072", 6518, 60);

 Mix\_Curves("Curve AAR-12711", "Intcal20", "Baltic", 50,50);

 R\_Date("Cremated human, Grave A144 AAR-12711", 6154, 45);

 };

 Boundary("End burial activity");

 C\_Date("Sea level rise",-4700,50);

 Boundary("Island inaccessible");

 };

Phase("Nivagard dates")

 {

 Mix\_Curves("Curve Ka-6610", "Intcal20", "Baltic", 60,10);

 R\_Date("Human Ka-6610", 6845, 65);

 Curve("IntCal20");

 R\_Date("Red deer LuS-7381", 6770, 50);

 R\_Date("Red deer LuS-7379", 6435, 50);

 R\_Date("Red deer LuS-7378", 5940, 100);

 Curve("Marine","marine20.14c");

 Delta\_R("Baltic",-234,61);

 R\_Date("Cod LuS-7380",5400, 50);

 };

};