The potential of overlooked material in museum repositories

Revisiting grave materials in Falbygden through multiproxy analyses

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ABSTRACT

In this article we aim to highlight the potential of forgotten grave materials in our museum depositories for gaining insights into prehistoric life. By applying a multi-proxy approach to the skeletal remains of two graves of uncertain types from Falbygden in western Sweden, we were able to acquire new knowledge of burial practices, subsistence, health and mobility in Late Neolithic and Early Bronze Age communities. One of the studied graves proved to be the earliest attested gallery grave in the area, while the other is one of the few known graves from the first period of the Bronze Age. The results indicate that some overlooked excavated materials in our depositories might stem from certain time periods from which we think archaeological remains are lacking and/or from practices which are not fully understood. These remains may prove to be important for our understanding of prehistoric societies when thoroughly studied combining archaeological, osteological, biochemical and geochemical methods.

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Introduction

Museum repositories are unique sources of new knowledge about the past and are thus invaluable for research. Even poorly documented materials can provide useful information to improve our understanding of prehistoric societies, not least in view of the latest developments in scientific methods. These overlooked remains may in fact represent time periods where we lack known material and/or poorly understood practices. In this study, we want to highlight the burial customs and lifestyle of Stone Age and Early Bronze Age people by studying two forgotten materials stored in the repository at Falbygden Museum.

Our knowledge of the Stone Age in Falbygden is mainly based on studies of megalithic graves and their contents (Ahlström 2009; Sahlström 1932; Sjögren 2003). The megalithic graves in Falbygden consist of dolmens and passage graves from the Early and Middle Neolithic (*c.*3500-3000 BC) Funnel beaker complex (TRB) and hällkistor/gallery graves from the Late Neolithic (2200-1700 BC, see Blank 2021, 13; Blank et al. 2020, 2) period. The material from the megalithic graves has been collected mainly in the early 20th century when most of the graves were only partially investigated, although later excavations also occur (e.g., Cullberg 1963; Persson and Sjögren 2001). The focus of interest has been on the numerous and impressive passage graves found in the area, although in recent years new knowledge about the dolmens and gallery graves have come to light (Blank 2021; Blank et al. 2020; Sjögren et al. 2023). Wetland finds, deposits, loose finds, and settlements have also contributed to what we know about the Stone Age communities in Falbygden and the surrounding area (e.g., Sjögren 2003; Sjögren et al. 2017; Sjögren et al. 2019; Weiler 1994). The Early Bronze Age (1700-1100 BC) period in the area is less studied and the confirmed burials from this period consist of the continued use and reuse of gallery graves and low profiled cairns (Blank 2017; Sahlström 1932; Weiler 1994).

Substantial archaeological and bioarchaeological work has been carried out on the relatively well-preserved skeletal remains from the Middle Neolithic passage graves (Rascovan et al. 2019; Seersholm

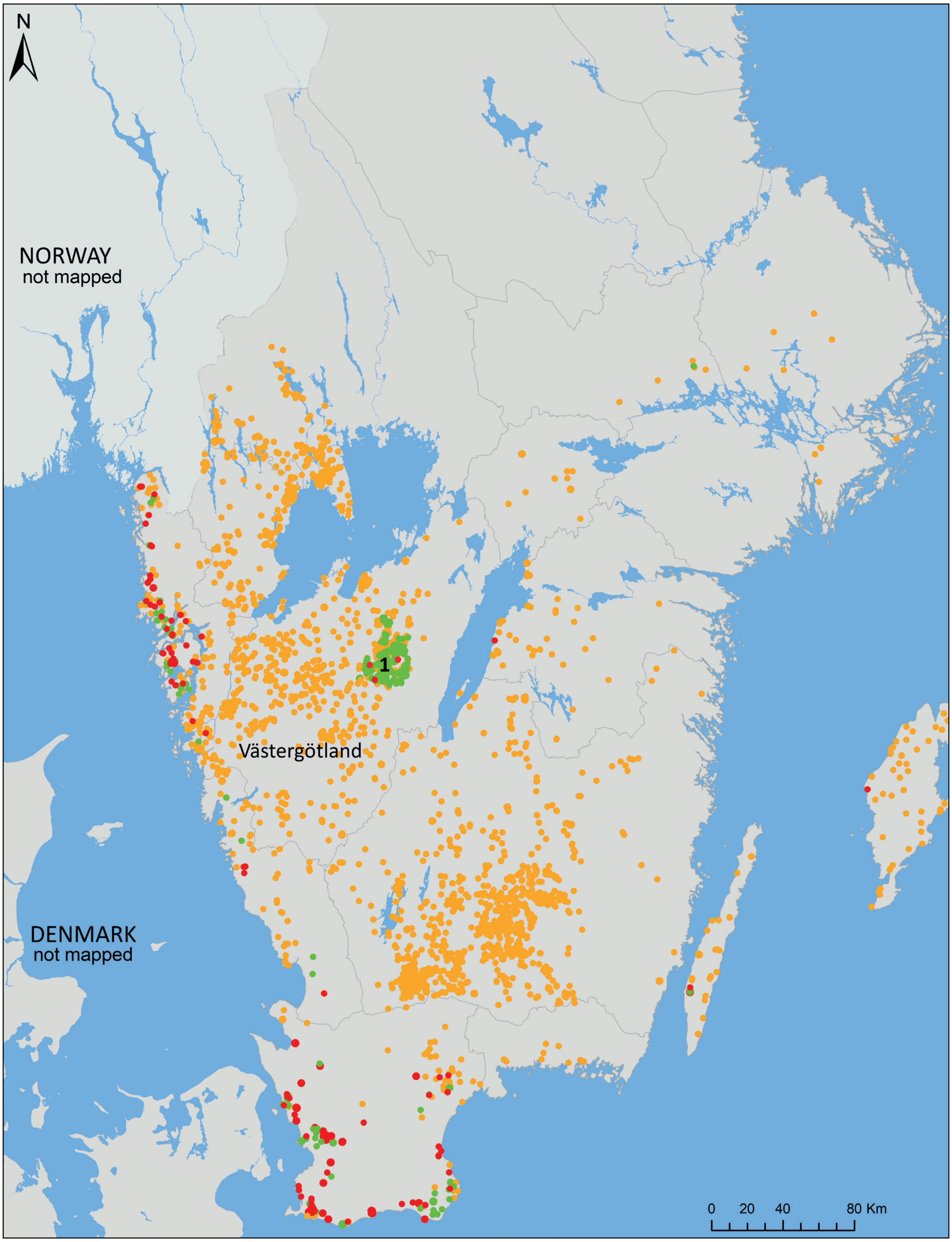

Figure 1A. Overview of southern Sweden with the distribution of megalithic graves (red dots: dolmens, green dots: passage graves, orange dots: gallery graves). 1: Falbygden (see figure 1B).

et al. 2024; Sjögren 2017; Sjögren et al. 2009; Skoglund et al. 2012; Skoglund et al. 2014) and Late Neolithic gallery graves (Blank et al. 2018a; Blank et al. 2020; Blank et al. 2021), as a consequence of recent methodological advancements in archaeology. These studies have provided new insights into the chronology of interments, as well as the diet, health, and mobility of the interred individuals. Furthermore, analyses of Middle Neolithic burials have evidenced outbreaks of plague (*Y. pestis*) thousands of years prior to the 14th Century AD pandemic (Rascovan et al. 2019; Seersholm et al. 2024). Much of our knowledge is thus based on the remains and relics with varying states of preservation that have been collected over the years.

The burials with poor bone preservation (often fragmented and leached) as well as the graves with co-mingled and/or few skeletal remains have however been unprioritised since they were considered to not contribute to the understanding of the actual burials or Neolithic society in general. Several graves in the area have been damaged by farming or other activities and are therefore difficult to assign to a specific type and/or time period. These materials are often considered troublesome and tend to be avoided in research. Other neglected materials are the ones with minimal documentation. New methodological developments within the last few years might however change this situation and increase our knowledge about people also outside the areas with the most favorable preservation. This article is based on two such assemblages. Both assemblages consist of a few artefacts and bone remains from severely damaged graves.

We provide here an in-depth study of two graves in Högstena and Kymbo, Falbygden (Figure 1A and 1B), where the preserved bones are few, fragmented, and macroscopically in poor condition. The aim is to illuminate the scientific potential of these neglected skeletal remains, when using a multi-proxy approach by combining osteological, archaeological, chronological, geochemical and biomolecular methods.

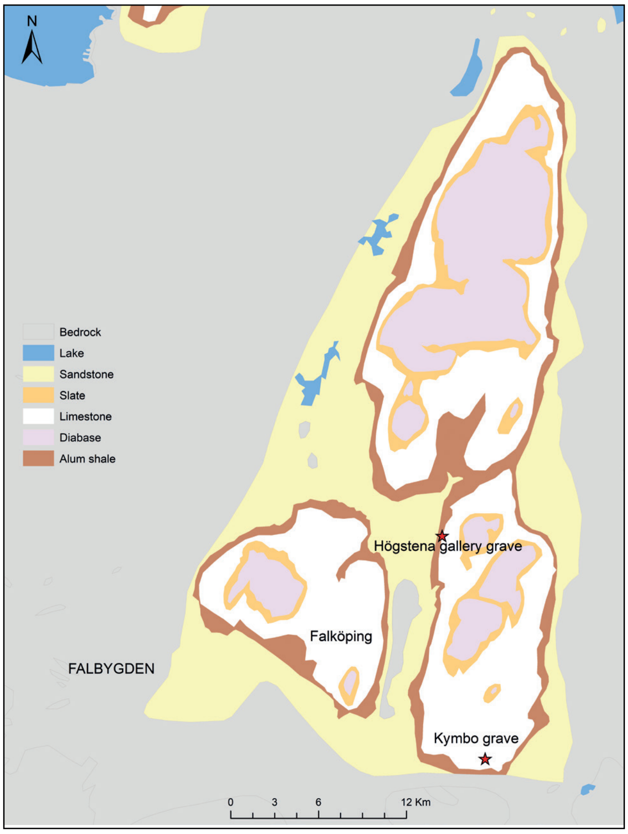

Figure 1B. 1: Falbygden. Close-up of Falbygden showing the Högstena and Kymbo sites.

Material and Methods

Introduction

The study included archive research at Antikvarisk-topografiska arkivet (ATA), Stockholm and Falbygdens museum (FM), Falköping, literature studies and investigating and typological dating of the find material. For typological dating of the daggers, we used Apel (2001) and Blank (2022) interpretations of Lomborgs types (1973). For typological dating of the amber and metal finds, museum collections and literature (see result section) were used.

Osteological analysis was conducted on all remains. Samples for radiocarbon, stable isotope and peptide analyses were selected from as many different individuals as possible. The osteological results were decisive for the sampling process as we wanted to ensure that no individual was sampled multiple times. We applied a Minimum Number of Individuals (MNI) approach and targeted the same skeletal element from the same side or used clear age indicators to separate unique individuals when a different skeletal element was sampled.

In addition, three of the sampled individuals from the Högstena grave and one from the Kymbo grave were analysed for ancient DNA (aDNA). However, the bones did not yield sufficiently preserved genetic material.

Högstena, Olof Ingemarsgården

This presumed grave was found in 1932 when the landowner removed a limestone slab in the field. He found two flint daggers and observed some unburnt bones. The site was then investigated by Gustav A. Hellman, antiquarian at the Swedish National Heritage Board, who collected the unburnt skeletal remains, a bone awl and a flint flake (FM1075). Apparently, some smaller limestone slabs had been removed from the same area earlier. Hellman (1933) concluded that these were the remains of a destroyed gallery grave. The size of the grave was estimated to be 3 m x 1.5 m (in a north-south direction) and to a depth of about 0.4 m, based on the size of the slab and the distribution of the skeletal remains (Hellman 1933).

The grave is registered as a gallery grave in the Swedish National Heritage Board's register (FMIS, Högstena 45:1). The nearest archaeological sites consist of a passage grave *c.*50 m northwest of the gallery grave, a Stone Age settlement about 100 m to the west and another passage grave *c.*100 m southwest of the site (FMIS). The site is located about 11 km northeast of the city of Falköping and the prehistoric remains in Högstena parish are dominated by megalithic graves from the Middle and Late Neolithic period.

In this study, the finds were examined, and the bone assemblage underwent osteological analyses. Six human bones (one fibula, one mandibula with molars, and four femora) were sampled for radiocarbon dating, stable isotope analysis and one tooth was subjected to amelogenin peptide and strontium (Sr) isotope analysis (see below).

Kymbo, Backgården

This site is not registered in FMIS. It was found in the 1930s during a rearrangement of the road to the Backgården farm in Kymbo. The site was located approximately 75 to 100 m from the main road and was described by the road builder as a small cairn filled with stones and soil (Forntidskort FM 1677:1-5, notes from 1941). The finds were handed to the local Falbygden museum and consisted of an iron key, an iron mounting, a bronze button, an amber bead, a few pieces of charcoal, and fragmented burnt and unburnt bones. At the same occasion an east-west oriented gallery grave measuring about 3 m x 1 m was found, which had been constructed completely underground (notes from the Falbygden Museum archives-Kymbo parish). It is unclear if these two structures were connected.

Kymbo is located about 15 km southeast of Falköping city, and the area is rich in Iron Age sites. The nearest prehistoric sites consist of an Iron Age cemetery with fourteen round stones settings located *c.*150 m southwest of the site, and a stone age settlement *c.*500 m northwest of the assumed grave. No gallery graves are registered in Kymbo parish, but three passage graves are listed in the FMIS register, the closest of which is about 650 m from the grave.

From this grave assemblage, we studied the finds and conducted osteological analysis. Four human individuals (one mandibula with one first molar as well as two loose premolars and one loose first molar) were sampled for radiocarbon dating, stable isotope, Sr isotope and peptide analysis (see below). In addition, one bovine bone and one dog tooth were sampled for radiocarbon dating and stable isotope analysis (Supplementary material 1).

Osteology

The remains from both gallery graves were severely fragmented and poorly preserved (Figure 2) which significantly limited the amount of information that could be gained osteologically. There is, however, nothing in the fragmentation pattern that suggests intentional breakage of the remains; the assemblages constitute primarily cortical bone and teeth, which is expected from taphonomic processes of non-anthropogenic origin. The aim of the osteological analysis was therefore primarily to get insight into the minimum number of individuals and, if possible, retrieve demographic information, such as age and sex. The osteological information was thus considered to contribute to a deepened understanding of the usage of the graves and possible differences in diet and mobility related to age and sex.

Figure 2. The bone material from the Kymbo grave.

Because of the limitations associated with the poor preservation, there was a necessity to apply the osteological analysis pragmatically. The number of inhumed individuals was assessed through an MNI approach, through calculations of the most frequently occurring skeletal element from the same side with recognisable landmarks, such as distal humerus. Age, size and robusticity were used as discriminators in the calculations.

Sex estimations based on primary characteristics of the pelvis (Milner 1992; Phenice 1969) could not be carried out since relevant elements were absent. Preliminary sex could be assessed in one case based on secondary characteristics of the cranium (Acsádi and Nemeskéri 1970). Substantially different dimensions of joints and long bones were further used for preliminary sex estimations in a few cases.

Subadult age was estimated using dental development (Ubelaker 1978) and epiphyseal fusion (Scheuer and Black 2000). Adult age was estimated using dental attrition (Brothwell 1981). Considering the individuality in dental attrition depending on diet and other cultural and ecological factors, we only used attrition to divide young adults with low levels of attrition from older adults with high levels of attrition.

Amelogenin peptide analysis

Amelogenin peptide analysis is a new technique that can be used to uncover the biological sex of skeletal remains, which for various reasons cannot be determined by osteological methods. The method was developed by Stewart et al. (2017) and provides a minimally destructive and robust tool of identifying the biological sex by acid etching of tooth enamel and following identification of sexually dimorphic isomers of amelogenin peptides.

The analyses reported in this study were performed at the Archaeological Isotope and Peptide Research Laboratory (AIPRL) at the Archaeology Department at Durham University and at the School of Pharmacy and Biomolecular Sciences, University of Brighton, United Kingdom. The procedure of amelogenin peptide extraction of the teeth was carried out following the Stewart et al. (2017) method. The preparation and analyses are described in detail in Rogers and Montgomery (2023) and Stewart et al. (2017).

Radiocarbon dating and stable isotope analysis

Radiocarbon dating is a groundbreaking and since long, well-established method of dating dead organic material by measuring the amount of ^{14}C present in the sample. The method was developed in the 1940s by Willard Frank Libby (1965) and has since then had a major impact on our understanding of prehistory. Stable isotope analysis ($\delta^{13}C$ and $\delta^{15}N$ values) on human bone collagen is a widely used method in archaeological research of estimating possible reservoir effects and general consumption patterns in prehistory (Sealy 1986, 2001). The consumption of aquatic foods can affect radiocarbon dating results. This is caused by the fact that carbon consumed by organisms in the water is older than that consumed by organisms on land (Philippsen 2013; Siegenthaler et al. 1980).

The $\delta^{13}C$ value is used for estimating if the protein intake was mainly from marine or terrestrial sources, while the $\delta^{15}N$ value reflects the trophic level of a consumer with increasing values higher up in the food chain (Sealy 1986). Nevertheless, nitrogen isotope fractionation is complex, and the enrichment seems to vary between species as well as between individuals due to differences in diet composition, as well as to physiological and genetic variation (Hedges and Reynard 2007). Furthermore, $\delta^{15}N$ values can be affected by breastfeeding, the consumption of juvenile herbivores (as these are one trophic level above their mothers), physiological stress and the intake of manured crops (Bogaard 2012; Fraser et al. 2011; Fuller et al. 2006; Hedges and van Klinken 2000).

The radiocarbon dating and carbon and nitrogen stable isotope analysis were conducted at the 14Chrono Centre at Queen's University in Belfast, United Kingdom. The Belfast laboratory employs AMS measurement and methods with several cleaning steps including ultrafiltration. Collagen was extracted through a modified Longin method (Longin 1971), developed by Brown et al. (1988). The samples were pretreated using a simple ABA treatment, followed by gelatinization and ultrafiltration with a Vivaspin filter cleaning method (Reimer et al. 2015). A Thermo Flash 1112 elemental analyser coupled to a Thermo Delta V mass spectrometer (EA-IRMS) were used to measure %C, %N, $\delta^{13}C$ and $\delta^{15}N$ of the sample. For more information about the different steps of the sample preparation and radiocarbon and stable isotope analysis see Reimer et al. (2015).

Strontium isotope analysis

In recent years, the study of human mobility in prehistory has seen a breakthrough by the employment of Sr isotope analysis (e.g. Blank et al. 2021; Nehlich et al. 2009; Oelze et al. 2012; Snoeck et al. 2020). Strontium originates mainly from weathered rock minerals and the isotope ratio of the bioavailable Sr largely reflects the local geology, which depends mostly on the type and age of bedrock (Faure 1986). Strontium passes through soil and water into the biosphere and enters the food chain and the human skeleton. The relatively small mass differences between the different Sr isotopes, together with the lack of preferential metabolic processing, mean there is minimal isotopic fractionation (Bentley 2006). Therefore, the Sr isotope ratio can be used to trace mobility if consumption of local water and food can be assumed. Other factors such as an extensive intake of marine foods can also alter the Sr isotope ratio (Blank et al. 2021). Moreover, it should be kept in mind that the samples only reflect a specific time span of the individual's life, depending on for example when the sampled enamel of a specific tooth was crystalized, and that mobility only can be detected if the Sr isotope ratios differ between the areas where the movement took place. For more detailed information on Sr isotope methodology see Bentley (2006) and Faure (1986).

The find sites in this study are located in Falbygden, which chiefly comprises Phanerozoic sedimentary and intrusive rocks surrounded by older Precambrian crystalline bedrock and thus has distinctive Sr isotope signals, quite different from the neighbouring regions (Ahlberg et al. 2013; Blank et al. 2018b). However, glacial deposits add to the complexity of bioavailable Sr and may affect or mask the signatures characteristic of the under-

Figure 3. The intact flint dagger recovered from the Högstena grave.

lying bedrock. The available Sr isotope baseline for Falbygden and the larger province (Blank et al. 2018b), thus, makes this area even more suitable for mobility studies through Sr isotope analysis.

In this study we employed Sr isotope analysis using an ESI NWR 193 nm excimer laser ablation system coupled to a Nu Plasma II (upgraded to Nu Plasma 3) multicollector ICP mass spectrometer (LA-MC-ICP-MS) at the Swedish National Research facility Vegacenter at the Swedish Museum of Natural History, Stockholm. The analyses were conducted in September 2023. A fin spine from a velvet belly lantern shark (*Etmopterus spinax*) was used as the primary standard to which data were normalised to correct for mass bias and intra-session instrument drift; secondary standards comprised teeth from a hare (*Lepus timidus*) and a sperm whale (*Physeter macrocephalus*) previously characterised in-house by thermal ionisation mass spectrometry (TIMS), as well as the USGS reference basalt glass BCR2-G (GeoReM preferred values, Jochum et al., 2005). The instrument was tuned to suppress oxide formation (ThO/Th < 0.5%) to minimise isobaric interferences by CaPO-based polyatomics on mass 87 (Mulder et al., 2023). Each analysis comprised a line *c*.250 μm long with a spot size of 130 μm; where tooth size permitted, 14 such lines were ablated from the dentine-enamel junction (DEJ) to the tip of each tooth, thus covering the complete time of tooth mineralization. Data and analytical settings are fully reported in supplementary material 2. For more information about the analytical procedure, see Boethius et al. (2022).

Results

Typological dating of the finds

Högstena, Olof Ingemarsgården

Two flint daggers were recovered from the Högstena gallery grave, one of which was an intact dagger and the other a piece of a broken dagger. Both are made of southern Scandinavian flint and are of the early Lomborg types; the intact one is a type II (Figure 3) and the fragmented one is a type I/II dagger. According to the typological dating of the daggers (Apel 2001; Blank 2022; Lomborg 1973) we can assume that the grave was already used in the first part of the Late Neolithic. A small flint scraper was also found and handed in to the museum. The recovered bone awl was osteologically estimated to be either sheep or goat and further determined to be sheep according to ZooMS analysis (Blank 2021, 55). The sheep bone was radiocarbon dated (see below).

Kymbo, Backgården

The remaining artefacts from the Kymbo grave consist of an iron key, an iron mounting, a bronze button, and an amber bead. The iron key is of a Late Iron Age type (see Nordström 2021). A Late Iron Age date may also be assumed for the bronze button and the Iron mounting. Similar buttons have been found at Helgö, Uppland and dated to 200-800 AD (Holmqvist et al. 1961, 1964). The amber pendant is fragmented and can only be assigned to the Neolithic period in general (see Axelsson et al. 2015; Ebbesen 1995a, 1995b, 2002).

Osteology

Högstena, Olof Ingemarsgården

The MNI of the Höstena grave was estimated to be four: two adults and two children. The postcranial bones associated with the adults indicate one gracile and one substantially larger and more robust individual. It is plausible that the differences in size indicate individuals from one of each sex, but the results are not conclusive. None of the adult remains were possible to assess to specific age or age-group. However, considering that none of the bones evidenced degenerative lesions, it is possible that none of the adults died in advanced age. *Ligamenta flava* (ossified ligaments in the neural canal) was found in one thoracic vertebra. The incidence of *Ligamenta flava* increases with age but could affect individuals in their 20s and 30s as well (Kudo et al. 1983). The lesion is common and usually doesn't cause any discomfort. Advanced cases could affect the nerves of the spine, and cause numbness and affect the ability to move (van Oostenbrugge et al. 1999).

Subadult bones were few: a mandibular fragment with a developing first molar *in situ*, a fragmented femur, metacarpals and metatarsals, and a larger fragment of a clavicle. The development of the first molar is consistent with an age of approximately five years, which is also in accordance with the size of the femur. The sizes of the metapodials and the clavicle were smaller than could be expected from a five-year-old, which indicates the presence of a younger child of approximately two-three years.

In addition to the human remains, a burnt bovine vertebra was identified in the material.

Kymbo, Backgården

The MNI of the Kymbo grave is also four; one older adult, one adolescent or young adult, and two children, approximately six and twelve years old.

The MNI calculation is based on preserved teeth and differences in development and attrition. Most skeletal parts were large and robust, which might indicate male sex. One fragment of a temporal bone, however, exhibited a mastoid process of female characteristics. A few of the larger and more robust bones evidenced osteophyte formation of the joint, which might point to a more advanced age.

A few animal bones were also found in the bone assemblage, which were determined to be dog and bovine.

Amelogenin peptide analysis

All five teeth that were analysed yielded results. Only one tooth from the Högstena grave, a child of the age of *c*.5 years (Hog3), was analysed and provided positive results for AMEL-Y peptides and is thus determined to be of the male sex. Teeth from all four individuals of the less preserved Kymbo grave were analysed and yielded three negative and one positive AMEL-Y peptides. The results of the peptide analysis thus confirm the osteological sex assessment of one male and one female adult. Contrary to the preliminary osteological assessment, the young adult, KY2, was determined to be male and the old individual KY3 to be female. This could either point towards the presence of an additional older male in the assemblage, which was not represented by preserved teeth, or that the

Sample ID	Site	Age of death (years)	AMEL-X	AMEL-Y	Sex
K1677:1	Kymbo	*c*.12	Present	Absence	Female
KY1	Kymbo	6-7	Present	Absence	Female
KY2	Kymbo	15-20	Present	Present	Male
KY3	Kymbo	old ind.	Present	Absence	Female
Hog3	Högstena	*c*.5	Present	Present	Male

Table 1. Results from amelogenin peptide analysis.

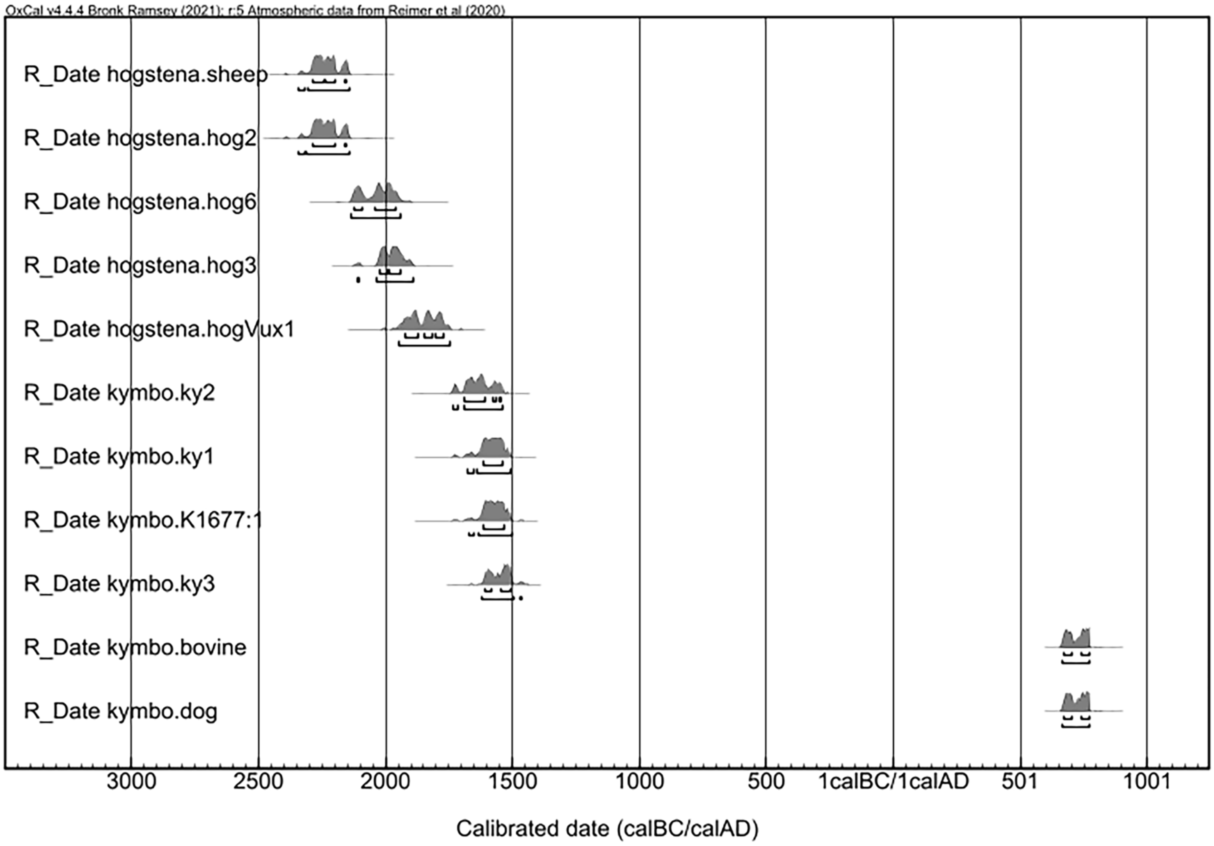

Figure 4. Calibrated radiocarbon ages of human and animal remains in the Högstena gallery grave and the Kymbo grave. Oxcal version 4.4, Bronk Ramsey (2021) with atmospheric data from Reimer et al. (2020).

results reflect the problems in accurately assessing sex in the youngest and oldest age groups based on secondary or tertiary morphological traits where young males might carry female morphological traits and old females might be more robustly built, hence being sexed as males. Both children turned out to be of female sex (Table 1).

Radiocarbon dating

In this study, twelve samples were sent for radiocarbon dating. Of these, two failed due to poor quality of the collagen (Hog4 and Hog5). For the remaining samples the reported values for C:N atomic values ranged from 3.1 to 3.3 which is well within the recommended range, indicating well preserved collagen (Bronk Ramsey et al. 2004; van Klinken 1999). Furthermore, the $\delta^{15}N$ and the $\delta^{13}C$ values (see below) do not indicate any signs of a reservoir effect caused by the consumption of protein from marine or freshwater sources. In figure 4, all radiocarbon dates from humans and animal remains, including the date of the already published bone awl (Blank 2021), are plotted showing the 95.4% and the 68.2% probability spans.

In the Högstena gallery grave the radiocarbon dates are rather dispersed. The two earliest dates, from the sheep bone (awl) and one of the children (a fibula-Hog2), span from 2340 to 2140 cal BC, 95.4% probability, which covers the transition between the Middle and Late Neolithic as well as the first part of the Late Neolithic I (2200-1950 BC). These two dates do not overlap with the rest of the radiocarbon dates from the grave. Hog6 and Hog3, representing an adult individual and the ca. 5 years old boy, both date to the Late Neolithic I, although the boy has a slightly later date that spans into the second part of the Late Neolithic. The latest date in this grave belongs to an adult individual of unknown sex (HögVux1) and spans between 1950 and 1750 cal BC (95.4% probability), within the Late Neolithic II.

The radiocarbon ages from all four individuals in the Kymbo grave overlap. The results from the

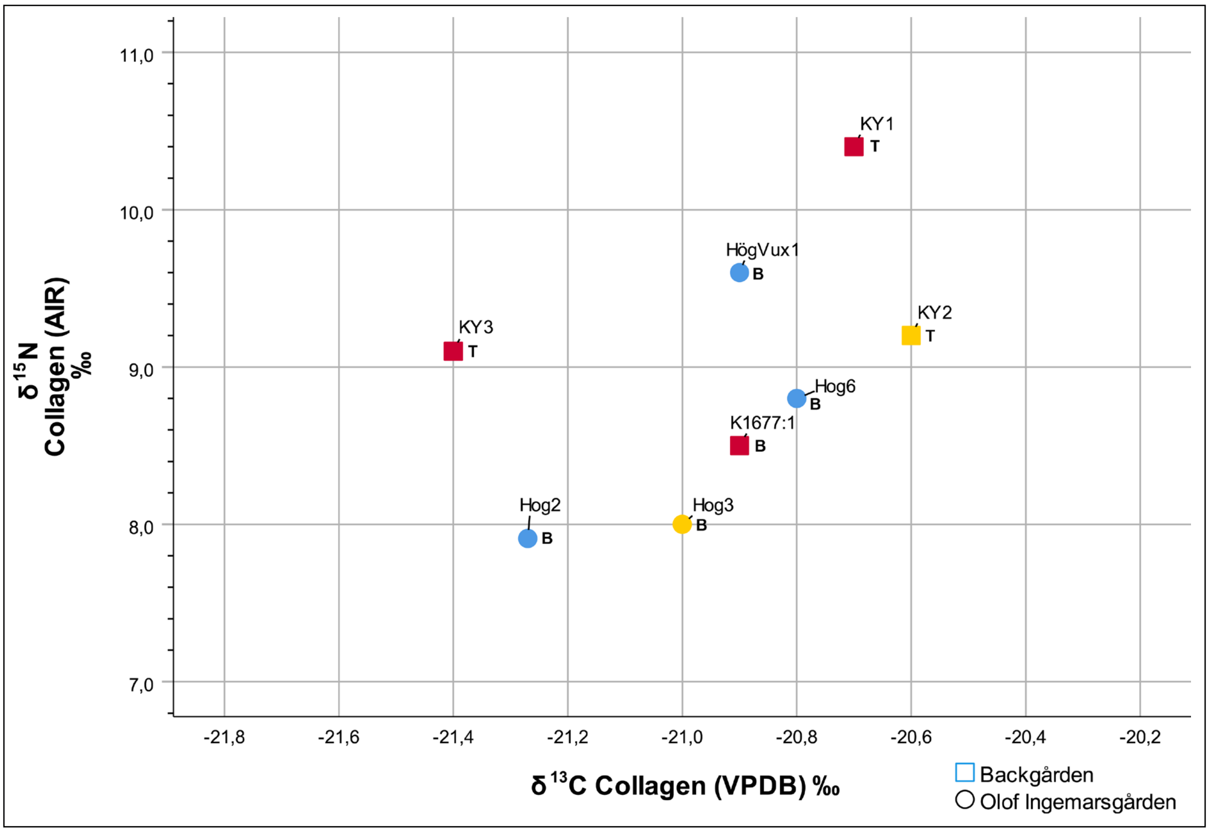

Figure 5. Scatterplot of $\delta^{13}C$ and $\delta^{15}N$ values (‰) from human remains in the investigated graves. Squares: Kymbo, Backgården grave. Circles: Högstena, Olof Ingmarsgården. Red: female. Yellow: male. Blue: unknown sex. T: tooth. B: bone. Data from supplementary material 1.

three female individuals are very similar while the dating of the young adult male (premolar-KY2) is slightly earlier and has a more expanded range. The dates more or less range within the Bronze Age period I (1700-1500 cal. BC). The radiocarbon ages from the two animals are also very similar, spanning from 660 to 770 cal. AD, which is concurrent with the Late Iron Age metal finds in the grave (see above).

Stable isotope analysis

The same samples that were successfully radiocarbon dated, also yielded stable isotope data. In general, the teeth yielded higher $\delta^{15}N$ values than the bone samples, which already have been pointed out in a previous study of Neolithic and Early Bronze age individuals in Falbygden (Blank 2021). This might suggest a change in diet based on age, but we do not have stable isotope values from both tooth and bone from the same individual to confirm such an assumption. Furthermore, the only two samples that represent an adult diet (bones from adult individuals) are Hog6 and HögVux1, while the remaining samples reflect the protein intake between the ages of *c*.3 and 12 years (bones from children and teeth, Supplementary material 1). The observed pattern might also result from a breast-feeding effect in the teeth, nevertheless the bone samples from the two young children (Hog2 and Hog3) have the lowest $\delta^{15}N$ values of 8‰ of them all (Figure 5).

In the Högstena gallery grave, only bones were analysed and the $\delta^{13}C$ values range from -21.3‰ to -20.8‰, while the $\delta^{15}N$ values span from 7.9‰ to 9.6‰. The highest $\delta^{15}N$ value belongs to the youngest burial and the only skeletal remain dated to the second part of the Late Neolithic (HögVux1), suggesting that this individual consumed more protein from a higher trophic level than the other individuals or consumed proteins from a place with a deviating baseline.

In the Kymbo grave the $\delta^{13}C$ values vary between -21.4 and -20.7‰, and the $\delta^{15}N$ value

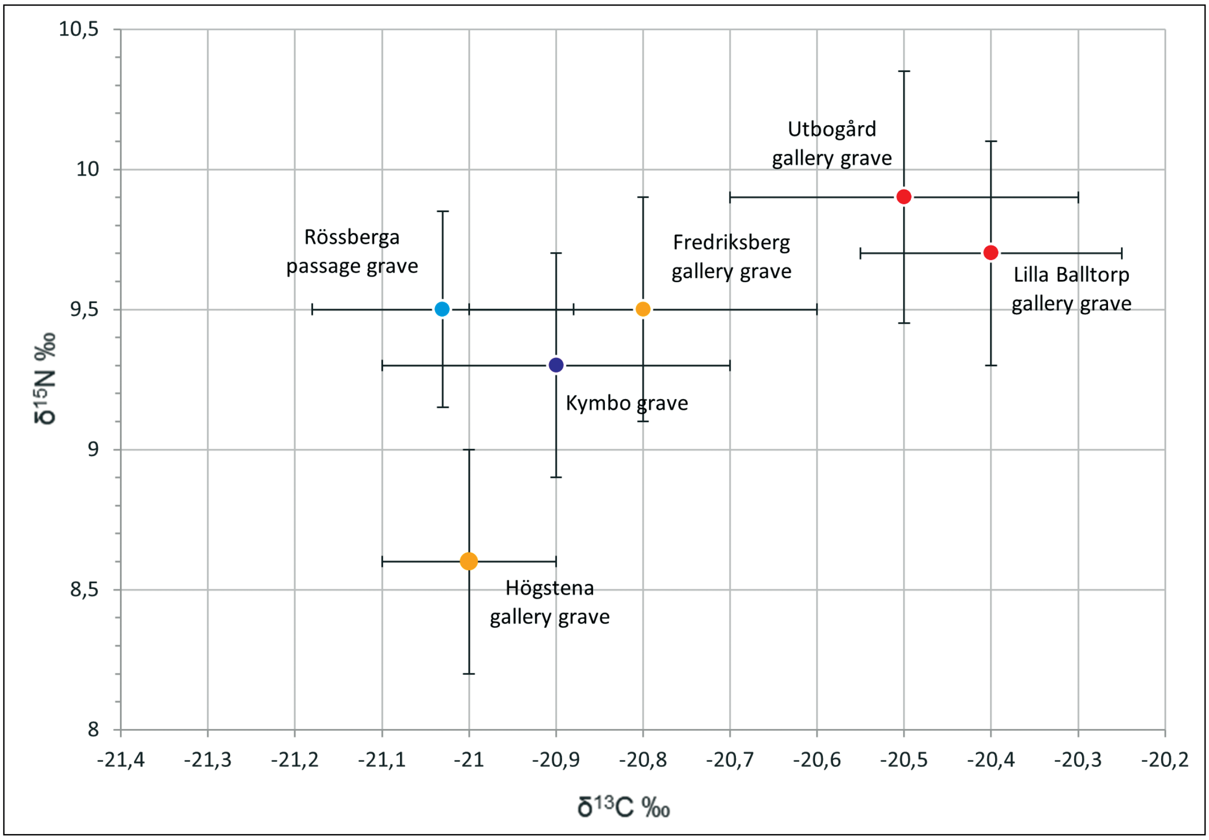

Figure 6. Mean values (‰) with standard deviations (SD 2) of $\delta^{13}C$ and $\delta^{15}N$ from human remains in graves from Falbygden. Data from supplement 1, Blank et al. 2018, and Blank 2021, appendix 1. Högstena gallery grave N=4, Kymbo grave N=4, Rössberga passage grave N=28, Fredriksbergs gallery grave N=22, Utbogård gallery grave N=8, Lilla Balltorp gallery grave N=33 (Blank 2021, Appendix 1). Purple: Early Bronze Age dates. Red: Late Neolithic II and Early Bronze Age dates. Yellow: Late Neolithic I dates. Blue: Middle Neolithic dates.

between 8.5 and 10.4‰. The lowest $\delta^{15}N$ value was measured in the mandible from the *c.*12 years old girl (K1677:1) and the highest in a first molar of the *c.*6 years old girl (KY1). The high $\delta^{15}N$ value may be a result of breastfeeding, as the roots of the first molars begin forming at the age of three (Fuller et al. 2006; Hillson 1996).

In figure 6, the average stable isotope values of the skeletal remains from the Högstena and the Kymbo grave are plotted along with measurements from human remains found in other Middle and Late Neolithic megalithic graves in Falbygden.

According to figure 6 the highest means in both $\delta^{13}C$ and $\delta^{15}N$ values can be observed in the large gallery graves with port-holes, Lilla Balltorp and Utbogård, where the human remains date to the Late Neolithic II and the Early Bronze Age. The Kymbo grave would be expected to plot with these graves, considering the Early Bronze Age radiocarbon dates, but instead it clusters with the Middle Neolithic Rössberga passage grave and the Fredriksbergs gallery grave containing remains radiocarbon dated to the Late Neolithic I.

The sheep bone from the awl, yielded a $\delta^{13}C$ value of, -21‰ and a $\delta^{15}N$ value of 4.2‰. It is dated to the transition between the Middle and Late Neolithic and is the only sheep from the area which can be affirmed to belong to the period between the last part of the Middle Neolithic and the Early Bronze Age. In addition to this bone, a couple of goat bones have been radiocarbon dated to the second part of the Late Neolithic, which yielded similar $\delta^{13}C$ values (*c.*-21‰) and slightly higher $\delta^{15}N$ values (*c.*4.5‰, Blank 2021, paper V). Furthermore, a few Middle Neolithic sheep bones, which yielded similar $\delta^{13}C$ values but higher $\delta^{15}N$ (*c.*6.5%) values are known from Falbygden (Blank 2021, paper V). The stable isotope results of the two other animal bones, radiocarbon dated to the Iron Age, are reported in supplementary material 1.

The trend of higher $\delta^{13}C$ values in individuals dated to the Late Neolithic II than in the Middle Neolithic and Late Neolithic I human remains which have been observed in Falbygden (Blank 2021), can also be attested here, nevertheless, the trend does not seem to continue into the Early Bronze Age. The $\delta^{13}C$ values in the Högstena gallery grave, with radiocarbon dates spanning from the transition between the Middle and Late Neolithic into the first part of the Late Neolithic, are similar to the values in the Middle Neolithic Rössberga passage grave.

The lowest $\delta^{15}N$ values appear in the Högstena grave and these values only slightly overlap with the $\delta^{15}N$ values in the Kymbo grave (Figure 6). The same shift can be observed with a slightly lower $\delta^{15}N$ value in the sheep bone from the Högstena grave compared to the values yielded from Middle Neolithic sheep bones from Falbygden (see above).

Strontium isotope ratios and mobility

The spatially resolved Sr isotope data obtained through the laser ablation analysis provide significantly higher resolution for understanding mobility in the sampled individuals than only informing on local versus non-local childhood origin. From the Högstena gallery grave only one individual was sampled for Sr isotope analysis, a first molar from a 5-year-old boy. From the Early Bronze Age grave at Kymbo, four teeth, two first molars and two premolars, from four different individuals, three females and one male were sampled. These teeth reflect the Sr isotope signals from early childhood. The first molars reflect the first years of childhood (between the ages of *c.*1.3-3.3), and the premolars crystallize between the ages of *c.*3 and 6 (Goodman et al. 1980; Reid and Dean 2006).

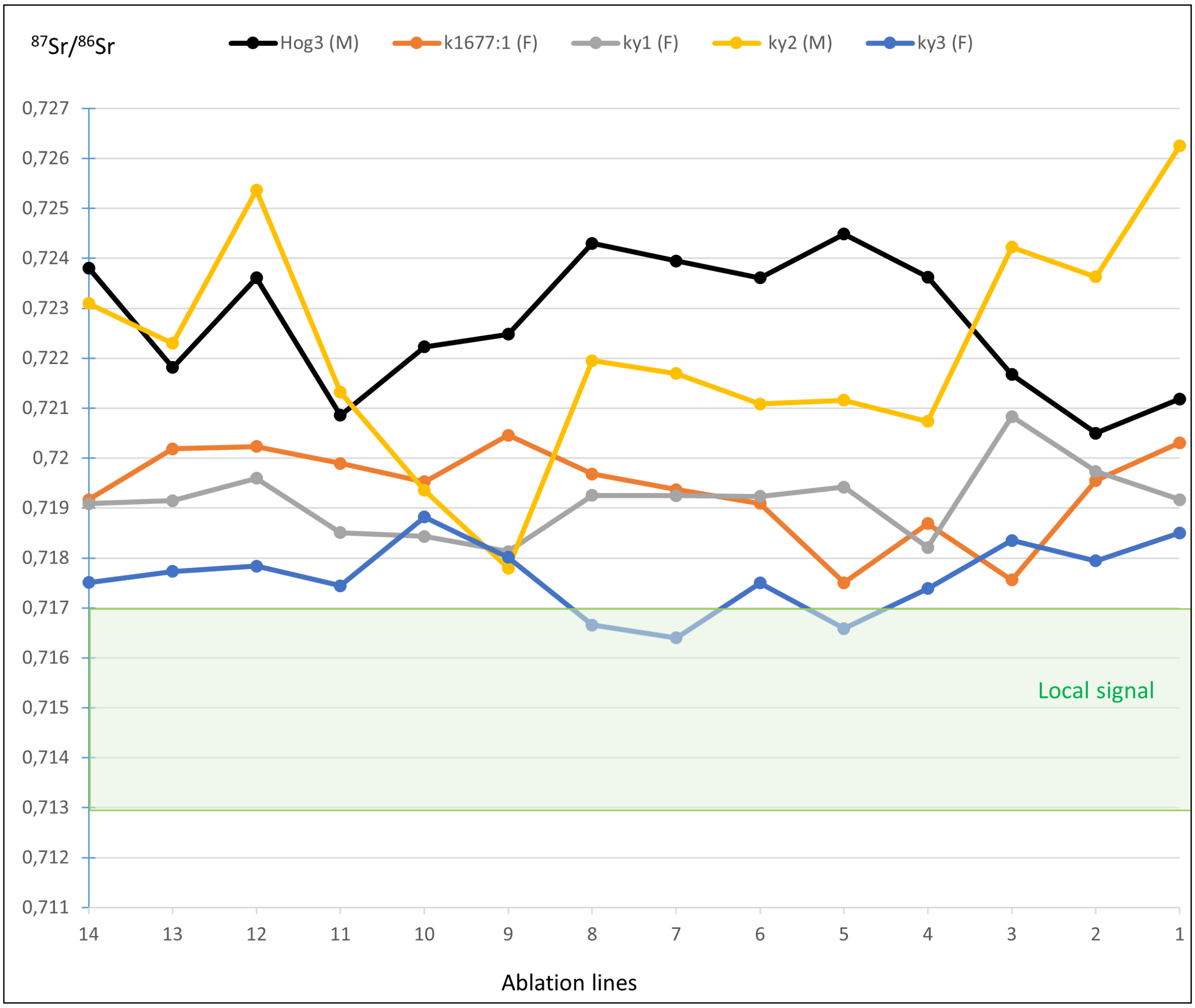

Figure 7. The sequential strontium isotope results from the teeth sampled from the four individuals. The local signal is based on Blank et al. 2018b. Number 1 on the x-axis represents the DEJ and number 14 the tip of the tooth.

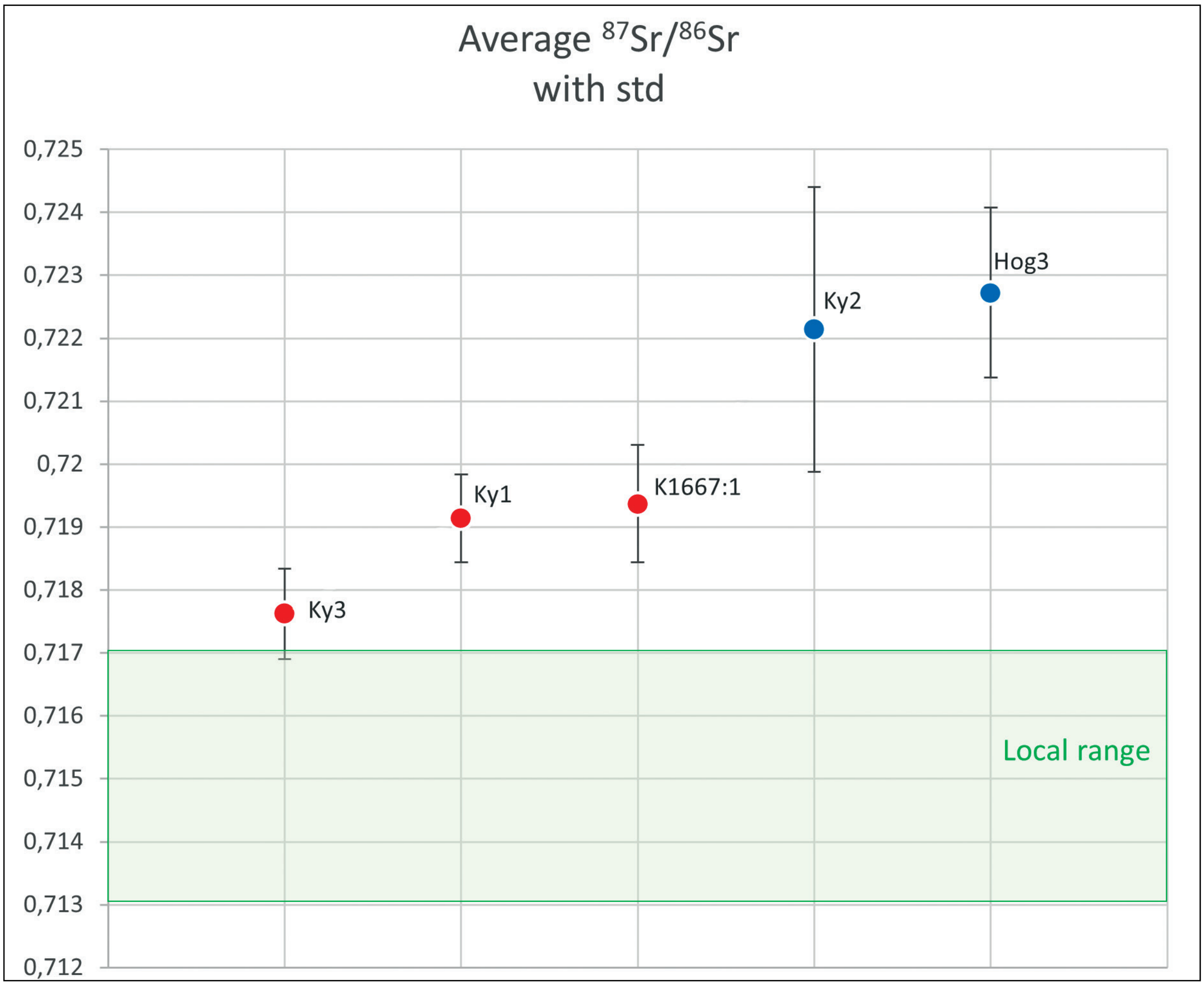

Figure 8. The average strontium isotope ratios plotted with the standard deviations (SD 2) of the four teeth. Red circles: females. Blue circles: males.

All of the sampled teeth measured non-local Sr isotope ratios (Figure 7, 8). The females, two children and one adult, yielded rather consistent Sr isotope ratios between 0.716 and 0.721. Bioavailable Sr isotope ratios within this span can be found a few km outside the sedimentary area of Falbygden, in other parts of Västergötland (Blank et al. 2018b; Figure 9) and further away (Boethius et al. 2022). The lowest Sr isotope ratios, between 0.716 and 0.718, belong to an old female from the Kymbo grave. These ratios are present in the outskirts of Falbygden and might be found a few kms from the grave (Figure 9). The male individuals on the other hand, exhibit higher ratios up to *c.*0.726, which are found further away in a restricted area of central Västergötland but are more common east and northeast of Falbygden (Blank et al. 2018b). The male individuals also show a higher standard deviation and more variation within the teeth which may indicate movement in the landscape during early childhood (Figure 7). The Sr isotope ratio averages of the teeth indicate that these five individuals may have spent their early childhood in three different locations, possibly in the outskirts and neighbouring areas of Falbygden.

Discussion and conclusion

The bone material in the graves does not necessarily represent all the buried individuals. In many of the old excavations only parts of the skeletal remains were collected, especially skulls. In the case of the studied sites, various bone elements and even smaller fragments were saved. Nevertheless, the graves were already damaged by farming when they were excavated.

The Högstena grave is the earliest attested gallery grave in the region, confirmed by radiocarbon dating, with the exception of a few human bones

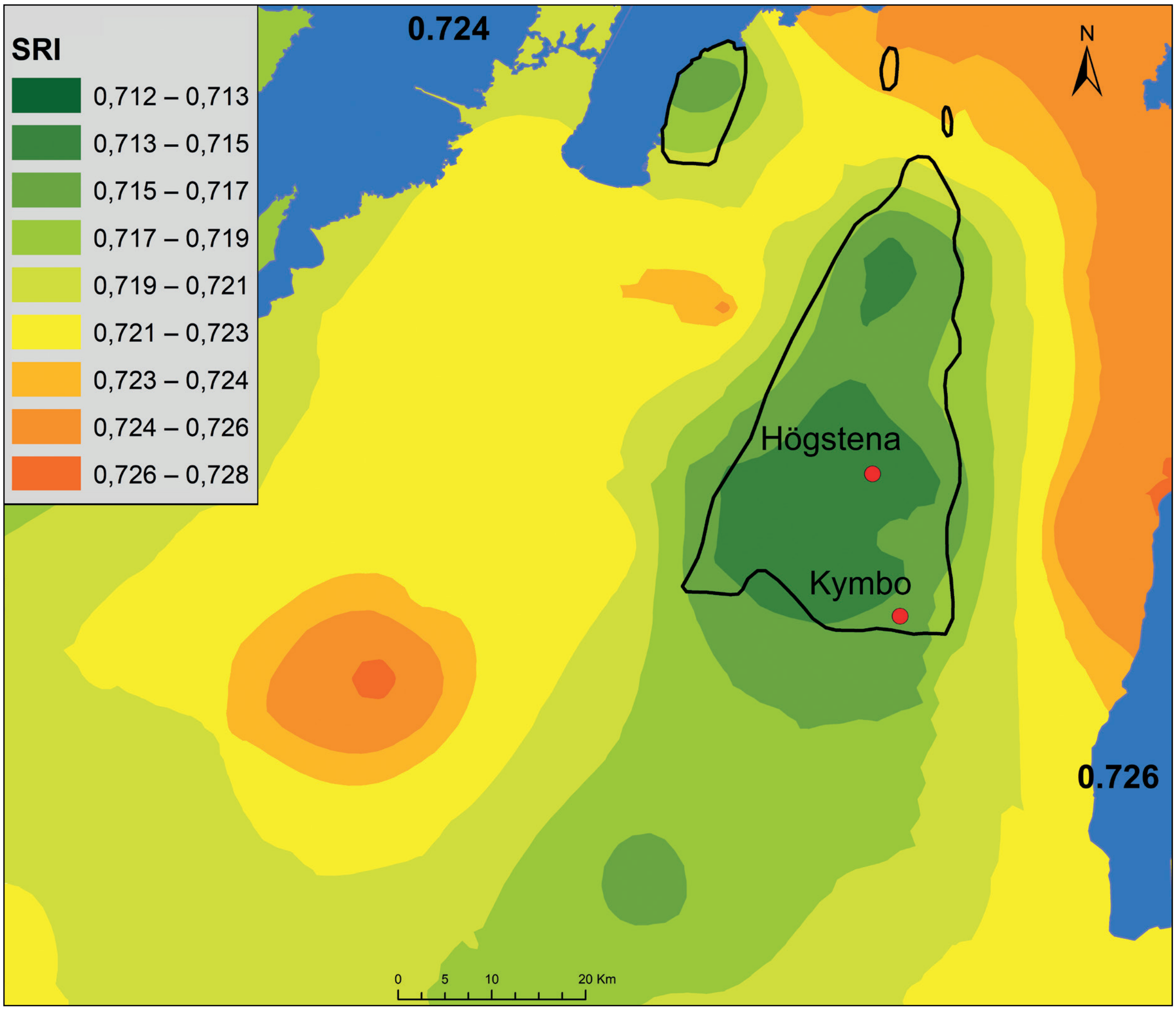

Figure 9. Investigated graves plotted on baseline map from Blank et al. 2018b. SRI: Sr isotope ratio. 0.724: Sr isotope ratio of lake Vänern, 0.726: Sr isotope ratio of lake Vättern.

dated to *c*.3000 cal BC recovered from a couple of gallery graves that may be explained by the deposition of skeletal parts from older graves or relics (Blank et al. 2020). The estimated small size of the grave and the early radiocarbon ages coincide with previous research that suggested that the smaller gallery graves are younger than the larger ones (Blank et al. 2020).

The radiocarbon ages in the Högstena gallery grave indicate that the grave has been used at least at two or three different occasions, which agrees with the general assumption of successive inhumations as the dominating burial practice in gallery graves (Ahlström 2009; Blank 2021; Tornberg 2018; Weiler 1994).

The Kymbo grave is the first grave that has been directly radiocarbon dated to the Early Bronze Age in Falbygden. There are radiocarbon dates of human remains from this period in gallery graves as well as in passage graves (Blank 2016; Blank et al. 2020; Persson and Sjögren 2001), but these graves were constructed earlier. There are some documented Early Bronze Age graves determined by typological dating of the finds, but only a few can be attributed to the first period (Oldeberg 1974; Sahlström 1932, 1939; Weiler 1994). Thus, this study indicates that we might already have excavated materials belonging to time periods from which we think we lack evidence and that overlooked remains (due to poor preservation, poor documentation, or small amount of fragmented and mixed bones) may provide information on the chronology and origin of the human bones as well as new insights into burial practices. By revisiting the museum collections and archives, and conducting multidisciplinary investigations on neglected materials, materials of uncertain origins or age, or materials which are difficult to interpret, untold stories can come to light and new knowledge of prehistory may be accomplished.

There is no detailed description of the cairn, and it is also possible that the cairn and the mentioned gallery grave might have been connected. The Bronze Age cairns in the area are generally low profiled, and sometimes contain stone cists. The Stora Lycke grave in Falbygden, is an example of a low cairn that covered a 2 m x 0.5 m large stone cist constructed below ground, and in many aspects resembles some of the Late Neolithic gallery graves. The cist contained skeletal remains from one or several inhumations and was typologically dated by the finds to the second part of the Bronze Age. Several deposits of burnt human bone were also recovered from the cairn (Sahlström 1939, 36-39). There are also examples of Late Neolithic gallery graves which have been covered by Bronze Age cairns (Blank 2016).

According to the radiocarbon dates, the individuals in the Kymbo grave may have been placed here at one single event, although several occasions within a rather short time span cannot be ruled out. The animal bones and the metal artefacts were deposited in the grave, possibly at one single event, in the Vendel period of the Late Iron Age. Reuse of older graves, including a variety of different practices, such as burials, depositions of artefacts and animal bones or other types of activities altering the grave constructions, was a common phenomenon during the Late Iron Age and has been attested in several Swedish regions including Falbygden (Artelius 2004; Blank 2016; Sjögren 2003). The radiocarbon dates together with the sex determinations and age estimations support the hypothesis that these graves were possibly family graves with representatives of both sexes and all ages. Numerous studies support close biological kinship between the human remains found in megaliths and other cemeteries during the Neolithic (e.g. Fowler et al. 2022; Schroeder et al. 2019) in other European contexts, and a recent aDNA study of Middle Neolithic passage graves in Falbygden demonstrates that several generations of the same families were buried also in these graves (Seersholm et al. 2024).

Considering the stable isotope data from these two graves, it is difficult to know if it is representative for the two time periods in question, the transition between the Middle Neolithic and the Late Neolithic, and the Early Bronze Age I, as there are very few burials radiocarbon dated to these periods in the study area. Nevertheless, the relatively low stable isotope values in the Middle Neolithic/Late Neolithic bones from the Högstena may strengthen the hypothesis of a change in the values towards slightly higher $\delta^{13}C$ values and more varied stable isotopes at the onset of the second part of the Late Neolithic (Blank 2021). The reason for this change is still not resolved, but one suggestion is that a cooler and more humid climate related to the 4.2 ka BP event, may have affected the stable isotope values of crops and/or might have triggered changes in subsistence strategies and, thus, dietary patterns. The climatic event, which actually encompasses *c.*2450-1900 cal BC caused climate changes with regional variations in Europe (Butruille et al. 2017; Kleijne et al. 2020). Even though the effects on Scandinavia have been questioned (McKay et al. 2024), oxygen isotope studies from inland southwestern Sweden confirm a change toward a more unstable and humid climate with cooler temperatures from about 2000 cal BC (Hammarlund et al. 2003; Seppä et al. 2005). The unstable climate may have led to more diverse cultivation and husbandry practices regarding the composition of livestock, where the animals were kept and what they were fed, the locations of the fields, and the amount of fertilisers used etc. (Blank 2021, paper V). The lack of Late Neolithic and Early Bronze Age animal and plant remains in general and from the area is unfortunate, but an ongoing study with the aim of analysing domestic animals and crops for stable and oxygen isotopes, may help resolving this issue.

The lower values in the Early Bronze Age Kymbo grave may indicate that the Late Neolithic II is the phase with deviating stable isotope values. However, it could also be explained by social or cultural differentiations resulting in different diets between people who were buried in large gallery graves and small cairns.

Overall, the stable isotope values suggest a terrestrial protein intake with little or no marine or freshwater input. Thus, the $\delta^{13}C$ and the $\delta^{15}N$ values are consistent with a terrestrial based diet, which is dominating in the Neolithic TRB and Late Neolithic and Early Bronze Age societies of southern Scandinavia (Blank 2021; Blank et al. 2023; Kirleis et al. 2014; Sjögren 2017; Tornberg 2018).

The Sr isotope values indicate that most of the buried individuals consumed water and food from elsewhere or spent their childhood outside of Falbygden. At this time the most likely scenario is that the Sr isotope ratios reflect movement in the landscape confirming a high degree of mobility in the region during the Late Neolithic and Early Bronze Age (Blank et al. 2021; Blank et al. 2023). The increasing human mobility in the Late Neolithic compared to the earlier period may also have resulted in changes and more variation in the stable isotopes values. Taking into consideration that the Sr isotope baseline, subsistence strategies and food traditions may have varied between the different locations where the people grew up.

The peptide analyses revealed that the male individuals most probably moved into the area from further away than the female individuals. Furthermore, it seems like the male individuals, which were sampled in the two graves, for some reason have been more mobile or exposed to a more geographically varied diet during childhood than the female individuals, or, at least, have been exposed to more varied Sr isotope ratios in the early years of their life. This pattern might be consistent with a tradition of male children being introduced to pastoral practices, such as transhumance early in life while female children might have been involved in other types of duties. In a strontium isotope study of a Neolithic settlement in Germany, transhumance was claimed to have been identified in young children (Nehlich et al. 2009). Furthermore, ethnographic studies of pastoralists support that the transfer of knowledge relating to subsistence and cultural practices commenced in early childhood (Bira and Hewlett, 2023). Nevertheless, the different patterns of Sr isotope variation in our case might also have other explanations, hence, other comparative studies are welcomed to increase the dataset.

This article demonstrates that the use of scientific analyses can actually help us to understand grave sites for which we have little or poor archaeological data and to better distinguish between different burials. The application of sex dimorphic amelogenin peptides on poorly preserved remains can strongly contribute to the understanding of burial practice and biosocial utterances in past societies. Not only can peptide analysis be used to confirm or dismiss ambiguous and uncertain osteological sex assessment, but the analysis can also provide sex determinations of subadult remains that are impossible to sex osteologically. This peptide analysis is not only cost-effective, but it is also performed on the hardest biological tissue, which is most likely to survive taphonomic processes. Thus, it is possible to determine the sex of a higher proportion of the inhumed individuals than when only using skeletal traits. Further, poorly preserved remains are presently unlikely to yield sufficiently preserved genetic material, thus hampering a fruitful outcome of archaeogenetic results. For this reason, poorly preserved remains have been neglected within the scope of archaeogenetic research. We argue that it is time to revisit the graves that were previously scientifically passed over, since some of the biochemical methods that were developed in recent years can significantly contribute to new knowledge of past populations when contextualised, especially in multi-proxy endeavors.

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Supplementary Material

Material see also .xlsx-attachment