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Beyond the settlement grid: investigating social differences through archaeobiology in waterlogged sites

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Abstract

Waterlogged sites represent an invaluable source of archaeological data. Houses dated to exact calendar years by dendrochronology yield countless artefacts and well preserved organic remains. In 150 years of research, a wealth of economic, environmental and chronological information on the circumalpine Neolithic and Bronze Age has been accumulated. The social historical potential of these sites has however been largely neglected, which is in part due to widely held preconceptions on prevailing social conditions drawn from common knowledge rather than research. Due to uniformly large houses arranged in rows, communities are generally perceived as being egalitarian and economically uniform.

In an interdisciplinary case study of the Swiss Arbon Bleiche 3 settlement on Lake Constance, the vast potential of the archaeobiological data from waterlogged sites for investigating social issues is explored. Statistical analyses of animal bones and botanical remains reveal several distinct economic strategies and/or dietary preferences, suggesting the existence of a socially diverse settlement community. Our results not only generate multifaceted social data but also contradict a number of preconceptions on lakeside communities. Methodologically, it becomes clear that archaeozoological and archaeobotanical remains are differentially biased by taphonomic processes and sampling strategies. These systematic differences will have to be addressed in further studies.

Keywords: Arbon Bleiche 3 • pile dwelling • waterlogged sites • multivariate statistics • social history

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Zusammenfassung

Feuchtbodensiedlungen stellen eine Quelle an archäologischen Informationen von unschätzbarem Wert dar. Die dendrochronologisch jahrgenau datierten Häuser liefern zahllose archäologische Artefakte ebenso wie gut erhaltene organische Materialien. Im Verlauf von 150 Jahren Forschungstätigkeit wurde eine Fülle an Informationen zu Umwelt, Wirtschaft und Chronologie des zirkumalpinen Neolithikums und der Bronzezeit gesammelt. Das sozialgeschichtliche Aussagpotential dieser Fundplätze wurde in der Vergangenheit jedoch weitgehend vernachlässigt. Dies ist zum Teil darauf zurückzuführen, dass es weitverbreitete Vorstellungen über die vorherrschenden sozialen Bedingungen gibt, die nicht auf Forschungsergebnissen sondern im Alltagswissen gründen. Angesichts der einheitlich grossen, in Reihen angeordneten Häuser geht man im allgemeinen davon aus, dass die Gemeinschaften egalitär und wirtschaftlich uniform waren.

Im Rahmen eines interdisziplinären Projektes zu der Siedlung Arbon Bleiche 3 am Bodensee wird das immense Potential von Feuchtbodensiedlungen zur Beantwortung sozialgeschichtlicher Fragestellungen ergründet. Statistische Analysen zu Tierknochen und botanischen

Resten offenbaren die Existenz unterschiedlicher ökonomischer Strategien und/oder Ernährungspräferenzen, was wiederum auf eine sozial facettenreiche Siedlungsgemeinschaft schliessen lässt. Unsere Resultate generieren nicht nur vielfältige soziale Daten, sondern sie widerlegen auch eine Reihe vorgefasster Meinungen zu Feuchtbodensiedlungen. Aus methodischer Sicht wird deutlich, dass archäozoologische und archäobotanische Reste durch taphonomische Prozesse und Beprobungsstrategien in unterschiedlicher Weise beeinflusst werden. Dies eröffnet ein weites Feld für zukünftige Studien.

Introduction

Europe's prehistoric settlement remains in circumalpine lakes and bogs represent an exceptional class of archaeological sites: No other source permits such detailed insights into the daily lives of prehistoric communities – even down to the level of individual calendar years. As a result, findings from wetland archaeology have contributed substantially to the development of chronological systems and to the understanding of the Central European Neolithic and Bronze Age. These waterlogged sites represent genuine cultural treasure troves. Even though the sites have been under investigation for the past 150 years, their significance has only recently been acknowledged by politicians and the general public. At the same time, there is an increasing public awareness that they are acutely threatened by erosion, desiccation or harbor construction projects. An application launched by six Alpine states under the leadership of Switzerland to have the waterlogged settlements in the Alpine region included in the list of the UNESCO world cultural heritage was approved in June 2011 [1] in recognition of the outstanding significance of these sites (Hafner/Harb 2008; Suter/Schlichtherle 2009).

At the present, almost 1000 so-called lakeside settlements or pile dwellings are known from all around the Alps, dating from around 4300 to 850 BC. Located in waterlogged environments of lakes and bogs, they have provided exceptional conditions for the preservation of material remains through the millennia. This applies particularly to organic remains like timber, plant food and textiles, which are not normally preserved in mineral soils. With regard to their exact dating, their preservation and their scientific potential for archaeobiological, sedimentological and climatological analyses, these wetland sites are a truly unique source of archaeological information.

The foundations for the exploration of wetland sites were laid in Switzerland. From the time of their discovery in the winter of 1853/54, scientific analyses have been accompanying the archaeological excavations in order to reconstruct former economies and climates. Today, the interdisciplinary investigation of sites by prehistoric archaeology and scientific analyses are a standard procedure in wetland archaeology. Decades of research have yielded detailed information on the chronology as well as on settlement, economic and environmental histories (Della Casa/Trachsel 2005; Menotti 2004; 2012; Schibler et al. 1997a). Wetland archaeology research results are basal to our knowledge of the archaeological cultures and the climate history of the Neolithic and the Bronze Age in the circumalpine area. Due to their great depth and detail they are exemplary in supplying new impulses for archaeological research in other areas as well. Wetland archaeology is therefore equally basic archaeological research.

This success story, however, also has its downside: The potential which wetland sites hold for investigating issues of social history by reason of their unique source material has hitherto hardly been tapped, in spite of the many results generated by 150 years of

1 See palafittes.org [accessed 20 December 2012].

Fig. 1. The dense regular arrangement of houses on a reconstruction of the Arbon Bleiche 3 settlement is reminiscent of a terraced housing estate; buildings of about the same size suggest the absence of social differences (modified after Leuzinger 2000, Fig. 269; drawing AATG, D. Steiner).

Abb. 1. Die zeichnerisch rekonstruierte Siedlung Arbon Bleiche 3 erinnert aufgrund ihres dichten und regelmässigen Bebauungsmusters an eine „Reihenhaussiedlung" mit gleich grossen Häussern, die keine sozialen Unterschiede vermuten lassen (modifiziert nach Leuzinger 2000, Abb. 269; Zeichnung AATG, D. Steiner).

interdisciplinary research encompassing numerous scientific disciplines (Trachsel 2005). This applies foremost to the subsistence economies and the structure and development of the settlements. As a rule, the few social interpretations explicitly addressed as such are merely side products of research on settlement histories or palaeoeconomies. Consequently, they are not the result of systematic research undertaken to specifically investigate social issues, but rather represent isolated yet promising vistas (see below).

From the beginning, the special arrangement of the pile dwellings has time and again given occasion to social interpretations. In the 19th century, the erroneous idea prevailed that the houses had been constructed on a priorly erected platform made of stakes and from this was inferred a good citizenship of the inhabitants, who had all worked for the common good because they had first erected the communal platform and only afterwards had built their own houses. This mode of construction was also a central building block of the widespread idea of the lake dwellers being an arch-democratic and peaceable people. The prehistoric forebears therewith epitomized the self-image of the Swiss Confederation founded in the year 1848. They were ideally suited to stand for the archetypical Swiss and acted as "representatives" for their nation during the 1867 World Fair in Paris, where Switzerland presented itself with archaeological artifacts rather than with industrial goods (Kaeser 2006).

Today we know that the houses were not erected on a communal platform on the lake but were built individually on the shore. They are constructed similarly, are alike in size and are arranged at regular intervals, thereby generating an impression of row houses occupying a regular settlement grid (Fig. 1) and giving rise to different, partially opposing social interpretations. On the one hand, the regular arrangement of the houses is interpreted as an indication for social stratification, because it is presumably inconceivable for such a feature to occur without the central leadership of a village chieftain (Stöckli 1990, 94). Other researchers view the "plan of regular row houses" as evidence for germ settlements (Osterwalder Maier 1990, 90). The most widely held – but rarely explicitly stated – concept, however, regards the regular structure of the settlements as an indication of social and economic equality reflecting an egalitarian society. This also involves the idea that each house was inhabited by a largely self-sufficient family and that all families followed identical subsistence strategies (for details see chapter "Implicit premises and latent preconceptions" p. 7) – possibly a continuing effect of the idea of the arch democratic, egalitarian pile dwellers vastly popularized during the 19th and 20th centuries. It is, in any case, a clear manifestation of idyllic concepts of Western nuclear families projected onto prehistory (Lutz 2010; Röder 2013).

While this projection is only implicitly present in scientific publications, it is all the more in evidence in illustrations reconstructing the daily lives in these settlements (Röder 2010). On such representations latent preconceptions on the social conditions in lakeside settlements become tangible which, although implicit, nonetheless shape archaeological research (see p. 7). The number of children on such reconstructions may serve as an example: Children are blatantly underrepresented so that all of the depicted populations would have died out within a very short time had the demographic structure portrayed been real. Equally dubious are the roles assigned to children and adolescents on the pictures: Babies seem to be a kind of gender-indicating accessory for women, and children are depicted as passive bystanders in a world of adults. Only adolescents are allowed social roles which they fill by helping with the daily chores according to a strictly gender specific roster (Röder 2008, 69–71). This also reflects modern bourgeois circumstances in which children enter "professional lives" late. When modeling labor in prehistoric communities we initially also disregarded the children. Labor, however, emerged as the decisive limiting factor, showing that essential tasks could not be accomplished without the children – and the elderly – also participating. In subsequent modeling attempts we therefore included these sections of the population in the work force (Gross et al. 1990). Interestingly enough, the question of child labor was equally pivotal among a group of thirteen adults and children who, for two months, lived "like in the Neolithic" in the summer of 2006. The project was launched by a German television station and supported by archaeologists[2]. Mostly unaccustomed to regular chores in their everyday lives, it proved almost impossible for the totally overburdened adults to motivate the children to help with their strenuous work, resulting in continuous friction. In modern agrarian societies, however, it is quite normal that children, being an important pillar of economy, regularly start working early, sometimes even at the age of five (e.g., Nieuwenhuys 1994, 13; for further examples see Röder forthcoming). According to new investigations of musculoskeletal markers in subadults, it seems quite feasible to assume similar patterns for prehistoric agrarian societies. In a Neolithic skeletal series analyzed by one of us (S. P.) for example, children exhibit noticeable musculoskeletal stress markers from the age of six[3]. This example should suffice to illustrate the importance of reflecting one's own cultural patterns and beliefs (e.g., "children do not work") so that they are not inadvertently introduced into archaeological research as latent premises and analogical models. It also underlines the essential necessity of systematically incorporating palaeodemography and anthropology in archaeological research. Both of these requirements have seldom been met in wetland archaeology. There is, therefore, a vast social historical potential waiting to be tapped.

Within the scope of an interdisciplinary project we aim to develop new methodological and theoretical approaches for the investigation of wetland sites, thereby contributing to basic research in archaeology[4]. Building on promising results generated in an earlier project (Jacomet et al. 2004), we mainly focus on two core areas. In a case study of the Neolithic lakeside settlement of Arbon Bleiche 3 on Lake Constance, we systematically explore the social historical potential of archaeobiology (archaeozoology, archaeobotany, anthropology and palaeodemography). In parallel, we also analyze the epistemological foundations of social historical interpretations in archaeological publications while permanently scrutinizing our own epistemological concepts in a self-reflective process.

Like the earlier mentioned approaches, our case study starts from the settlement structure. In the past, the terraced arrangement of the houses was frequently interpreted as a reflection of social and

2 See swr.de/ steinzeit [accessed 20 December 2012]
3 Pichler in prep. Child's play – identifying musculoskeletal indicators for child labor
4 See sozialgeschichte.unibas.ch [accessed 20 December 2012]. The project is funded by the Swiss National Science Foundation SNSF.

economic equality. In the last few years, however, archaeobotanical and archaeozoological analyses have been supplying increasing evidence that archaeobiological remains are unevenly distributed across the settlement areas of investigated sites. In Arbon Bleiche 3, for example, distribution plots revealed conspicuous concentrations and gaps for various plant and animal remains (Marti-Grädel et al. 2004; for details see chap. "From archaeology to parasitology: a broad spectrum of analyses" p. 14). Drawing on domestic and international social historical investigations, we are presently exploring these phenomena by statistical procedures in order to arrive at plausible explanations for the observed similarities or differences between houses. Augmented by anthropologic and palaeodemographic findings from comparable contexts, we are hoping to achieve a better understanding of the everyday lives and social conditions in Neolithic pile dwelling sites [5].

The scientific potential of archaeobiological remains in wetland sites: optimum prerequisites for social historical research

The essential starting point of case studies such as ours is a sound assessment of the social historical potential of the source material. On the basis of results from wetland archaeology and archaeobiology, we will summarize the possibilities for such investigations in wetland sites and address implicit premises and latent ideas which influence and hinder social historical research there.

The social historical potential of wetland sites

Because of the excellent conditions for the preservation of organic matter, wetland sites contain a broad spectrum of everyday remains. Organic materials in settlement layers are preserved in a subfossil (uncarbonised) state (Jacomet/Kreuz 1999, 57–59). They consist mainly of diverse types of biogenic remains like architectural elements (timbers, roof shingles, collapsed walls etc.) and a multitude of artifacts – from tools and containers made from wood (e.g. chipwood boxes containing bead strings, spoons and beaters, disc wheels) to wickerwork and textiles including sandals, hats and garments. Furthermore, there is a wide range of plant and animal food remains or waste: fruits of a large variety of cultivated and wild plants, bones of wild and domestic animals, fish scales and bones, food crusts in cooking pots and more. There are also curious items, such as pieces of birch tar with tooth impressions, which document that toddlers and adults chewed this prehistoric glue in order to soften it before use. Alternatively, the prehistoric chewing gum is said to alleviate tooth or stomach ache. Human coprolites are of special interest: They show that the ancient populations were affected by various, partly life-threatening parasites. The parasites in turn permit conclusions on dietary habits and food preparation, indicating that frogs were consumed quite frequently and that both meat and fish were often eaten either raw or undercooked, permitting the transmission of parasites to the human population. Unspectacular remnants like chaff or threshing remains provide information on activities carried out in the settlement [6]. Specific plant remains permit the reconstruction of the inhabitants' radius of activity (for recent examples of comprehensive analyses of archaeobiological data see Jacomet et al. 2004; Schlichtherle et al. 2011). Last but not least, animal dung yields information on where the different species

5 Presently there are no cemeteries for lakeside settlements and only few skeletons and isolated bones.

6 Threshing remains comprise all by-products of the processing or cleaning of domestic plants which are unfit for human consumption (rachis segments, glumes, rhachillae etc.)

of domestic animals were kept throughout the year (Kühn/Hadorn 2004). In short, a comprehensive analysis of both organic remains and of artifacts made from non-perishable materials disclose detailed and varied insights into the everyday life and cultural practices of former populations, augmented by precise information on former environmental conditions and the economy.

The degree of detail achieved in social historical analyses is not only determined by the amount and variety of the archaeological remains but also by the focus of the investigation: A focus on the settlement as a whole will yield more general results than a focus on individual houses, which, in wetland contexts, are often dated to exact years (Billamboz 2004; Bleicher 2009a). The current state of research clearly indicates that most of the lakeshore settlements mirror very well the ancient activities at the time of the settlement layers' deposition. In many wetland sites, researchers were able to establish that the finds – artifacts and archaeobiological remains alike – represent unmediated, *in situ* evidence of the activities carried out in specific houses. Burnt houses even provide a kind of snapshot of the last phase of occupation. In most houses, occupation layers represent the deposits of several years and may also comprise hiatus due to short term erosion phases (e.g. during summer maxima of lake levels in the wake of the snow melt). The houses' period of use can frequently be established by dendrochronologically dated repair timbers so that the time segment represented by the artifacts it contained can be narrowed down and taken into account in the analyses (see below, chapter "Social historical aspects of economic and evironmental analyses").

Against this background, numerous analyses are made possible. On the house level, for example, questions regarding subsistence strategies, consumption habits, and so forth can be addressed. There is also the issue of whether individual houses represent the place of residence of one domestic group or whether such a group inhabited several houses. This brings us to the next level of analysis: the comparison between individual houses or house groups, focusing on the spectra of archaeological remains from contemporaneous houses. These shed light on the fact whether different economies, modes of subsistence, cultural practices etc. were extant within one settlement. In a further step, observed differences can be examined as to evidence for different social groups, discriminated e.g. by gender, age or ethnicity.

In addition to these analyses on a synchronous level, the exact dating of houses also opens perspectives for diachronic investigations, e.g. when variation over time in the spectrum of finds permits the reconstruction of change. In some cases, it is even possible to retrace settlement histories on the year level, enabling the investigation of the continuity of local social groups and thereby highlighting the demographic dynamics of the communities.

In conclusion, one may state that lakeside settlements possess a vast potential for detailed social historical investigations with fine temporal resolution with respect to both contemporaneous and diachronic aspects. This potential will, however, stand or fall by the analysis of the archaeobiological remains. That is to say that the spectrum, quality and precision of conclusions depend directly on a systematic on-site sampling. Only then is it possible to reconstruct intra-site patterns. This point is of lesser importance for hand-collected bones, but highly significant for those archaeobiological remains which require systematic sampling: plant remains, small animals and fish. With results showing an uneven distribution of plant remains in the settlement area, the Arbon Bleiche 3 project (see below, chapter "Arbon Bleiche 3: a wetland site with great social historical potential") has clearly demonstrated the necessity of a dense and extensive sampling strategy (Jacomet/Brombacher 2005). Only then, and if the excavated area is sufficiently large, can plausible interpretations on the social aspects of everyday life be reached.

An important prerequisite for a representative archaeobiological investigation is the exact dating of the settlement layers, an assignment of single strata to settlement phases and in general an evaluation of the archaeological features and finds (artifacts). Ideally, the archaeological evaluation is conducted at the same time as the archaeobiological investigation so that it becomes possible to consider archaeological findings in the analysis of the archaeobiological data.

Wetland (and other) sites are usually explored in rescue excavations with tight time schedules. As a consequence, only few of the known sites provide optimum conditions for social historical investigations. For well-preserved sites it is therefore all the more important to secure research grants for the detailed analysis of the excavated material and use it to conduct basic research, as was done in Arbon Bleiche 3. Results obtained by this procedure can then be used to develop sampling and research strategies to be successfully applied in future rescue excavations.

Implicit premises and latent preconceptions

In view of the exceptional preconditions for social historical investigations of wetland sites, their potential has been exploited surprisingly little. Up to the present, investigations mostly focused on aspects such as typochronological analyses of the material culture, settlement histories, economic and environmental issues. The social conditions in Neolithic and Bronze Age lakeside settlements have hardly ever been a topic of research. This might be due to a lack of interest in social history – possibly because the social conditions are commonly believed to be well known already. That thesis seems almost compelling when illustrations reconstructing the everyday lives from the Palaeolithic to the Iron Age are analyzed. In spite of all the historical changes occurring within that time span, the pictures present vastly stereotypical social conditions (Röder 2004; 2007; 2010), leading us to conclude that quite specific ideas already exist on prehistoric social life. It seems to make little difference whether the illustrations were produced or authenticated, respectively, by amateurs or archaeologists: Both groups apparently likewise project idyllic images of Western bourgeois nuclear families and the patriarchal gender relations they involve onto prehistory. In doing so, they reproduce concepts of gender, familial and generational relations developed by 18th and 19th century middle-class society. These social forms have been so thoroughly explained and legitimized by naturalizing and archaizing the concepts in biology and (pre-)history ("it is only natural", "the aboriginal order"), that we still believe them to be prototypical (Röder 2004; 2007; 2010; 2013).

Lakeside settlements, reminiscent of modern terraced housing estates, are especially well suited to serve as projection planes for staging bourgeois idylls with an egalitarian touch. Such latent preconceptions of the social conditions in Neolithic and Bronze Age lakeside settlements are present even in scientific publications, albeit between the lines (Lutz 2010). We have identified ten such commonly held preconceptions:

1. Beyond the individual, nuclear families represent the basic units of former communities. They comprise a monogamous couple, their joint offspring and possibly additional unmarried biological relations. On average, there are four to five family members.

2. Nuclear families constitute long-lived and stable social units.
3. Each nuclear family forms a household.
4. Each house is the place of residence of one household.
5. Each household represents an autarkic unit of production and consumption.
6. Households are autarkic economical units of subsistence which meet their own needs.
7. Due to the lack of surplus production, social hierarchies based on "wealth" or on dependency from others cannot develop.
8. All households follow identical strategies of subsistence, i.e. they use the same resources and means of production in identical ways.
9. The settlement community is made up of egalitarian households. It is free of domination and determined by ties of kinship. All members have equal access to natural resources and means of production.
10. The settlement community is autonomous.

We shall test the validity of these premises within the scope of our case study, centering on the archaeobiological remains from Arbon Bleiche 3. Combining these with other artifacts, we shall address, for example, the question whether the architectural unit "house" was necessarily identical with the social unit "family". Furthermore, we will also test the postulated uniformity of houses in view of their subsistence strategies, dietary habits, consumption and so forth. In order to do so, we have to clearly realize the bases for social historical interpretations of archaeological findings.

The social historical potential of archaeobiology: anthropology/ palaeodemography – archaeozoology – archaeobotany

Practically from the very beginning, when "pile dwellings" were discovered in Swiss circumalpine lakes in the mid-19th century, botanists (Heer 1865), zoologists (Rütimeyer 1861) and other specialists accompanied the archaeological investigations. Their results repeatedly implied social aspects. Starting from this long tradition, we are attempting to explore and realize the potential of archaeobiological data for the investigation of social history, specifically from the fields of physical anthropology and palaeodemography, archaeozoology and archaeobotany.

Physical Anthropology and palaeodemography: seeking the ancient population

Physical Anthropology has been undergoing fundamental changes, both in focus and methods during the past decades. Promoted by the progress in analytical procedures in biochemistry and molecular genetics, anthropologists are now able to address questions of human origins and evolution, ethnicity, long-range or seasonal migration, subsistence patterns and dietary habits, social differentiation and the spread and prevalence of pathogens by the analysis of stable isotopes, trace elements and the information encoded in a(ncient)DNA (Brothwell/Pollard 2005). Chemical anthropology has fundamentally altered our view of past populations. Yet, as is the case with the archaeological findings, the social implications of the data obtained by geochemical or molecular fingerprinting are hardly ever addressed. Notable exceptions are investigations of the weaning age of infants (Wright/Schwarcz 1998) or of differential dietary patterns between either the sexes or between distinct social classes in burial communities (Dürrwachter et al. 2006). Such data, combined with basic information on individual skeletons or mummies obtained by "classical" methods can provide us with valuable insights into social aspects of the daily lives of our forebears. Birth spacing, causes of infant and adult mortality, age and gender related division of labor, type and frequency of accidental or violent lesions are just some examples for parameters affecting populations past and present. Such observations are especially interesting if viewed on the population level by a palaeodemographic approach.

Palaeodemography investigates ancient populations, seeking to reconstruct basic features of former communities: population size, structure, dynamics and density, fertility and mortality as well as mobility or migration (Chamberlain 2006). These seven parameters are used in characterizing individual populations and in comparing different populations to each other, both in humans and other lifeforms alike.

Unlike plant or animal communities, however, the demography of human groups is determined to a large extent by factors beyond biological givens. Human populations are perceived as social units comprising individuals who share a common cultural experience, i.e. behavior patterns, beliefs, institutions and so forth. Such communities or "cultures" are therefore united by cultural affinities, their mutual social recognition of ancestry and kinship, and by co-residence or geographical proximity (Kreager 1997), acknowledging the intrinsic nature of culture for the essential human condition (Arendt 1998; Tomasello 2001).

In archaeological contexts, human skeletal remains are the staple source of data for palaeodemographic investigations. From the 1930s onward, steady progress was made in estimating ages-at-death and sexing human skeletal remains, assessing the representativeness of skeletal samples as reflecting former populations, appreciating the under-representation of infants and, especially during the past two decades, introducing maximum likelihood approaches and validating palaeopopulation data by model life tables (Boquet-Appel 2008; Boldsen et al. 2002; Chamberlain 2006; Paine/Harpending 1998; Wood et al. 1992). By now, palaeodemographic studies have become routine procedures in skeletal assemblage analyses and archaeologists readily read life tables and cite data on life expectancy at birth, population sizes and mortality patterns of excavated cemeteries and contrast these with estimates of population numbers based on surface areas of houses and settlements or on-site catchment analyses (Brothwell/Pollard 2005; Ebersbach 2005; Lüning 1988).

Curiously enough, as a consequence of disciplinary divisions, basic concepts and methods from both fields of research have little permeated the other, with palaeodemographers not necessarily considering cultural, economic and environmental proxies and archaeologists remaining largely unaware of demographic principles. For Switzerland, existing concepts of residential groups throughout the ages illustrate this observation. For the Neolithic, Stöckli (1990) proposed residential groups of three adults and two children, perfectly matching the five-member archaeological "model family" (Pichler et al. 2009), whereas Vogt (1969) suggested average domestic groups of four adults and four children. Based on descriptions in Caesar's *Commentarii de Bello Gallico*, Martin-Kilcher (1981) hypothesized that each Roman villa, a large rural agricultural estate, was inhabited by 35 to 40 adults and ten children. For medieval times, Etter (1990) surmised throngs of eight adults and seven children occupying a single house.

Calculating the specific child-woman ratios, one arrives at ranges from two children to each woman for the Neolithic (Vogt) up to an inverse ratio for Roman times. These numbers are in stark contrast to current vital statistics, stating population replacement rates at 2.1 children per woman for industrialized and 3.8 children per woman for developing countries (epp.eurostat.ec.europa.eu; who.int/whosis; Bongaarts 1998). Yet we expect to find not just stable population numbers but steady population growth, however moderate, throughout prehistory. So, realizing that presumed child-woman ratios for archaeological time periods are not founded on sound demographic principles, what do these numbers signify? They illustrate that, as often as not, the perception of ancient populations is colored by present-day concepts of human societies, rather vague ethnographic parallels and, once again, by little-reflected epistemological foundations (for details see above, chapter "Implicit premises and latent preconceptions"; Doppler et al. 2011; Pichler et al. 2009).

Only rarely are factors such as carrying capacities, settlement evolution or household cycles considered in palaeodemographic studies (Howell 1986; Vitousek et al. 2004). However, if palaeodemography is to make a substantial contribution to both the cultural and biological history of ancient populations, an integrative approach represents the most promising option: "We must have basic control over the cultural setting and a knowledge of possible cultural or biological conditions [...]. If it is to be successful, palaeodemographic study cannot and must not be an isolated endeavor" (Paine/Harpending 1998, 239). This holds especially true for Swiss lakeside settlements, where, due to a near-complete absence of human skeletal remains, only archaeological, archaeozoological and archaeobotanical data is available for palaeodemographic studies. The sheer mass and quality of information as well the tight chronological control made possible by the wealth of dendrochronological data nonetheless represents a unique situation with vast possibilities (see below, chapter "The site").

Designed as a contribution to basic research, we aim at integrating data from a whole range of disciplines to achieve a better, more holistic understanding of former populations. Not only will physiological givens like menarchal and menopausal age be addressed, but also health indices like nutritional status, stress markers, child mortality, adult life expectancy and the frequency and gravity of palaeopathological conditions including indications of interpersonal violence. Of equal importance will be the discussion of social rules and conventions which have a bearing on demographic parameters: differential ages at marriage, birth spacing, lactation periods, exogamy, residence rules and similar data. Further information is provided by routine archaeological and archaeobiological analyses, such as data on the economic basis and subsistence strategies of a given community (which might imply division of labor as well as a seasonal dispersal of subgroups), the homogeneity of the cultural remains (which might suggest exchange networks or a presence of "alien" individuals), the patterns of growth or disintegration of settlements (supplying hints at the stability of local communities as well as their social organization), the number and structure of contemporaneous houses (providing clues to the internal structuring of settlements and the number of households or residential groups respectively), varying patterns of resource exploitation (which might hint at differential resource access or age and gender specific practices), to mention just a few. We intend to combine this data in such a way as to generate a broad foundation for future palaeodemographic reconstructions, appreciating former populations as free agents making decisions within the limits of their specific cultural and ecological settings. Shifting the focus of research from the dead buried in cemeteries to the living populations these represent will establish palaeodemography and physical anthropology as valuable tools in addressing social issues in prehistoric research.

Archaeozoology and archaeobotany

In the past two decades, social historical research results based on archaeozoological and archaeobotanical data have regularly been discussed in scientific papers published in Great-Britain and the United States. This stands in sharp contrast to research in Continental Europe, which focuses primarily on biological or environmental aspects like domestication or environmental change. A short side note on the history of research should help to explain these fundamental differences in research subjects and interests. Initially, for many decades both archaeozoology and archaeobotany have developed in quite similar ways in the European and North American focal areas. Put simply, three phases can be identified: a pioneer phase starting from around the 1860s, followed by a stage of scientific specialization in the first half of the 20th century, and finally a gradual upswing in the post-WW II era. This last phase paved the way for the examination of the social historical potential of archaeobiological data. During this phase, archaeozoological and archaeobotanical research was increasingly incorporated in archaeological investigations and as a result converged on theoretical archaeological currents. This is especially true for the Anglo-American countries, where the ideas of Processual Archaeology and, to a lesser degree, of Post-Processual Archaeology distinctly influenced the archaeobiological disciplines. In Continental Europe, however, neither archaeobiology nor archaeology were as open to these ideas and were therefore not much influenced by them. In our estimation, it was this "theoretical separation" that led to the differences in development of European and North American-British archaeobiology – differences which are still reflected in the unequal designations of archaeozoology vs. zooarchaeology and archaeobotany vs. palaeoethnobotany respectively.

In the course of the 1980s, social historical investigations using archaeobiological data received growing attention. Anglo-American research was initially focused of modern sites (Scott 1996), whereas the few Continental European papers covered Roman Age material (Schibler/Furger 1988). A comparable treatment of prehistoric data emerged – again primarily in the English speaking countries – during the 1990s when it was realized that archaeozoological and archaeobotanical data offer insights beyond traditional issues and permit interesting conclusions on social and symbolic aspects, leading to a better understanding of the complex social processes and relationships in former communities (e.g. Becker 1998, 85; Crabtree 1990, 156; Dietler 1996, 116; Gifford-Gonzalez 1991, 216; Gumerman 1997, 109; Hachem 1997, 258; Kent 1993, 373; Marciniak 1999, 298; O'Connor 1996, 12; Samuel 1999, 121; Schuster Keswani 1994, 255; Scott 1996, 339).

To date, the discussion on the social historical potential of archaeobiological data has resulted in producing a remarkable variety of approaches, interpretations and publications clearly illustrating the potential of such research (e.g. Bogaard 2004; Jones O'Day et al. 2004; Marciniak 2005; Miracle/Milner 2002; Rowley-Conwy 2000; Snyder/Moore 2006; Valamoti 2005; Van der Veen 2007). Topics cover a wide variety of subjects, like feasting (Dietler/Hayden 2001; Jones 2007), luxuries (Ervynck et al. 2003; Van der Veen 2003), ritual (Grant 1991; Jones O'Day et al. 2004), taboo (Harris 1988; Vigne et al. 2005), household (Arbogast et al. 1997; Doppler et al. forthcoming a), specialization (Hachem 1997; Grant 2002a), status (Grant 2002b; Wiessner/Schiefenhövel 1996), differential dietary patterns (Schibler/Furger 1988; Schibler et al. 1999), cooking methods (Montón Subías 2002; Speth 2000), ethnicity (Palmer/Van der Veen 2002; Scott 1996) or gender (Counihan/Kaplan 1998; Pfeiffer/Butz 2005), to name just a few (for more details see Doppler 2013). Some issues will be revisited further down when we discuss our sample cases. It will then become evident that the excellent data base represented by waterlogged sites is especially well suited to address archaeobiological-social historical questions.

Here we should add that social historical analyses of archaeozoological remains offer far better opportunities than for archaeobotanical remains. The archaeozoological data are based on hand collected bones which may be treated like any other artifacts. Plant remains, as well as the bones of small mammals and fish, are small and fragile in most cases and require complex procedures for recovery and analysis as well as incurring greater costs. There are also a number of methodical problems which hinder, or occasionally even prevent, a review of archaeobotanical data. In most cases, excavation areas are only sampled rather than extensively covered for archaeobotanical remains. Furthermore, the different states in which plant remains may be preserved (charred, mineralized or subfossil) are pivotal for the verifiable spectrum of species. Social historical interpretations therefore depend directly on good conditions of preservation and systematic sampling strategies for archaeobiological remains: preconditions which have both been met in the case of Arbon Bleiche 3.

Arbon Bleiche 3: a wetland site with great social historical potential

The site

Arbon Bleiche 3 is located on the Swiss southern shore of Lake Constance, Canton of Thurgau (Fig. 2). The Neolithic settlement was situated directly on the shore of a now silted-up and partially raised

Fig. 2. Location of Arbon Bleiche 3 in northeast Switzerland on the southern shore of Lake Constance.

Abb. 2. Arbon Bleiche 3 liegt im Nordosten der Schweiz am Südufer des Bodensees.

Fig. 3. Preservation of organic remains *in situ* (after Sormaz 2004, Fig. 78; photograph AATG, D. Steiner)

Abb. 3. Erhaltung von organischem Material in situ *(nach Sormaz 2004, Abb. 78; Foto AATG, D. Steiner).*

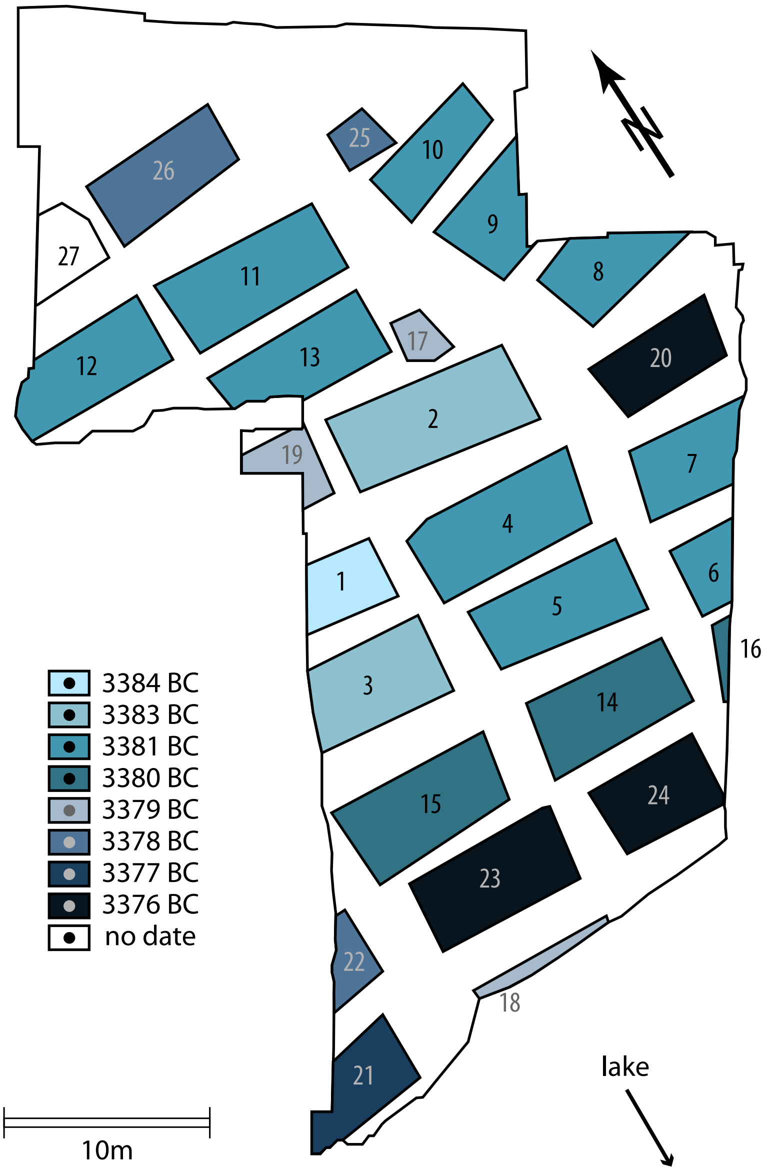

Fig. 4. Arbon Bleiche 3 settlement plan showing houses dated to exact building years by dendrochronology. Varying shades of blue designate the chronological sequence (modified after De Capitani et al. 2002, 21).

Abb. 4. Siedlungsplan von Arbon Bleiche 3 mit den einzelnen dendrodatierten Hausgrundrissen. Die unterschiedlichen Farbstufen indizieren die chronologische Bauabfolge (nach de Capitani et al. 2002, 21, modifiziert).

bay and was explored in rescue excavations by the Archaeological Service of Canton Thurgau from 1993 to 1995. The cultural layer was mostly waterlogged so that archaeological structures and organic remains are very well preserved due to the lack of oxygen (Fig. 3). Twenty-seven houses were completely or partially exposed (Fig. 4), which corresponds to a third, possibly even half of the former settlement area (Leuzinger 2000). Compared with other wetland sites, this represents a substantial section of the site so that results and interpretations can be viewed as exemplary for the settlement as a whole.

All houses are surprisingly uniform, with an average size of about 4x8 meters, the only exceptions being two small, almost rectangular buildings measuring 2x2 meters (houses 17 and 25). The houses are arranged in rows separated by alleyways. With one exception, all are dated to particular years by dendrochronology, which permits the reconstruction of the settlement's development and shows that it was only occupied between 3384 and 3370 BC. This time slot coincides with the transition from the Pfyn to the Horgen culture which has gained prominence because Ötzi, the Iceman from Hauslabjoch, dates to roughly the same period. Due to its short duration, the single-phase, 15-year occupation of the site is of special significance for social historical analyses. There are neither older nor younger settlement traces at that particular site, so there is no possible mixing with other archaeological material. This exceptional situation was put to optimal use from the outset. From the very beginning, the excavation as well as the analyses was scheduled as interdisciplinary ventures so that experts from various fields were present on site and gained firsthand knowledge which they used in their work. All team members were able to develop specific sampling strategies and take their own samples which resulted in a unique research oriented approach for the site (which, in this form, has rarely been achieved in Central Europe). In spite of the huge amount of data and the number of disciplines and specialists involved, the archaeological material was analyzed and published in full within ten years (De Capitani et al. 2002; Jacomet et al. 2004; Leuzinger 2000).

From archaeology to parasitology: a broad spectrum of analyses

The broadly conceived interdisciplinary analyses have yielded a wide range of results, making Arbon Bleiche 3 a model site for wetland archaeology [7]. Some exemplary analyses may illustrate the settlement's special standing. The waterlogged occupation layer, preserved under the exclusion of air, is made up mainly of organic food and manufacturing waste as well as human and animal feces. In addition to the "standard" investigations of ceramics, artifacts made of stone, bone and antler and of the animal bones (De Capitani 2002; Deschler-Erb/Marti-Grädel 2004b; Leuzinger 2002) there were also in-depth analyses of the organic remains. Dendrochronological analyses of construction timbers revealed information on the development of the settlement, its dating, and on forest utilization practices (Leuzinger 2000; Sormaz 2004; see also Bleicher 2009a). Sedimentological, micromorphological, archaeobotanical and palynological analyses as well as the consideration of mollusks showed that the settlement remains underwent hardly any displacement with *in situ* findings (Brombacher/Hadorn 2004; Haas/Magny 2004; Hosch/Jacomet 2004; Ismail-Meyer/Rentzel 2004; Thew 2004). This observation represents an important prerequisite for any further cultural-historical investigations.

Meticulous analyses of pollen and macroremains show that these reflect activities that took place in the course of several years and

7 Analyses and research were funded by the Swiss National Science Foundation SNSF (project no. 1253-052498 und 1253-063539) – www.snf.ch.

during different seasons, indicating an uninterrupted occupation of the site. Numerous ceramic vessels exhibited food crusts that were analyzed (Martínez Straumann 2004), e.g. for identification of food items or fatty acids (Spangenberg 2004). Besides large animal bones, small animal remains were also investigated, e.g., of amphibians and fishes (Hüster-Plogmann 2004). Due to the excellent layer preservation and the far-sighted sampling strategy, it was even possible to identify parasites in animal dung and human coprolites (Le Bailly/Bouchet 2004; Le Bailly et al. 2003). Excrement investigations provided insights into foddering practices (Kühn/Hadorn 2004), and finally, it was possible to isolate ancient DNA from cattle dung, demonstrating the feasibility of molecular techniques for material from waterlogged environments (Turgay/Schlumbaum 2004).

Even though the above list is certainly not comprehensive, it still serves to demonstrate the great worth of the Arbon Bleiche 3 site for archaeology and to exemplify the potential of well thought out and systematically organized interdisciplinary cooperation. Overall, the extensive investigation disclosed interesting features of the site's social and economic complexity which also emerges in its far-ranging contacts (De Capitani 2002; Hosch/Jacomet 2004; Leuzinger 2002). The extensive material remains from Arbon (ca. 70,000 animal bones, 73 analyzed archaeobotanical samples with a total volume of over 370 liters and thousands of macroremains, 1150 kg of ceramics, roughly 3000 antler and bone artifacts, 1800 flint objects,…) enables in-depth analyses of everyday life which have been inconceivable previously. Arbon Bleiche 3 therefore offers optimum conditions for social historical research.

Social historical aspects of economic and environmental analyses

Even though the archaeobiological analyses targeted economic and environmental issues, they nonetheless yielded numerous social historical references. Distribution maps of archaeobiological, especially archaeozoological remains, are particularly productive in this respect, yielding significant differences both on the house and settlement levels (Marti-Grädel et al. 2004). On the house level, two houses stand out for their large amounts of wild animal bones, particularly considering their Neolithic setting. In addition, the frequent occurrence of certain species of wild animals in specific houses also stands out, as well as concentrations of goat bones in two neighboring houses.

On the settlement level, the distribution of cattle and pig bones and fish remains is conspicuous. In the seaward half of the settlement, there tend to be more pigs and whitefish, whereas in the landward half there seems to be a trend toward more cattle and fish of the carp family. This is especially interesting since the two kinds of fishes inhabit different water areas and are caught in different ways: whitefish stay in open water and are caught from boats with trawl nets during the cold season, whereas carp are caught close to the banks (Hüster-Plogmann 2004).

It is quite obvious that socio-cultural factors are behind these differences. In the primary analysis, three factors are cited as an explanation: a) division of labor and economical specialization, b) relational or economic exchange, and c) ethnic or relational social groups. The high proportions of wild animal bones in two houses were attributed to specialized hunting and the houses tagged as "hunters' houses" (Deschler-Erb/Marti-Grädel 2004b, 232, 251), implying "professional hunters". Conspicuous similarities in animal bone spectra of neighboring houses (e.g., with respect to the goats) were associated with especially close relational or economic ties between these houses

(Doppler et al. 2010). The bipartition of the settlement emerging on the basis of the archaeobiological remains was interpreted as representing the residences of either relational (clans) or two ethnic groups (Deschler-Erb/Marti-Grädel 2004b, 251). The latter was based on the ceramic analysis which showed a significant proportion of foreign vessels. Archaeometric analyses revealed that these were produced locally, but feature forms and decorations from the Bavarian Altheim culture and the Baden culture in the Vienna basin (De Capitani 2002; Freudiger-Bonzon 2005). Social historical interpretations were also presented for a number of individual findings which permit conclusions on the labor organization and radius of activity of the inhabitants. The presence of Alpine plants was taken as a sign that members of the settlement community spent time in the Alpine area, possibly the summer grazing area of the domestic herds (Hosch/Jacomet 2004).

Detailed discussion of social historical aspects

The selected examples should suffice to demonstrate the social historical potential of Arbon Bleiche 3. We want to expand the work already done from three entry points: a methodological advancement of the distribution analyses, an increased reflection of the epistemological foundations and a systematization and expansion of social historical interpretations.

The existing distribution maps of archaeobiological and archaeological finds have certainly yielded interesting and valid results, yet they can undoubtedly be carried further by multivariate statistics. These can, for example, be used to test the validity of the observed differences as well as expanding existing distribution data to include animal or plant species and artifacts in addition to combinations of parameters. Such procedures will possibly lead to the disclosure of additional findings of social significance. Owing to the precise dating of the houses, in Arbon Bleiche 3 such findings can further be apportioned chronologically, making it possible to include the temporal dimension of object distributions as a further analytical parameter.

A further topic to be addressed concerns our reflective approach to epistemological foundations. Hitherto, many of the above-mentioned premises common in wetland site studies have also been underlying analyses in Arbon: It was assumed, for example, that each house harbors one "family". Yet previous results already contradict some of the premises listed above and so deconstruct the prevalent images of middle-class terraced housing bliss. It is our goal to develop more adequate premises within the scope of our case study and to replace the projected idyll with a new, empirically founded picture.

Further potential lies in a systematic assessment of individual interpretations which hitherto have rarely been interlinked or related to extant premises. For example, it was not discussed how the existence of "hunters' houses" correlates to the premise of each house being inhabited by one "family".

Probing the internal consistency of various interpretations represents a crucial prerequisite for constructing new scenarios. The latter is aided further by broadening the interpretational spectrum – be it by including further categories of analysis, like age or gender, or by taking into account ethnographical data. In a society structured by age-classes, the "hunters' houses" might thus have been the residence of young unmarried men who met their subsistence needs primarily by hunting. The existing interpretation stating economic specialization and division of labor would consequentially be embedded in a social context, highlighting a concern central to our work: to move social historical topics from the periphery into the center of research.

Multivariate statistics as an explorative approach in social historical research

As outlined above, Arbon Bleiche 3 represents a site which is ideally suited for social historical research. Up to now, only few such studies have been conducted, requiring basic groundwork to be done in a first step. As explained in the chapter "Detailed discussion of social historical aspects" (see above), we deem the distribution maps of archaeobiological and archaeological remains to be a good starting point for further analysis by statistical methods. Depending on the problem given, different procedures can be applied. In the course of our study we will test the usefulness of cluster analysis, correspondence analysis, factor analysis and network analysis as well as system dynamics modeling, the latter being especially promising when social and demographic parameters are included in the modeling procedure (Pollmann et al. 2007). In the present paper we will confine ourselves to correspondence analysis and demonstrate its potential for social historical data analysis using two examples (for further applications see Doppler et al. 2010; 2011; forthcoming b; Doppler 2013).

Correspondence analysis as an explorative method

Correspondence analysis allows the fairly simple analysis of large complex sets of data. The empirical raw data is visualized in a graph with two axes (illustration of the correspondence space) which can then be interpreted. The structural interrelationships of the data are protected, the overall data structure becomes easier to comprehend, and the graphical realization of the empirical observations simplifies data analysis. Associations and differences emerge which may be difficult or impossible to detect in the raw data tables. Correspondence analysis offers the possibility to analyze the interdependency of different data and variables and to illustrate the results in a graph. The closer two items are in the correspondence space, the larger their intercorrelation. The arrangement of the data with regard to the axes (called "dimensions") permits conclusions as to which parameters are responsible for the emerging associations. The first dimension explains the largest percentage of the scatter, the second dimension the largest portion of the remaining scatter and so forth. The dimensions therefore show which factors have the greatest influence on the arrangement of the items in the correspondence space. Due to difficulties in displaying the results, only the first two dimensions are depicted in most cases. Dependent of the specific data matrix, however, clearly more than two dimensions are analyzed in correspondence analysis – this in fact constitutes the multidimensionality of the method. The statistical evaluation provides the information on the proportions of the scatter variance significant for interpreting the data set (cf. for instance Shennan 1997).

Correspondence analysis is widely used in archaeology. Its application is, however, mostly limited to chronological issues, mostly in connection with the seriation of grave inventories. Its potential for the detection of associations beyond chronological questions – in the sense of exploratory data analysis – has hardly been realized thus far. The method offers great potential for the analysis of archaeobiological data with regard to social historical issues as demonstrated in first attempts by Hachem (1995, 157–178), Moreno-García et al. (1996), Hüster-Plogmann et al. (1999), Valamoti (2005), Jacomet/Schibler (2006) or Van der Veen (2007).

Social historical analysis: two case studies

As demonstrated above, research in Arbon Bleiche 3 has already shown that the supposed uniformity in archaeobiological and archaeological spectra in all houses hardly conformed to reality. We want to follow up on this observation and illustrate our approach by means of an archaeozoological and an archaeobotanical example while at the same time testing the validity of some of the premises listed in chapter "Implicit premises and latent preconceptions" (see above).

Case study 1: archaeozoological data

In this case study we will explore the question whether the picture of autarkic houses following identical strategies of subsistence really does apply. For this, we have considered archaeozoological data and archaeological artifacts by house to search for correlations between houses, wild and domestic animal bones and hunting tools or methods (bird arrows, flint and bone arrowheads) respectively. As the houses were occupied for unequal time periods, we standardized the house specific data prior to the analysis in order to insure comparability by dividing the number of bones per species in each house as well as the number of artifacts by the number of dendro-years for the specific house (Leuzinger 2000, 51–87). The basis for our calculations are therefore "bone fragments per house year" and "hunting tools per house year" respectively (i.e. find density values; Tab. 1), assuming that houses were in use from the year they were erected until the settlement came to an end.

Based on this data, correspondence analysis reveals that the first two dimensions given in figure 5 add up to explaining almost 70% of the data scatter, which is quite remarkable and enables plausible interpretations. When looking at the graph (Fig. 5) one notices that all wild animals are arranged within or nearby the left upper quadrant.

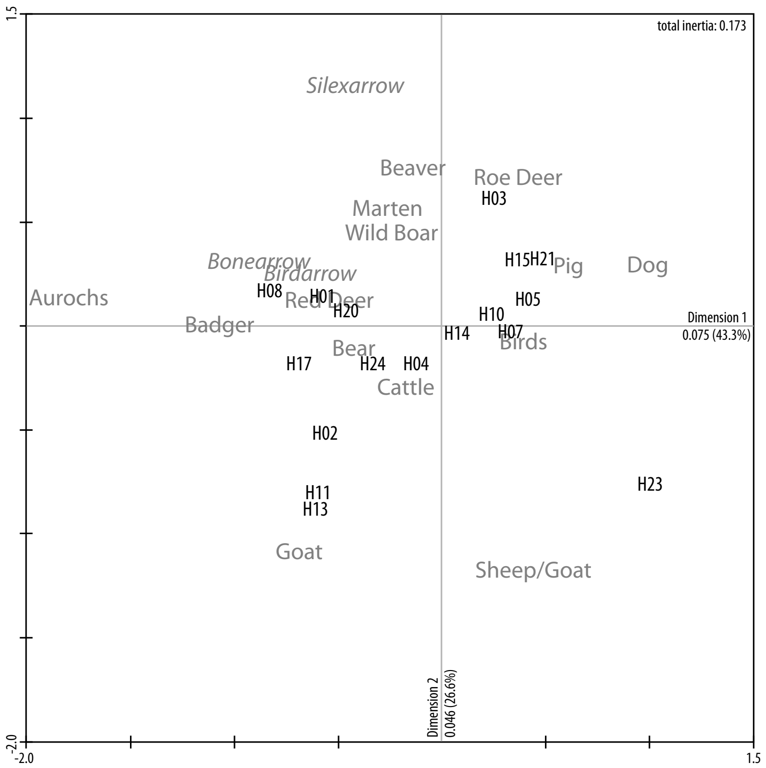

Fig. 5. Correspondence analysis of domestic and selected wild animal species plus hunting tools arranged by houses (H) on the basis of density values (see Table 1); symmetrical diagram. Total inertia 0.173. The 1st and 2nd dimensions combined explain 69.9% of the data scatter. Canoco 4.5 software.

Abb. 5. Korrespondenzanalyse der Haustier- sowie ausgewählter Wildtierarten und Jagdgeräte nach Häusern (H) auf Grundlage von Dichtewerten (vgl. Tab. 1), symmetrische Darstellung. Gesamtträgheit: 0.173. Abgebildet sind die 1. und die 2. Dimension, die zusammen 69.9% der Streuung in den Daten erklären. Die Analyse wurde mit Canoco 4.5 durchgeführt.

QUANTITY (bone fragments)	Cattle	Pig	Sheep	Goat	Sheep/Goat	Dog	Red Deer	Aurochs	Roe Deer	Wild Boar	Bear	Badger	Marten	Beaver	Birds	Silexarrow	Birdarrow	Bonearrow	sum
H01	254	191	3	4	39	6	332	1	15	92	13	1	4	4	8	0	7	1	**975**
H02	357	172	34	21	101	2	396	4	20	108	20	1	7	8	6	0	0	2	**1259**
H03	852	2455	15	9	133	47	1370	2	105	464	155	4	16	44	41	7	12	6	**5737**
H04	458	508	42	10	147	5	501	6	27	190	25	2	9	5	28	2	4	6	**1975**
H05	277	543	14	7	74	13	249	0	14	63	10	0	7	5	9	0	4	1	**1290**
H07	160	273	16	5	46	10	115	1	4	55	2	13	3	3	6	1	3	3	**719**
H08	324	343	5	4	86	6	694	35	3	155	49	18	5	13	12	3	10	10	**1775**
H10	112	113	0	2	8	0	31	0	3	19	6	0	0	1	0	1	0	1	**297**
H11	130	63	3	12	50	0	128	3	1	17	11	0	1	1	1	0	1	0	**422**
H13	358	164	29	23	124	0	339	3	2	47	99	8	0	1	2	0	8	3	**1210**
H14	358	457	14	18	85	22	284	4	15	118	35	3	1	8	10	1	3	0	**1436**
H15	183	500	12	9	58	20	226	2	19	83	41	4	4	5	7	1	4	1	**1179**
H17	34	21	0	0	8	0	45	1	2	3	4	0	0	1	0	0	0	0	**119**
H20	397	397	8	7	67	12	498	16	9	127	20	25	4	8	11	2	4	4	**1616**
H21	73	139	3	1	15	17	62	0	2	26	8	0	0	6	4	0	2	2	**360**
H23	279	648	70	3	222	22	140	0	9	35	11	2	0	3	18	0	0	0	**1462**
H24	114	174	7	9	63	3	268	0	5	29	12	0	0	5	5	0	0	0	**694**
sum	**4720**	**7161**	**275**	**144**	**1326**	**185**	**5678**	**78**	**255**	**1631**	**521**	**81**	**61**	**121**	**168**	**18**	**62**	**40**	**22525**

DENSITY	Cattle	Pig	Sheep	Goat	Sheep/Goat	Dog	Red Deer	Aurochs	Roe Deer	Wild Boar	Bear	Badger	Marten	Beaver	Birds	Silexarrow	Birdarrow	Bonearrow	house years
H01	16.93	12.73	0.20	0.27	2.60	0.40	22.13	0.07	1.00	6.13	0.87	0.07	0.27	0.27	0.53	0.00	0.47	0.07	**15**
H02	25.50	12.29	2.43	1.50	7.21	0.14	28.29	0.29	1.43	7.71	1.43	0.07	0.50	0.57	0.43	0.00	0.00	0.14	**14**
H03	60.86	175.36	1.07	0.64	9.50	3.36	97.86	0.14	7.50	33.14	11.07	0.29	1.14	3.14	2.93	0.50	0.86	0.43	**14**
H04	38.17	42.33	3.50	0.83	12.25	0.42	41.75	0.50	2.25	15.83	2.08	0.17	0.75	0.42	2.33	0.17	0.33	0.50	**12**
H05	23.08	45.25	1.17	0.58	6.17	1.08	20.75	0.00	1.17	5.25	0.83	0.00	0.58	0.42	0.75	0.00	0.33	0.08	**12**
H07	13.33	22.75	1.33	0.42	3.83	0.83	9.58	0.08	0.33	4.58	0.17	1.08	0.25	0.25	0.50	0.08	0.25	0.25	**12**
H08	27.00	28.58	0.42	0.33	7.17	0.50	57.83	2.92	0.25	12.92	4.08	1.50	0.42	1.08	1.00	0.25	0.83	0.83	**12**
H10	9.33	9.42	0.00	0.17	0.67	0.00	2.58	0.00	0.25	1.58	0.50	0.00	0.00	0.08	0.00	0.08	0.00	0.08	**12**
H11	10.83	5.25	0.25	1.00	4.17	0.00	10.67	0.25	0.08	1.42	0.92	0.00	0.08	0.08	0.08	0.00	0.08	0.00	**12**
H13	29.83	13.67	2.42	1.92	10.33	0.00	28.25	0.25	0.17	3.92	8.25	0.67	0.00	0.08	0.17	0.00	0.67	0.25	**12**
H14	32.55	41.55	1.27	1.64	7.73	2.00	25.82	0.36	1.36	10.73	3.18	0.27	0.09	0.73	0.91	0.09	0.27	0.00	**11**
H15	16.64	45.45	1.09	0.82	5.27	1.82	20.55	0.18	1.73	7.55	3.73	0.36	0.36	0.45	0.64	0.09	0.36	0.09	**11**
H17	3.09	1.91	0.00	0.00	0.73	0.00	4.09	0.09	0.18	0.27	0.36	0.00	0.00	0.09	0.00	0.00	0.00	0.00	**11**
H20	56.71	56.71	1.14	1.00	9.57	1.71	71.14	2.29	1.29	18.14	2.86	3.57	0.57	1.14	1.57	0.29	0.57	0.57	**7**
H21	9.13	17.38	0.38	0.13	1.88	2.13	7.75	0.00	0.25	3.25	1.00	0.00	0.00	0.75	0.50	0.00	0.25	0.25	**8**
H23	39.86	92.57	10.00	0.43	31.71	3.14	20.00	0.00	1.29	5.00	1.57	0.29	0.00	0.43	2.57	0.00	0.00	0.00	**7**
H24	16.29	24.86	1.00	1.29	9.00	0.43	38.29	0.00	0.71	4.14	1.71	0.00	0.00	0.71	0.71	0.00	0.00	0.00	**7**

Table 1. Quantity and density data of the archaeozoological case study.

Tabelle. 1. Stückzahlen und Dichtewerte des archäozoologischen Fallbeispiels.

The hunting tools also concentrate around this area, illustrating the close association of prey animals and hunting tools. It is also interesting to look at individual houses. We see that houses no. 1, 8 and 20 are arranged with the wild animals and hunting tools, indicating that these houses seem to be closely associated with hunting activities and possibly also the processing of wild animals. Against this background, house 23, located in the lower right quadrant, stands out clearly and hints at a very different association: a close correlation with domestic sheep. Further conspicuous patterns are evident in houses no. 5, 7 and 15, which are arranged near the domestic pigs, or houses no. 11 and 13, which are correlated with goats. Even these few findings suffice to contradict the presumed uniformity of all houses.

Case study 2: archaeobotanical data

Conspicuous and significant differences emerge from our analysis of the archaeozoological data. In a second step, we will test the archaeobotanical data for similar discrepancies. We deemed it useful to analyse domestic plants in combination with weeds of cultivation (cf. specifications in Hosch/Jacomet 2004, 120–138). In doing so we had two objectives. On the one hand we tried to find out whether the statistical analysis would confirm or disprove the presumed lack of differences in the spectra of cultivated plants in all the houses of waterlogged sites. On the other hand, we wanted to investigate possible associations between cultivated plants and certain weeds, and whether differing exploitation patterns among houses or house groups might possibly emerge by analysing house-specific weed spectra.

Archaeobotanical samples were not collected from all the houses, so the archaeobotanical data involves a different number of houses than the previous analysis (Fig. 6). As botanical samples are based on units with different sample volumes, we again had to standardize the plant spectra of the individual houses prior to our analysis by dividing the number of items in each group of plants by the volume of all the samples from the specific house. The density values thus obtained are the basis for the correspondence analysis. Because the archaeobotanical samples penetrated the occupation layer to different depths, unlike in the first case study we were not able to incorporate the house years in our analysis. Some plant remains are preserved both charred and uncharred. As charred remains are mostly present in low quantities only, we have included these with the uncharred plant remains (Tab. 2).

Our first calculations yielded quite interesting results (Fig. 7) with the first two dimensions explaining 76.2 % of the data scatter (dimension 1: 47.6%; dimension 2: 28.6%). There was a distinct separation of the threshing remains of barley (*Hordeum vulgare*; HOVUL-c) and wheat (*Triticum* sp; TRDIC-c, TRAED-c, TRMOC-c). Furthermore, most weeds of cultivation were grouped with the threshing remains of wheat. There was also a promising association of remains of flax (*Linum usitatissimum*; LIUSI-c) processing and Cretan catchfly (*Silene cretica*; SICRE), a naturally co-occurring weed species. The overall impression seemed to indicate clear differences between specific houses.

However, a detailed discussion of the results soon raised questions on their taphonomic stability. The clear differences between the threshing remains of barley (HOVUL-c) and wheat posed special problems. Threshing remains of barley are much more fragile than those of wheat – especially when uncharred – and they disintegrate under little mechanical influence. This led us to suspect that our analysis may have produced a distorted picture – caused by the differing robustness of the charred and uncharred threshing remains of barley.

In order to test this we ran a second analysis which only considered uncharred threshing remains and the already uncharred weeds (Tab. 3). Even though the first two dimensions again explained a vast portion, i.e. 88.3%, of the data scatter (dimension 1: 62.1%; dimension 2: 26.2%), a vastly different picture emerged (Fig. 8). The disassociation of the threshing remains of barley and wheat, which had been so apparent in our fist analysis, was no longer there, neither was the association of flax and Cretan catchfly. These results clearly show that the archaeobotanical data does in fact incorporate a taphonomic bias.

Fig. 6. Soil samples for analyses of archaeobotanical, small animal and fish remains were collected from 9 houses (blue shading), equal to about 1/3 of the excavated area.

Abb. 6. Bodenproben zur Analyse von pflanzlichen Resten, Kleintier- und Fischknochen wurden in 9 Häusern entnommen (blau hervorgehoben), was ca. 1/3 der ergrabenen Siedlungsfläche entspricht.

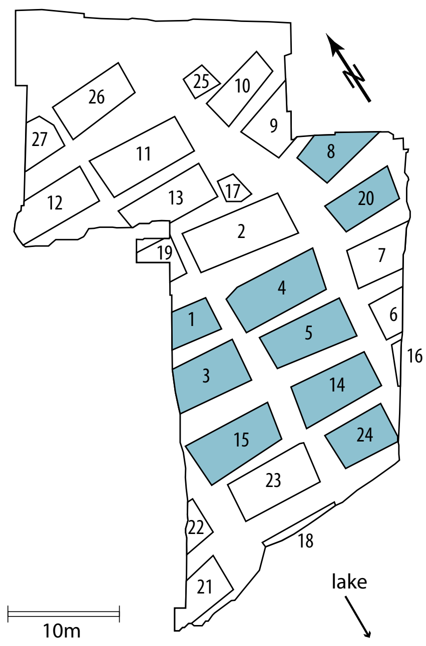

Table 2. Archaeobotanical data used in calculation of Fig. 7.
Tabelle. 2. Die archäobotanischen Daten zur Berechnung von Abb. 7.

category	scientific notation	english notation	code	QUANTITY (raw data) houses									DENSITY (raw data/sample volume) houses								
				H01	H03	H04	H05	H08	H14	H15	H20	H24	H01	H03	H04	H05	H08	H14	H15	H20	H24
cultivated plants	*Linum usitatissimum*	flax (seeds)	LIUSI-s	11007	39616	19355	22280	6531	24135	33838	10801	12884	1.21356	0.86122	1.29899	1.42364	2.17700	1.76168	0.75700	1.72816	1.03072
	Linum usitatissimum	flax (capsules)	LIUSI-c	2	3996	2777	1211	1792	6952	3971	1580	8126	0.00022	0.08687	0.18638	0.07738	0.59733	0.50745	0.08884	0.25280	0.65008
	Papaver somniferum	opium poppy (seeds)	PASOM-s	13923	12859	14471	22307	5376	12354	7449	3188	11274	1.53506	0.27954	0.97121	1.42537	1.79200	0.90175	0.16664	0.51008	0.90192
	Hordeum vulgare	barley (grains)	HOVUL-g	40	37	14	12	6	10	49	7	109	0.00441	0.00080	0.00094	0.00077	0.00200	0.00073	0.00110	0.00112	0.00872
	Hordeum vulgare	barley (chaff)	HOVUL-c	90	31	11	5	1	18	90	3	33	0.00992	0.00067	0.00074	0.00032	0.00033	0.00131	0.00201	0.00048	0.00264
	Triticum aestivum/durum/turgidum	wheat (grains)	TRAED-g	19	22	13	11	5	15	66	0	24	0.00209	0.00048	0.00087	0.00070	0.00167	0.00109	0.00148	0.00000	0.00192
	Triticum aestivum/durum/turgidum	wheat (chaff)	TRAED-c	7	845	3134	28	517	802	1720	21	1057	0.00077	0.01837	0.21034	0.00179	0.17233	0.05854	0.03848	0.00336	0.08456
	Triticum dicoccum	emmer (grains)	TRDIC-g	0	2	0	0	0	6	0	0	1	0.00000	0.00004	0.00000	0.00000	0.00000	0.00044	0.00000	0.00000	0.00008
	Triticum dicoccum	emmer (chaff)	TRDIC-c	11	1631	290	59	836	992	1779	9	1737	0.00121	0.03546	0.01946	0.00377	0.27867	0.07241	0.03980	0.00144	0.13896
	Triticum monococcum	einkorn (chaff)	TRMOC-c	0	0	2	2	1	167	1	0	76	0.00000	0.00000	0.00013	0.00013	0.00033	0.01219	0.00002	0.00000	0.00608
	Pisum sativum	pea (seeds)	PISAT-s	1	2	3	0	0	1	0	0	0	0.00011	0.00004	0.00020	0.00000	0.00000	0.00007	0.00000	0.00000	0.00000
wild plants	*Arctium spec./minus/tomentosum*	burr	ARCT	0	12	6	2	3	19	5	2	16	0.00000	0.00026	0.00040	0.00013	0.00100	0.00139	0.00011	0.00032	0.00128
	Camelina spec.	false flax	CAME	0	0	0	0	0	4	1	1	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00029	0.00002	0.00016	0.00064
	Campanula rapunculoides	bellflower	CARAP	0	1	1	0	1	3	0	0	6	0.00000	0.00002	0.00007	0.00000	0.00033	0.00022	0.00000	0.00000	0.00048
	Chenopodium polyspermum	manyseed goosefoot	CHPOL	0	0	0	1	0	1	1	0	2	0.00000	0.00000	0.00000	0.00006	0.00000	0.00007	0.00002	0.00000	0.00016
	Fallopia convolvulus	climbing bindweed	POLCO	0	2	3	4	0	1	4	5	9	0.00000	0.00004	0.00020	0.00026	0.00000	0.00007	0.00009	0.00080	0.00072
	Galeopsis tetrahit	common hemp-nettle	GATET	1	5	0	0	0	2	1	0	0	0.00011	0.00011	0.00000	0.00000	0.00000	0.00015	0.00002	0.00000	0.00000
	Lapsana communis	common nipplewort	LACOM	7	895	7	257	3	379	213	80	35	0.00077	0.01946	0.00047	0.01642	0.00100	0.02766	0.00477	0.01280	0.00280
	Moehringia trinervia	three-nerved sandwort	MOTRI	3	15	101	17	1	19	11	5	52	0.00033	0.00033	0.00678	0.00109	0.00033	0.00139	0.00025	0.00080	0.00416
	Nepeta cataria	catnip	NECAT	1	2	0	0	0	0	2	0	0	0.00011	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004	0.00000	0.00000
	Polygonum aviculare	common knotgrass	POAVI	0	12	1	2	0	4	0	0	5	0.00000	0.00026	0.00007	0.00013	0.00000	0.00029	0.00000	0.00000	0.00040
	Polygonum persicaria	redshank	POPER	0	2	0	1	1	4	0	0	4	0.00000	0.00004	0.00000	0.00006	0.00033	0.00029	0.00000	0.00000	0.00032
	Ranunculus repens	buttercup	RAREP	3	5	2	2	0	7	15	1	21	0.00033	0.00011	0.00013	0.00013	0.00000	0.00051	0.00034	0.00016	0.00168
	Rumex conglomeratus	clustered dock	RUCON	0	0	0	0	0	0	1	0	1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00000	0.00008
	Rumex crispus	curled dock	RUCRI	0	0	0	0	0	0	0	1	1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00016	0.00008
	Silene alba	white campion	SIALB	1	1	3	4	0	7	1	11	10	0.00011	0.00002	0.00020	0.00026	0.00000	0.00051	0.00002	0.00176	0.00080
	Silene cretica	Cretan catchfly	SICRE	13	6	174	15	3	132	6	114	328	0.00143	0.00013	0.01168	0.00096	0.00100	0.00964	0.00013	0.01824	0.02624
	Solanum nigrum	black nightshade	SONIG	0	0	1	0	1	1	1	1	7	0.00000	0.00000	0.00007	0.00000	0.00033	0.00007	0.00002	0.00016	0.00056
	Sonchus asper	prickly sow-thistle	SOASP	0	2	0	4	0	7	2	1	2	0.00000	0.00004	0.00000	0.00026	0.00000	0.00051	0.00004	0.00016	0.00016
	Stellaria media	chickweed	STMED	1	1	2	0	0	0	1	0	1	0.00011	0.00002	0.00013	0.00000	0.00000	0.00000	0.00002	0.00000	0.00008
	Urtica dioica	stinging nettle	URDIO	5	2	6	2	1	5	6	1	6	0.00055	0.00004	0.00040	0.00013	0.00033	0.00036	0.00013	0.00016	0.00048
	Valerianella dentata	narrowfruit cornsalad	VADEN	0	1	0	0	0	2	0	1	1	0.00000	0.00002	0.00000	0.00000	0.00000	0.00015	0.00000	0.00016	0.00008
	Verbascum spec.	mullein	VERB	0	0	0	0	0	4	0	0	3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00029	0.00000	0.00000	0.00024
	Viola tricolor	heartsease	VITRI	1	0	0	0	0	0	0	0	1	0.00011	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00008
		sample volume (ml)		9070	46000	14900	15650	3000	13700	44700	6250	12500									

Table 3. Archaeobotanical data used in calculation of Fig. 8.
Tabelle 3. Die archäobotanischen Daten zur Berechnung von Abb. 8.

category	scientific notation	english notation	code	QUANTITY (raw data) houses								DENSITY (raw data/sample volume) houses							
				H03	H04	H05	H08	H14	H15	H20	H24	H03	H04	H05	H08	H14	H15	H20	H24
cultivated plants	*Linum usitatissimum*	flax (capsules)	LIUSI-c	3994	2777	1210	1792	6952	3970	1580	8122	0.08683	0.18638	0.07732	0.59733	0.50745	0.08881	0.25280	0.64976
	Hordeum vulgare	barley (chaff)	HOVUL-c	2	3	0	0	2	16	0	8	0.00004	0.00020	0.00000	0.00000	0.00015	0.00036	0.00000	0.00064
	Triticum aestivum/durum/turgidum	wheat (chaff)	TRAED-c	408	7	1	512	717	869	4	810	0.00887	0.00047	0.00006	0.17067	0.05234	0.01944	0.00064	0.06480
	Triticum dicoccum	emmer (chaff)	TRDIC-c	771	283	2	832	983	1302	5	1729	0.01676	0.01899	0.00013	0.27733	0.07175	0.02913	0.00080	0.13832
	Triticum monococcum	einkorn (chaff)	TRMOC-c	0	0	0	0	166	0	0	71	0.00000	0.00000	0.00000	0.00000	0.01212	0.00000	0.00000	0.00568
wild plants	*Arctium spec./minus/tomentosum*	burr	ARCT	12	6	2	3	19	5	2	16	0.00026	0.00040	0.00013	0.00100	0.00139	0.00011	0.00032	0.00128
	Camelina spec.	false flax	CAME	0	0	0	0	4	1	1	8	0.00000	0.00000	0.00000	0.00000	0.00029	0.00002	0.00016	0.00064
	Campanula rapunculoides	bellflower	CARAP	1	1	0	1	3	0	0	6	0.00002	0.00007	0.00000	0.00033	0.00022	0.00000	0.00000	0.00048
	Chenopodium polyspermum	manyseed goosefoot	CHPOL	0	0	1	0	1	1	0	2	0.00000	0.00000	0.00006	0.00000	0.00007	0.00002	0.00000	0.00016
	Fallopia convolvulus	climbing bindweed	POLCO	2	3	4	0	1	4	5	9	0.00004	0.00020	0.00026	0.00000	0.00007	0.00009	0.00080	0.00072
	Galeopsis tetrahit	common hemp-nettle	GATET	5	0	0	0	2	1	0	0	0.00011	0.00000	0.00000	0.00000	0.00015	0.00002	0.00000	0.00000
	Lapsana communis	common nipplewort	LACOM	895	7	257	3	379	213	80	30	0.01946	0.00047	0.01642	0.00100	0.02766	0.00477	0.01280	0.00240
	Moehringia trinervia	three-nerved sandwort	MOTRI	15	101	17	1	19	11	5	52	0.00033	0.00678	0.00109	0.00033	0.00139	0.00025	0.00080	0.00416
	Nepeta cataria	catnip	NECAT	2	0	0	0	0	2	0	0	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004	0.00000	0.00000
	Polygonum aviculare	common knotgrass	POAVI	12	1	2	0	4	0	0	5	0.00026	0.00007	0.00013	0.00000	0.00029	0.00000	0.00000	0.00040
	Polygonum persicaria	redshank	POPER	2	0	1	1	4	0	0	4	0.00004	0.00000	0.00006	0.00033	0.00029	0.00000	0.00000	0.00032
	Ranunculus repens	buttercup	RAREP	5	2	2	0	7	15	1	21	0.00011	0.00013	0.00013	0.00000	0.00051	0.00034	0.00016	0.00168
	Rumex conglomeratus	clustered dock	RUCON	0	0	0	0	0	1	0	1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00000	0.00008
	Rumex crispus	curled dock	RUCRI	0	0	0	0	0	0	1	1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00016	0.00008
	Silene alba	white campion	SIALB	1	3	4	0	7	1	11	10	0.00002	0.00020	0.00026	0.00000	0.00051	0.00002	0.00176	0.00080
	Silene cretica	Cretan catchfly	SICRE	6	174	15	3	132	6	114	328	0.00013	0.01168	0.00096	0.00100	0.00964	0.00013	0.01824	0.02624
	Solanum nigrum	black nightshade	SONIG	0	1	0	1	1	1	1	7	0.00000	0.00007	0.00000	0.00033	0.00007	0.00002	0.00016	0.00056
	Sonchus asper	prickly sow-thistle	SOASP	2	0	4	0	7	2	1	2	0.00004	0.00000	0.00026	0.00000	0.00051	0.00004	0.00016	0.00016
	Stellaria media	chickweed	STMED	1	2	0	0	0	1	0	1	0.00002	0.00013	0.00000	0.00000	0.00000	0.00002	0.00000	0.00008
	Urtica dioica	stinging nettle	URDIO	2	6	2	1	5	6	1	6	0.00004	0.00040	0.00013	0.00033	0.00036	0.00013	0.00016	0.00048
	Valerianella dentata	narrowfruit cornsalad	VADEN	1	0	0	0	2	0	1	1	0.00002	0.00000	0.00000	0.00000	0.00015	0.00000	0.00016	0.00008
	Verbascum spec.	mullein	VERB	0	0	0	0	4	0	0	3	0.00000	0.00000	0.00000	0.00000	0.00029	0.00000	0.00000	0.00024
			sample volume (ml)	46000	14900	15650	3000	13700	44700	6250	12500								

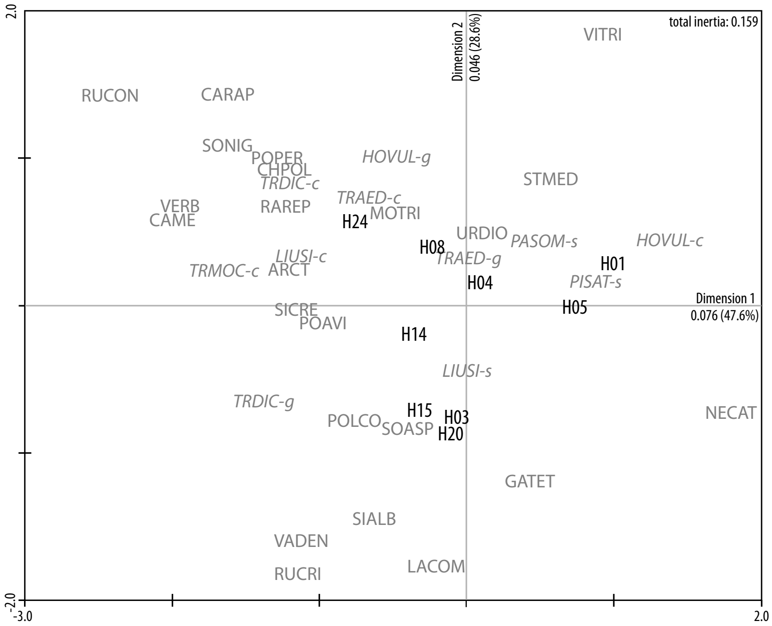

Fig. 7. Correspondence analysis of cultivated plants and cultivation weeds based on density values and arranged by houses (H); charred and uncharred remains (see Tab. 2 for code of plant names); symmetrical diagram. Total inertia 0.159. The 1st and 2nd dimensions combined explain 76.2% of the data scatter. Canoco 4.5 software.

Abb. 7: Korrespondenzanalyse von Kulturpflanzen und Ackerunkräutern nach Häusern (H) auf Grundlage von Dichtewerten – verkohlte und unverkohlte Reste (für die Kodierung der Pflanzennamen s. Tab. 2), symmetrische Darstellung. Gesamtträgheit: 0.159. Abgebildet sind die 1. und die 2. Dimension, die zusammen 76.2% der Streuung in den Daten erklären. Die Analyse wurde mit der Software Canoco 4.5 durchgeführt.

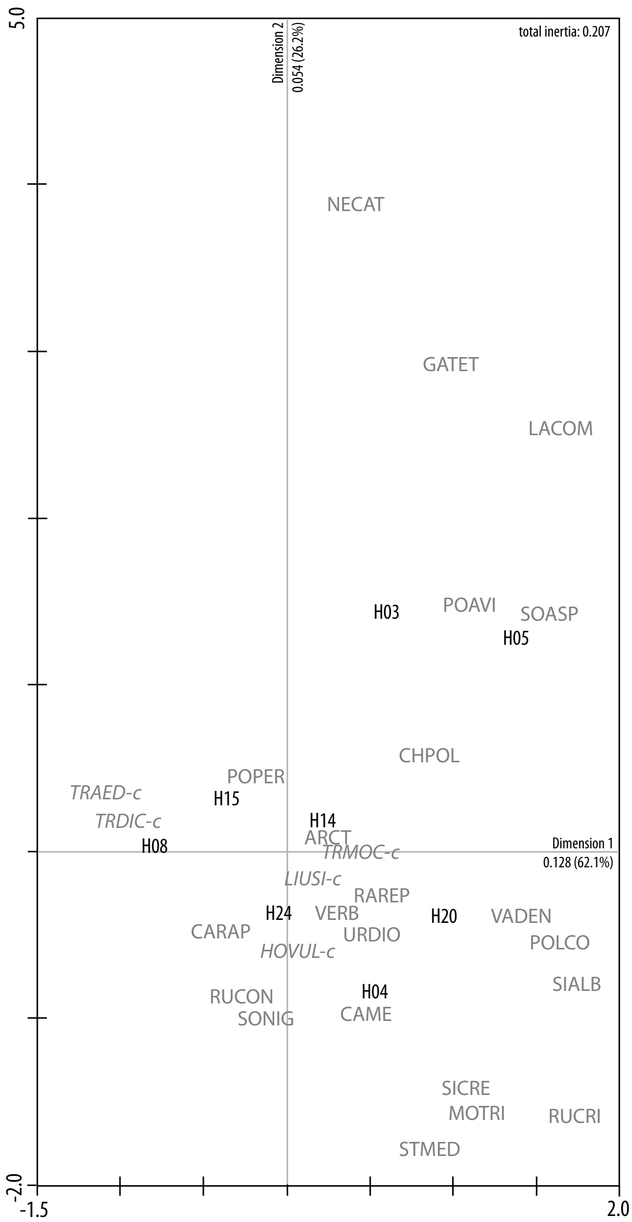

Fig. 8. Correspondence analysis of cultivated plants and cultivation weeds based on density values and arranged by houses (H); uncharred remains (see Tab. 3 for code of plant names); symmetrical diagram. Total inertia 0.207. The 1st and 2nd dimensions combined explain 88.3% of the data scatter. Canoco 4.5 software.

Abb. 8. Korrespondenzanalyse von Kulturpflanzen und Ackerunkräutern nach Häusern (H) auf Grundlage von Dichtewerten – unverkohlte Reste (für die Kodierung der Pflanzennamen s. Tab. 3), symmetrische Darstellung. Gesamtträgheit: 0.207. . Abgebildet sind die 1. und die 2. Dimension, die zusammen 88.3% der Streuung in den Daten erklären. Die Analyse wurde mit der Software Canoco 4.5 durchgeführt.

Discussion

The results from the two case studies bear on two different levels: the level of social historical interpretation and the level of method development, both of which we will discuss in the following. Let us first take a look at the social historical conclusions which are the result of the statistical evaluation.

Social historical results

The statistical analysis of archaeozoological data and hunting tools (see above, chapter "Case study 1: archaeozoological data") revealed not only distinct differences but also similarities and correlations between certain houses, animal species and hunting tools. The differences between houses with regard to hunting tools and animals suggest differences in economic self-supply. If, based on the statistical results, we accept that different subsistence strategies existed within one settlement, this would then imply that individual households or specific social groups (structured, for example, by age or gender) might have used different landscapes or animal resources in discrete ways. It is also conceivable that other social practices are behind the observed distribution patterns, like specialization in the sense of a division of labor, or landscape use limited by socially restricted access rights. At all events, these observations challenge the widely held assumption that all households in wetland sites follow identical subsistence strategies (see above, chapter "Implicit premises and latent preconceptions", premise no. 8).

The statistical results also challenge premise no. 4 stating that each house harbors one household. Against this background, houses no. 11 and 13 stand out because they cluster closely in the correspondence space (Fig. 5) and therefore exhibit great similarities with regard to the relevant data. Concerning the issues of "houses" and "households" or "residential groups" respectively, this raises the question whether these groups of houses do not represent units functioning as economic entities. Houses no. 11 and 13 are immediately adjacent and were erected in the same year (Fig. 4) – facts that might, in view of our commonly held western concept of household, represent further evidence for this hypothesis .

Yet another variant becomes evident in houses no. 8 and 20, which again are immediately adjacent and reflect similar activities but which were built in the space of some years. This situation also provides valid arguments in favor of addressing these houses as one jointly managed household. One must not disregard the fact that households are by no means static entities but that they grow or shrink as a result of demographic or social dynamics. In the present case, households are understood as representing houses which appear similar. A different yet equally valid approach may state that several complementary houses form one household. Archaeologically, such houses would present unequal inventories, while in correspondence analysis they would appear as points lying well apart in the graphical display. In such cases, the identification of "individual household styles" of ceramics (cf. Pétrequin et al. 1994) may supply a basis for identifying groups of houses as jointly operating households.

While statistical analyses of archaeozoological remains yield numerous new insights (Doppler et al. 2010; 2011; 2012; forthcoming a & b; Doppler 2013), valid results for the tested parameters could not be compiled by correspondence analysis of the archaeobotanical remains of the Arbon Bleiche 3 settlement. We explain this phenomenon with a distinct taphonomic bias that massively affects the archaeobotanical database. The issues we addressed, namely the differences and association between cultured plants and weeds, can therefore not be resolved or interpreted in a social historical context. This confirms our observation from in chapter "Archaeozoology and archaeobotany" (see above) that social historical investigations of archaeobotanical remains represent a much greater challenge than those of animal bones.

Methodological results

The "negative" results obtained with the archaeobotanical data in the correspondence analysis are all the more surprising if one considers the high explanatory percentage indicated by the first two dimensions. If these supposedly significant results are of no social historical significance, however, how must they be interpreted? Can valid interpretations be achieved if different methodical approaches are used, or other research questions asked, or other associations are sought for? The given situation in which our approach yields conclusive results for the archaeozoological but not for the archaeobotanical data represents a methodological challenge which we will have to meet in the future. Our current state of knowledge identifies two central problems to be addressed: the effect of taphonomic processes and the sampling strategies for archaeobotanical remains.

Starting with taphonomy, it is evident that – in spite of the excellent overall preservation and the *in situ* findings of artifacts and biofacts – taphonomic issues play a much greater role in Arbon Bleiche 3 than previously anticipated. These issues do not relate to object sedimentation and displacement but rather concern hitherto neglected considerations of the differential preservation and stability of subfossil or charred plant species or parts thereof. Not only do large-scale taphonomic aspects have to be considered, which are fairly straightforward to assess, but miscellaneous small-scale influences must also be observed.

Applying the concepts of *Middle-Range Theory* (Binford 1977; Schiffer 1987), one perceives that archaeobotanical remains are subject to other filter mechanisms than animal bones. Regardless of the c-transformation (active, diversely motivated cultural selection processes) acting on both categories of finds, the subsequent taphonomic processes – the n-transformation – appears to affect the various archaeobotanical remains in a more differentiated manner than it affects the faunal remains. The commonly held assumption that taphonomy acts upon archaeobotanical and archaeozoological remains in the same way is therefore inaccurate. Further bias is introduced by botanical sample preparation procedures (Hosch/Zibulski 2003).

It is precisely the excellent preservation of botanical remains which alerts us to possible taphonomic distortions and introduces new methodological challenges. By contrast, investigations of sites in mineral soil, which mostly contain restricted spectra of predominantly charred threshing remains and weeds, seem less problematic (Bogaard 2004). Against this background, one might consider charred remains only in Arbon Bleiche 3. This would, however, mean disregarding the special potential of the excellent preservation. If one considers that – with the exception of cereal grains – only an estimated 2.5 % of the original plant remains are preserved charred (Hosch/Jacomet 2004, 116), such a *modus operandi* seems hardly appropriate.

The taphonomic effects we observed point out the necessity of thoroughly considering all such processes separately for each category of finds. For the archaeozoological remains in Arbon Bleiche 3, taphonomic processes have already been discussed in detail. Compared with botanical remains, animal bones have great advantages with regard to their preservation. Under favorable conditions, burnt and unburnt bones of large and small animals are no different in wetland sites. Neither is there the methodological question of sampling which affects archaeobotanical and microzoological remains. Animal bones are systematically and extensively hand collected like other archaeological artifacts in the course of an excavation. Calculations of the bone shrinkage showed that the amounts of excavated animal bones represent the food waste of several years rather than the terminal phase of occupation only (Deschler-Erb/Marti-Grädel 2004a, 99), making it possible to introduce the chronological staggering of the houses and thus the settlement dynamics (on the basis of the different lengths of occupation for each house). All of these considerations permit us to conclude that little taphonomic distortion affected the hand collected archaeozoological remains in Arbon Bleiche 3. Explorative analyses of animal bones (in combination with archaeological artifacts) therefore allow plausible results and interpretations.

In principle, we attach the same importance to archaeobotanical and archaeozoological remains as information sources. However, the analysis of archaeobotanical data remains problematic because data-specific taphonomic issues have not yet been fully realized for Arbon Bleiche 3. Over the course of our research, these data may still serve to corroborate findings from archaeozoological and artefactual investigations. Generally speaking, explorative analyses of archaeobotanical data are most promising if and when a site exhibits a homogenous taphonomic situation, for example as a result of an extensive conflagration, and if the site was representatively sampled. This given, one may assume an *in situ* situation able to yield undistorted and plausibly interpretable results. That permits the archaeobotanical remains to be interpreted on the lines of the archaeozoological ones so that special attention can be devoted to the socially determined cultural selection, which is always more difficult to estimate. The burnt layer of the Hornstaad Hörnle IA (D) site, also situated on Lake Constance, seems a promising candidate for such an approach as the archaeobotanical remains have already been intensively investigated there (Maier 2001).

The second problem identified in our study concerns the effect of different sampling strategies on the data. Analyses of archaeobotanical and microzoological remains are based on a selection of the houses only, because not all the houses were sampled (Fig. 6). As a result, a much smaller segment of the settlement can be monitored as compared to objects collected from the whole excavated area. Furthermore, there are also methodological problems with archaeobotanical sampling, for example different individuals taking the samples, varying sample volumes and sampled areas or layer thickness (cf. Jacomet/Brombacher 2005). Not least due to these shortcomings we were unable to factor the length of occupation for the individual houses in the standardization of the archaeobotanical data.

These observations can provide valuable suggestions for future excavations. In order to enable social historical investigations of archaeobotanical data, not only should the complete area be systematically sampled, but standardized sampling strategies should also be employed, like sampling by few individuals, sampling the whole depth of the settlement layer, or sampling clearly defined occupation layers respectively. Such strategies need to be implemented in close collaboration of all disciplines involved. The wetland site Bad Buchau – Torwiesen II on Federsee Lake (D) was comprehensively and systematically sampled (Schlichtherle et al. 2010; 2011) and will be certain to produce ground-breaking results in the near future.

Conclusions

A central premise of Neolithic and Bronze Age lakeside archaeology maintains that the uniformly organized grid-like settlements with houses of nearly identical size and construction must needs be equally homological in socio-economic and demographic matters. The case study of the Arbon Bleiche 3 Neolithic site highlights the fact that this premise is wrong. Equally flawed is the idea that each house represents a kind of "nucleus of society" inhabited by a standardized nuclear family of five who operated as an autarkic household, and that all households followed identical subsistence strategies. Such assumptions are not based on empirical research but rather represent projections of Western bourgeois nuclear family and household standards onto prehistory; standards which we perceive as "natural" or "original" due to strategies of justifications and legitimization constructed in the 18th and 19th centuries (Röder 2004; 2007; 2010). Shifting social historical issues from the margin into the focus of research has thus induced distinct cracks in the picture of bourgeois row house idylls.

If one leaves such projections aside and instead taps the social historical potential offered by the excellent data base in waterlogged sites, wholly new perspectives emerge.

We have been able to show that such results are directly dependent on three prerequisites: that the settlement be excavated to a large extent, that there be a high resolution archaeobiological record, both chronologically (vertically) and horizontally, and that data be collected systematically and in utmost detail during the excavation. An additional prerequisite is that the archaeobiological remains are considered from the start and are conjointly analyzed with the archaeological data. It is vitally important that these analyses are not conducted independently of one another but are embedded in the interdisciplinary framework of a closely collaborating group of researchers. Only then does it become possible to develop mutual research questions and premises, coherent theoretical approaches, stringent methodological procedures and subsequently to reach consistent cultural interpretations of the results. In addition, this type of research design not only provides ideal conditions for formulating new research questions but also gives impetus to the development of theory and methods. It also furthers an epistemologically reflexive approach because it requires the epistemological foundations of each discipline involved to be made explicit in order to enable the individual researchers to enter into a productive dialogue.

Next to the outlined research setting, our case study proved the usefulness and productivity of the methodological approach selected. The results of the correspondence analyses have greatly changed our view of Neolithic communities, a view which had previously been shaped to a large extent by our disciplinary socialization. It is striking that in Arbon differences in the spectrum of finds emerge much more clearly than the comparative homogeneity of a few houses. This shows that the archaeologically prevailing image of prehistoric communities is too simplistic. On the one hand this may be due to the fact that archaeology is ultimately confronted with thanatocoenoses which comprise rudimentary material remains left behind by former communities and in their rudimentariness suggest conditions of little complexity. On the other hand, topical everyday beliefs of supposedly primeval social conditions become manifest here, the attraction of which not least lies in their seeming simplicity and straightforwardness – values appearing almost idyllic in view of the complexity of our own everyday lives. Instead of archaeological thanatocoenoses and everyday beliefs, research issues and premises should rather be developed from the perspective of living societies in order to avoid an intrinsic reduction of complexity in the research design (Röder 2012; Röder et al. forthcoming).

Against this background we advocate the most diverse on-site data collection possible and to analyze the resulting data matrix with the help of multivariate statistics with regard to differences and correlations, as we have done in the case of Arbon Bleiche 3. In order to arrive at a more reality-oriented approach for data analysis and data interpretation from the very beginning, one should expect to find diversity rather than uniformity and dynamic instead of static conditions. The potential dynamics of prehistoric societies become accessible in lakeside settlements via dating houses and repairs to exact years and thereby establishing the length of their occupation. Wetland archaeology impressively confirms that Neolithic and Bronze Age settlements on lakes and bogs were both highly dynamic and relatively short-lived settlement types overall (Bleicher 2009b; Ebersbach 2010). They cannot be compared to the mostly static villages in historic Europe, some of which have existed for centuries.

What are the consequences for the demography of ancient communities, for their social organization and the utilization of the hinterland if such settlements were hardly ever occupied beyond the span of 30 years and if there was a perpetual coming and going of inhabitants, as suggested by abandoned houses? The common equation of one house = one nuclear family = one household certainly becomes contestable. The obvious dynamics also draws attention to the fact that wetland archaeology has been assuming widely static social units. Pointedly put, the population structure implicit in many publications resembles that of newly erected terraced housing estates: Each house is inhabited by a young family comprising a mum, a dad and their children. In contrast to modern-day families however, there are no archaeological patchwork families but rather lifelong monogamous unions of parents and their direct offspring (Pichler et al. 2009). There are further differences: In archaeological families, the children do not grow older, nor are they ever orphaned, and group size is not increased by new births or the incorporation of other individuals (cf. Röder et al. forthcoming).

It is self-understood that the assumption of such "frozen" demographic situations eases archaeological interpretations. These will, however, be far from former realities. During the next phase of our project we will therefore draw on palaeodemography, historical demography and social anthropology to attempt a more realistic reconstruction of who inhabited the individual houses of a lakeside settlement and what social or economic putty may have kept them together. We are well aware that such questions will never be answered conclusively. We believe, however, that any expansion of the all-pervasive concept of bourgeois nuclear families, which at present constitutes the sole interpretational model, would be a step forward. The introduction of alternative models and new scenarios should in turn generate new interpretations and more sophisticated considerations and bring us closer to the long-term objective of our case study: to replace the projections of idyllic terraced housing estates by new, empirically based images.

Much remains to be done. We realize the differences and correlations between houses revealed in the correspondence analyses. We can, however, only insufficiently explain what caused them. Different subsistence strategies or differential access to resources seem as plausible as dietary preferences or taboos of specific social groups determined by age, gender or ethnicity and so forth.

Economic crises are another conceivable scenario (Doppler et al. forthcoming b; Schibler et al. 1997b).

Starting from extant societies, hypotheses will have to be developed about the causative social mechanisms, groups or practices behind the differences we observe. Finally, we will address the question whether our data permits empirically based hypotheses on the political organization structure of these former communities; to be contrasted with the subjective, intuitive – and contradictory – interpretations of settlement structures (above, chapter "Introduction"). A differential access to calories or high quality foodstuffs may well provide cues for a stratified social system and become manifest in the archaeobiological remains.

Even though we are still in the middle of the research process it is evident that our results will contribute towards an increased awareness of social historical issues and a reconsideration of common premises and assumptions in wetland archaeology. In addition, our results ultimately raise the question of whether the widespread concept of "household" is in any way useful – a question we will address in the near future.

The re-evaluation of familiar concepts and approaches is mostly due to the evident social historical potential of archaeobiological remains. In the past, archaeozoological and archaeobotanical remains were mostly investigated with regard to economic issues. Now they are increasingly perceived and utilized as social historical sources (e.g. Arbogast et al. 1997; Schlichtherle et al. 2010, 2011).

Wetland sites take a methodological and theoretical lead in this process. The excellent preservation of organic remains and the investigation of similarities and differences to the level of houses dated to exact years permit insights of extraordinary detail. Like no other type of site, lakeside settlements provide the opportunity to find plausible answers to social historical questions relating to the everyday lives of prehistoric communities. Condition for this is the development of suitable methodological and theoretical approaches as well as of differentiated social historical questions and premises. As a result, our case study of one of the best preserved and most intensely researched lakeside settlements becomes a pilot study. The newly developed approach of "investigating social differences through archaeobiology" is readily applied to other wetland sites. Its portability to mineral soil sites stands or falls with the preservation of organic remains. But even in the case of poorly preserved archaeobiological remains our results are still of interest. They highlight the necessity for avoiding intuitive social interpretations from settlement structures but instead to virtually go beyond the settlement grid and integrate a broad, empirically founded range of data before wider conclusions are drawn.

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