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Norm and difference

Stone Age dietary practice in the Baltic region

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Abstract
Stone Age research on Northern Europe frequently makes gross generalizations about the Mesolithic and Neolithic, although we still lack much basic knowledge on how the people lived. The transition from the Mesolithic to the Neolithic in Europe has been described as a radical shift from an economy dominated by marine resources to one solely dependent on farming. Both the occurrence and the geographical extent of such a drastic shift can be questioned, however. It is therefore important to start out at a more detailed level of evidence in order to present the overall picture, and to account for the variability even in such regional or chronological overviews. Fifteen Stone Age sites were included in this study, ranging chronologically from the Early Mesolithic to the Middle or Late Neolithic, c. 8300–2500 BC, and stretching geographically from the westernmost coast of Sweden to the easternmost part of Latvia within the confines of latitudes 55–59° N (Fig. 1, Table 1). The most prominent sites in terms of the number of human and faunal samples analysed are Zvejnieki, Västerbjers and Skateholm I–II. Human and faunal skeletal remains were subjected to stable carbon and nitrogen isotope analysis to study diet and ecology at the sites. Stable isotope analyses of human remains provide quantitative information on the relative importance of various food sources, an important addition to the qualitative data supplied by certain artefacts and structures or by faunal or botanical remains. A vast number of new radiocarbon dates were also presented.

In conclusion, a rich diversity in Stone Age dietary practice in the Baltic Region was demonstrated. Evidence ranging from the Early Mesolithic to the Late Neolithic show that neither chronology nor location alone can account for this variety, but that there are inevitably cultural factors as well. Food habits are culturally governed, and therefore we cannot automatically assume that people at similar sites will have the same diet.

Stable isotope studies are very important here, since they tell what people actually consumed, not only what was available, or what one single meal contained. We should not be deceived to infer diet from ritually deposited remains, since things that were mentally important was not always important in daily life. Thus, although a ritual and symbolic norm may emphasize certain food categories, these may in fact contribute very little to diet. By the progress of analysis of intra-individual variation, new data on life history changes have been produced, revealing mobility patterns, breastfeeding behaviour and certain dietary transitions. The inclusion of faunal data has proven invaluable for understanding the stable isotope ecology of a site, and thereby improve the precision in interpretations of human stable isotope data. The special case of dogs, though, demonstrates that this animal is not useful for inferring human diet, since dogs due to the number of roles they possess in human society could, and in several cases has proven to, deviate significantly from humans in their diet.

When evaluating the radiocarbon data of human and animal remains from the Pitted-Ware site Västerbjers Gotland, the importance of establishing the stable isotope ecology of a site before making deductions on reservoir effects has been further demonstrated.

The main aim of this thesis has been to demonstrate the variation and diversity in human practice, challenging the view of a "monolithic" Stone Age. By looking at individuals and not only on populations, the whole range of human behaviour has been accounted for, also revealing the discrepancy between norm an practice, which frequently is visible both in the archaeological record and in present-day human behaviour.

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An optional title for this thesis could be *Same, same, but different*. However, there are a number of people and institutions without whom it wouldn't have been the same at all, but indeed entirely different.

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Contents

List of papers

This thesis is based on the following papers, which will be referred to by their roman numerals. The published papers are reproduced with kind permission from the publishers.

I. Lidén, K., Olsson, A., Eriksson, G. & Angerbjörn, A. ms. Nitrogen isotope analysis of deciduous teeth: a tool for tracing weaning patterns. Submitted to *Proceedings of the Royal Society, Series B*.

II. Eriksson, G. & Zagorska, I. 2003. Do dogs eat like humans? Marine stable isotope signals in dog teeth from inland Zvejnieki: *Mesolithic on the Move: Papers presented at the Sixth International Conference on The Mesolithic in Europe, Stockholm 2000*, pp. 160–168. Oxbow Monograph. Oxford.

III. Eriksson, G., Lõugas, L. & Zagorska, I. 2003. Stone Age hunter–fisher–gatherers at Zvejnieki, northern Latvia: radiocarbon, stable isotope and archaeozoology data. *Before Farming (www.waspjournals.com)* 2003/1 (2), pp. 1–26.

IV. Eriksson, G. ms. Part-time farmers or hard-core sealers? Västerbjers studied by means of stable isotope analysis. Submitted to *Journal of Anthropological Archaeology*.

V. Lidén, K., Eriksson, G., Nordqvist, B., Götherström, A. & Bendixen, E. ms. "The wet and the wild followed by the dry and the tame" – or did they occur at the same time? Submitted to *Antiquity*.

VI. Eriksson, G. & Lidén, K. ms. Skateholm revisited: New stable isotope evidence on humans and fauna. Manuscript.

1. Introduction

The simple question "What did Stone Age people eat?" covers many dimensions, and the nutritional point of view is only one aspect. First of all, the Stone Age spanned many millennia, during which a number of major changes occurred, not least affecting diet, and secondly, diversity seems to have been a trait characterizing even a relatively limited area such as the southern Baltic region, which is the focus of this thesis. Although Stone Age research on Northern Europe frequently makes gross generalizations about the Mesolithic and Neolithic (Bonsall et al. 2002; Price 1991; Schulting & Richards 2002b; Zvelebil 1996), we still lack much basic knowledge on how the people lived. It is therefore my belief that we need to start out at a more detailed level of evidence in order to present the overall picture, and that we need to account for the variability even in such regional or chronological overviews.

The archaeological debate over the Neolithic in southern Scandinavia has long been dominated by the notion of archaeological cultures. The Swedish Neolithic is traditionally held to comprise three "cultures": the farming Funnel Beaker Culture, the foraging Pitted Ware Culture and the farming Battle Axe Culture (equivalent of the Corded Ware Culture). These are defined by certain artefacts or other features, but are often also considered to represent different economies. Artefacts and faunal remains rarely give unambiguous answers, or when they occasionally do, the accuracy can be questioned. This is one reason why dietary reconstruction by means of bone chemistry, especially stable isotope analysis, has become so important.

Stable isotope analyses of human remains provide quantitative information on the relative importance of various food sources, an important addition to the qualitative data supplied by certain artefacts and structures or by faunal or botanical remains. The archaeological record is not only full of pits, but also of pitfalls. Thus, apart from the taphonomic factors/processes affecting what is left for us as archaeologists to investigate, intentional deposits such as burials are imbued with connotations which may tell us much about the symbolic world of the people concerned but less about their everyday lives. This is not to say that the latter aspect is more important than the former, but it is vital to recognize that we may perceive Stone Age life in a distorted way because of the emphasis on certain aspects in a burial or a monument (cf. Parker Pearson 1999). One illustration of this is the presence of numerous tooth pendants deposited in graves, which do not necessarily tell us what species made the most important contributions to the diet, or the accumulations of pig bones in association with a cemetery, which do not automatically imply the importance of pork as a meat. Similarly, finds of bone from domestic animals such as sheep or cattle are not inevitably evidence of a farming economy.

The transition from the Mesolithic to the Neolithic in Europe has been described in terms of "turning their backs to the sea" (Schulting & Richards 2002c:155), entailing a radical shift from an economy dominated by marine resources to one solely dependent on farming. Both the occurrence and the geographical extent of such a drastic shift can be questioned, however. Here dietary analyses of individuals from numerous locations are vital for an understanding of how widespread this allegedly "monolithic" norm was.

Yet another reason for studying dietary practices during the Stone Age, and by no means the least important, is the recurrent use of this period as a key to the notion of "natural behaviour" (Audette 1999; Ljungberg 1997), the "biologically normal" or "original lifestyle" (Lindeberg 1997). In such lines of reasoning the Stone Age way of life is "natural", which by definition is good, i.e. the only right way. The argument is implicitly normative, and the underlying assumption seems to be that Stone Age people were in some way savages, less influenced by culture than the present-day population. Accordingly, we are told, we should only eat this and that, treat our babies this and that way, and appreciate gender inequalities – because it is only “natural”. Apart from being based on biological reductionism, such arguments signal an unawareness of the diversity of human practices during the Stone Age. Any attempt to grasp this multiplicity through simple dichotomies such as Mesolithic/Neolithic, coastal/inland or female/male will inevitably fail, as will be demonstrated in the present study.

2. Sites studied

The fifteen Stone Age sites included in this study range chronologically from the Early Mesolithic to the Middle or Late Neolithic, c. 8300–2500 BC, and stretch geographically from the westernmost coast of Sweden to the easternmost part of Latvia within the confines of latitudes 55–59° N (Fig. 1, Table 1). The most prominent sites in terms of the number of human and faunal samples analysed are Zvejnieki, Västerbjers and Skateholm I–II, although the latter produced very limited stable isotope data because of poor preservation. All three sites comprised extensive cemeteries with associated cultural layers, but while both Skateholm I–II and Västerbjers seem to have been in use for several hundred years, Zvejnieki was evidently used for five millennia (!). They also differ in that Zvejnieki was located inland, whereas Skateholm was situated at a lagoon, and Västerbjers by a narrow bay of the Baltic Sea. The remaining sites are represented in this material by just a few individuals from various contexts– regular burials as well as isolated human bones scattered in cultural or transgressed layers. A range of locations in the landscape are represented, and although there is an emphasis on hunter–fisher–gatherer contexts for sites with both Mesolithic and Neolithic dates, four sites also included burials attributed to the farming Corded Ware Culture (Sarkani, Selgas, Kastanjegården and a few of the Zvejnieki burials).

The geographical focus is to some extent a consequence of availability and preservation conditions. There are simply no well-preserved Stone Age human bones available from the northern half of Sweden, nor from the mainland of Finland, largely on account of soil conditions. Moreover, even for southern Sweden, the Mesolithic is not exactly characterized by a wealth of well-preserved human remains, which is one reason why the present work has benefited greatly from the

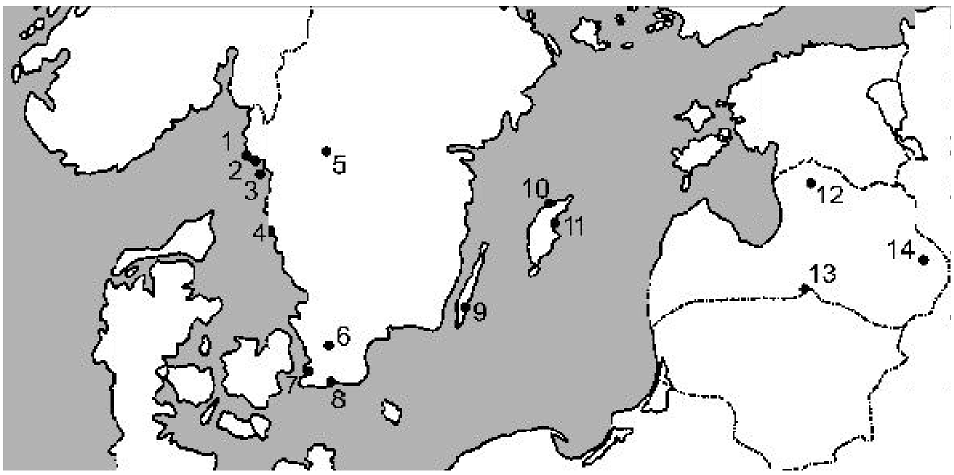


Fig. 1. Locations of the sites included in this thesis. 1 – Uleberg, 2 – Evensås, 3 – Huseby klev, 4 – Rolfsåker, 5 – Hanaskede, 6 – Ageröd, 7 – Kastanjegården, 8 – Skateholm, 9 – Alby, 10 – Ire, 11 – Västerbjers, 12 – Zvejnieki, 13 – Selgas, 14 – Sarkani.

Table 1. Sites included in the study, sorted by date.

site	arch. date	approx. ^{14}C date (uncal. BP)	chronozone	location	context	analysed samples human (n individuals)	analysed samples faunal	paper	no. in Fig. 1
Huseby klev (deep pit, tent)	EM	9000, 8500	PB/BO	coastal, outer archipelago	transgressed layers	5 (5)	9	V	3
Hanaskede	EM	8800	BO	inland	stray find	3 (1)	–	V	5
Ageröd I	EM/MM	7900–7400	AT	inland	intermingled cultural layers	5 (5)	20	V	6
Zvejnieki	MM–LN	8200–4200	BO/AT/SB	inland	cemetery, cultural layers	43 (33)	98	II, III	12
Uleberg	LM	6600	AT	coastal, outer archipelago	burial	1 (1)	–	V	1
Skateholm I–II	LM	6300	AT	coastal, lagoon	cemetery, cultural layers	27 (24)	45	VI	8
Alby	LM/EN	5300	AT	coastal, lagoon	burial	6 (1)	–	V	9
Evensås	EN	5000	SB	coastal, outer archipelago	disturbed burial	1 (1)	–	V	2
Skateholm VI	EN	4900	SB	coastal, lagoon	stray find	1 (1)	–	V	8
Rolfsåker	MN	4500	SB	coastal, inner archipelago	burial	1 (1)	–	V	4
Västerbjers	MN	4300	SB	coastal	cemetery, cultural layers	86 (26)	64	IV	11
Ire	MN	4300	SB	coastal	cemetery, cultural layers	–	14	I, IV	10
Sarkani	MN/LN	4300	SB	inland	burial	1 (1)	–	III	14
Selgas	MN/LN	4200	SB	inland	double burial	3 (2)	–	III	13
Kastanjegården	MN/LN	4000	SB	inland	triple burial	1 (1)	–	III, V	7

Key: EM, MM, LM = the Early, Middle and Late Mesolithic respectively,
EN, MN, LN = the Early, Middle and Late Neolithic respectively,
PB = Preboreal, BO = Boreal, AT = Atlantic, SB = Subboreal

inclusion of Latvian material. The situation for Neolithic material is better, although one could always wish for more. The main justification for the choice of material is not accessibility, however, although this necessarily delimits the options available, but a conscious desire to go into detail within a limited area. It was also felt important to include sites both east and west of the Baltic Sea, to avoid the imbalance in much previous Stone Age research, which has tended to discuss either the westernmost parts of Europe, or only the eastern parts. This has in part been caused by the geopolitical situation of much of the past century, of course, but whereas the Iron Curtain has disappeared, this imbalance has prevailed. This is unfortunate, not least because there is little evidence that this division was of relevance to people during the Stone Age; for the Baltic in particular, the sea was a uniting feature, not a divisive one (the "Uniting Sea" was also the theme of a recent workshop in Uppsala 2002).

3. Method

There are several elements with naturally occurring stable isotopes which can be used in archaeological studies, two of which are nitrogen and carbon. While early stable carbon and nitrogen analyses were characterized by sheer optimism about the possibilities of the method, the following decades saw a growing awareness of some of the problems and limitations (e.g. Katzenberg 1992; Pate 1994; Schoeninger & Moore 1992; Schwarcz & Schoeninger 1991; Sealy 2001). Many of these have now been overcome, however, and, after having been successfully used for a quarter of a century, stable carbon and nitrogen isotope analyses are one of the most important techniques employed in archaeological research today.

The method has been described in detail elsewhere (e.g. Ambrose 1990; Brown et al. 1988; Lidén 1995b), so I will only reiterate here the basic principles, concepts and limitations. The two basic principles underlying stable isotope analysis of bone are (1) "you are what you eat", i.e. body tissue is synthesized out of components from the diet, and (2) the proportions of the stable isotopes, ^{13}C vs. ^{12}C and ^{15}N vs. ^{14}N, alter as a consequence of various biological, physical and geological processes. The first means that a dietary record is incorporated into our skeletons, reflecting the time of formation or remodelling, and the second that this record can be traced and that there is enough variation to make it a valuable source of information. For the area of interest here, the Baltic region in the Stone Age, the most important difference exhibited in carbon isotope values ($\delta^{13}C$ values, expressed in per mil, ‰, relative to the standard, PDB) is that between the marine input to the diet and the terrestrial or freshwater contribution. The major information gained from the nitrogen isotope value ($\delta^{15}N$, expressed in ‰ relative to the standard, AIR) concerns levels in the food web, the value increasing for each additional step in the food chain. These stable isotope ratios can be measured by mass spectrometry, and simultaneous analyses of the two are valuable, since variation in a two-dimensional space extends the possible combinations relative to information gained from a linear scale.

An important feature facilitating the interpretation of stable isotope data from human remains is the addition of faunal isotope data. Although the approximate stable isotope end-values, i.e. maximum and minimum values for marine vs. terrestrial and herbivorous vs. carnivorous organisms, have been established for the region, there can be considerable variation on account of the particular ecology of a site, and faunal remains from the same context as the human remains should therefore ideally be included in the analysis.

The stable isotope analyses are performed on collagen, the predominant protein present in skeletal tissue, and the values mainly reflect protein intake (Ambrose & Norr 1993). As cremation destroys the structure of the collagen, only unburned bone will produce reliable data (DeNiro et al. 1985; DeNiro 1985; Götherström 2001). Bone is constantly being remodelled during a person's lifetime, and its stable isotope signature therefore reflects the average diet over a period of several years prior to death. Teeth, by contrast, are formed early in life, and the dentine (the bony substance of teeth, partly covered by the enamel) is not subject to any collagen turnover, which means that the isotopic signal reflects the diet which prevailed when the teeth were formed, i.e. in childhood. An analysis that includes both bone and teeth from adults therefore in effect expands the population studied to include children who survived into adulthood, a group otherwise severely underrepresented in archaeological research.

The collagen turnover rate in bone varies with age and the skeletal element concerned, but there are also differences within a bone element, with a slower turnover rate in compact bone (see Lidén & Angerbjörn 1999 for a review on factors affecting collagen turnover). Since the preservation of bone collagen is as a rule better in compact, cortical bone, skull bones or the diaphyses of long bones are generally preferred over the spongy, trabecular bone of the epiphyses and various flat and irregular elements of the skeleton. This does not imply that the latter bone elements cannot be used for analysis, of course. On the contrary, the sampling strategy, extraction protocol and quality criteria applied ensure that only data from intact collagen will be considered.

The main aspect separating bone chemistry from conventional archaeological data, especially in connection with graves, is not the biological character or that the data were scientifically produced, but the fact that the data were not *intentionally* deposited at a burial or in any other ritual. Accordingly, there was no communicative or normative intent which resulted in a certain stable isotope value *at the time of deposition*, making it relatively unbiased as compared with grave goods, for instance. On the other hand, the diet, and thereby indirectly the isotopic signature, is culturally governed, of course, and the body is loaded with meaning (Johannisson 1997; Liukko 1996). Furthermore, bone chemistry is contextually independent, meaning data will be produced regardless of the presence of contextual information. Contextual data will add to the value of the findings, but cannot be regarded as a prerequisite for their employment. Consequently, individuals can be studied who are habitually excluded from burial analysis because they lack grave goods, are subadult, fragmented, found in multiple burials or dispersed in cultural layers, or have otherwise been treated differently from what we perceive as regular burials. Inclusion of those who deviate from our preconception of a "normal" burial improves the representativeness of the material and enhances our possibilities for understanding the full range of human behaviour in prehistory.

4. Results and discussion

4.1 *Intra-individual variation*

An important advance brought about by the application of $\delta^{13}C$ and $\delta^{15}N$ analyses to prehistoric skeletal remains is the possibility for tracing dietary variation on the individual level, i.e. to obtain dietary life histories for individuals. Stable carbon and nitrogen isotope analyses of human bone and/or dentine have only rarely been employed earlier to study intra-individual variation (but see Sealy et al. 1995; Wright & Schwarcz 1999), since most previous analyses have been concerned either with animal tissue (e.g. Balasse et al. 1999; Hobson 1998; Koch et al. 1995; Wiedemann et al. 1999), or with dental enamel, often focussing on other stable isotopes such as strontium and oxygen (e.g. Balasse et al. 2002; Balasse et al. 2001; Wright & Schwarcz 1998).

In the case of archaeological subjects for whom whole crania were available, both bone and teeth were subjected to analysis (see in particular Paper III). The strategy involved sampling the first, second and third permanent molar teeth for each individual, where present. The samples were taken with a dentist's drill directly below the crown of each tooth. The reasons for sampling several teeth from each individual instead of taking appositional samples from one tooth are related to the morphology of human teeth. The main tissue making up the teeth is dentine, with a composition similar to that of bone, inside which are the cavities formed by the pulp chamber and root canal(s). The dentine of teeth is laid down in angled layers starting from the crown and proceeding down to the root (Hillson 1996), and in order to obtain a sample representing as limited a time of formation as possible, drilling should accordingly take place perpendicular to the longitudinal axis of the tooth (Fig. 2). Since the crown is coated with enamel, a very hard mineral substance, drilling of the crown would make separation of the dentine from the enamel difficult, and could also cause the tooth to fracture, so the samples had to be positioned below the crown. Molar teeth as a rule have several roots, however, and one root is too thin to produce large enough samples, especially since the surface layer must always be discarded to avoid contamination, so the only possible position for sampling was just below the cervix. This position was also ideal since it caused very little damage to the tooth – if removed from the jaw prior to sampling, the tooth would hardly show any visible signs of drilling once replaced in position (Fig. 2c) – an important consideration for archaeological specimens.

The approach of using the three types of molar was employed in order to obtain samples representing three age spans. The specific sections sampled on each tooth type could be estimated to correspond to three age categories based on the timing of formation of each tooth section (Fig. 3) (Hillson 1996; Reid et al. 1998). Although there is considerable individual variability in the timing of tooth formation and the ages assigned to each category should accordingly be regarded only as approximations, the ages of formation of these teeth do not overlap, but follow in a sequence. The second molars, if unavailable, were occasionally replaced by premolars, however, since the timing of crown formation in the latter overlaps to a great extent with formation of the second molars. Although the sampling strategy necessarily involved the inclusion of several consecutively formed layers of dentine, it excluded those portions of the dentine formed at the very beginning and end of tooth formation, thereby narrowing down the age span represented by each sample.

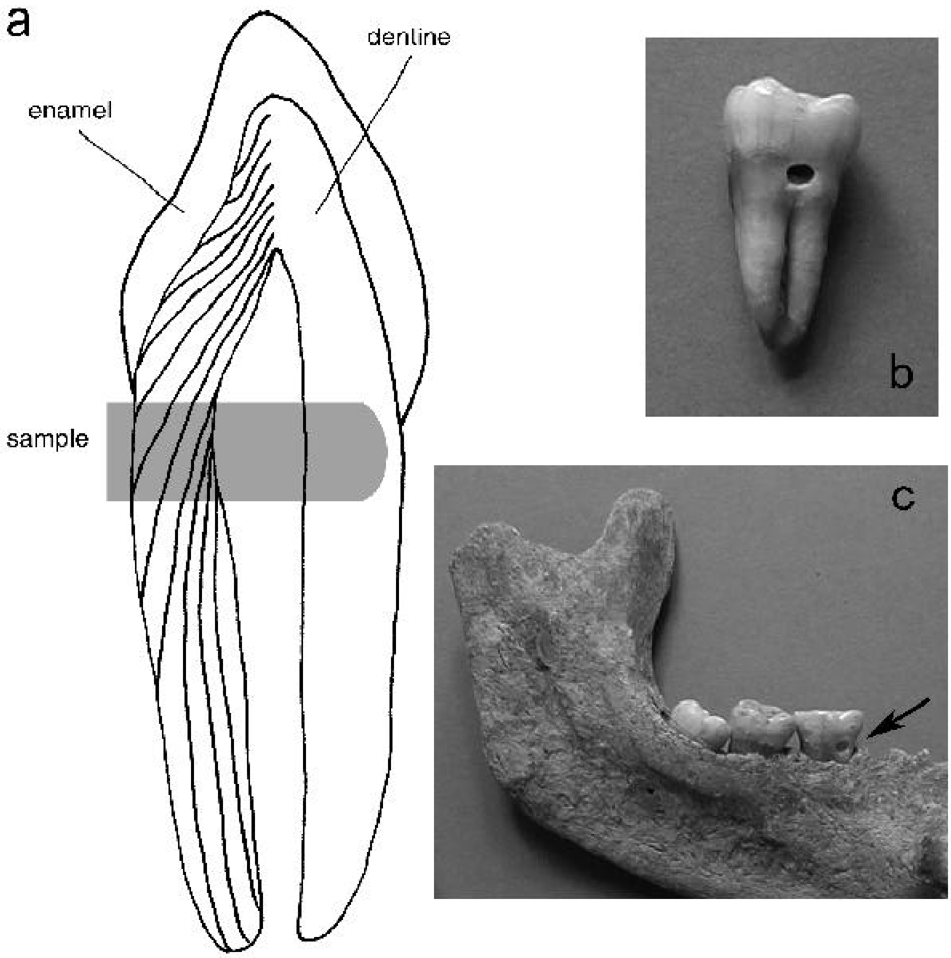


Fig. 2. (a) Simplified cross-section of an incisor showing the dentine layering, which starts at the crown (adapted and redrawn from Steele & Bramblett 1988). (b) All the permanent tooth samples were drilled from the same section of the tooth, just below the cervix, illustrated here with a second molar. (c) Sampling caused very little damage to the material; it was hardly visible once the tooth was back in position in the jaw (here a mandible). Note the sample drilled from the first molar, indicated by an arrow.

Even bone can be used for tracing intra-individual change in certain cases, since the collagen turnover rate varies in different bone elements. This is likely to be most pronounced in growing individuals, as was demonstrated by the analysis of both skull bone and a humerus from a newborn, or possibly stillborn, infant at Zvejnieki (Paper III), which exhibited large differences caused by the mother changing her diet during pregnancy (bearing in mind that the bones were formed *in utero*). The fact that short-term changes in diet are recorded in bone from children could furthermore be utilized to trace seasonal mobility at the population level, since whereas the isotopic signature of adult bone is levelled out due to the slow collagen turnover rate, the isotopic record of children would show a

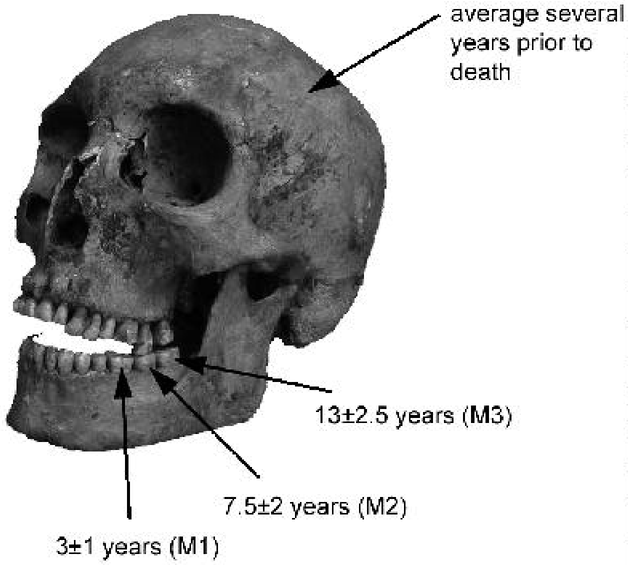


Fig. 3. The collagen of the skull and the various teeth sampled was formed at a specific age in each case, and samples from these represent different ages in the life of the individual. Skull from Västerbjers burial 93, photo by the author (published with permission from the Museum of National Antiquities).

lesser degree of averaging and thus higher variability (Fig. 4). It should also be possible to demonstrate this high variability in teeth as well as bone, provided that the time represented by each sample is short enough to record only one season.

4.2 *Breastfeeding*

Breastfeeding and weaning practices have important health implications for both the mother and the child, and could affect population growth and mobility, but they are also ultimately a matter of control over reproduction, making this issue an important field of study of relevance to both modern life and prehistory. Maybe this is also why norms for breastfeeding practice are often so dogmatic, although they range from the introduction of the first solids right after birth to the end of weaning at the age of 5–8 years (Coates 1993; DeLoache & Gottlieb 2000; Dettwyler 1995; Eriksson et al. 2000; Fildes 1995; Gartner & Stone 1994; Jelliffe & Jelliffe 1978; Quandt 1995; Riordan 1993; Short 1984; Stuart-Macadam 1995).

The term "weaning age" is somewhat misleading, as it implies that weaning is a distinct event, whereas in most cases it should be regarded as a process, beginning with the first introduction of other foods and ending with the last breastfeeding (Riordan & Auerbach 1993)(the exception, of course, would be abrupt weaning, which turns this process into a distinct event). Regarded this way, the weaning process is a part of the breastfeeding practice, and will in many cases constitute the main part of it.

One important contribution to the investigation of intra-individual changes is thus the possibility to trace breastfeeding patterns in individuals by means of stable nitrogen isotope analysis of deciduous teeth (Paper I). Previous studies of prehistoric breastfeeding and weaning have analysed bone from whole populations, including children, typically plotting the $\delta^{15}N$ values against age at death (Fig. 5), and inferring weaning age from the position of the peak and

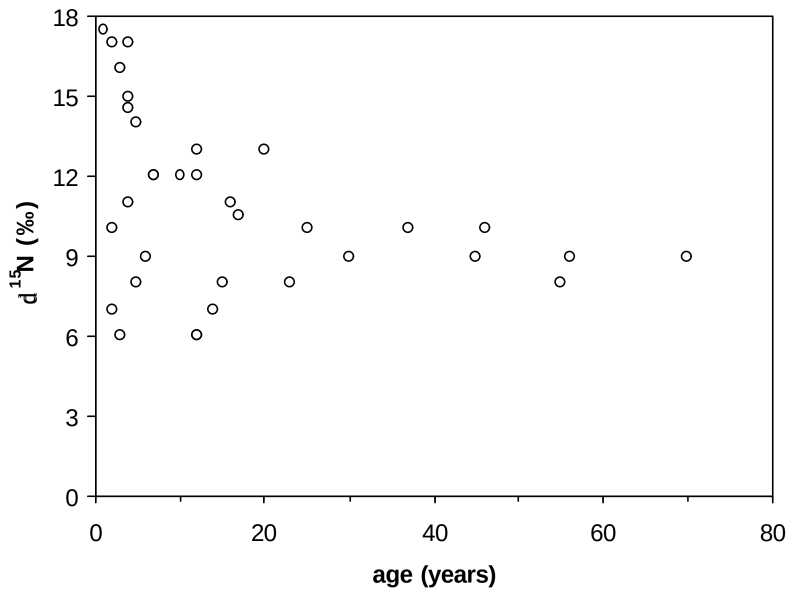


Fig. 4. Hypothetical bone stable nitrogen isotope values plotted against age at death for a population using isotopically different food sources over the course of a year. The variation recorded for growing individuals is levelled out for adults because of the slower collagen turnover rate.

subsequent drop in the curve (e.g. Fogel et al. 1989; Katzenberg et al. 1996; Richards et al. 2002; Schurr 1997). There are several problems with this approach, however: (1) the actual weaning age will in fact be earlier than that deduced from the curve produced from the bone isotope values, since there is a time-lag between the intake of a certain food and the incorporation of the stable isotope value into the skeletal tissue due to collagen turnover (cf. Lidén & Angerbjörn 1999), (2) the bone isotope values represent children who died during childhood, potentially because of early weaning, which causes problems of representativeness, (3) the evidence of weaning only shows an average for the population and does not take individual variation into account. The first problem can be overcome by correcting for the time-lag, although there is a need for more detailed data on the effect of collagen turnover and growth on isotope values (cf. Lidén & Angerbjörn 1999). The second problem is related to the specific demography of dead populations, which differs considerably from living ones; the fact that we are faced with those who never survived into adulthood must never be forgotten, and will inevitably cause a bias in the data. This fact underlines the importance of the progress made in tracing childhood diet by analyses of the permanent teeth of adults (Papers III, IV). The problem of using population averages instead of individual data is also one of representativeness, since it does not account for the variability in breastfeeding practices within one population (cf. Fig. 6). Even though norms for how and when weaning should take place may be rigid, practices may differ significantly from the norm, as in so many other instances. Furthermore, each infant–mother pair is unique, and the weaning process may therefore differ between siblings, even though the mother is the same (cf. Paper I).

All stable isotope studies of the weaning process in prehistoric populations should also bear in mind that particular food taboos during pregnancy and lactation could cause stable isotope signatures to deviate from the expected. Food avoidances associated with pregnancy or lactation have been attested in various parts of the world (Eichinger Ferro-Luzzi 1980a; Eichinger Ferro-Luzzi 1980b; Fieldhouse 1996; Wilson 1980). Moreover, since the deciduous teeth are eventually shed and replaced by permanent teeth, the earliest record of dietary practice will be lost when children grow older, although there will still be evidence of their early diet in the first molars, for example. It could even be speculated that the drop in $\delta^{15}N$ values in the first molars (corresponding to an age of three years) in the Västerbjers population (Paper IV:table 7) to a level significantly lower than for the third molars (early adolescence) or for adult bone from the same individuals could be interpreted as representing the final phase of the weaning process. Such a drop was frequently seen at this stage in the modern individuals studied (Paper I:Fig. 3), and a corresponding drop, though at an earlier age, was also recorded for the Pitted-Ware child at Ire (Paper I:Fig. 4).

Breastfeeding is a complex process which interacts with a number of biological, ecological, economic, social, cultural and individual factors, and no single factor will account for all the variation in practices, so that breastfeeding in prehistory can be expected to vary widely. The quest for an "original" or "natural" manner of breastfeeding (Knutsson 1995; Ljungberg 1995) is a vain undertaking.

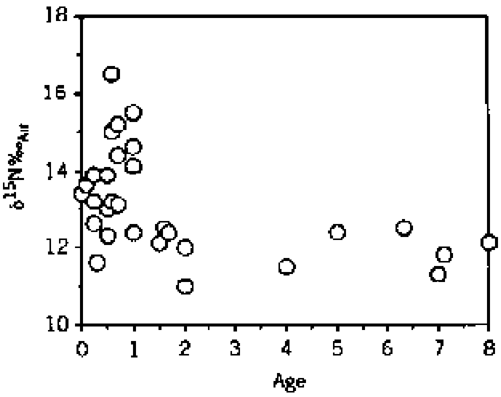


Fig. 5. Bone stable nitrogen isotope values plotted against age at death. Weaning was inferred to occur at age one year in this case (reproduced from Katzenberg & Pfeiffer 1995).

4.3 *Faunal analyses and stable isotope ecology*

The extensive analyses of faunal remains presented here contributed substantially to the interpretation of the human data (Papers II, III, IV, VI). An understanding of the stable isotope ecology of a site is crucial to its comprehension, and will in many cases provide detailed information which it would not otherwise be possible to glean. At Västerbjers (Paper IV), the inclusion of faunal analysis demonstrated the importance of seals in the human diet on a very detailed level, and also indicated that the proportion of fish ingested may previously have been overestimated (Fig. 7). Furthermore, it was shown that the importance of pork in the diet could be ignored. Without the faunal baseline it would only have been possible to conclude that marine protein constituted a significant portion of the diet, but not to go into detail regarding how and to what extent marine resources were exploited.

For Skateholm I and II (Paper VI) it is even more obvious that without the faunal data we could not have achieved the same level of confidence in our interpretations. Although both the human and animal bones were in poor condition and very few produced collagen for stable isotope analyses, the few that did generated enormously important data, indicating that certain people travelled between the west coast and the Skateholm lagoon during the Late Mesolithic. Similarly, the Ageröd faunal isotope data (Paper V) lead to the interpretation that the human bones recovered there were from individuals who had contact with people from the west coast, as indicated by the presence of dog bones, but who themselves gained their subsistence from the east coast. The mobility patterns suggested by the combined faunal and human analyses at both Ageröd and Skateholm could not have been inferred from the human data alone.

The Zvejnieki Stone Age complex (Papers II, III) offers another example of the signific-

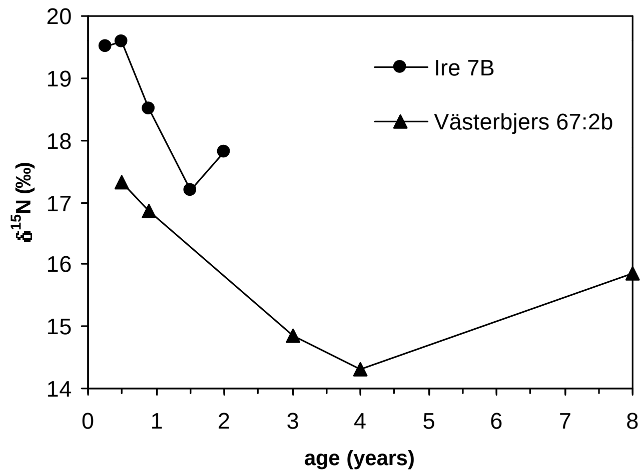


Fig. 6. Stable nitrogen isotope values for two children from Pitted-Ware sites on Gotland, plotted against crown formation age and estimated age based on bone collagen remodelling. Weaning was initiated at six months for both children, but completed at 1.5 years for the Ire child and not until 4 years of age for the Västerbjers child. (Note: the data points for the Västerbjers child were from ITM measurements corrected by a factor calculated for the particular run. Three of the samples were replicated at GEO and conformed entirely to the corrected values.

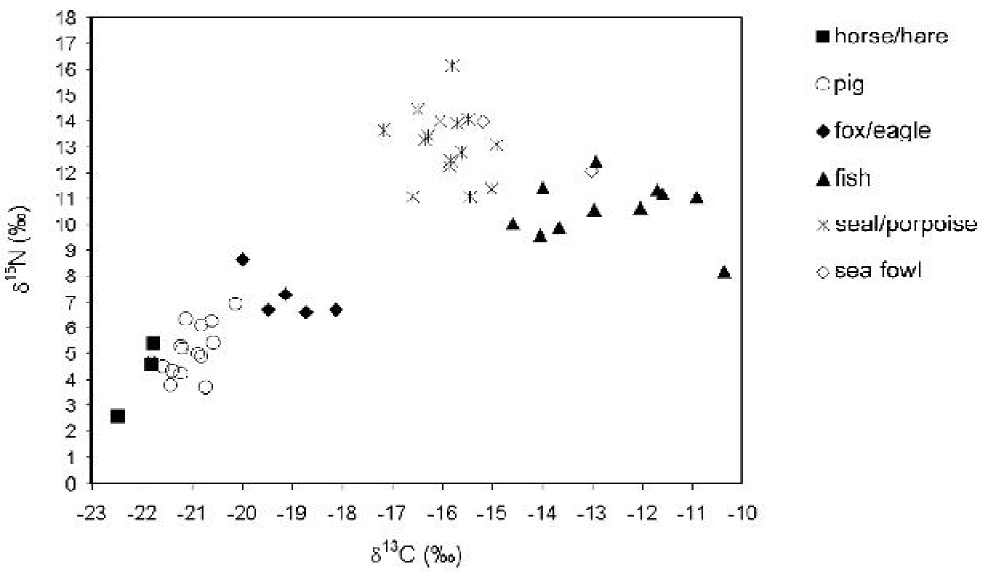
ance of faunal data. It was possible by reference to the various faunal species included to demonstrate not only the predominance of freshwater fish in the diet, especially during the oldest periods for which the cemetery was used, but also to suggest that the whole population had at least three or four major constituents in their diet.

The complex natural history of the Baltic Sea makes it especially vital to establish the stable isotope ecology when studying sites in this region. Salinity and sea level have varied considerably both spatially and temporally within the region, emphasizang the importance of analysing faunal remains *from the same site* and *of the same date* as the human material, since the stable isotope ecology could be specific to the site and period. This is also exemplified by the "fossil fuel effect", which has caused $\delta^{13}C$ values to decrease globally by some 1.5‰ compared with the pre-industrial era (Marino & McElroy 1991).

The analysis of animal bones could also assist in challenging widely held views about certain animals and their relations to human populations, e.g. the issue of pigs in the Middle Neolithic on Gotland. The stable isotope data provide no support for the hypothesis that these were domestic, or "freeland pigs", but suggest instead that they were wild boar or possibly feral pigs. Nevertheless, these animals were obviously of great symbolic importance to the Pitted Ware Gotlanders, as displayed by the numerous finds of boar tusks, mandibles and pig bones in Pitted Ware cemeteries (Paper IV), although they seem to have offered the meat to their dogs rather than consuming it themselves. As for the dogs and their relation to the human population, they deserve a section of their own.

4.4 Dogs

Four of the sites studied yielded both human and dog bones, namely Ageröd (Paper V), Skateholm (Paper VI, Eriksson & Lidén 2002), Zvejnieki (Papers II, III) and



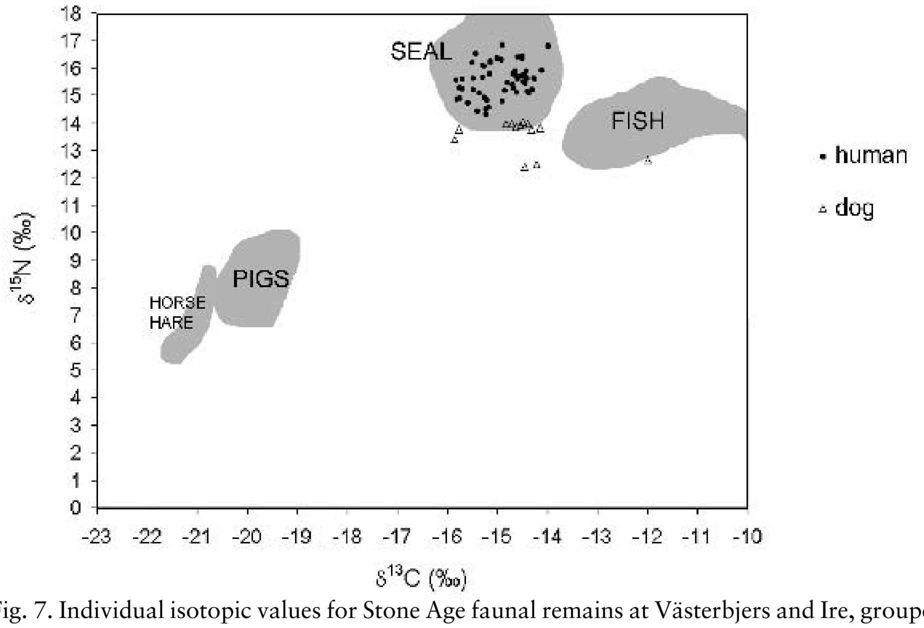


Fig. 7. Individual isotopic values for Stone Age faunal remains at Västerbjers and Ire, grouped by category (top). Humans and dogs plotted against isotopic expectancy values for individuals living entirely off any of four groups of potential foods (bottom). For ease of interpretation, the human and dog values affected by lactation (i.e. measurements from dog teeth and child skeletons) were excluded from the plot.

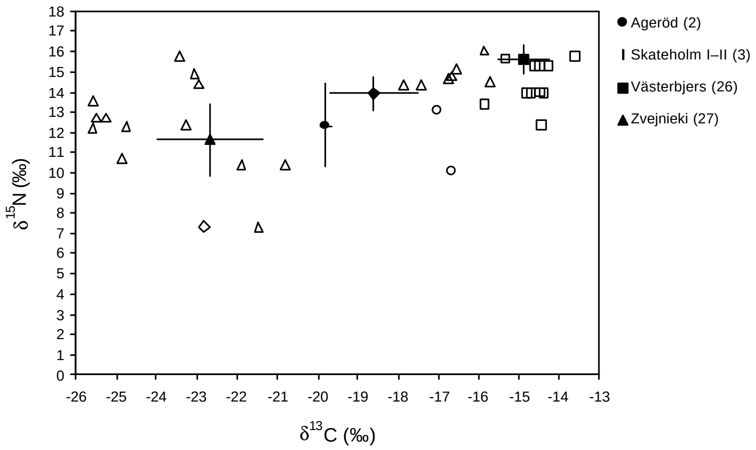


Fig. 8. Stable isotope plot for dogs (open symbols) and humans (closed symbols, mean±s.d., number of individuals analysed in brackets) at four sites. Data from Paper IV (Västerbjers), Paper V (Ageröd), Paper VI (Skateholm I–II), Paper III and unpublished material (Zvejnieki).

Västerbjers (Paper IV). It has previously been claimed that dogs could be used as proxies for humans in dietary studies, whereupon a stable isotope analysis of dog remains could be regarded as providing a good approximation for the human diet (Clutton-Brock & Noe-Nygaard 1990; Noe-Nygaard 1988; Persson 1998; Schulting & Richards 2000; Schulting & Richards 2002a). However, as is evident from the analyses at these four sites, dogs are of limited or no value as substitutes for people in dietary reconstruction (Fig. 8).

The two dogs analysed at Ageröd had about 3‰ more positive $\delta^{13}C$ values than the two human subjects, indicating a much higher marine protein input. The $\delta^{13}C$ value for the grey seal remains examined at this site, –19.2‰, indicates in turn that this seal had bred in the Baltic, which was still at the Ancylus Lake stage, i.e. it had a much lower salinity than in later times, and suggests that the people could have consumed protein from the Baltic, whereas the dogs evidently obtained their marine protein from the west coast of Sweden. The interpretation is impeded by the mixed layers at this site, spanning a period of some 800 years. The human remains analysed at Skateholm show an exceptionally high range of carbon stable isotope values, but the one dog analysed nevertheless gave a result lying far beyond this range, as was also true of the nitrogen isotope value. At Zvejnieki the dogs exhibited an extraordinary variability in stable isotope values, with evidence of a freshwater fish diet for one group, whereas others evidently fed on seals and a third group seems to have comprised terrestrial scavengers. The stable isotope analysis of human remains, on the other hand, indicated a diet of predominantly freshwater fish. Finally, the people at Västerbjers relied almost entirely on seals, while the dogs were in most cases fed on fish, and possibly occasionally pork. The detailed faunal analyses of the sites discussed here facilitated the interpretation and helped distinguish between potential food sources for dogs and humans.

It is clear from the above that the dogs at both inland and coastal sites ranging from the seventh to the third millennium BC deviated substantially in their diet from the human population. This is furthermore apparent from various other stable isotope studies of dog and human remains (e.g. Katzenberg 1989; White et al. 2001; White & Schwarcz 1989). Although it is still possible that the dogs at some sites could have had diets equal to those of the people, it would be totally erroneous to deduce the human diet from

Fig. 9. An "original" and "natural" family? Mobility and sexual division of labour in the children's book *Tomtebobarnen* by Elsa Beskow, originally published in 1910.

analyses of dog remains only.

Having established this, it must be said that analyses of dogs could nonetheless be of importance in their own right. Dogs in all probability had a number of different functions and roles in prehistory, both ritual and practical, which were not necessarily mutually exclusive (Olsen 2000; Serpell 1995). Practical use of their skills included roles as hunting partners, draught animals, guard dogs, herding animals, and scavengers, while their wool (Schulting 1994), fur (Noe-Nygaard 1995), meat (Serpell 1995) and teeth (Paper II) are also known to have been used. The company and affection of dogs and the status conferred by their possession were other important traits, as was their use in rituals (Crockford 2000). Dogs are easy to move about and are likely to have accompanied people who went from the interior to the coast or vice versa, as suggested by the differences exhibited between the human and dog isotope signatures reported here (Fig. 8, Papers II–VI). Moreover, because of their value, they are likely to have been traded and exchanged between various groups of people.

Although there are no general criteria that apply cross-culturally to distinguish between ritual and non-ritual dog deposits (Olsen 2000), the numerous finds and various manners of dog deposition at Stone Age sites in the Baltic region bear witness to the importance of these animals and their ritual significance (Benecke 1987; Larsson 1990; Lepiksaar 1984; Lõugas et al. 1996; Paaver 1965). The treatment displayed in burial rites could differ greatly from their daily treatment, however, and the dogs buried with full ceremony in graves of their own could still have been regarded as "polluted" creatures in their lifetime (e.g. Serpell 1995) – an ambivalence which again illustrates the discrepancy between norm and practice.

4.5 Radiocarbon dating and reservoir effects

Radiocarbon dating is of great importance for the interpretation of the archaeological record, and thereby for the application of dietary analysis. Correctly applied and combined with archaeological data, radiocarbon dating may help in sorting out the stratigraphy at a site, narrowing down the likely time of use, or establishing an absolute date for an archaeological event. Conspicuous examples are the human bones recovered at Huseby klev (Fig. 1), the earliest human remains hitherto found in Sweden, where radiocarbon dating of these and various other materials and structures aided in establishing the early dates, and also in demonstrating that the stratigraphically separate zones did not overlap chronologically (Nordqvist 2000). Radiocarbon results have been crucial for the present study in several instances (Papers III, IV, V and VI), and therefore some issues of relevance need to be brought up here.

The importance of making careful assessments of the archaeological problem to be solved by radiocarbon dating has been pointed out by Nelson (1998), for example, who used the terms "archaeological event" and "radiocarbon event" to distinguish between the event of archaeological interest, such as a burial, and the time represented by the dated sample. If dating teeth from a buried adult, the discrepancy between the radiocarbon event (in this case the childhood of the interred person) and the archaeological event of interest (the burial) could be as much as 50 years, depending on the age of the subject and the teeth used for dating. This need not be a problem, however, if it is taken into account when calibrating the date. In the study of Västerbjers (Paper IV), where this would be applicable, no age offset corrections were applied to the radiocarbon dates, in order not to confuse the discussion on the reservoir effect, since the former correction must be applied *after* calibration, whereas the reservoir age correction should always be applied *prior to* calibration. This may well be done in a future study going into the details of individual graves, however.

With the software currently available, such as OxCal or Calib (both freely accessible on the Internet), calibration of radiocarbon dates produced from collagen is a relatively straightforward matter for terrestrial herbivorous samples, but a marine correction should be applied before calibration for samples with a considerable marine influence, such as seals or humans living off seals (Arneborg et al. 1999; Stuiver & Braziunas 1993; Taylor 1992). This reservoir effect is principally caused by upwelling of water from lower depths in large basins (oceans, seas or larger lakes) and its mixing with surface water. As the water from deeper levels has not had the same carbon exchange with the atmosphere, it contains lower amounts of ^{14}C than the surface water and thus exhibits an apparent radiocarbon age (Taylor et al. 1996). It is well known that samples from the Baltic Sea may incorporate carbon with such marine reservoir ages (e.g. Olsson 1986), and because of the complicated natural history of the Baltic, the extent of this effect has fluctuated with time, so that the discrepancy must be established separately for any given period. Moreover, it can be expected to have varied widely within the basin, both vertically and horizontally, due to the circulation system imposed by the topography, salt-water inflow and freshwater runoff (Bonsdorff & Blomqvist 1993; Ojaveer & Elken 1997). A less well-known phenomenon, perhaps, is the freshwater reservoir effect, which was first brought to light by Lanting & van der Plicht (1996; Lanting & van der Plicht 1998), and has recently been observed in the Danube Gorges, referred to as the Iron Gates, where humans consuming large amounts of freshwater fish produced radiocarbon dates several hundred years older than terrestrial herbivores from the same contexts (Cook et al. 2002; Cook et al. 2001).

To estimate the extent of the reservoir effect for a given archaeological setting, the customary approach is to date material from the same closed context, such as a burial, which can be assumed not to be affected by any reservoir effect (e.g. bone or antler from a terrestrial herbivore) along with the human bone potentially affected by it. Although there is always a risk that the dated material will have been in circulation for some time before deposition, i.e. that the radiocarbon event may be much earlier than the archaeological event, this has to be balanced against the importance of dating a closed context, i.e. to have a reliable association between the interred human and the animal.

This methodology was applied at Västerbjers (Paper IV), demonstrating a considerably smaller marine reservoir effect for seal hunters on Middle Neolithic Gotland than previously suggested, 70±40 radiocarbon years. The fact that the Baltic is brackish and of limited size could probably account for this effect being much smaller than in large oceans, where the marine reservoir effect is generally estimated to between 400 and 500 radiocarbon years, with some regional differences (e.g. Arneborg et al. 1999). Considering the fact that the Zvejnieki population (Paper III) had a high consumption of freshwater fish, one has to take into account the possibility of a freshwater reservoir effect for this site. The extent of the effect for an Iron Gates subject with a 100% intake of freshwater fish was estimated by Cook et al. (2002) at roughly 500 radiocarbon years. However, two individuals from a multiple burial at Zvejnieki, who must be considered coeval on archaeological grounds, exhibited radiocarbon dates which differed by around 300 radiocarbon years, but in the "wrong direction" relative to their diets, the individual with the higher consumption of freshwater fish as indicated by stable isotope analysis having the later date, contrary to expectations. It may be that the reservoir effect for Zvejnieki (if present at all) is considerably smaller than that found at the Iron Gates. An attempt to estimate the extent of any freshwater reservoir effect has been initiated, and the findings will be discussed in a future paper (Lidén & Eriksson forthcoming). The chronological trends seen at Zvejnieki nevertheless seem to be valid regardless of any reservoir effect (see Paper III for a detailed discussion).

4.6 *Methodological concerns*

There are some pitfalls involved in the analysis and subsequent interpretation of stable isotopes in collagen which I would like to bring to focus here in addition to the discussion of intra-individual change, faunal data and representativeness. One concerns contamination, i.e. the inclusion of substances other than that intended for analysis, which could be caused by both prehistoric burial practices and modern techniques of handling skeletal remains at an excavation or in the laboratory. Another is diagenesis, chemical alteration caused by degradation of the skeletal remains. Both processes will distort the stable isotope signature. Fortunately, there are a number of precautions and measures that can be employed in order to avoid contamination and ensure the integrity of the collagen.

The sampling strategy employed here was to discard the outermost layer when drilling samples from a tooth or bone, preceded if necessary by immersing the element in distilled water and subjecting it to ultrasonication for less than one minute to remove contaminations. The collagen extraction protocol used (Brown et al. 1988) includes an ultrafiltration step, which selects for high-molecular weight remnants, thereby isolating the collagen from degraded protein remnants or from any contaminating substances which are smaller than the >30 kD fraction. In addition to the precautions against contamination or degraded collagen during extraction, there are a number of quality criteria which must be fulfilled for the sample to produce reliable stable isotope data. These include an atomic C/N ratio within the range 2.9–3.6 for unaltered collagen (DeNiro 1985), carbon and nitrogen concentrations within the limits for collagen from modern bone (Ambrose 1990), a given extraction yield (cf. van Klinken 1999), and visual appearance (Ambrose 1990).

The only source of nitrogen in the diet is the amino acids in protein, and experiments have shown that carbon from ingested protein is routed to collagen (Ambrose & Norr 1993; Gearing 1991). The $\delta^{13}C$ and $\delta^{15}N$ values for collagen therefore mainly reflect protein intake. The collagen $\delta^{13}C$ value is enriched by some 5‰ compared with ingested protein $\delta^{13}C$ (DeNiro 1985), although this enrichment factor varies between tissues and even between compounds in the same tissue. Consequently it is very important that any lipids, carbonates, contaminating substances or degraded collagen should be removed from the collagen prior to analysis, in order not to distort the $\delta^{13}C$ values. This fact should be emphasized, since different tissues and compounds typically have different stable isotope signatures even if they derive from the same individual. There is a common misunderstanding that the $\delta^{13}C$ range for collagen is applicable to other compounds as well, a possibility most commonly discussed in connection with the radiocarbon dating of organic residues on pottery (e.g. Edenmo et al. 1997, but see Isaksson et al. ms. for a discussion; Persson 1997). A $\delta^{13}C$ value of –22‰ should thus only be interpreted as terrestrial if derived from collagen.

Stable isotope analysis gives a measure of how uniform the diet is throughout a population, in that the standard deviation of $\delta^{13}C$ for a population with a homogeneous diet has been estimated to be around 0.3‰ (Lovell et al. 1986), a higher standard deviation thus indicating differential food intake. This was reported for a population mainly living off terrestrial herbivores, however, and may be less valid for seal hunters, for example. The approach used at Västerbjers (Paper IV), to estimate ranges for expectancy values based on faunal data, has proved successful and should be applied where possible (see also Schwarcz 1991). The standard deviation is nevertheless an important measure, although the absolute value of 0.3‰ may not be applicable to all ecological settings. The use of different skeletal elements for analysis could also influence the variability and should therefore be taken into account.

Ideally, the samples analysed should be consistently from the same skeletal elements, and from individuals representative of the whole population with regard to age, sex and manner of deposition. However, the archaeological and antiquarian reality is such that it has not always been possible to optimize the selection of individuals or of skeletal elements for analysis, because the material was not available, sampling not permitted, or the elements of interest were not sufficiently well preserved (cf. Papers III, IV). Taken together, these deficiencies of course impede the assessment of possible gender differences, for instance. The apparent underrepresentation of children and subadults, on the other hand, is alleviated by the fact that teeth from adults actually represent children that survived childhood – a group that is normally invisible in the archaeological record.

The present study was initiated in 1997, and the many hundreds of samples included were processed continuously over the years, the mass spectrometry and elemental analyses being run in several batches at two laboratories. Unfortunately, the precision and consistency of the data from one of these laboratories, that of the Institute of Applied Environmental Research (ITM) at Stockholm University, proved insufficient for the present purposes, replicate measurements of some 150 samples carried out at the Dept. of Geology and Geochemistry, Stockholm University (hereafter GEO), having shown poor agreement. The ITM experienced problems with uneven voltage, which may account for some of the irregularities. Furthermore, there was a consistent difference in the observed (by GEO) vs. the assumed values of the standards used by ITM, showing a 0.6‰ offset in $\delta^{13}C$ and 0.4‰ in $\delta^{15}N$ (i.e. the values recorded at GEO were higher in both cases). In addition, the reference gas used at ITM was isotopically not within the same range as the measured samples, which reduced the accuracy of the measurements, and the ITM performed recalibrations for every run, which resulted in differences that varied for each batch of samples. Thus the mean inter-lab difference for each ITM run varied from –0.2‰ to +0.9‰ for $\delta^{13}C$, and from –1.0‰ to +0.8‰ for $\delta^{15}N$, the standard deviations being as a rule of the order of 0.3‰ or less for both $\delta^{13}C$ and $\delta^{15}N$ (with some exceptions).

Not all the samples run at ITM could be successfully re-measured – either because there were insufficient amounts of collagen left from the previous measurement, or because the remaining collagen had been used for radiocarbon dating. This was unfortunate for several reasons, of course, not only because the extractions were time-consuming and the analyses costly, but above all because the archaeological remains are not infinite. In working with prehistoric remains, measures are always taken to avoid inflicting unnecessary damage on the material. This includes drilling as small samples as possible, avoiding destruction of any morphological characters, and, not least, always making an assessment of the amount of information gained in relation to the number of samples and the damage caused to the archaeological collections. It is frustrating, of course, to have caused damage to the material without achieving any data, but the same is also experienced with material of insufficient quality and is "part of the deal", so to speak.

The strategy in dealing with these problems was (1) to reproduce as many measurements as possible at GEO, (2) to calculate the offsets in both $\delta^{13}C$ and $\delta^{15}N$ for each run at ITM, (3) to discard data derived from those samples for which the analysis could not be replicated at GEO, or (4) if the analysis could not be replicated but the sample was of key importance and offsets could be calculated from the same run, to correct the values. The latter correction was applied to only ten samples (Papers V, VI), where the crucial importance of the sites made an estimation of the values justifiable. Nevertheless, it must be kept in mind that the precision of the estimates is poorer than for the other samples.

4.7 *Diet and "the Edible"*

Our attitudes towards food are often strong and less rooted in biology than one would at first imagine. Although we all rely by nature on certain nutrients for our survival and health, diet is one of the most forceful examples of culturally dependent phenomena (Fieldhouse 1996). Cultural and social aspects not only govern what is considered edible in a given society, but they also regulate when certain foodstuffs or dishes should be eaten, or sometimes even by whom they should be eaten. Social identity and position could thus affect both the amount and frequency of access to certain foodstuffs, and the overall variation in diet (Hastorf 1999). We consume only a limited proportion of the potential food resources available, a fact that is equally valid for the present day and for Stone Age people, and thus what is considered edible in a given society is not predictable from the accessible resources alone, neither is it self-evident that foodstuffs which were important on a symbolic or ritual level were actually consumed to any great extent (Arrhenius 1987; Fieldhouse 1996).

Since food habits are so closely bound to cultural and social identity, they are likely to be as strong indicators of group identity as any artefacts customarily used for attribution to an archaeological "culture". The concept of what is edible is accordingly central to the understanding of cultural identity formation. Feelings of disgust towards certain food categories are largely culturally conditioned, and will function as a divider between "us" and "them". Similarly, the attraction of certain exotic edibles will sometimes serve as a driving force for conflicts or for inducing change.

4.8 *Mobility*

One important aspect of the various Stone Age groups studied is their degree of mobility. As has been pointed out by several researchers, there is no inevitable relationship between agriculture and sedentism, or between foraging and mobility (Orme 1981; Kent 1989; Kelly 1992). On the whole, any clear-cut distinction between mobility and sedentism is difficult to make – it is rather a matter of degree. Large cemeteries such as Zvejnieki, Skateholm and Västerbjers are of course indicative of territoriality as such, but this in effect says little about mobility patterns. The stable isotope evidence gives some more hints, but these are not applicable in all instances. At Skateholm, the wide range of human carbon isotope values and their relation to the faunal data reveal that some of the interred individuals must have spent some time on the coast beyond the Baltic Sea proper, i.e. beside the Kattegatt, Skagerrak or the North Sea. Similarly, one Zvejnieki individual showed signs of having a marine input in his diet, although it could not be determined whether this implied a change of residence or commuting between the interior and the coast. An additional analysis of a tooth or another bone element from this individual could give further support for one or other of these alternatives. The Västerbjers stable isotope data show that all the individuals studied were distinctly coastal, even though this could entail both sedentism and mobility. For the inland site of Ageröd, the faunal data indicate that the values obtained from human remains were from people who derived some of their protein from the Baltic, implying some kind of mobility, while the Alby individual provides some indications as to differential input of marine protein between childhood and adulthood, but the differences are not huge and the marine predominance is overwhelming at all age for which data are available. The Hanaskede individual, on the other hand, does seem to have moved about a bit, with a more pronounced marine contribution during his childhood and possible traces of seasonal mobility. While marine indications for individuals deposited inland are evidence of some kind of mobility, the opposite, i.e. terrestrial/freshwater indications for coastal individuals, could be interpreted as evidence either of mobility or of a different form of subsistence, whether based on foraging or farming. This is the case for the individuals from Rolfsåker and Skateholm VI, who were both recovered from coastal sites but were markedly terrestrial in their dietary focus. For the remaining individuals analysed, nothing can be said about mobility, since there are only individual values which do not contrast with the location.

4.9 *The non-monolithic Stone Age*

What is apparent when considering all the sites included in the present study in the light of the stable isotope results is the great complexity and diversity of the Stone Age in this region. Two sites stand out as particularly important for understanding this period in the prehistory of the Baltic, Zvejnieki and Västerbjers (Papers II, III, IV). Both comprise cemeteries with large numbers of inhumations associated with extensive cultural layers, and are characterized by hunter–fisher–gatherer groups. To fit a traditional perspective, which sees the Mesolithic/Neolithic transition as one encompassing a shift from foraging to farming, both sites would thus have to be Mesolithic, which is obviously not the case. The inland site, Zvejnieki, includes both Mesolithic and Neolithic burials and cultural layers, while Västerbjers has a much narrower time span, the Middle Neolithic (disregarding the intrusive Bronze Age deposits).

The transition to farming has often been portrayed as something inevitable and irreversible, i.e. once foraging groups came into contact with farming, they were bound to adopt it – it was supposedly a point of no return (but cf. Bailey & Milner 2003; Rowley-Conwy 2001; e.g. Zvelebil 1996). The archaeological evidence from Västerbjers and Zvejnieki indicate that this is an oversimplified view, however. There are numerous indications of contact with coeval farming groups (i.e. the Corded-Ware or Battle-Axe Culture) at Västerbjers and other Pitted-Ware sites on Gotland, but no evidence of any agricultural activity, neither pastoralism nor horticulturalism (Paper IV). The occurrence of battle-axes, antler stabbing weapons and sheep bone in Pitted-Ware burials show that they were well aware of the possibility of practizang agriculture, but they actively chose not to do so. The hypothesis that the Corded-Ware and Pitted-Ware Cultures on Gotland represented the same people, who commuted between inland areas and the coast, can be refuted once and for all (cf. Andersson 1998, p. 73; Carlsson 1991; Carlsson 1998, p. 59ff; Persson 1986). In my opinion the Pitted Ware populations on Gotland should be regarded as a separate group with their own cultural identity, closely connected with seals (see Paper IV for a detailed argument).

Zvejnieki, on the other hand, does seem to involve a shift in diet, although not from foraging to farming, but from a diet completely dominated by freshwater fish, to one also including noteworthy contributions of birds and mammals, although still with a considerable intake of fish, and showing a much higher variability than earlier. A parallel to the Västerbjers contacts with people who practised farming could be observed in the coastal contacts evident in the Zvejnieki population. Although there are obvious signs of frequent contact with people living by the coast, there is as yet only one example of an individual actually moving between the coast and the interior (Paper III).

As for the other sites studied, there is no unambiguous evidence suggesting that one single factor, whether location, chronology or cultural attribution, accounted for all the variability. There is simply no general picture of either the Mesolithic or the Neolithic which applies to all the sites, despite the fact that they are located within such a limited area. The flexibility of the human mind defies all attempts to assign people to discrete and unchangeable entities which apply to large regions.

The concept of *variation* is central to the present study; referring here to (dietary) difference or lack of difference within or between individuals or populations. Variation is also often taken to mean deviation from an implicit norm or standard, as is commonly seen in the approach to the archaeological record, where the attempt to look for the typical often results in neglect of the atypical, i.e. the variation. This tendency is obvious in discussions of Neolithic "cultures", since a fixed and static notion of culture is unable to deal with variation, whether you call it culture, economy, tradition, ideology, lifestyle or social organization. The same goes for the one-sided arguments on the characters of the Mesolithic and Neolithic, in which peripheral parts of Western Europe are held up as standards of neolithization in Europe, based on selective data from the British Isles which it is claimed are "consistent with what is known from elsewhere in western Europe *outside northern and eastern Scandinavia*" (Schulting & Richards 2002b:1015, emphasis added). Apart from being a very complicated way of saying Denmark, I resent the way data from Sweden, Åland, Estonia and Latvia are ignored and marginalized. Moreover, the evidence from Denmark is much less unequivocal than is suggested by this way of describing the alleged transition. Stable carbon isotope values reported for the Danish coastal megalith Klokkehøj, for example, are intermediate with regard to the terrestrial–marine continuum, ranging from –19.9 to –18.1‰ (Lidén 1995a), i.e. they involve up to one third marine protein (employing the same manner of calculation as Schulting & Richards 2002b).

The concepts of normality and the normative have been challenged by Strassburg (2000), who attempted to solve this problem in his study of the South Scandinavian Mesolithic by making the deviant, or queer, into the norm, claiming that cemeteries such as Skateholm represent queer and dangerous individuals who had to be controlled and "normalized". He didn't really solve anything by merely reversing the roles between the "normal" and the "queer", however, since he still failed to account for the variation. Moreover, although imaginative, his interpretations seem to have left the actual archaeological evidence behind. A more viable perspective on the non-normative would perhaps be *not* to think of in terms of the constant battle and resistance portrayed by Strassburg, but instead to concentrate on a discrepancy between norm and practice, which need not involve a conflict. This gap between how things should be, i.e. the norm, and how things are, i.e. practice, could be bridged if one sees the norm as flexible, perceiving deviations from it as provisional exceptions, and allowing for both individual variation and human agency which may alter the norm in the long run. Such an ability to find excuses for all kinds of irregular behaviour is a human trait which is quite easy to relate to, and which would account for the differences between norm and practice found at Zvejnieki (Paper III) and Västerbjers (Paper IV), for instance. That people tend to give rather idealized accounts of their behaviour, which deviates significantly from that observed, is also a fact that is described in textbooks covering any kind of fieldwork in living populations (e.g. Renfrew & Bahn 1991; Rössner 1988).

4.10 "Nature" as a norm

Fieldhouse (1996:155), in his account of 19th century food reform, states: "Food reformers have always had a pre-occupation with a 'natural diet'. To call a food natural is to call it good.". This is equally true of today's advocates of a "Neander diet" or "biologically normal" food (Audette 1999; Ljungberg 1997).

The romantic idea of the happy Stone Age savage representing something original and purely natural, not affected by culture and untouched by the evil forces of present-day civilization, is of course nonsense, and is based on several misconceptions. First of all, we have to define who these original Stone Age people were – early hominids, Neanderthals, Palaeolithic *Homo sapiens*, any pre-Neolithic people, or just any hunter–gatherers at all? Having defined this, we then have to ask what they actually consumed. For pre-Neanderthal hominids, the evidence is very scanty, with concurrent hypotheses pointing to scavenging, predating or gathering as the means of obtaining food (Lee-Thorpe et al. 1994; Sillen et al. 1995), whereas stable isotope studies on Neanderthals have yielded few results (Bocherens et al. 1991; Pettitt et al. 2000; Richards et al. 2001).

. Even so, it must be explained why their diet is of relevance to modern humans – after all, they all became extinct. The key traits of our species, *Homo sapiens sapiens*, appear to be adaptive and innovative abilities, which led these individuals to populate new ecological niches throughout prehistory, inevitably leading to changes in diet, and to invent new technology, including new ways of preparing food. This resulted in a great diversity in food strategies for hunter–gatherers, and in such a rich range of edibles that it is pointless to describe the variability by reference to "nature". To claim that evolution shows that we should live according to some allegedly "original" norm is to ignore not only the diversity of human practice but also the actual facts of evolution. The lactose tolerance of adults in cattle herding populations in Africa and the Middle East, for example, as well as in the populations of northern Europe, is a genetic adaptation which seems to have first occurred during the Neolithic (McCracken 1971). Thus those of us who have this ability to break down the lactose in cow's milk are no longer "original".

A normative reference to supposedly "natural" traits is also frequent in arguments that try to justify present-day gender inequalities, in that biological essentialists tell us that such differences are normal because men and women are intrinsically different (Thornhill 1994) (Fig. 9). Not only is it claimed (without supporting evidence) that the division of labour in traditional societies and in prehistory is always a strict one, without overlap between males and females, but it is also maintained that there will never be any gender equality as long as women give birth – "her role as a mother was given to her by evolution" (Burenhult 2002, my transl.). The prescriptive and predictive value of prehistory in the hands of a biological essentialist is seemingly endless, and, needless to say, completely lacking in credibility. It seems to be based on a nature–nurture dichotomy, entailing a core of biology (nature) upon which some cosmetic casing in the form of culture (nurture) is applied. Biology and culture cannot be separated that way, however, and since they continuously interact, one cannot extract one from the other. Consequently, to use an alleged situation in prehistory as a norm is to abuse archaeology and to disregard the archaeological evidence of diversity.

5. Conclusions

In conclusion, a rich diversity in Stone Age dietary practice in the Baltic Region has been demonstrated. Evidence ranging from the Early Mesolithic to the Late Neolithic show that neither chronology nor location alone can account for this variety, but that there are inevitably cultural factors as well. Food habits are culturally governed, and therefore we cannot automatically assume that people at similar sites will have the same diet.

Stable isotope studies are very important here, since they tell what people actually consumed, not only what was available, or what one single meal contained. We should not be deceived to infer diet from ritually deposited remains, since things that were mentally important was not always important in daily life. Thus, although a ritual and symbolic norm may emphasize certain food categories, these may in fact contribute very little to diet. By the progress of analysis of intra-individual variation, new data on life history changes have been produced, revealing mobility patterns, breastfeeding behaviour and certain dietary transitions. The inclusion of faunal data has proven invaluable for understanding the stable isotope ecology of a site, and thereby improve the precision in interpretations of human stable isotope data. The special case of dogs, though, demonstrates that this animal is not useful for inferring human diet, since dogs due to the number of roles they possess in human society could, and in several cases has proven to, deviate significantly from humans in their diet.

When evaluating the radiocarbon data of human and animal remains from the Pitted-Ware site Västerbjers Gotland, the importance of establishing the stable isotope ecology of a site before making deductions on reservoir effects has been further demonstrated.

The main aim of this thesis has been to demonstrate the variation and diversity in human practice, challenging the view of a "monolithic" Stone Age. By looking at individuals and not only on populations, the whole range of human behaviour has been accounted for, also revealing the discrepancy between norm an practice, which frequently is visible both in the archaeological record and in present-day human behaviour.

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