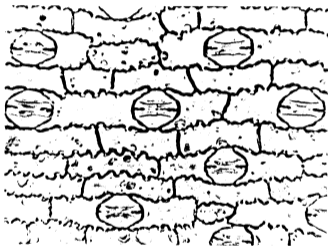


Volume 1 Number 2 May 1983

# circaea



**This Issue:** Murphy on the Fens - van der Veen  
on Flotation - Book Review - Miscellany - Burhinus

The Bulletin of the  
Association for  
Environmental Archaeology

CIRCAEA is the Bulletin of the Association for Environmental Archaeology, and is published three times a year. It contains news and short articles as well as more substantial papers and notices of forthcoming publications and conferences. Editorial policy 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, such as papers which consider in detail methodological problems like the identification of difficult bioarchaeological remains.

Circaea is edited by Allan Hall, Harry Kenward and Terry O'Connor, and is assembled and printed at the University of York. Circaea is distributed free to members of the AEA and is available to institutions and non-members at six pounds sterling per annum. At present, copyright resides with individual authors. Circaea is published by the Association for Environmental Archaeology, c/o Room 530, Fortress House, 23 Savile Row, London W1X 2AA. Enquiries concerning membership of the AEA should be sent to N. D. Balsam at that address.

#### Notes to contributors

Articles for inclusion in Circaea should be typed double spaced on A4 paper. Line drawings should be in black ink on white paper or drawing film to fit within a frame 165 x 245 mm. Captions should be supplied on a separate sheet of paper, and labelling on figures should either be in Letraset (or an equivalent) or should be in soft pencil. Half-tone photographs can be accommodated, but authors wishing to make extensive use of photographs, or colour, should note that they may be asked to contribute towards the high cost of production. The editors will modify short contributions to fit the layout and convention of Circaea. The same principle will be applied to idiosyncracies of spelling and punctuation. Scientific articles will be submitted to referees: authors may, if they wish, suggest suitable referees for their articles. TWO COPIES of scientific articles should be submitted. Authorities must be given to Latin names, either at their first mention or in a comprehensive list, and species lists should follow a named check-list. References should follow the so-called modified Harvard convention, but with journal titles preferably given in full, not abbreviated. World list abbreviations will, however, be acceptable if the author has a definite preference. For guidance as to the preparation of material for publication, contributors are referred to The British Ecological Society's booklet 'A Guide to Contributors to the Journals of the BES', and The Royal Society's 'General Notes on the Preparation of Scientific Papers' (3rd ed. 1974, The Royal Society). Text proofs of papers will be provided and should be returned within three days of receipt. Ten free reprints will normally be supplied to the authors of scientific articles: further copies will be available, if requested at the time proofs are returned, at a charge of 5p per page plus postage.

Back-numbers and a limited supply of articles can be purchased at the following rates: back-numbers - two pounds per part; articles - 5p per page plus postage.

Copy dates: January issue - 15th November; May issue - 15th March; September issue - 1st July.

The Editors, c/o Environmental Archaeology Unit, University of York, York YO1 5DD, U.K.

Contents

Editorial	43
Miscellany	45
Book review	63
Cartoon	68
The Inside Back Page	69

PAPERS

PETER MURPHY - Studies of the environment and economy of a Bronze Age Fen-edge site at West Row, Mildenhall, Suffolk: a preliminary report. (With a contribution by A.K.C. Jones.)	49
MARLIJKE VAN DER VEEN - Seeds and 'seed-machines'	61

---

 Editorial
 

---

Response to the first issue of *Circaea* has, with a few exceptions, been favourable. The two criticisms were (1) that there was insufficient gravity, and (2) that there was too much gravity. We take this to indicate that the right balance has been struck for the bulletin of a young organization. To those who complained of difficulties in pronouncing the name of *Circaea*, we offer the suggestion that 'air-asser' would be acceptable in all but the most classically-educated circles.

There are signs that the new bulletin has served to attract at least some new members: we hope to hear the full story from Nick Balaam in due course. We also hope to have a steady supply of copy. Remember that anything from requests for material through to erudite papers can be accommodated in these columns. We anticipate continued improvement in the quality of typography and presentation.

The Opinion article on standards of refereeing and publication prompted Gay Wilson to remind us about her article on this very subject in *Antiquity* (47, 264-8; 1973), and to observe that little has changed in the past decade. She suggests that AEA members should publish their experiences of dubious publication practices in *Circaea*. Gay Wilson also suggests, and this may have a more immediate effect, that constructive dissections of particularly bad cases be published in these columns as an extension of the normal process of reviewing. We will gladly publish material of this kind providing that it can be seen to be constructive. We must emphasise that the review in this issue is not intended to fall into the 'expose' category; it is a detailed review of what is considered to be an important work. Where appropriate, the featured individuals or publication officers naturally will be given the opportunity to reply. Harry Kenward, doffing his editor's hat for that of author, observes that Gay Wilson put the point over much more cogently in 1973 than he did in 1983.

Marijke van der Veen's article about sieving machines and her letter asking for an antidote to waterlogged preservation for charred seed analysts (this issue) have set the Editors thinking once again about the various fundamentally different approaches to bulk-sieving. She emphasises that analysis of carbonized cereal remains requires examination of not only the comparatively easily extracted and sorted grains, but also the tiny apikelet fragments that are easily lost during processing or overlooked during sorting. She needs to bulk-sieve to obtain adequate samples. In complete contrast, some workers regard bulk-sieving as a way of removing the smaller remains to obtain large representative samples of, for example, small bones or fruitstones. To some extent, there is a division between those who concentrate their efforts on the residue and those who grab the flot - unfortunately, as Marijke shows, some material is distributed in unpredictable proportions between the two. Some see bulk-sieving as a most useful way of screening trowelled soil both for its inclusions - whether biological or

---

Cover photograph - stem epidermis of a reference specimen of a *Carex* species mounted in lactophenol. From a project investigating non-reproductive plant remains from archaeological deposits. Photograph - P. Tomlinson and A. Macdonald.

artefactual - and to appreciate its overall structure and composition. Clearly there are logistical problems in satisfying everyone's needs with a single tank. The present problem appears to stem from transferring a technique primarily designed for deposits of low organic content to highly organic ones. Maybe the readership will be able to offer both a solution for Marijke and some comment and argument for these pages.

The last several months have seen the production of a report regarding publication in archaeology produced by a committee jointly of the Department of the Environment and the Council for British Archaeology. The AEA committee have pooled their thoughts: perhaps any readers who have both the time and the stamina to read the report would care to use these columns to express their thoughts.

#### Back numbers of the Newsletter

There are a few copies of Newsletters nos. 3, 6, 7, 9 and 10 cluttering up our laboratory. They will be sent free to members on a first come first served basis. Don't all rush at once.

The Editors

Joint AEA/BSEI conference, Newley House, Oxford  
24-27 September 1984

---

Archaeology and the flora of the British Isles  
Man's influence on the evolution of plant communities

Preparations for this conference are under way and the programme is materialising. We shall have five sessions, dealing with woodland, grassland and arable land, moorland, and urban wasteland respectively. There will be a field excursion on the Saturday afternoon. Each session will comprise a small number of 45-60 minute papers, and the proceedings will be published.

We have had to be fairly selective with the wide range of potential contributions, but further offers of papers will receive consideration if there is time left in the appropriate part of the programme.

Please contact Martin Jones, Department of Archaeology, 46 Saddler Street, Durham DH1 3NU if you are interested in offering a paper.

---

#### Errata - Vol. 1 no. 1

Page 7, para. 2, line 8, for 'acheiving', 'achieving'; page 35, para. 1, line 8, for 'abberation', 'aberration'; page 36, section 6, line 1, for 'giving', 'getting', page 40, throughout, for '1982', '1983' and line 7, for 'Archaeology', 'Archaeology'.

---

 MISCELLANY
 

---

Cess pits

Toilet paper was mentioned again at Durham (AEA AGM 1982) and this reminded me that again in the USSR this summer I saw the provision of baskets alongside WCs to receive used toilet paper (it is necessary to provide one's own), presumably so that it does not get into the cess pit. I visited Beamish (Co. Durham) on the way to Durham and saw a detailed exhibit of the recent removal of 'night soil' (and ash) from earth closets to the land - there was no mention of toilet paper.

M. L. Ryder.

Michael Ryder has also sent us an article on the use of human ordure in modern Chinese agriculture (see *Farmers Weekly*, May 21st 1982, 10-13). Your Editors, keen allotment-holders to a man, found the article most interesting.

Waterlogging - a limiting factor?

Most environmental archaeologists will see the presence of waterlogged deposits on site as an advantage, as the good preservation of the biological data will ensure a high level of environmental reconstruction. However, can it also occasionally hamper the work? I seem to have come across a situation like that and would like to invite everybody to advise me on the following.

On the present excavations at Carlisle I am trying not only to look at the waterlogged plant remains, but also to study the carbonised grains and seeds. The extraction of the seeds from non-waterlogged deposits is fairly straightforward and does not cause any problems. However, how does one extract carbonised seeds out of waterlogged deposits? Applying flotation techniques one finds that almost the entire deposit floats and no reduction in the bulk of the sample occurs. It is clearly impossible to sort microscopically through ca. 3 buckets of material. So how does one extract the carbonised seeds from the flot? Who can suggest a method for getting rid of the waterlogged remains, while preserving the carbonised seeds? Sorting just a small proportion of the sample does not work, as the number of carbonised seeds obtained would be too small. One really needs at least 100 fragments in each sample, which in Carlisle means a required sample size of 2-5 buckets of deposit. The method will have to be fairly easy to apply, as it involves many large samples, and if chemicals are used they have to be of the kind that one is allowed to flush down the normal drains in large quantities.

I welcome any suggestions! Please write to:

Marijke van der Veen, Department of Archaeology, University of Durham,  
46 Saddler Street, Durham DH1 3NU

Information needed

I am in the process of writing part of a handbook for the CBA on 'Biological remains', directed at the excavator. In it I intend to deal with how to anticipate, recognise, record, collect, store and to some extent process (on site sieving and flotation). As there is the off-chance that someone might read the handbook and act upon it, I thought it would be in everybody's interest to canvass the Association on some of the more debatable points. So here are a few questions to which I would be grateful for as many answers as possible.

1. How useful (or useless) for your category of material are: (a) hand picked items and (b) bulk floated items?
2. What sample size and sieve mesh aperture do you use?
3. What information do you like to have on the labels of received samples, or together with those samples?
4. What procedure do you use for bagging up waterlogged material? (There must be some civilised alternative to Mark Robinson's practice of sucking the residual air out of the bag!)

Information to Martin Jones, 46 Saddler Street, Durham DH1 3NU by the day before yesterday, please (I've got to finish the manuscript by Christmas 1982).

Environmental archaeology and the Community Programme Schemes  
of the Manpower Services Commission

At a meeting held immediately after the Spring Conference, members of the Committee of the AEA discussed the increasing importance of MSC funded archaeological projects and the way in which funding from this source might affect British archaeological research in general and the interests of members of the Association in particular. Several questions arose. One concerned the extent to which the priorities of the MSC might or might not coincide with those of archaeologists; another was concerned with salary levels offered to environmental specialists on such projects. An example of the latter was brought to the attention of the Committee: in this case an 'experienced archaeological scientist' was sought by the Western Archaeological Trust in Gloucester to do environmental sampling and the preparation of specialist reports on excavations funded under a Community Programme. A total remuneration of 3808 pounds was being offered for what was effectively a full year's work, a salary substantially lower than those offered to Site Assistants on some MSC schemes.

The Committee intends to seek further information from the MSC and the Western Archaeological Trust, and proposes to raise these matters at the CSA. It would, therefore, be helpful to the Committee if members would write to us about their experiences and knowledge of the MSC schemes, and express their views on the issues raised above or any other related matters.

Communications to: Dr N. Ralph, c/o Department of Prehistory and Archaeology, University of Sheffield, Sheffield S10 2TN as soon as possible; these letters will be circulated to all Committee members.

### The Mary Rose Trust

#### Environmental Archaeology

Although the excavation and the recovery programme of the hull remains has been successfully concluded, additional evidence of Tudor life is currently being revealed at the Headquarters of the Mary Rose Trust. Processing of environmental material raised from the excavations, although limited by facilities and financial restrictions, has shown encouraging results.

Every aspect of Tudor environment and technology is considered and initial examination of samples has revealed new information about the Tudor seamen and the conditions under which they lived. The relationships between the men and their personal possessions, tools and weapons, forms a significant part of the investigative work. This is particularly important within the context of an underwater archaeological excavation.

Aspects of the study include personal hygiene and medicine (insect remains from combs, the Barber-Surgeon's material), food remains (animal and fish bones, fruit stones), stores and provisions (contents of barrels and other containers), plant materials (seeds, flowers, straw), use of raw materials (wood, horn, tar, mortar, etc.), artefact manufacture (metals, textiles, glass), the history of the site in general (marine environments, stratigraphy, sediments) and its effect on the preservation of the whole variety of materials present.

The wide spectrum of the analysis offers the opportunity for a mutually beneficial co-operation between specialists of many disciplines and archaeologists. Significant insights into the Tudor period can be gained from this integrated approach to the post-excavation investigations.

This must represent an encouraging prospect for the Mary Rose, the study of the Tudor period and underwater environmental archaeology in general.

Additional information can be obtained from: Ian Oxley, Environmental Archaeologist, The Mary Rose Trust, 48 Warlington Street, Portsmouth, Hants.



Wanted - fleas!

I am making a reference collection of fleas to help me identify material from archaeological sites. I would welcome any specimens - except cat fleas, which I can collect in my living room any day. Skeleton preparers may find fleas (and lice, which I'd like too) on their victims. Please send them along. Preferably dead.

Harry Kenward

Bones that cats gnawed upon ...

I am interested in obtaining information on the effects of feline gnawing upon bone, with the eventual aim of being able to distinguish between dog-gnawed and cat-gnawed bones from archaeological deposits. Readers who co-habit with voraciously osteophagous moggies and have observations or specimens to contribute are asked to contact me, c/o The Editors.

Terry O'Connor

Proposed abstracting scheme

We have been promising some form of recent publications list for a long time now, but the thing has never got off the ground. If pressure of work permits we intend to ask selected members to send us lists of recent papers (a) relevant to their 'geographical area' and (b) dealing with their research specialities. We would hope to publish a reference and a string of keywords for each entry. Please let us have any suggestions as to the most useful form for this list. We would also like to hear from anyone prepared to offer their services as an official (honorary) scanner.

The Editors

Pollen slides for sale

We have received notice from the Department of Geography, University of Keele, of pollen reference slides for sale as teaching sets. Please contact Dr F. M. Chambers, Department of Geography, University of Keele, Keele, Staffs ST5 5BG, U.K. for further information.

Studies of the environment and economy of a Bronze Age Fen-edge site  
at West Row, Mildenhall, Suffolk: a preliminary report

Peter Murphy \*  
 With a contribution by A.K.G. Jones \*\*

Introduction

West Row Fen lies on the edge of the Suffolk peat fens about 5 km (3 miles) WNW of Mildenhall. It includes an area of hummock-and-hollow micro-relief, consisting of sand ridges surrounding shallow depressions filled with peats and, at some sites, shell- or Chara-marls (Scale 1975). Drainage and recent ploughing have caused peat wastage, and unhumified structured peats are now very restricted in area, confined to deeper depressions and areas close to the present channel of the River Lark. There is evidence for a relatively high density of Bronze Age settlement and several sites of this period have now been investigated.

During the summer of 1982 part of an Early-Middle Bronze Age settlement site was excavated by Edward Martin for the Suffolk Archaeological Unit (County Site No. MSNL 165; TL 654769). The settlement was centred on a long sand ridge rising to 2.5 m O.D. in the excavated area. An occupation layer spread into an adjacent hollow, 1.7 m O.D. at its deepest, and was overlain by thin humified peat. This layer had been ploughed away on the crest of the ridge, where, amongst other features, post-holes of a small porched round-house were located. Three large pits in the lower part of the site were dug to below present water-table levels (at 0.9 m O.D.). Two of these were relatively wide and shallow: pit no. 0901 was 6.5 x 3 m and 0.88 m deep and 0912 was 4 x 3 m and 0.68 m deep. A third, 0921, was smaller: 1.6 m in diameter and 0.68 m deep. Numerous other pits and post-holes were excavated, but only these three large features contained structured organic deposits.

Samples were taken for biological analysis from the occupation layer, pits and post-holes. Deposits, and hence preservation conditions, were very varied, ranging from dry sand to waterlogged organic layers. Macrofossils were extracted from the wet deposits using methods described by Kenward et al. (1980): 1-2 kg samples were generally found to be sufficient. Larger samples, normally 5-10 kg, were examined from the dry sands. Manual water flotation was used to extract carbonized plant material from these samples, and the residues were wet-sieved to recover other macrofossils. Categories of macro- and microfossils currently being examined by Professor Brian Funnell, Dr

---

\* Peter Murphy Esq., Centre of East Anglian Studies, Earlham Hall, University of East Anglia, Norwich NR4 7TJ, U.K.

\*\* Andrew (Bone) Jones, EAU, University of York, York YO1 5DD, U.K.

Maureen Girling, Andrew Jones, Roger Jones, Dr Peter Lambley, Katherine Manson, Dr Terry O'Connor, Dr Rob Scaife and the writer include diatoms, mosses, pollen, fruits and seeds, wood, charcoal, Foraminifera (from imported clay samples), cladocerans, ostracods, insects, land molluscs, and the bones of fish, amphibians, reptiles, birds, and mammals. Since further excavation seasons are planned it is unlikely that the results will be published fully for some years, and an interim summary account of results of some of this work may therefore be of interest.

In this paper some results from plant macrofossil analysis will be outlined, with brief reference to other lines of study. The work was undertaken with several specific questions in mind. There seemed reason to suspect that the West Row settlement and others like it may have been occupied primarily in order to exploit fen pasture at times when summer droughts reduced grassland productivity on adjacent Breckland sands. Was the site, then, purely a seasonal grazing camp or were crops also utilized? If they were, was there local cultivation or were cereals and other plant foodstuffs imported from permanent settlements on higher ground? Would it be possible to obtain any direct evidence for seasonal activities? Finally, what was the character of the local environment? The first season's work has produced information relating to all these questions.

#### Cereals and crop weeds

Carbonized cereal remains (Fig. 12) and weed seeds, as well as carbonized hazel (*Corylus*) nutshell fragments, were found in 39 of the 56 samples examined from the occupation layer, pits and post-holes. In addition, the wet lower layers of pit 0921 produced uncharred wheat remains, comprising glume bases, spikelet forks and some other badly degraded inflorescence bracts. Despite the survival of uncharred grass caryopses (including *Alopecurus* sp.) no uncharred cereal caryopses or periderm fragments were observed in these layers. The taxa identified from the samples are *Triticum dicoccum* Schubl. (emmer), *Hordeum* sp. (hulled barley) and, in three samples, *Triticum spelta* L. (spelt). Some uncertainty still attaches to the status of spelt as a pre-Iron Age crop in this country (Hillman 1981a, 187), and it must therefore be emphasised that the spelt from West Row came from shallow contexts directly beneath the modern ploughsoil. Deeper, more securely-stratified, contexts produced only emmer and barley. The possibility of some later contamination cannot therefore be excluded, though there is no direct evidence for arable farming in the vicinity until recent times, and known Roman settlement sites are on slightly higher ground to the east. Clearly, further sampling will be required to determine whether spelt remains are confined to shallow deposits elsewhere at the site.

The samples of carbonized material include small numbers of grains, glume bases, spikelet forks, rachis internodes and 'weed seeds' (*Stellaria media*-type, Chenopodiaceae, *Polygonum aviculare* agg., *P. persicaria/lapathifolium*, *P. convolvulus* L., *Rumex* sp., *Plantago lanceolata* L., *Galium aparine* L., *Bromus mollis/secalinus* and *Carex* sp.). Cereal culm nodes were present in only two samples. Applying the criteria defined by Hillman (1981b, 142) these samples provide no evidence for the early stages of crop-processing such as might be expected at 'primary producer' settlements: they need only indicate processing of part-cleaned spikelets, which could have been imported to

the site. The deposit of uncharred cereal spikelet fragments from pit 0921 can be interpreted similarly. Further work during future seasons may produce deposits of initial cleaning waste, but at present local cereal growing cannot be established. Pollen analysis is unfortunately of little help here since Robinson and Hubbard (1977) have shown that cereal pollen can be transported on bracts of hulled cereals. Cereal inflorescence bracts are present in at least some wet deposits at the site, and thus cereal pollen, if present, need not indicate local cultivation.

#### Flax

Seeds of flax (*Linum usitatissimum* L.) at densities of about 5 seeds per kg of soil were found in the lower wet deposits of pit 0921, in association with capsule fragments. In the upper fills, seeds and capsule fragments were not observed, but conspicuous small bundles of plant fibres were present. The fibres are black and opaque, due perhaps to impregnation with tannins, and isolated fragments of fibres taper gradually to attenuated points. Their original length cannot be determined since they are fragmentary. Figs. 13 to 16 show scanning electron micrographs of a fibre bundle from 0921 compared with modern flax fibre taken from plants growing as weeds. Measurements taken from micrographs show that the archaeological fibres average 23 microns in thickness (range 18-27 microns) which compares well with dimensions of 20-23 microns for modern commercial flax fibre given by Berger (1969) and Gill and Vear (1980). The modern reference fibres photographed are more slender: the plants were not well-developed. The fibres from 0921 appear to be of two types. Some lengths are relatively featureless, but others have a longitudinally grooved and noded appearance. This may be a consequence of mechanical damage and collapse of the cell lumen. In the modern flax fibres these features are less well-developed, though grooves and nodes are visible on some specimens. Examination of further modern reference material from other fibre-producing plants, combined with results from earlier studies of plant fibres (e.g. Körber-Grohne 1967, 161) will be required before the fibres from 0921 can be specifically identified. At present it can only be said that these fibres may be of flax.

Flax was a traditional Fenland crop. Together with heep it was widely cultivated in the Fens during the Middle Ages (Godwin 1978, 156). The factors determining its importance in this area were soil drainage conditions - it requires ample moisture during early stages of growth - and the ready availability of water for retting. These factors must also have applied during the Bronze Age, particularly if the evidence for dry climatic conditions at this time is accepted. It therefore seems very probable that the flax seeds and capsules from 0921 represent local cultivation. One is led, then, to ask whether 0921 was a retting pit. There are some difficulties in such an interpretation. The lower deposits contained some waste plant material including cereal spikelet fragments and, as noted below, waste trimmings from woodworking. These may, however, merely indicate some secondary use of the pit for refuse disposal. Less easily explicable is the lack of direct association between fibres and flax seeds and capsules. However, despite these problems, the pit certainly held standing water and did produce flax remains, and for these reasons interpretation as a retting pit seems plausible.

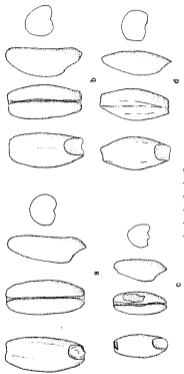
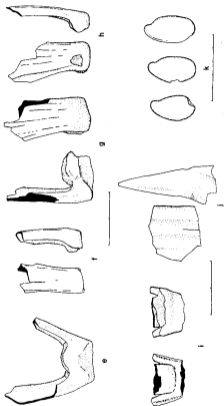


Fig 12. Crop plant remains from MN 165.

a-c - *Triticum* cf. *dicoccum* caryopses (0927 i, 0942, 4006); d - *Hordeum* sp. *caryopsis* (0933); e - *Triticum dicoccum* spikelet fork (0925); f - *Triticum dicoccum* glume base (0946/0460); g - *Triticum spelta* partial spikelet fork (0338); h - *Triticum spelta* glume base (0938); i - *Hordeum* sp. rachis node (0387); j - *Linum usitatissimum* capsule fragments; k - *Linum usitatissimum* seeds.



Scales graduated in millimetres.

### Wood and charcoal

Most of the wood from the site came from wet layers in pit 0921, though a few other features produced wood. The wood from 0921 is of alder (Alnus sp.), holly (Ilex sp.), oak (Quercus sp.), Prunus sp. and possibly willow (Salix sp.), mostly twigs and small branches, showing a variety of transverse, mainly oblique, cuts. Samples from pit 0921 produced, in addition, 'cones' and fruits of alder, leaf fragments of holly and indeterminate deciduous species, very young oak twigs, a roseaceous thorn and various buds and bud-scales. This deposit therefore seems to have consisted mainly of waste-trimmings with leaves, thorns, buds and inflorescences attached. The only wooden item appearing at all intentionally worked is an 8 cm-diameter alder stake with bark. It has a multi-faceted sharpened tip showing axe-mark scars.

Charcoal was abundant at the site. In order to determine whether there was any pattern to its distribution absolute charcoal densities (g/kg of soil) were determined for most samples. For practical reasons only charcoal fragments larger than 2 mm were weighed: other porous materials in the flat such as small bone fragments and iron hydroxide concretions could not easily be removed from the finer fractions. Complete extraction of charcoal from the waterlogged organic deposits was not possible, and charcoal weights were therefore not determined for these contexts. The charcoal density plan for the site shows 'background' levels of under 10 g/kg for the occupation layer and excavated features near the centre of the settled area, falling away to under 1 g/kg at the periphery, with a few marked charcoal concentrations. The highest concentration (73 g/kg) came from layer 0967 at the base of a narrow shallow pit (0934), about 3.6 x 0.9 m and 0.25 m deep, with fire-reddened sides. The charcoal was predominantly of oak, including fragments of mature wood and also many finely-preserved young oak twigs with buds and immature acorns in their cupules. One of these cupules is attached to a stalk which, though fractured, clearly continued to support a second cupule, and thus the presence of Q. robur L. can be established. The excellent preservation of fine details of the twigs, buds and cupules indicates slow carbonization in the total absence of free oxygen. It is suggested that this unusually-shaped feature was a charcoal-burning pit, originally covered over with turves or soil.

### Other plant macrofossils

The organic layers of pits 0901, 0912 and 0921 produced fairly large 'seed' assemblages, comprising around 70 taxa. As at most settlement sites, weed species predominate and, amongst others, species in the families Caryophyllaceae, Chenopodiaceae, Polygonaceae and Compositae are common. Wetland and aquatic plants are also well-represented, including charophytes, Ranunculus acularatus L., R. subgenus Batrachium, Hypericum sp., Hydrocotyle vulgaris L., Polygonum hydropiper L., Lycopus europaeus L., Ajuga reptans L., Alisma plantago-aquatica L., Lemna sp., Juncus spp., Iris pseudacorus L., Typha sp., Eleocharis palustris L., Carex spp. and Alopecurus sp. Some of these plants may have been growing in and around the pits themselves, but many fruits and seeds probably came from wetland vegetation outside the settlement area either by natural dispersal or with harvested rushes, hay or other materials.

The distribution of charophyte oogonia and seeds of *Lemna* sp. in these pits is of some interest. Oogonia were not observed in the lower deposits of the pits but only in their uppermost layers, some of which seem to have formed naturally after abandonment of the site. This distribution may reflect the inability of charophytes to tolerate turbid or polluted water (Fritsch 1961). Suspended sediment and high nutrient loadings with consequent growth of phytoplankton may have inhibited the growth of stoneworts whilst the site was occupied, but on its abandonment water in these pits was perhaps purer and clearer. A similar effect may be represented in a deep hollow adjacent to another nearby Bronze Age settlement (MNL 130). Here, peats thought to have been formed whilst this settlement was in use contain very few stonewort oogonia, but in peats deposited subsequently absolute frequencies of oogonia rise. These peats are overlain by a 30 cm thick calcareous shell marl which included abundant oogonia (about 75/g), calcified thallus fragments and shells of freshwater molluscs, representing shallow water. The upper pit fills at MNL 165 are probably contemporary with this marl deposition. Increasing wetness, culminating in the formation of shallow base-rich peres in the deeper hollows, is thought to have been the main factor causing abandonment of these Bronze Age settlements.

Seeds of *Lemna* were present in most layers of pits 0901 and 0912, but not in 0921. Duckweeds thrive in organically polluted water; and indeed samples of fill from 0912 contained high concentrations of phosphate in the range 301-340 mg P/100 g, compared with mean values of 15 mg P/100 g in the natural subsoil (D. Gurney, pers. com.), providing direct evidence for nutrient enriched conditions in this feature. These high phosphate levels are not apparently related to deposition of food refuse. One plausible interpretation proposed by the excavator is that the large, shallow pits 0901 and 0912 were cattle water-holes. Water in these features may have been fouled by excreta. It is hoped that diatom and insect analysis may provide further support for this interpretation. The absence of *Lemna* seeds from the smaller pit 0921 is not readily explicable, but may be related to its function. If it was a retting pit, as suggested above, it may only have been open after the flax harvest when temperatures were too low for *Lemna* to fruit.

Remains of some woody plants have already been noted. Carbonized hazel nutshell fragments were very common and undoubtedly these nuts were consumed. The complete range of tree and shrub species from the site comprises *Ilex aquifolium* L., *Rubus fruticosus* agg., *Prunus spinosa* L., *Crataegus monogyna* Jacq., *Alnus glutinosa* L., *Corylus avellana* L., *Quercus robur* L., *Solanum dulcamara* L. and *Sambucus nigra* L..

Until analysis of pollen samples is completed little can be said about the density and overall composition of local woodland, though results from the analysis of molluscs and small vertebrates at MNL 165 indicate locally open conditions. The molluscan fauna is dominated by *Fupilla muscorum* (L.); its abundance is related to the well-drained unstable characteristics of the sand hummock. Other open-country taxa include *Trichia hispida* (L.), *Helicella itala* (L.), *Vallonia excentrica* Sterki and *V.* cf. *pulchella* (Muller). Shade-requiring taxa are exceedingly rare; there is a single burnt shell of *Clausilia bidentata* (Strom) which may have reached the site with firewood. The dominant small vertebrate species are short-tailed vole (*Microtus agrestis* L.) and common frog (*Rana temporaria* L.) with water vole (*Arvicola terrestris* L.), wood mouse (*Apodemus sylvaticus* (L.)), and unidentified



snake and newt species. Other small vertebrates occurred at lower frequencies and the assemblage as a whole is consistent with wet grass-tussock conditions, possibly with some scrub or trees nearby (T. P. O'Connor, pers. comm.).

There is some direct evidence for Bronze Age woodland clearance in the vicinity. For example, a section exposed less than 1 km to the north of the present site (MNL 137) showed a thin rendzina soil formed on calcareous marls which themselves had been deposited in shallow freshwater and marsh conditions on the evidence of mollusc and charophyte remains. The soil contained a woodland mollusc fauna dominated by *Carychium tridentatum* (Risso) and also produced a cheek tooth of bank vole (*Clethrionomys glareolus* (Schreber)) (det. P. Lawrence). On the surface of the soil was a 5 cm thick layer of heat-shattered flint and charcoal of ash (*Fraxinus* sp.), oak (*Quercus* sp.), hazel (*Corylus* sp.) and hazel/alder (*Corylus/Alnus* sp.), which gave a carbon 14 date of 3650±100 bp or 1700 bc (BAR 2690). This burnt layer was covered by humified peat disturbed by recent ploughing. It is hoped that further examination of such sections, combined with pollen analysis, will yield a detailed picture of local woodland.

#### Seasonality

Interpretation of the site's function depends upon establishing when, in the course of the year, it was inhabited. Some of the results outlined above seem relevant to such interpretation but must be viewed with caution. Summer temperatures during the Bronze Age may have been about 2-3° C higher than at present on average (Tinsley 1981, 211) and this must have resulted in some acceleration of plant growth and maturation. Bearing this qualification in mind, the following results are thought to be significant:

1. Flax cultivation. There are good grounds for thinking that flax was grown locally. The crop is normally sown in mid-April nowadays, though sowing is possible between March and May. The time of harvest is variable, depending on the product required (Percival 1918, 400).
2. Cereal cultivation. It is not known whether cereal crops were produced in the vicinity of the site. The association of *Galium aparine* fruits with cereals does, however, suggest some autumn sowing. This weed has shown by M. Jones and P. Reynolds to be confined to autumn-sown crops when 'primitive' cultivation methods are used (Reynolds 1981, 112).
3. The very immature acorns in cupules from 0967 suggest that the twigs carbonized in this feature were collected in early summer.
4. The association in pit 0921 of alder branches, twigs, 'cones' and fruits, together with deciduous leaf fragments (besides holly leaf fragments) may suggest that this deposit formed in autumn.

Clearly these results are of variable value, but taken together they do seem to indicate occupation in the spring, summer and perhaps autumn months. To demonstrate winter occupation from botanical evidence is obviously much more difficult. However, if in future seasons of excavation evidence suggesting local cereal cultivation is obtained,

then year-round occupation may reasonably be inferred on the assumption that autumn-sown crops would require a resident population in winter to tend them. Fortunately, however, there are other lines of evidence for seasonality which should supplement the botanical evidence. One of these is the study of growth increments in pike (Esox lucius L.) vertebrae from the site, discussed below by Andrew Jones.

It is hoped that this brief outline of results from the first season at MSL 165 gives some impression of the great potential of fen-edge sites for yielding data on the economy and environment of some Bronze Age communities in East Anglia. The interpretations presented are clearly not definitive. Some are intentionally speculative, and are given in the hope of generating comments and criticisms.

#### Acknowledgments

I am most grateful to Terry O'Connor and David Gerney for their work on small vertebrates and soil phosphate, some of which is referred to above. Allan Hall kindly provided information on plant fibres.

#### Fish bones from West Row, Mildenhall

Andrew Jones

Fish bones were not abundant in the deposits but they may eventually provide valuable evidence for seasonal activity on the site. To date, only five identifiable fish remains have been found. Three are vertebrae of pike, Esox lucius L., the others stickleback spines, Gasterosteus aculeatus L.. Two of the vertebrae were sent to Nanna Roe-Nygaard of the Institute of Historical Geology and Palaeontology, University of Copenhagen, who is currently making a detailed study of incremental growth rings on modern and archaeological pike bones. She was able to say that one of the fish died in the summer half-year. She also stressed the great dangers of concluding from this bone whether or not fish were commonly eaten in the Bronze Age. Clearly we need more bones, but it is hoped that the future seasons' work on the site will produce large groups of well-preserved fish remains and will allow the potential of incremental growth rings in vertebrae to be exploited.

### References

Berger, J. (1969). The world's major fibre crops: their cultivation and manuring. Zurich.

Fritsch, F. E. (1961). The structure and reproduction of the algae. Cambridge.

Gill, N. T. and Vear, K. C. (1980). Agricultural botany. I. Dicotyledonous crops. (3rd ed.) London.

Godwin, H. (1978). Fenland: its ancient past and uncertain future. Cambridge.

Hillman, G. C. (1981a). 'Crop husbandry: evidence from macroscopic remains', in Simmons, I. G. and Tooley, M. J. (eds.) The environment in British prehistory. London.

Hillman, G. C. (1981b). 'Reconstructing crop husbandry practices from charred remains of crops', in Mercer, R. (ed.) Farming practice in British prehistory. Edinburgh.

Kenward, H. K., Hall, A. R. and Jones, A. K. G. (1980). A tested set of techniques for the extraction of plant and animal macrofossils from waterlogged archaeological deposits. Science and Archaeology 22, 3-15.

Körber-Grohse, U. (1967). Geobotanische Untersuchungen auf der Feddersen Wierde. Wiesbaden.

Percival, J. (1918). Agricultural botany (5th ed.). London.

Reynolds, P. (1981). 'Deadstock and livestock', in Mercer, R. (ed.) Farming practice in British prehistory. Edinburgh.

Robinson, M. and Hubbard, R. N. L. B. (1977). The transport of pollen in the bracts of hulled cereals. Journal of Archaeological Science 4, 197-200.

Seale, R. S. (1975). Soils of the Ely district. Memoirs of the Soil Survey of England and Wales. Harpenden.

Tinsley, H. N. (1981). 'The Bronze Age', in Simmons, I. G. and Tooley, M. J. (eds.) The environment in British prehistory. London.

Photographs: School of Environmental Sciences,  
University of East Anglia.

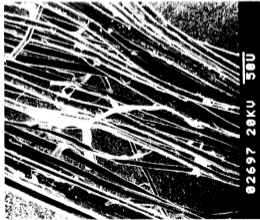


Fig. 13. Modern flax (*Linum usitatissimum*)  
fibres (50 micron scale)

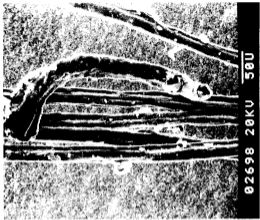


Fig. 14. Fibres from 0921 (50 micron scale)

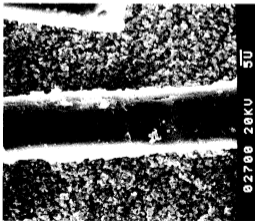


Fig. 15. Detail of fibre from 0921 (5 micron scale)

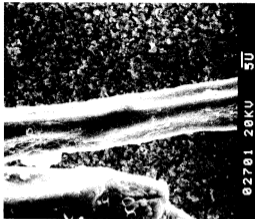


Fig. 16. Detail of 'grooved and noded' fibre from 0921 (5 micron scale)

Seeds and 'seed-machines'

Marijke van der Veen \*

Most environmental archaeologists will be familiar with the sight of a 'seed-machine' in operation on excavations. Often they will have asked the archaeologists to acquire one in the first place. The most common 'seed-machine' used in Britain seems to be a model based on the 'Straf-machine' (Williams, 1973); that is, an oil drum in which a 1.0 mm sieve is suspended, and with a weir welded on at the rim to channel the floating plant remains into a smaller sieve constructed outside the drum. The machine is designed to retrieve environmental data, but also serves to collect coins and other small archaeological objects. Generally speaking, the sieve inside the drum, 1.0 mm mesh size, collects the small animal bones, while the plant remains float in the water and are channelled over the weir into the sieve outside, 0.5 mm mesh size.

The method appears to work well for the collection of small animal bones, but whether the method is equally adequate in the retrieval of plant remains is subject to some uncertainty and doubt. The plant remains are meant to float in the water and be collected in the small sieve. If they do not float they may be 'lost', as the residues, i.e. the material in the large sieve inside the drum, is rarely, if ever, sorted microscopically. Even if they were, large quantities of the smaller weed seeds or chaff fragments will have disappeared through the holes of the 1.0 mm mesh.

To find whether I was justified in doubting the 'machine's' adequacy in retrieving carbonised plant remains, I decided to carry out some tests. The 13 samples used came from the excavations at Carlisle. For the test (and in fact now in common practice) the mesh size of the sieve inside the drum was changed from 1.0 mm to 0.5 mm. The mesh in the sieve outside was also 0.5 mm. To test how large a proportion of the plant remains had floated to the surface of the water and were collected in the sieve outside the drum, the residue (i.e. the material retained in the sieve inside the drum) was dried, sorted for bones, and then subjected to flotation again, this time manually in the laboratory. The plant remains from the site flot and those from the residue were then sorted microscopically and the number of identifiable fragments counted. Table 6 lists the proportion of plant remains recovered in the flot as against that found in the residue.

A recovery rate of over 85% was regarded as good, between 75% and 85% as acceptable, below 75% as bad and below 50% as very bad. Of the 13 samples studied in this way, the recovery rate of four was classified as good, two as acceptable, three as bad and four as very bad. Admittedly, the number of samples on which these tests were carried out

---

\* Marijke van der Veen, Biological Laboratory, Dept. of Archaeology, University of Durham, 46 Saddler Street, Durham DH1 3NU, U.K.

was small, and one would have preferred to work with samples in which N was rather larger, but these factors cannot obscure the general impression that the efficiency of this method in retrieving carbonized plant remains is pretty low.

One of the reasons for this bad performance may lie in the fact that a large amount of the plant remains does not actually float to the surface of the water, but is in suspension in the water. The 'seed-machine' only collects material floating on the surface, while with manual flotation (using a bucket) the water is poured into a 0.5 mm sieve, thus recovering material which is floating and in suspension. Carbonized plant remains also float better when dry, a condition not frequently met on site (at least not in Britain).

Table 6. Proportion of seeds recovered from flot and residue.

sample	flot %	residue %	N	Recovery rate
23	99.0	1.0	115	good
25	54.0	45.0	109	bad
32	20.8	79.2	53	very bad
35	0.0	100.0	31	very bad
39	84.0	16.0	50	acceptable
41	96.7	3.3	30	good
42	41.9	58.1	43	very bad
43	88.2	11.8	17	good
44	94.7	5.3	19	good
45	15.9	84.1	69	very bad
46	71.4	28.6	42	bad
47	83.9	16.1	81	acceptable
48	53.8	46.2	39	bad

Instead of ending on a negative note in classifying the 'seed-machine' as unsuitable for the retrieval of carbonized seeds, I would like to suggest that, if manual flotation is found to be undesirable, it can be used as long as one applies a 0.5 mm mesh size inside the oil drum (which the excavator in Carlisle informed me did not prove a problem). The residue then has to be subjected to manual flotation in the laboratory (after drying and sorting for bones) to ensure the retrieval of all plant remains. Only when these conditions are carried out consistently will one be able to trust the results.

#### References

Williams, D. E. (1973). Flotation at Straf. Antiquity 47, 198-202.

Paper received on 15th April 1983.

Book review

Wilson, R., Grigson, C., and Payne, S. (eds.) 'Ageing and sexing of animal bones from archaeological sites'. British Archaeological Reports British Series 109 (1982). Soft cover 11 pounds sterling.

The idea for this volume originated with Bob Wilson, and the first meeting in connection with it took place in September 1978, followed by another in 1979. At this point it was decided that the volume would be important and definitive, to which end four editors were appointed, who adopted a policy which was considered by some to be draconian, derisive, and nit-picking. This resulted in the withdrawal of a number of papers by established workers and of the senior editor. In the end, the remaining editors contributed 106 out of 282 pages.

Bob Wilson confines himself to an introduction. He bewails, quite rightly, the fragmented state of archaeozoological studies and the lack of decently funded research, but pads it out with some rhetoric and jargon, and a table which demonstrates that his thinking is firmly anchored to the 20th century consumer society. 'Species selected for eating' conjures up a vision of Mme. Asterix in her local branch of Viandes Celtique et Cie. (no connection with the Roman firm of the same name) demanding her husband's favourite joint of wild boar. The ability to age and sex a bit of tatty old bone, Wilson tells us, will lead to greater respect from our non-environmentally orientated colleagues. He does not say why.

Dr Grigson contributes two papers. The first is a useful review of current knowledge of ageing and sexing from the literature, and as always her knowledge of the German language places us in her debt. I am a bit dubious about her first figure, however, even though it is labelled as a sketch. All except one of the acetabulae of *Bos taurus* which I have examined have a postero-medial notch (which may be converted into a foramen in the older animal) which lies just at the point where one might wish to measure the vital feature, and this is not shown or mentioned. Her second paper is devoted to her own research on the Neolithic bovine, in particular its skull and horn-core morphology. She comes to the conclusion that most of the specimens found at Windmill Hill were mature females, and that any males present were young, but she has not been able to study castrate males, so these remain an enigma.

Sebastian Payne also presents two papers, each with a collaborator. The Angora goat herds of the Turkish Government (studied with Professor Deniz) must have seemed very promising for a study of tooth eruption and wear, but many of the animals' ages were shepherd's guesstimates and there were not a large number of animals over 6 years old, particularly males. Also the teeth were difficult to see in winter (could not one of his numerous assistants have carried a torch?). Payne disguises his problems in graphs of ever-increasing complexity, so that in the end he even has graphs to summarise graphs. His 55 pages of text result in only 23 lines of summary. He suggests male goats, of which there were few available, wear their teeth out faster than the female because of the necessity of fuelling 'their greater activity' - how about the metabolic activity required to complete a successful gestation and lactation? I also suspect that not all the animals got their fair share of 600 gm of hay.



Payne's other paper was written with G. Bull, and is inadequate from title onwards. 'Tooth eruption and epiphyseal fusion in pigs and wild boar' - since when was a wild boar not a pig? Again he has no accurate knowledge of the age of the animals from which he obtained his data. 'Local information is that most wild boar births are in April and May.' One of the specimens he illustrates (his fig. 1) has a crowded upper dentition, one of the premolars being at an angle of 45 degrees to the normal direction, which must alter its occlusion with the mandible, and in any case is a sign of malnutrition earlier in life, all of which passes without comment. He prefers the hallowed data of Lesbre on epiphyseal fusion to that of Rieland, because Lesbre gives a definition of his point of closure, though he nowhere states how many animals he used, or of what sex, or how accurately they were aged, and Rieland, using radiology in a journal written for radiologists assumes that his readers do not need to be given a definition of his criteria of closure.

The literature survey runs to 10 items, two of which are standard anatomy texts using Lesbre as a basis. Payne complains of a lack of modern data correlated with environmental factors. Half an hour with my card index produced 13 more titles which seem relevant, a few of which are itemised: Weaver et al. (1966; 1969) describe the eruption pattern in miniature swine, which are of considerable interest because they carry a considerable genetic component derived from native Latin American pigs which in turn derive from medieval Spanish animals. Wenham et al. (1973a; b) contribute two radiological studies of the growth of long bones and skulls in pigs. Payton (1932) gives some fusion data on animals from an era of less intensive farming. Wiarda (1954) describes the post-cranial skeletons of a number of pigs of known age and pedigree. Ripke (1964) illustrates wear stages in the porcine incisor even if one's German is not very good. Above all there is the vast study of under-nutrition in the pig carried out by McCance and his colleagues starting in 1960 and still being published (22 papers at the last count, e.g. McCance et al. 1961; 1968) which used no less than 70 animals. At least four of these papers are relevant, for example Tongue and McCance (1973) on normal as well as abnormal development of the mandible and dentition, and Pratt and McCance (1964) on the development of the long bones. Moskalewska (1982) has demonstrated that the bone structure of the medieval domestic pig was unlike that of the wild pig, which might give pause for thought. Finally, in a paper published since Payne and Bull completed their study, Wijngaarden-Bakker (1982) has published data of bone fusion from Dutch wild boar of fairly accurately known age.

Andrew's paper on dental eruption in cattle comes as a valuable corrective to all the inexactitude described above. His animals were aged to the day. He knew their breeding and their diet precisely. He used up to 2900 animals in some of his studies. He describes the requirements of an accurate study, and defines his terminology clearly and exactly. Despite this, he finds there are between one and three hundred days difference in some of his eruption stages.

It was inevitable that Grant's and Payne's rival systems of tooth wear recording should be compared in this volume. Grant now has 52 TWS (tooth wear stages) and MWS (mandible wear stages). Since these have never been worked out on material of known age they must remain very subjective, and so Hamilton found when she tried both methods on the same sample of Iron Age sheep mandibles. Levitan, on the other hand, came out in favour of Grant when he conducted a splendidly stringent time and motion study on the two methods, but largely because Payne's

ideograms take so long to draw. Grant has, however, worked on sufficient sites herself to make comparisons with her own work, and in fact she has 16 of her own references in her paper.

Bullock and Rackham contribute a much simpler system of assessing tooth wear, which they employ on a sample of 29 feral goats found dead on the mountains of Southern Scotland. They base their ageing on horn rings, which normally occur annually but which may record traumatic events in the animal's life other than winter inanition. The ages of epiphyseal fusion they found on these animals are very late indeed, and the normal order of metapodial before proximal femur is reversed in a group of four males whose tooth wear is rather varied.

The tooth wear marathon is completed by Levine, who contributes data on ten New Forest ponies of approximate age supported by five more of possibly known age. Levine's text is hard to follow, and the two halves of a sentence often seem to contradict each other. However, she can assure us that horses' teeth do wear down in time, and that large horses have larger teeth than small ones.

Another method of assessing chronological age in teeth is by counting the annual incremental rings in the cementum, usually that of the upper root. Stallibrass contributes a review of the literature on this topic which reads very well, but she has a total disregard for the gross anatomical differences between the teeth of different species, happily illustrating 'a molar' which would appear to be that of a deer.

Coy, Jones and Turner have actually tried this method and demonstrate that it is much easier said than done, at least on cattle. Considering the thought, care and hard work that obviously went into this project, the results are disappointing. However, the authors pronounce themselves undefeated and are still trying to perfect the method.

There remain two more mammal papers in this volume. Armitage has devised a system of ageing and sexing the horncores of late medieval longhorn cattle. He deduced that there were two types of male, entire or castrate. He has also produced a useful age series based on the surface appearance of the horn core bone, but he knows too much about the variability of animals to put any chronological tags upon it.

Maltby tackles the subject from an entirely different point of view, that of distribution on a site and of taphonomy. His queries can only be answered by detailed studies on large total excavations. However, there is a simpler explanation for one of his problems than that which he suggests. There is an apparent discrepancy between dental and epiphyseal ageing data on the post-medieval sheep of Exeter. The age of fusion may well have dropped, suggesting that Kerridge may be correct in his belief that stock improvement was taking place earlier than is commonly supposed: lambs may have grown much better if the widespread medieval practise of early weaning in order to milk the ewe had been discontinued.

The volume ends with three papers about bird bones. This is not my special subject, so I can only say that I found all of them informative and biologically sound.

In general, this collection of papers demonstrates, with some honourable exceptions, that a little biological learning is a dangerous thing as far as archaeozoology is concerned. It underlines the necessity of obtaining more modern material from which unequivocal deductions can be drawn, and any money that is available should be spent on commissioning this rather than on supporting students through research projects of little scientific value.

#### References

Moskalewska, S. Lasota- (1982). Microscopic comparison of bones from medieval domestic and wild pigs. Ossa 7, 173-8.

McCance, R. A., Ford, E. H. R., and Brown, W. A. (1961). Severe undernutrition in growing and adult animals 7: development of the skull, jaws and teeth in pigs. British Journal of Nutrition 15, 213-30.

McCance, R. A., Owen, P. and Tonge, C. (1968). Severe undernutrition in growing and adult animals 18: the effects of rehabilitation on the teeth and jaws of pigs. British Journal of Nutrition 22, 357-68.

Payton, A. (1932). The growth in length of the long bones in the milder fed pig. Journal of Anatomy 66, 414-25.

Fratt, C. W. M. and McCance, R. A. (1964). Severe undernutrition in growing and adult animals 14: shafts of long bones in pigs. British Journal of Nutrition 18, 613-24.

Ripke, W. (1964). Beitrag zur Kenntnis des schweineige Bisses. Anatomische Anzeiger 114, 118-211.

Tonge, C. H. and McCance, R. A. (1973). Normal development of the jaws and teeth in pigs and the delay and malocclusion produced by calorie deficiencies. Journal of Anatomy 115, 1-22.

Weaver, M. E., Jung, E. P. and McKean, C. F. (1966). Eruption pattern of deciduous teeth in miniature swine. Anatomical Records 154, 81-6.

Weaver, M. E., Jung, E. P. and McKean, C. F. (1969). Eruption pattern of permanent teeth in miniature swine. Archives of Oral Biology 14, 323-31.

Wenham, G. and Fowler, V. R. (1973a). Radiographic study of age changes in skull, mandible and teeth of pigs. Journal of Agricultural Science (Cambridge) 80, 45-61.

Wenham, G., Fowler, V. R. and McDonald, I. (1973b) Radiographic study of skeletal growth and development in the pig. Journal of Agricultural Science (Cambridge) 80, 125-33.

Wiarda, H. (1954). Über wuchsforme bei Haustieren: eine Studie an Schweine-skeletten. Zeitschrift für Tierzüchtung und Züchtungsbiologie 63, 335-379.

Wijngaarden-Bakker, L. H. van and Maliepaard, C. H. (1982). Age determination of the wild boar *Sus scrofa* Linn. 1758 based on the skeleton. Lutra 25, 30-7. (Dutch with English summary and figure titles).

Barbara Noddle, Dept. of Anatomy, University College, P.O. Box 78, Cardiff CF1 1XL.



