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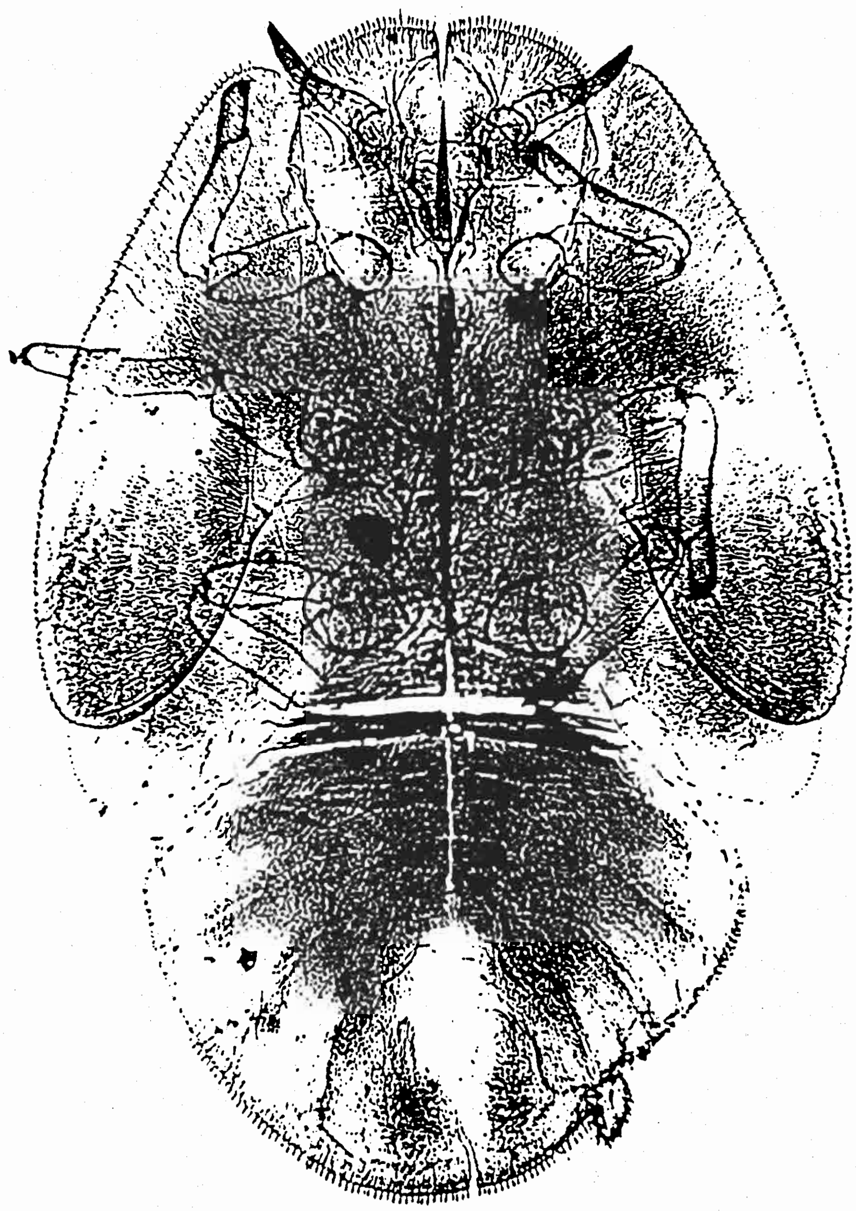
Circaea



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.

Circaea is edited and assembled by Allan Hall, Harry Kenward and Terry O'Connor, at the University of York, England. It is distributed free to members of the AEA and available to institutions and non-members at £9.00 per annum. Back-numbers: vols. **1** and **2** and vol. **3**(1)—£2 per part; vol. **3**(2) onwards—£3 per part; articles—5p per side, plus postage.

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Editorial

The first issue of volume **7** of *Circaea* sees another change in style and in the means of reproduction; we are now able to originate copy on an IBM-compatible micro-computer and pass files for printing to the laser printer linked to the University of York mainframe computer. We hope that readers will approve of the new format!

In this issue, we are publishing two major articles, one a bibliography of books and papers relevant to the identification of plant macrofossil remains, the other a lengthy review of domestic mammal physiology in the context of domestication. Some of the references in these compilations have been obtained from secondary sources and they may not all be complete in detail—hence the occasional omission of page numbers, a publisher, or a place of publication. There are also three book reviews and some comments on the AEA's 10th Anniversary meeting in 1989.

We very much hope to produce part 2 of volume **7**, the second part for 1989, soon after this one, and then proceed swiftly to volume **8** (for 1990). Needless to say we apologise to the readership and, most especially, to our authors, for these delays; we hope the use of new technology will speed the process up.

Grateful thanks from the Editors are due to John Carrott for typing in the paper by Barbara Noddle. The paper by Mark Nesbitt and James Greig arrived on a 5¼" floppy disk and saved immense amounts of editorial time! Please note that we are able to transfer files produced on 3" Amstrad disks (from LocoScript and LocoScript 2, WordStar or NewWord) and from 5¼" floppies (from WordPerfect or WordStar). Files formatted using WordPerfect (version 5.0) are currently the most acceptable. We can also utilise copy transmitted through JANET from computers in Britain (and perhaps also from further afield); our address is BIOL8 at UK.AC.YORK.VAX (please let us know by more conventional means—e.g. carrier pigeon—if you have any difficulties with electronic mailing).

Front cover: Photomicrograph of a nymph of the psyllid bug or jumping plant louse, *Trioza albiventris* Förster, associated with willows, *Salix*, from Anglo-Scandinavian deposits at 16–22 Coppergate, York (Photograph: Dr E. P. Allison).

Book reviews

H. Küster (ed.) (1988). *Der prähistorische Mensch und seine Umwelt*. Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg, **31**. Festschrift für Udelgard Körber-Grohne zum 65. Geburtstag. Stuttgart: Konrad Theiss Verlag. ISBN 3 8062 0799 2. 430pp., figures and pls. Price DM 125,– (approx. £41).

Udelgard Körber-Grohne may be considered one of the trendsetters in palaeoethnobotany. Her publications, especially, show the importance of botanical methods for the study of the relationship of man and his environment in the past. Not only has she paved the way for the development of a methodological framework in palaeoethnobotany, but again and again she has proved that the boundaries of the identification of archaeobotanical material could be expanded (e.g. Körber-Grohne 1977; Körber-Grohne and Piening 1980).

The role of palaeoethnobotany in environmental archaeology has changed considerably during recent decades. At first merely the study of (sub)fossil macroscopic remains of cultivated plants, concentrating on the reconstruction of subsistence economy, diet, and vegetation and landscape, it now focuses increasingly on more sophisticated techniques such as the interpretation of archaeological features and the reconstruction of human behaviour (what Martin Jones (1985) calls 'archaeobotany beyond subsistence reconstruction'). In 1967 the definitive step to integrated eco-archaeological research was made by the publication of Körber-Grohne's monumental *Geobotanische Untersuchungen auf der Feddersen Wierde*. This study of a 1st–4th century AD habitation mound in the coastal area of northwestern Germany not only contains examples of 'classic' research in vegetation reconstruction, but also a thorough discussion on the spatial distribution of plant remains and their connection with the archaeological context, in relation to different stages in crop processing.

Since then, her name has stood for palaeoethnobotanical research of outstanding quality, as was recently proved by the publication of another *chef d'oeuvre, Nutzpflanzen in Deutschland* (Körber-Grohne 1987).

For the occasion of the 65th birthday of Professor Körber-Grohne, Hansjörg Küster has brought together a number of papers of palaeobotanical signature, under the title

'Prehistoric man and his environment'. Going through the index, it appears that this title does not really cover the contents of the book. The contributions are arranged in five sections: General, neolithic, Bronze and Iron Age, Roman period, and Middle Ages. The last two are represented by five and six papers, respectively, so about one-third of the contributions fall outside the timespan suggested by the title. Moreover, a number of papers, however interesting, are only remotely, if at all, concerned with the relationship of man and his environment.

Clustering the papers in a manner perpendicular to Küster's division, the following topics (although a strict separation is not quite possible) may be discerned: General, Vegetation history/Phytosociology, Methodology, and Descriptive articles/Site reports. In spite of the development of archaeobotany towards the area beyond subsistence reconstruction, a large part of the contributions belong to this latter category. Dissatisfaction with the descriptive approach does not remove its necessity; it is generally acknowledged that it is often difficult or impossible to discuss archaeobotanical finds simply through lack of comparable material (Jacomet: *Forschungslücken*; Behre: *Unzureichende Kenntnisstand*). Illustative of this category are the papers on *Pinus pinea* (Kislev), *Raphanus sativus* (Hopf; Buurman), *Vitis vinifera* (Gyulai), *Prunus cerasifera* (Stika and Frank), the use of *Polytrichum commune* for the plaiting of rope (Knörzer), and Schlichtherle's study of seeds as ornamental objects during the neolithic.

Site reports are presented by Piening (three papers on charred plant material from prehistoric sites in southwestern Germany, with an interesting observation on remains of hay from the Iron Age site of Stuttgart–Mühlhausen), Behre (a discussion of a find of charred grain from the Bronze Age settlement of Toos–Waldi, in Switzerland), Karg (Uhingen, Bronze Age), Küster (Burkheim, Iron Age), Tomzyńska and Wasylikowa (Kamieniec, Poland, Iron Age), S. Maier (Köngen, Roman well) and U. Maier (Bruchsal, medieval bishop's residence). Bakels' preliminary report on the neolithic site of Hekelingen (Netherlands) not only describes the plant remains, but also includes a discussion of the economy of the settlement.

The category 'General' is represented by, among others, an introduction by Planck to the state of archaeobotanical affairs in Baden–Württemberg, and a discussion by Opravil of plant material from medieval urban and rural contexts. Especially interesting in this category are van Zeist's study of the relations between medieval settlements in the clay and sand regions of the northern Netherlands, Jacomet's paper on mediterranean taxa represented in neolithic lake-shore sites in Switzerland, and Rösch's article on the interpretative value of mosses for palaeoenvironmental research in general and the use of plant material by prehistoric man in particular.

In the category 'Vegetation History', the papers of Kalis (Rhineland, early neolithic), Smettan (Kupfermoor, neolithic to medieval) and Liese-Kleiber (Federsee, neolithic to Bronze Age) show what essential contributions 'classic' pollen analysis can make to settlement archaeology. The paper by Gaillard and Jacquat illustrates that the boundary between palaeoethnobotany *sensu stricto* and palynology is not sharply delimited: both disciplines are essential in the study of the relationship of man and his environment in the past. Phytosociological contributions concentrate on vegetation influenced by human activity: the phytosociology of weeds is discussed by Willerding (in general) and Jones (for southern England) and the importance of the preservation of existing field weed communities is stressed by the paper of Lange and Illig. In her contribution on forest border vegetation, Wilmanns shows the implications of changes in land-use for the interpretative value of (groups of) plant species in palaeoethnobotany.

The category 'Methodology' includes some articles of special interest. Greig, for example, discusses the interpretation of palaeoenvironmental results from Roman well fills and the processes involved in the formation of the different organic assemblages; Kreuz was able to establish functional differences of excavated structures on the basis of charcoal analysis; she also suggests taxon-specific gathering of firewood by the inhabitants of a Band-keramik settlement and management of hedgerow vegetation for this purpose. The only paper with a statistical approach is van der Veen's study of the Roman grain from South Shields (NE England), which also includes a discussion of sampling methods.

Although the standard of the papers is variable, the book derives its main interest from the fact that it includes several original contributions on methodological topics (Greig, Kreuz, Rösch, van der Veen, van Zeist). The relatively large number of 'site reports' is not significant, given the state of affairs within the research discipline, but inherent to the character of a *Festschrift*. Many authors consider it an opportunity to present 'goodies' from excavations for which the final reports are not going to appear in the near future, or to devote a discussion to an interesting and/or controversial species or groups of species.

The production of the book is fine—immaculate—although a few readers may be annoyed by the fact that scientific plant names are not printed in italics and that the tables are rather wasteful of space.

About two-thirds of the contributions are written in German (without a summary in English). This might be prohibitive for a large international distribution, which is a pity, because at a time when £40–50 is the normal price for a basic textbook, 125 D-mark is relatively cheap for such a splendid publication.

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Reviewer: **Jan Peter Pals**
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Hiko-Ichi Oka (1988). *Origin of cultivated rice*. Developments in Crop Science **14**. Amsterdam: Elsevier. ISBN 0 444 98919 6. 254 pp. Price Hfl. 185 (approx. £61).

This quarto volume is comparatively thin for the price. It was very disappointing at first reading, perhaps because, given the title, the reviewer expected something with a higher and better quality of archaeological and palaeobotanical input. In fact Oka takes a rather wider view but the main thrust is from the point of view of genetics and on a second, thorough, reading this proved to be of considerable interest.

There are ten chapters, preceded by a brief synopsis. The titles of some chapters are in somewhat clumsy English, as is much, unfortunately, of Chapter 6, possibly a result of literal translation from the Japanese. The chapter titles, however, give a good impression of the general flavour of the book, apart from indicating the content. They are as follows :

1. The genus *Oryza* (this includes an enumeration of the species, notes concerning the confusion in species naming and the habitats of wild rice species);

2. The ancestors of cultivated rices (the contents are self-evident);

3. Ecology of population biology of common wild rice (!); common wild rice is taken as the *Oryza rufipogon* complex as far as the possible progenitor of *O. sativa* (long-grained rice) is concerned and *O. breviligulata* as far as the likely progenitor of *O. glaberrima* (glutinous rice) is concerned and the chapter considers distributions and habitats, variations in breeding systems, adaptive strategies and regeneration success;

4. Genetic variations and evolutionary dynamics;

5. The dynamics of domestication (including sections on the characteristics of domesticated plants, hybridization, selection, weedy forms of rice and the geographical distribution of genetic diversity);

6. The homeland of *Oryza sativa* (archaeology and history in relation to the origin of long-grained rice);

7. Indica-Japonica differentiation of rice cultivars (with sections on the classification of varieties into groups, differences

between Indica and Japonica types and intervarietal hybrid sterility);

8. Functions and genetic bases of reproductive barriers (this chapter considers reproductive barriers found in cultivated rices and their wild relatives, hybrids between *O. sativa* and *O. glaberrima*, etc.);

9. Variations in adaptability of environment (photoperiodic response, adaptation to upland and deep-water conditions, fertiliser response, and so on);

10. Germplasm conservation; not directly concerned with agricultural origins, more with agricultural futures, and unlikely to be of interest to archaeologists.

An integrating concluding chapter might of been of more value than an opening synopsis, as the book ends somewhat abruptly.

Oka states in his preface that the intention was to review the present state of our knowledge on the origin of rice cultivation, and the book must be assessed in terms of how far he succeeds in doing this. He goes on to assert that he is not competent to write such a review, saying that it was beyond his ability to cover the whole range of sciences related to the subject. On the face of it, this is a damning indictment of the weakness of the book, but one must not be too harsh. As in many areas of research these days, it is simply not possible for a single writer to produce a watertight overview of the whole field. Oka is clearly most at home with his own specialist area of genetics, and indeed he presents the findings of much experimental work conducted over many years by himself and colleagues in several countries, into the ecology of wild and cultivated rices. He should, however, have invited archaeologists and palaeoecologists to collaborate in writing Chapter 6, especially, or at least asked for their comments. It is a pity that the chapter that is so directly about the origins of rice cultivation is the weakest in the book.

The concern of the book is substantially, but certainly not exclusively (since Oka has carried out fieldwork in Africa) with the origin of *Oryza sativa*. While his definition of the *Oryza rufipogon* complex may be criticised, few would question his postulated origin of *O. sativa* in *O. rufipogon* and in this respect he is not really telling us anything new. However, he has verified that *O. rufipogon* has greater gene diversity than other wild rice species and that the common wild rices of Africa and South America are isolated from *O. sativa* by reproductive barriers. Apparently *O. rufipogon* can be a perennial under everwet conditions or an annual in seasonal swamps and the two forms are very similar genetically although the perennial can reproduce vegetatively. Oka sees the origin of *O. sativa* in the perennial whereas Chang (1976) envisaged evolution from the perennial to a wild annual (*O. nivara*) and thence to an annual cultivar, like the other cereals. Oka dismisses the fact that the other cereals are annuals as 'not pertinent' and claims that *O. sativa* is essentially a perennial, a view which he does not substantiate anywhere in the book. Chang (1989) simply ignores Oka, whilst Oka deals rather sparingly with Chang's views—the very stuff of science! A compromise must be possible.

Turning to *O. glaberrima*, there is, likewise, little doubt that it originated in *O. breviligulata* in Africa, where it is endemic. What is open to question is when it originated. Oka (p. 12) gives a 'date' of 1500 BC from a source written in 1939. The truth of the matter is that the origin of glutinous rice is even more obscure than that of long-grained rice. So, again, Oka is not telling us anything which is essentially new.

Returning to *O. sativa*, which is the more important of the two cultivars, not only does Oka disagree with Chang on the method of origin but also on the number of races which can be distinguished in the cultivar. Oka recognizes Indica (Hsien) and Japonica (Keng) types only, while Chang (1976) also distinguished a Javanica type. Oka claims that this name has never been formally published and argues his case very convincingly using genetics: apparently Javanica has almost the same isozymes as Japonica and it may simply be a tropical sub-group. He acknowledges that both may have sub-types. Temperate-area rice cultivars are exclusively Japonicas (these have higher cold tolerances) but they also include hill-rices of the tropics and subtropics. At least the two writers agree that gathering preceded cultivation—something which neither can, of course, prove! Oka makes the bland comment (p. 140) that phytoliths (opal silica) may be useful in separating Indica and Japonica races, but we hear nothing more of them and there is no reference to the literature on rice phytoliths even from Japan, e.g. Fujiwara (1976) and Watanabe (1968).

Despite the information outlined above, Oka, perhaps rightly, is not prepared to defend a case for separate origins of Indica and Japonica races. There is an interesting section on weed rices, which he suggests are possible relics of ancient cultivation. These include the 'red' rice of Japan which has both Indica and Japonica types and which he unconvincingly states might represent intermediate stages in the domestication of wild plants as they accumulate genes of cultivars by introgression.

There is little mention of rice pollen except in relation to plant breeding. He is correct in stating that *O. rufipogon* pollen tends to be oval in shape and that this cannot be regarded as diagnostic as intermediates with the more usual spherical shape occur. He makes no comment on why rice cultivar pollen, unlike that of other cereals, shows no tendency to gigantism. Could this be because cultivated rice is of more recent origin? (This reviewer is not a geneticist and would hesitate to stick his neck out, however.) As with phytoliths, there is no reference to the data on rice pollen, which are mainly published in Indian journals. The statements about pollination mechanisms seem partly contradictory. At first *O. sativa* is said to be predominantly self-pollinated, then (p. 35) that both it and the wild species are wind-pollinated and finally (p. 83) that common wild rices are partly self-pollinated. There is general agreement in the literature (reviewed by Maloney, 1989) that *O. sativa* is self-pollinated, that the pollen is not dispersed very far and that it produces fewer pollen grains per anther than the wild species. Oka is at least consistent in producing data which support the latter finding.

Having been fairly critical so far, the points which have been made are, perhaps, minor in comparison with those which have to be made about the archaeological survey, which is naive in the extreme. He starts badly: one of the general comments made (p. 126) is that man has been on the earth for two million years—the source is a book written in 1975. The attempt at amateur comparative linguistics on p. 135 is even worse, however. As far as the evidence from Thailand is concerned, one of his main sources is the now infamous paper written by Solheim in 1972. There is no reference to more recent research, which I will spare the reader by not quoting at length, but many quite important articles have been published in the *Indo-Pacific Prehistory Bulletin*, various conference proceedings and there is Higham's important three-volume *British Archaeological Reports* on Ban Nadi. The supposed date of *c.* 6,000 bc for the first rice cultivation in Thailand may well prove to be true (cf. Maloney *et al.* 1989) but cannot be substantiated at present. Both myself and my research partner, Charles Higham, agree that rice cultivation could have originated anywhere in a broad area ranging from southern China to the Red River valley of Vietnam to Thailand. Both the book under review and Chang (1989) draw attention to a secondary source which claims that cultivated rice occurs in archaeological contexts dated 6,570±210 bc to 4,530±185 bc at Maharaga, Uttar Pradesh, India—considerably earlier than dates from other Indian sites. No laboratory numbers are given for the radiocarbon dates and this writer would prefer to see the primary source before passing judgement on this report. Nevertheless, Oka states on p. 130 that archaeological evidence and historical records (which?) show that rice culture in China started some 1,000 years earlier than in India! It should be noted that the attribution of *O. sativa* to *c.* 4,000 BC at Ulu Leang, Sulawesi, in Chang's table is obsolete. It is now known that the true age is much younger.

The account of rice in Chinese archaeological contexts is the best part of this chapter although this, too, is not completely up-to-date. It is useful to have translations of summary accounts of the literature in Chinese, however. There is no mention of rice origins in Japan, but what information there is suggests that it is late.

Based on an insufficient review, Oka has claimed simultaneous origins for rice cultivation in India, Thailand and China. If the Indian site is ignored, most people would at present opt for a southern Chinese origin around 7,000 BC.

The inference (p. 137) that the expansion of the Indica varieties began in the last millenium is highly questionable because of the extent of the source material and the methods used, of which Oka himself is critical. The data consist of length/breadth measurements, mainly on impressions in brick. Oka admits that these are not reliable in differentiating modern material, that there is a 39% possibility of misclassification, and that even if you could distinguish fossil Indica from Javanica this does not prove which race originated first.

Chang (1976) argues against an origin for rice in the humid tropics, partly because of its sensitivity to photoperiod. Oka points out that wild species are usually sensitive but common wild rices from Sumatra and Borneo, which have a long period of vegetative growth, are not—nor are some cultivars (tropical Japonicas). The corollary of this is that Chang is correct, but an early expansion into the humid tropics cannot be ruled out.

It is clear from this review that the topic of rice agricultural origins is not readily resolved. From the point of view of the archaeologist and palaeobotanist, the attempt to seek origins is futile: all that can be achieved is to push the date backwards and, as far as south-east Asia is concerned, the possibility that the earliest sites lie deep beneath the sea on the Sunda Shelf cannot be neglected.

Oka's book is not one which is easy reading for the non-geneticist but, with the exception of Chapter 6, it is worth the effort as the most thorough survey of the background to the agricultural origins of rice in existence. It is not the book for every environmental archaeologist's collection but it is an important specialist work of reference and it is to be hoped that there will be a second edition which will meet the criticisms delineated above. However it does not meet the intended aim of an up-to-date review of knowledge on the origins of rice agriculture because of the weakness of Chapter 6.

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Wheeler, A. and Jones, A. K. G. (1989). *Fishes*. Cambridge: University Press. ISBN 0 521 30407 5 Pp. xiv + 210, numerous illustrations. Price £32.50 ($59.50).

This book is the sixth in the series *Cambridge Manuals in Archaeology*, other titles in which include Simon Hillson's *Teeth* (1986) and Richards and Ryan's *Data Processing in Archaeology* (1984). The series describes itself as 'reference handbooks designed for an international audience of professional archaeologists and archaeological scientists in universities, research laboratories, field units, and the public service' (back cover). *Fishes* has fourteen chapters, which may be divided into four sections. Chapters 1–3 provide an introduction to archaeological fish remains, their importance and potential, and provide some background on fish ecology. Chapters 4–8 examine the nature of the evidence, looking first at how to recover it, then at taphonomy and finally at the skeletal anatomy of fish. Chapters 8–12 deal with analysis and interpretation. Finally, chapters 13 and 14 are a sort of miscellany, detailing the preparation of reference collections and indicating future directions for research. There is a useful and extensive list of references (over eleven pages) and an index. The book is well packaged and presented, with many fine line drawings and a small number of photographs, but is very expensive, working out at 14.5p per page, and will be beyond the pocket of many at whom it is aimed.

Archaeology is becoming an increasingly diverse and specialised discipline with the result that there is a growing gap between those involved in the very specialised areas (e.g. archaeological scientists) and excavators. There are even problems of communication between archaeological scientists, let alone between scientists and other archaeologists! Often the excavator will also have his or her own specialisation, which traditionally is oriented towards artefacts, such as pottery or coins. Although the situation is changing slowly, this diversity often leads to the situation where the excavator has too little knowledge of the specialist subject to be able to understand and integrate the results, whilst the specialist may not be well-enough versed in stratigraphy, for example, to be able to understand the archaeological potential and problems of the project. The result is often the 'relegation' of scientific reports to the appendices of excavation reports and little or no attempt to integrate the findings. This the authors recognise and address early in the book (p. 7). They have attempted to write a book that is useful and accessible to both excavator and scientist, and it is a brave try, but I feel that the authors never quite find the right balance, with the result that in many places the book goes into too much detail at too basic a level on one side or the other. This would be fine if it were directed at undergraduate students or excavation supervisors, but the series is aimed at a much higher level, and one where much of the information provided seems like overkill. For example, the 22 pages devoted to methods of recovery (chapter 4) include ten pages itemising methods of sieving even to the extent of providing a 'shopping list' of materials required: clean trowel; nylon string; sample book and pencil; and so on (p. 48). It would be an insult to suggest that any competent excavator should require such information in a book like this, whilst this amount of detail is irrelevant as far as the scientist is concerned. Other examples could be quoted. One feels that the authors could not quite make up their minds whom they were addressing: novice, excavator or scientist.

Conversely, there are areas which could profitably have been covered but which have either been glossed over or ignored. For example, the authors mention historic and prehistoric evidence in the form of pictorial representations (p. 3). They dismiss it, however, as being able to provide 'only a rough guide to the knowledge the respective cultures possessed of their fish fauna' choosing not to cover it in any detail. I feel this is a great loss because it has been shown in the case of other animals that such evidence can be extremely useful and revealing (for example in Michael Ryder's *Sheep and man*, 1983, which makes extensive use of this kind of evidence for his chosen species). The authors themselves use such evidence in places, as when describing wall-paintings from Egyptian tombs which confirm ideas about ancient processing (p. 65). Furthermore, there is increasing evidence that prehistoric depictions can be highly precise in details concerning hunting and capture of prey, and pertaining to processing—after all, ancient peoples had minute empirical knowledge of their environment and the habits and habitats of their prey; it is only logical this should be communicated in their art. Linked to this is documentary evidence, and again the authors pay little heed to the importance of it.

A second sad omission is the lack of 'a survey of the interactions between fishes and man' (p. 2). Were this book a manual of fish recovery and identification only, such an omission would be understandable, but it aspires to be a book about fish remains and archaeology (p. 1), and archaeology, by definition, involves man. Any archaeologist wishing to learn more about the potential of fish remains would list as a primary criterion the interactions between fishes and man. These, then, are the main failures of this book. There are a few minor points which hardly need labouring for they are insignificant (Table 5.3, for example, is not referred to in the text and appears incomplete).

The book as a whole, however, is not a failure. To write it off as such on the basis of the omissions described above would be folly, for it fills an important gap in the literature, the subject being long overdue for this sort of treatment. There is no lack of literature regarding fishes, as the references show, but there has hitherto been no attempt made to provide a broad but detailed account which will be accessible to scientist and excavator alike (Richard Casteel's *Fish remains in archaeology*, 1976, was aimed primarily at the specialist, and was a very unsatisfactory book on both levels). This book is readable and literate and contains a mine of valuable information. For instance, the two chapters (6 and 7) on fish anatomy are clear and most usefully enumerate those elements that are best preserved and most useful for identification in the context of archaeological remains, and the inclusion of a comparative list of the main schemes of nomenclature (Table 7.1) is a real boon. Similarly, the discussion of methods of recording and analysis (chapters 8–11) are well argued and presented (if slightly patronising in one or two places).

Despite its flaws and its price, this book must be compulsory reading for any archaeologist with a genuine interest in fish remains. And with increased standards of recovery on modern excavations there will be fewer situations where fish remains are not encountered (especially on urban sites). The authors deserve every congratulation and encouragement. They honestly admit the areas where simply not enough work has been done, and it is hoped that their endeavour will spur others on to fill those gaps in our capability and knowledge.

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Cinderella's kitchen: a personal view of environmental archaeology past and present.

The 10th Annual Symposium of the AEA invites historical thoughts. I cannot say exactly when the archaeological virus permeated my existence turning me into an archaeozoologist, environmentalist or whatever, because 25 years ago, which is approximately when it happened, these terms were not in use. The inclusion of the Greek 'logos' in the word archaeology should indicate that it is a science, and so it may well have seemed in the early days when excavated objects were constrasted with classical literature. Prehistory, blending as it does with palaeontology in its Palaeolithic period, ought to have increased the scientific bias, but an obstinate public, although it enjoys spectacular grave-goods and stone circles, believes that they too have something to do with the Romans.

In the early days of the subject, archaeologists were amateurs, frequently wealthy ones: the professional barrow-openers who performed before excursion parties from antiquarian societies can hardly be included. These people were often landowners interested in agriculture or in natural history, and in any case everybody rode or at least drove horses, so animal as well as human bones received some attention. Abercrombie's ceramic revolution had not yet taken place, so as far as they were concerned potsherds were either decent Samian or 'quantities of rude pot'. Environmental interests were probably at their nadir during the first half of the 20th century. Some work was done by museum staff, apparently voluntarily and without payment; they probably gained their expertise on the job. As recounted in a recent AEA Newsletter, the Institute of Archaeology in London was set up just before the last war, against the odds, with a strong environmental interest, but a subject with so many constituent sciences is a difficult one both to teach and to study. I was delighted to learn that it does form a whole degree course at one enlightened polytechnic and a second degree at the Institute of Archaeology. Nevertheless, Ian Cornwall found himself having to become a jack of many biological trades and to his great credit mastered most of them and taught them well.

However, the powers that be, whether University Senates or the late UGC, were firmly of the opinion that archaeology belongs amongst the humanities, if anywhere. One gains the impression that the recently-retired generation who once had charge of the Civil Service thought archaeology to be a dilletante subject unsuited to taxpayers financial support, though it probably served to keep the long-haired and trendy Left out of mischief. The general public, however, was fired by the enthusiasm of Sir Mortimer Wheeler and Glyn Daniel on the television, and their interest was maintained by the excellent *Chronicle* series. The early death of Paul Johnstone, chief *Chronicle* producer, was a sad loss to archaeology. During the 1960s and early 1970s, amateur 'rescue' excavations were carried out with a crusading zeal within inches of bulldozers, as redevelopemt took place with unprecedented speed. Extra-Mural classes, at least in Glasgow where I acquired most of my archaeological knowledge, were usually over-subscribed.

Purveyors of environmental appendices to excavation reports were in very short supply. Museum and university staff were overwhelmed, as were those interested parties in industrial laboratories who had been so helpful in metallurgy and such fields. Extra-Mural departments were again called upon to help, giving courses not only about the various disciplines, but also in DIY. Dedicated amateurs actually travelled long distances and paid to attend weekend courses. I did so myself, and eventually came to run my own 'bone weekends' for the University of Bristol. And I must say how gratified I am by the subsequent work of some of those who attended.

It is a pity that some professional archaeologists have depised the amateurs and the general public. In an age troubled by accelerating change, a sentimental attachment to the past is a source of comfort, and if the archaeologist wants financial support from the taxpayer he should also seek its interest. The public is certainly becoming more interested in its present and future environment. It would not be so comforted by the past if it better appreciated the destructive effect which man has had on his surroundings. Knowledge of the past should be general knowledge for the environmentally-aware and its increase should be supported. To some extent the public is extending its interest beyond the trappings of the rich. I was delighted to hear the forthright comments of a formidable lady with a strong northern accent at Knossos: 'Never mind about dining room. Where's bloody kitchen?'. Needless to say, the guide could not answer.

The Civil Service eventually gave way to the archaeologists' demand for environmental data, and the Ancient Monuments Laboratory was established. Unfortunately, it was conceived as an industrial type of laboratory, staffed by technicians carrying out prescribed tests to order for the Ancient Monuments Inspectorate, and part of the then Department of the Environment. The environmental divisions of the Institutes of Archaeological Research set up in Holland and Scandinavia would have been a more fortunate model. However, the establishment of regional AML outposts associated with universities greatly improved the situation, and recent changes amongst the upper echelons of the staff may indicate that the word *research* is less of an anathema in the future.

Archaeology tends to study the remains of top people, be they rulers or priests, or both. Their magnificent grave-goods and fine dwellings are comparatively easy to locate and excavate. They are obvious raw material for the tourist/heritage trade, and are thus potential income-generators. In contrast to this, the slave leaves little but his or her chains, whilst the anonymous peasant (who still bears much of the world on his shoulders) and the hitherto-despised savage hunter-gatherer leave nothing but an altered environment. One of the few positive contributions of the Marxist school of history has been to develop an interest in these underlings, though proponents have done little about it in their home territories. However, this climate of opinion, together with the revelation of the antiquity of the indigenous inhabitants of the Americas, provided a great stimulus to environmental studies in the USA.

Here they caught the interest of the late Eric Higgs, whose major achievement was to transmit his enthusiasm to the University of Cambridge, the British Academy, and thence to a large part of the archaeological fraternity. Higgs' former students have done magnificent work, particularly in Australasia. However, he himself could not be called a genuine scientist, though he espoused science like a religion, thinking that enthusiasm and repetition of jargon would allow him to add up two and two to make far more than the prescribed four in order to support preconceived conclusions. Unfortunately some of his former students still impart this ethic to their students. There is still a tendency to extract revolutionary new ideas from limited and dubious new data, supported by a partial (in both senses of the word) reading of the literature, denigrating received wisdom as the product of outmoded fuddy-duddies. These would-be scientists gain much support from their computer programmes, obediently printing out results to the third decimal place with spurious accuracy.

But how is the would-be environmentalist to get a proper training? An excellent starting point is of course to have a degree in the parent science, the diversity of which is indicated by the qualifications of the Institute of Archaeology's staff. These scientists can take the Institute's MSc course, but this is possible only for a few, and the expense is considerable. Also, not all the relevant disciplines have a relevant parent science, in particular archaeozoology. The most relevant discipline is veterinary anatomy, not separable from a full veterinary course, or perhaps a degree in animal husbandry. The archaeozoologists of Eastern Europe work in agricultural colleges or universities, a very remote possibility in this country. There is a distinct tendency, in my opinion, for archaeozoology to win Cinderella's wooden spoon in this, as in several other respects.

What of the naive undergraduate, not even armed with science 'A'-levels, or whatever it is they have to take nowadays? Most university archaeology departments have at least one resident environmental archaeologist who may be an outstanding scholar in his or her own branch of the subject. Compare this to a department of music, where the principal subjects are music *per se* and music history, but where the student would be expected to be a competent performing musician. A would-be clarinettist would not accept that the only available teacher happened to be a violinist, and that student would probably have passed the 8th Grade in music exams before entering the university. It may be argued that this makes the comparison invalid, and that any environmental scientist can teach the rudiments of all the sciences, but it means that the student who wishes to specialise in an environmental subject which is not the specialism of the techer is out on his or her own, and the skills used even in an honours dissertation will have to be self-taught.

Given the size of most archaeology departments, which is about what it should be in such an individualistic 'hands-on' subject, the situation outlined above is inevitable. My remedy is again suggested by the musical world; to use peripatetic teachers. These teachers could be recruited part-time from amongst the AML's misnamed and underpaid technicians. In the form of an intensive teach-in, this could be a stimulating and profitable experience for both parties. Research students expect and get help from staff of other universities. Some of them, indeed, seem to think that their right to other peoples' time and expertise is such that they need not even bother to acknowledge replies to their letters, particularly if these point out the impossibility of an ill-advised project.

Nevertheless, environmental archaeology is out of place in a humanities-oriented department, a Cinderella whose funds are administered by an unsypathetic Baron Hardup. This analogy casts non-environmental archaeologists in the role of the Ugly Sisters, an allegation that contains some truth, though less so than in the past. However, there is still a dislike of this poorly-understood subject, extending its tentacles into more and more artistically-conceived typologies. Professor Ian Simmons has compared this to the opinion of the general public about vaccination: 'they accept it as a necessary evil but they have no wish to know what is in the syringe'. There are, of course, real converts who do not just pay lip-service to the specialists. As long ago as the seminar held by the publishers Duckworth to launch Ucko and Dimbleby's seminal volume *The domestication and exploitation of plants and animals*, David Allchin stated, apparently without rancour, that he could imagine himself excavating under the direction of a number of persons in white coats. More recently, Bill Britnell (Director of the Clwyd–Powys Archaeological Trust) has said that he would be quite happy to attend a course giving instruction in the type and quantity of samples which should be collected for environmental studies.

Funds are, in theory, available for environmental research, and are so ear-marked by the Science and Engineering Research Council. I have vetted a number of applications for such grants. The norm seems to be for some £30–45,000, to be paid over three years, supporting a research student and a technician and usually allowing for the purchase of an expensive machine and its consumables. This must, of course, be housed in an established department and be backed by a senior academic. The latter are in short supply in the relatively young discipline of environmental archaeology, and such a project would have to be 'sold' to the professor of either an archaeology department or of the parent science involved. Were I to embark on such an application, I would expect it to take about six months, allowing for other activities. Expert secretarial assistance would be a great help and there would be a considerable bill for telephone and postal charges. A successful trial-run might well be required for a really new technique. This is out of the question as far as I am concerned, as it is for the majority of environmental archaeologists as they slave away at their never-ending site reports. This situation was pointed out by the Hart Committee, which was good on diagnosis, but largely silent on therapy.

To achieve such a grant would indeed be like Cinderella to the ball and getting her man (after all, she used decent environmental materials such as mice and pumpkins). And when it was all over, would she be back in her kitchen? It was suggested at one AGM (I think) that the AEA should now have sufficient standing to be allowed to administer a SERC grant but, within the normal limitations of a 24-hour day, who is there to organise it? No doubt we shall muddle on much as we are, stretching the *ad hoc* shoestring (and mixing our metaphors) to unbelievable lengths.

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A bibliography for the archaeobotanical identification of seeds from Europe and the Near East

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Summary

Over 350 references on seed and fruit identification, likely to be of use in the identification of ancient charred and waterlogged seeds, are listed.

Introduction

This list is limited to references likely to be of use to the archaeobotanist studying charred or waterlogged macroscopic plant remains. Where the contents of a paper are not obvious from the title, brief annotations have been made. Two classes of literature not included are taxonomic monographs and studies of crop evolution. Taxonomic literature can be found using indexes available in good botanical libraries, and is also conveniently listed by Davis (1965–88). Literature on crop evolution and archaeobotany in general is indexed each year by J. Schultze-Motel, in the journal *Die Kulturpflanze*.

We have not listed references on the vegetative materials included in Delcourt, Davis and Bright's (1979) bibliography: phytoliths, conifer needles, wood and charcoal, and vegetative plant fragments. However a comprehensive bibliography on phytoliths is in preparation by Irwin Rovner of North Carolina University; one on wood has been published by Gregory (1980). However, her bibliography does not include references specifically on charcoal identification.

General reports on ancient plant remains that have especially useful drawings or discussions of identification criteria are included in a separate section. The publications of W. van Zeist are particularly outstanding examples of well illustrated reports, of value to all archaeobotanists. We would stress that although this list of literature may look quite long, the number of really adequate studies on seed identification is still tiny, and much useful work remains to be done. The need now is less for comprehensive seed manuals; more for detailed studies at the level of genus or tribe.

The authors would be glad to hear of additions or corrections to this bibliography; these should be sent to James Greig.

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Symbols and abbreviations

* indicates references of outstanding usefulness; copies of these should be to hand in all archaeobotanical laboratories

+ indicates references that we have not been able to check and these may sometimes be incomplete

USDA United States Department of Agriculture

Journals/Series:

BAR *British Archaeological Reports* (Oxford)
MB *Monographiae Botanicae* (Warsaw)
PISTA *Proceedings of the International Seed Testing Association*
SST *Seed Science and Technology*

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Flesh on the bones

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Summary

The first part of this paper comprises a summary of the nutritional and reproductive physiology of the domestic ruminants, in particular its seasonal aspects. Using data derived from primitive, 'third world' livestock and archaeological literature livestock productivity and husbandry of former times are suggested, including work capacity and manure production, comprising the second part.

"In my end is my beginning" (T. S. Eliot)

Archaeozoological studies normally begin at the death of an animal. However, maintaining it alive was of considerable interest to its owners or keepers, and it is therefore relevant to investigate the husbandry of livestock of the past using not only such literary and archaeological evidence as is available, but also drawing analogies with the performance and husbandry of the primitive and often poorly maintained livestock of the present day. This evidence is decidedly patchy, particularly the literary sources. A number of writings from the classical periods have survived, but these were not often written for persons who were likely actually to handle the stock. The most reliable information comes from the medieval monasteries, where economic returns were a definite consideration.

The animals to be investigated are the major food producing domesticates of the temperate world: cattle, sheep, goat and pig. All are artiodactyls, and the first three are ruminants. Ruminants are herbivores, as are pigs to a large extent. All vertebrates lack enzymes for digesting cellulose, but various evolutionary strategies have been acquired to obtain the products of cellulose by other methods, mainly based on the possession of a diverticulum in the form of a caecum derived from the hind gut. The ruminants also possess a more sophisticated set of diverticula derived from the stomach. Both form a habitat for a complex flora comprising bacteria and protozoans which do possess cellulases and other enzymes, capable of making proteins that can be utilised by the host, out of nitrogenous compounds not otherwise available in plants. The ruminant has an advantage over the monogastric herbivores in that both excess rumen flora and its products pass through the whole of the digestive and absorptive gut, whereas caecal products only pass through a short part of the hind gut. Although cellulose is a polymer of glucose, the rumen flora does not break it down into this carbohydrate; the products are the so-called short chain fatty acids—acetic, propionic and butyric—and it is upon these that the normal energy metabolism, other than that of the nervous system, depends. Brain, foetus and lactating mammary gland do require glucose, but this can be made from propionic acid by reversing the normal direction of the tricarboxylic acid (Krebs) cycle. An outline of the physiology and biochemistry of the rumen and its flora are given in Blaxter (1962) and Moir (1968).

The botanical production of cellulose is highly seasonal in most parts of the world other than the equatorial regions. Grass does not grow below 8°C. and only deep-rooted vegetation is productive during the dry season of the savannah areas of the earth's surface. In an upland area of Scotland, for example, of the 42 tonnes of dry matter per hectare produced in a particular season (there can be as much as a fivefold variation between different years) 85% was produced in the six weeks of maximum day length and there were seven months without any growth at all (Frame *et al.* 1985). Similar data for an area of lowland unimproved pasture are supplied by Eadie (1970). It is therefore necessary for the grazing animal in these areas to be highly seasonal also, although the pig can supplement its diet by starchy woodland products (Henry and Conley 1972).

The ruminants of the far North, particularly in the American continents where there is such an extensive area of High Arctic tundra, are indeed seasonal animals. The muskox *Ovibos moschatus* withstands the winter *in situ* by entering a form of hibernation on its feet. Eating practically ceases and the metabolic rate drops; the pregnant female may lose 40% of her body weight, despite which she can deliver a live calf, though she may not rear it in an adverse season (Hilbert 1977). Caribou *Rangifer tarantus* migrate long distances away from the extreme north but during the return journey they eat very little and, incredibly, the metabolic rate again drops (Kelsall 1968). White-tailed deer *Odocoileus virginiana* in the USA exhibit 'yarding behaviour' during the winter, gathering in a sheltered area of woodland and eating very little, but this behaviour is less obvious in the deer of more temperate areas (Hickersen 1968; Chapman and Chapman 1975). Feral Soay sheep in the Western Isles of Scotland do not obtain adequate nutrition for body maintenance during the months January to April (Gwynne and Morton Boyd 1970). The exceedingly hardy Herdwick sheep of the English Lake District are reported to have survived over 30 days buried by snow on more than one occasion (Youatt 1837).

The main food reserve permitting these activities is fat, not only the obvious subcutaneous intramuscular and perirenal fat (and the tail fat of some African and Near Eastern sheep breeds) but also that of the bone marrow. This latter has been shown to be a reliable indicator of body condition in many ruminants (Sinclair and Duncan 1972; Brooks *et al.* 1977). It is withdrawn from the medullary cavities of the proximal limb bones before the distal ones and thus animals with depleted metapodial marrow have reached the end of their fat reserves. This is to be expected in the migrating caribou, and the results have been graphically described by Binford (1978) and Spiess (1979). Muscle fat is so depleted that the flesh of American bison killed in late winter will not support human life for more than a few weeks (Dary 1974). The muscle itself is metabolised by the animal, leaving its supporting connective tissue framework (Yeates 1964).

The same sequence of events can be demonstrated in the animals of the African savannah during an exceptionally prolonged dry season, for example in the African buffalo *Syncerus kaffir* (Sinclair 1977). It would therefore appear to be normal for the ruminant to live at the extreme limit of its resources, and reasonable to suppose the domesticate can tolerate a similar dearth, as has been mentioned above. Controlled experiments actually estimating marrow fat have not been carried out. Mitral and Ghosh (1980) carrying out trials on two Indian breeds of sheep in an apparently normal season found that a ewe's body weight varied by 17% in different seasons, whilst that of another breed varied by no less than 30% Gunn (1965) and Russell *et al.* (1968) specifically mention bone weight-loss in Scottish mountain sheep.

Even when food supplies are adequate, the ruminant suffers a seasonal loss of weight, as reported in deer (Hoffman and Robinson 1966), red deer, and the primitive Soay sheep (Kay 1985 and P. J. Reynolds pers. comm.) and amongst range cattle in Missouri considered to be on a high plane of nutrition (Moulton *et al.* 1921). The majority of these animals were pregnant females. This effect is less marked in modern stock (Kay 1985) and this is one of the major factors distinguishing such early maturing stock from its predecessors (Ledger *et al.* 1970). However, even modern stock retain the capacity to maintain the foetus at the expense of their own body tissues. In a recent beef cow trial (ADAS 1981) it was found that this 20% weight-loss had little effect on the calf or its mother's milk supply provided the postnatal diet was adequate.

Apart from the exceptional animals of the High Arctic, more seasonal malnutrition does seem to affect the foetus, and new-born animals of below-average birthweight frequently do not survive. The viability of hill sheep is strongly influenced by birthweight (Russell and Young 1959; Ragab *et al.* 1954), as in the pig (Winters *et al.* 1947), and the African buffalo cow usually rejects her calf altogether if it weighs much less than half the normal (Sinclair 1977). Malnutrition in early pregnancy is another matter. In the sheep, a sudden environmental or nutritional setback may cause resorption of a single foetus, or selectively one out of a multiple pregnancy (Gunn *et al.* 1972). Abortion was common amongst sheep suffering from two years of 'hyponutrition' (Mahia 1983). Shepherds from earliest times have been well aware that the conception rate of lambs was much improved if the ewes were on a rising plane of nutrition when the rams were introduced (Ryder 1983), and the converse is also true. Even at the present day, the commonest cause of failure to conceive in beef cattle is malnutrition (Lowman 1985) and some animals may fail to come into oestrus altogether, or even to reach puberty at the normal age (Wiltbank 1965). Puberty is normally attained at about 80% of adult body weight (Wiltbank *et al.* 1965). On the other hand Sahari and Salini (1976) found that Indian ewes maintained their oestrus cycle despite an 8% loss in body weight in the course of a month.

The part of the reproductive cycle most vulnerable to malnutrition, however, is milk production. The modern dairy cow, bred to produce sufficient milk to rear some ten calves during a prolonged lactation, will 'milk off her back' if necessary, but the results may be profound metabolic disorders and failure of the oestrus cycle (Krebs 1966). It has been demonstrated time and again that the adult size of an animal, and the economic performance of which it is capable, depend upon the first year of life, of which the suckling period is a very important part, and the mother's lactation is very dependent upon her nutritional status (see, for example, Suttie *et al.* 1983; Suttie and Hamilton 1983 (red deer); Lawler and Hopkins 1981 (sheep); Sachdeva *et al.* 1973 (goats); and King and Dunkin 1986 (pig)). About 40% of piglets failed to survive following a 14% drop in food supply (Anon 1984).

Since a successful lactation is dependant on an adequate food supply, the artiodactyl of seasonal areas must be a seasonal breeder. Away from the equator, changing day length stimulates the endocrine system to induce oestrus cycles in the female (Lincoln and Short 1980). Seasonal breeding in the male artiodactyl has been less thoroughly investigated, but it certainly occurs in deer, in some antelopes, and in Soay sheep (Short and Mann 1966).

Whether it is increasing or decreasing day length that provides the effective stimulus depends upon the length of gestation; thus the bovine nine-month period requires a spring oestrus, whereas the five-month sheep is an autumn breeder. Goats are particularly sensitive to day length change and consequently tend to give birth in midwinter in the far north, so that they are not likely to have been amongst the earliest domesticates in these areas (Mackenzie 1971).

In the absence of major seasonal day length changes, increasing nutrition is likely to be an important stimulus to the pituitary gland. However some African sheep breeds appear to be entirely non-seasonal (Sefidbackht *et al.* 1978). Modern domestic animals accustomed to a high plane of nutrition have become non-seasonal breeders in some cases—particularly cattle. Pigs also have become non-seasonal and hence capable of producing two litters in a year. Columella (trans. Forster and Hefner 1968) indicates that Roman pigs could do this, but it was not so in Early Christian Ireland (F. McCormick pers. comm.). However, fertility varies at different times of year (Maughet 1982). Sheep in temperate latitudes remain seasonal breeders. Lactations have also become longer, particularly in the goat, but this is a fairly recent phenomenon (Low 1848).

The seasonal appetite variation has not been fully explained; it is not geared to day length by the same endocrine mechanisms as the reproductive cycle (Kay 1987). Two factors have been identified, however. Forage with a nitrogen level of less than 4% is not usable by the rumen flora and is rarely consumed. The animal seems aware of the law of diminishing returns, and will not bite at material which gives fewer then about one mouthful for twelve bites unless very palatable material such as spring pasture is involved (Hodgson 1975; Stobbs 1973).

The wild ruminants rarely produce more than one offspring at a time, although the wild pig may produce a litter of five or six (Maughet 1982). Twins in cattle are quite exceptional even in the domesticated form, and recent research designed to promote them met with little success (Hammond *et al.* 1972). Goats on the other hand are frequently more prolific and twins are found regularly amongst wild species (Schaller 1977). Present day domestic goats have a kidding percentage (offspring per 100 females) of 150 to 180. However, perinatal mortality is said to reach 20% in 'the more primitive breeds' (Doney *et al.* 1982).

The prolificacy of sheep is intermediate, compared with the above. Twins are rare in the American bighorn *Ovis canadensis*, with the exception of a Californian population in which they reached 40% The subspecies of *Ovis aries*—mouflon and urial —bear twins from time to time, but the argali can be very prolific; one population was found with some 33% of twin pregnancy and one case of triplets (Geist 1971). A captive argali produced a number of multiple births but it was very inbred and none of the lambs was viable (Lambden 1966). Non-seasonal breeding sheep such as the Barbados blackbelly may be exceedingly prolific, lambing more than once a year (Mason 1980). Noteworthy instances of fecundity amongst British sheep include a Swaledale cross which produced 23 lambs in six years (Stobbs 1984) and two Jacob ewes producing 20 in eight years and 25 in nine years, all of which were reared (Anon 1984).

However, particularly when nutrition is poor, it can be a major problem whether some domestic artiodactyls conceive at all, and where breeding is seasonal a whole year's production is lost. The majority of American bison cows calve in alternate years though there are records of captive females breeding annually and one exceptional beast calving almost every year for nearly 40 years (Dary 1974). Schaller (1977) presents information on the smaller ruminants of the Himalayan region, which must include the action of predators. In one particular year, 72% of wild goat females were observed pregnant, but later only 35% were observed with live young. For urial sheep the equivalent figures were 91% and 33%

Amongst domestic cattle of the 'third world', calving rate for the Nelora breed of Brazil was 50% and for a particular region in Colombia the calving rate was 67%, and 60% were weaned (Monterio *et al.* 1981; Miles and McDowell 1983). In Zimbabwe calving rate was 50% for cows in poor condition, and 90% in well fed beasts (Richardson *et al.* 1975). The nadir of breeding success probably belongs to the free-ranging cows of Hindu India which may only breed once in about six years (Harris 1965) so poor is their nutritional status. For sheep, an average lambing rate in the Middle East has been estimated to be 70% (Foote 1977).

The perinatal period is the most dangerous in the life of the artiodactyl, wild or domestic. Lamb losses amongst nomadic flocks may reach 60% (Sternafeldin 1982), and they may be up to 30% amongst some Indian sheep (Ragab *et al.* 1954), 26% amongst British hill sheep (Owen 1981), 16-34% (averaging 22%) in American range sheep (Hoversland *et al.* 1957), and 13% in British Upland sheep (Speedy 1981). These data suggest an 'archaeological yield' of weaned lambs would be about 65% of ewes, but where disease strikes this can be much less; Lloyd (1978) reports a case from 14th century monastic records of only about 10% of lambs being reared in one year.

Losses amongst young pigs can be very high. As late as 1943, 25% losses 'were to be expected' (Winter *et al.* 1947).

Processes of growth in artiodactyls have been the subject of much research and are well understood. The basic pattern was first documented in the sheep by Hammond (1932) although American workers in state institutes had published much nutritional data before this (Trowbridge *et al* 1918; 1919). Hammond showed that, for the first few months of life, growth of the skeleton has first claim to nutritional resources. This is followed by priority for muscle growth after which fat is extensively laid down. Present day strategy is to induce the animal to grow as much as possible prior to the fat-producing stage, which is no longer desired and also takes 20% more metabolic energy to produce than protein (Fahmy and Lelonde 1975). The results of recent investigations into the growth of wild ruminants were considerably better than anticipated. Blaxter *et al.* (1974) found that red deer grew as fast as modern meat-producing domesticates, and Klein (1970) described growth in the caribou as phenomenal. Ledger and Smith (1964) found that the Uganda kob (antelope) took two years to reach mature body weight, which typically included only 6% fat.

A characteristic of artiodactyl growth, geared to the seasonal nature of their food supplies, is that of compensatory growth (referred to as catch-up growth in man). Provided that growth rate has not been restricted to less than 20% of normal (Steen 1986) compensation may take place, though it may take more than one year (Moulton and Trowbridge 1921). Slow-maturing cattle were the subjects of both these experiments. Domestic buffalo are capable of greater compensatory growth than cattle (Moran 1986) as are sheep and goat (Thornton *et al* 1979; Jackson *et al* 1986). During the initial stages of realimentation, the sheep's ability to use the ingested food rises above normal levels, so that the compensating animal may outgrow its continuously-fed companion (Barley and Bishop 1973).

The differences in growth patterns between wild and domestic artiodactyls shed some light on the process of domestication and subsequent husbandry. There has been considerable speculation as to the causes and nature of domestication. The most plausible is the gradual assumption of a control over a particular herd by a particular group of people, first as a hunting relationship (and keeping the animals away from plant material either cultivated or desired by man) and later by the manipulation of individual animals. This view is supported by Baskin (1974) on behavioural grounds. Archaeological evidence for domestication is scanty, but it is generally agreed that a preponderance of the bones of young males in food remains indicates sufficient control over the animal. Corrals do not seem to have either been looked for or found in that area of the Zagros Mountains where early domestication is believed to have taken place. In any case, such structures might be used purely for hunting as they have in North America (Frison 1973) or they could have been constructed of organic materials which have since decayed.

Animal herds forced to live in close proximity to man would have suffered in two ways. Firstly, they were not allowed to graze where they wished, or for as long as they required (eight to ten hours daily for the cape buffalo (Sinclair 1977)). Secondly, they were under stress in other respects. Such stress has been shown to cause abortion or prolonged gestation in some circumstances (Müller and Horsten 1981). Since the gestation periods of wild and tame species are in fact much the same, this effect on pregnancy may have had other results. It has been suggested that domestic animals retain juvenile characteristics, but this is certainly not true in the case of modern meat animals which differ more in conformation from the juvenile form than do primitive stock (Hammond 1932). The only unequivocal evidence for domestication will be the finding of quantities of bone in an area where the wild form never occurred.

There is no doubt that domestication brought about a reduction in size of the livestock, and it would seem that slow-growing animals were being unconsciously selected by the prevailing conditions. However, the size reduction took several centuries in Central Europe (Bökönyi 1974). It seems to have been more immediate in Northern Europe; Degerbøl and Fredskild (1970) were able to distinguish the earliest domestic cattle from the aurochs. However, these in turn became even smaller. The cattle of neolithic Orkney (and also the sheep) were much larger than those of Southern Britain (Noddle 1983 and unpublished; Grigson 1965). However, the bulls illustrated in the famous picture from Mycenaean Crete show large but domesticated animals. Smaller stock might have been preferred in some circumstances. If numbers were significant, as they are in African tribal society, more small animals could be kept. They would be easier to handle, and produce meat in perhaps more manageable quantities when slaughtered. If skins were valued, three small animals, for example, will have a greater surface area than two larger ones.

However, the most likely selection factor is likely to have been survival in far from optimal conditions. Conscious selection, apart from a realisation that the desired traits are heritable (growth rate is heritable, but not strongly), requires the overall control of a herd, and a sufficient surplus to cull and select the most desirable males. It is probably this last factor that has been in abeyance for most of the history of domesticated animals. In the wild the dominant sire selects himself as fitted to the environment by surviving to breeding age and by driving off his rivals. This process is exhausting, and the male arrives at the end of the rutting season in poor condition, even to the loss of fat from the bone marrow (Brooks 1978). If the rutting season is immediately followed by the adverse season, a high proportion of breeding males will not survive to breed with their daughters (Geist 1971). In the case of domestic animals, the best males are likely to be sacrificed to greedy gods or rapacious landowners, or else castrated to become beasts of burden; in this last instance a compromise might have been reached by delaying castration of bulls to two years of age, as was sometimes the case in republican Rome or 18th century Britain (Forster and Heffner 1954; Youatt, 1870). However, in times of land shortage or economic stringency some very inadequate sires might have been utilised. Even as late as the 1930s agricultural depression, when it should have been appreciated that the male was responsible for half his offspring's genes, the British government had to institute a system of bull licensing because such poor animals were being used in dairy herds. Only in the case of ancient Egypt, when desirable animals such as the bull of Apis were venerated alive rather than being sacrificed, was ritual usage likely to have been to the advantage of the herd. Because the bull is large and quite expensive to feed, as well as being rather difficult to handle, cattle have always suffered more in this respect than the smaller livestock. In some instances, such as the New Guinea pig (Rappaport 1968) or perhaps the Saxon pig (Clutton-Brock 1976), the domestic sow has chosen her own mate from wild or feral stock.

Although the earliest domestic animals had to support themselves entirely by their own foraging activities, as they still do in most areas outside Europe and North America, the conservation of winter fodder has been an important part of animal husbandry since prehistoric times. Straw has always been available anywhere where grain has been harvested, and it is likely to have been more nutritious than straw of the present day because of the weed content. Hay is not a good subject for archaeological investigation. Greig (1984) has reviewed the available evidence, of which there is little before the Iron Age, when large scythes capable of cutting grass began to be produced (Rees 1979). Rees believes that the smaller bronze and flint sickles of previous eras were used to cut grain near the head. However, there are some species of grass which, at least when they are growing on soil which has been recently cultivated (such as fallow), can easily be plucked by hand when they are in the early stages of flowering and are still quite nutritious (personal experience). Having observed the ease with which farmers in the Orkney Islands make silage by placing fairly mature cut grass in natural clefts in the rock (Caithness sandstone) it seems possible that farmers of earlier periods might have discovered the same technique. Sansoucy (1981) cites a reference stating that silage was made by both ancient Egyptians and Carthaginians. Preserved hay from the Roman period has been found in both Britain (Murphy 1985) and Germany (Knörzer 1979) and coprolites from the British site, in which hay and barley were mixed, indicate that it was fed to cattle. However, no attempt was made to conserve hay in Early Christian Ireland (McCormick 1983). Fenton (1976) reports that in the Western Islands of Scotland remarkably little effort was made to conserve hay, but that both seaweed and fish waste were fed to stock.

Another source of fodder is tree foliage, which also requires conservation in the case of deciduous species. The use of elm branches in the Scandinavian neolithic was first described by Troels-Smith (1960). For a long time the characteristic drop in elm pollen at this period was attributed to this practice, but the present epidemic of 'Dutch' elm disease suggests an alternative explanation. Birch is also used for this purpose in Northern Norway and there is evidence that this was employed by the first neolithic farmers in the area (Vorren 1979). Birch foliage also proved palatable to modern British beef cattle in the 1976 drought (reported in the farming press). Quantities of ivy pollen have been found on several occasions suggesting that they were the result of stacking cut material for fodder; besides domestic stock in the neolithic period, wild herbivores seem also to have been supported in the mesolithic era (Simmons and Dimbleby 1974).

Working animals require food of higher energy content than all but the best spring grazing, and normally receive it in the form of grain. The amount needed in those areas of the tropics where grazing is scarce is considerable. Clark and Haswell (1970) give a figure of 300 kg per animal per annum. To produce this amount, the grain production per head of the community must be 500 kg per annum. A traditional feed for British plough oxen was oats fed unthreshed, oat straw having a fairly high feeding value (Lamond 1982). Working animals and pigs also have a higher protein requirement than other forms of livestock (horses need even more) and pulses were grown to meet this need. Biddick (1984) makes some deductions about the quantities involved in the medieval period, using monastic records.

As is well known, the introduction of root crops in the 18th century was considered a major breakthrough in livestock husbandry. However, root crops were not unknown in Roman Britain, and Applebaum (1975) suggested a fairly detailed scenario including their use at a villa in Southern Britain.

The energy demands of an animal may be markedly reduced by providing it with adequate shelter. Cheyne *et al.* (1974) give a detailed description of this in the case of a moribund Soay sheep. The act of grazing, particularly of rough and scanty pasture in itself demands energy (Graham 1964), perhaps 60% more than for a housed animal (Osuji 1974). The value of 'zero-grazing', that is to say the cutting and carting of fodder to housed stock, is well known to a number of husbandmen from classical authors to Indian peasants. This practice reduces energy demands and increases fodder utilisation; none is wasted by trampling and the animal is induced to eat material which it would reject if it had more choice. Dung can also be collected.

Evidence for specialised animal housing (usually of cattle) is a layout of postholes at distances suitable for stalls and the provision of a drain behind the supposed standing. A detailed description of an Iron Age cattle byre in Netherlands is given by Waterbolk (1975) but he believes that such housing was employed at a much earlier date. Similar byre layouts have been described at the Shetland site of Jarlshof dating from the Viking era back to the Bronze Age (Trow-Smith 1957). However, such byres are conspicuously lacking in the circular huts of the British prehistoric period, whereas parts of the longhouses characteristic of the European continent were probably so used. This has led Bradley (1978) to suggest that the British climate did not enforce winter housing. Roman cattle sheds, though described in the literature, do not seem to have been found on the ground, at least not in Britain (Morris 1979) but Tatton-Brown (1980) believes that he has found a quantity of pig sties associated with villas in Italy. By the Middle Ages, cattle occupied part of the traditional longhouse, but in the drier East Midlands it is possible that they were wintered in the so-called crew-yards, a practice which made excellent manure (Beresford 1975).

Not all buildings associated with animals are for their shelter—some are for the herdsmen (Ramm 1970)—but a medieval sheep-dairying unit was excavated by Raistrick (1965). There is a large and growing literature on field boundaries and corrals, most of which will be discussed below in conjunction with British neolithic husbandry. There were in the Iron Age of Southern England a number of characteristically-shaped animal pens with a funnel entrance, known as 'banjo enclosures' (Coy 1978).

Sherratt (1981; 1983) introduced the concept of a 'secondary products revolution', taking place in the early Bronze Age. He suggested that domesticated animals were at first used entirely for meat and skin production, and that agriculture took place in some sort of garden situation. Later, with population expansion, cattle were used for traction and their milk was utilised. Lack of space necessitated the adoption of transhumance to utilise the seasonal herbage production of upland areas. Sheep became wool producers. This concept breaks down for a number of reasons, though Greenfield (1974) and speakers at the 1986 ICAZ Symposium found that transhumance in the Balkans did develop at the appropriate time. Sherratt's principal misconception was that ploughing dated from the time when it was first represented artistically, whereas stone ploughshares, which required animal traction for their employment, occurred in the remote Shetland Islands some thousand years before this (Rees 1979).

The consumption of meat by prehistoric people requires some consideration. Meat has never formed a major part of the human diet unless it was very easily acquired, or there was insufficient vegetable matter available. Pleistocene populations during the last glacial period were able to utilise migrating ungulates, as are the Caribou Eskimo. The American bison herds could support a small number of Plains Indians (Frison 1973). High Arctic Eskimos live largely on fish and marine mammals. Deschler (1965) calculates that the Dodos tribe of Uganda, which lives largely off its cattle, consume about 25 kg of meat per head per year, but also utilise milk and blood. In 16th century Orkney and Shetland, grain production was frequently not sufficient for subsistence and the milk and blood of cattle was relied upon, but the 'meat' eaten was fish (Fenton 1976). Halstead (1981) estimated that a nuclear family of six would require 120 sheep if it was going to be their only food supply.

The concept that domestic animals were intended only to supply meat as ordinary everyday food also requires comment. Writers of the 19th and early part of the 20th centuries, impressed by the frequent description of animal sacrifices to various divinities by both the classical authors and writers of the Old Testament suggested that animals, and cattle in particular, were domesticated to supply these sacrificial beasts, and that the consumption of their flesh was secondary and purely ritual. Hahn (1896) devoted an entire book to the subject. Anthropologists working amongst African tribes reveal that an animal is always slaughtered for a particular occasion, although everybody gets their share of the meat (Allen 1965). This does involve genuine sacrifice, as the animals have individual owners and have considerable value, being a form of walking currency used to purchase wives and settle blood feuds. The exact value of the animal depends only partly on its size or quality—colour or the shape of horns are often very important. Fukui (1986) studied the cattle of the Booi tribe of Ethiopia, which are very varied in both colour and in the pattern of that colouring upon a white ground. These patterns and colours have meteorological significance; for example, a black rain-patterned animal will be sacrificed at the time of sowing. The genetics of these various forms are appreciated and careful breeding is carried out. Amongst the Masai, a tribe may have a specialist whose task it is to know every animal in the herd and its pedigree, using behaviour as well as appearance to distinguish the animals (Galaty 1986). Ritual meat consumption persisted in the early urban civilisations: at Eauna (Uruk middle Assyrian period), for example, there is a carved text describing the proper distribution of a sacrificed sheep, including the guts and genitalia (McEwan 1983). The sequence of events during which pigs are assembled and maintained for long periods before a huge tribal feast in New Guinea are described by Rappaport (1968).

There is a strong tradition in European cultures for the use piebald and, later, white cattle. Ryder (1984), examining hair of an early form of domesticated form of cattle from Orkney, deduced that the animal had been reddish in colour and concluded this was aurochs' colour. Zeuner (1963) presented some evidence from the cave paintings of France that a piebald form of aurochs might have been illustrated, leading to the piebald cattle used in the Cretan bull games.

Some of the cattle painted or modelled in Egyptian tombs of about 2000 BC are also piebald, but there are other colours also. There is a longstanding tradition of using white cattle for sacrificial purposes, first mentioned by Aristotle (Bökönyi 1974). White cattle, usually heifers, were preferred by Roman priests. St Luke's ox, illustrated in the Ravenna mosaics, is also white, and there is a tradition that the large white Chianina breed of cattle local to that area dates from Roman times. The breed certainly has a close resemblance to many Roman representations of cattle. White cattle continue to have a ritual or magical connotation well into the Christian era. Westwood (1985), in a book entitled *Albion: a guide to legendary Britain*, mentions several stories of magic white cattle which produced vast amounts of milk in times of famine. Teams of white heifers (on occasion called freemartins) were capable of carrying out enormous and devil-defeating tasks. The use of the word freemartin is of considerable interest. In modern terminology this is a female twin to a male rendered sterile by his hormones whilst *in utero*, but there is another congenital condition, also rendering the animal sterile, that is linked to the white colour known as white heifer disease, and which is very common, for example, in the White Swedish breed. Such animals are undoubtedly sexually pure because they lack the anatomical structures to be otherwise (Adsell 1969).

A variant on the pure white animal (and which is found in the British Isles) has black or sometimes red ears, muzzle and feet—the colouring of the Chillingham wild cattle (Whitehead 1953). Such animals are mentioned in both early Welsh and Irish writings. In the Welsh example, the early medieval laws of Hywel Da, one of these animals is said to be worth ten of other colours in the payment of blood debt (Clutton-Brock 1970). In the Irish example, they are mentioned in an outrageously high bride-price (Ganz 1981). However, this colour has also occurred in the very rare Florida scrub breed of cattle (Olson 1987). (Colour may not be of any great significance on occasion; in the same paper it is mentioned that the animals are becoming more and more spotted because this is favoured by the children who select which male calves shall be kept for breeding.)

There is a considerable volume of evidence for ritual slaughter, with or without butchery, from prehistoric sites (mostly Iron Age) in the British Isles. This evidence is most forcefully presented by Grant (1984a; b), who detected a ritual element in most of the numerous pits within the hillfort at Danebury. Other Iron Age animal burials include calves at South Cadbury, Somerset (Alcock 1972) and Twywell, Northampton (Jackson 1975) and sheep and goat at Garton Slack (Noddle 1981). 'Important groups of ritual animal burials' at Stanton Harcourt were mentioned prior to a report being written (Cleere 1986). Ritual burials continued into the Roman era, for example cattle graves at Wolters, Groningen, the Netherlands (van Es 1967) and thousands of sheep and goat bones resulted from the rituals at the Roman temple at West Hill, Uley, Gloucestershire (Levitan 1978). There are also token sacrifices involving the head and feet of animals presumably killed for normal consumption, sometimes carefully arranged as if the animal was lying trussed up on its back. These were found from the Roman period at Garton Slack, Yorkshire (Noddle 1981) and Haddenham, Essex (Anon 1983–4), both of which instances involved cattle, and at Barnsley Park, Gloucestershire (Noddle 1985), where sheep were found. Even as late as the 12th century AD, foundation sacrifices were made; thus, for example, a sheep was buried at Birkenhead Priory, Cheshire (Irwin and McMillan 1969).

It is during the Roman period in Britain that a true urban meat market developed (Maltby 1984) which affected the agriculture of surrounding areas. Where the market was small it could be supplied by very young stock (possibly sickly) and adults which had served other purposes, such as breeding, traction or wool production. As it enlarged, stock was bred especially for meat production and was slaughtered at 2.5–3.5 years of age, which must have been expensive as it performed no other economic function (though the value of the hide should not be forgotten). These two circumstances occurred at the Roman towns of *Glevum* and *Corinium*, both in Gloucestershire (Noddle unpublished). The same relationship between wealth and age at slaughter has been observed on some African sites. Gifford-Gonzales and Kimenzich (1984), working on sites in Kenya, found that when the area was first occupied by pastoralists they could afford to keep their cattle to a later age than was possible later when the population pressure was higher.

Another of the changes envisaged by Sherratt in his 'secondary products revolution' was the exploitation of the stock for milk production. More protein could be obtained from livestock in this way than by slaughtering. However, the evidence obtainable from excavated bones as to whether they constitute the remains of a dairy herd are tenuous in the extreme. Bogucki (1981) identified some ceramic fragments as cheese strainers very similar to those in use today, and these came from some of the earliest neolithic sites in Poland. Such bone evidence as there was indicated a majority of mature female cattle. Legge (1981a; b), also using bone evidence, suggested that milk production was a very important function of British neolithic and early Bronze Age cattle. The site upon which Legge based his theory, Grimes Graves in Suffolk, yielded more bones from neonatal and juvenile cattle than any other category, and Legge assumed they had been killed in order to obtain the milk for human consumption. He also believed that such adult bones as were present were from female animals. This preponderance of calf bones is not unique to this site; it also occurs at two sites in neolithic Orkney (Watson 1981; Noddle 1983 and unpublished) and at one of a number of neolithic sites in Spain (Harrison 1985). However, it is very unlikely that such primitive domesticates as were present in Orkney at the time would allow their entire milk yield to be withdrawn by man. There is plenty of evidence that cattle in the Near East and ancient Egypt required the presence of a calf to 'let down' their milk, and the same was true of Early Christian Ireland (McCormick 1983). Hayman (1973a; b) demonstrated that present day zebu cattle will not only fail to ejaculate their milk in the absence of a calf, but will fail to establish and maintain a lactation and this behaviour is so tenaciously held that the modern Indian dairy industry is based upon domestic buffalo. Neither will the majority of African native cattle milk without the presence of a calf, and not all of these are zebu (Dyson-Hudson 1969). There are a number of neolithic sites in Britain where neonatal cattle do not predominate—in particular Windmill Hill (Grigson 1965)—and the phenomenon has not been found in Denmark (Rowley-Conwy 1985). Also, it has never been observed at Iron Age sites. This, together with the observation that most of the unidentified proportion of the bone assemblage from one of the Orkney sites mentioned above (Knapp of Howar (Noddle 1983)) comprised the debitage of bone working suggests that the high proportion of juvenile bone resulted from the absence of adult bone, which was removed for manufacture of items that were made of iron when it became available. There is some evidence that, in Britain, cattle became free-milking around the 12th century. The Domesday survey of Somerset lists a large number of goats (Whale 1902). By the 13th century there is little mention of them (Postan 1953) but the village of Cheddar is becoming known for cheese production (Trow-Smith 1957). In the preceding Saxon period dairy farms were so rare they often gave their name to the locality in which they occurred (Hooke 1985). Even in medieval times the calf was important and was reared, milk being obtained by the early weaning. This process was described by Walter of Henley, a 12th century farm-steward (Lamond 1932) and took place 6–8 weeks after the birth of the calf.

Before the medieval period, the principal dairy animals were sheep and goat. Of these, the goat is the more efficient milk producer, although it has a slightly higher maintenance requirement (Devendra 1975; Wahed and Owen 1986). Problems with the milk ejection reflex do not seem to have been discussed for either of these species, probably because the offspring is normally reared. Either early weaning is practised or the human milker competes with the offspring. Mills (1982) states that lambs can be removed at birth from modern dairy breeds of sheep, but Stern (1985), using a breed of sheep not normally used for milk production, thought it was advisable to allow the lamb to suckle for a week to establish a lactation. It was noticed in a recent television film (BBC 1986) that an African child was using one hand to suckle a goat whilst he held its kid nearby with the other.

Little information is available for milk yields of any species. Even at the present day this is difficult to determine when the offspring is being fed. About half a litre daily may be all that is available from an African cow that is suckling its calf (Dysen-Hudson 1969). The hardy Egyptian Barki sheep will give 40 litres in a complete lactation (Famhi and Galal 1969). In 1923, an Awassi sheep of Israel (now an important dairy breed) gave 40 litres in addition to rearing its lamb (Finci 1957).

Cattle were employed for traction quite early in their domesticated history. Sherratt's Bronze Age date, based upon the appearance of the plough in art, is surely far too late. Stone ploughshares occur in the Northern Isles rather earlier (Rees 1979) and plough marks have been found in a number of neolithic situations, preserved below burial mounds. Reynolds (1982) believes these to have been made by what he terms a 'rip plough', used when first breaking grassland. Simmons and Dimbleby (1974) believe that such areas of grassland were formed by mesolithic man clearing areas for wild species to graze where they might be killed by bow and arrow. Though the word ox, the legal definition of which is a castrated male over four years of age (Bull 1926), is usually employed for working animals, it is very likely that females were used in the past. Peter Reynolds (pers. comm.) finds that the services of two Dexter cows, the smallest modern breed available, are perfectly adequate to plough about 0.5 ha daily, which they can complete in a few hours. His first working pair bred satisfactorily every year and have recently retired at the ages of 13 and 14 years, although their working ability seemed unimpaired. They were capable of pulling a load of some 300% of their body weight, whether on wheels or on a sledge. Harijan cattle, an Indian breed specialised for traction, were capable of similar effort, but their maximum working day was only four hours (Mukherjee *et al.* 1961). Clark and Haswall (1970) confirm this and state the normal working year is only 160 days. However, Columella (trans. Forster and Hefner 1968) states that a working cow could not rear a calf on the normal Roman diet, and that she should work one year and breed the next. Harijan cattle, the Indian working breed, will not conceive during their nine-month lactation period (Dhillon *et al.* 1970).

Clark and Haswall regard traction animals as something of a luxury in many situations, owing to their consumption of grain. Given sufficient time, human labour (even with stone tools) can break grassland (Steensburg 1986). Hand-cultivation is reckoned to take 25 man-days per hectare, and this figure seems applicable to African conditions and a Scottish croft. However, when cultivation time is short, as in India, when the land is only workable after the rains that will grow the crop have commenced, plough beasts are essential and every cultivator needs his own, resulting in a population of one ox for every four persons in the Punjab. Nevertheless Clark and Haswall (*op. cit.*) remark that in some instances the manure produced by the plough beast is of greater value than its labour. Working animals are not always used to the best advantage; in fact the traditional pair can be replaced by a single animal (Gryseals *et al.* 1986) if the harness is well designed. This is frequently not the case, and some unfortunate animals may spend their whole working lives in pain (Smith 1981; Goe 1983). One wonders whether this was the case in Sumeria, where the cultivation instructions known as the farmers' almanac (Kramer 1963) place such heavy emphasis on the use of whips and goads.

Though the scratch plough can be pulled by a pair of cattle, the mould plough, capable of inverting heavy soils, requires more. Contemporary illustrations suggest that teams of four were used in the early medieval period, and six or eight later. The early medieval ox was larger than that of the later medieval period (Noddle 1975). Such teams required an almost equal number of back-up cows to breed replacements and since, with rising populations, there was difficulty in reserving enough pasture for their needs, fertility was probably low. Thirsk (1959) reports as many as 300 working cattle being maintained in a village in the later medieval period, but earlier (just prior to the Black Death) the number would have been much lower (Postan 1962).

A number of authors have described bone

changes thought to be the result of using animals for traction. Von den Driesch (1975) described a splaying of the distal metapodial epiphysis, which seems to be valid. Mateescu (1979) also described bone changes, mainly in the radius, and cited this as evidence for early use of the plough on the lower Danube. Higham *et al.* (1981) described the posterior projection of the lateral posterior 3rd phalanx from which they attempted to deduce traction by Banteng cattle in Thailand, but in British cattle this phenomenon, which is rare, seems to be the result of old age (Greenhough *et al* 1981). Mgassa *et al.* (1984) noted signs of laminitis in 50% of African plough cattle, which they attributed to overwork. Changes resulting from laminitis have been observed by the author on a number of sites, and the most common present day cause (gross overfeeding) does not seem likely to pertain to these archaeological specimens. Armour-Chelu and Clutton-Brock (1985) attribute arthritis of the limb girdles to overwork.

The final innovation that Sherratt believed to have occurred as part of his 'secondary products revolution' was the development of transhumance. Whilst this may have followed early exploitation and overpopulation of more favoured areas in the Near East and the Balkans (Greenfield 1984), this method of using seasonal herbage production seems to have occurred earlier in other parts of Europe. Bogucki (1984) believes that the earliest occupation of central Poland was seasonal, as was the case in Northern Norway (Vorren 1979), where reindeer instigate the movement of their own accord. It is not known whether *Bos primigenius* was a migratory animal, but the American bison certainly changed location with the changing seasons (Dary 1974), as do the antelopes of Africa. There are, of course, many advantages in removing livestock from the area of arable cultivation during the growing season, thus protecting the crops and allowing forage to be conserved, and it is the basis of farming in upland areas to this day. If the livestock was to spend the whole summer season away from the winter settlement, it was necessary for a number of herders to accompany them.

If predators (human as well as animal) were present in the upland area, the number of persons involved was considerable. In Southern Italy during the Roman Imperial era, the annual movement of the flock was a spectacular event, and one person was considered necessary for only 20 sheep. Once the animals had arrived at their summer grazing, half that number of herders was needed (Wiedemann 1981). In Northern England, where the Pennine grazings were exploited by the monastic flocks, one person was capable of caring for 250 animals (Raistrick 1947). Some of the labour was needed to milk the animals and store their produce in the form of cheese. The most spectacular migration of all, however, must surely have been that of the Baktari tribe of Iran where the whole tribe and their animals travelled for ten weeks for a considerable distance, fording several major rivers, for the sake of some three months of mountain grazing. Not surprisingly, the losses amongst pregnant stock going in one direction and young, barely weaned animals in the other were considerable (Ryder 1983).

Transhumance involved the construction of buildings. In the grazing areas these were mainly to house the herdsmen and their families, and their names survive. In Britain these little settlements had special names. The Scottish word *shieling* has been adopted as a generic name for such structures, and their distribution and migration routes have been described in detail for some areas (for example by Ramm 1970). In Wales such a settlement was called *hafod*, and this word has been incorporated into the names of several modern places. Raistrick (1955) excavated and described a sheep dairy in the Pennines which was used by the monastic flocks. Not only sheep were involved in this activity, however. The Pennine valley of Nidderdale and its surrounding uplands specialised in cattle production both for milk and for the breeding of calves destined for plough teams. Large cattle sheds known as 'lodges' were constructed to house the animals in winter. Sheep houses were built in Somerset to house animals grazing marshland in summer, the area being flooded in winter (Platt 1969).

A form of transhumance grew up to supply the urban meat market. Though this may well have operated during the Roman occupation of Britain, it is not well described until the medieval era and later. This was the practice of droving. Animals born as far away as the Hebridean Islands were sold as yearlings, usually to pay the rent, and spent the next three years of their lives slowly making their way towards the London meat market. An early assembly point was the southern Scottish town of Falkirk, where the animals were assembled into droves. The second summer of their lives was spent in an area such as Malham

Moor (Yorkshire Pennines), whilst the drovers obtained temporary agricultural work harvesting in the nearby Vale of York. The animals were regrouped at the end of the summer, usually shod, and continued their journey south to such places as the grazing lands of East Anglia, from which they went to the London market. The trade involved special roads not much used by other traffic, and holding areas such as the field known as Great Close in Malham (Raistrick 1947; Haldane 1973). Wales was another source of drovers' stock, and the trade was already in operation in the 14th century (Skeel 1926). The cattle favoured for the droving were small and active: records from the Kentish Weald during the 16th century mention the purchase of Welsh cattle and 'northern runts', a term which is believed to refer to the Scottish *kyloe*, a small black animal now extinct, though it contributed to the present day West Highland breed (Zell 1985; MacDonald 1811).

The last function of livestock to be considered is as providers of manure, a matter of great importance prior to the introduction of artificial fertilisers, and which influenced the methods of husbandry adopted and even the type of animal kept. The value of manure seems to have been recognised in very early times; flint and potsherds, the imperishable part of the midden, are usually found very widely scattered around a settlement, and the limit of such spread may be used to identify ancient boundaries long since vanished (E. Price pers. comm.). The famous trio of Roman authors Cato, Varro and Columella (all of whom drew heavily on the lost writings of Greek and Carthaginian authors) discuss the merits of various animal manures and their rates of application. These, according to White (1970) are some 25% less than those recommended for present day crop plants that have been bred to benefit from heavy manuring. Modern manure derived from animals fed on protein-rich concentrates, contains much higher concentrations of plant nutrients than that of earlier stock, and even so is considered adequate for only 50% of the needs of the most prolific modern plants (Eadie 1970).

Carting and spreading of manure from a yarded or housed stock is very hard work (Mate 1985) and it is much easier to pen the animal where its droppings are required. Folding, that is the construction of temporary pens in arable fields, was practised in Roman times (White 1970) and is well known in medieval Britain, particularly in the case of sheep, whose actions were described as 'the touch of the golden hoof'. Tenancy agreements stipulated that peasants' sheep should be folded on the lord's land at certain times of year, and were the subject of bitter dispute (Yates 1984). The animals spent their days grazing the waste, uncultivated land usually lying between settlements, and brought their load of valuable manure back with them to be deposited overnight. As the population grew, sheep had to walk further and further and the active long-legged Norfolk Horn breed is believed to have been developed for this purpose, although its flesh was also highly regarded. Eventually, in the late 13th century, pressure on land was such that only four sheep were available for each hectare of arable land (Postan 1963). The resulting poor crop yields and malnutrition paved the way for the devastating pandemic of bubonic plague.

Lewthwaite (1981) quotes a figure for the annual production of manure by a sheep as 500 kg (breed and weight of sheep, moisture content of manure not given).

The beneficial effects of overnight folding were well known outside Europe. Migrant cattle herders of North India were invited, even paid, to allow their animals to provide this service (Allchin 1963). However, deposits of what was believed to be cattle dung dating from a very early period suggests that overnight penning, probably to protect the stock from predators, preceded an appreciation of the benefits of manure. At a later date the manure was more likely to have been used as fuel, as it is today where firewood is lacking. This is another important function of the so-called sacred cow of India (Harris 1965). In parts of Africa, manure is only used for fuel, and Voigt and Plug (1984) report that there was no tradition of using it as a fertiliser amongst the native peoples of Southern Africa. Also, in the Northern Isles of Scotland, valuable fertiliser was burnt in the absence of other forms of fuel (Fenton 1976). However, in Nepal the value of yak manure is well appreciated, but it takes four times the area of yak grazing to arable field to produce sufficient (BBC 1986).

One last property of animal excreta, in this case urine, has been used by archaeologists. This is the quantity of phosphate left in the ground (not to be confused with that left by decaying bone) (Craddock *et al*. 1985). Fleming (1979) has used this information as strong evidence in favour of his theory that some very early walls enclosing vast areas on the open land of Dartmoor were used in some form of animal ranching. The same phenomenon has come to light in other areas, for example the fens of East Anglia (Pryor 1976) and the whole subject has been discussed by Bradley (1978). But animal husbandry in the British neolithic was by no means confined to these ranching activities. Sufficient land clearance and ploughing took place to destabilise the soil in such areas as the Severn catchment area with massive erosion (Shotton 1978).

The subject of wool production has been omitted from this essay, as it has been very fully covered in Ryder's (1983) encyclopaedic monograph.

Economic strategy is a term that has been much used by archaeologists in recent years, but is not applicable to the early livestock husbandman; his 'stratagems' were probably the problem of obtaining enough food to eat until next harvest and placating the malign 'powers that be', whether human or divine. The modern farmer may be aware that the cost of producing a tonne of grass may be about 3% of the value of a milking cow. The Bedouin shepherd is sublimely unaware that the five-year-old barren ewe that he has just chosen to slaughter has a food conversion ratio of some 325% compared with that of a yearling lamb (Maxwell 1986; Foote 1977).

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