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Circaea

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Front cover: Based on illustrations of ostracods from key by Griffiths, Rouse and Evans (see pp. 53-62)

Processing freshwater ostracods from archaeological deposits, with a key to the valves of the major British genera

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Summary

Techniques for the extraction, preservation and examination of freshwater ostracods from Holocene deposits are reviewed, and a key to the valves of British Holocene and modern genera provided.

Introduction

Ostracods are a diverse group of small, bivalved crustaceans, which occur in almost all aquatic environments, including both permanent and ephemeral lentic and lotic waters. The animals themselves are essentially shrimp-like, but with a bivalved, calcareous shell (carapace). Many species occur in fresh waters, almost 100 of which are known from modern Britain and British Pleistocene and Holocene deposits (Griffiths and Evans, in press).

The analysis of ostracod valves from ancient freshwater sediments has become increasingly important in palaeolimnology and other branches of palaeoecology. Ostracod valves preserve well in a wide variety of depositional environments, and may also occur in very large numbers. As a result, small sediment samples may yield a useful range of species and their various ontogenic stages. These assemblages can provide quite specific information on the nature of the environment from which they derive.

Although many archaeozoologists are aware of freshwater ostracods, very few attempts have been made to apply ostracod analysis within environmental archaeology. There are a few published accounts of ostracods recovered from archaeological sites; however, formal ostracod analyses are unusual—notable exceptions being the work of Robinson (1986) and Bradbury *et al.* (1990). Despite this,

ostracods are recognized as valuable indicators of palaeohydrology, palaeoclimate, and other parameters (see De Deckker and Forester 1988; Carbonel *et al.* 1988; Delorme 1989).

This article gives some details of methods whereby ostracod valves can be extracted from archaeological sediments, and information on the handling and storage of specimens. An identification key to the genera of British Holocene freshwater taxa is provided.

Methods

1. Sources of material

Ostracods may be expected to occur in almost any non-acidic, water-lain deposit. As ostracod shells are calcareous, optimal preservation occurs in calcareous deposits such as tufas and marls, but they also occur in other fine sediments. Preservation is poor in peats and other acidic, humic sediments, from which subfossil ostracods may be entirely absent (Kempf 1971).

In river valleys and other non-lacustrine environments, ostracod valves are usually collected during bulk sediment sampling (e.g. monolith sampling) from sections exposed during excavation, perhaps primarily for Mollusca, thin section studies or other types of sedimentological analysis. In other environ-

ments, and particularly in the case of lake deposits, sampling usually involves taking sediment cores with a Russian or Piston corer, or similar devices.

Once obtained, ostracod-bearing sediments should be wrapped carefully, protected from desiccation, and labelled. Cores can be protected by extrusion into plastic piping, and then wrapped in cling-film and silver foil. Sediments should be stored until required, deep-freezing being the best method.

Small numbers of ostracods may also be collected during the routine sieving of sediments for molluscs, vertebrate remains, etc. In this case, many smaller species may be lost unless a proportion of each sample is sieved through the finer mesh sizes. Ostracods thus extracted should be mounted directly onto micropalaeontological slides and stored dry, or (less desirably) preserved dry in labelled specimen tubes. Ostracod shells must never be stored in formalin which, unless buffered, causes dissolution of the calcareous shell matrix.

2. Sampling resolution and sample size

Sampling resolution may be dictated by a number of factors, including both the nature of the sediments under examination, and the

time and resources available for specimen processing and identification. The range of other taxa being investigated during palaeoenvironmental analysis may also constrain sampling strategy and sample size. The number of ostracod valves within a given amount of sediment may vary by several orders of magnitude; lacustrine calcareous muds and tufas may include hundreds of valves per gram of sediment, but in some deposits valve densities may be less than 1 valve per gram. Where ostracod densities are high, it is usually possible to sample distinct horizons of a sediment sequence at regular intervals. This sampling is usually based on depth-related lithostratigraphic intervals, and undertaken in a consistent manner in regularly spaced horizons (for example, with sampling at 1 cm intervals, by examining one in every five samples, or taking alternate 5 cm sections). Sampling across lithostratigraphic boundaries should be avoided wherever possible. As resources permit, an entire sequence may be sampled, or just key horizons at strategic points within a sequence.

Equitability of samples may be achieved either volumetrically (x cm^3 of sediment/sample) or by weight (x grams of sediment/sample). Where weights are used, they should be based on the weight of the sample following air- or oven-drying to constant weight. Processing samples by standard weight is preferred
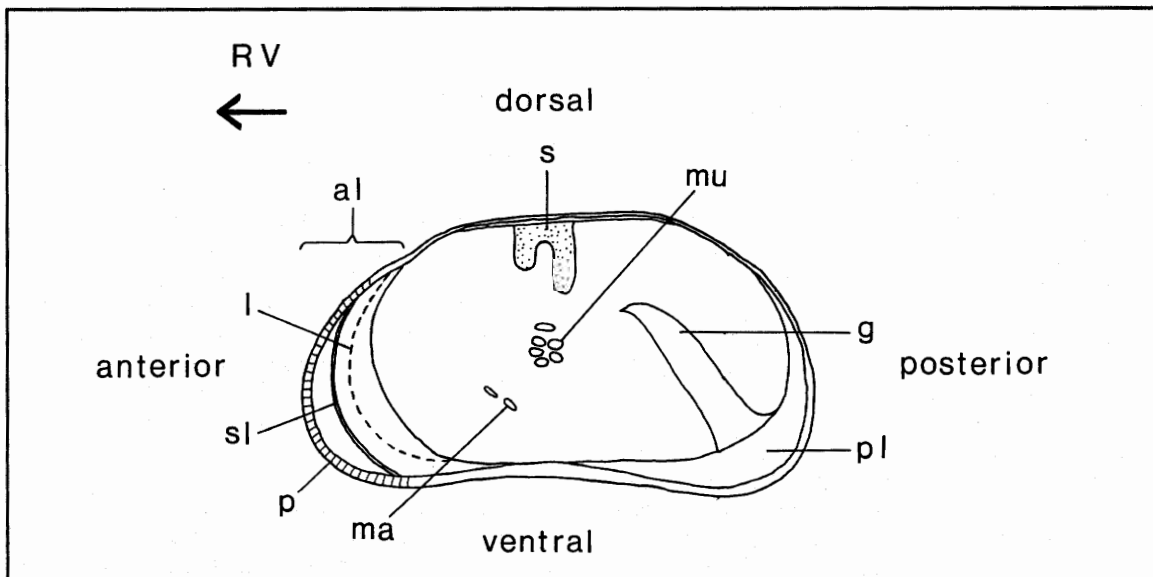

Figure 24. Inner view of the right valve (RV) of a composite freshwater ostracod, showing diagnostic characters used in the key: al = anterior inner lamella; g = genital impression; l = list; ma = mandibular scars; mu = muscle scars; p = pore; pl = posterior inner lamella; s = sulci; sl = selvage.
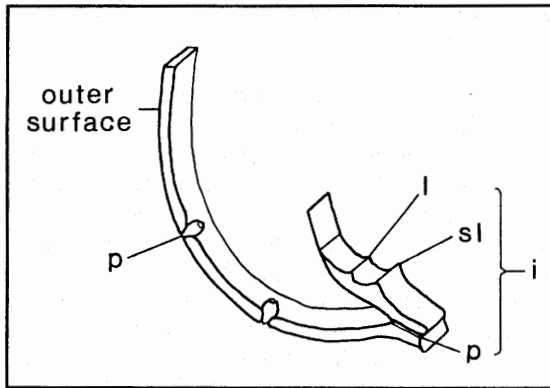
Figure 25. Cross-section through the antero-ventral margin of an ostracod valve: i = inner lamella; l = list; sl = selvage; p = pores (based on Van Morkhoven 1962).

where ostracod extraction is coupled with sampling for Mollusca. Twenty grams of sediment is usually sufficient from most calcareous depositional environments, although a certain amount of trial and error is often required to determine sample size. Lake marls, in which ostracod numbers may be very high, may require the adoption of a sub-sampling regime. Although rather different sampling strategies are possible from one sequence to another, within-sequence consistency is important.

3. Processing

Techniques for the extraction of ostracods are essentially similar to those used in the extraction of terrestrial Mollusca (Evans 1972). Most sediments require disaggregation in dilute (approximately 5% v/v) hydrogen peroxide. Digested residues should be washed through a 125 μm sieve and then oven-dried. This process may need to be repeated several times, particularly when the sample contains large amounts of organic matter. Should valves prove difficult to remove from such sediments, extraction under water, or even under dilute alcohol, may be required. Dry extractions are best undertaken in a small sorting tray coated with blackboard paint (which increases contrast and reduces static). Wet extractions are best undertaken in square `Petri' dishes. Where sediments are compacted, the reaction rate of the digestion can be increased by applying heat at the start of the digestion process, or by either increasing the concentration of the peroxide solution or the number of digestions. In such circumstances, care must be taken to avoid damaging the valves, and repeated checking is required. Other methods are used occasionally; some workers repeatedly freeze and thaw samples until the sediments disaggregate, or utilise flotation techniques (e.g. De Deckker 1979). We have found the performance of flotation techniques to be both unreliable and unpredictable.

Valves rarely require additional cleaning, although sometimes this may be necessary to allow the examination of the muscle scars (Figs. 24, 26). Cleaning should be undertaken with extreme caution and many agents, e.g. laboratory detergents, may cause valves to
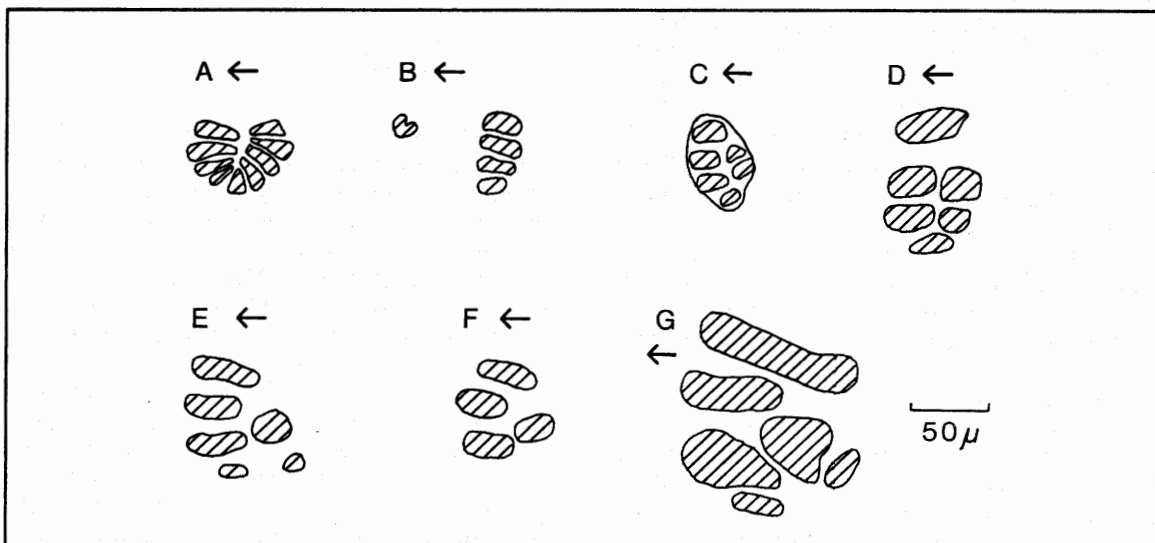

Figure 26. Major muscle scar field types, seen fom ext. LV (redrawn from Ghetti and McKenzie 1981).

disintegrate. Gently brushing with a fine sable hair paintbrush and deionised water is recommended.

Many ostracod valves are damaged by microbial, chemical and physical processes, and in practice it is often difficult or impossible to identify valves that have been badly damaged. Identifications should be limited to largely intact valves and carapaces, although valve fragments representing <50% of the original may be retained for referral if necessary. Ostracods are best extracted by individually hand-picking valves from sediments under a dissecting microscope, with a fine, damp sable paintbrush. The extracted valves are then cleaned (if required) and transferred to micropalaeontological slides, previously washed with an aqueous solution of gum tragacanth (Macarthy's, Romford, Essex). Gum tragacanth dries quickly, but is water soluble and will mount damp ostracod valves firmly, but releases them readily if required. Micropalaeontological slides are sealed with a normal microscope slide, are easily stored, and will protect the specimens for many years, with minimum curatorial effort and negligible expense.

4. Sub-sampling

Although it is theoretically preferable to extract all ostracod valves from a given sediment sample, their abundance may make this impracticable. Ostracod valve numbers may also be increased considerably by the presence of juvenile moult-stages. Examination of juveniles provides additional taphonomic information, as a full range of juvenile moult-stages strongly indicates *in situ* preservation (see Whatley 1988). Unfortunately the identification of juveniles is often difficult, so many ostracod workers do not examine juvenile moult-stages at all. Adults are recognisable by the greater degree of calcification of the valves, by their size as compared with that of the juvenile moults, and sometimes by the presence of impressions of the testes or ovaries on the inner wall of the shell (Fig. 24). The size of the sample examined is largely a matter of personal preference; we have achieved good specific representation from samples of 500 valves. Species-acquisition curves, and other methods of determining optimal sample size are unreliable, as these may differ considerably from one horizon to the next so that separate

determinations would be required for each part of the sequence.

A standard sub-sampling regime has been proposed by Danielopol and Casale (1989) in which the ostracod sample is spread evenly upon a gridded, numbered micropalaeontological tray. In our variant of this procedure, the tray is divided into 32 equally-sized, numbered squares, and 500 ostracods are extracted from the numbered squares as dictated by a train of random numbers (generated by a random-number generator). In addition, the number of valves (where an intact carapace = 2 valves) is counted from ten squares, again following the sequence of random numbers. This results in sample size of 500 valves, and ostracod counts from ten squares of the tray. The mathematical distribution of ostracods in the tray is then described following Elliott (1977). This allows the estimation of the total number of ostracods in the original sample.

5. Data presentation

From the extrapolated values obtained, ostracod data may be presented as either tables of raw numbers, or as diagrams of percentage abundance or absolute numbers. These can be plotted in exactly the same way as molluscan diagrams. In addition, various techniques may be used to characterize ostracod assemblages, e.g. diversity indices such as Brillouin's Index (Magurran 1988), clustering and ordination techniques, e.g. TWINSPAN or DECORANA (Gauch 1988) or taxocene analysis (Griffiths and Evans 1992).

6. Identification of ostracod material

There are very few works that deal with the identification of subfossil freshwater ostracods other than Absolon (1973), which deals with central European species. The valves of British marine and brackish-water faunas are illustrated in detail by Athersuch *et al.* (1989). Modern British freshwater species are illustrated by Henderson (1990), although the taxonomic keys are primarily based upon soft-part anatomies. Ecological information may be obtained from Klie (1938), Nüchterlein (1969) or Henderson (1990), and a good introduction to the taxonomic literature is provided by Kempf (1980a-d; 1991). The collection of modern reference material is also a valuable aid to identification, and allows the development of a first-hand appreciation of

natural ostracod communities (e.g. Griffiths and Evans 1991).

Ostracod valves can be orientated by examining the location of the muscle scars, which usually lie anterior to the mid-point of the valve. Valves should be examined under a high-power dissecting microscope, with particular attention being paid to the overall shape and structure of the shell (Fig. 24), the structure of the inner lamellae (Fig. 25), and the pattern of the muscle scars (Fig. 26). Where the muscle scars are not visible, improved resolution may be achieved by gently brushing the valve with dilute food colouring, or by placing the valve onto a microscope slide in a drop if glycerine, and then viewing in transmitted light. An excellent introduction to ostracod morphology is provided by Van Morkhoven (1962).

The key presented here will allow the assignation of most adult specimens to genera, although other faunal works should also be consulted. Identification to genus is often sufficient for preliminary environmental reconstruction (Griffiths and Evans 1992). The generic nomenclature used here conforms to current European usage (e.g. Meisch *et al.* 1990; Griffiths and Evans, in press). The group *Candona s.l.* is taxonomically difficult, and although it is usually agreed that *Candona s.l.* is composed of several genera, reference must be made to specialist faunal works. Absolon (1978) illustrates the species of *Candona s.l.* known from the German Quaternary.

Valve key to the genera of Holocene and modern British freshwater ostracod taxa

In the key and figures the following abbreviations have been used: RV—right valve, LV—left valve, ext.—exterior, int.—interior.

01. Valves swollen, elongate, narrower anteriorly than posteriorly. Muscle scars in a rosette with (usually) nine components (Figs. 26A, 27) . . . . *Darwinula*
—Valves and scars not like this 02

02. Muscle scars as in Fig. 26B; four scars arranged in a vertical row, often with a `V-shaped' scar in front 03
— Muscle scar pattern of various types but never as above 06

03 Valves clavate, robust, often noded, but without reticulate surface ornamentation. Internal surface of valves with large, conspicuous pores (Fig. 28) . . . . . . *Cytherissa*
— Valves not as above, and with punctate or reticulate surface ornamentation 04

04. Valves swollen, especially posteriorly, sub-oval in lateral view, with regularly punctate external surface. Never beaked in dorsal view (Fig. 29) . . . . *Metacypris*
— Valves and carapaces not sub-oval or swollen. Males `slipper-shaped', females sub-trapezoidal (Fig. 30). Surface with reticulate or punctate external ornamentation, sometimes also noded. Anterior end often beaked in dorsal view 05

05. Anterior pore canals short and straight (Fig. 30) . . . . *Limnocythere*
— Anterior pore canals long and branched (Fig. 31) . . . . *Paralimnocythere*

06. Valves >0.8 mm, conspicuously punctate. Lateral outline sub-rectangular (Fig. 32). Dorsal inward folds (sulci) present (Fig. 24). Valves plain, spined or with denticulate margins. No anterior rostrum . . . . *Ilyocypris*
— Valves without sulci, and otherwise not as above 07

07. Valves elongate with a `Z-shaped' posterior inner lamella (Fig. 33) . . . . . *Stenocypria*
— Lacking this structure 08

08. Shell in lateral view sub-lanceolate (Fig. 34) . . . . *Dolerocypris*
— Valves not sub-lanceolate 09

09. Valves large (>1.8 mm), sub-rectangular (not sub-triangular) and with large, conspicuous muscle scars (Fig. 35) . . . *Herpetocypris*
— Valves not as above 10

10. Valves flat, 1.1-1.4 mm long. Anterior inner lamella dorsally notched, very wide, and extending ventrally for the first two-thirds of the valve (Fig. 36) . . . . *Isocypris*
— Valves without these structures 11

11. Valves 2.0-2.6 mm long, globular, with very conspicuous selvage on anterior inner lamella. Either two large backwardly-pointing lateral spines, or tiny spines on the anterior margin, and a postero-ventral spur (most noticeable on RV; Fig. 37) . . . . *Cypris*
— Without conspicuous anterior selvage, or if present valves not large and globular, and lacking these external structures 12
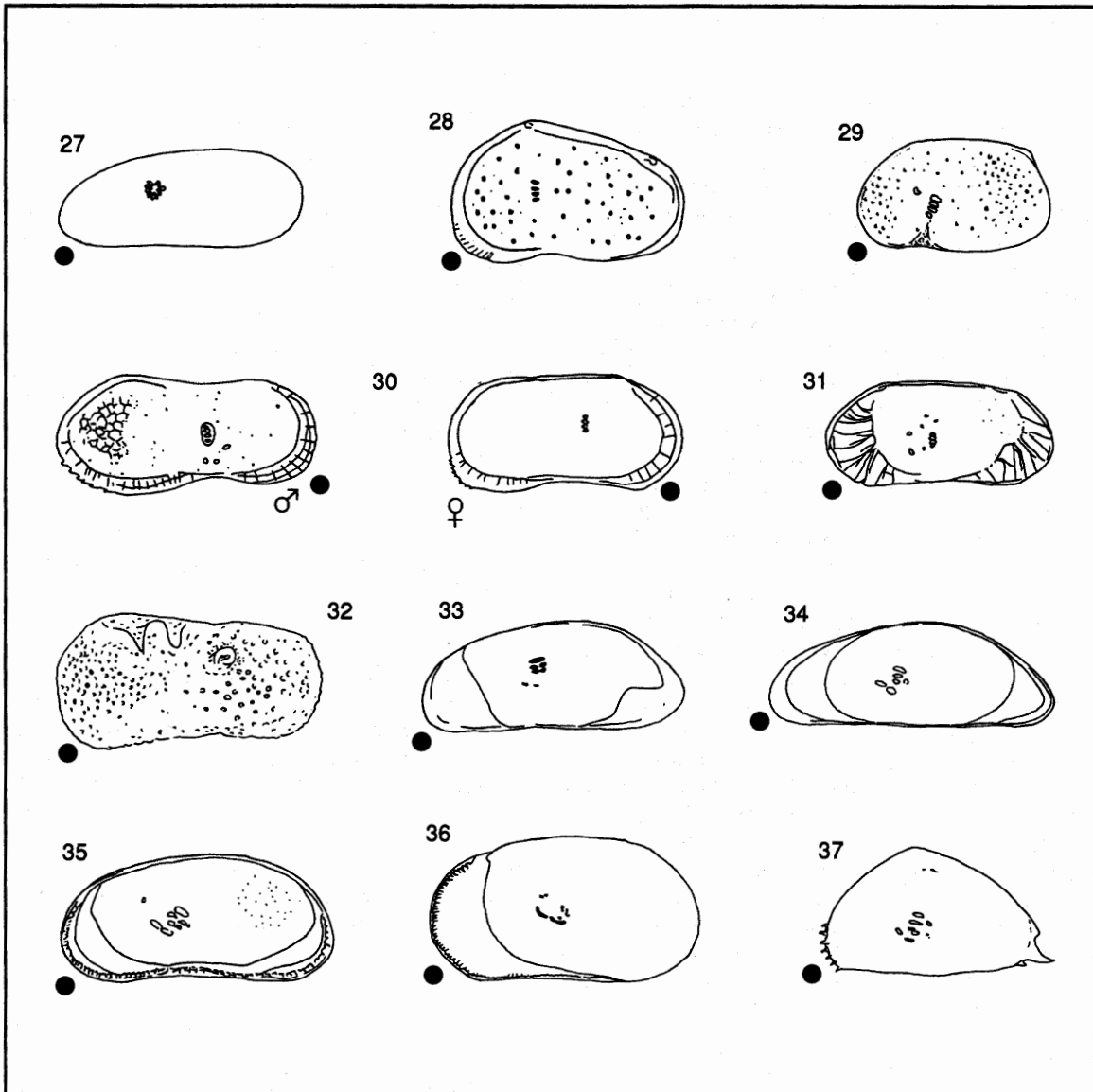
Figures 27-37. Figure 27. ext. LV Darwinula; Figure 28. int. RV Cytherissa; Figure 29. ext. LV Metacypris; Figure 30. int LV Limnocythere; Figure 31. ext. LV Paralimnocythere; Figure 32. ext LV Ilyocypris; Figure 33. int. RV Stenocypria; Figure 34. int. RV Dolerocypris; Figure 35. int. RV Herpetocypris; Figure 36. int. RV Isocypris; Figure 37. ext. LV Cypris. ●—marks anterior end.

12. Valves >1.2 mm. Anterior inner edge of right valve with a row of tiny denticles (Fig. 38) . . . . *Heterocypris*
— These denticles not present 13

13. Muscle scars as in Figs. 26D or 26E . . 14
— Muscle scars not like this 16

14. Muscle scars resembling a `paw print' of four or five elements with a rounded or slightly elongate scar above (Fig. 26D) . . 30
— Three slightly elongate scars anteriorly and

in a vertical row, one smaller one below, and (usually) two smaller scars behind (Fig. 26E) 15

15. Valves swollen (Fig. 39) . . . . . *Cyclocypris*
— Valves relatively flat (Fig. 40) . . . . *Cypria*

16. Dorsum curving gently downwards anteriorly, but posteriorly broadly rounded. Valve with wide anterior inner lamella. Not globose as in *Cyclocypris* (Fig. 41) . . . *Scottia*
— Valves not like this 17
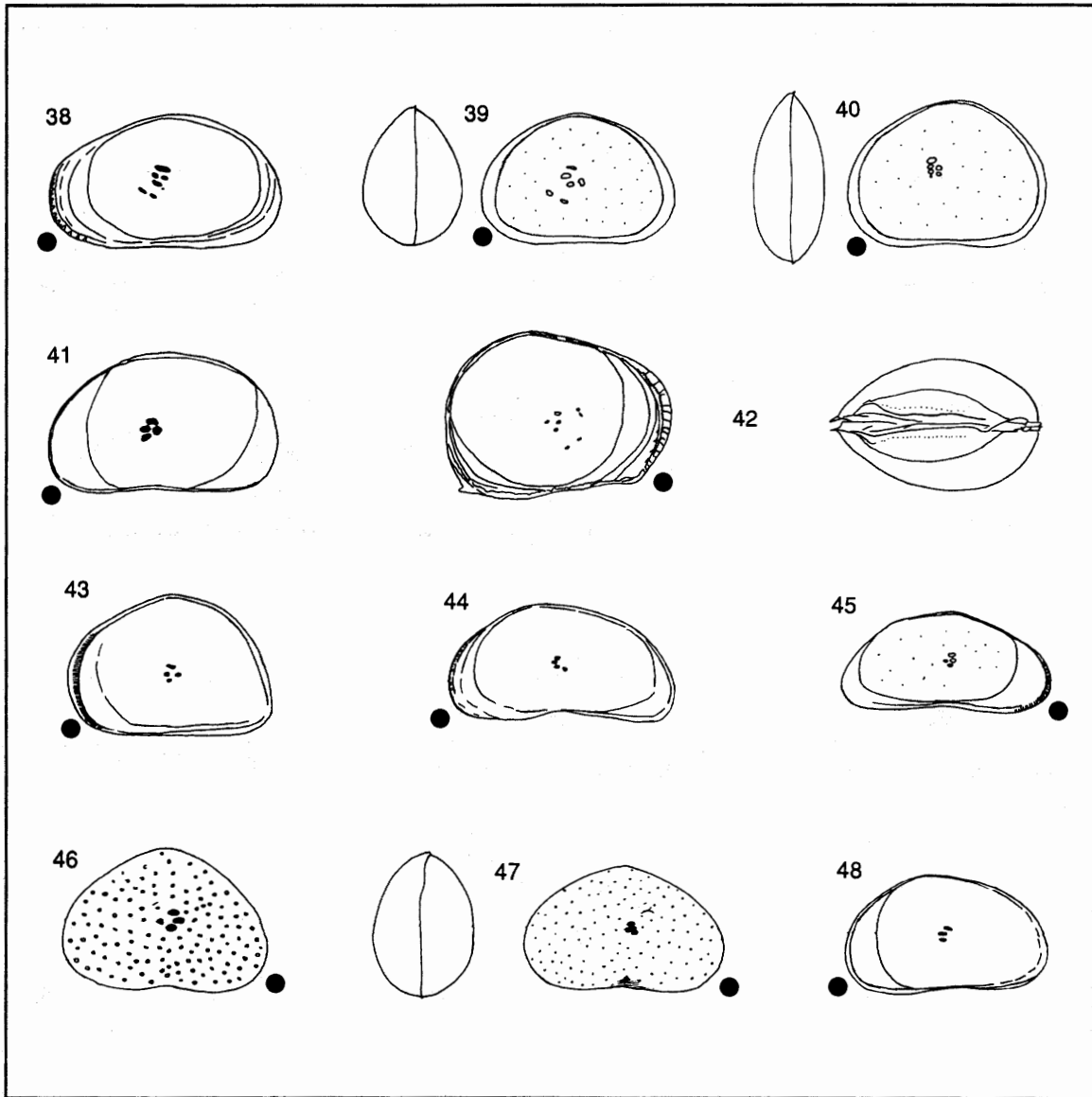
Figures 38-48. Figure 38. int RV Heterocypris; *Figure 39. dorsum and int. RV* Cyclocypris; *Figure 40. dorsum and int. RV* Cypria; *Figure 41. int. RV* Scottia; *Figure 42. ventrum and int. LV* Notodromas; *Figure 43. int. RV* Cyprois; *Figure 44. int. RV* Potamocypris; *Figure 45. int. LV* Cavernocypris; *Figure 46. ext. RV* Sarscypridopsis; *Figure 47. dorsum and ext. RV* Cypridopsis; *Figure 48. int. RV* Plesiocypridopsis. ●—*marks anterior end.*

17. Valves swollen, >1.0 mm, conspicuously ventrally flattened (Fig. 42) . . . . *Notodromas*
— Valves not ventrally flattened 18

18. Valves with unusual, irregularly sub-ovoid outline, pore canals of anterior margin very conspicuous, in dorsal view valves not markedly swollen (Fig. 43) . . . . *Cyprois*
— Valves not like this, and lacking highly conspicuous anterior pore canals 19

19. Valves <0.85 mm, muscle scars simple (Fig. 26F). Outline sub-ovoid or crescentic . . . 20
— Valves >0.95 mm. One large elongate scar above, scars below irregular and not tightly clustered 24

20. Valves crescentic, with curved or angled dorsal margin (Fig. 44) . . . . . . *Potamocypris*
— Valves sub-ovoid or elongatedly sub-ovoid 21
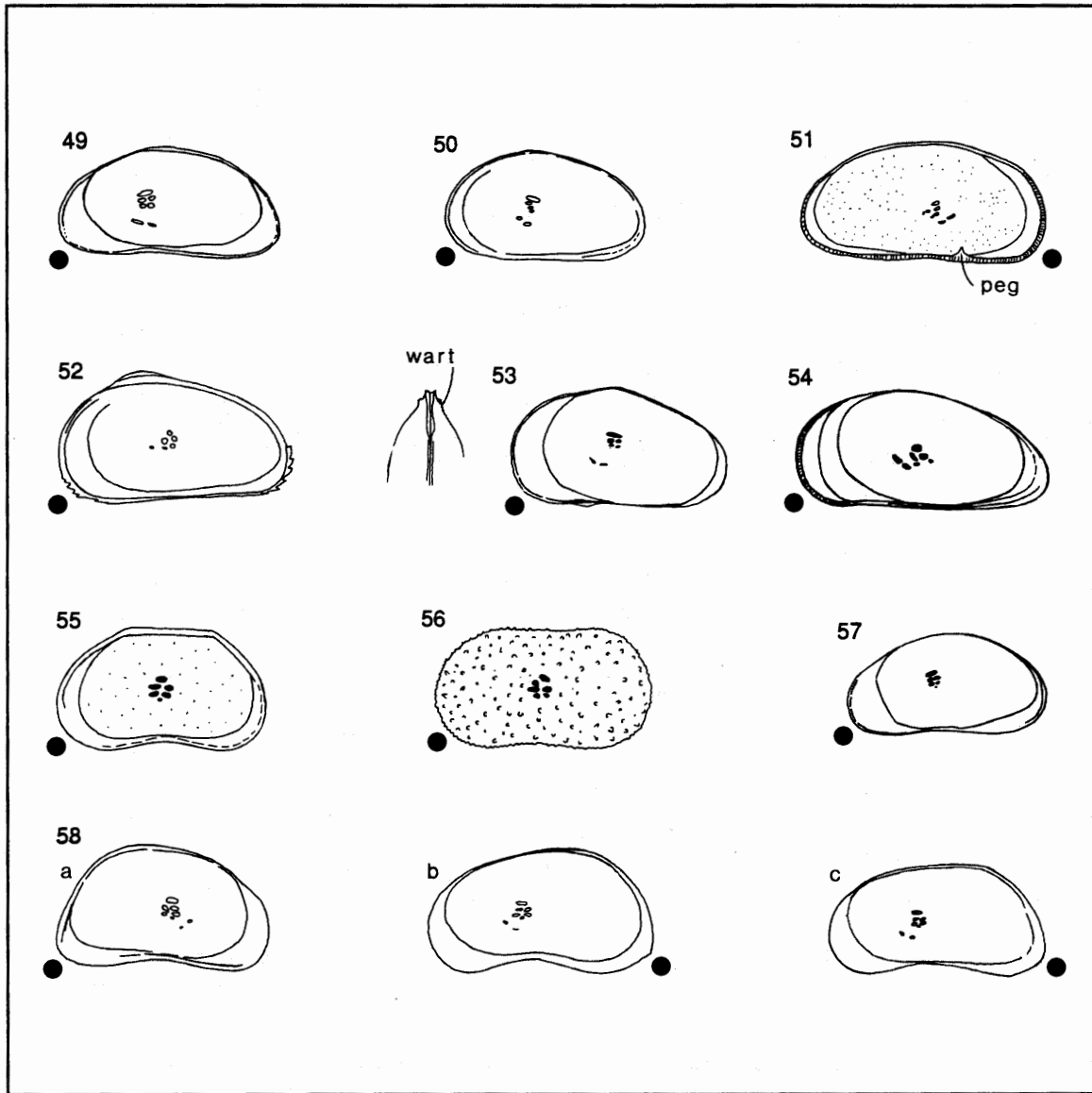
Figures 49-58. Figure 49. int. RV Psychrodromus; *Figure 50. int. RV* Strandesia *and* Bradleystrandesia; *Figure 51. int. LV* Tonnacypris; *Figure 52. int. RV* Prionocypris; *Figure 53. dorsum and int. RV* Eucypris; *Figure 54. int. RV* Trajancypris; *Figure 55. int. RV* Nannocandona; *Figure 56. ext. LV* Paracandona; *Figure 57. int. RV* Candonopsis; *Figure 58. (a) int. RV (b, c) int. LV* Candona *s.l.* ●—*marks anterior end.*

21. Valves elongate, with a wide posterior inner lamella (Fig. 45) . . . . *Cavernocypris*
— Valves sub-ovoid or sub-triangular, with a narrow posterior inner lamella 22

22. Valves heavily punctate, with a markedly peaked dorsal margin; not conspicuously swollen (Fig. 46) . . . . *Sarscypridopsis*
— Valves smooth or punctate, not dorsally peaked 23

23. Valves sub-ovoid, very swollen in dorsal view, and with narrow anterior inner lamella (Fig. 47) . . . . *Cypridopsis*
— Valves not distinctly swollen, elongatedly sub-ovoid, with a wide anterior inner lamella (Fig. 48) . . . . *Pleisiocypridopsis*

24. Valves robust, height/length ratio <0.5, elongatedly sub-ovoid with a wide anterior inner lamella (Fig. 49) . . . . . . *Psychrodromus*

— Valves sub-ovoid, or roundedly sub-triangular, height/length ratio usually >0.5 .
.... 25

25. Valve surfaces finely punctate or tuberculate, but no other ornamentation of any type. Anterior inner lamella narrow 26
— Anterior inner lamella always wide. Valves smooth or sometimes with denticulate margins, or a row of small `warts' on the anterior external surface 27

26. Valves sub-ovoid, exterior surface modestly pitted (Fig. 50) .... *Strandesia*
— Valves elongatedly sub-ovoid, exterior surface modestly tuberculate ....
.... *Bradleystrandesia*

27. Anteroventral inner lamella of LV with a blunt peg (Fig. 51) .... *Tonnacypris*
— Peg absent 28

28. Ventral margins denticulate (Fig. 52) ....
.... *Prionocypris*
— Denticles absent 29

29. Valves with a row of warts on the exterior anterior surface (Fig. 53) ...... *Eucypris s.s.*
— Valves lacking these warts, shell outline sub-clavate (Fig. 54) .... *Trajancypris*
(If <1.1 mm, *Eucypris pigra*)

30. Valves punctate or tuberculate 31
— Valves without surface ornamentation ...
.... 32

31. Shells <0.60 mm long, dorsal margin straight, ventral margin concave, slight antero-posterior asymmetry (Fig. 55) ......
.... *Nannocandona*
— Adult shells *c.* 0.75 mm long, anterior and posterior margins equally rounded, the dorsal margin somewhat concave. Surface of valves with conspicuous tuberculate ornamentation (Fig. 56) .... *Paracandona*

32. Valves sub-reniform and with a wide, almost straight anterior inner lamella. Uppermost muscle scar markedly elongate (Fig. 57) .... *Candonopsis*
— Anterior inner lamella not like this, muscle scars arranged in a `paw print' with the uppermost scar round or sub-ovoid. Most species 1.0-1.8 mm long, but sexually dimorphic and of a variety of shapes, although never sub-ovoid or markedly swollen in dorsal view. Always lacking surface ornamentation. (Fig. 58 a-c) .. *Candona s.l.*

Acknowledgements

References

Absolon, A. (1973). Ostracoden aus einigen Profilen spät- und postglazialer Karbonat-ablerungen in Mitteleuropa. *Mitteilungen der Bayerischen Staatsammlung für Paläontologie und historische Geologie* **13**, 47-94.

Absolon, A. (1978). Die Gattung *Candona* (Ostracoda) im Quartär von Europa. *Rozpravy Ceskoslovenské Akademie Ved, Rada Matematickych a Prirodnich Ved* **88** (5), 1-73.

Athersuch, J., Horne, D. J. and Whittaker, J. E. (1989). *Marine and brackish-water ostracods. Synopses of the British fauna (New series)*, No. 43. Leiden: E.J. Brill, for the Linnean Society of London and the Estuarine and Brackish-waters Sciences Association.

Bradbury, J. P., Forester, R. M., Bryant, W. A. and Covich, A. P. (1990). Paleolimnology of Laguna de Cocos, Albion Island, Rio Hondo, Belize, pp. 119-54 in Pohl, M. D. (ed.), *Ancient Maya wetland agriculture. Excavations on Albion Island, Northern Belize*. Boulder: Westview Press.

Carbonel, P., Colin, J.-P., Danielopol, D. L., Löffler, H. and Neustrueva, I. (1988). Palaeoecology of limnic ostracodes: a review of some major topics. *Palaeogeography, Palaeoclimatology, Palaeoecology* **62**, 413-61.

Danielopol, D. L. and Casale, L. (1989). A technique for the laboratory sub-sampling of fossil non-marine ostracods. *Journal of Micropalaeontology* **7**, 31-8.

De Deckker, P. (1979). The Middle Pleistocene ostracod fauna of the West Runton Freshwater Bed, Norfolk. *Palaeontology* **22**, 293-316.

De Deckker, P. and Forester, R. M. (1988). The use of ostracods to reconstruct continental palaeoenvironmental records, pp. 175-99 in De Deckker, P. Colin, J.-P. and Peypouquet, J. P.

(eds.), *Ostracoda in the earth sciences.* Amsterdam: Elsevier.

Delorme, L. D. (1989). Methods in Quaternary ecology, No. 7. Freshwater ostracodes. *Geoscience Canada* **16**, 85-90.

Elliott, J. M. (1977). Some methods for the statistical analysis of samples of benthic invertebrates. *Freshwater Biological Association Scientific Publication* No. **25**. Ambleside: Freshwater Biological Association.

Evans, J. G. (1972). *Land snails in archaeology.* London: Academic Press.

Gauch, H. G. (1982). *Multivariate analysis in community ecology.* Cambridge: University Press.

Ghetti, P. F. and McKenzie, K. (1981). *Guide per il riconoscimento delle specie animali dell acque interne Italiane. 11. Ostracodi (Crustacea, Ostracoda).* Verona: Consiglio Nazionale delle Richerche.

Griffiths, H. I. and Evans, J. G. (1991). Some freshwater ostracods (Crustacea, Ostracoda) from South Wales. *Freshwater Forum* **1**, 64-72.

Griffiths, H. I. and Evans, J. G. (1992). A simple notation scheme for the description of time-averaged ostracod assemblages (Crustacea, Ostracoda) by their taxonomic composition. *Journal of Micropalaeontology* **11**, 31-5.

Griffiths, H. I. and Evans, J. G. (in press). An annotated check-list of British Pleistocene, Holocene and Modern freshwater Ostracoda. *Journal of Micropalaeontology* **12**.

Henderson, P. A. (1990). *Freshwater ostracods. Synopses of the British Fauna (New Series), No.* **42**. Oegstgeest: Universal Book Services for the Linnean Society of London and the Estuarine and Brackish-water Sciences Association.

Kempf, E. K. (1971). Ostracoden-Forschung als Hilfswissenschaft der Ur- und Frühgeschichte. *Informationsblätter zu Nachbarwissenschaften der Ur- und Frügeschichte* **2** (*Zoologie* 3), 1-5.

Kempf, E. K. (1980a). Index and bibliography of nonmarine Ostracoda. 1. Index A. *Sonderveroeffentlichungen der Geologisches Institut der Universitaet zu Koeln* **35**, 1-188.

Kempf, E. K. (1980b). Index and bibliography of nonmarine Ostracoda. 2. Index B. *Sonderveroeffentlichungen der Geologisches Institut der Universitaet zu Koeln* **36**, 1-180.

Kempf, E. K. (1980c). Index and bibliography of nonmarine Ostracoda. 3. Index C. *Sonderveroeffentlichungen der Geologisches Institut der Universitaet zu Koeln* **37**, 1-204.

Kempf, E. K. (1980d). Index and bibliography of nonmarine Ostracoda. 4. Bibliography A. *Sonderveroeffentlichungen der Geologisches Institut der Universitaet zu Koeln* **38**, 1-186.

Kempf, E. K. (1991). An index and bibliography of nonmarine Ostracoda 5. Bibliography B. *Sonderveroeffentlichungen der Geologisches Institut der Universitaet zu Koeln* **77**, 1-232.

Klie, W. (1938). *Krebstiere oder Crustacea III: Ostracoda, Muschelkrebse. Die Tierwelt Deutschlands und der angrenzenden Meersteile.* Teil **34**. Jena: Gustav Fischer Verlag.

Magurran, A. E. (1988). *Ecological diversity and its measurement.* London: Chapman and Hall.

Meisch, C., Wouters, K. and Martens, K. (1990). Liste annotée des ostracodes actuels non-marins trouvés en France (Crustacea, Ostracoda). *Travaux Scientifiques du Musee National d'Histoire Naturelle de Luxembourg* **15**, 1-62.

Nüchterlein, H. (1969). Süsswasserostracoden aus Franken. Ein Beitrag zur Systematik und Ökologie der Ostracoda. *Internationale Revue der gesamten Hydrobiologie* **54**, 223-87.

Robinson, J. E. (1986). Ostracods from Meare East. *Somerset Levels Papers* **12**, 102-5.

Van Morkhoven, F. P. C. M. (1962). *Post-palaeozoic Ostracoda, Volume 1.* Amsterdam: Elsevier.

Whatley, R. C. (1988). Population structure of ostracods: some general principles for the recognition of palaeoenvironments, pp. 245-65 in De Deckker, P., Colin, J.-P. and Peypouquet, J. P. (eds.), *Ostracoda in the earth sciences.* Amsterdam: Elsevier.

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Using modern bone assemblages to estimate ancient populations

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Summary

Archaeologists trying to characterise palaeoeconomies sometimes wish to work backwards, using populations of bones persisting in the modern lithosphere to infer the sizes, or at least, relative sizes of bone populations associated with human subsistence activities. This raises a serious inferential problem; unless we can make allowances for consistent variation in dismemberment strategy, dumping behaviour and survival probabilities both within and between species, we will get the wrong answer.

It is over 25 years since Krantz (1966) published a statistic which, he argued, solved this problem. The theoretical underpinnings of Krantz's method appeared shaky and many more years elapsed before Fieller and Turner (1982) put it on a firmer base. Both Krantz and Fieller and Turner required that we be able to match left-right paired bones reliably. This paper will show there is no reason why the sorts of inferential methods conceived by Krantz, Fieller and Turner among others could not be modified and applied to assemblages with less than perfect pairing data and to some assemblages with no left-right pairing data at all. It is even possible to obtain estimators from populations of potsherds and chipped stones as well as bones.

The methods described here were developed in the course of a fixed-term research contract funded by SERC. Although case studies are in preparation, many more will be needed before their practical usefulness can be evaluated and no further work is envisaged in the immediate future. This interim description has been prepared to bring them to the attention of interested colleagues.

Sediments as traps

A body of sediments is a sort of 'deadfall trap' removing objects from the biosphere as they fail and are discarded. Some of these discarded objects will 'escape' by being re-deposited, rendered unrecognisable, destroyed or missed in excavation. Others will remain in the trap and form the archaeological *assemblage*. Each sedimentary unit will 'access' a limited range of space-time within which populations of objects, including animals and plants, reside; this is the *catchment* of the sediments. The populations of objects within the catchment of a designated sedimentary unit are called the *target populations*.

A deer that fell dead on a site will obviously be within its catchment but a deer that died half a mile away may not. A deer killed half a mile away and brought back for consumption will have been within its catchment. The catchment is not something we could draw a ring round on a map. Target populations are sets of objects which have an appreciable probability of being recovered from a given body of sediments. Archaeologists often talk about target populations without realising that these can only be defined with reference to a specific body of sediments and class of artefacts or other remains. Sedimentary units that are close to each other may have had identical, or at least very similar catchments, while the catchments of units further apart may have been profoundly different.

When we start thinking about sediments as traps it is natural to think about the trapping of animals and the analytical tricks used to estimate population size from the numbers trapped. One of the best known of these is the Lincoln Index. In its simplest form, the Lincoln Index requires that a sample of size S_1 be caught, marked and returned to the (closed) population of size N. A new sample of size S_2 is then caught of which M will be marked. Assuming the distribution of marks in the population to be random and that no animal will learn to avoid capture during the

course of the experiment, we might suppose the proportion of marks in S_2 to approximate the proportion of marks in the whole population:

$$S_1/N \approx M/S_2$$

which, on re-arranging gives:

$$N \approx S_1 * S_2/M \dots \dots \dots \dots (1).$$

This method can be applied to archaeological data whenever analogues of S_1, S_2 and M can be recognised.

Archaeozoologists take the number of right and left hand bones as analogues of S_1 and S_2 and the number of matched pairs as M. This gives us a *Probable Number of Individuals* (PNI) statistic based on the Lincoln Index:

$$PNI = \frac{Rt * Lt}{Pr} \dots \dots \dots \dots (2)$$

where Rt is the number of rights, Lt the number of lefts and Pr the number of left-right pairs. The Lincoln Index is a *Maximum Likelihood Estimator* (MLE) of N subject to the assumptions that the capture probability of a given individual is fixed and that all capture events are statistically independent. A Maximum Likelihood Estimator is that value most likely to have resulted in the observed data given the validity of the probabilistic model. Although sometimes biased, MLEs are generally very efficient estimators when sample size is large.

Bailey (1951) has shown that, when the number `recaptured' individuals is small (less than ten or so) a less biased release-recapture statistic can be constructed. Converting Bailey's modified formula into an archaeozoological form gives:

$$PNI = \frac{(Rt+1) * Lt}{Pr+1} \dots \dots \dots \dots (3).$$

There are clearly two alternatives for Bailey's formula. We could also use:

$$PNI = \frac{Rt * (Lt+1)}{Pr+1} \dots \dots \dots \dots (4).$$

Averaging the two gives:

$$PNI = \frac{(Rt+1) * Lt + (Lt+1) * Rt}{2(Pr+1)} \dots \dots (5).$$

The difference between the modified and unmodified versions are small when numbers are large, so Bailey's formula can be used in any circumstance.

Using either method on animal bones raises two obvious problems. Firstly, the probabilistic assumptions are unrealistic unless the likelihood of recovering a right hand bone is unaltered by the capture or non capture of its left hand pair. This may not be the case in practice. If a dog finds a chicken carcass it is likely to eat all of it. If a dog fails to find a chicken carcass, it eats none of it. We can not expect the capture of left and right paired chicken bones in a scavenged assemblage to be statistically independent events. The independence assumptions are reasonable for animals like sheep or cattle that are too large to be dismembered, consumed, dumped and scavenged in a single sitting; they are also reasonable with small animals whenever the material is not heavily scavenged. In general, the impact of slight statistical dependence will be less severe when estimates are made from large assemblages than when estimates are made from small ones.

The second problem is that of reliably recognising pairs. It is hard enough to tell one sheep from another in the flesh, but distinguishing animals of similar stature from bone fragments is even harder. Inefficient estimates of the number of left-right pairs recovered can vitiate PNI studies. An analogous problem to this has also been faced by population biologists who may be obliged to overestimate the number of animal `recaptured' and a further estimator derived with this problem in mind is applicable in archaeozoology. The removal estimator has been used recently to estimate the size of populations of migrating bowhead whales from sightings at two points a few kilometres apart. Because the biologists can not always be certain whether they have actually sighted the same whale twice, they take a conservative approach, assuming that any whale at the second station that might have been among those sighted at the first is not a `new' whale. The analogy with archaeozoological pairing studies is clear since any attempt to use morphology, age and size to recognise pairs may form `pseudo-pairs' by matching left and right elements from animals of similar stature. Since true pairs are unlikely to be missed by well executed pairing exercises, archaeozoologists take a similarly conservative approach to recapture. The removal estimator

is a MLE of target population size subject to certain assumptions (Winder 1992a and references therein). Archaeozoological formulations of the removal estimator using conservative pairing data can be had from one of two formulae, one for right:

$$PNI_r = \frac{Rt^2}{(Rt-Lt+Pr)} \qquad \cdots \cdots \cdots (6)$$

and one for left elements:

$$PNI_l = \frac{Lt^2}{(Lt-Rt+Pr)} \qquad \cdots \cdots \cdots (7).$$

The removal estimate is only a MLE if its divisor is positive. If both versions have positive divisors the two can be averaged. Although inefficient estimates of Pr will have adverse effects of the overall efficiency of the removal estimate, the problem of estimating abundance with conservative recapture (i.e. pairing) data is obviously not insurmountable. Another way of using release recapture statistics with bones that can not be paired perfectly is described in the next section.

Turning MNI statistics into PNI statistics

Minimum Number of Individuals (MNI) is a descriptive statistic which pivots on the central notion of the reconstructed individual (the animal, the pottery vessel, the flint core). MNI is the minimum number of individuals required to recreate an assemblage and can be used as a measure of the number of individuals captured in a body of sediments. MNI statistics were introduced to archaeozoology by White in 1953. More refined methods for bones were proposed by Bökönyi (1970) and Chaplin (1971) among others. Interestingly, MNI statistics for potsherds are described by Vince (1977) and similar methods can be used to obtain MNI statistics from refit assemblages of chipped stone artefacts.

To produce an MNI statistic, we sort and identify the fragments, refitting broken pieces as far as possible. We then reconstruct recognisable individuals from the refitted fragments. Fragments which might have come from the same individual are treated as if they had done so, even when it is not possible to show that they did. If we use MNI as a measure of the number of individuals captured by a body of sediments, this conservative approach to counting implies that

an individual which can not be distinguished from another individual has, in effect, 'escaped'.

Many archaeologists are unhappy about MNI methods. They point out that it is hard work getting MNI statistics and unwise to use them as estimates of the relative size of target populations because of consistent variation in capture probability. Some are also worried by their non-additivity when assemblages from two sedimentary units are aggregated. Consider a simple archaeological site split into two 'contexts', 1 and 2. We can obtain three separate MNI statistics from this site: MNI_1 is the MNI statistic from Context 1 alone, MNI_2 is that from Context 2 alone and MNI_{tot} is that obtained when objects from both contexts are combined. These MNI statistics satisfy the inequality described by Grayson (1973; 1984):

$$MNI_{tot} \le MNI_1 + MNI_2 \qquad \cdots \cdots \cdots (8).$$

MNI statistics were originally used to infer the percentage contribution of different animals to the diet and it was felt that non-additivity was not the sort of property one would expect such a statistic to possess. Since other descriptive statistics (fragment counts and weights, for example) are additive across aggregated contexts, many archaeologists felt there must be something odd about the MNI statistic.

There is, of course, nothing odd about non-additivity. If the catchments of Contexts 1 and 2 overlap to some degree, some of the individuals captured at Context 1 may also have been captured at Context 2. These individuals should not be counted twice on amalgamation of contexts. The Grayson inequality is evidence that MNI behaves precisely as it should, given that the same individual may be captured more than once.

We can make Lincoln Indices or Removal Estimates from MNI statistics whenever it is reasonable to suppose that two sedimentary units may have had identical catchments with similar capture probabilities by treating the MNI statistics as independent 'trappings' from a closed population of individuals. Thus for the Lincoln Index we take:

$$S_1 = MNI_1$$

and

$$S_2 = MNI_2.$$

The number of individuals trapped twice will, by the Grayson inequality, be

$$M = MNI_1 + MNI_2 - MNI_{tot}.$$

From which we obtain a generalised PNI statistic (PNI_G) based on the Lincoln Index:

$$PNI_G = \frac{MNI_1 * MNI_2}{(MNI_1 + MNI_2 - MNI_{tot})} \quad \ldots \ldots (9).$$

An alternative, using Bailey's modification and averaging gives:

$$PNI_G = \frac{(MNI_1+1)*MNI_2+MNI_1*(MNI_2+1)}{2(MNI_1+MNI_2-MNI_{tot}+1)} \ldots$$
$$\ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (10).$$

Equation (10) can be calculated from any assemblage capable of yielding MNI statistics. Equation (9) requires that an extreme form of the Grayson inequality holds:

$$MNI_{tot} < MNI_1 + MNI_2 \quad \ldots \ldots \ldots (11).$$

This can best be arranged by using large sample units and one of the more refined MNI methods. Such MNI procedures facilitate the `capture' of poorly preserved individuals that would have `escaped' from more primitive methods and enhance the efficiency of the PNI estimate by boosting assemblage size.

For the purposes of estimation, an individual that can not be reliably distinguished from another in the assemblage is deemed to have `escaped'. The probability that an individual will escape from the MNI method chosen must be constant both for subsets 1, 2 and the aggregated assemblage. Systematic errors caused by variation between the diagnostic criteria used by collaborating archaeozoologists could cause problems here as could the possibility that escape probabilities are dependent on assemblage size. Aggregating assemblages 1 and 2 may increase the relative frequency of spurious pairs. Pairing exercises based on assemblages whose catchments do not overlap at all (like distinct time phases or populations of bones of the right side, for example) could be used to test for density-dependent escape probabilities and to estimate suitable correction factors.

The capture probability of an individual at Context 1 must not be affected by its having been captured in Context 2. This is not so restrictive an assumption as that which underpins `pairing' methods, but should not

be ignored. Essentially, it is up to the archaeologist to employ a sampling stratagem for which the assumptions are supportable, at least as a working hypothesis. On the rare occasions when distributions seem `clumped' with whole skeletons dumped in one location, the method should not be used.

Although the size of the two captured populations and the efficiency of PNI estimates are positively correlated, this does not necessarily mean that a small site can produce so few reliable PNI estimates that we will be forced to face the sampling problems caused by basing inferences on too few data points. Suppose, for example, we have ten quadrats, $Q_1, Q_2, ... Q_{10}$. These can be split into two, arbitrary subsets of 5 quadrats each to obtain a single PNI statistic. There are 252 different ways of selecting 5 quadrats from a set of ten and so 252 PNI estimates can be obtained by splitting the assemblage into two halves. These could be averaged to produce an overall estimate for the 10-quadrat `site'. Of course, the computational problems raised by generating MNI statistics on such a grand scale are considerable but they are by no means insurmountable; suitable computer programs have been available in the literature since the late 1970s (Creak 1978).

We could use the frequency distribution of PNI estimates from different partitionings to test the PNI assumptions. If the distribution is unimodal with a small variance, we have a stable mean PNI estimate. If large variances are obtained, the estimates are unstable. Multiple modes would imply some `clumping' in patterns of deposition. This method of testing the PNI assumptions could be a valuable analytical tool in its own right. Any analysis that could provide an empirical refutation of the PNI assumptions would allow us to search for spatial discontinuities in target populations within a given time phase. Classical spatial analysis is restricted to characterising discontinuities in the surviving assemblage.

Any given catchment may contain many target populations. Within limits it is possible to re-classify the assemblage so as to select which of the target populations we will investigate. Separate PNI statistics could be obtained element by element to look at differences in the catchments of sub-assemblages of particular interest on ethnographic or taphonomic grounds. Taxa can be aggregated to compare the target populations of specific

sets of the elements of taxa and compound taxa within and between phases. We could compare the target population of ovicaprid tibia with pig tibia, small artiodactyl long bones with large artiodactyl long bones and so on. The key to exploiting the analytical leverage PNI methods provide is to work creatively with the target populations we can actually access, rather than to agonize about the inaccessibility of populations on some theoretician's wish-list.

Conclusions

Even non-archaeozoologists know that one of the reasons animal bones are collected is to allow us to study palaeoeconomies. Information about the relative contributions of different species to the diet is, of course, an important aspect of this work. Rather fewer outsiders realise that the differential preservation we can infer by comparing bone assemblages with whole skeletons and can observe in taphonomic and ethnographic data means that almost everything written on the subject is based on hopeful guesswork. It is hard to see why so little effort has gone in to overcoming the theoretical difficulties raised by the early PNI methods when, for all their imperfections, they provided the best independent check on traditional methods.

Although statistics have been derived for pottery assemblages by Orton (1982) which some think are similar to the faunal estimators, all the pottery methods hinge on the assumption that artefacts may be broken but will never be destroyed. Orton's pottery statistics can be used to get cost-effective figures for relative frequencies in the modern assemblage but offer no analytical leverage when trying to infer the relative sizes of ancient populations. Archaeozoology is alone among the post-excavational specialisms in having methods that may compensate for some of the effects on assemblage composition of different recovery probabilities. The potential pay-off to be won by applying these palaeoeconomic estimators both to inter- and to intra-stratum studies and, indeed, of extending their use to populations of chipped stone and potsherds, is considerable.

An initial case study has been undertaken in which a few dozen PNI statistics have been calculated from a faunal dataset describing about 10,000 fragments. These suggest capture probabilities between 0.32 and 0.36 for the mandibular teeth of ovicaprids and 0.41-0.49 for those of cattle in the plough-damaged, abandonment fills of a Romano-British Farmstead (Winder 1992b). However, much more work will be required to refine these methods further and to prepare data for their serious evaluation. A custom-built, computerised database and computer programs capable of obtaining MNI statistics from any context or group of contexts both for bones and potsherds or bones and chipped stones would be a prerequisite of such a study. Statistical software to analyse the frequency distributions of replicate PNI estimates and graphical software to superimpose colour-coded target population densities on three-dimensional representations of the excavated sediments would also be needed for the preparation of reports.

References

Bailey, N. (1951). On estimating the size of mobile populations from capture-recapture data. *Biometrika* **38**, 293-306.

Bökönyi, S. (1970). A new method for the determination of the minimum number of individuals in animal bone material. *American Journal of Archaeology* **74**, 291-2.

Chaplin, R. (1971). *The study of animal bones from archaeological sites.* New York: Seminar Press.

Creak, G. A. (1978). Matching routines. *Auckland University Computer Centre Technical Report* **11**.

Fieller, N. and Turner, A. (1982). Number estimation in vertebrate samples. *Journal of Archaeological Science* **9**, 49-62.

Grayson, D. (1973). On the methodology of faunal analysis. *American Antiquity* **39**, 432-9.

Grayson, D. (1984). *Quantitative zooarchaeology: topics in the analysis of archaeological faunas.* New York: Academic Press.

Krantz, G. (1966). A new method of counting animal bones. *American Journal of Archaeology* **72**, 286-8.

Orton, C. (1982). Computer simulation experiments to assess the performance of measures of quantity of pottery. *World Archaeology* **39**, 1-20.

Seber, G. (1973). *The estimation of animal abundance.* London: Griffin.

Vince, A. (1977). Some aspects of pottery quantification. *Medieval Ceramics* **1**, 63-74.

White, T. (1953). A method of calculating the dietary percentages of various food animals utilized by aboriginal peoples. *American Antiquity* **18**, 396-8.

Winder, N. (1992a). The removal estimator; a `probable numbers' statistic that requires no matching. *International Journal of Osteoarchaeology* **2**, 15-18.

Winder, N. (1992b). The animal bones from Boxfield Farm, Chells. *Cambridge Faunal Remains Unit Archive Report.*

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Short contributions

Skin and wool remains from Hallstatt

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Introduction

The important site of Hallstatt is not well known, although it gave its name to an entire Iron Age culture. The name stems from a cemetery found last century in the valley above Hallstatt village. More recently, the salt mines excavated by Dr F. E. Barth inside the mountain at the head of the valley have yielded much extremely well preserved organic material. The skin and wool have come mainly from the 'East Group' of finds dated by radiocarbon assay and dendrochronology to the third to eighth centuries BC, with a few from the 'North Group' dated to the ninth or tenth centuries BC (Barth, Felber and Schauberger 1975).

The Hallstatt skin and wool remains are of particular interest because of the general lack of such material from the period compared with the preceding Bronze Age and the succeeding Roman period, and also because they comprise a large collection allowing

adequate analysis. The cloth had been subjected to textile analysis by Hundt (1959; 1960; 1967; 1987), but neither this nor the skin had been investigated biologically.

Following an examination of the material in the Naturhistorisches Museum, Vienna in 1986, a microscopic study of samples of the skin and wool cloth was made. The wool gave information on the range of fleece types indicating the stage of development of the fleece of sheep in the Iron Age (Ryder 1990a). Gross observations on skins made at the museum during 1989 were described by Ryder (1991). The object was to identify the species represented and to ascertain the numbers and colour of the different domestic animals, as well as to gain an indication of breed type. This was done mostly from the type of coat, although some skins were large enough to indicate the size of the animal, and to show colour variations over the body. The larger skins were from such objects as bags, caps and clothing. None of the skins had any association with bones. This means that even those from small mammals are unlikely to have been from animals that had died in the mines.

The wool in the cloth

Wild sheep and the primitive domestic sheep of the Neolithic period had a double coat like that of deer in which a very coarse outer coat obscures very fine underwool (Fig. 59). The
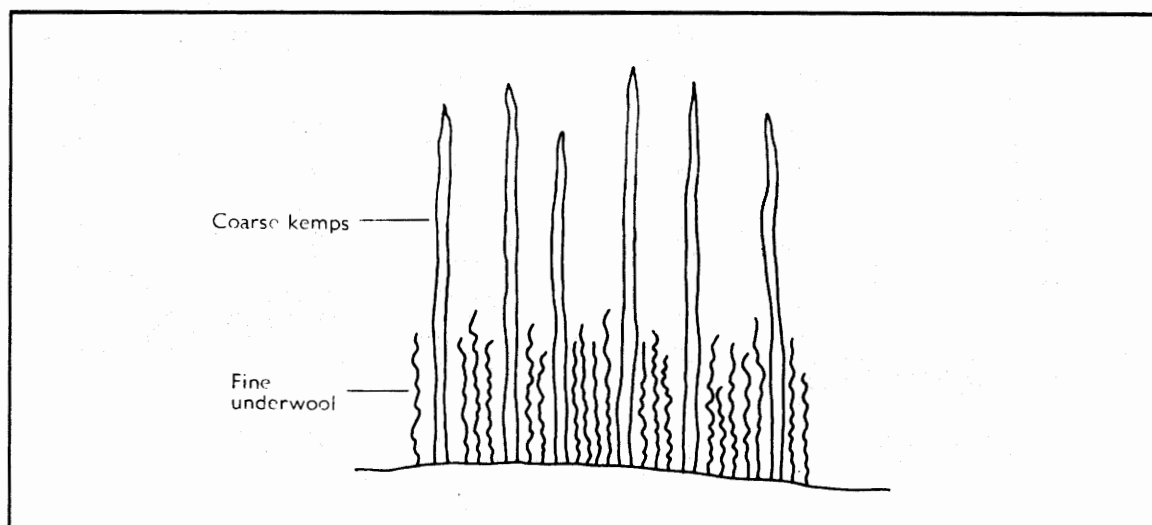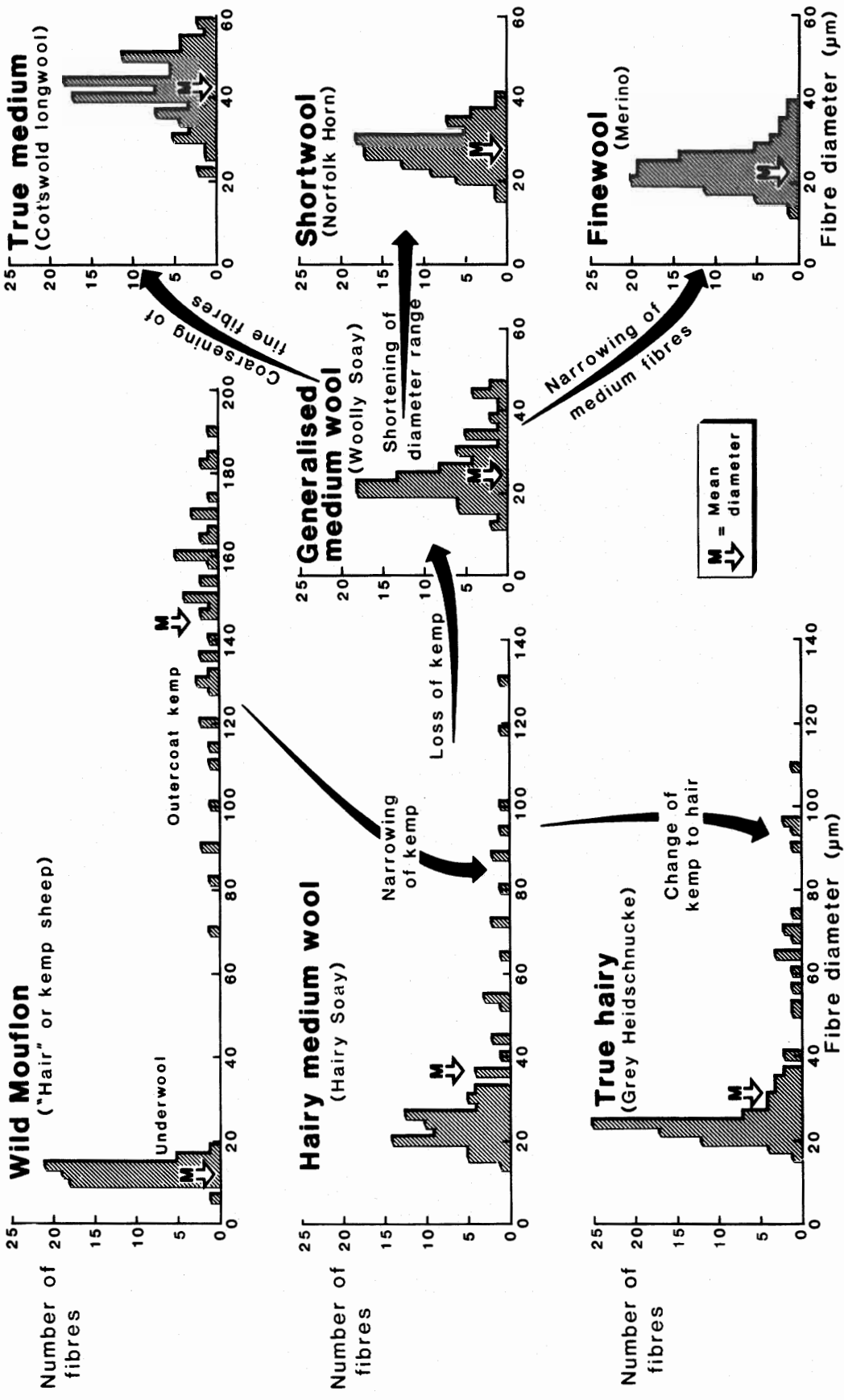

Figure 59. Diagram of the 'wild' coat structure in which a coarse, hairy outer coat obscures very fine underwool (from Ryder 1983).

Changes in fibre diameter distribution during fleece evolution

first fleece to develop came about by a narrowing of the outer-coat hairs of the wild type of coat (Ryder 1983; 1987; 1988). I have not found this Hairy-medium fleece before the Bronze Age. During the Bronze Age there was further narrowing of the outer-coat hairs to give fibres of medium diameter in an additional fleece type, the Generalised-medium wool (Fig. 60).

The modern types to the right of Figure 60 were thought to have appeared first during the Roman period, but the present investigation has confirmed that they were beginning to develop in the Iron Age. The existence of white as well as coloured sheep was shown by some cloth on display in the Naturhistorisches Museum, the bulk of which was woven from non-pigmented yarns. Into this was woven a rectangular pattern of bands of black or dark brown wool, which was reminiscent of a Scottish plaid.

The wool described by Ryder (1990a) comprised 56 yarns taken from 28 pieces of cloth. A further 83 yarns investigated since will be described in a subsequent paper. A whole mount microscopic preparation was made of wool fibres from each yarn and the diameter of 100 fibres in each sample was measured using a projection microscope. The fleece types were defined from wool fibre diameter distributions (Ryder 1983).

These measurements showed that the fleeces represented were predominantly of Hairy-medium and Generalised-medium type, which were present in almost equal proportions (Table 5). There was one Medium wool, not found previously before the Roman period, and four Semi-fine wools, one Semi-fine wool having been identified on an Iron Age site at Ronberg in Denmark (Ryder 1982). The paucity of Iron Age material means that comparisons must be made with Roman wool. Vindolanda, a first century AD site on Hadrian's Wall, near the border between England and Scotland, was chosen because the wool was thought to be local rather than a Roman import, and because it provided a similarly large number of yarns. Whilst Vindolanda had relatively more Hairy-medium fleeces than all other European

Roman sites put together (Ryder 1981), there were proportionally fewer Hairy-medium fleeces than at Hallstatt (Table 5). There was no evidence at Hallstatt for the use of coarser wool in the warps than the wefts, something which is common in later periods.

Nearly half of the Hallstatt wools contained a mixture of coloured and white fibres, which supports the postulated predominance of grey sheep in the European Iron Age (Ryder 1983). The comparison with Vindolanda is shown in Table 6, the proportions in the two collections being sufficiently close to suggest similar colour inheritance (Ryder 1990b).

Cloth remains from the Roman site of Vindolanda, and the fleeces of surviving unimproved breeds in various pockets throughout Europe, suggested that Iron Age wool was predominantly of primitive Hairy-medium and Generalised-medium fleece type (Ryder 1983). The findings from Hallstatt confirmed this expectation. The appearance of a range of colours, including white, but with a high proportion of grey, in contrast to the almost universal brown of Bronze Age sheep is also confirmed.

The skin remains

Caps made from sheepskin indicated that the coloured animals included brown as well as black individuals (Fig. 61). Few of the gross observations, however, produced evidence of grey sheep. Ryder (1990a) studied 33 samples of skin and the length and appearance of intact hair or wool added extra data to the fibre diameter measurements, which were carried out as with the wool from the cloth. Some of each skin sample was sectioned by the method of Ryder (1970).

The amazing state of preservation of the Hallstatt skin meant that microscopic details such as cell nuclei were clearly visible, but the arrangement of the hair follicles was often distorted, and this made identification difficult (see figures in Ryder 1990a). The different parts gave the same staining reactions as fresh skin, which does not necessarily indicate rawhide since oil-tanned skin gives the same colours. The skin was not vegetable tanned since this changes the colour.

It was immediately clear that the coats of the skin samples were hairier than the fleeces used in the cloth. Also, from evidence of hair

Figure 60 (opposite). Diagram showing how the 'wild' coat gave rise first to primitive hairy and woolly fleece types and how these later evolved to different modern fleeces (from Ryder 1983).

	Hairy medium	General medium	Medium	Semi-fine	Fine
Vindolanda	34% (19)	51% (29)	2% (1)	4% (2)	9% (5)
Hallstatt	46% (26)	45% (25)	2% (1)	7% (4)	0

Table 5. Comparison of fleece types from Hallstatt with those from Vindolanda (Great Britain, Roman).

follicle inactivity within over half of the skin samples, it was apparent that more animals had been killed (or had died) in autumn-winter than in spring-summer. The predominance of follicle inactivity led to the expectation that coat length would be at a maximum, but owing to wear and breakage few of the samples had a length approaching the 50-60mm expected even in sheep lacking a fleece. The skin thickness was noted as well as the colour and structure of the coat, i.e. the relative coarseness and whether or not underwool was obvious, and whether the hairs were straight or wavy.

Using these criteria, and evidence from skin sections, the samples were divided by eye into: Wild-type coat without a fleece, Hairy-medium, Generalised-medium (as found in the cloth samples) and a true Hairy fleece. The samples with a wild-type coat probably included some domestic goats as well as the wild ibex—it is difficult to distinguish the coat of a sheep without a fleece from that of a goat. The true Hairy type of fleece originated in the Iron Age from the Hairy-medium type when many of the short, moulting kemp-hairs changed into long, continuously-growing hairs (Fig. 60). This change was apparently
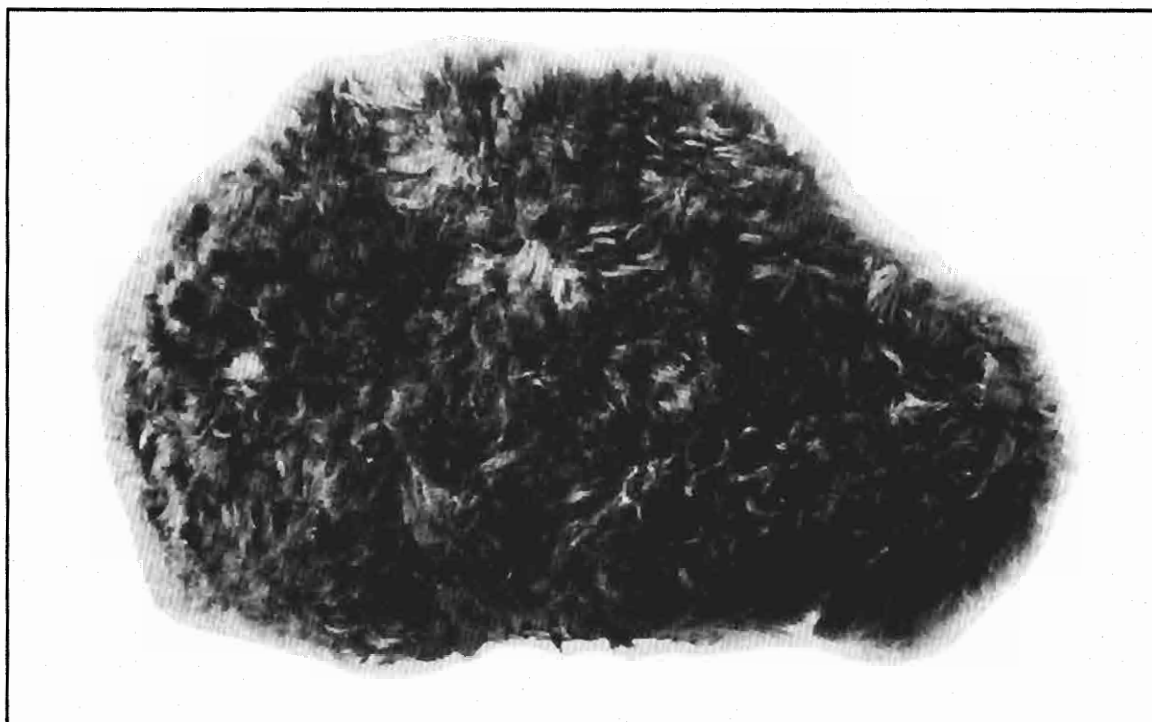

Figure 61. Brown sheepskin beret (35.713). Copyright: Naturhistorisches Museum, Wien.
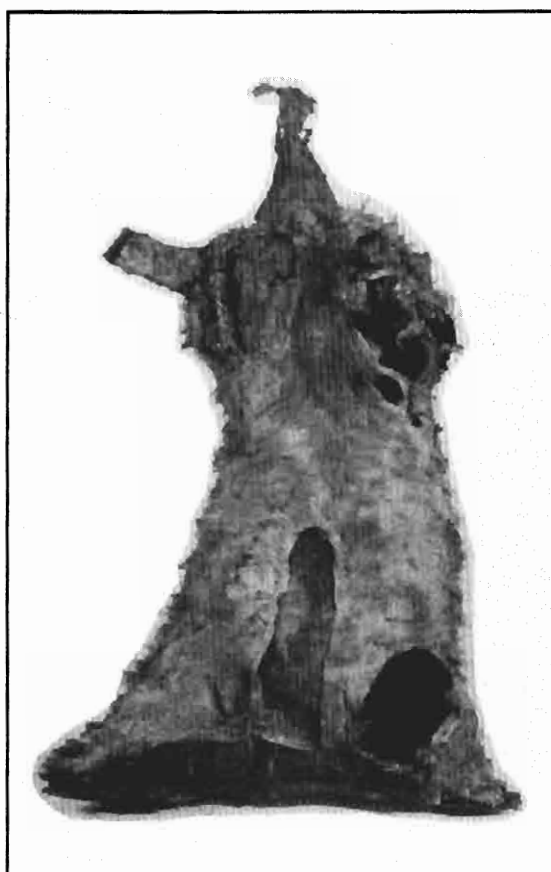
Figure 62. White sheepskin bag (35.718). Copyright: Naturhistorisches Museum, Wien.

associated with selective breeding for a continuously-growing fleece following the invention of iron shears which allowed sheep to be shorn and so avoided the loss of wool during the spring moult (Ryder 1982; 1983; 1987).

Ryder (1992) identified by eye the entire collection of skin bearing hair or wool. The dimensions ranged from a few square

associated with easier to identify larger pieces partly because the colour pattern over the body was clear.

The species identified

Of the 229 skins, 87% were from livestock species. Of these 70.5% were from sheep, 21.5% from goats and 8% from cattle. Most of the sheepskins had a fleece. The remaining 32% had a Wild-type (non-fleeced) coat structure with a big difference in diameter between the outer coat and the underwool (Fig. 59). Difficulties of identification arise with this type of skin since other species (e.g. goats and deer) have the same basic coat structure. The relatively longer (and coarser) hair of goats allowed these to be distinguished by eye from non-fleeced and Hairy, fleeced sheep.

A mysterious brown group of skins with a similar coat structure comprising 11% of the total did not appear to be from domesticates and I thought that these might be from chamois (*Rupicapra rupicapra*) and ibex (*Capra ibex*). These wild ruminants still live in the area and their bones have been found on other sites, but not at Hallstatt. About half of these skins were dark brown, and possibly from chamois. The other half had a paler brown (tan) colour and I thought that these might be from ibex.

Sheepskins with a fleece

Most of the skins (61%) were of Hairy-medium type or coarser, whereas all the textiles were of this type or finer. Only 2% of the skins were of Generalised-medium type; 5% were of true Hairy type. Since the staple tip of black wool usually fades to dark brown during the year on the sheep, it was surprising that many of the skins with black

	All fibres coloured	Mixture of coloured and white (grey)	No colour (white)
Vindolanda	9% (5)	50% (28)	41% (23)
Hallstatt	7% (4)	48% (27)	45% (25)

Table 6. Comparison of natural colours of the Hallstatt skins with those from Vindolanda (Great Britain, Roman)
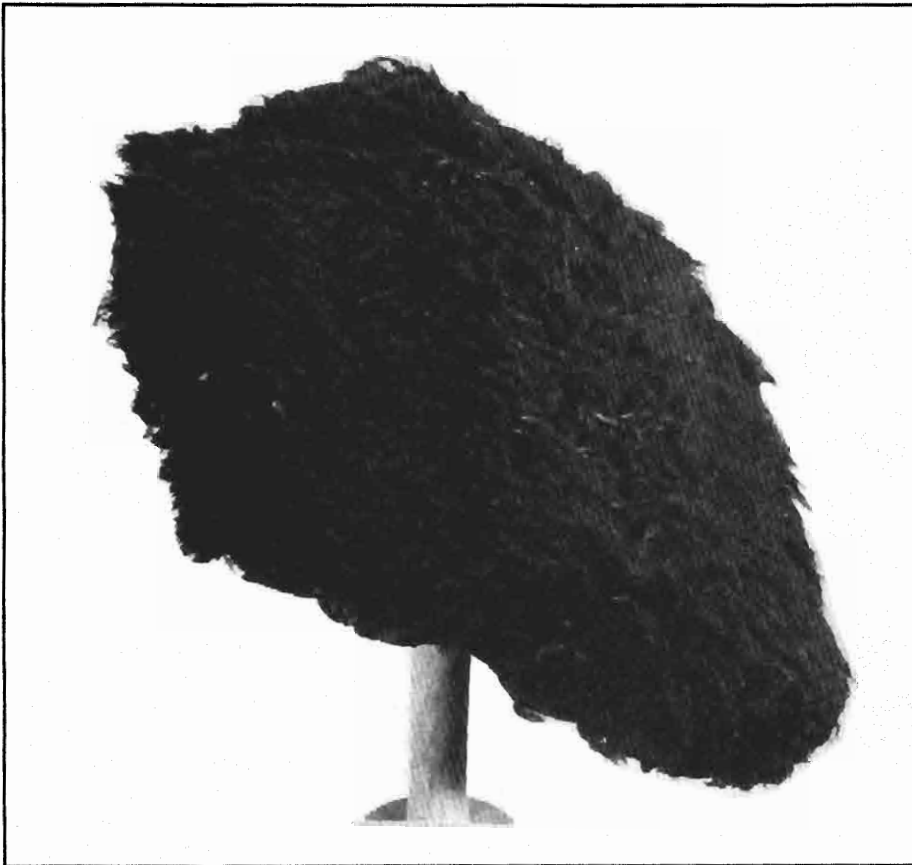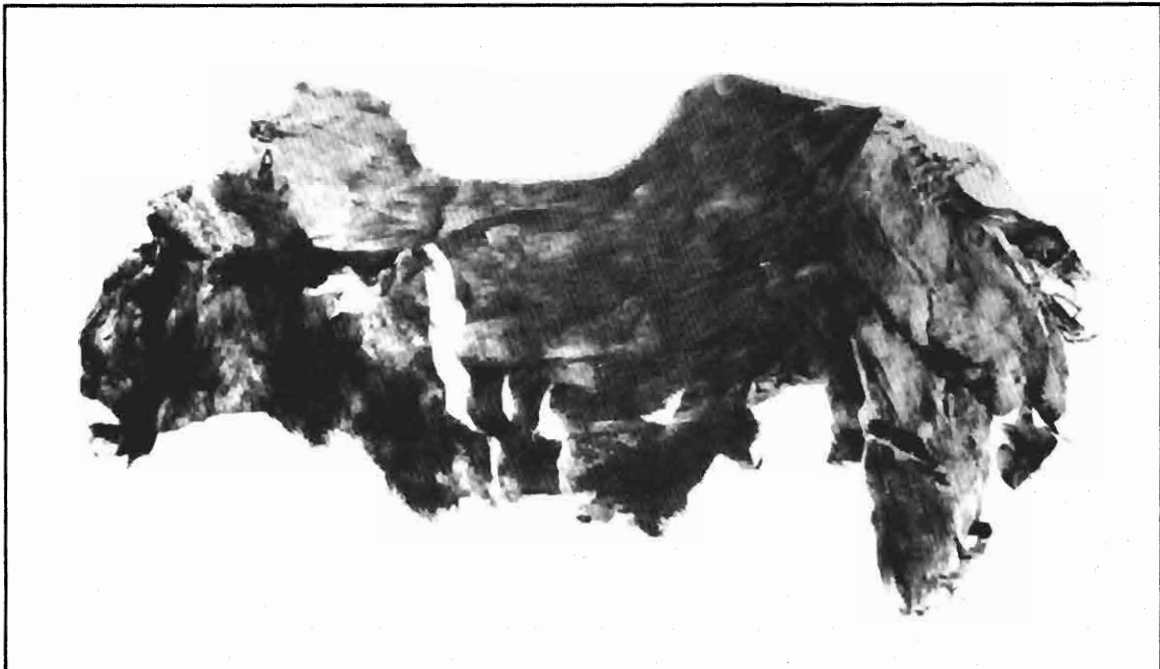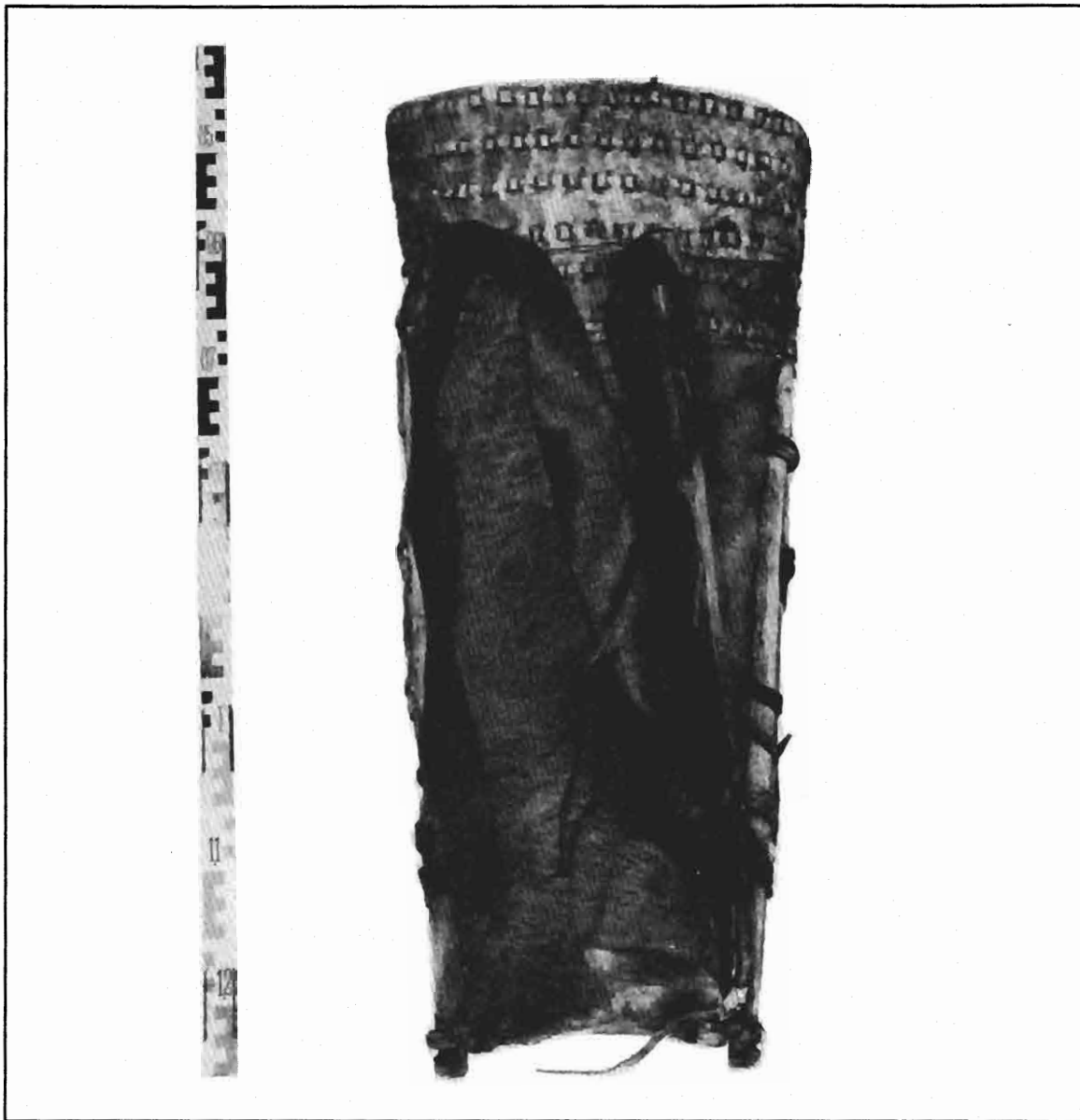
Figure 65. Cowhide spoil carrier (86.599). Copyright: Naturhistorisches Museum, Wien.

wool had not faded. The explanation was breakage of the tip so that the part left was the unfaded base of the wool staple. Where the longer and finer wool of a Hairy-medium fleece had worn away, the hairy fibres remained to give the impression of a short, hairy coat in which it was not easy to see the now even shorter wool.

The berets and the white bag (Fig. 62) had a Hairy-medium type of fleece. A conical hat (museum no. 73.381) has the wool inside and was sewn from several pieces of skin of Generalised-medium as well as Hairy-medium, type. Two black and white sheepskins, which at first sight appeared to be from a piebald animals, on closer inspection were seen to be black skins sewn to a white ones. The wool on the black beret (Fig. 63) had a curl like that in the modern Swedish Gotland breed, one of the apparent survivors from the European Iron Age (Ryder 1983). Most Gotland sheep are now grey, which predominates in Iron Age textiles. The observations by eye suggested that only 5% of the skins had grey wool, but the microscope

revealed that the apparently white wool of some skins had small proportions of coloured fibres, that in cloth would have led to the designation `light grey'. The brown cap (Fig. 61) would in fact have been regarded as brown-grey by microscopic examination alone.

The black beret (Fig. 63), and another sample (75.946b), were identified as Hairy-medium fleeces by eye, but the microscopic measurements indicated that they had a symmetrical fibre diameter distribution more like that of the true Medium type. Since this was the period when such modern fleece types were developing, these samples probably represent a primitive Medium wool at an intermediate stage, but on a different evolutionary line, between the Hairy-medium and tru medium types.

The white bag (Fig. 62) was 95 cm long and was made from an entire skin (removed as a tube) from a small sheep the size of primitive European breeds such as the Gotland. The size of black skin 78.538 was similar—91 cm (excluding the neck) by 60 cm.

Sheepskins with a wild-type coat structure (no fleece)

The 32% of samples without a fleece could be split into 19% (26) that were coloured with a white belly like the `wild' Mouflon and 13% (18) that represented a range of colours. The Mouflon sheep of Mediterranian islands is now thought to be not truly wild, but a feral domesticate from the Neolithic period. The Hallstatt skins with a range of colours therefore confirm that a non-fleeced sheep persisted into the Iron Age. Those with a white belly indicate either that some domestic sheep had the primitive mouflon colour pattern, or that there were feral mouflon sheep in the area. Confusion with ibex and/or chamois is just possible since both have a white belly and some of each species have a black flank band.

Goatskins

Hair and wool fibre diameter measurements of the goatskins showed summer as well as winter coat structures. Skin 75.759 comprised a strip from the white belly, across the dark brown flank to the black line which commonly marks the backbone, the total length being 40

cm. (Fig. 64). This indication of the depth of the body confirms the adult size of the goat, which as with the coat is broadly similar to that of British feral goats. Two-thirds had black hair, a colour that in recent times has been associated with the goats of the Middle East, although certain feral herds, e.g. in northern England, are black.

Only 5% were grey, which is the predominant colour in Scottish feral goats. The other colours recorded are represented today in specific breeds, e.g. dark tan (9%) in the Swiss Toggenburg breed, black with a white belly (7%) in the British Alpine breed, white (9%) in the Swiss Saanen, and light tan (2.5%) in the Golden Guernsey.

Cattle skins

The spoil-carrying bags (Fig. 65) were made from thick cowhide with light brown hair. Each bag had been made from a strip of skin about 170 cm long by 50 cm wide. Since the hair slope was across the strip, the skins had been cut along the backbone, and so two bags could be made from each skin. The length of the strip represents the length of the animal and the width indicates the depth of the flank—in keeping with the size of the small `Celtic ox'.

Small mammal skins

There is no indication of the use of the five skins from small, furred mammals. That skins 75.910 with tan hair, and 78.556 with grey hair, could be from the domestic dog (*Canis familiaris* L.) is suggested by the microscopic appearance and measurments of the hair. The skin and hair characteristics of tan-coloured sample 75.789 and two other tan fragments not studied in detail, suggest a marten (*Martes*) species. Another possiblity is the (tan-coloured) forest dormouse (*Dryomys nitedula*), one of these having been found `mummified' in the mine workings (Morton 1959; Gehlert 1970).

Discussion and conclusions

It is interesting that the recognisable objects were made from cowhide and sheepskin, since traditionally goatskin has given better leather than sheepskin. The sheepskin bag from the East Group is similar to the waterskins still

used in the Middle East, but it has been interpreted as a simpler version of the cowhide spoil-carrying bags (above) from the North Group of finds (Barth 1982). Not surprisingly, fleecy sheepskin was used for the hats and clothing. The berets on show in the museum have the curly wool on the outside and are similar to those worn by shepherds in central Asia today. Some of the skins had been sewn together to increase the size, and although one had a wear pattern suggesting usage as an apron, in general there were no recognisable articles of clothing.

The cattle were brown in colour, going against the preconception from British surviving `Celtic' breeds, which are black, but were small like the `Celtic ox'. Goats were small like feral domestic animals from the past; and sheep were similar in size to the small Iron Age type. Much more coat variation has occurred in sheep which is seen as the development of different fleece types, but the sheepskins were more hairy than the wools found in the Hallstatt textiles. It was evident from the skins that Neolithic sheep without a fleece survived into the Iron Age. Clothing made from this type of skin was reported from the Danish Iron Age by Walton (1988).

Two-thirds of the Hallstatt skins still had the wild-type, white belly colour pattern of the Mouflon of Corsica, which is thought to be a feral remnant of the first domestic sheep of the Neolithic period. The remainder had representatives of all the colours seen in fleeced sheep, except grey: brown, black, white, tan and piebald (spotted). Although change from brown to a range of colours is a feature of Iron Age fleeces there is evidence from Egyptian wall paintings that some breeds acquired a range of colours before the development of a fleece (Ryder 1987). The Hallstatt skins confirm that European sheep without a fleece already included white individuals, although the later selective breeding of fleeced white sheep is likely to have been associated with the development of dyes.

Several aspects of fleece evolution were evident in the Hallstatt material. There were primitive Hairy-medium fleeces (with only kemp and wool, and no medium fibres) representing the first stage of fleece development after the Neolithic coat (Ryder 1988). One of the later stages of evolution evident is that of the true Medium wool. Also evident is the true Hairy type, which is rare in

textiles because of its coarseness (later being used in carpets).

The skin in this unique and important collection of Iron Age livestock remains has elucidated more species and provided more dimensions to add to the fibre diameter distributions used to define the fleece type of the wool in textile remains. It is hoped that this summary of findings using relatively simple techniques will stimulate further investigations as more advanced techniques become available. In particular, DNA studies could be used to check the specific identities in doubt and also to investigate the possiblity that different fleece types might show DNA polymorphisms. Any variations found in the skin and or wool could then be sought among the more numerous and more widespread bone remains.

References

Barth, F. E. (1982). Prehistoric saltmining at Hallstatt. *Bulletin of London University Institute of Archaeology* **19**, 31-43.

Barth, F. E., Felber, H. and Schauberger, O. (1975). Radiokohlenstoffdatierung der prähistorischen Baue in den Salzbergwerken Hallstatt und Durrnberg-Hallein. *Mitteilungen der Anthropologischen Gesellschaft in Wein* **105**, 45-52.

Gehlert, O. (1970). Zwei subfossile Haselmäusenester aus dem Salzberg von Hallstatt. *Kalkberger Korrespondendenz* **178**, 69-73.

Hundt, H.-J. (1959). Vorgeschichtliche Gewebe aus dem Hallstatter Salzberg. *Jahrbuch des Römisch-GermanischenZentralmuseums,Mainz* **6**, 66-100.

Hundt, H.-J. (1960). Vorgeschichtliche Gewebe aus dem Hallstatter Salzberg. *Jahrbuch des Römisch-GermanischenZentralmuseums,Mainz* **7**, 126-50.

Hundt, H.-J. (1967). Vorgeschichtliche Gewebe aus dem Hallstatter Salzberg. *Jahrbuch des Römisch-Germanischen Zentralmuseums, Mainz* **14**, 38-65.

Hundt, H.-J. (1987). Vorgeschichtliche Gewebe aus dem Hallstatter Salzberg. *Jahrbuch des Römisch-Germanischen Zentralmuseums, Mainz* **34**, 261-86.

Morton, F. (1959). *Viertausendfunfhundert Jahr Hallstatt im Bilde*. [Abb. S. 59./figure on p. 59]

Ryder, M. L. (1970). Remains derived from skin, pp. 539-54 in Brothwell, D. R. and Higgs, E. S. (eds.) *Science in Archaeology* (2nd ed.). London: Thames and Hudson.

Ryder, M. L. (1981). Wools from Vindolanda. *Journal of Archaeological Science* **8**, 99-103.

Ryder, M. L. (1982). European wool types from the Iron Age to the Middle Ages. *Archäologische Textilfunde. Textilsymposium. Neumünster. May 1981*.

Ryder, M. L. (1983). *Sheep and man*. London: Duckworth.

Ryder, M. L. (1987). The evolution of the fleece. *Scientific American* **255**(1), 112-9.

Ryder, M. L. (1988). Danish Bronze Age wools. *Journal of Danish Archaeology* **7**, 136-43.

Ryder, M. L. (1990a). Skin and wool textile remains from Hallstatt. *Oxford Journal of Archaeology* **9**, 37-41.

Ryder, M. L. (1990b). The natural pigmentation of animal textile fibres. *Textile History* **21**, 135-48.

Ryder, M. L. (1992). Haired animal skin remains from Hallstatt, Austria. *Oxford Journal of Archaeology* **11**, 55-67.

Walton, P. (1988). Dyes and wools in Iron Age textiles from Norway and Denmark. *Journal of Danish Archaeology* **7**, 144-58.

Eagles in Anglo-Saxon and Norse poems

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The research on which this note is based was undertaken while writing a paper on a skull of a white-tailed eagle *Haliaeetus albicilla* (L)., from Roman Leicester (Baxter 1993) and has been subsequently exapanded with the aid of further references from Dr Susan Limbrey of the University of Birmingham and Dr D. W. Yalden of the University of Manchester.

Reid-Henry and Harrison (1988, 78) state that it is the white-tailed eagle (rather than the golden eagle, *Aquila chrysaetos* (L.)) that is the companion of the raven in Anglo-Saxon and Norse poems as a carrion-feeder at battlefields. There are two kinds of evidence to support this assertion, based on the differences of habit between white-tailed and golden eagles on the one hand, and upon literary evidence on the other. The white-tailed eagle is more sociable than the golden eagle and much more likely to avail itself of carrion, irrespective of season or abundance of live prey (Bannerman and Lodge 1956, 288; Brown 1978, 86; Pycraft in Kirkman 1913, 92). In this, the white-tailed eagle is similar to the bald eagle of North America, to which it is more closely related. Bald eagles are attracted in great numbers to the present-day salmon spawning grounds of Alaska to feed on dead and dying fish. Prior to 1871, as many as forty white-tailed eagles could be seen together, attracted by carrion on the Scottish coast (Bannerman and Lodge 1965, 286). Such flocking by white-tailed eagles is facilitated by their greater sociability than golden eagles and much smaller home range: 600-800 ha per pair for white-tailed eagle, and 4500-5300 ha per pair for golden. The extensive home range required by golden eagles is apparently not determined by the abundance or scarcity of suitable prey (Brown 1978, 86).

White-tailed eagles are much more catholic in their tastes in food than golden eagles and will even eat gulls and the eggs of other birds. In one standard reference work (Cramp 1980, 52), the white-tailed eagle is described as `predator, scavenger and kleptoparasite'. The

marked preference for carrion displayed by this bird compared with the golden eagle is probably related to morphological differences such as greater body weight, more massive bill construction, and inferior aerial performance (Brown 1978, *passim*).

Golden eagles seem always to have preferred upland and mountainous areas and to have had a relatively low population density, even under optimum conditions. Brown (1978, 179) considers that the Scottish population of golden eagles was probably never much larger than it is now and that England and Wales, together, could not have supported more than fifty pairs at any time since the last glaciation. As a lowland and waterside eagle with a small home range and more sociable habits, the white-tailed eagle was probably the more common of the two in the past.

In the Anglo-Saxon poems, the white-tailed eagle is called the *earn*, a word closely related to the Gaelic *erne*, by which the species was commonly known in old ornithological works (e.g. Newton and Gadow 1899; Dresser 1871-81), and the Icelandic *ørn*. Although Gelling (1987, 175) has pointed out that the Anglo-Saxons used the word *earn* indiscriminately—'eagle' being derived from Middle English *egle*, from the Old French *egle* or *aigle* (Martin 1992, 28)—it would seem that it is the white-tailed eagle that is meant in poems such as *The Seafarer*, lines 24-5, where it is described as `with dripping feathers' (Kershaw 1992, 21), or *Elene*, line 11 and *Judith*, line 205, where it is `the dewy-feathered' (Gordon 1962, 211 and 323, respectively), or *The Battle of Brunanburh*, line 63, where it is `the dun-coated white-tailed eagle' (Kershaw 1922, 181, note 63). The trio of the wolf, raven and [white-tailed] eagle is a standard grouping in Anglo-Saxon literature (*ibid.*).

In the Norse (Icelandic) poems, the white-tailed eagle is the *ørn*. Under this name it is mentioned in lines 138 and 182 of *Helgi and Sigrun* (Vigfusson and Powell 1965, I, 136-7), line 58 of *Hialmar's Death Song* (*ibid.*, 163) and lines 66 and 70 of *Atlamál* (*ibid.*, 334), among others. *Arnar* has also been translated as erne (i.e. white-tailed eagle) in some poems, e.g. in line 15 from *Grani-skald* (verses 2, 3 from *Edda*; Vigfusson and Powell 1965, II, 218). The expressions `to give the eagle food' and `feed the eagles' were well known kennings for `kill enemies'. Examples of this are the inscription on the rune-stone commemorating Harald,

Ingvar's brother, at Gripsholm, Kärnbo parish, Södermanland in Sweden:

> *They fared like men*
> *far after gold*
> *and in the east*
> *gave the eagle food.*
> *They died southward*
> *in Skerland.*

(translated by Jansson (1962, 41) and illustrated by Sawyer (1982, pl. IV)), and lines 4-6 of *Olaf of Sweden's Praise*: `Olaf feeds the eagles; the lord of the Swedes is foremost. The erne drinks his supper; the she-wolf laps the blood; the wolf stains his jaws; the eagle gets his meal there.' (Vigfusson and Powell 1965, II, 157).

It is probable that the giant eagle of the wind (*arnar*) in verse 36 of *Vafthrundismál*, named `carrion-gulper' (*ibid*, 66) was a white-tailed eagle and the bird also appears at the end of *The Prophecy of the three Sibyls* (lines 183-4): `The waters are falling, the erne hovering over them, the bird that hunts the fish in [the streams of] the mountain.' (*ibid.*, 628).

The golden eagle is much more difficult to identify in the Norse poems, although there are words that signify `eagle' in general, such as *ari*, which occurs in the children's jingle `An eagle sat upon a rock' (Vigfusson and Powell 1965, I, 400). The recent literature is not always clear, with authorities giving different names. Hence Newton and Gadow (1899, 175) give *Ørn* as Icelandic for *Erne* or white-tailed eagle and Swainson (1885, 136) gives the Danish *Oern*, while Dresser (1871-81) has for the white-tailed eagle the Danish *Havørn* or *Fiskeørn*; Icelandic *Œrn*; Norwegian *Havœrn*; Swedish *Hafsörn*; and Gaelic *Erne, Joliar-Bhuidhe* and *Joliah-Riamhach*. For golden eagle, Dresser (1871-81) gives Gaelic *Iolair dhub*; Danish *Steen-arend*; Norwegian *Kongeörn, Stenörn*, and *Fjeldörn*; and Swedish *Kungsörn*.

The golden eagle does not occur in Iceland, while the white-tailed eagle does, and was once common (Cramp 1980). To an Icelander, *Ørn* would be the white-tailed eagle and the Norse poems as they have come down to us are Icelandic creations. The prefixes to the bird names in the modern Scandinavian languages where the particular eagle is identified as `fish' eagle, `king' eagle, or `stone' eagle, etc., do not figure in the sagas and cannot be used as an aid to identification. It seems reasonable to conclude, therefore, that the linguistically

related names *Earn* and *Ørn* in Anglo-Saxon and Norse poems generally refer to the white-tailed eagle, *Haliaeetus albicilla*.

A most interesting paper by Gelling (1987) draws attention to the topographical nature of Anglo-Saxon place names in which *earn* is the first element. Many of these have as their second element words indicating woodland, particularly *lēah*. Most of the names referring to woodland eagles are inland locations situated near major rivers, including the Thames, Severn, Mersey, Ribble and Don. Others relate to lesser rivers, and include Arley (*Earn-lēah* = `eagle clearing') in Warwickshire, between the Rivers Anker and Tame, close to the Roman site of Mancetter and not far from Leicester. Such locations would have been ideal nesting sites for white-tailed eagles, which seem to have had a widespread distribution in wooded riverine and lacustrine habitats in England during Anglo-Saxon and earlier times.

Gelling (1987, 176) notes that these woodland names and others referring to more open and upland areas have a complementary distribution and speculates that the two groups may indicate the former presence of different kinds of eagles. Certainly, there are records of golden eagles resident in the Peak of Derbyshire, the Lake District and the Cheviots in the past and of vagrants occurring in Sussex, Berkshire, Norfolk, Lincolnshire and Northamptonshire (Newton and Gadow 1899, 179; Witherby 1939, 40). However, the white-tailed eagle is also on record as having formerly bred in the Lake District and on Dartmoor (Newton and Gadow 1899, 175; Bannerman and Lodge 1956, 286) and a certain amount of overlap in distribution is to be expected. For example, the present author finds it difficult to accept uncritically that the eleven Devonshire names listed by Gelling which have suffixes indicative of valleys or high places necessarily relate to the golden rather than the white-tailed eagle in view of the proximity of the coast, of major rivers such as the Taw and Dart, and of the presence of the latter species in the area in relatively recent times. These could also be the former haunts of white-tailed eagles.

There seems little doubt, in view of the additional information given above, that the Leicester specimen was a resident in Roman times and that the species had a much more widespread inland distribution in Britain in the past, being pushed out towards the coast and extinction with the expansion of human population and habitat destruction. The popular name `sea eagle' reflects the final status of the species as a British resident and the more scientifically correct name white-tailed eagle should be applied throughout its temporal span.

References

Bannerman, D. A. and Lodge, G. E. (1956). *The birds of the British Isles*. V. Edinburgh and London: Oliver and Boyd.

Baxter, I. L. (1993). An eagle, *Haliaeetus albicilla* (L)., skull from Roman Leicester, England, with some speculations concerning the palaeoecology of the Soar valley. *Circaea, The Journal of the Association for Environmental Archaeology* 10 (1), 31-7.

Brown, L. (1978). *British birds of prey*. London: Collins.

Cramp, S. (ed.) (1980). *Handbook of the birds of Europe, the Middle East and North Africa. The birds of the Western Palearctic*. II. Oxford: University Press.

Dresser, H. E. (1871-81). *A history of the birds of Europe. Including all the species inhabiting the western Palaearctic region*. V. London: H. E. Dresser.

Gelling, M. (1987). *Anglo-Saxon eagles*, pp. 173-81 in Turville-Petre, T. and Gelling, M. (eds.) Studies in honour of Kenneth Cameron. *Leeds Studies in English. New Series* **18**. University of Leeds.

Gordon, R. K. (1962). *Anglo-Saxon poetry*. London: Dent.

Jansson, S. B. F. (1962). *The runes of Sweden*. London.

Kershaw, N. (1922). *Anglo-Saxon and Norse poems*. Cambridge: University Press.

Kirkman, F. B. (ed.) (1913). *The British bird book*. London and Edinburgh: P.C. and E.C. Jack.

Martin, B. P. (1992). *Birds of prey of the British Isles*. Newton Abott: David and Charles.

Newton, A. and Gadow, H. (1899). *A dictionary of birds*. London: Adam and Charles Black.

Reid-Henry, D. and Harrison, C. (1988). *The history of the birds of Britain*. London: Collins with Witherby.

Sawyer, P. H. (1982). *Kings and Vikings*. London: Methuen.

Swainson, C. (1885). *Provincial names and folk lore of British birds*. London: Trubner and Co.

Vigfusson, G. and Powell, F. Y. (1965). Corpus Poeticum Boreale, *the poetry of the Old Northern Tongue from the earliest times to the thirteenth century*. I, II. New York: Russell and Russell.

Witherby, H. F. (ed.) (1939). *The handbook of British Birds*. London: Witherby.

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A method for the preparation of very small animal skeletons

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David and Payne (1992) describe a variety of methods by which the skeletons of animals can be prepared. These include maceration, simmering in water and, in one instance, immersion in the waters of a Greek harbour, where small carnivorous organisms will deflesh the specimen. This is reminiscent of Bolin's method (quoted by Casteel 1976) in which marine isopods of the American Pacific coast would clean a fish in only 24-42 hours.

At the risk of spoiling the opportunities that zooarchaeologists have to claim travel grants to Greek harbours and the Pacific USA for specimen preparation, I have found that other, more local organisms can be used to achieve an excellent result in cleaning the skeletons of very small animals. While simmering or burial work well for larger specimens, small fish of <15 cm length, or small birds or mammals, present a tedious job in extracting the small bones from fish or vole soup. To avoid this, it is worth enlisting the help of tadpoles.

Tests were made in a small garden pond which contained an abundant spring population of both common frog (*Rana temporaria* L.) and common toad (*Bufo bufo* L.).

The tadpoles of each species emerge from the spawn in spring, and soon become enthusiastic carnivores. A small specimen of the gudgeon, *Gobio gobio* L., measuring 10 cm from the nose to the tail fork, was perfectly prepared in about 10 days. Similarly, small birds robin or sparrow size are quickly cleaned. In the case of birds and mammals, an additional incentive can be given to the tadpoles by skinning the specimen; in the case of small fish, the abdominal cavity can be opened. The specimens are placed in a small metal container such as a food tin, with its sides perforated with 6-8 mm holes above the level of the specimen. A small piece of 10 mm mesh prevents the specimen from floating. The container is suspended a few centimetres below the water surface. Tadpoles locate this food source within a few minutes. The skeletons are thoroughly cleaned by these industrious amphibians, and by observing the process frequently, perfectly clean but articulated skeletons can be obtained. These are easily disarticulated if separated bones are needed.

Tadpoles feed with horny jaws, though the microscopic examination of very small fish bones does not show any abrasion to the bone surface. The rate of growth and subsequent metamorphosis in tadpoles are both food- and temperature-dependent. At high populations densities, metamorphosis takes several months, though it is probable that an abudant food supply in the form of your comparative specimens would shorten this time. The desired small animals could be stored in a freezer until the processing season.

By this method, the zooarchaeologist may save much frustrating work in cleaning small specimens, and assist, too, in the propagation of our increasingly urbanised amphibians.

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What are we measuring?

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When I began studying animal remains from archaeological sites it was common for archaeologists to keep only a few examples of any bones found for identification and subsequent listing in the excavation report.

The amount of information that could be gained from the wider studies of bones that are now routine was not appreciated. I was an early advocate of more detailed study including, of course, the measurement of bone remains from livestock (Ryder 1958), but later, daily contact with animal geneticists, who commonly held the view that archaeozoology was impossible (because one could not replicate the findings), led me gradually to question the way in which bone measurements could be interpreted.

In a discussion of the problem (Ryder 1982, 21), I pointed out that there have been virtually no studies of variation in the size and proportions of the skeleton either between or within modern breeds of livestock, and I cautioned that it is going to be an enormous task to distinguish differences in size that reflect breed from within-breed variation related to sex, diet or genetic variation. Ten years on, Geist (1992) makes the same point more strongly, and in a more sophisticated way, in order to stress the difficulty of using metrical criteria to identify animals suspected of being killed in contravention of conservation laws. The fact that his discussion refers to wild animals strengthens rather than weakens the argument. I quote his statement in full:

`A fatal flaw in much large-mammal taxonomy is the use of comparative morphometrics as a taxonomic tool. Comparative morphometrics of crania or skeletons of free-living populations can no more be used to measure taxonomic (genetic) differences than a rubber band can be used to measure distance. Every set of compararable measurements conceals genetic, epistatic, environmental and statistical variation. That is, the gross variation is a mixture of different types of variation, within which the genetic variance is undefined. It remains indefinable, despite various approximations. Comparative morphometrics as a taxonomic tool is logically flawed. It confuses phenotype with genotype, analogy with homology, ecotype with taxon, and does not reveal the taxonomic and evolutionary differences between the populations compared. The origins of the differences revealed remain obscure.*

This flaw is not uncommon in other branches of biology when quantitative comparisons between populations are used to bolster evolutionary analysis. Such comparisons are futile if the proportion of variance attributable to heredity is unknowable. The closer the relationship between populations of a given form, the more speculative must be the conclusions about evolutionary

relationships, because large phenotypic differences can arise from closely related phenotypes in different environments. Taxonomic or evolutionary differences in close relatives should be studied experimentally provided [the] different variables affecting ontogeny are subject to effective control.'

This does not mean that we should stop measuring bones—remember all those frustrating reports from the early years in which no measurements were given—but rather that we should be more cautious about how we interpret changes in animal size between periods. Some people might prefer a genetic explanation resulting from a change of breed. Others might think that a change in the plane of nutrition was the cause. The true reason is likely to be more complicated. The application of statistics to archaeozoology is in its infancy. The investigation of biochemical polymorphisms (blood types and DNA) in bones is only just beginning. A full interpretation of metrical variations in bones must await evidence from these and other techniques as yet undiscovered.

References

Geist, V. (1992). Endangered species and the law. *Nature (Lond.)* **357**, 274-6 (28 May).

Ryder, M. L. (1958). Animal bones in archaeology. *New Scientist* **3**, 27-9.

Ryder, M. L. (1982). Sheep—Hilzheimer 45 years on. *Antiquity* **56**, 15-23.

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Sheep fleece and bird legs: a pathological observation

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Introduction

In a recent systematic programme to improve and enlarge the comparative collections of the Environmental Archaeology Unit, numerous specimens of mammals and birds have been

Figure 67. As Figure 66, posterior aspect.

Figure 66. Modern curlew tarsometatarsus, anterior aspect, showing prolific bony growth at the distal end of the shaft, and associated phalanges showing other evidence of infection.

acquired and prepared using the methods outlined by Davis and Payne (1992).

As part of this programme, a trip to my old home on the island of Hoy, in the Orkney Islands, Scotland, enabled me to collect the carcasses of a number of seabirds, waders and wild geese, which were brought back to York for preparation. Of these, two curlews (*Numenius arquata* (L.)) proved of particular interest since they both exhibited a distinctive pathological condition which may possibly be recognised in archaeological bird bone assemblages.

Figure 68. Modern curlew tibiotarsus anterior aspect, indicating loss of limb and subsequent remodelling of the bone.

Figure 69. As Figure 68, medial aspect. Note tapering of distal callus.

The material

Specimen 1 shows evidence of quite excessive 'periosteal new bone' growth or osteophytic apposition in a fairly localised area above the distal articulation of the left tarsometarsus (Fig. 66). The morphology of this localised lesion shows a marked flattening on the anterior surface and a distinctive groove running horizontally through the middle of the lesion on the anterior, medial and lateral aspects, the posterior surface seeming to be

little affected (Fig. 67). In addition there appears to be associated degeneration of the distal articular surfaces, the medial trochlea most severely affected, and more generalised periosteal new bone development along the shafts of the associated phalanges (Fig. 66). This type of lesion is very reminiscent of that caused by the practice of 'hobbling' or tethering larger domestic mammals.

Specimen 2 shows the complete absence of the distal third of the left tibiotarsus with, instead, a large rounded bony callus evident at the

most distal point (Fig. 68). The morphology of the callus exhibits a very rounded appearance on the anterior and distal surfaces with a noticeable tapering towards the posterior aspect (Fig. 69). It appears from the evidence that the distal portion of the leg has been lost, perhaps the result of some specific traumatic event, and the extent of subsequent remodelling of the bone indicates that the individual survived for some considerable time.

Aetiology

The aetiology of these lesions is relatively straightforward and involves the `tourniquet-like' effect of sheep wool. Its presence was clear from the unprepared carcase of specimen 1 where a `knot' of fleece of fairly long staple length was noted around the area of the left tarsometatarsus previously described. In this case it is clear that the pressure exerted by the tightening knot irritated the periosteum thus stimulating osteoblast activity in a very localised area of the shaft. It appears that there was little or no associated infection since adjacent areas of shaft show no signs of any diffuse new woven bone. The more general-ised infection that appears to be evident on the phalanges is likely to have been a direct result of accidental trauma associated with the semi-immobilisation and possible loss of sensation in the limb below the knot. It is likely that a slow necrosis of the distal portion of the shaft and leg was occurring which, if prolonged, would have resulted in rarefaction of bone in that isolated region of the shaft. This would render the bone far more prone to fracture during normal use, leading ultimately to the loss of the limb below this region.

This is exactly what appears to have occurred with specimen 2, whose owner had survived much longer, as shown by the substantial remodelling of the affected region. The flatter and more rounded areas are located on the anterior surface whilst the more pointed and less well modelled areas are toward the posterior surface. The tapering seen on both specimens is almost certainly a direct result of differential pressure exerted on the shaft the tightening of the knot during forward loco-motion. The trailing knot of fleece would almost certainly snag on vegetation, for example, leading to a compensatory action by the bird which would exert more force in pulling the leg forwards, producing more pressure on the dorsal surface and less on the plantar.

Interpretation and archaeological implications

During the period in which I lived at the southern end of Hoy, on the island of South Walls, I often observed large flocks of waders feeding in fields used primarily for grazing cattle and sheep. This usually occurred during or immediately after spells of bad weather and during the nesting season. Numerous un-improved and semi-improved sheep breeds (particularly coloured Shetlands and Shetland cross-breeds) are kept by a number of farmers on the island in addition to, and sometimes instead of, the more improved modern breeds. During the late spring and early summer months the fleeces of these unimproved sheep `rise' and if not plucked, sheared or collected will gradually fall off in small clumps and remain in the fields. Much is caught on vegetation (particularly thistles) or is blown onto barbed wire. It is at this time that the waders, particularly curlews and oyster-catchers, are at most risk. I have observed a number of birds with sheep fleece wrapped around one or both legs and once had to `despatch' an oystercatcher, both of whose legs were fractured in exactly the region affected by the fleece and hanging on only by soft tissue.

The condition was observed quite commonly, usually affecting medium-sized waders and some smaller species. It occurs only at a particular time of the year and is associated with the presence of domestic unimproved or semi-improved sheep, whose fleeces, being of limited economic importance, were mostly left to rise and disperse naturally.

With the refinement of systematic recovery procedures, more useful assemblages of bird bones are likely to be obtained and the condition discussed here may well be recognised. It may provide an insight, albeit tentative and somewhat second-hand, into one aspect of sheep husbandry from coastal settlements.

Reference

Davis S. and Payne S. (1992). 101 ways to deal with a dead hedgehog: notes on the preparation of disarticulated skeletons for zooarchaeological use. *Circaea* **8**, 95-104.

Disk copy received October 1992

Conference review

ICAZ Bird Working Group—first meeting, Madrid, Spain, 7-10 October 1992

The first meeting of the ICAZ Bird Working Group was held at the Universidad Autonoma de Madrid. It was organised by the continually effervescent Arturo Morales and his colleagues at the University who managed to ensure that things ran exceedingly smoothly. They provided a non-stop and highly efficient taxi service from the hotel to the university and back in everything from a Porsche turbo to Arturo's battered VW Beetle. They also arranged an excursion to the archaeology museum in central Madrid, as well as a visit to their new departmental offices, laboratories and, most importantly, comparative collections.

The meeting attracted a number of aviophiles from a range of countries as far afield as Canada, Sweden and Israel, and a rather large contingent from Britain.

Accommodation and victualling for delegates revolved around a seven star establishment, according to the logo and sign over the foyer. It was in fact the hotel of a large training college for budding catering stars and we were their captive 'guinea-pigs'.

Not being used to this kind of decadence, I found the accommodation quite splendid, clean and modern, if a bit clinically sparse. An en-suite bathroom, complete with bidet or executive drinking fountain, was an added luxury. The food was, in my opinion, excellent —served with verve by shifts of keen students whose occasional understandable mistakes lent an air of 'Fawlty Towers' to the proceedings. This was a great relief from the usual horribly formal atmospheres of hotels and restaurants. The catering devotees had obviously been briefed about zooarchaeologists' penchant for alcohol and I was more than pleased to see my wine glass refilled at every opportunity. They had obviously been recently shown a brash method of pouring liquids which, unfortunately, a number had not quite mastered, resulting in some liberally splashed table cloths and laps.

The only major gripe was the bar—or the lack of one, to be more precise. It did exist but appeared to be permanently closed at night and rumoured to be open during the day—not much good for thirsty delegates five kilometres away. Sterling efforts in tracking down a nearby off-licence by Anton Ervynck, Dick Brinkhuizen and colleagues (collectively known as the 'Benelux Boys') ensured that the evenings were well lubricated.

The serious part of the conference was opened by Arturo Morales who announced to the world that he did not like birds, thought domestic mammals were tedious, and much preferred to work with fish, which were in his opinion less problematic to identify. Strenuous cries of protest followed but soon subsided during the remainder of his animated talk in which it became obvious that he was playing the role of devil's advocate. He skilfully addressed a number of important issues such as the limitations of small reference collections and small assemblages, and highlighted a number of problems involved when using modern analogues and models for archae-ological interpretation. His story of a friend's mother's lettuce-eating pet kestrel was definitely the highlight for me. This introduction stimulated much debate and set the scene for the rest of the conference.

The first session was launched with a fascinating paper by Angela von den Driesch on her work on the vast quantities of mummified bird bones from the temple of Tuna-el-Gebel, in Egypt. Despite the ravages of time, pillagers, tourists and the Egyptian Department of Antiquities, a vast dataset is being recorded. She alluded to some fascin-ating and tantalising preliminary information about the range of species used in religious rites, probable management of local bird sanctuaries, and how and at what time of year these birds were collected.

A number of papers had a strong method-ological theme. Norbert Benecke discussed a biometrical study of chickens using multivariate statistics, including principal components analysis, to try to separate hens, cocks and possible capons in material from archaeological assemblages and modern comparative specimens. Comparison of results and interpretations were problematic, not least because not all assemblages were directly comparable in terms of recovery techniques and hugely variable numbers of bones.

Don Brothwell carried the palaeopathological torch by highlighting the range of conditions which have been and are likely to be identified in archaeological bird bones and what they may imply about husbandry practices.

Darlene McCuaig-Balkwill's paper showed the fundamental problems of using a whole range of biometrical criteria to identify closely-related species of the subfamily Tetraoninae (grouse and relatives). Attempts by Eitan Tchernov during the discussion to isolate some functional differences, i.e proportions of distal wing elements, were valid—although they didn't help much with disarticulated archaeological material.

Moving away from bones, a study of eggshells, carried out by Jane Sidell, provided a fascinating insight into the potential of such material in archaeology. Basic identification appears relatively straightforward using scanning electron microscopy and Jane provided an example from Freswick, North Scotland, where the identification of quantities of fulmar (*Fulmarus glacialis*) eggshell indicated the presence of nearby breeding colonies otherwise unrecorded in living memory. Although major interpretative problems remain, and much more work is needed on modern comparative studies, it was suggested that it may be possible to establish whether an egg has hatched, something which would have considerable interpretative value. In any event, Jane is assured of receiving all our unwanted eggshell!

A number of papers reviewed some very broad ornithopaleoecological data from the northern hemisphere. Cecile Mourer-Chauvire detailed our present knowledge of the Pleistocene avifaunas of Europe (no mean feat in 45 minutes), whilst Leif Jonsson reviewed the somewhat sparse evidence of bird remains from prehistoric sites on the Swedish west coast and tried to highlight the possible reasons for the appearance and disappearance of certain species. He suggested that both climatic and, more importantly, associated eustatic and isostatic sea-level changes, dictated the biotopes available to birds, particularly the waders and gulls. Some interesting corroborative evidence was available from the presence of large numbers of fish remains, particularly of the bogue (*Boops boops*), a species only found today as a vagrant, but present at a Neolithic site in Jonsson's area.

Per Ericson provided an outline of the history of the Swedish bird fauna, similar in its coverage to that by Leif Jonsson. An important aspect of Ericson's talk concerned the compilation of a database of 75% of all archaeological bird analyses from Sweden to date. Such databases are something which we all should be working towards, and certainly not just for bird bones.

Papers dedicated to the study of archaeological bird bone assemblages were numerous and varied. Two contrasting papers from Kevin MacDonald dealt with the bird remains from Haua Fteah in Libya and the geese from medieval Dublin, Ireland. Haua Fteah, although producing quite a small assemblage, yielded some interesting palaeozoogeographic and environmental data, as evidenced by the changing frequencies and diversity of bird taxa, some now alien to the region. The study of material from medieval Dublin attempted to establish whether the majority of goose remains were of domestic or wild stock through biometrical means. This was less conclusive since medium-sized domestic breeds and wild grey lags are indistinguishable on size alone. Much larger sets of modern biometrical data than those presented are needed to make any real progress on this problem.

Dale Serjeantson presented a fascinating paper on a very strange assemblage from Iron Age Haddenham in Cambridgeshire, England, which was dominated by swans, ducks, coots and pelicans, and interpreted as a specialist wild-fowling centre. Anneke Clason detailed some of her work in the Netherlands, suggesting a possible example of prehistoric taxidermy, whilst Wietske Prummel tried to present a survey of bird bone assemblages from numerous Roman and later sites also in the Netherlands. Her interesting paper was prematurely cut short by the intervention of university electricians who decided to shut off the power to the whole building at 7 pm for maintenance.

A pleasant interlude from the round of papers was Wietske's video of modern wild-fowling techniques in the Netherlands, which involved the complicated use of sprung trap nets, and model and live decoys. Thankfully, these birds were only caught for ringing and then released. The video certainly reinforced just how much skill, thought, time and effort were involved in this somewhat unreliable procurement system.

Christine Lefevre presented some preliminary results of the bird bone assemblage from midden deposits on Buldir Island in the Aleutians. Her vivid descriptions of trips to Patagonia and the Aleutians over lunch that afternoon certainly stirred up my own hankerings for travel.

A rather animated talk was given by Anton Ervynck on bird bone assemblages from medieval Flanders. I was gratified to realise this was a man after my own heart, since the crux of his paper was a healthy scepticism of interpretations based on comparisons of assemblages which had been recovered by a whole range of techniques. At last, someone who actually mentioned sieving!

Eitan Tchernov's paper on the exploitation of birds in the Natufian and early Neolithic of the southern Levant was one I was particularly interested in hearing, having worked on material of similar date from several sites in Northern Iraq. It was a little disappointing, however, since it seemed to be a somewhat standard lecture on the shift to 'broad spectrum economies' during this period with little that was very new. It also had a slightly isolationist slant, subtly implying that these events began, and were confined to, the Levant, which patently was not the case. However, Eitan provided a detailed account of the possible effects of intensive exploitation of resources around a permanent settlement as well as offering evidence that these were the cradles of speciation of the house mouse (*Mus*) and house sparrow (*Passer domesticus* (L.)).

In a similar vein, Zlatozar Boev postulated the classification of different sites based on the proportions of synanthropic and 'syn-urbanistic' birds present in the assemblage. He went on to detail the results of such a study of 23 different sites in Bulgaria, dating from the Bronze Age to the late medieval period.

A broad cultural slant was given by two short papers by Roel Lauwerier and one by Ellen Vreenegoor. The discovery of a near-complete Roman 'cork-ware' pot from the Netherlands containing the remains of 30 briskets of song thrush (*Turdus philomelus* Brehm.) is a rare example of direct archaeological association. It appears that this pottery type, where rim fragments are often found together with evidence of pitch, were used for long-distance storage of perishable items, the fabric originating in Belgium or the Eiffel district of Germany. Roel suggested that the Romans may well have begun the tradition of eating song birds, an interesting pedigree for this disgusting habit. His other paper dealt with a re-interpretation of the bird and other offerings often found in Roman graves. He suggested, quite rightly, that the preponderance of chicken and pig bones, and their association with the sex of the individuals buried, may mask the true picture. The numerous empty plates in the graves may equally have been laden with huge fillets of beef or other organic remains which leave no trace.

Ellen's stimulating paper on bird fibulae from the Roman and early medieval periods dealt with both their functional and possible symbolic aspects. She presented a whole range of bird 'shapes' and discussed how these may have had both religious and socio-economic significance through time.

It was decided at the round-table session at the end of the conference to instigate a newsletter for the bird working group. In this it is hoped to keep everyone informed of projects and research, publish lists of comparative collections and relevant publications, requests for help, information, data, etc. This will be a positive move and should stimulate much co-operation between individuals and institutions.

Everyone thought the gathering was a great success (even Arturo, who unfortunately likened the experience to 'being at your own wedding'). This was one of the most enjoyable and stimulating conferences I have been to in a long while, the kind from which one returns itching to do something—in this case to start measuring bird bones. It was just the right size to keep everything on an informal and very sociable basis and this meant that you could meet and talk with most people at leisure. It also encouraged frank and diverse questions and discussions during papers and later over lunch and dinner. I, for one, was very glad of the opportunity to meet colleagues from a range of other countries, since we are all too often ignorant of each other's work. I very much look forward to the future exchange of information the proposed newsletter will offer and congratulate the organisers for setting the wheels in motion and oiling them so well.

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Book notices and reviews

Bell, A. D. (1991). *Plant form. An illustrated guide to flowering plant morphology.* Oxford, New York, Tokyo: Oxford University Press. 341 pp. + 315 figs. ISBN (paperback) 0 19 854219 4; £25.00.

In introducing this enormously useful and beautifully produced book, I can't do better than reproduce two quotations. The first is from the first edition of 'Willis' (1897), quoted by Bell before his preface: *'The study of the external features of plants is in danger of being too much overshadowed by that of the internal features. The student, when placed before the bewildering variety of forms does not know where to begin or what to do to acquire information about the plants'.*

Nearly a century later, that danger is surely *more*, not less serious? The second quotation is offered by Bell in the preface itself and is from his namesake, Professor P. R. Bell (1985): *'In recent years the spectacular advances in molecular biology have generated such excitement that there has perhaps been a tendency for organisms to be overlooked. Biology must nevertheless remain "organismic", and the researcher who loses the concept of organisms seriously weakens his claims to be a biologist'.*

That said, Adrian Bell gives us a book which he hopes is *'attractive, the better to woo the budding botanist and the curious amateur plantsman'.* This botanist, though no longer budding (indeed, increasingly deciduous!) was certainly wooed—and won.

The guide is, in essence, an illustrated dictionary and like all good dictionaries it is the sort of book to pick up to answer a particular question and to put down only when a more urgent matter calls.

The first section deals with the morphology of leaves, roots, stems and reproductive organs, the second with developmental aspects of plant growth (in which, as Bell puts it, *'the organs of a plant are progressively accumulated'*). This is, above all, as visual exposition on one corner of botany and the book is superbly illustrated both with colour photographs (taken, with one exception, by the author), and with line drawings by Alan Bryan, which are of excellent clarity, even where a great amount of detail is shown. Comprehensive cross-referencing using page numbers as figure numbers allows the user to steer around the

book more easily and to track down quickly more detailed information or explanation of a term or concept, and it also provides the basis for an extended 'dip' into the book.

The coverage is worldwide, so many plant forms will be unfamiliar to botanists primarily concerned with N. Hemisphere temperate floras, for example (keen gardeners—and the author's *curious plantsmen,* and especially those who grow houseplants—will, however, be familiar with many of the more 'unusual' forms). As the book's subtitle indicates, only flowering plants are considered, though a reader opening the book at pp. 210-1 could be forgiven for thinking that algae and lichens had found their way in, for on these pages are some delightful plants described by Bell as 'misfits'—*'a few plants'* which *'are evolving forms that cannot sensibly be accommodated in traditional descriptions'* such as Sach's classical quadripartite division of plant organs into stems, leaves (including leaves modified to form flower parts), roots and hairs.

We appear to have strayed a long way, here, from archaeology or, indeed, archaeobotany; but all of us who investigate 'bits of dead plants' must at one time or another have wondered whether we were identifying the *part* of the plant correctly (indeed, one of our commonest *faux pas* is to term as seeds those propagules more correctly called fruits). When we use a key to identify a living plant whose 'seeds' we collect for reference purposes, how sure are we that we understand terms like trichome or cicatrice? Can we tell a rhizome from a root? Do we know why one fruit is a lomentum, another a samara, and a third a drupe (though ironically, *cypsela*, a term introduced to me by Gay Wilson when I was making my first faltering identifications of 'seeds' over a decade and a half ago, is frustratingly missing from Bell's section on fruits and seeds).

I might add that I wasn't taught much about plant morphology either at school or university, 20 and more years ago, and I can't believe that anyone has taught it in any great detail in more recent times. I make no apology for recommending archaeobotanical colleagues to have access to a copy, and to all other colleagues to enjoy it as a work of art, if nothing more. My only cavil is at the shape of the book: with a 'landscape' format it sits a trifle uncomfortably on the shelf. With so many plants having their long axis in the

vertical, it seems a mite capricious to illustrate a book with pages wider than high!

References

Bell, P. R. (1985). Introduction, in Arber, A., *The mind and the eye. A study of the biologist's standpoint.* (reissue of 1954 edition, with an Introduction). Cambridge: University Press.

Willis, J. C. (1897). *A manual and dictionary of the flowering plants and ferns.* 2 vols. Cambridge: University Press.

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Postscript, June 1993: When I bought this book in 1992, there were hardback and paperback editions. The latter, a copy of which I bought, was £19.50, the hardback £20-something. On checking the price of the hardback edition for this review, I find that it appears no longer to be available; the paperback edition is now £25.00!

Hillson, Simon (1992). *Mammal bones and teeth. An introductory guide to methods of identification.* London: Institute of Archaeology. 64 pp. + 59 figs. ISBN 0 905853 30 X. £22.50

In this manual, Simon Hillson provides aids to the identification of the teeth and bones of the large mammals most commonly found on archaeological sites in Europe. These are horse, cattle, bison, sheep, goat, dog, cat, human and European deer (although the elk and the reindeer are rather oddly called by their American names of moose and caribou). The work is intended for beginners in comparative osteology and, as Hillson stresses, it should not be used on its own but always with named reference material. I believe that the manual will fulfil this function admirably. The writing is lucid and Hillson has made a brave attempt to unravel the complexities of planes and names for parts of the bones. I wonder, however, about his preference for some little-used terms, for example 'palmar' and 'plantar', and why he does not refer to the anterior and posterior sides of a bone? The line drawings are very clear and the inclusion of the patterns of root sockets for the teeth

will be particularly useful as these are not often given in identification keys.

Having written these words of praise, I should now like to digress a little on some general aspects of the identification of animal remains from archaeological sites: pattern recognition is the basis of all systematic classifications, whether of sherds, fossils, or living plants and animals. The ability to compare like with like, to assess variations, and to evaluate important differences, Øs Øntegral to all research in archaeology and the life sciences. It is therefore not surprising that so much effort is put into the production of identification keys. But identification of a specimen is not in itself enough—it must be named and it must be given a context. The use of names that are consistent and easily understood is of the utmost importance and, regrettably, Hillson's manual , lapses in this respect (p. 1), for he has misunderstood Corbet and Hill (1986) who he claimed use the same Linnaean name for the wild species, say of the wolf (*Canis lupus*) as for its descendant the dog (called by Linnaeus *Canis familiaris*). Corbet and Hill do not use the same name, but even if they did it would be a great mistake: take for example, a Japanese archaeozoologist trying to understand the report in English on finds of dog and wolf together at Star Carr. How could these canids be distinguished if both were called *Canis lupus*? What Corbet and Hill (1986, 6) actually wrote was this:

...since clearly distinguishable domesticated forms do not in fact interbreed with the wild species to the extent of losing their separate identity (even though they are potentially capable of doing so), they should not be considered a part of the ancestral wild species and consequently the names applied to domesticated wild forms should not be used as the names of the wild species. Only the wild species are listed here, but any domesticated derivatives are noted after the range.

Hence *Bos primigenius*
        (*taurus*)

Further discussion on the use of Linnaean names for domestic animals is given by Clutton-Brock (1987, 194-7) and Corbet and Clutton-Brock (1984, 434-8).

Leaving nomenclature and looking back on more than thirty years as an archaeozoologist, I am reminded that Ian Cornwall's *Bones for the archaeologist* was first published in 1956, the year before I began work for a Ph.D. under F.

E. Zeuner, at the newly-built Institute of Archaeology in Gordon Square. Since that time the study of animal remains from archaeological sites has become a science in its own right, practised by more than 600 people all over the world. Cornwall's book is not cited in Hillson's new manual and it is unlikely that many students refer to it today. At the time of its publication, I did not have a very high regard for the book; the illustrations were small and over-shaded and the 255 pages of writing seemed to be too descriptive and rather elementary.

Strangely, today, Cornwall's book appears to me to be far-sighted and densely packed with information that would be useful to students in many fields of work. Perhaps the title was too specific and gave the wrong impression, as the book had a much wider range than mere bones for archaeologists. Cornwall had the great merit of seeing the skeleton inside the body rather than as a collection of dissociated elements (Fig. 70) but, although his final chapter was on study and interpretation, he failed to mention the need for quantification, without which a faunal assemblage is valueless. For the science of archaeozoology (or zooarchaeology) is based not only on pattern recognition but also on change. Whatever is under study, whether it is the process of domestication, or the development of a breed, or nutritional status, or sexual dimorphism, all are dependent on the recognition of changes in size and shape of the bones and teeth. And these changes can only be assessed and recorded by means of standardised measurements. I therefore consider that Hillson should have referred in his book to the measurement manual of Von den Driesch (1976) and emphasised that any study of zooarchaeology has to be based on accurate identifications, correct nomenclature, and standardised measurements.

References

Clutton-Brock, J. (1987). *A natural history of domesticated mammals*. Cambridge: University Press and British Museum (Natural History).

Corbet, G. B. and Clutton-Brock, J. (1984). Appendix: taxonomy and nomenclature, pp. 434-8 in Mason, I. (ed.) *Evolution of domesticated animals*. London: Longman.

Corbet, G. B. and Hill, J. E. (1986). *A world list of mammalian species*. London: British Museum (Natural History).

Cornwall, I. W. (1956). *Bones for the archaeologist*. London: Phoenix House.

Von den Driesch, A. (1976). *A guide to the measurement of animal bones from archaeological sites*. Bulletin 1, Peabody Museum of Archaeology and Ethnology, Harvard University.

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Fig. 70 (overleaf). The skeleton hunt. Reproduced, with the publisher's permission, from Cornwall (1956, fig. 1).
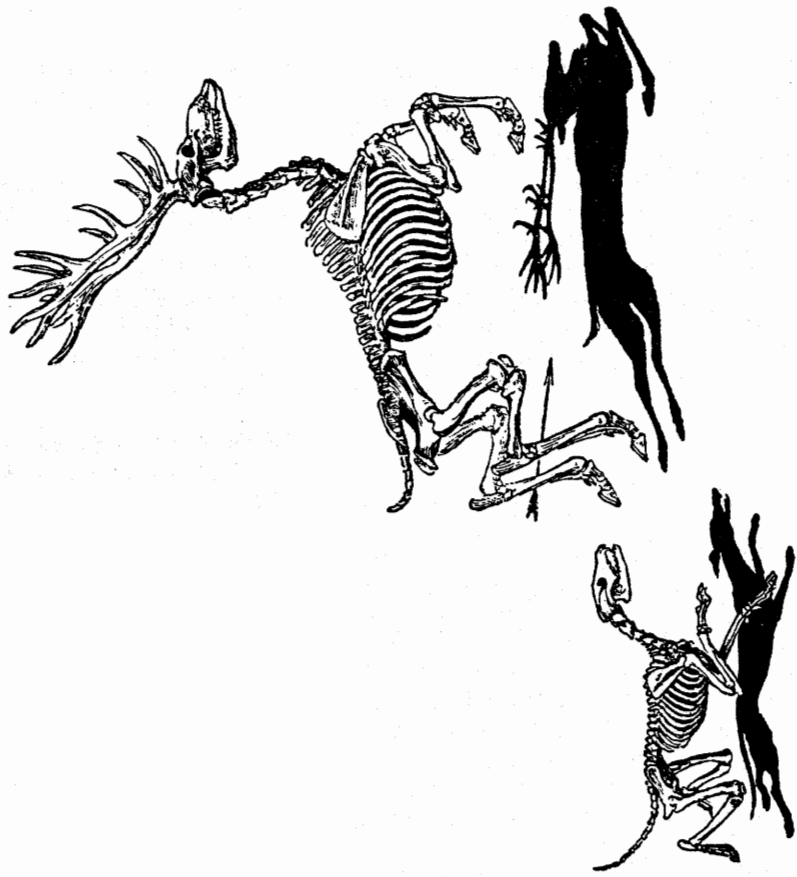
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Contents

Circaea