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Circaea

Association for Environmental Archaeology

Circaea

Circaea is the Journal (formerly Bulletin) of the Association for Environmental Archaeology (AEA) and—as from Volume **4**—it is published twice a year. It contains short articles and reviews as well as more substantial papers and notices of forthcoming publications.

The *Newsletter* of the Association, produced four times a year, carries news about conferences and the business of the Association. It is edited by Vanessa Straker, to whom copy should be sent (c/o Department of Geography, University of Bristol, Bristol BS8 1SS).

Editorial policy for *Circaea* is to include material of a controversial nature where important issues are involved. Although a high standard will be required in scientific contributions, the Editors will be happy to consider material the importance or relevance of which might not be apparent to the editors of scientific and archaeological journals —for example, papers which consider in detail methodological problems such as the identification of difficult bioarchaeological remains.

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*Front cover: Spelt (*Triticum spelta *L.) and emmer* (T. dicoccon *Schrank) ears grown on an allotment on Walmgate Stray, York, in the 1989/90 season, as part of a long-term experiment (cf. Van der Veen,* Circaea **7**(1), *71–6 (1989). The crop of bread wheat (*'Triticum aestivo-compactum'*) was completely destroyed, probably by small rodents!*

Editorial

This is the first part of volume **8**, nominally for 1990; much of **8**(2) has already been put together and all being well it will follow in weeks rather than months. Please don't let this stop you sending copy—it would be splendid if we could publish volume **9** (for 1991) *this* year, too!

It may be worth remarking that some back numbers of *Circaea* are in critically short supply, and we currently have no plans to reprint them because of cost. Those that are especially short are **2**(2)–**3**(3) inclusive, for all of which there are less than 10 copies in stock. Buy now to avoid disappointment! (Details of prices are given on the inside front cover.)

We have been toying with the idea of producing an index to *Circaea;* have any readers any thoughts on the subject of its desirability and the level at which indexing should be carried out?

Book Reviews

K. A. Boyle (1990). *Upper Palaeolithic faunas from South-West France. A zoogeographic perspective.* Oxford: British Archaeological Reports, International Series **557**. ISBN 0 86054 704 3. 283 pages+bibliography and appendices. £27.00.

The *BAR* series has been a useful source of the information otherwise buried in all those theses that must pile up somewhere in university and departmental libraries. It represents a laudable attempt to match the system in many European countries, where theses are produced in multiple copies, precisely so that their contents can reach a wider audience.

On the negative side, the average archaeological thesis needs a good deal of cosmetic work before it can be allowed out in public. Simply reformatting it into camera-ready copy rarely produces something fit for consumption by humans (as distinct from external examiners). We all know, don't we, of the need to mention every trivial piece of work in the field and the resultant tendency to produce a thesis twice as long as it need be. We also know that a thesis rarely stands scrutiny as a piece of polished writing. Yet many of the *BAR* volumes tend to suffer from these problems in their translation into book form, and Boyle's is no exception. This is not entirely the fault of the author, since the volumes are edited.

The volume is not cheap. For that price, I do not really want to have to wade through or to ignore chunks of information on the history of work in the chosen region (Chapter 2), Perigordian cultural chronology, or the physical geology (Chapter 3), included because the examiners of the original thesis would have required it. (Does anyone ever really want to know when the bedrock of the region in question formed?) All of these details could be presented more concisely, with references to the necessary sources. Chapter 5, a review of previous ideas on seasonality, repeats quite a lot of what was said in Chapter 2 on the general outline of earlier work. Yes, Bouchud's arguments on year-round presence of reindeer are specious. A lot of people know that.

The presentation of the first five chapters is not helped by the fact that the English is often clumsy, and by Boyle's somewhat irritating use of the present tense when discussing the literature.

Chapters 6 to 9 present an analysis of the assemblages in relation to chronological patterning, associations between species, zoogeography and butchery and carcase management, using data taken largely from the literature. Much of the information employed is usefully presented in tabular form in Appendix I. Boyle discusses the methodology in Chapter 1, where she admits that the form in which the data are available does pose problems for the analyst. It is difficult to gauge from this discussion just how much material she has seen at first hand, and therefore to assess her ability to interpret the literature. But she argues in that chapter that the most appropriate method for quantifying assemblages is to use the number of identified specimens per taxon, or N.I.S.P. (would N.I.SP. or N.I.S.T. not be more logical?), and here she seems to have fallen into the trap of dressing up necessity as a virtue. If N.I.S.P. figures are the only data available, and if you can address issues that are robust to that fact, then go ahead and use them. But I really cannot be impressed by arguments (p. 7) that we should use them because there will be little discrepancy in N.I.S.P. counts by different analysts (so what?) or that use of such figures offers the advantage of a larger assemblage from each site. This despite having just listed five problems using such counts, including (number 3) the question of the extent of fragmentation. It is in relation to this point, in particular, that the question of hands-on experience starts to assume importance: how else does one realise, for example, that

reindeer metapodia often remain identifiable even when highly fragmented into many countable pieces, while those of other artiodactyls of similar overall size may not. I may have missed it, but I saw no discussion of such points. Then to be told (p. 8) that detailed attention has primarily been given only to assemblages totalling at least 100 identifiable specimens does not inspire confidence, author's caveats notwithstanding.

The N.I.S.P. figures are used in Chapters 6, 7 and 8. In Chapter 9, on butchery and carcase management, the method of quantification is modified to produce fractional minimum numbers of individuals (fM.N.I.s), which are then graphed against modified general utility indices derived from Binford's work. I think that extra discussion could usefully have been given to the methodology adopted in Chapter 9, using the space created by cutting down some of the earlier chapters. I think this could be the most valuable part of the volume, if one can maintain confidence in the figures (Boyle shows no sign of realising that M.N.I. figures are estimates rather than counts), but I think that most readers will need more guidance. (How many of us at five minutes' notice could give a coherent account of Binford's derivation of these figures, even [especially?] if armed with his book?) I also think that Boyle may have underestimated the part played by large carnivores (relatively abundant spotted hyenas and wolves and the odd lion) in forming her 'natural' deposit at Jaurens.

I am less convinced that the results on faunal associations presented in Chapter 7 really necessitated the amount of analysis expended on them, and whether we need P.C.A. to tell us that fairly self-evident associations of species may be seen in assemblages. And I am really not at all convinced that the analyses presented in Chapter 8 offer us much zoo-geographic insight. If we are going to use data based on fragment counts from archaeological deposits to tackle problems of biogeography then we need to address larger-scale questions that are likely to be less sensitive to passing through a cultural mincer. Chapter 6, on the chronological patterning of the assemblages, offers some parallels between environmental changes and the grosser shifts in relative abundances, but here again the problems of confidence in the figures intrudes, and one must wonder whether anything significant in being revealed.

In all, an interesting idea, to take a wider view of the large body of osteological data now available from south-western France, is marred by the method adopted (which involves an over-reliance on the published data), by the resultant restriction on quantification techniques, and by a failure to restructure the work for publication.

Reviewer: **Alan Turner**
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Greig, James (1989) *Handbooks for Archaeologists No. 4. Archaeobotany*. European Science Foundation. Strasbourg. 93pp. Available free on request*.

This is the fourth in an already very useful series of handbooks produced by the European Science Foundation to 'promote co-operation between archaeology and the natural sciences'. The author, realising the rate of development of archaeobotany over the past decade, aims to 'present the outlines of the subject as it is now as helpfully as possible for both professional and amateur archaeologists, as well as students'.

The six main chapters of the handbook cover: (1) an introduction, with a useful outline of the history of the subject; (2) principles and procedures, which attempts to explain general botanical principles, taxonomy, plant ecology and the preservation of fossils, all in twelve pages; (3) sampling techniques; (4) laboratory methods for extraction and processing of plant remains; (5) identification; and (6) interpretation of the results. Each chapter discusses charred, waterlogged and pollen remains. There is plenty of useful, detailed information covering the whole range of the subject.

The section on taxonomy could, perhaps have been improved. Assuming the archaeological readers are unfamiliar with plant names and the fact that they need to understand botanical reports (particularly the species lists, pollen diagrams and interpretation) it is very important that they should be familiar with, for example: what a family, genus and species actually represents; what we **really** mean by '*cf.*' or 'indet.'; what the limitations of pollen 'types' are; and the significance of the different 'seed' parts. A brief guide to the correct procedure for printing Latin plant names would also have been helpful. A reference or two to introductory plant taxonomy and ecology textbooks might have been sensible, particularly for the student

readers. Why is there no explanation of Compositae Liguliflorae (Cichorioidae), which is mentioned twice in the text, occurs so often in pollen lists, but what does it mean in terms of interpretation?.

Chapter 8, in two short paragraphs, discusses the importance of co-operation between archaeologists, historians and archaeobotanists. A useful point made is that even if there is forward planning with the 'environmentalist' before excavation and a good research strategy, unless there is suitable preservation of plant remains, nothing can be achieved.

The final chapter consists of a list summarizing the authors' view of the major 'rules' in archaeobotany. I would suggest on the first point that archaeological knowledge for archaeobotanists is not just "very useful" but absolutely essential, particularly for the interpretation of results. We cannot expect archaeologists to be broad-minded if we are not likewise.

The handbook is well illustrated with 'archaeobotanist-in-action' photographs. There is also a good balance of pictures of plants and plant remains. It may have been useful to use some diagrams to explain certain topics within the text which are written in a rather long-winded way (for example, the explanation of the relationship between archaeobotany and other sciences on p. 3). A copy of one each of the standard recording site and laboratory forms might have been helpful as a guide to the categories generally recorded (but, as every laboratory has its own version, choosing the best might have been difficult!). The six-and-a-half pages of references, which provide an invaluable bibliography for beginners in the subject, cover the major papers in the European archaeobotanical literature.

A list of the names and addresses of the laboratories and individuals who offer an archaeobotanical service to archaeologists should have been included, particularly as this was one of the objectives of this handbook series (see Goormaghtigh in the preface to No. 2). This would have been a good opportunity to provide a glossary of terms, perhaps with German/Dutch/French/Italian translations?.

In summary, despite the few shortcomings I have mentioned, this is an invaluable guide to the subject. It should be essential reading for archaeologists and students alike. It might also be a useful reminder to established workers that we have a long way to go before our methods and techniques are suitably standardized, for example, with regard to the comparison of data from different sites.

[* Copies of all four handbooks in this series may be obtained, free of charge, by writing to: The European Science Foundation, Standing Committee for the Humanities, 1 quai Lezay-Marnesia, F 67000 Strasbourg. Sadly, this botanical book is the last in the series.]

Reviewer: **Philippa Tomlinson**
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Conference Report

Archaeological integration: Association for Environmental Archaeology, Autumn Conference, Cambridge, September 1990

This conference was organized by Drs Peter Rowley-Conwy and Rosemary Luff, and attended by about 75 people altogether. The theme was the contribution of environmental archaeology to the interpretation of sites, and the integration of all aspects of archaeology. With these goals in mind, papers were divided among four sessions: (i) successful case-studies and methods; (ii) the specialist as project director; (iii) integrated studies; and (iv) integration: current achievements and problems. The conference structure was good and in general the papers were of a high standard, but the audience was often insipid. The proceedings are to be published.

The first session was opened, unconventionally for an environmentally-based group, by a ceramicist. Problems of data collection which so often plague the environmental archaeologist are common to other specialisms. Chris Going graphically described how things can go drastically wrong when the specialist is not involved from the start. He contrasted this with successful examples of communication and pooling of ideas: numismatists, ceramicists, vulcanologists, seismologists and historians working together were able to fix the time of the destruction of Chorion, Cyprus, to within twenty minutes. The theme of co-ordination and communication was constantly repeated throughout the two days, both as an approach which yields far more detailed results, and for the unfortunates among us, as a desperate hope for an ideal archaeological world.

From there we were taken to the daunting total organic preservation at Qasr Ibrim,

Egypt. Peter Rowly-Conwy showed that artefacts assumed to relate to occupation, as on any 'normal' site with little organic preservation, may actually be later abandonment debris. This surely has very important implications for interpretation. To a very different climate, next: Paul Buckland talked about Bessastadir, Iceland, and the various classes of artefact that have suggested differential status and activity areas. (He talked briefly first on the evidence for body paint on Lindow Man.) Beautiful landscape shots of the Outer Hebrides were included in Alix Powers' slides, illustrating her study of phytoliths, ancient and modern, to learn about ecological areas used by past inhabitants. We also had a look at some bone assemblages from Neolithic and Bronze Age sites on Down Farm, England (Tony Legge) and what happens to fish bones when they get digested (Andrew Jones). The morning session ended with Nick Winder demonstrating the database he has developed to record animal bones efficiently (Faunal Remains Database—FRUD). It looked good to me. Could anyone do the same thing for seeds, insects, shells, soils, pollen and everything else?

The afternoon session featured 'the specialist as site director'. We heard Geoff Bailey talking about Klithi in Greece; Mark Robinson describing excavations at Mingies Ditch by the River Windrush; Frank Green and Kris Lockyear discussing an urban site in Romsey; Jim Innes' pilot study to locate wetland sites by non-destructive means; and further geographic variation with Umesh Chattopadhyaya, who took us to the earliest known sites in the Ganges Valley and Vindhyas in India. Bob Wilson also gave a paper on spatial patterning of bones and artefacts in the Upper Thames Valley.

Most people, both presenting and commenting, took exception to reference to 'the excavator' and 'the specialist', as this implies specialists are not archaeologists, and that the two roles are completely separate. Several speakers agreed that, having first studied environmental artefacts, they were more aware than many site directors about proper recovery, study of environmental remains and natural (as opposed to human-created) deposits, as well as about the co-ordination of all sources of data afterwards. Geoff Bailey encouraged constant trial of excavations techniques to develop the strategy best suited to each site. A willingness to learn from techniques which were not entirely successful, in order to improve future excavations, was advocated by several speakers. This is a good attitude, it seems to me.

Sunday morning and the third session started rather early for some, with James Rackham on the problems encountered when trying to integrate different types of archaeological data. He brought up the topic of developer-funding, an issue which is causing particularly grave concern amongst archaeologists working in England (of which more below). The emphasis, repeatedly throughout the day, was the necessity for including environmental work as an integral part of any excavation, from the very first planning and costing stages.

The remainder of the morning was taken up with site case-studies where integration is actively and successfully pursued: Amarna, Egypt (Rosie Luff—animal remains; Delwen Samuel—bread and beer project); Tofts Ness, Sanday, Orkney (Steve Dockrill—director; Ian Simpson *in absentia*—soils; Annie Milles—snails; Janet Ambers—carbon isotope analysis; Julie Bond and G. Davis—plant and animal remains); and Abu Salabikh, Iraq (Nicholas Postgate—director; Wendy Matthews-soil micromorphology; Keith Dobney—animal remains).

In the final session, various excavators and specialists were asked to discuss current achievements and problems of integration. Achievements were little examined: the focus was on problems, which it was very necessary to deal with, I suppose, but depressing. Two points emerged most strongly

First of all, environmental archaeologists working in Britain are on the defensive. Again and again, people spoke of their work being considered peripheral, not part of the general research strategy, an afterthought, or being paid lip service, with nothing behind the fine words. Some made outright denials of specialization. There are many archaeological administrators and even, still, directors of sites who undervalue the environmental contribution. However, this conference can leave no doubt that people who specialize in *whatever* branch of archaeology, produce more interesting and meaningful results if they can: (i) be actively involved from the beginning and spend at least part of the time on-site (not necessarily digging); (ii) be personally familiar with where their material comes from; (iii) know how it relates to stratigraphy, architecture, and other classes of artefact; and (iv) share and co-ordinate their findings with other members of the team.

The second point which arose from the final session, and particularly in general discussion, was the perennial problem of funding.

Everyone feels underfunded. Part of the inferior status some participants experienced came from this. Indeed, intense discussion was stimulated by the changes in funding now being implemented. In England, English Heritage has been largely responsible for funding excavation, but the government wants rescue archaeology to be entirely funded by developers. As Phil Dixon pointed out, this means that budgets *must* include environmental work as an integral part of excavation, and that there will be an end to extra dollops of money after digging is over and the samples have piled up. Is this not a challenge, *and* an opportunity? A big concern was the lack of obligation for developers to get excavations published.

I personally was disappointed in the final discussion. From the first it was directed to the subject of funding (with nearly total focus on the situation for archaeology in England). The conference theme, integration, was completely lost. Many of the case-studies and examples were inspiring. A discussion of them and how to encourage integration as a standard archaeological goal, would have been positive, instructive, and stimulating. Instead, although much discussed and certainly an important issue, no one seemed to have anything new to say on funding problems. A few ideas on concrete action were voiced. Had a resolve to pursue them by committee or other mechanism resulted, perhaps this airing would have had some use. As it was, the discussion eventually petered out, the participants rapidly dispersed, and I wended my way home with a distinct feeling of discouragement. Not the best way to end a conference celebrating the successes of the profession.

Reviewer: **Delwen Samuel**, Department of Archaeology, University of Cambridge, Cambridge CB2 3DZ, U.K.

Summaries of papers presented at AEA Spring Meeting, Oxford, 25th March 1991

A mess of pottage; food processing or detoxification of Old World pulses—Ann Butler, Institute of Archaeology, University College London, 31–4 Gordon Square, London WC1H 0PY, U.K.

Wild legumes characteristically accumulate a number of toxic secondary metabolites in the seeds, which act as deterrents to predators (Harborne 1988). Consequently, although rich in nutrients, legume seeds in the past may have been unsuitable as staple food resources for humans. However, as part of a broad-based feeding regime, small-scale consumption may have been tolerated (Stahl 1984).

The large-seeded cultivated grain legumes (pulses) indigenous to temperate regions of Western Asia, North Africa and Mediterranean Europe are mainly members of the tribes Vicieae and Cicereae, which include *Pisum sativum* L. (pea), *Lens culinaris* Medic. (lentil), *Vicia faba* L. (broad bean) and *Cicer arietinum* L. (chickpea). Although most are considered harmless today, their low toxicity may be largely the result of selective breeding. Historical documentation records a previous need for detoxification prior to consumption of even such innocuous pulses as the pea (Drummond and Wilbraham 1939).

The toxicity of the wild legumes and early pulse cultigens might explain in part the paucity of pulses relative to cereals amongst the remains of charred plant material from certain early agrarian contexts. Processing of legumes to reduce toxicity will have become a necessity when a generalised feeding strategy was replaced by the more specialised diet that resulted from cultivation, and prior to the development of toxin-low cultigens. Some common food-processing methods may represent ancient detoxification strategies. However, the antiquity of the development and use of such traditional techniques as dehulling, soaking, heating, fermentation and sprouting is unknown.

Archaeological evidence of the past processing of food legumes is hard to find; one example is the possible leaching of *Lathyrus sativus* seeds at the Bronze Age site of Servia, an interpretation suggested by their distribution (Hubbard 1979).

The analysis of plant food residues on ceramic sherds has provided some clues to cooking techniques (Hastorf and De Niro 1985); chemical analyses by such methods as infra-red spectroscopy, already successfully applied in the identification of charred ancient seeds (McClaren *et al.* in press) may provide in the future more direct evidence of the chemical properties of past legume food resources, and augment our understanding of ancient diets.

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House Gardens in Sipsongpanna, China—Charlotte Herxheimer, Institute of Archaeology, University College London, 31-4 Gordon Square, London WC1H 0PY, U.K.

Ethnoarchaeological fieldwork was carried out amongst the Dai people of Sipsongpanna, South West China to investigate house gardens and their role in the traditional subsistence system. House gardens have long been postulated as likely arenas for early plant domestication, but have never previously been the object of archaeological study.

The nature of house gardens and the range of natural resources available to the Dai was described. House gardens closely mimic a forest structure with many plant layers and a vast range of crops, both cultivated and 'weeds', providing fruit, vegetables, stimulants, herbs, medicines, fibres, dyes, poisons, etc. Gardeners continue to experiment with crops through transplanting of plants from the wild and exchange of plants/seeds over long distances.

The possibility of recovering archaeological house garden remains was investigated. The archaeological potential of these gardens has not so far been realised, partly because of a lack of understanding of the taphonomy of remains. Observations were made on the extent of contact with fire of utilised and discarded plant parts. Samples were taken for flotation from ground beneath houses and from gardens where ash had been used as a fertiliser, so that the nature of deposition of the plant remains can be investigated. With a better understanding of the taphonomy of remains preserved in house garden deposits a major, yet until now archaeologically invisible, component of traditional subsistence can potentially be identified.

The conclusions of this study will be relevant for South East Asia in particular and the tropics in general. It is also suggested that the problems involved in the recovery of evidence from tropical house gardens may not be so dissimilar to those of studies of early temperate horticulture.

Acorns in South East Turkey—Sarah Mason, Institute of Archaeology, University College London, 31-4 Gordon Square, London WC1H 0PY, U.K.

One topic receiving increasing attention within archaeobotany is the role of wild plant resources within predominantly agricultural societies. There has been little consideration of the possible role of acorns (fruits of *Quercus* spp.) in this context, but they should be of particular interest to archaeologists because they are potentially a staple food. Good archaeological evidence for acorn use is poor, but this may be partly for taphonomic reasons. Acorns are often thought of, at best, as a marginal resource; but amongst people in many parts of the world, including those practising agriculture, they have been an esteemed wild food. An abundant and readily-available wild resource of this kind might enable people to weather years of poor agricultural harvest when they would not otherwise be able to do so.

The talk described a visit to parts of South East Turkey in October 1990 undertaken with Mark Nesbitt, then archaeobotanist at the British Institute of Archaeology in Ankara, to look at oaks and to investigate any evidence of acorn use.

Two species predominate in the areas concerned, and both are used: *Quercus brantii* Lindley, with sweet acorns; and *Quercus infectoria* Olivier subsp. *boissieri* (Reuter) O. Schwarz, with bitter acorns. Bread-making

with acorns was apparently quite common there until perhaps 40 years ago. The main use of acorns now is as a snack food, and they are still apparently gathered in considerable quantities and stored for this use. Harvest, storage, processing, and modern usages were described, as was the management of oaks in the landscape.

Much of the information was obtained from chance encounters, emphasising the continuing importance of acorns (and oak trees) within what is essentially a modern, often high-technology, agrarian society. There are other areas of Turkey, adjacent countries, and other parts of the world where there may be similar use of acorns now, or in the recent past, and the speaker would welcome any information of a similar nature obtained by AEA members on their travels.

Cyprinid fish teeth: a systematic approach to identification—Brian Irving, Institute of Archaeology, University College London, 31–4 Gordon Square, London WC1H 0PY, U.K.

The pharyngeal or throat dentitions of cyprinid fishes have received very little study in terms of their morphology for systematic identification to species level. As part of a wider research brief, the author was faced with a large collection of both single pharyngeal teeth and pharyngeal bones complete with teeth from archaeological and palaeontological excavations.

The only previously published work on the morphology of the pharyngeal apparatus is that of Rutte (1962). Rutte covered every species of European cyprinid with regard to the general shape of the pharyngeal bone drawn as a silhouette, and a single tooth of each species drawn three-dimensionally. The paper was used as a base line for the present work. Secondly, because of the paucity of skeletal material in Britain, the author spent a month collecting live specimens from the Danube catchment in Bulgaria, and received specimens from the Natural History Museum in Sofia. The outcome is probably the most comprehensive comparative osteological collection of cyprinids in Britain.

Laboratory and microscope work followed in which the bones and teeth were drawn three-dimensionally and the most diagnostically useful teeth (in some cases numbering five individual teeth from each species) were photographed using a scanning electron microscope and drawn using a stereo microscope with drawing tube (camera lucida). The outcome is a dichotomous key for the identification of the most diagnostic teeth and pharyngeal bones from all 26 European cyprinid species (Irving in prep.).

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A chemical method of identifying plant foods from coprolites—S. Wales, Department of Human Environment, Institute of Archaeology, University College London, 31–4 Gordon Square, London WC1H 0PY, U.K. and J. Evans, Environmental Sciences Division, Polytechnic of East London, Romford Road, Stratford, London E15 4LZ, U.K.

This paper dealt with current work to develop chemical methods of investigating coprolites in order to identify the plant component of diet. The aim was to identify plant foods that were not identifiable on morphological grounds, and so complement work on pollen and plant macrofossils.

Waxes were seen as being the most useful plant component for investigation because: (a) they have taxonomic potential; (b) they survive human digestion as demonstrated by the authors in a dietary study carried out with the Department of Food and Nutritional Sciences, Kings College London (Wales *et al.* in press); and (c) they survive well in archaeological contexts (e.g. Needham and Evans 1988).

The material to be investigated is first extracted sequentially with a variety of solvents in a soxhlet apparatus. This is a piece of apparatus which functions very like a coffee percolator. The method of extraction removes various chemical compounds without exposing the sample to extreme heat or necessarily damaging it. This means that samples of plant material can survive morphologically intact. The extracted material is then investigated by two principal methods: infra-red spectroscopy (IR) and chromatography, principally gas liquid chromatography (GLC).

The coprolites currently being investigated are well-preserved samples from Hinds Cave in Texas (Edwards 1990).

Before investigating the coprolites it was essential to establish that the suspected plant foods could be identified chemically. This has been demonstrated with a selection of modern samples of probable plant foods from Texas.

Investigation of the coprolites themselves involved the study of both the amorphous matrix and the visible plant fragments. It has been possible to suggest identifications for the plant fragments studied from the IR and GLC data. The identification has been supported by gas chromatography/mass spectroscopy (GCMS) carried out by the SERC Mass Spectroscopy Service at Swansea.

Work is continuing on the study of diet from these and other coprolites, as well as investigation into the confirmation of the faecal origin of coprolite fragments, and the identity of the donor species.

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Notes on the skull of a 17th century horse from Chichester, West Sussex, U.K.

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Summary

Osteometric study of an excavated equid skull from Chichester, West Sussex, U.K., has yielded information on the size and general (facial) appearance of a male horse from the post medieval period. This animal pre-dates the crossing of English equine stock with imported Arab horses—which took place throughout the late 17th and 18th centuries—and so will form a useful basis for comparison with the later, much-modified horses when their skeletal remains are recovered from archaeological sites in Britain.

Introduction

Excavations carried out at 14/15 East Street, Chichester, West Sussex, in 1984, directed by Alec Down FSA, uncovered a post-medieval refuse deposit. Amongst the material recovered from this context was an intact horse skull, which is dated by the associated pottery to the mid/late 17th century. This skull was subsequently donated to the Booth Museum of Natural History, Brighton, and under that museum's catalogue scheme was assigned the registration number (osteological collections) 101241.

Although a detailed study was made of this specimen by the author (who was then working at the Booth Museum), the results of this research have until now remained unpublished; the main purpose of these notes is therefore to bring this find to the wider attention of fellow archaeozoologists and others interested in the early development of British equine stock.

Our knowledge of horses in Sussex in the post-medieval period is at best very scanty. Their importance in the agricultural economy is certainly well documented—as has been discussed by Kerridge (1968, 51–3) who observed that "About Chichester ... not many oxen were reared and then only to draw wains, for horses were more suited to the hilly fields and roads and were generally employed in ploughing, mostly in teams of four". Despite their obviously important role there is, however, no evidence for the existence of a well-defined (distinctive) local type as there was, for example, in East Anglia at this time where a "specialist farm horse or punch" was produced (ibid., 318). Sussex farmer Leonard Mascall, who farmed near Lewes in the late 16th century and was author of *The Governmente of Cattell* (1587), gave advice on the selection of horses with the right coat colour, but made no mention of the size or conformation of the local animals. Even as late as the 1800s, at a time when horses in other counties such as Lincolnshire were undergoing significant improvement (see Bewick 1790, reprinted 1980, 10), the horses of Sussex apparently remained isolated from the attentions of the livestock improvers, and the Rev. Arthur Young in his survey of Sussex reported that "The horses employed in the husbandry of the county have nothing in them which deserves particular notice" (Young 1813, 376).

In the absence of any available surviving contemporary descriptions of Sussex horses in the 17th century (or indeed later times), the Chichester skull has provided useful insight into the size and general appearance of at least one of these post-medieval animals.

Osteological description

(i) Age and sex of the horse

Using the criteria of incisor wear described in the booklet published by the American Association of Equine Practitioners (1966), and by comparison with the series of illustrations of incisor wear in horses given in HMSO (1908, 35–45), the age at death of the Chichester horse is estimated between seven and eight years. The presence of well-developed canine teeth indicates that this animal is male or castrate: in the female these teeth are either rudimentary or entirely absent (Scott and Bray Symons 1964).

(ii) Dental anomaly

Both right and left upper rows of cheekteeth have an additional rudimentary 'wolf tooth' in

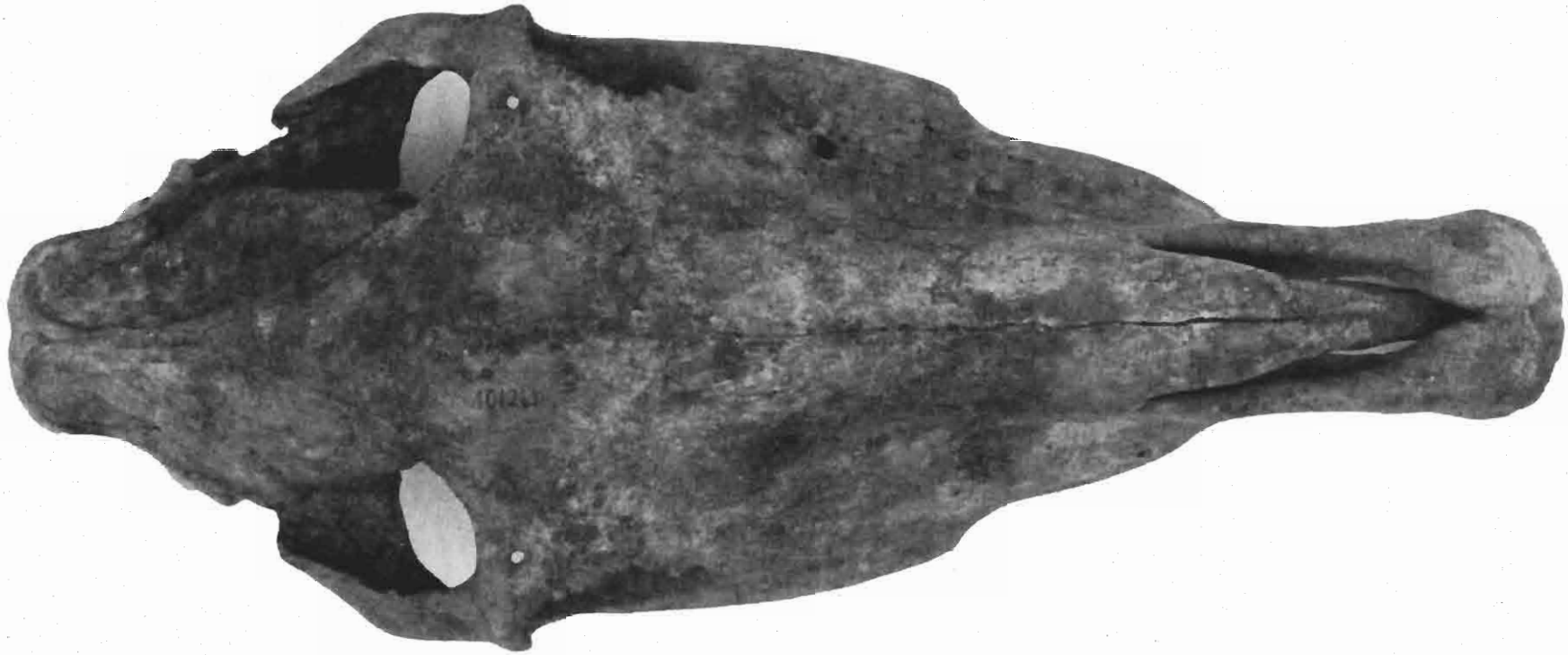

Fig. 1. Horse skull from Chichester: dorsal view.

Fig. 2. Horse skull from Chichester: right lateral view.

Table 1. Measurements (in mm) of the horse skull from 14/15 East Street, Chichester, West Sussex. Collections of the Booth Museum of Natural History, Brighton, reg. no. 101241. Measurement codes follow von den Driesch 1976.

Code	Measurement	
1	Profile length	553
2	Condylobasal length	545
3	Basal length	513
3a	Basilar length	508
8	Viscerocranium length	318
9	Upper neurocranium length	176
10	Facial length	390
21	Length of the diastema (*excluding* P1)	93.5
22	Length of cheektooth row (*excluding* P1)	183
34	Width across the occipital condyles	95.4
38	Greatest neurocranium width	104
41	Greatest brow width	221
43	Facial width	195
45	'Snout' width	77.2
47	Least width of the diastema	67.0
48	Maximum palatal width	136
50	Maximum (basion) skull height	118
	Upper right third molar: length	26.4
	breadth	23.4

Table 2. Size of the Chichester horse skull in comparison with modern specimens in the collections of the Booth Museum of Natural History, Brighton, and the British Museum (Natural History). Basal length is von den Driesch's (1976) measurement 3.

	Basal length (mm)
Post-medieval:	
Chichester, mid 17th century	513
Modern:	
Booth Museum collections, Sussex horses of unknown history (reg. nos.):	
100866	542
101226	500
101614	553
British Museum (Natural History) collections:	
Shire stallion, Blaisdon Conqueror reg. no. H14	604
Shire stallion, Prince William reg. no. H8	598
Shire mare, Starlight reg. no. H20	595
Thoroughbred male, Royal Hampton reg. no. H31	525
White Arabian stallion, Skowrone reg. no. 1937.1.26.7	474
Arab male, Little Joker reg. no. H40	482
Arab male, Dwarka reg. no. 1924.5.4.1	492

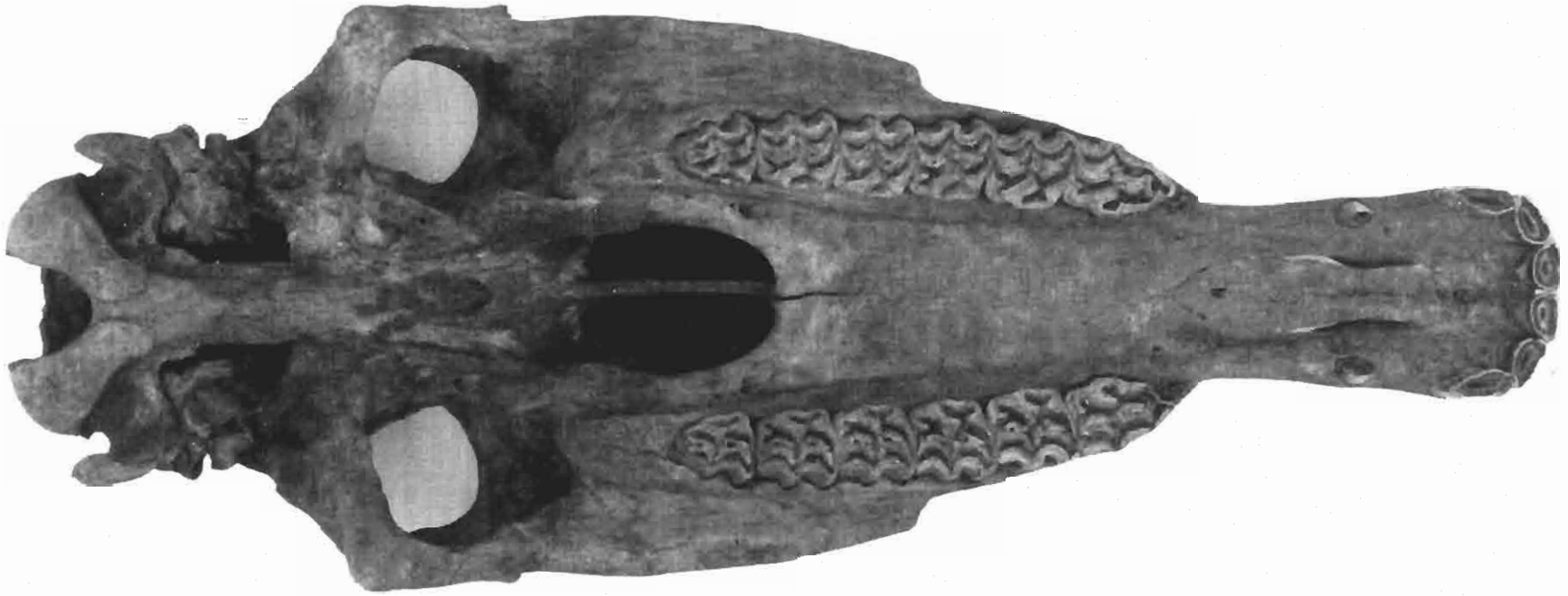

Fig. 3. Horse skull from Chichester: ventral view.

front of the second premolar. In his discussion of horse skulls from Hungarian archaeological sites, Bökönyi (1974, 291) states that this tooth is found rarely in modern domestic horses and where it does appear it is considered a form of atavism. According to Simpson (1951, 181–9) this additional tooth is a relic of the first premolar, which in extinct equids never played a part in the masticatory process and so was lost in the evolutionary development of their dentition. Despite Bökönyi's assertion that 'wolf teeth' *rarely* occur in modern domestic horses, Colyer (1936, 141) mentions that in 173 female skulls examined there were 37 cases of this condition (21.4% of the sample) and in 208 male skulls there were 31 cases (14.9%). Examination of a series of Sussex horse skulls in the Booth Museum collections revealed that one of the three specimens (reg. no. 101226, a female) also had 'wolf teeth'.

(iii) Size of the skull

A summary of the measurements taken of the Chichester skull is given in Table 1 and some comparisons with modern specimens are presented in Table 2.

(iv) Shape and general appearance of the skull

Viewed from the lateral aspect, the dorsal profile of the Chichester skull appears virtually straight, and may be compared with those horse skulls which are dished or convex in profile.

As discussed by Luff (1982, 205–14), various workers have devised morphometric indices for analysing equid skulls, and two of the more widely used of these have been applied in the study of the Chichester skull (see Table 3).

According to the classification scheme proposed by Nobis (1962) the value for the frontal index (43.5%) places the Chichester horse in the 'average-broadforehead' category (defined as those skulls with indices in the range 42.6-45.0%); skulls in the narrowforehead and broadforehead categories respectively have indices below 42.5% and above 45.0%). The calculated value for the craniofacial index (45.1%) indicates that the face of the Chichester horse was of average length relative to cranial length.

Discussion

Apart from the presence of 'wolf teeth', the Chichester horse skull is, perhaps, unremarkable, in that it does not exhibit any distinctive morphological features such as an unusually broad forehead relative to length or an unusually short and narrow face. However, the specimen is of historical value as it represents an example of the older, largely unimproved stock of British horses in the period immediately prior to their transformation from crossing with imported Arabian 'hot-blooded' horses. The first such crossings took place in the latter half of the 17th century (Clutton-Brock and Burleigh 1979, 192) and continued throughout the 18th century to produce the ancestors of the modern racehorse. During the same period in Britain, certain regional types of horses, such as the Black Horse of Lincolnshire, underwent significant improvement, as documented by Bewick (1790, reprinted 1980, 10–15).

It is to be hoped that future excavations of post-medieval sites in Britain will yield examples of skulls of these later, much-altered late 17th and 18th century horses, and the Chichester skull may then form a useful basis

Table 3. Values obtained for two common craniometric indices based on measurements of the Chichester horse skull. Measurement numbers in parentheses are those given by von den Driesch (1976).

Index	Method of calculation	Result
Frontal Index (after Bökönyi 1974; referred to as Cephalic Index by Osborne 1912)	100 x Frontal width (41) /Basilar length (3a)	43.5%
Cranio-facial Index (after Osborne 1912)	100 x Length of cranium (9) /Length of face (10)	45.1%

for comparative study with these specimens, thereby making a contribution to our understanding of the stages in the historical development of horse breeding in Britain.

Acknowledgements

I wish to express my sincere thanks to Alec Down FSA for kindly allowing me to study the Chichester horse skull and for helpful discussion on its archaeological dating. My thanks also go to Dr Juliet Clutton-Brock for allowing me to measure and examine the comparative horse skulls in the collections of the BM(NH), and to Jeremy Adams (Booth Museum of Natural History, Brighton) and Dr Rosemary Luff (Department of Archaeology, University of Cambridge) for their help.

The photographs were taken by Fred Woodley, Booth Museum of Natural History, Brighton.

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Some problems encountered in identifying *Phragmites* pollen in modern and fossil pollen assemblages

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Summary

A modern pollen study, conducted near a lake on the shores of which there was a narrow fringe of *Phragmites australis*, demonstrated the difficulty of separating this genus from other grasses using pollen grain dimensions. The results indicate that, in fossil deposits, identifying *Phragmites* using pollen grain size criteria is difficult, especially where the grass pollen assemblage may have included genera whose pollen grains span the same size range as those of *Phragmites*.

It is hoped that this short paper may serve to caution palynologists attempting to identify pollen of *Phragmites australis* (Cav.) Trin. ex Steudel (*P. communis* Trin.) in fossil pollen assemblages. A fringe of *Phragmites* on a lake shore may influence the dispersal of pollen in the vicinity of the lake; therefore it is desirable to identify this component of the local flora in fossil pollen assemblages.

In their *Textbook of Pollen Analysis* Fægri and Iversen (1975) state (p. 253): 'the homogeneous nature of grass pollen causes one of the greatest difficulties in pollen analysis. It is impossible to identify more than a few genera by pollen morphology'. On p. 254 they state: '*Phragmites* can be separated from other grasses'. This is fortunate, because in European pollen analysis it is the only grass of any importance that is normally not favoured by human activity, and because it is by far the most common aquatic grass in Europe.

Fægri and Iversen stress that the micro-structure and micro-sculpturing of the exine is of great importance and that careful observation using strong light and filters or phase contrast is necessary. In their key, the description of pollen grains of *Phragmites* type is *Grain less than 26 micrometers; punctae imperceptible, except in swollen grains. Greatest diameter of grain 21–26 micrometers.* Similar diameter measurements are given by Andrew (1980). Measurements of grain diameters performed by the author on material gathered from a number of locations in mid Co. Down, Northern Ireland, ranged from 18 to 25 µm. In all cases, quoted measurements were of grains embedded in silicone fluid. In comparison with those of many other grasses, the pollen grains of *Phragmites* are quite small.

In a pollen analytical study of a coarse detritus mud from Lough Henney, a small interdrumlin lake in Co., Down, N. Ireland (Grid. Ref. J350585), low values of *Typha angustifolia* (under 3%) indicated that the edge of the lake had a semi-aquatic flora of which *Phragmites* could have been a component. As there was no macrofossil evidence for *Phragmites* in the deposit, only palynological criteria could be used to attempt to establish the point at which this grass became a component of the local flora. In the upper samples from the deposit grasses were present at values of 30% based on pollen sums exceeding 1000 grains. In these samples the grass pollen grains spanned a wide size range, including that spanned by *Phragmites*.

Comparison of the sizes of the subfossil grass pollen grains in these upper samples of the fossil deposit with grass pollen in moss polsters collected for study of the local modern pollen rain demonstrated that in both there were small numbers of grass pollen grains whose size and surface features resembled *Phragmites*, yet many of the moss polsters had been collected well away from *Phragmites* stands. Furthermore, measurements of pollen of type material of grass genera including *Dactylis*, *Cynosurus* and *Holcus* (common components of the grass flora of the fields and hedgerows in this part of N. Ireland today), held in the reference collection at the Palaeoecology Centre, showed that these, too,

contained small numbers of grains whose dimensions and surface features bore a superficial resemblance to *Phragmites*.

The non-arboreal pollen assemblage from the upper part of the deposit is similar to that produced by the vegetation around the lake at present. This vegetation includes a narrow fringe of *Phragmites* between the lake and the surrounding grazing land (which is enclosed by hawthorn hedges). Little of the area has been re-seeded, so there is a diverse grass flora, including species of *Poa*, *Holcus*, *Dactylis*, *Alopecurus*, *Arrhenatherum*, *Festuca*, *Lolium*, *Agrostis* and *Bromus*.

To determine if pollen of *Phragmites* could be confidently separated from that of other grasses at this site, measurements were made of the long axes of grass grains that were components of the modern pollen rain (i) in the vicinity of the lake and (ii) 0.5 km from it. It was hoped that the results obtained would indicate whether routine examination of small grass pollen grains in the fossil assemblage was sufficiently rigorous to allow confident identification of *Phragmites* pollen.

To investigate the modern pollen rain, moss polsters were collected mostly from stones and trees in late September 1988. It was not possible to collect the polsters at regular distances from the edge of the lake as the mosses were usually present only around the field boundaries. Cushion-forming mosses were chosen to minimise between-sample variation (Boyd 1986). Samples from 22 moss polsters were pre-treated by the standard procedures of Fægri and Iversen (1975) and all were embedded in silicone fluid. Measurements were carried out at a magnification of x640, using an eyepiece graticule; surface features were examined using bright field illumination. A pollen count of 50 grains per sample was possible for 20 samples.

The state of preservation of the grass pollen was variable. In most of the polster samples, grass percentages between 60 and 70% were common, the remainder being composed mostly of pollen of taxa growing close to the sampling point (Hall 1989b). Two moss polster samples collected within 5 m of *Phragmites* plants contained approximately 20% of grass grains with the same size, shape and surface features as *Phragmites*. Careful examination of more grass pollen grains from these samples showed some to have the same size range as those of *Phragmites*, but with different surface features (i.e. a coarser surface than is characteristic of *Phragmites*). In some cases, the poor state of preservation of the pollen with a long axis within the range for *Phragmites* prevented examination of the grain surface.

At distances greater than 5 m from the plants, the percentage of grass grains of the size range of *Phragmites* fell sharply to values of about 7%, but among these, too, there were some grains similar in size, but not in surface features to *Phragmites*. At distances greater than approximately 40 m from the edge of the lake, pollen that could be confidently identified as *Phragmites* was often present as single grain occurrences only. Within these sample, too, there was pollen within the *Phragmites* size range but with surface features sufficiently different to indicate that they were not *Phragmites*.

A number of points arise from these observations. The work of Haslam (1972) indicates that *Phragmites* may not produce much pollen. A previous modern pollen rain study which I carried out at Lough Henney, this time using grass foliage as the trapping medium (Hall 1989a) showed that in a pollen sum of 100 grains a maximum of 15% *Phragmites* pollen was present in samples where grass foliage had been collected from beneath *Phragmites* when it was in flower. These results contrast with those from a study of the modern pollen rain from a reconstructed 19th century farm (Hall 1989b). At that site, up to 80% of the pollen was grass in samples where grass foliage was used as the pollen trapping medium.

Terrestrial grass pollen is thought to be over-represented in grass foliage pollen traps, but the low percentages of *Phragmites* pollen trapped by grass foliage in the immediate vicinity of *Phragmites* plants is unexpected. Even lower values might therefore be expected where moss polsters were used as the trapping medium. Secondly, the results from the moss polsters at distances greater than 40 m from the lake edge indicate that *Phragmites* pollen is not readily dispersed. Thirdly, pollen of the size range of *Phragmites* was present in samples throughout the study area, even where relatively small pollen sums were used. The study indicates that small grass pollen grains are common in the pollen assemblages produced by agricultural systems such as this, which is primarily devoted to grazing.

In fossil deposits where there is pollen evidence from a semi-aquatic flora for *Phragmites*, and where the contribution made by grass pollen is significant, it is especially necessary to examine a representative sample of grass pollen grains using the criteria of Fægri and Iversen to determine if *Phragmites* is present. Where the contribution made by grasses is small, careful examination of all features of any grass pollen grain of the size range of *Phragmites* is essential before identification is attempted, and it may be necessary to examine a number of likely *Phragmites* grains before the taxon can be identified with certainty. Particular attention must be paid to surface features, as size and shape alone are obviously misleading. Positive identification can still prove difficult, as it did at Lough Henney, where the state of preservation of some of the grass grains in crucial samples was not thought adequate to allow confident determination.

Although this study is limited, the results may caution palynologists against assuming that small grass pollen grains in certain fossil assemblages are *Phragmites*, especially where the pollen record implies that the taxon might have been present. Unfortunately there is little in the literature to encourage a wary approach to the interpretation of pollen diagrams for sites where the catchment area could have included both *Phragmites* and species-rich grassland. The results of this study may be of even greater significance in mainland Britain and continental Europe, which have a richer grass flora than Ireland.

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Seed reference collections and archaeobotany

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Summary

Advice is given on how to collect modern seeds to aid the identification of ancient ones. Voucher pressed-plant specimens are essential; arrangements should be made to give them to a herbarium in exchange for identification. Careful collecting notes are very important and a sample form is given. After drying, seeds should be frozen for 48 hours to kill insects. Seeds can be stored best for easy reference in transparent boxes in shallow-drawered filing cabinets. Detailed plans are also given for an alternative storage system that uses glass test-tubes in wooden racks. A small label in each tube gives basic provenance data.

Introduction

Although it is essential for archaeobotanical work, the building up of a seed reference collection is a time-consuming and potentially expensive business. Perhaps because of this, little guidance is available on how to do it in an efficient manner (Bohrer and Adams 1977, 43–6; Gunn 1972; Pearsall 1989). Conversations with fellow archaeobotanists suggest that many of us (even those with a background in taxonomic botany) make the same mistakes when we start. This paper draws on five years' experience as user and curator of one of the larger seed collections, that of the British Institute of Archaeology at Ankara, Turkey, and offers practical recommendations for every stage of collecting. Although my experience has been gained in the Near East, the procedures given here are equally applicable, with adaptation, to other areas, and to other types of material (vegetative parts, phytoliths, charcoal) not discussed in detail here.

Why are reference collections necessary?

Although seed identification manuals exist (see Nesbitt and Greig (1989) for a full bibliography), they all too frequently concentrate on the most common seeds of one particular region, and many of the characters given apply only to fresh material. The kind of treatment needed for archaeobotanical purposes—focused on one or a few genera, with coverage of all the species that might appear in ancient material, and taking into account the effects of charring, waterlogging and other preservation processes—usually does not exist, although one outstanding example of such a work is Körber-Grohne's (1964) identification key to waterlogged grass fruits and rush seeds. Even where such treatments exist (and it is up to archaeobotanists to write them) there is no substitute for looking at ancient and modern material side-by-side, especially if dissection is needed to confirm an identification.

Identification should be based on comparison not only with what the archaeobotanist considers 'likely' taxa, but also with other closely related ones. The presumption that what today is the most common species was likewise most common in the past is widespread, but runs the risk of leading to a 'self-fulfilling prophecy'. In order to develop valid, consistent, identification criteria it is necessary to have to hand reasonable-sized samples of modern seeds from a number of different populations (so that both intra- and inter-population variability can be studied) of all the possible species concerned. The only way of doing this is to have a large enough seed reference collection.

Looking at seed on pressed plant specimens in herbaria is not a satisfactory alternative, as it would take far too long to pull out each specimen; herbarium specimen collectors tend to prefer flowering (rather than seeding) material, and even if there are seeds on the specimen there are usually too few to allow a good number to be removed. Looking at seeds in a herbarium can be a useful last resort, but

it cannot be the everyday method.

Funding of reference collections

Setting up a reference collection is not necessarily enormously expensive, but it does need a consistent level of effort over a number of years. Only a few institutions have given steady support to archaeobotanists, and therefore the number of good reference collections housed in institutions is very small. Part of the reason for this is the tendency in Britain to contract out bioarchaeological work to free-lance specialists, each of whom builds up their own collection. However it is only in institutions that adequate secretarial, technical and financial resources are likely to be available to curate collections properly and, above all, permanently. Additionally, institutional collections can (like herbaria) acquire specimens from more than one person, and thereby build up large and wide-ranging collections.

Given that a bioarchaeological laboratory wishes to get a collection going, how can material be obtained?

(i) By sponsoring collecting trips, perhaps as part of an associated activity such as an excavation. A clear understanding should be made between the collector and the institution that in exchange for assistance, the collector will collect duplicate seed collections for the institution. This is the system operating in Ankara, where the Institute gives me time off, pays some travelling costs, and all curation expenses, and in exchange all of my seed collections are split with the Institute's collection.

(ii) By encouraging donation or exchange of relevant, *well documented* material by other collectors. If a large quantity of material is involved, some of the collecting expenses should be paid. Gifts of this kind will be encouraged by two factors: whether the material is quickly and efficiently added to the institution's collections, and secondly, whether the collection is freely available for consultation to all.

In general, there is perhaps an obligation on collectors who have made collections of seed with 'public' funds to give surplus material to a publicly accessible collection, but only if there is a collection willing to take the material and look after it properly.

Genebanks and botanical gardens

The seeds sold by commercial firms, and given away by botanical gardens and genebanks are a tempting source of material. However there are some major problems:

(i) Many of the seeds will be mis-identified, particularly (indeed almost invariably) those of crop plants. Even if there is a good crop plant taxonomist to hand (as at most genebanks) material is often mislabelled during harvesting and packing. All seeds received from these sources must be checked against reliably determined material and, if necessary, grown on.

(ii) Strange cross-breeding often takes place, if plots are sown too close to each other. I have seen many weird forms of wheat from botanical gardens that are artifacts of careless growing practices.

(iii) The application of irrigation and fertiliser, and the growing of the plant outside its native region, in nursery plots, will affect the size of the seed.

(iv) Often the area of origin of the seed material is not known. As seed size often varies with area of origin, misleading comparisons can be made. It is always best to work with material collected in the wild or in farmers' fields, preferably from the same region as the ancient plant remains.

Despite these difficulties, getting seeds from these sources is an easy way of filling gaps. It is important that the reference collection labels indicate the seeds are not from the wild.

Archaeobotanists should avoid swamping botanical gardens and genebanks with long lists of requests. Seed and offprints of publications should be offered in exchange. A personal approach is often helpful. The best way to see botanical garden seed-lists and to order from them is to contact your local herbarium or botanical garden. Lists of genebanks that store the seed of crop plants and their wild ancestors are published by the International Board for Plant Genetic Resources, an agency of the United Nations' Food and Agriculture Organisation (FAO) based in Rome. Curiously, although British

scientists did much to establish the principle of genebanks in the 1960s and 70s, there is virtually no germplasm stored in Britain.

Food and spice markets are always a useful source of minor crop plants and of wild medicinal and food plants, and when working on excavations in an area with good markets, time should be allowed for one or two days of systematic buying. It will be necessary to consult (beforehand if possible) handbooks to the spices and herbs of the area to identify the materials. With a good knowledge of the local language, or an interpreter, notes should be made on the uses and area of origin of such collections. Local university departments of pharmacy are usually a good source of reliable identifications. Even in western Europe, health food shops can be a good source for uncommon crops and spices.

The importance of voucher specimens

When one first collects, the temptation is often to just collect the seeds, perhaps with a scrap of flower or leaf to aid identification. This approach is only acceptable where the collector is confident of identifying the species at the time of collection, or where it is not possible to collect the whole plant. Such conditions really only apply to areas such as Britain, where the number of species is relatively small, good field books on identification are available, and the collector may well have a great deal of experience in the botany of the region. Also, in Britain and some other European countries, it is illegal to uproot plants without the permission of the landowner (and some are too rare to be uprooted at all); in this case, where necessary, voucher herbarium specimens can be collected by removing a small, diagnostic part of the plant.

In countries where the flora is very large, and the flora less well known (this includes all of the Near East) voucher herbarium specimens (i.e. pressed plants) are absolutely essential. Even in cases where the species appears obvious to the collector, later study of the relevant *Flora* often shows that two or three closely-related species or subspecies are involved, which can only be separated by vegetative characters. This is particularly the case with grasses (including the wild and cultivated cereals) and with edible fruits, but these are the two classes of plant where the temptation to collect just seed is greatest. The other major disadvantage is that the identification cannot be checked by later workers—and even the best botanist makes mistakes sometimes (for more on the importance of voucher specimens, see Bye 1986).

For these reasons I recommend that collectors *always* take good herbarium specimens at the same time as they collect seed material. A further, major, advantage of this is that identification can take place at a time and place convenient to the collector: herbarium specimens are easily stored and posted. Many herbaria will identify specimens free of charge, in exchange for the specimen. Best practice is to collect between two and four duplicate specimens of each plant, so that collections can be divided between different herbaria.

The archaeobotanist must often collect seed from mature plants which are desiccated and in poor condition. This difficulty is exacerbated if collecting takes place in the Near Eastern summer. However, although dry plant material is difficult to collect and press, it is perfectly feasible, and I have had only a handful of plants disintegrate in the press.

Should a seed reference collection should retain a set of voucher herbarium specimens? They will consume time, money and lots of space for mounting and storage cabinets. My view is that if, as is usually the case, a set of specimens can be given to a well-run *local* herbarium which will always be easily accessible, that is the best solution. Otherwise, a set should be kept so that identifications can easily be checked. However, I would not usually recommend that individuals build up private herbaria. This is only feasible given a large home and plenty of time—neither of which are usually available to archaeobotanists. In the special case of phytolith studies, where any part of the plant may be needed, a backup collection of specimens kept boxed in storage specifically for this purpose will be useful.

What should be collected?

Collections for a seed reference collection will often be primarily focused on the segetal and ruderal flora of the region of interest, but should also consider other kinds of vegetation that may have been used—e.g. grazing land and wetlands—and will also need to include plants from areas that are not under heavy

grazing pressure, as plants growing there may well have grown closer to village sites in past times. For example, woodland in the Near East is often restricted to relict patches on mountainsides distant from villages, and the flora in these will, like the woodland, have been more widespread in the past. Fenced areas—e.g. a university campus, factory or archaeological site—are always worth careful collecting. In summary, Bohrer and Adams (1977, 43) list the following locations that tend to retain higher proportions of plants sensitive to over-grazing:

- steep northern or northeastern slopes;
- loose scree or talus slopes;
- shelves, niches, terraces in canyon rims;
- rough, broken, rocky topography;
- areas fenced against grazing;
- beneath and among shrubs;
- sand bars in rivers protected by steep embankments;
- steep inner banks of irrigation ditches.

There is of course no need to aim for complete collection of a country's flora: alpine plants, for example, are unlikely to be relevant to most excavations. Judicious use of a flora and common sense generally suggest which areas should be botanised.

Surveying a vegetation map or transect around a site is usually best done after some of the archaeobotanical samples from the excavation have been studied; these will suggest specific areas of enquiry. Chapman and Moore (1986) and Kershaw and Looney (1985) are useful guides to techniques for recording vegetation. It is important that botanical fieldwork does not distract resources from the more important task of recovering good ancient samples—a full time job in itself at most excavations. If work can take place during university vacation then botany students (who often have access to travel grants) can be enlisted for assistance.

Particular attention should be given to cultivated plants and their weeds and wild relatives. All too little is known about weed ecology, and any observations on how the weed flora changes with different cultivation practice—e.g. irrigation, time of sowing—will be valuable. Specimens, with information on their husbandry and use, of all the cultivated plants (old *and* new) of a region should be collected. Special attention should be given to cultivars described by farmers as being of local origin, as opposed to those from agricultural extension services or commercial seed suppliers. The longevity of trees means that races of fruit and nut may stay in cultivation long after local varieties of annual crops have been lost (cf. Körber-Grohne 1984). Zeven and de Wets' (1982) *Dictionary of cultivated plants* is an excellent handbook to all the categories of crop plant to the found in the different regions of the world. Many ornamental garden plants are recent introductions, but selective collection (especially for anyone working on garden archaeology) may be worthwhile.

Basic collecting practice

The budding collector must read one of many handbooks for the collection of plants and the maintenance of herbaria. The most recent is the reasonably priced *Herbarium handbook* of Forman and Bridson (1989), which should be owned by all archaeobotanists, although Fosberg and Sachet (1965) and Womersley (1981) are still worth looking at. Useful hints are also given by Davis (1961), and many herbaria produce their own short manuals. I do not intend to replicate the information found in these, but there are some points worth stressing.

In the field

Having arrived at one's chosen collecting location, the first step is to choose plants that have mature seed (the term 'seed' is used in this paper in the broadest sense, to include propagules of all types). If the seed is slightly immature, it will often ripen after collection. If plants with flowers can be found (perhaps in a shadier part of the collecting location) both flowering and fruiting material should be pressed; this will often aid identification. If a location can be visited twice, first for flowering species, and then later for fruiting material, so much the better. A collecting number should then be allocated, notes made and photograph taken. An on the spot list of photographs should be made in order to avoid guessing games a few months later.

Enough flowering/fruiting material of the plant should be collected, pressed and dried to fill the required number of herbarium sheets. Initially, collections are dried in newspaper folders, which are easily available, absorbent and much the same size as herbarium sheets. Care must be taken to include all the potentially diagnostic parts of the plant; this includes

the basal leaves and roots. Herbaria will not welcome plant scraps. The only case in which it is not necessary to collect the whole plant is when it is too large to press (e.g. trees).

Seed should be collected into an small top-sealing envelope (the kind sold as wage-packets), sealed with a paper-clip. Do not seal the envelope with gum and do not use self-sealing envelopes. If wood specimens are being taken, these should preferably be cut off from dead branches. Top quality secateurs are a wise investment. Care must be given to ensure that *everything* is indelibly labelled with the collecting number. Sufficient whole plants to fill 2–4 herbarium sheets should be pulled up (using a trowel or pick if necessary), labelled with collecting numbers on stringed tags, and either pressed straight away in newspaper folders, or put in individual plastic bags with a drop or two of water to keep them fresh until pressing.

Pressing

By deferring pressing to the end of the day, the quantity of specimens obtained can be greatly increased, but the collector is then condemned to catching up with pressing in the long, lonely hours of the night. In addition, plants pressed in preceding days will need to be checked and straightened out where necessary, and drying papers must be changed. Under no circumstances must the plants be left unpressed overnight. To quote Peter Davis (1961, 284): "Some collectors get up at dawn, others label and change their presses late into the night, but few can do both for long".

The number of specimens collected each day will vary with the richness of the habitats and the experience of the collectors. With a willing companion, I aim at between 30 and 40 species a day (good quality triplicate herbarium specimens, with seed, photographs and wood where appropriate) if the material is pressed immediately; 50–60 if pressing is deferred.

Immature seed

If the seeds are still quite immature, whole plants should be uprooted and placed in paper bags to dry, in the hope that the seeds will ripen further on the plant. This often works, but one can easily end up with several hundred paper bags of plants waiting to be winnowed. This technique is also useful for plants such as *Echium* that are too prickly to de-seed in the field.

Cereals

Cereals are best collected as ears and placed inside tall paper bags that will keep them upright and intact. I use specially made bags 33 cm high, 15 cm wide, with a pleat on each side. These bags are also useful for large seeds and fruits, and for permanent storage of cereal ears. The special problems of collecting crop plants are discussed by Hawkes (1980).

Fruit

When fleshy fruits are collected, some should be sun dried, and the seeds should be extracted from the rest. This is tedious work; a kitchen sieve is often helpful for washing seeds clean. When seeds are collected in capsules or pods, be sure to keep some of these along with the winnowed seed, as fragments are often found along with seed in ancient material.

Seeds and plants should never be stored for more than a few hours in plastic bags, or they will start to rot. Grain samples, on the other hand, can be kept in plastic bags, but must be left open to air-dry for several days.

Documentation in the field

Good recording practice greatly increases the value of specimens, as well as facilitating their identification. It is absolutely crucial that field notes are made at the time and place of collection; what seems an important fact will soon be forgotten in the collecting fray if not written down.

The standard botanical practice of using a small notebook, with one or a few collections on each page, is not suitable for the special needs of reference collections. The information in a botanist's typical notebook is transferred to herbarium labels; thereafter the notebooks are no longer needed. In a reference collection, however, it would be quite impossible to fit all the data onto a tiny label in a tube of seeds. Instead, basic information is put on the label (identification, collector number, Flora number), and the user can then refer to the detailed notes elsewhere. Small notebooks also have the disadvantage of being wasteful to photocopy, fiddly to handle and easy to lose. The cramped pages can easily degenerate into untidiness.

The efficient collector has two choices: a large notebook with hand-ruled columns, or a specially printed form. In Ankara we use A4 printed forms (Fig. 4, which may be freely copied). The column headings remind the collector to note all necessary data; the format is flexible and economical (*c.* 10 collections per page), and the pages are easily removed from a ring-binder for photocopying. Whichever system is chosen, it is essential that permanent black India ink is used, and that sufficient blank margins for good photocopying are left.

An excellent discussion of field records is given by Womersley (1981, 1–16). All collectors need to be familiar with correct, detailed, recording procedures. Only a brief summary of what is needed is given here:

1. All collections must be allocated a unique collecting number. Standard practice is that collectors use *one* series throughout their career. A new series should not be started for each trip or for each year. Maintaining one series does require a little forethought—it is easy to set off on a trip without noting one's latest number—but this is by far the best system. If a number of people are collecting together, the numbers should be allocated from one person's series. Since a unique number identifies all collected material, it is important that no labelling errors are made.

All accessions to a collection should be given a collecting number, whether or not they come from the wild.

2. Date of collection.

3. Field identification—even just to family is helpful.

4. Locality. Country, administrative region, village, distance from a point located on a readily available map (city and/or main road).

5. Altitude: an altimeter (which need not be expensive) is useful here.

6. Aspect and slope: e.g. NW, 40°.

7. Taxonomic notes: anything that might not be preserved or obvious once the plants have dried (e.g. flower colour, or form and height of tree).

8. Frequency, using the *dafor* scale (dominant; abundant; frequent; occasional; rare), qualified by 'local' where appropriate.

9. Habitat notes: geology, soil, landform type, plant cover type, drainage features, disturbance factors such as grazing. These ecological notes will be useful for the interpretation of ancient material too.

10. Ethnobotanical notes. Local names and uses should not be noted unless you know the language well enough to be sure this information is correctly recorded.

11. Material collected: at Ankara we use the following codes: H—herbarium specimen; S—seed or fruit; C—cereal packet specimen; W—wood specimen; P—slide photograph; BW-black and white photograph.

Identification

Once the seeds and the plants are back in the laboratory, safely dried and labelled, the question of identification arises. In countries with a relatively small, well-known flora (e.g. Britain) the archaeobotanist should be able to identify most herbarium specimens soon after collection. Where a larger flora is concerned this is a hopeless prospect: even if the archaeobotanist is a good herbarium taxonomist, he or she is most unlikely to have time to identify everything. It is, of course, essential to invest some time in identifying the commoner species, both so as to develop a good working acquaintance with the flora of the region, and to hone up the skills necessary for checking identifications. However, this is the point at which all the labour expended on good duplicate herbarium specimens becomes worthwhile. Most herbaria offer identification of pressed plant specimens in exchange for the gift of the specimens. Not all identifications are of equal value. The only really certain ones are those made by a specialist on the genus, but for most purposes a determination by a competent taxonomic botanist is sufficient. It must be stressed that the identification of difficult taxa requires comparison with other, reliably determined, specimens, as well as the use of a Flora.

Choice of herbarium

The ideal herbarium is one that is actively working on the plants of the country concerned. Where this is not the case (e.g. for Turkey, where the *Flora of Turkey* project at Edinburgh has now ended), considerable care is needed in choosing an institution. Most of the great National Herbaria are interested in

Collector:

Date	Locality	Alt. m.	General Habitat	Asp.	Coll. no.	Binomial	Taxonomic Notes	FQ	Specific habitat	Mtl

Fig. 4. Form for collecting notes. Key to abbreviations: Alt.-altitude; Coll. no.—Collection number; FQ—frequency; Mtl-(Type of) Material.

plants from all over the world, but unless there is a specialist interested in your region, you may wait a long time for identifications. A smaller herbarium may well be interested in your material, and offer a more personal service.

For example, my own material goes to Reading University, with further duplicates from two difficult groups sent to specialists in Southampton and Berlin. This enables me to devote enough time to identifying taxa such as the cereals in which I have a special interest. Initial contact should always be established with herbaria before specimens are sent. Addresses of herbaria are given in the *Index Herbariorum*. When collecting abroad it is an important courtesy to deposit a set of specimens at a herbarium in the host country (with labels and identifications).

Export of specimens

Help in arranging the export of herbarium specimens is usually best obtained from local herbaria. There is a well-established tradition in taxonomic botany of unrestricted exchange of herbarium material. Ministries of Agriculture tend to be more concerned with commercial collectors of plant material, and with the political issues of germplasm, and can therefore be unhelpful. Herbarium specimens may be posted to most countries (including the UK) provided they are addressed to *The Curator* at an established herbarium.

Preparation of labels

Many herbaria input collecting notes into a computer database and use this to print labels for the herbarium specimens. This saves the collector a great deal of time in typing up labels, and is highly recommended. The labels can be photocopied and sent to the other herbaria where material has been deposited. If these facilities are not available from the herbarium, and many specimens need labelling, the collector may find it worthwhile setting up a computer database in the laboratory.

Documentation in the laboratory

Paperwork after collection must be kept to the minimum. The main function of a seed reference collection is as an aid to seed identification, it is not an end in itself. At the same time, there must be a simple system to check the identification and collection notes of each specimen, and which can also cope with later additions.

The system in Ankara fits in two A4 ring binders. One contains a copy of all the collecting notes; one contains our special 'identification forms' (Fig. 5). After seed material is collected, it is either placed straight into a test-tube with a temporary hand-written label, or it is stored in an envelope. When a definite identification has been made, either by the collector or by a herbarium, the identification, together with any comments, is noted on the appropriate identification form. A separate sheet is used for each genus. A special label (Fig. 6) is filled in with the identification, the collection number, and the Flora of Turkey number (see below for an explanation of this).

This system has two advantages. There is a listing of all accessions, in *Flora of Turkey* order, on the identification forms, which also note where seed and herbarium specimens have been deposited. Also, firmly identified material can be easily distinguished from provisionally identified by the special labels. The alternative to special identification forms is simply to write the firm identifications on the collecting notes. However it would be necessary to leave ample space for these and for identification comments.

If sufficient secretarial assistance is available, both the collection notes and the identification notes can be entered onto a computer database. I doubt whether this is worth the time and expense in most cases, unless it is planned to produce herbarium labels. The paper-based system outlined above is perfectly adequate and reasonably time-efficient. However, in Ankara we are now setting up a computer database of identifications (but not collecting locations) with the specific aim of printing test-tube labels for the seed collection. A useful subsidiary product will be a catalogue of the collection.

Pest control

Pests in herbarium material are not usually an immediate worry, so long as the specimens are properly dried. Herbaria will use their own control methods before accessing material. With seeds, problems are likely: it is remarkable how quickly a bag of vetch seeds,

BRITISH INSTITUTE OF ARCHAEOLOGY AT ANKARA HERBARIUM (B.I.A.)	DET.	DATE / /

COLL. NO.	COLL. NOTES	FLORA OF TURKEY NO.			SPECIES NAME & AUTHORITY	COMMENTS	1 SHELF NO.	2 HERB B.I.A.	3 HERB ANK.	4 SEED HERB.	5 SEED B.I.A.	6 SEED LON.	7 SEED R.M.N.	8 WOOD	9 CHARCOAL	10	11	12

Fig. 5. Form for noting final identifications.

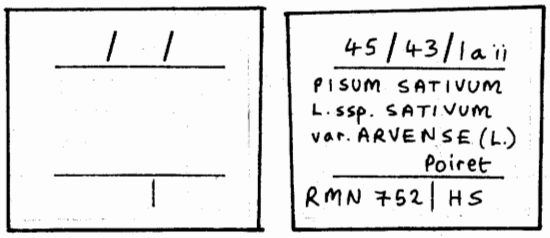


Fig. 6. Label for test-tubes, blank and filled in.

acorns or cereal grains can turn into a seething colony of bruchid beetles and maggots. There is a very simple solution: deep freeze the seeds (once they have had a several days to dry out) at –20°C for 48 hours. If a good domestic freezer is not available, the ice compartment of a refrigerator can be used as a temporary substitute. After freezing, we put small chunks of Vapona moth killer (a product widely available for protecting clothes) inside bags of grain for further protection. All grain samples are stored in three layers of polythene bag, to avoid insect contamination.

Naphthalene (as in old-fashioned white crystalline mothballs) should not be used as it can cause cataracts. Further guidance on pest control can be found in Zucherman (1988) and Forman and Bridson (1989, 13–19). In the unlikely event that insects are active in a seed tube, this will be indicated by the presence of frass, and the tube can be frozen.

Arrangement of reference material

Two decisions need to made concerning the storage of a collection: arrangement, and the type of container to be used.

Four considerations will affect the choice of system of arrangement: seed material should be located quickly; containers should be easily returned or added in the correct sequence, even by those with relatively little botanical knowledge; evolutionarily related material should be placed close together, and the system should not be based on a classification that will soon be out of date, and thus unfamiliar to those using the collections in 50 years time. As changing the ordering system is a very time consuming process, it is worth investing much thought at the outset.

Ordering of the material will be determined in part by the scope of the collection. It is highly advisable to keep geographically separate collections apart: for example, New World and Old World plants should not be mixed in the same cabinets. It would be equally unwise to split up collections into too narrow regions. In most cases, for example, a single sequence for European or Near Eastern plants would be sensible, but a single sequence for Europe and the Near East together would grow too unwieldy.

Many seed collections are divided into two series, a main one with two or three examples of each species, stored in easily accessible glass containers, and a separate 'back-up' series of further collections, kept in cheaper containers and available if needed. My own experience is that the more accessions that are to hand, the better, and I would prefer to have all material integrated into the main collection, with the reserve collection simply holding extra quantities of material beyond what will fit into the standard containers (*cf.* the cereal packets described below).

Most collections are still based on the flora of one country or region. Where a good flora has been published, and is unlikely to change much, it forms a very convenient basis. For example, in Ankara we follow the arrangement of the *Flora of Turkey* (Davis 1965–89). This Flora gives every family, genus and species a series of running numbers; for subspecies and varieties, which are not numbered by the Flora, we allocate letters (a,b, etc) and numbers (i, ii etc). Thus 45/43/1/a ii is the code for Leguminosae/ *Pisum*/ *sativum*/ ssp. *sativum*/ var. *arvense*. Having the seed tubes arranged exactly as the Flora is highly convenient, and means that closely related taxa will be found next to each other. There is a space on the test-tube labels for the Flora number (Fig. 6). We can follow the Flora both because it incorporates a sensible numbering system, and because it is unlikely to be replaced in the next 50–100 years. Newly described species, and other taxa not in the Flora, are simply placed at the end of each genus or family sequence.

Other countries with an authoritative Flora that is unlikely to be superseded for many years include Israel, Jordan (*Flora Palaestina*), Iran (*Flora Iranica*), Iraq (*Flora of Iraq*), Syria

(*Nouvelle flore du Liban et de la Syrie*) and Cyprus (*Flora of Cyprus*). Relatively little taxonomic work is done in these regions, and therefore once the heroic effort of preparing a Flora has been made it is unlikely to be repeated. The situation is much more difficult where there is no Flora, or it is hopelessly behind schedule, or where the National Flora is regularly revised, with a different numbering system each time.

An alternative possibility for the Near East would be the *Conspectus Florae Orientalis* (Zohary *et al.* 1980–) which is making good progress. Although it lacks a numbering system, this could easily be added. For the Mediterranean countries there is the *Med-Checklist* (Greuter, Burdet and Long 1984–).

For the European countries one has three alternatives:

(a) To use the system of a national *Flora* and to ignore rearrangements in later editions on the basis that, in areas as botanically well known as Europe, these changes are unlikely to very significant. For example, a British collection could use the *Flora of the British Isles* (despite its expense and the mis-numbering of the families!), or could opt to wait for the second edition of J. E. Dandy's standard *List of British Vascular Plants* (due from the Botanical Society of the British Isles soon). Anyone contemplating using the *Flora Europaea* should bear in mind that a second edition has just started publication, and that the classifications adopted in some of the earlier volumes of the first edition are not always satisfactory.

(b) To follow many herbaria and arrange families and genera by one of the 'evolutionary' systems devised in the late nineteenth century by Engler, and Bentham and Hooker. The species are then arranged in alphabetical order. These have the disadvantage of being out of date and unfamiliar. The worst possible arrangement, although used by many herbaria, is to have families in evolutionary order, then genera and species in alphabetical order.

(c) To put families, genera and species in alphabetical order. This system is the easiest to arrange, but has the great disadvantage that it separates closely related species and genera—very unhelpful for identification purposes. This is a fine as a temporary system for collections, but is unsatisfactory in the long-term.

Cultivated plants are rarely well treated in Floras (indeed, some exclude them altogether). Where this happens, the collection curator will have to insert them at the appropriate place. In any case, most seed collections will have species that are no longer cultivated in the region. In Ankara this is mainly the case with the cereals, and we follow the sensible and comprehensive classification of these by van Zeist (1984).

Storage of reference collections

The most inexpensive system is to put seed envelopes in rows in boxes or drawers. The disadvantages are obvious, and most collections use glass jars, specimen tubes, test-tubes or plastic boxes. Standard specimen tubes are really too small and take up a lot of space. For collections in areas such as Europe, where the materials are easily available, a system based on small, transparent plastic boxes stored in shallow-drawered filing cabinets is recommended. For areas such as Turkey, where the boxes are not easily obtainable, glass test-tubes in wooden racks may be more suitable, and this is the system used in Ankara.

The advantages of using boxes in shallow drawers are that the boxes are easily scanned while in the drawer, and are easy to remove and replace. This is particularly important if specimens are to be handled by large numbers of inexperienced users. Compared with glass tubes, the system is less compact and a little more expensive, but these should not normally be the major factors guiding the choice of a storage system.

Transparent polystyrene boxes with sliding tops are widely available in at least two convenient sizes: small (75 mm long x 44 mm wide x 20 mm deep) and large (120 x 77 x 18). For most seeds the small boxes will be suitable. An example of a widely-available filing cabinet contains 15 drawers, each 371 x 233 x 44 mm. Assuming each drawer holds 24 boxes on the bottom and 10 on the second layer, each cabinet could comfortably hold about 500 boxes. The specimen labels simply sit inside the boxes. Care should be taken to ensure that the drawers are easily removable from the cabinet.

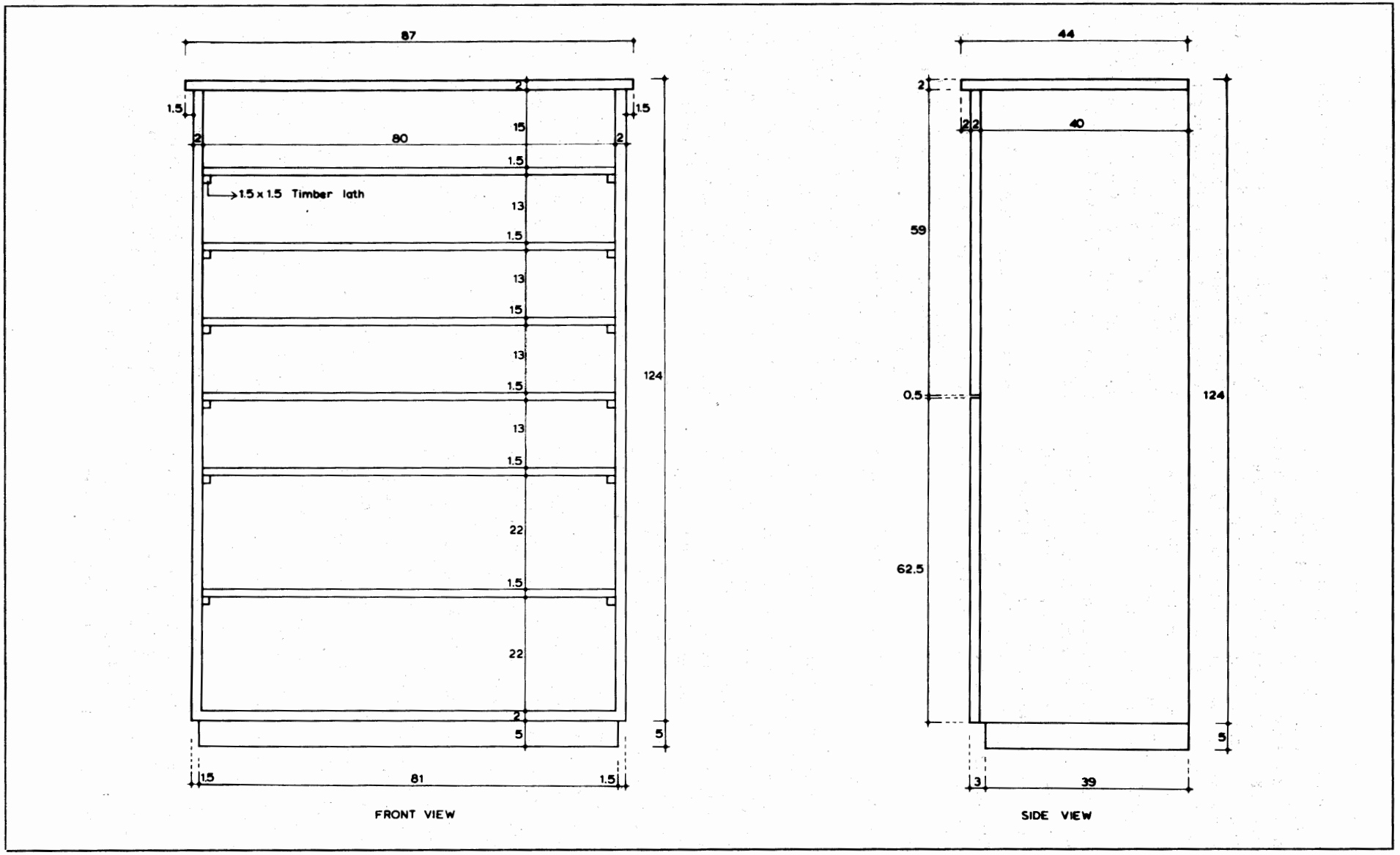
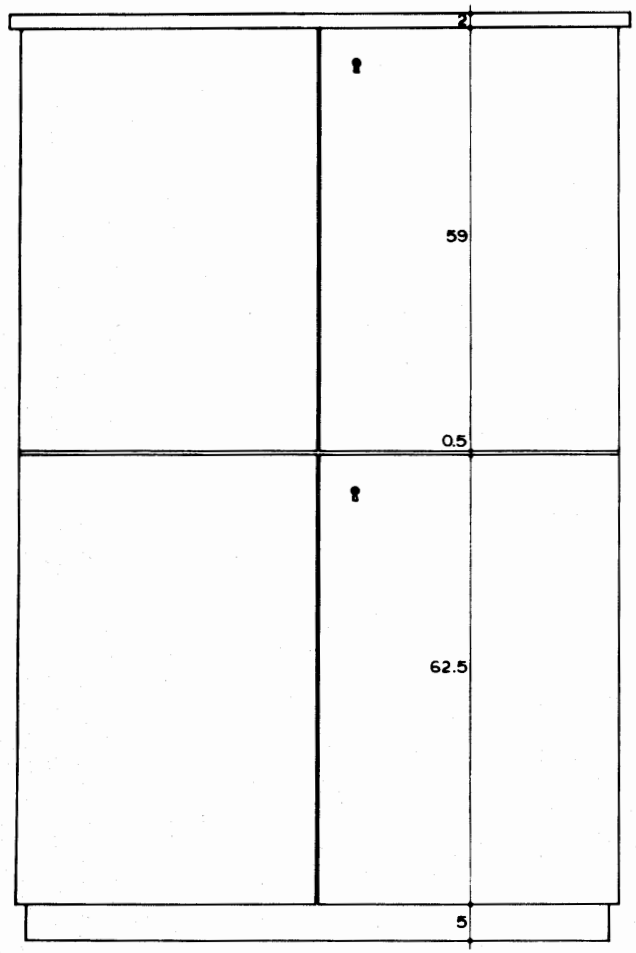
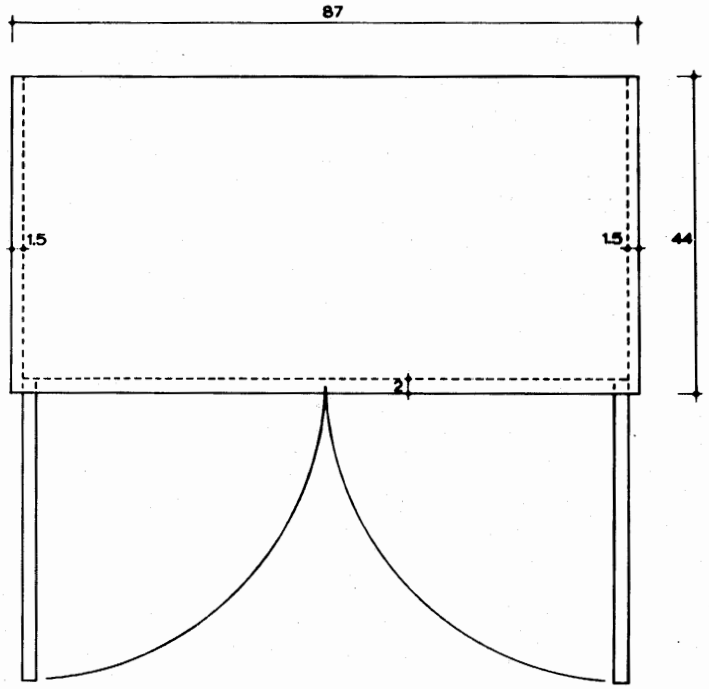


Fig. 7. Front and side view of wooden seed cabinet.



FRONT VIEW WITH DOORS



TOP VIEW

Fig. 8. Front view with doors and top view of wooden seed cabinet.

The system used for storing test-tubes at the British Institute of Archaeology in Ankara, designed by Gordon Hillman in the 1970s, is described at greater length as it requires some carpentry.

We use standard test-tubes with a flared rim (this makes tipping seeds in and out easier), 105 mm high with a diameter of 12.5 mm. The tubes are stoppered with cotton wool. Larger seeds are kept in a separate series of larger tubes, H 160 mm, D 16 mm. The tubes are stored upright in depressions drilled into solid wood blocks. Blocks hold 48 standard tubes, or 24 large tubes. Our wooden cabinets each hold 55 racks of standard tubes (total 2640) and 26 racks of large tubes (624). The wooden racks can be conveniently slid in and out and can be easily rearranged when extra racks are inserted. The wooden blocks are very stable. The end of each rack bears a label giving the family(ies) (with Flora of Turkey number) in the rack. A cheaper alternative to wooden racks would be expanded polystyrene racks, of the kind used for holding specimen tubes. However, these hold too many test-tubes for easy use, and will eventually disintegrate. Another possibility is the kind of open lattice test-tube metal rack used in laboratories. Joy McCorriston has found these to have the advantage of allowing scanning of tube contents at a glance, with no need to remove tubes until a closer examination is desired. They are perhaps less stable and easy to handle than solid wooden blocks, but would certainly be worth a trial.

The seed cabinet is illustrated and drawn in Figs. 7 and 8; also shown are the standard rack (Fig. 9) and the large-tube rack (Fig. 10). Although the Ankara cabinets have locks with keys, it would be preferable to use non-locking catches—keys are all too easily lost. A ready-made metal cabinet could be used if economy is important, but a specially made wooden cabinet will be comfortable to use.

We do not keep the racks full of tubes, so as to allow further accessions to be easily added. Care is needed when a tube of seeds is taken out of a rack for study. Although the Flora of Turkey number on its label ensures it can be returned to the right spot, it is easier simply to mark the appropriate depression by putting a brush or pencil in it. Taking seeds out of more than one tube at the same time is best avoided, as it introduces the risk of returning the seeds from the Petri dish to the wrong tube.

An ingenious storage system is described by Christian de Vartavan (1988). Specimen tubes fit into longitudinal slots that are cut into cork tiles. Although easily carried, I suspect that fitting the tubes in and out of their slots could be more fiddly than simply placing a tube into a wooden rack. I also wonder how well this system would work with stoppered test-tubes rather than specimen tubes (which are too small for holding an adequate number of seeds for many species). However de Vartavan's system would be suitable for collections where ease of carrying is a major consideration, and is very cheap.

Some older collections are kept in small 'cells' mounted on slides. This system has the advantage of allowing very quick browsing, but is laborious to prepare, and does not allow the seeds to be handled. Where such a collection already exists it can be very useful and should be maintained, but I would not recommend starting one from scratch.

Very large seeds and fruits

These are best kept in rectangular transparent polystyrene boxes, stored in drawers. A variety of sizes should be kept available so as to ensure the most economical use of space.

Cereal ears

Typical cereal ears tend to get stuck in test-tubes, and in any case they will not hold the minimum 3–4 ears that should be to hand from each collection. The most satisfactory solution is, again, transparent plastic polystyrene boxes with lift-off lids. We use two sizes, as described above (p. 31): small—mainly for loose spikelets and grain—and large-for intact ears.

We also have a back-up collection of ears stored in tall paper-bags (as recommended for collecting), arranged inside a plastic-lined wooden crate. Each bag contains around 10–30 ears, and these have proved very useful for large-scale studies of variation, and also for the provision of intact ears if all those in a box have been dissected.

Wood and charcoal specimens

In Ankara we have followed the practice of the Institute of Archaeology, London, by using enamelled steel cabinets containing transparent plastic drawers; these are widely sold in hardware stores for storing small items.

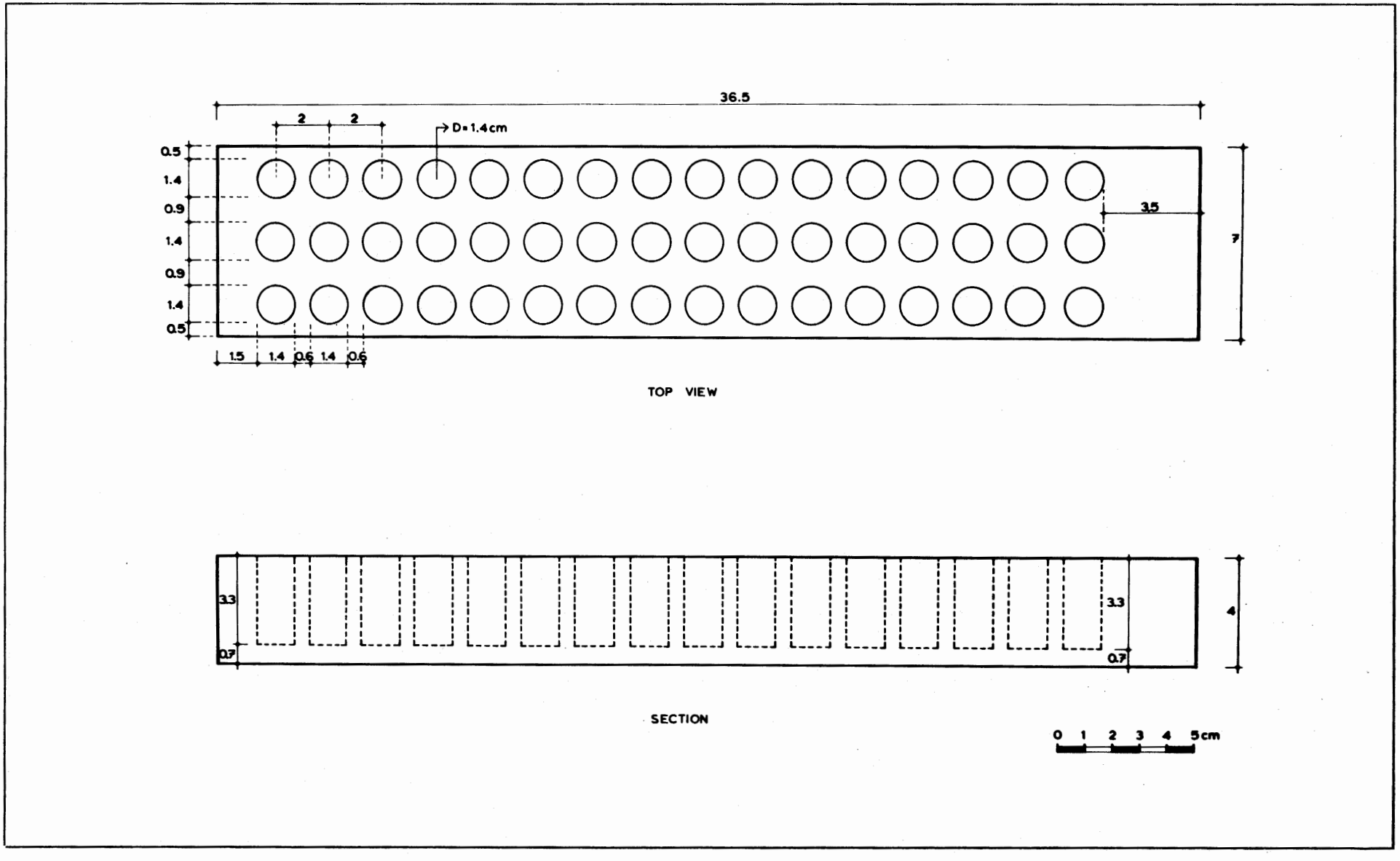


Fig. 9. Top view and section of rack for standard test-tubes.

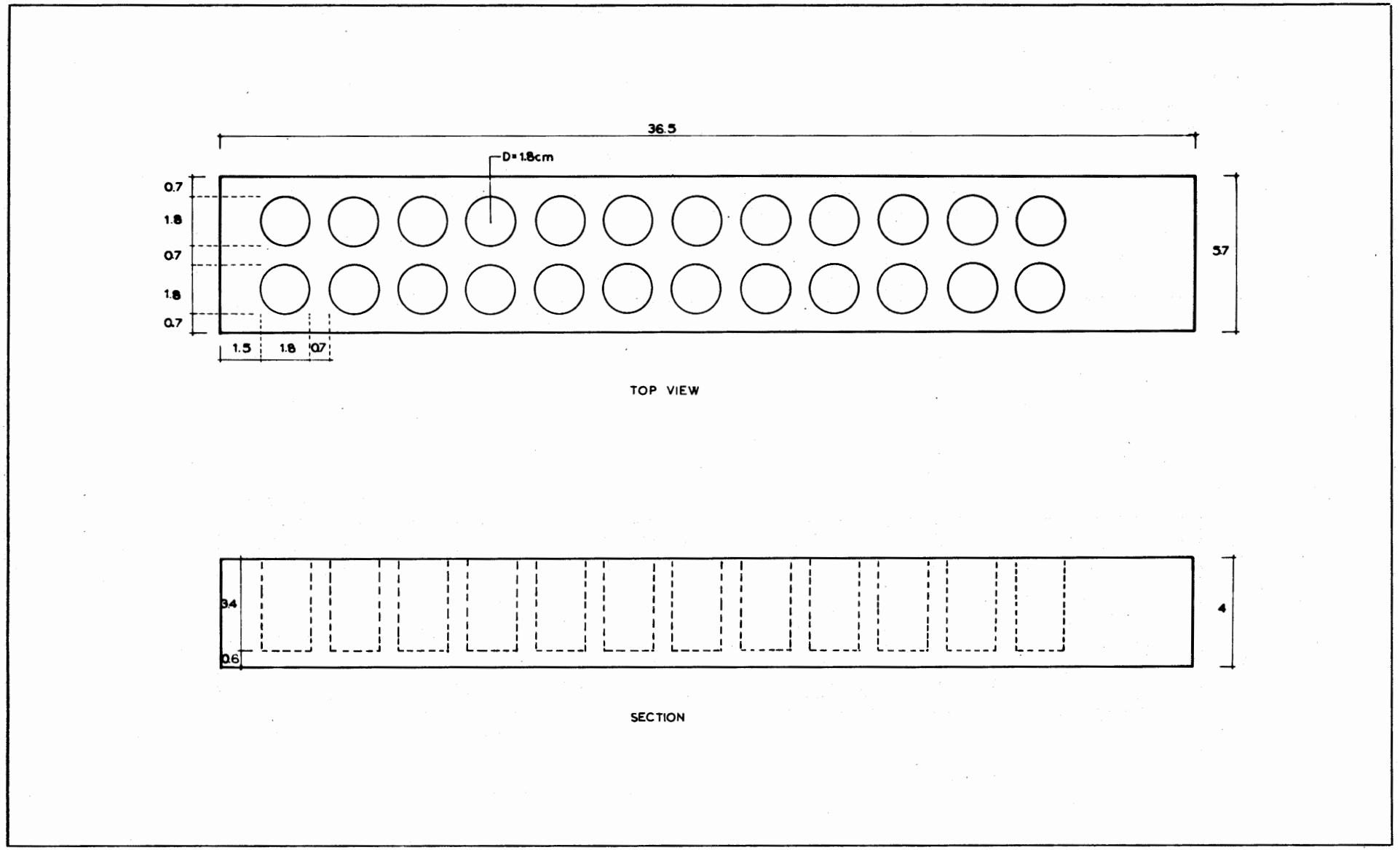


Fig. 10. Top view and section of rack for large test-tubes.

The drawers have label holders on the front, and if separate collections of trunk wood, twigs and roots have been made, each drawer can be split up with plastic dividers to accommodate these. An alternative procedure would be to glue radial, cross and tangential sections to a jar lid interior, and then screw this into the short jar to protect the samples from dust and wear. In earlier times charcoal used to be identified by comparison to mounted slides with thin sections of modern wood. Today ancient charcoal is identified by comparison with lumps of modern charred wood, and the painstaking preparation of thin sections only necessary if uncharred wood is to be identified. For charcoal and wood specimens the same kind of label as described for seeds should, of course, be used.

Pollen

Modern pollen can be extracted from dried flowers on herbarium material, but collectors interested in collecting for pollen specimens should consult a palynologist beforehand. In general, it is helpful if insect pollinated flowers can be collected within a day of opening, as in older flowers there is a risk of insect-borne cross contamination from other species.

Phytoliths

If it is intended to extract phytoliths (silica bodies), the appropriate parts of the plants should be placed in a paper bag for extraction treatment in the laboratory (see Piperno 1988 for more details). As with seeds, voucher herbarium specimens must be collected.

Seed viability

Many seeds will retain some viability under the storage conditions of a normal seed reference collection (i.e. room temperature), and I have successfully grown a number of seeds from collections made twenty years ago. If it is particularly desired to keep seeds viable, standard procedure in genebanks is to reduce seed moisture to 4% and store in sealed containers at around –20°C. This will keep the seeds of most species viable indefinitely. A good domestic freezer is perfectly suitable. If this is not possible, then higher temperatures (–10° or –5°C) will still give reasonable protection of viability. However seed moisture must always be reduced to a low level, either by sun-drying or low heat, before freezing. Further details on these procedures are given in Dickie, Linnington and Williams (1984), Ellis, Hong and Roberts (1985), Hawkes (1987) and Holden and Williams (1984).

Using the collection

Anyone working with charred or waterlogged material will need to carry out artificial treatments on some of the reference material for comparative material. Charring of both wood and seeds is a relatively simple matter, providing a high enough temperature can be obtained. Domestic ovens [in Turkey at least] generally have a maximum temperature of 250°C, which will char seeds far too slowly (10–20 hours). Two hours at 350° in a muffle furnace is satisfactory (Ann Butler, pers. comm.); the seeds should be placed in sand. A simpler method of charring is to heat the seeds in a sand-bath with a Bunsen burner (or domestic stove) for ten minutes (Jacomet 1987, 21) or, as described by Kosina (1984, 178) over a gas burner in a layer of powdered clay, with 0.25 kg of sand on top for about three hours. Anyone interested in the effects of charring on seed size will need to carry out experiments at different temperatures, times and levels of seed moisture. Once the charred seeds have been examined, they can be placed in a gelatin capsule labelled with details of temperature and time, and returned to the seed test-tube.

Ancient waterlogged plant material can look very different to modern material, owing to the loss of the softer tissues. Techniques for replicating this effect on modern material are given by Tomlinson (1984). Material treated this way will need to be mounted on slides and stored separately. Care should be taken to ensure that the appropriate collector number is applied to mounted material.

Eight "do's" in building up a seed reference collection

1. Read one of the handbooks on plant collecting and follow its advice.

2. Always collect herbarium voucher specimens.

3. Give all accessions to the collection a unique collection number; use only one series in your collecting career.

4. Keep tidy collecting notes, in permanent black ink, on well laid out forms; ensure a photocopy of these notes is safely housed in an institution.

5. Deposit sets of duplicate herbarium specimens in at least one good herbarium, in exchange for a list of identifications.

6. Deep freeze all seed material to kill pests.

7. Split seed collections made with grants or other official funds with at least one institutional collection, so that this material is available to other scholars.

8. Use a seed storage system that is 'self-organising' and easily expanded.

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I am grateful to Gordon Hillman for encouraging publication of the storage system he designed for the Ankara laboratory, and for many helpful discussions. Vorsila Bohrer, Allan Hall, U. Körber-Grohne, Joy McCorriston and Delwen Samuel (cheerful veteran of many nights of non-stop pressing in Turkish hotels) made useful comments on this paper. Pervin Bilgin drew the figures.

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The use of tarsometatarsi in sexing and ageing domestic fowl (*Gallus gallus* L.), and recognising five toed breeds in archaeological material

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Summary

A paper by Latimer (1927) is brought to the attention of readers to add information on the fusion of the proximal epiphysis of the tarsometatarsi of domestic fowl (*Gallus gallus* L.) to that given by West (1985). It shows that, in slower-maturing birds, the earliest age at which the fusion line had completely disappeared was 139 days for females and 195 days for males.

The difference between the description in the literature of the fusion of the spur core to the tarsometatarsus (Juhn 1952) and personal observations is discussed. It is suggested that, in birds with spurs, evidence from the tarsometatarsus that a spur is present develops relatively late. Such birds may therefore be older than was previously thought.

As birds were castrated mainly to provide better quality meat, and taking into account the information in the first two parts of the paper, it is felt that few capon bones will be recognised in archaeological material.

Five-toed fowl have been in existence since at least Roman times. Diagrams and descriptions of the differences between these and the more common four-toed breeds are given to help with their identification and to show some of the variations that may be found.

Introduction

In 1988 I acquired and buried the carcase of a bantam cock. The bird had been killed by a farmer because he was "being a nuisance" in the hen house. He was at least one year old with well developed spurs but when I dug the skeleton up and cleaned it, the tarsometatarsals showed no sign of this fact. They were completely mature and as these bones, when found in archaeological collections, are generally sexed on the basis of the presence or absence of a spur or 'spur socket', I would have had no hesitation in saying that they were female. After studying as many fowl skeletons as I could find and the available literature I came to the conclusion that there are three problems for archaeologists:

(i) Male tarsometatarsi may not show any sign of a spur, such as a socket primordium, even when mature.

(ii) The way the spur core fuses onto the tarsometatarsus may mean that the period of the bird's life when there is no evidence on the shaft of the presence of a spur is longer than previously thought.

(iii) Capon tarsometatarsi found in archaeological material are likely to be unfused and therefore not measured and they are unlikely to have any sign of a spur.

In December of that year I wrote to eighteen establishments which keep rare fowl breeds and asked them to send me the lower limbs of any slow-maturing domestic fowl which died between the ages of four months and one year, and the lower limbs of cocks which died between the ages of one and three years. I was hoping to get some indication of the age at which the proximal epiphysis of the tarsometatarsus of these slow-maturing birds unites with the metaphysis and a guide to the age at which the spur core fuses with the shaft of the tarsometatarsus. The response was disappointing. I received only four specimens, three of which were from Dorkings which are a five-toed breed. Whilst dissecting and cleaning these specimens, I made observations which are the basis of the fourth section of the discussion which follows.

Fusion of the proximal epiphysis of the tarsometatarsus.

It has often been stated in bone reports that mature unspurred tarsometatarsals are female but this is not always the case. Information from two studies on the postnatal growth of the chicken skeleton was studied. The data presented by Latimer (1927) are based on results using single comb white Leghorn chickens and those given by Church and Johnson (1964) (quoted by West 1985) on New Hampshire/Barred Rock crossbred birds. Latimer's work is more useful for the purposes of this paper as the breed used matures more slowly than those chosen by Church and Johnson and so are more likely to be similar to archaeological specimens. Also, individual weight variations became apparent after the age of six days in the birds used by Church and Johnson and was interpreted as resulting from the cross of the two breeds and might be expected from the fact that the Barred Rock averages a full pound heavier than the New Hampshire Red when mature (Church and Johnson 1964, 532). The fact that the offspring did not develop uniformly may have masked differences between male and female as some females will have been more influenced by their heavier mothers and some males will have grown more like their smaller fathers. Latimer found that the male skeleton was heavier than the female when mature but that the females matured earlier. The male tarsometatarsus stopped increasing in length at an average of 142 days (about five months) and the length was 102 mm. The same bone in the females stopped increasing in length at an average of 110 days (about four months) and the average length was 85 mm (Latimer 1927,

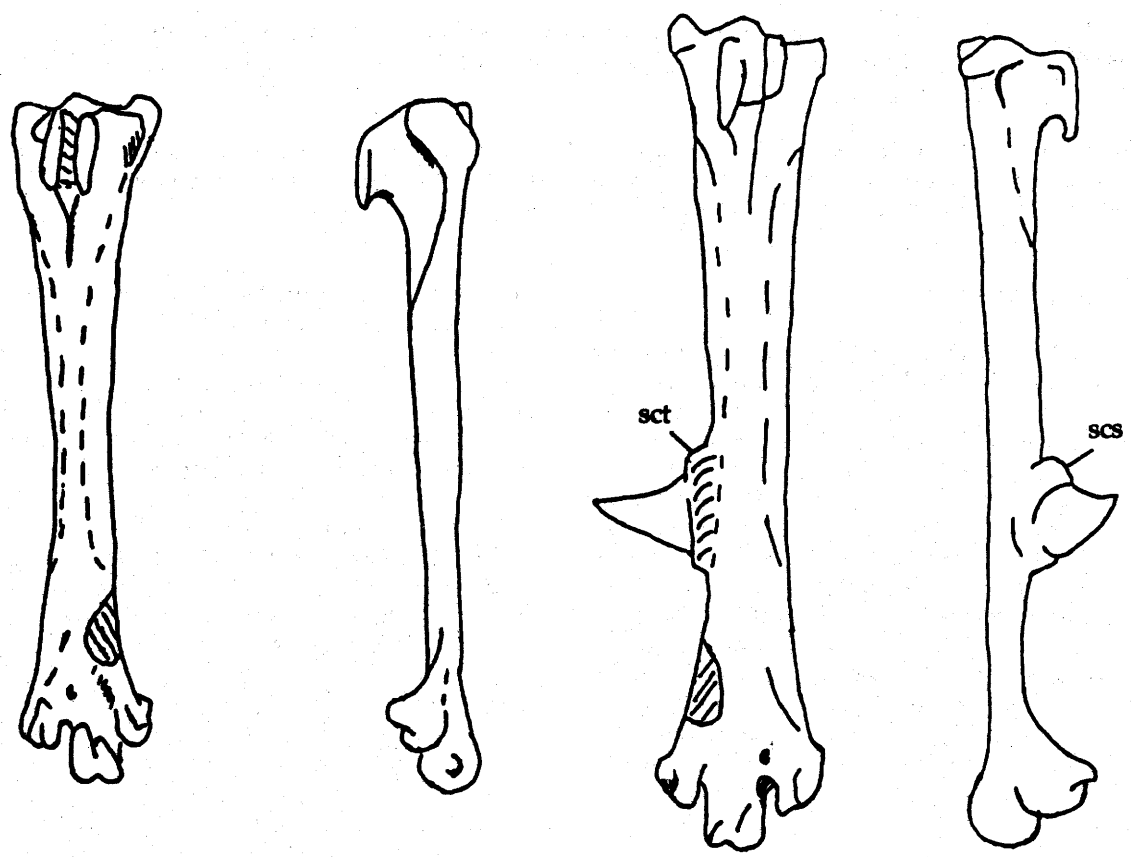

Fig. 11. fowl tarsometatarsi: (a) unspurred; (b) spurred. Key: sct—portion of spur core base curved around tendons, etc.; scs—portion of spur core base fused to shaft.

41). The birds were killed at various time intervals which were more frequent in the early stages of growth and, when the lengths were measured, the age at which the ossification of these bones was completed was observed and recorded. Latimer's table 4 (ibid., 53) shows the age in days of the youngest specimen in which the epiphysial line had completely disappeared. This was 195 days (about seven months) for males and 139 days (about five months) for females. For comparison, the faster maturing breeds used by Church and Johnson (1964) fused between three-and-a-half and four-and-a-half months.

Development of the spur core and its fusion to the tarsometatarsus

As mentioned above, domestic fowl tarsometatarsals from archaeological sites have often been sexed on the presence or absence of a spur. Whilst it is normally true that the female does not have a spur, there are rare exceptions caused by hormonal defects (West 1985, 14). The normal situation, illustrated in Fig. 11, is described by Lucas and Stettenheim (1972, 609):

> "The spur of the female retains a juvenile appearance throughout its entire life. The spur cap of the cock is not supported by bone until about the sixth month and soon thereafter the bone fuses with the os tarsometatarsus. Fusion occurs regularly in the male but only as an abnormal development in the female."

A paper by Juhn (1952) deals with spur growth and although the main interest of her investigations is the effect of thiouracil on the spur she also establishes the normal processes of spur calcification. The fowl used were New Hampshires, White Plymouth Rock/New Hampshire crosses and Barred Rock, which mature faster than the Leghorns used by Latimer (see above) and therefore probably faster than birds represented in archaeological material. Juhn used X-radiographs in her study:

> "The developments discussed in this paper are based entirely upon records furnished by X-ray films of the spur region of normal and experimental birds." (ibid., 150)

Describing the early development of the spur core, Juhn wrote:

> "Minute granules are visible at a distance of 4 mm from the tarsometatarsal surface in bird 735 and fragments are present in 755. The next stages show the organisation of a diminutive central core. The spur proper is gradually increasing in length with these developments and for a considerable period the distal apex of the central core tends to retain its relative position toward the spur tip while progressively extending its proximal margin toward the tarsometatarsal surface." (ibid., 152)

It appears that the new bone growth is being produced at the base of the spur core.

> "Next, at a certain point of its advance towards the shank, the core throws forward slight dorsal and ventral swellings. Simultaneously, the hitherto smooth surface of the shank gives rise to two small thickenings that project towards these paired lobes. The tarsometatarsal proliferations increase in size and expand to fuse with each other while leaving the centre free, thus forming a ring-shaped structure—the socket primordium. At the same time a delicate series of fibres arise connecting this primordium with the adverted core surface. These fibres are the scaffolding, so to speak, for the final developments, in which the socket wholly embraces the basal section of the spur core." (ibid., 153)

Whilst using X-radiographs may be a very useful method for recording the development of the spur core, it seems to be inadequate for observing and accurately describing the fusion of the spur core to the shaft. No spurred tarsometatarsal that I have seen shows the circular basal section of the core embraced by a socket. What is observed is that only a portion of the spur core contacts and fuses to the shaft whilst the remainder forms a curve around the tendons and soft tissues which extend down the posterior surface of the bone (see Fig. 11b). If the approaching spur core does not affect the shaft and fusion takes place when they are in contact, it is possible that even more of the male tarsometatarsi found will show no sign that a spur was present. Juhn (1952, 152, table 1) lists the distance between the core and the tarsometatarsus in 28 birds. In eight of them the core is in contact

with the shaft. Of these, three aged seven months have no socket recorded, i.e. there is no thickening around the base, but four aged eighteen months and one of 30 months are said to have sockets. This could be interpreted as showing that those aged seven months have only just reached the shaft and have not started fusing with it but the spur cores of the older specimens have spread as they came in contact with the shaft and the soft tissues, to form their support and to fuse with the tarsometatarsus. Examination of the plates at the end of the paper did not show any example of bone growth from the shaft before the spur core came into contact with it. Of the other 20 birds in Juhn's table 1 there are six aged seven months with an average distance of 3.5 mm still to grow to reach the shaft, and eight aged nine months with an average of 2.6 mm still to grow to close the gap. This very small sample suggests that fusion is likely to take place between seven and eighteen months in these faster maturing birds with tarsometatarsi that fuse proximally between three-and-a-half and four-and-a-half months.

Capons

Cockerels have been caponised from at least the 17th century. Aldrovandi (1600) (trans. Lind 1963, 410), quoted by West (1982), says:

> "Our farm wives pull out the testicles through the posterior parts after making a small incision with a knife. The wound is large enough to admit a finger above the genitals under the septum where the testicles adhere and is sufficient to draw

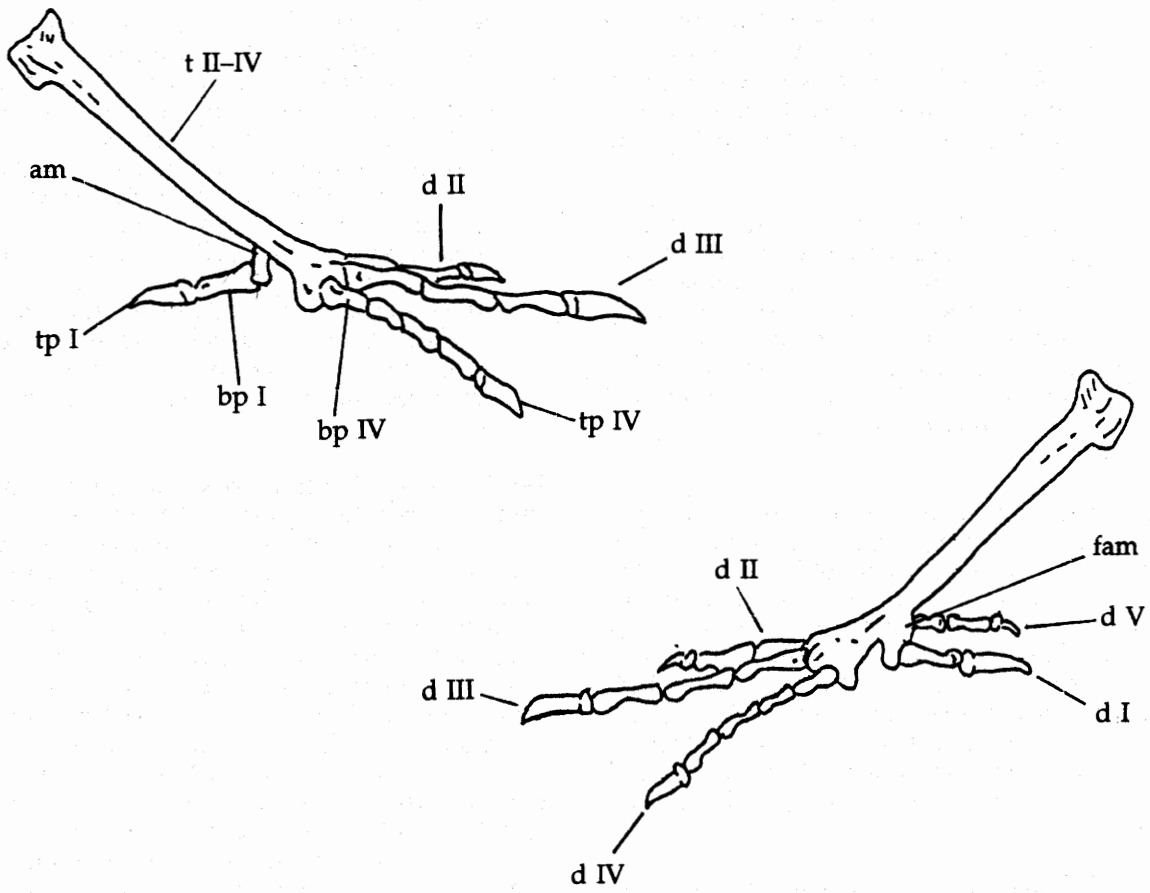

Fig. 12 (after Lucas and Stettenheim (1972, 35). (a) a four-toed fowl; (b) a five-toed fowl. Key: am—accessory metatarsus (os metatarsus I); bp I—basal phalanx of digit I; bp IV—basal phalanx of digit IV; d I–d V—digits I (hallux)–V; fam—fused accessory metatarsals; tp I—terminal phalanx of digit I; t II-IV—tarsometatarsus II-IV; tp IV—terminal phalanx of digit IV.

> them out one by one. When the testicles are removed they sew up the wound with thread and scatter ashes over it."

This implies that the chick was of a reasonable size when the operation was carried out. It is likely to have been between six weeks, which is the earliest age at which one can sex most birds, and the three months quoted by Coy (1983, 186). Surplus cocks and hens were also crammed for the table but the operation, which could be risky (Lind 1963, 411), was performed because the birds grew larger and the meat was thought to be of better quality. Varro recommended feeding twice a day for 20–25 days (Brown 1930, 169). This means that they are likely to be killed at three to four months, well before the proximal epiphyses or the spur cores fuse to the tarsometatarsi even though the core grows faster in the capon (Quigley and Juhn 1951, 901). In archaeological material therefore, few capon bones will be measured or represented with the male spurred tarsometatarsals.

Recognising five-toed fowl in archaeological material

All wild and most domestic fowl have four toes as shown in Fig. 12a. There is however, a fairly widespread variation in which a so-called fifth toe exists as shown in Fig. 12b. It is a breed characteristic in the Dorkings, Houdans, Faverolles, Sultans and Non-bearded Silkie Bantams. In these breeds the extra toe arises above the base of the hallux and projects upwards, never touching the ground.

Columella writing in the first century AD, described the best hens for breeding, then added:

> "Most noble of all are those who have five toes but not transverse spurs which stick out from their legs" (8.2.8.).

Pliny, writing at about the same time says:

> "Sometimes they have more than four toes, with one that runs transversely" (10.56.77.156).

Aldrovandi (trans. Lind 1963, 43) was aware of these comments by Columella and Pliny but said

> "I am at a loss what to say about such toes since we see in other respects that five-toed feet have not been observed in this genus of birds nor in any other except in freaks resulting from an abundance of matter, such as that five-toed male bird given to me by an unknown person and preserved in my museum" (ibid., 43).

It would seem that the value of the five-toed varieties as good breeders was not enough to make them commonplace in Italy by the 17th century although they had been present and even sought after in the first century AD. That they were present from at least the first century AD is certain and we should be able to recognise them when they are present in archaeological assemblages.

The following is quoted from Hutt (1949, 47):

> "The extra toe is not at all homologous with the fifth toe commonly found in other vertebrates. A cartilaginous rudiment of the fifth toe is found in the embryo on the outer side of the foot but it does not develop. The extra digit of polydactylous fowls arises from the metatarsal of the first toe, or hallux, on the inner side of the foot. Actually the fifth toe is not an extra digit but rather a duplication of the hallux and more comparable to the reduplication occasionally found in other parts of the body and in double monsters."

Polydactyly results from the action of a single dominant gene but its expression is extremely irregular (ibid., 50). Its effect can be enhanced, or completely or partially suppressed, by other genes contributing to the affected part so that the number of extra toes ranges from zero to three and the number of bones within an extra toe may also be variable.

A small group of specimens was collected, consisting of the lower limbs from:

> (i) a 4–5 year old Dorking cock (Figs. 13a, b) with two accessory metatarsals fused together but not to the main shafts and the spur cores supported on shields of bone which were starting to fuse to the tarsometatarsals;
>
> (ii) a Red Dorking male 2 years 10 months old (Fig. 13d) with two accessory metatarsals fused to each other and to the

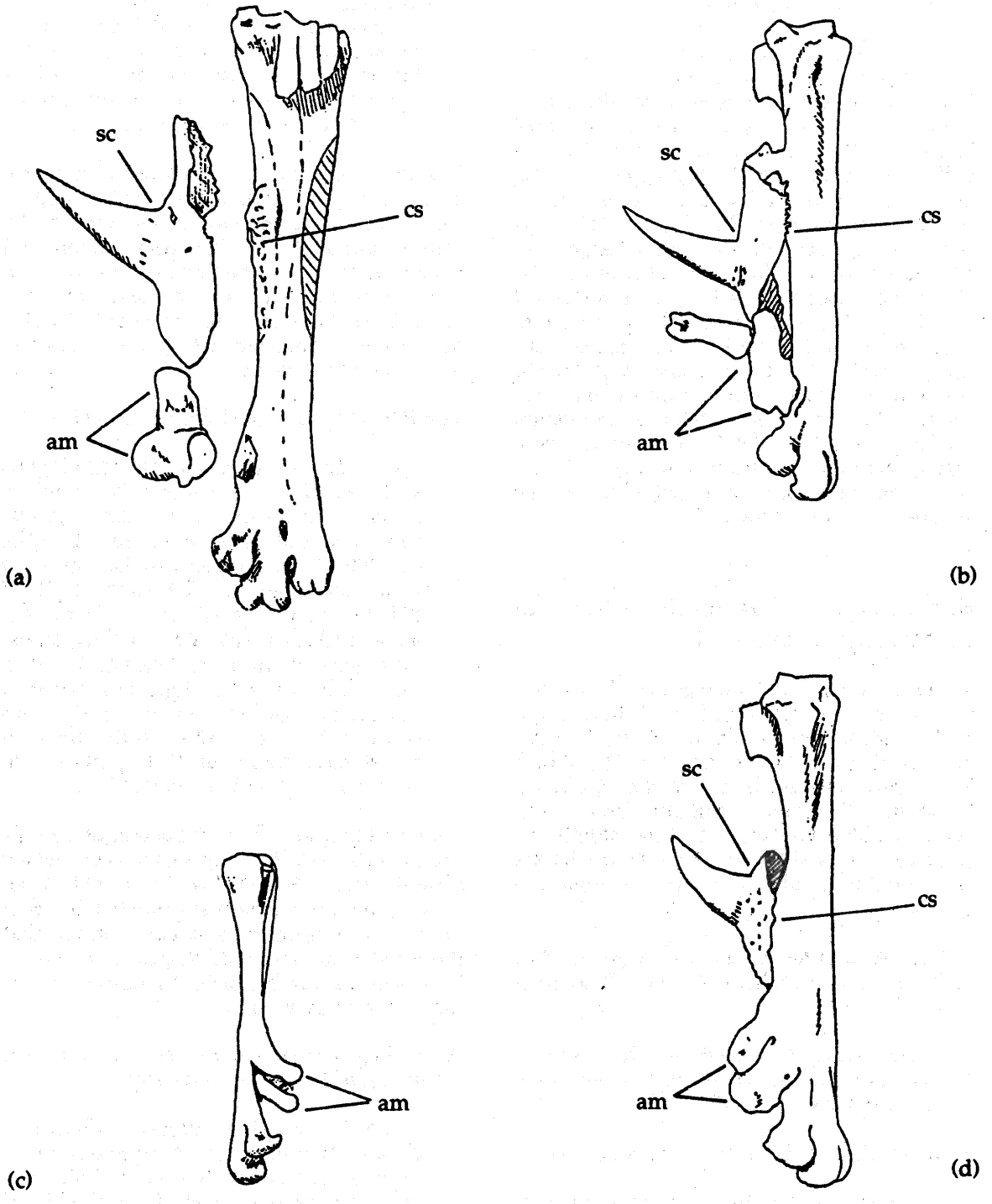

Fig. 13. (a), (b) Dorking cock, 4–5 years (a—right tarsometatarsus posterior view, b-left tarsometatarsus medial view; overall length 92 mm); (c) female Dorking, 4-5 weeks, overall length 39 mm; (d) Red Dorking cock, 2 years 10 months, overall length 118 mm. Key: am—accessory metatarsals; cs—area affected by contact with 'shield'; sc-spur core on 'shield' of bone.

main shafts and the spur cores supported on shields of bone which were starting to fuse to the tarsometatarsals;

(iii) and a female Dorking 4–5 weeks old (Fig. 13c) which already had one accessory metatarsal fused to the main shaft although the second was unattached.

The skeletons of a Dorking cock (reference 1868.2.19.54 C. Darwin) and a White Dorking hen (reference 1868.2.19.63 C. Darwin) were examined at the Ornithological Subdepartment of the British Museum (Natural History) at Tring. The female's lower legs were still partly covered in skin so it was impossible to study them closely but it appeared that there were two fused accessory metatarsals present as there were in the male skeleton. The male's spur core shield and the bony ridge on the tarsometatarsals were similar to those in Fig. 13a. I also examined specimen AML 450, a Silver Dorking male two years old, from the collection of the Ancient Monuments Laboratory in London. It was very similar to the 2 years 10 months old cock in Fig. 13d. In both, the natural ridge running the length of the tarsometatarsals was raised just above the accessory metatarsals.

These examples show very clearly the variation mentioned by Hutt (1949, 47) as being the most common, which is two separate digits, arising from two parallel metatarsals, one of which contains three or four phalanges, the other, two or three. Sometimes the two metatarsals are fused to each other. The left tarsometatarsus (not illustrated) of the young female shows a further variation in that the basal phalanx is single at the proximal end but bifurcated at the distal end.

The final development of the spur core appears to be different in the five-toed fowl from that in the four-toed bird. The circular basal surface of the spur core does not come into contact with the tarsometatarsal shaft (see Fig. 13a) as it does in the four-toed bird (see Fig. 11b) and the growth of new bone from the proximal surface continues to build a supporting shield for the horny spur around the bundle of tendons which run down the posterior region of the shaft.
In archaeological material, pointers to the presence of five-toed fowl are as follows:

(i) Accessory metatarsal(s) fused to the tarsometatarsal shaft.

(ii) If a site has been dug carefully, accessory metatarsals which have not fused to the shaft may be recovered in association with the tarsometatarsus.

(iii) A spur core on a shield of bone.

(iv) Ridges of raised bone on the shaft where the spur core shield was fusing onto the shaft.

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Note added in proof:

In March 1990, I prepared a skeleton of a six-year-old Faverolle cock. This is a composite breed, originally from France, made up of Dorking, Cochin and Houdan. It was interesting to note that it had the five toes of the Dorking and Houdan, and this was shown on the tarsometatarsus by the presence of two accessory metatarsals fused together and to the shaft (as is shown in Fig. 13d). The spur core, however, was fused to the shaft in the same manner as a four-toed breed and was not supported by a 'shield' of bone.

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Weed associates of recently grown *Avena strigosa* Schreber from Shetland, Scotland

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Summary

Weed seeds and other plant remnants were extracted from recent samples from Shetland of the now rarely grown *Avena strigosa* (bristle oats) and were found to include, in addition to seeds of typical arable weeds, those of plants not usually associated with cereal crops. An account of the location and conditions of the fields is given, with some information about the crop processing practices, to explain the range of seeds which could appear in archaeological deposits. The reclamation of a new field in a wet area is also described.

Introduction

Avena strigosa (bristle oats) is increasingly rarely grown as a crop, and then only in the marginal lands of north-west Europe, where it can tolerate poor, damp soil and withstand wind and rain. In Shetland, in recent years, it has been grown only in one or two of the outer islands, and few opportunities now remain to observe the results of unsophisticated harvesting methods.

For several years, during visits to the Shetland islands, small quantities of crops had been acquired which were subsequently sorted and weed seeds removed and identified. The results illustrated how seeds of plants of surrounding areas and atypical parts of a field can become incorporated in a harvested crop, and thus be of relevance to the interpretation of archaeological seed samples. Therefore the opportunity was taken in 1989 of visiting for a second time a farm at Breakon on the island of Yell, to obtain further samples. It was also possible to visit the fields in which the oats were grown and to note their surroundings. (It must be pointed out that the material was gathered as convenient, rather than by scientific sampling principles.) The oats from Fields 1 and 2 (see below) were acquired in 1979 and 1983 for reference and for growing; the weed seeds were extracted simply to see what might possibly be found in a sample of oats. All the results are tabulated for convenience, but numerical comparison is not intended as the samples differ in size and means of acquisition, in their post-harvest treatment, and in the soils, conditions, and surroundings of the fields in which the oats were grown.

The fields

The first sample came from a field near Underhoull on the west coast of Unst, the most northerly of the Shetland Isles (Field 1; see Fig. 14). This is in a region of grassland on peaty soil, mainly damp pasture for ponies and sheep where, in spring, some of the small meadows are almost entirely covered by flowers of *Caltha palustris* (marsh-marigold). There are a few fields for potatoes, turnips, cabbages, etc., but in recent years bristle oats have not been grown on Unst. The area has a long history of occupation and cultivation, and there are sites of Early Iron Age and Norse farmsteads, a souterrain and a broch nearby (Small, 1964–6).

Field 2 is on light sandy loam, not far from dunes at Breakon, on the north coast of Yell (Fig. 14), in one of the few fertile regions of this island, which is otherwise covered by thick deposits of peat. Situated on the slopes of a shallow valley, the fields and meadows are fairly well-drained and alongside them are streams and drainage channels which in June outline the fields in gold with their dense growths of *Caltha palustris*. Lower down, they are bordered by wetter areas with patches of *C. palustris* and extensive stands of *Iris pseudacorus* L. (flag iris) and *Equisetum* spp. (horsetails), etc.

Field 3 is about one kilometre to the west of Field 2, and is one of several created by ploughing and re-seeding an area of heath to improve grazing. The heath merges into damper woodland and, a few hundred metres further west, peat banks have been worked. The field has a micaceous, peaty soil, which

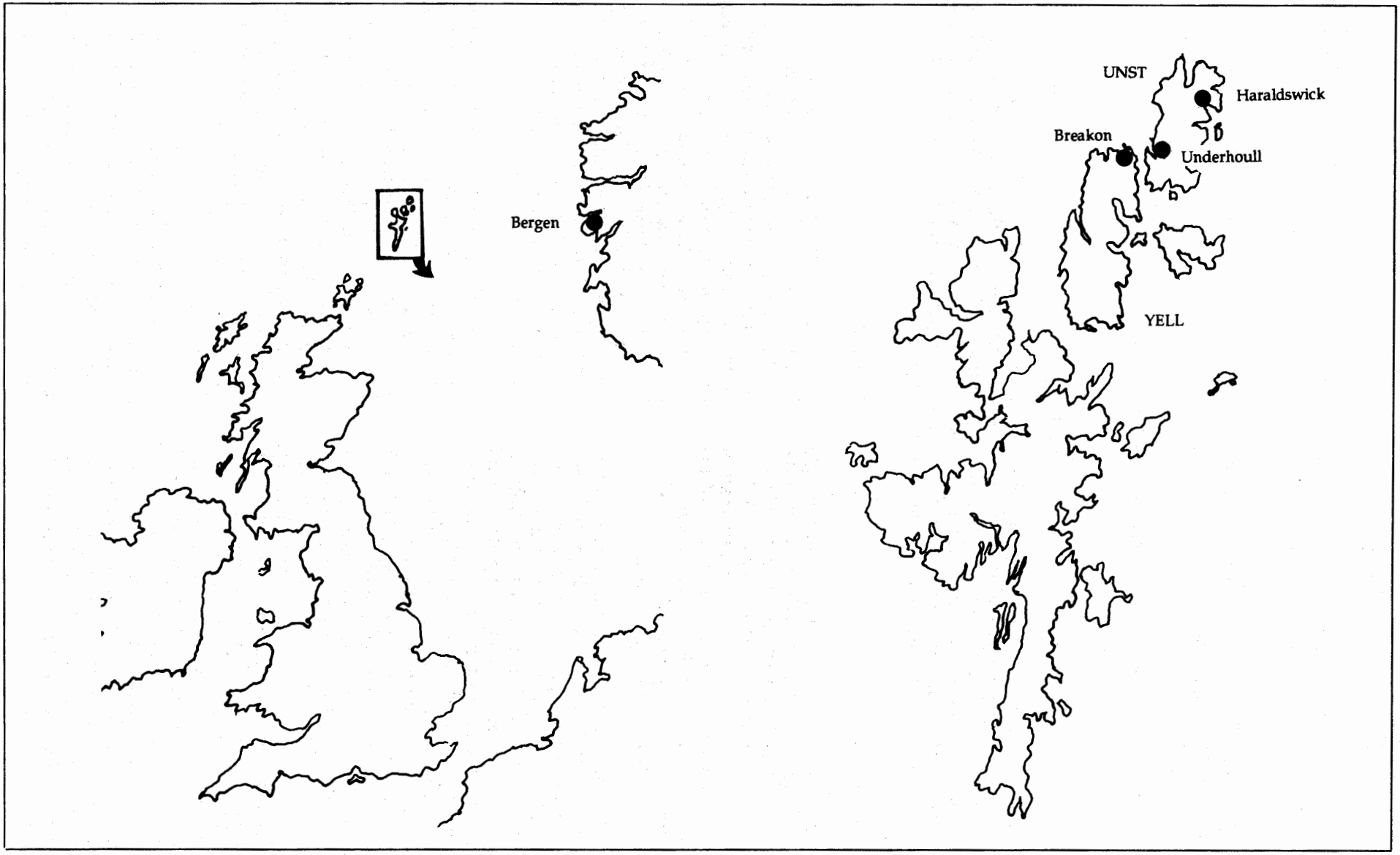

Fig. 14. Location of the Shetland Islands and sites mentioned in the text.

has been treated with 'muck and fertiliser' and in 1988 had been sown with oats and a commercial grass and clover mixture. The oats were harvested later that year and the 'under-sown' grasses were just beginning to put on new growth when the field was visited in June 1989. (Spring in Shetland usually begins about six weeks later than in southern England.) The field was sufficiently dry in one higher corner for the standing of three *scroos* (small, round, partly-thatched stacks) of oats from the 1988 sowing and a rectangular *dess* (small stack) of hay from the adjoining fields, but nearby were wetter areas with patches of *Eriophorum angustifolium* Honckeny (cotton sedge), *Carex* spp. (sedges), *Juncus* spp. (rushes) and mosses, including *Sphagnum* spp. *Scroos* of oats and *desses* of hay are illustrated by Fenton (1978, 351).

The samples

The oats from Field 1 were acquired through an intermediary, and the method of harvesting and subsequent treatment are uncertain. Threshing was most likely to have been done by beating the sheaves against a solid object; one crofter used to beat them against a grid from a discarded refrigerator. The oats must have been winnowed as there was no very light chaff in the sample, but the quantity of larger panicle parts suggests that they had not been sieved. More careful cleaning would have been unnecessary, since the oats were generally used as winter feed for the house cow.

The samples of oats from Fields 2 and 3 were obtained from two brothers who farm a large part of the Breakon area. They are two of the very few who still grow 'Shetland oats' in the Northern Isles, and they supply them to several crofters. They were kind enough to describe and demonstrate the treatment of their crops.

Harvesting of both fields had been by mowing machine, cutting about 0.1 m above the ground, the sheaves being bound by hand, stacked in *scroos* in the field, and brought into the barn for threshing.

Threshing was done by a small wooden-cased machine, one of many made in the nineteenth century by Messrs Shearer's of Aberdeenshire, in which the oats are passed between a concave surface and a revolving drum with rows of projecting spikes. The machine, now fitted with an electric motor, was originally hand- or treadle-operated, and the farmers described turning the handle while their mother fed in the sheaves. One of these machines is illustrated by Fenton (1978, 368).

Winnowing, to remove the chaff, was demonstrated in the wind outside the barn, the oats being dropped in handfuls onto sacking (previously, a *flaakie* or mat of oat straw would have been used). This might be followed by further winnowing and/or sieving, if the oats were intended for sowing, and I was shown a sieve made of sheep skin stretched on a wooden hoop, with pieced holes of approximately 3–4 mm diameter.

The sample from Field 2 was obtained in the summer of 1983, when there were very few oats left from the previous year, and the sample was tipped from the bottom of a sack. These oats would not have been used for sowing, since weed seeds tend to sink to the bottom.

The 'threshed and winnowed' sample from Field 3 was taken from the top of a sack of 'seed corn' to be supplied to a crofter, and I was told I would find no weed seeds in it! The second sample from Field 3 ('threshed only') was gathered in handfuls from beneath the threshing machine, avoiding the very bottom of the heap. While it is possible that the results of more than one threshing operation could become mixed here, only oats from Field 3 had recently been through the machine. Although the weight of this sample is less than that of the other from Field 3, the mass of light chaff and other fragments gives it greater volume. The main constituent of the other samples is, of course, the oat spikelets and grains.

Results and discussion

Table 4 shows the results from analysis of these samples.

The majority of seeds extracted from the samples from Fields 1 and 2 are of typical crop weeds, but those of *Caltha palustris*, *Angelica sylvestris* (wild angelica) and *Stachys palustris* L. (marsh woundwort) originated in the damp areas (particularly by the streams) which border the fields in this part of Breakon. The long-established grassland around both of these fields is reflected by the seeds of the hemi-parasites *Euphrasia officinalis*

	Field number:	1	2	3	3
	Treatment:	TW	TW	TW	T
	Approximate sample weight (g):	120	1500	1600	1000
Taxon	Parts recorded				
Sphagnum sp.	stem fragments	-	-	-	2
Musci indet.	"	-	-	-	2
Equisetum palustre L.	stem fragment	-	-	1	-
E. cf. *arvense* L.	"	-	1	-	-
Polygonum aviculare agg.	nuts and perianths	127	486	335	62
Rumex acetosa L.	"	7	82	1	2
R. longifolius DC.	"	-	-	2	43
R. crispus L.	"	-	54	-	5
R. obtusifolius L.	"	-	13	48	1
Rumex sp.	"	1	5	-	14
Montia fontana L.	seeds	-	-	-	2
Stellaria media (L.) Vill.	seeds	27	49	67	*c.*1300
———	capsules, mostly with seeds	-	6	45	184
S. alsine Grimm.	seeds	-	-	-	60
Cerastium fontanum Baumg.	"	-	20	4	560
———	capsules with seeds	-	2	-	48
C. glomeratum Thuill.	seeds	-	-	-	115
———	stem with leaves and 2 capsules	-	-	-	1
Spergula arvensis L.	seeds	3	11	1	1
Lychnis flos-cuculi L.	"	-	-	1	2
Caltha palustris L.	"	-	1	1	-
Ranunculus repens L.	achenes	-	3	1	5
R. acris L.	"	-	9	-	-
R. repens/acris	"	-	15	-	-
Capsella bursa-pastoris (L.) Medic.	seeds	12	-	68	33
———	siliculae	9	-	2	1
Brassica cf. *rapa* L.	seeds	-	-	9	-
Raphanus raphanistrum L.	"	-	-	1	-
———	siliqua segments (single, and groups if 2–4)	5	61	9	1
Potentilla palustris (L.) Scop.	achenes	-	-	3	-
P. erecta (L.) Räusch.	flower	-	-	-	1
Trifolium repens L.	seeds	1	2	-	1
———	flowers	-	-	-	94
———	leaf fragments	-	-	-	43
Vicia cracca L.	legume, with 3 seeds	-	1	-	-
Angelica sylvestris L.	mericarp	-	1	-	-
Calluna vulgaris (L.) Hull	stem and leaf fragments	-	-	-	2
Myosotis arvensis (L.) Hill	nutlets	6	10	1	-
———	calyces	5	5	2	-
Galeopsis tetrahit L.	nutlets	16	50	-	1
———	calyx	-	-	-	1
Lamium purpureum L.	nutlets	2	5	-	-
L. cf. *molucellifolium* Fries	"	-	-	4	-
Stachys palustris L.	"	-	1	-	-
Veronica agrestis L.	seeds	-	-	1	1
———	capsules	-	-	-	2
Euphrasia officinalis s.l.	seeds	2	1	-	-
———	capsules	3	5	-	-
Rhinanthus minor L.	seeds	5	62	-	-
———	capsules	3	5	-	-
Plantago lanceolata L.	seeds	1	-	-	1
———	half-capsules	-	-	1	1
Succisa pratensis Moench	involucel and calyx	-	-	1	-
Bellis perennis L.	achenes	2	3	-	2

Achillea millefolium L.	"	-	-	-	10
Matricaria perforata Mérat	"	24	138	340	182
———	capitula	-	-	1	2
———	involucral bracts	-	-	10	1
———	stem fragments	-	-	4	-
Chamomilla suaveolens (Pursh) Rydb.	achenes	-	-	-	11
Senecio vulgaris L.	achene	-	-	-	1
Cirsium arvense (L.) Scop.	capitulum	-	-	-	1
Sonchus asper (L.) Hill	achenes	-	-	-	6
Juncus conglomeratus L.	capsules (dehiscing)	-	4	-	-
———	seeds	-	-	-	35
J. squarrosus L.	"	-	-	9	7
———	capsules with seeds	-	-	1	1
J. cf. *bufonius* L.	seeds	-	-	-	34
Juncus sp.	"	1	-	2	-
Luzula cf. *multiflora* (Retz.) Lej.	"	-	-	3	-
———	capsules with seeds	-	-	2	-
Lolium perenne L.	spikelets*	2	5	92	*c.*900
———	stem and spike fragments	-	-	-	*c.*140
Poa annua L.	spikelets	1	10	-	-
Poa sp.	caryopses	-	-	7	4
Dactylis glomerata L.	spikelets	-	-	-	64
Cynosurus cristatus L.	"	-	2	-	-
Bromus cf. *hordeaceus* L.	"	-	4	-	-
Anthoxanthum odoratum L.	"*	1	28	5	2
Holcus lanatus L.	"*	5	61	11	5
H. mollis L.	"	-	4	15	19
Agrostis sp.	"	-	-	-	7
Phleum pratense L.	"	-	12	3	*c.*300
———	caryopses	-	-	-	10
———	rachis fragments	-	-	-	10
Gramineae indet.	leaf and stem fragments	-	-	-	*c.*50
Carex echinata Murray	utricles with nut	-	-	3	1
C. cf. *binervis* Sm.	"	-	-	-	1
C. nigra (L.) Reichard	"	-	-	3	2
———	male spike fragments	-	-	-	1

Table 4 (opposite and above). Weed seeds and other plant remains found in samples of recently-grown Avena strigosa (bristle oats) from Shetland, Scotland. Nomenclature and order follow Tutin et al. *(1964–80). Treatment codes: T—threshed, W—winnowed. *—sclerotia of* Claviceps purpurea *(ergot) present in a few spikelets.*

(eyebright) and *Rhinanthus minor* (yellow-rattle), absent from the more recently created Field 3, in an area of drier, ericaceous heath.

With the oats from Field 3, there are again the usual crop weeds, but there are also plants characteristic of different parts of the field and its borders. Among those typical of the more poorly-drained areas are *Stellaria alsine* (bog stitchwort) and *Montia fontana* (blinks), which occur frequently in wet flushes, and *Equisetum palustre* (marsh horsetail) and *Potentilla palustris* (marsh cinquefoil), frequently seen in the marshy areas and at stream edges. *Caltha palustris* and *Lychnis flos-cuculi* (ragged robin) are typical of the damp grassland of the adjoining fields and *Calluna vulgaris* (ling) is abundant in the heath from which the fields were reclaimed. The large numbers of spikelets and stem fragments of grasses and clover parts (estimated from a subsample) originate, of course, in the under-sowing of the oats with a grass/clover mixture for future hay or pasture.

The lists illustrate that, in addition to the 'normal' arable weeds, seeds of plants of differing habitat requirements may become included in samples from a harvested crop. They may come from atypical patches within the field (and the content of sheaves from different parts might vary considerably), or

originate in adjoining areas with different vegetation characteristics. In the latter case, the surrounding plants may invade (e.g. the rhizomes or rooting nodes of prostrate stems of *Caltha*), or other seeds may be accidentally included when cutting close to the field edges, which are not always clearly defined. Some, such as the wetland species, seem particularly out of place in a crop sample, but their occurrence is matched by, for example, Hillman's (1984) report of fruits of *Alisma lanceolatum* With. (a water-plantain) with grain in present-day East Anatolian granaries and Jones' (1978) records of *Eleocharis palustris* (spike-rush) from Iron Age grain assemblages from Oxfordshire.

Weed seeds in such numbers and variety are only likely to be found in samples of crops in the earlier stages of processing, and here the most comprehensive sample was the 'threshed only' sample from Field 3. The 'threshed and winnowed' sample from the same field had lost the light chaff, small flowers and some of the lighter seeds, but still included much that would have been removed by further winnowing and sieving if the oats had been intended for human consumption.

The making of a new field

During my latest visit to Shetland in 1989, I was fortunate enough to see something of the 'reclamation', or perhaps better the making *de novo*, of a field near Haraldswick, Unst.

In this case, the part-time crofter (who owns several hectares of this particular area, land which was wet enough for a number of his sheep to be drowned) had the opportunity of acquiring a supply of rubble and soil from the demolition of a building and the levelling of a site. After moving the topsoil of the new field to one side, he built up the area with rubble, and then replaced the topsoil, together with that from the building site, and in June he was harrowing repeatedly in preparation for the sowing of grass seed. He said that if 'Shetland oats' (*Avena strigosa*) were available, he would prefer to sow them. When this new field was visited, it was seen to be bordered on two sides by very wet areas (in which there were five sheep skeletons—evidence of his losses), swampy patches with *Potentilla palustris*, *Menyanthes trifoliata* (bog-bean), *Equisetum palustre* and slightly less wet parts with *Lychnis flos-cuculi*, *Cardamine pratensis* (cuckoo flower) and *Juncus* spp. The harrowing was breaking up and spreading the replaced soil, but it was also distributing many fragments of *Equisetum* and *Caltha* rhizomes throughout the field. A further visit to the island has not yet been possible, to see the result of the hard work in which the farmer took such a pride. Had oats been sown, it is very likely that samples of the harvest would have included examples of plants not usually associated with a cereal crop.

Acknowledgements

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Plant remains recovered from daub from a 16th century manor-house—Althrey Hall, near Wrexham, Clwyd, U.K.

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Summary

This paper demonstrates that well-preserved desiccated plant remains can be recovered from samples of daub from standing buildings. Where such material is well dated it can provide valuable information on cereal usage where there is preservation of large fragments of identifiable chaff.

Introduction

In 1987, conservation work on wattle and daub walls within a sixteenth century manor-house, Althrey Hall, near Wrexham, was undertaken by the Department of Archaeology, University College, Cardiff. A section of one wall, dated by wall paintings to *c.* AD1540, had been badly damaged. Since desiccated straw fragments were clearly visible within the clay matrix of the daub, the opportunity was taken to sample the daub for plant remains in order to determine their composition.

A 500 ml sample of daub was removed from the damaged section for this purpose. The sample was gently broken down by soaking it in hot water for an hour. The resulting slurry was then washed through a stack of sieves (minimum mesh size 250 µm) and the cleaned residues sorted under a binocular microscope for plant remains.

Results

The plant remains recovered are listed in Table 5. The taxa have been arranged in habitat groups to assist in the interpretation, but it should be noted that some species do not strictly adhere to these groupings. For example, stinking mayweed (*Anthemis cotula*) is a locally common arable weed of heavy soils but it can also be found in other cultivated and disturbed habitats. Many of the weeds in Section C of Table 5 grow in a wide variety of disturbed habitats such as waysides and waste ground. Some of the grassland taxa may also grow on disturbed land, for example buttercups and plantains.

Many of the cereal remains were well preserved and large fragments of cereal ears survived intact. A few fragments of rivet/macaroni wheat (*Triticum turgidum/durum*) rachis were identified by their trapezoidal shape and characteristic bulges at the point of disarticulation of the glumes (Hillman, forthcoming). Two-row barley rachis fragments were identified by the presence of sterile lateral spikelets.

Discussion

The plant remains contained within the daub had been preserved by desiccation and were generally recovered in a good state of preservation. From the composition of the assemblage it appears that the bulk of the organic matter used to temper the daub consisted of the waste products of cereal processing activities. Straw fragments were predominant, and some large fragments of cereal ears were present. Rachis fragments and glumes were also recovered, and approximately 15% of the weed seeds found were from weeds of arable land and were probably harvested with the crop. The threshing seems to have been quite thorough, as very few cereal caryopses were recovered. It is unlikely that this was due to differential preservation since larger numbers of grains have been found in other samples of daub (Green 1979; Arthur 1963).

Sixteenth century samples of daub examined by Arthur (1960; 1961) produced small fragments of straw less than 2" (50 mm) long, indicating that the material had been finely chopped prior to inclusion within the clay matrix. The straw incorporated into the Althrey Hall daub must have been chopped in a less careful fashion, since the fragments

A. Cultivated plants

Triticum aestivum L. (bread wheat)	rachis fragments	8	
	glumes	6	
T. cf. *turgidum/durum* (?rivet/macaroni wheat)	rachis fragments	4	
Triticum sp. (wheat)	rachis fragments	3	
Hordeum distichon L. (2-row barley)	rachis fragments	3	
Hordeum sp. (barley)	caryopses	3	
Hordeum sp. (barley)	rachis fragments	2	
Secale cereale L. (rye)	± complete ear	1	
	ear fragment	1	
	spikelets	4	
	rachis fragments	2	
Avena sativa L. (common oat)	florets	2	
	glumes	2	
cereal indet.	straw fragments	numerous	
Linum usitatissimum L. (flax)	seeds	12	
	capsule fragments	53	

B. Arable weeds

Agrostemma githago L. (corn cockle)	seed fragment	1	
Anthemis cotula L. (stinking mayweed)	achenes	15	h
Centaurea cyanus L. (cornflower)	achenes	7	
	fragments of head	4	
Chrysanthemum segetum L. (corn marigold)	achenes	4	a
Papaver dubium/hybridum L. (poppy)	seeds	3	

C. Weeds of cultivated and other disturbed soils

Arctium lappa L. (great burdock)	achene	1	
Atriplex hastata/patula L. (orache)	seed	1	
Chenopodium album L. (fat hen)	seed	1	n
Euphorbia helioscopia L. (sun spurge)	seed	1	
Euphrasia sp./*Odontites verna* (eyebright/red bartsia)	seed	1	
Fumaria sp. (fumitory)	seed	1	
Hyoscyamus niger L. (henbane)	seeds	6	n
Lapsana communis L. (nipplewort)	achenes	2	
Polygonum aviculare agg. (knotgrass)	nutlets	37	
Rumex obtusifolius L. (broad-leaved dock)	nutlet	1	
Sonchus asper (L.) Hill (spiny sow-thistle)	achenes	2	
S. oleraceus L. (sow-thistle)	achene	1	
Stellaria media (L.) Vill. (chickweed)	seeds	2	
Tripleurospermum maritimum (L.) Koch (scentless mayweed)	achenes	17	
Urtica dioica L. (stinging nettle)	achenes	2	n

D. Grassland taxa

Bellis perennis L. (daisy)	achene	1	
Gramineae gen. et sp. indet. (grasses)	caryopses	49	
Plantago lanceolata L. (ribwort plantain)	seed	1	
P. major L. (great plantain)	seeds	4	o
Prunella vulgaris L. (self-heal)	nutlets	7	
Ranunculus acris/bulbosus/repens (buttercups)	achenes	2	
Rhinanthus minor L. (yellow-rattle)	seeds	2	
Rumex acetosella agg. (sheep's sorrel)	nutlet	1	a, heath
R. conglomeratus Murr. (sharp dock)	nutlets	5	d
Torilis japonica (Houtt.) DC. (upright hedge-parsley)	mericarps	2	
Trifolium sp. (clover)	calyces	5	
	leaf	1	

E. Plants of wet grasslands, riverbanks and marsh			
Carex sp. (sedge)	nutlets	5	also dry
Eleocharis Subgenus *Palustres* (spike-rush)	nutlets	2	d
Juncus sp. (rush)	inflorescence frags	8	d
Polygonum hydropiper L. (water-pepper)	nutlets	8	ponds, rivers
Ranunculus Subgenus *Batrachium*	achene	1	ponds, rivers

F. Other habitats			
Alnus glutinosa (L.) Gaertn. (alder)	fruit	1	banks, scrub, woods, d
Cerastium sp. (chickweed)	seed	1	various
Pteridium aquilinum (L.) Kuhn (bracken)	frond frags	8	heath, scrub, a, l
Rosa sp. (rose)	thorn	1	woods, scrub, hedges
Rubus fruticosus agg. (blackberry)	seed	1	woods, scrub, hedges
Rumex sp. (dock)	nutlets	3	various
Silene sp. (campion)	seed	1	various
Leguminosae	pod fragments	4	various
moss	shoot fragments	7	various
	Total	347+	

Table 5 (above and opposite). Plant remains recovered from a 500 ml sample of daub from Althrey Hall. Key to preferred soil types in last column: a—acid; d—damp; h—heavy; l—light; n—nitrogen/phosphorus-rich; o—open. Nomenclature follows Clapham et al. *(1962).*

were variable in length, the longest being 120 mm.

Of the cereals represented by the caryopses and chaff remains, wheat, barley, cultivated oats and rye were identified. Both bread wheat (*Triticum aestivum*) and rivet/macaroni wheat (*T. turgidum/durum*) were present. It is not possible to distinguish between the rachis fragments of rivet and macaroni wheat but no evidence has yet been found for the cultivation of macaroni wheat in Britain (Moffett, forthcoming). Rivet wheat is said to have been the main wheat grown in southern England at one time (Peterson 1965), although it has only recently begun to be recognised amongst archaeological plant material. Greig (1988, 110) lists a number of sites dating from the eleventh to fourteenth centuries from which this free-threshing tetraploid wheat has been recovered, and Arthur (1960; 1961; 1963) recovered spikelets, glumes and rachis fragments of rivet wheat from late fourteenth to sixteenth century daub samples. It is a taller wheat than bread wheat so that the straw is ideal for thatching, but its soft, mealy grain is less suitable for bread-making and it does not grow well in poor soils.

Two-row barley (*Hordeum distichon*) was identified, but the presence of 6-row barley (*H. vulgare* L. emend.) could not be confirmed. Archaeological records of 2-row barley are sparse, as it is necessary to recover well preserved rachis segments in order to be sure of the identification. However, it has been recorded amongst Late Saxon carbonised remains from Stafford (Lisa Moffett, pers. comm.), from a thirteenth to fifteenth century site in Norwich (Murphy 1985) and from a late fourteenth to early fifteenth century daub sample from Kent (Arthur 1963). The presence of rachis fragments complete with well-preserved sterile spikelets in this sample of daub provides useful evidence for the cultivation of this cereal in the sixteenth century in North Wales. In the last few centuries it has become the most widely grown type of barley, being more suited to the production of malt than the 6-row variety. It is not possible to know whether the crop represented at Althrey was grown for malting.

Rye (*Secale cereale*) appears to have been of little importance as a cereal crop in late and post-medieval times in Britain, and Green (1979) found none in the sixteenth century daub samples that he examined from southern England. However, it is a useful crop on poor, acid soils. Oats (*Avena sativa*) also grow well on such soils, particularly in areas of high rainfall since they require little sun to ripen.

Several chaff fragments from both of these species were present in the daub from Althrey Hall.

The arable weed seeds recovered were probably introduced into the daub amongst crop processing debris, and so can provide further information concerning the soils cultivated. Corn marigold (*Chrysanthemum segetum*) is a weed of acidic, sandy soils such as occur in the locality overlying the sandstone bedrock. Stinking mayweed (*Anthemis cotula*) prefers heavy, damp soils and this may indicate the cultivation of alluvial soils on the floodplain of the River Dee.

Many of the weeds in section C, the weeds of cultivated and disturbed soils, can also grow as arable weeds and so could have been introduced into the daub amongst crop-processing waste. Some of the others, particularly those that prefer soils with a high nitrogen or phosphate content such as henbane (*Hyoscyamus niger*) and stinging nettle (*Urtica dioica*), may have been growing on waste ground close to the place of preparation of the daub.

An interesting addition to the list of cultivated plants recovered from the sample was cultivated flax (*Linum usitatissimum*). Both seeds and capsule fragments were recovered, the small size of the capsule fragments suggesting that the remains had been added when the capsules were dry and brittle. Flax grown for the use of the bast fibres in the stem is usually uprooted by hand, tied into bundles and left to dry in the fields. The plants are then pulled through a comb-like device to remove the dry leaves and seed pods, a process called rippling. It may have been the waste product from this process that had been added to the daub. Flax seeds are also grown as a foodstuff, being rich in linseed oil. None of the daub samples examined by Green (1979) contained flax remains, although several contained small amounts of other domestically used plant remains, such as hops and figs. The samples examined by Arthur contained primarily cereal caryopses, chaff and a few weed seeds. However, Willerding (1988) has recovered flax and rye from late medieval daub in half-timbered houses in Germany.

The recovery of a variety of grassland taxa, in particular seeds and capsule fragments from the hay meadow species yellow-rattle (*Rhinanthus minor*), indicated the inclusion of hay in the daub. Sheep's sorrel (*Rumex acetosella*) is a species often found in acidic grasslands. The presence of several riverside and wet grassland taxa, such as spike-rush (*Eleocharis* Subgenus *Palustres*) and sedges (*Carex* sp.) suggests the use of the damp soils of the floodplain for the cultivation of hay. The daub samples examined by Green (1979) and Arthur (1963) also contained some grassland taxa.

The small amounts of other plant remains such as moss fragments, fragments of bracken frond and a rose thorn, could have been introduced amongst hay or domestic waste in the area of preparation of the daub.

The large size of most of the straw and other plant fragments suggests that these plant remains were not added as constituents of herbivore dung. The examination of horse dung from a Roman well in Lancaster (Wilson 1979) demonstrated that although small seeds survived the passage through the gut intact, larger seeds and leaves were fragmented. Dung from ruminants is likely to contain even less intact plant remains due to repeated chewing and longer periods of digestion. However, it is possible that some dung was added. Green (1979) found evidence of the inclusion of dung into a bell mould, but not in the daub samples he examined.

The daub examined appears, therefore, to have been made up of waste plant material from a variety of sources including cereal processing, flax processing, hay making, and probably some domestic waste. As suggested by Green (1979), it is likely that the clay would have been mixed with whatever organic material was at hand at the time.

The value of examining plant remains from daub samples has previously been pointed out by Arthur (1960; 1961; 1963; and undated monograph) and Green (1979). Providing that the material can be securely dated, large quantities of well preserved plant remains can be recovered, particularly cereal chaff fragments which can be vital for accurate identification. Studies of this material could be of great value in obtaining evidence for the cultivation of free-threshing tetraploid wheats and two-row barley in post-medieval Britain. The potential for further research into daub from standing buildings in Britain is great.

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