

## 101 ways to deal with a dead hedgehog: notes on the preparation of disarticulated skeletons for zoo-archaeological use

Simon Davis and Sebastian Payne, *Ancient Monuments Laboratory, English Heritage, 23 Savile Row, London W1X 1AB*

### Summary

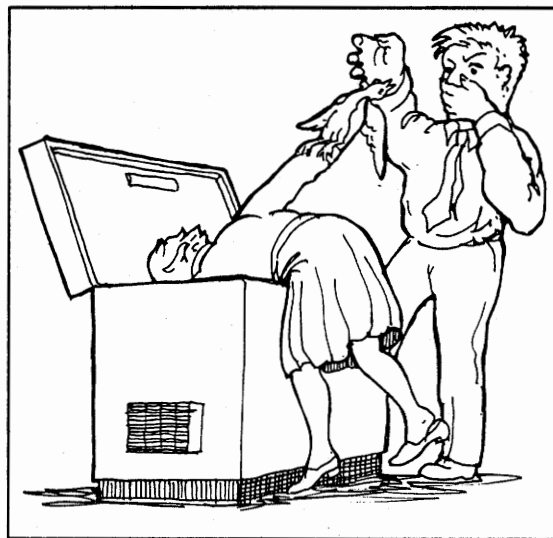
Two methods of preparing skeletons are described. After skinning, gutting and defleshing, large animals are buried for two months to two years in nylon mesh bags in leaf mould. Smaller animals are simmered in water for approximately 15 minutes and then allowed to macerate in warm water with a proteolytic enzyme for one to several days (fish should not be simmered). The resulting disarticulated bones are then thoroughly washed, dried and degreased with acetone or a mixture of methanol and trichloroethane.

### Introduction

Over the past twenty years we have between us prepared over 2000 skeletons, working in very varied conditions. The purpose of this note is to offer some suggestions, based on this experience, about how to get hold of animals, how to prepare better skeletons, and how to make the job simpler and less antisocial. It is not intended as a full guide to all the available methods; there are many ways to produce good skeletons depending on the animal you start with, the equipment available, space, climate and so on. All we intend to offer here are some methods that have worked well and reasonably reliably for us, advice that we hope may be useful, and some comments on mistakes to avoid.

Two general points at the outset. First, there are some risks associated with handling dead animals and preparing skeletons. It is important to be informed about risks from animal-borne diseases such as leptospirosis, psittacosis, tuberculosis and rabies, and pathogens associated with decomposing animal matter. Take sensible precautions such as not handling animals that died from disease or are likely to have died from disease, wear gloves and lab coats or overalls, cover broken skin, avoid and treat sharps injuries, and wash hands before eating, drinking or smoking. Risks should be formally assessed under the recent COSHH (safety) regulations, but should not be exaggerated—neither of us has had any problems, and the worst we know of is a septic finger caused by driving a bone splinter under a nail and ignoring it.

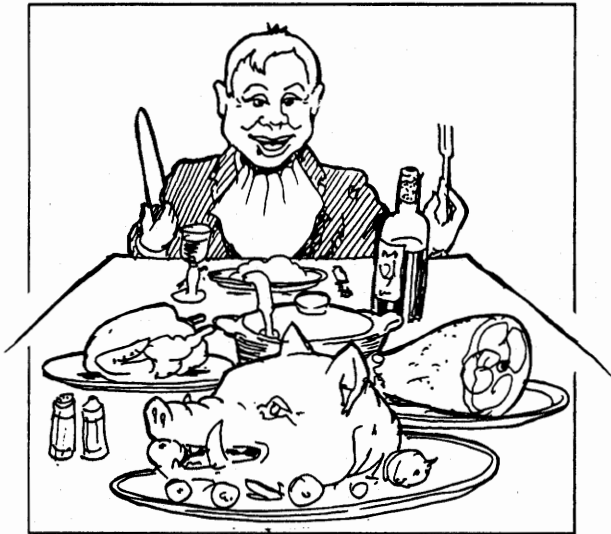
Second, everything is easier and less unpleasant if the animal is reasonably fresh. Never put off dealing with a dead animal: one of us still remembers all too vividly the awful job of finally dealing with a dead hedgehog left in a polythene bag in the engine compartment of a van and half-forgotten for three weeks during a Turkish summer. A deep freeze is an invaluable aid, but large or long backlogs should be avoided: we have cleaned out too many freezers full of half-rotten ten-year-old bodies.



*Don't leave animals in the deep freeze for too long*

*There's no reason not to eat an animal before you prepare it if it's edible—and you'll find*

out what it tastes like. If you do, stewing does less damage than roasting or frying (we haven't yet tried microwaving); and remember to take notes, measurements, weights and photographs first.



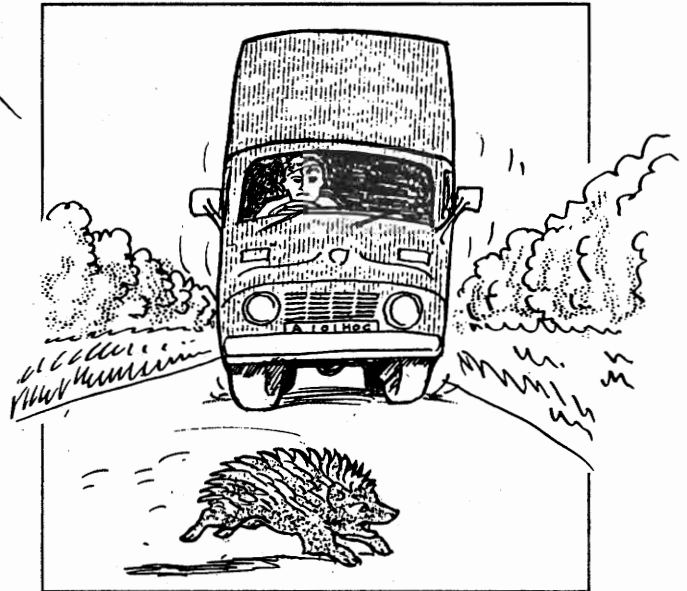
*There's no reason not to eat an animal first*

### Sources of animals

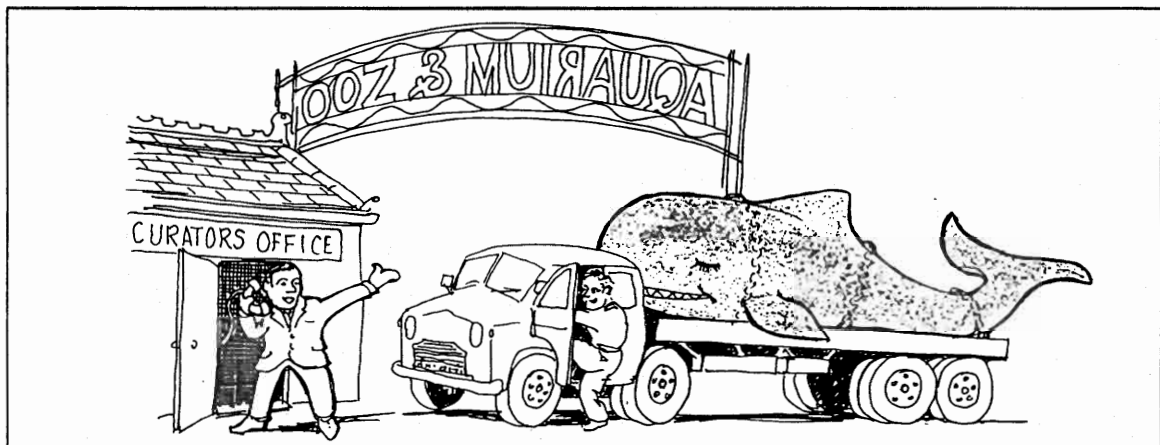
Times and attitudes have changed since Gilbert White wrote in 1767 (Letter 11): 'Three gross-beaks (*loxia coccothraustes*) appeared some years ago in my fields, in the winter; one of which I shot ....' But there are many other ways of getting hold of dead animals without going out and killing them. First and most important is to ask for help. A wide

variety of people come across or deal with dead animals, including amateur naturalists, fishermen, professional zoologists, conservation workers, gamekeepers, people who work on the roads, farmers and animal-breeders, vets, butchers, game dealers and fishmongers. Organisations that may be helpful include societies, museums and zoos.

It's important not to feel that you have to prepare every animal you get hold of. Preparation takes time and effort. It's not worth spending time on a skeleton that is poorly-documented, uncertainly identified, or



*First catch your hedgehog*



*It's important not to feel that you have to prepare every animal offered to you*

unlikely to be useful: better to spend the time getting hold of and preparing something you really will use. So, if someone gives you something you don't want, thank them kindly (they may bring you something you do want next time), 'phone round colleagues in case they want it, and, if not, dispose of it.

### Sending dead animals by post or rail

If someone rings you up and offers you a dead animal, but it's too far away to collect, or if you find an animal when you are a long way from base, it can be carried or sent reasonably easily by post or rail as long as it isn't too large or smelly. The golden rule is to make sure that it is wrapped up well, first with several absorbent layers (newspaper or kitchen towel) in case it starts to drip, then with two or three layers of polythene to contain any smell, and finally with a protective outer cover ('jiffy bag' or box). This should hold things well enough for two or three days. First class post is advisable; in warm weather avoid posting just before a weekend—better to hold the parcel in a deep-freeze and post on Monday. If you aren't there to receive the parcel, make sure that it is clearly marked (e.g. "perishable specimens"), and that you have arranged for someone to put it in the deep freeze when it arrives: you won't be popular if you arrive back from holiday to find a long-dead pigeon in your pigeon-hole.

If at all possible, it's better to take notes, weights, measurements and photographs (see below) and to gut and note sex and reproductive state before packing and sending animals. All these jobs become less pleasant and more difficult when a carcass is a few days older, and the gut and reproductive organs deteriorate particularly rapidly.

### Documentation

As with any other scientific collection, good documentation immensely increases the value of a reference collection of skeletons. Useful information includes locality, habitat, date and cause of death, weight and standard measurements, identification, sex and breeding condition, any other comments, a good colour photograph, and a record of the preparation method. It's important to record your reasons for identification in case there are any later doubts, and, if you are in doubt at the time, to

get an expert opinion. We accumulate (in the deep freeze) birds that we have difficulty in identifying, and periodically take them to be identified by an expert. For domestic animals, get as much information as possible about breed (including registration and flock/herd number) and history (age, diet, state of health, weight at different ages, and, if female, reproductive history). A copy of the catalogue sheet that we use is reproduced as Fig. 18 at the end of this paper (with a 'mock-up' as Fig. 19).



*Small bodies can be sent by post*

Labelling and marking are equally important—good documentation is no use if you can't link it to the specimen. Labels must first survive whatever preparation method you use. At the moment we use aluminium foil (0.15 mm thick, supplied by J. Smith and Sons (Clerkenwell) Ltd., 42-56 Tottenham Road, London N1 4BZ; tel. 081 253 1277), scratching or pressing heavily with a defunct biro. In the past we have successfully used 'Dymo' tape (it sometimes loses colour, but the embossing survives), aluminium garden labels (with pencil or scratched), and squares of plastic from yoghurt containers (important to choose a really permanent marking pen!). Once the skeleton is prepared, mark as many bones as you can, preferably with Indian ink. To make this quicker (and take less space on the bone), give each skeleton a number or other short code, and write identification, sex and locality

on one of the larger bones as well as the number so that the skeleton is not useless if the records are lost or inaccessible. Indian ink doesn't take properly on greasy bone, which should be de-fatted before marking (see below); if the ink 'spreads' on porous bones, the area to be marked can be prepared with a thin coat of a consolidant such as Paraloid or Primal.

## Preparation

There are many ways to produce good skeletons, often by taking advantage of local conditions and of equipment or facilities that are available to you. We start by describing two 'tried and tested' methods that are reasonably easy and usually give good results: maceration in warm water (preferably with an enzyme), which is quick but mildly antisocial and more suitable for smaller animals, and burial in leaf mould, which is slow but less antisocial and better for larger animals. We then comment briefly on a number of other methods.

### Warm water/enzyme maceration

#### *Skinning, gutting and defleshing:*

Having first taken notes, weights, measurements and photographs, the next thing to do to a mammal, or bird, is to skin it. There is no need to pluck birds before skinning, and no need to remove a neat whole skin (unless you want to keep it); but it's important not to cut into the bones (danger points include the muzzle, wrists and ankles) or to cut away the os penis. Wetting a bird's feathers before you start reduces the risk of disease. With small animals (rodents and most birds), it's usually easier to tear the skin gently away from the body rather than dissect it off; with larger animals it's often simplest to start by cutting off a wide strip of skin down the back, starting from a skin-fold at the nape of the neck, then either tear or cut down from the exposed edges. Small areas of skin, hair and feathers can be left on feet, at the ends of tails, and around eyes, muzzles and beaks, and there is no need to try to skin the 'scaly' parts of smaller birds' legs.

Next gut the animal, remembering to look for and make notes on the condition of the reproductive organs—you may need a lens or binocular microscope to do this for small birds, but won't be able to do it if the animal

isn't reasonably fresh. Unless the animal is very small (mouse/vole/thrush and smaller), it should then be roughly defleshed: up to about rabbit size, all that's needed is to cut away the larger muscles, while for larger animals try to leave no more than a centimetre depth of meat anywhere on the skeleton, and remove the diaphragm, heart and lungs. Again take care not to cut into the bones or remove bones that 'float' in soft tissues—parts at particular risk include the patella (don't strip it away with the muscles), the pelvis and shoulder girdle (remember the clavicle in species that have one), the vertebrae, and the hyoid bones (at the base of the tongue).

If you want to keep the vertebrae in sequence, this is the time to thread a nylon line through them. If you want to keep the bones of different feet separate, you'll need to cut them off, label them, and put them in separate containers or in separate mesh bags (we use lengths of old stockings or tights, tied off at both ends) in the same container.

Fish can be dealt with in much the same way, but remember to take a scale sample or to include the skin in the preparation.

Dispose of skin, guts and meat quickly and in a way that won't cause later problems. Small amounts can be treated as kitchen waste, but larger quantities should be incinerated, taken to a suitable dump, or buried: one of us buries waste in trenches below next year's runner beans.

#### *Simmering (mammals and birds only):*

Next, heat the whole defleshed carcass in water and bring it to near boiling point for long enough for the heat to penetrate fully. This helps to soften ligaments and tendons, speeding the next stage considerably. Avoid boiling as this may soften young or weak bone, avoid very rapid heating as this may crack the teeth, and don't be tempted to use a pressure cooker. Simmering is unnecessary for fishes, and should be avoided as it may damage their bones.

#### *Maceration:*

The defleshed carcass (and label!) should then be put into a container with water or an enzyme solution. Water by itself is much slower and the results not as dependable. We use an enzyme concentrate called Neutrase (available from Novo Nordisk Bioindustries

UK Ltd., 4 St George's Yard, Castle St., Farnham, Surrey GU9 7LW; tel. 0252 711212), which gives faster and better results, mixed about 1:50 with water (about one table spoon per litre). Liquid enzyme concentrates are to be preferred to powders because they are easier to handle safely, but care is still needed to avoid aerosol formation and inhalation of spray. Concentrates should be added to water rather than vice versa, and stirring and pouring should be done slowly. We have also used enzyme washing powders such as Ariel and Biotex, which are better than water but not as good as Neutrase. Trypsin works well but is expensive; papain also works well but is expensive and very smelly! Containers can be glass (e.g. beakers, coffee jars), plastic (e.g. buckets) or ceramic; metal should probably be avoided as it may inhibit bacterial or enzyme activity. Don't use too small a container—there should be at least ten times as much liquid as carcass; and don't cover or close the container—anaerobic conditions give poor results and may even completely destroy bone.

Some smells will be produced during maceration, and more when liquids are poured off; use a fume cupboard, or set things up somewhere where this won't trouble people. Temperature should if possible be kept between about 30°C and 50°C; it should not be allowed to go too high in case enzymes are deactivated and bacteria are killed, and should not be allowed to drop below about 15°C because activity will be too slow and may follow alternative pathways with poorer results. There are various ways of maintaining temperature at the right kind of level: we have used incubators, an aquarium heater, a commercial pie-warmer, radiators, and warm climates; it would also be fairly simple to set up a basic incubator with an insulated container (perhaps a plastic dustbin) and a light bulb. pH should be reasonably close to neutral, but this isn't usually a problem.

Evaporation will be fairly rapid: each container should be checked every two or three days and topped up with fresh enzyme solution if necessary. If enzyme solution is used and temperatures are at the right level the skeleton should be ready within a few days, by which time clean bones will be lying at the bottom of the container in a thin soup of breakdown products. (Fish are particularly quick to prepare.) If water is used by itself, or if temperatures are lower, maceration may take much longer and it may be necessary to

change the water; if so, avoid losing bones by pouring off through a sieve. A kitchen sieve is useful for medium-sized mammals, and a fine tea-strainer for small animals.

Once the skeleton is ready, pour off the 'soup' (think about where it's going!) and rinse in several changes of clean hot water, again taking care not to lose bones by pouring off through a sieve. Any remaining hairs or feathers usually come to the surface or stay in suspension at this stage, and can be decanted off, but take care not to lose floating bones. The hot water deactivates any remaining enzyme and helps to remove fat, which rises as globules to the surface. Repeat until the rinsing water is clear, and leave soaking for several hours; if still cloudy, repeat the process. Check that the skeleton is really clean (if not, return it to fresh enzyme solution for another day or two), then drain and set to dry slowly. Avoid rapid drying (sun or heat) as this may make bones crack.

#### Burial in leaf mould

This method is only recommended for larger animals. It's slow, and slightly more trouble, but gives good results and is relatively inoffensive.

#### *Skinning, gutting and defleshing:*

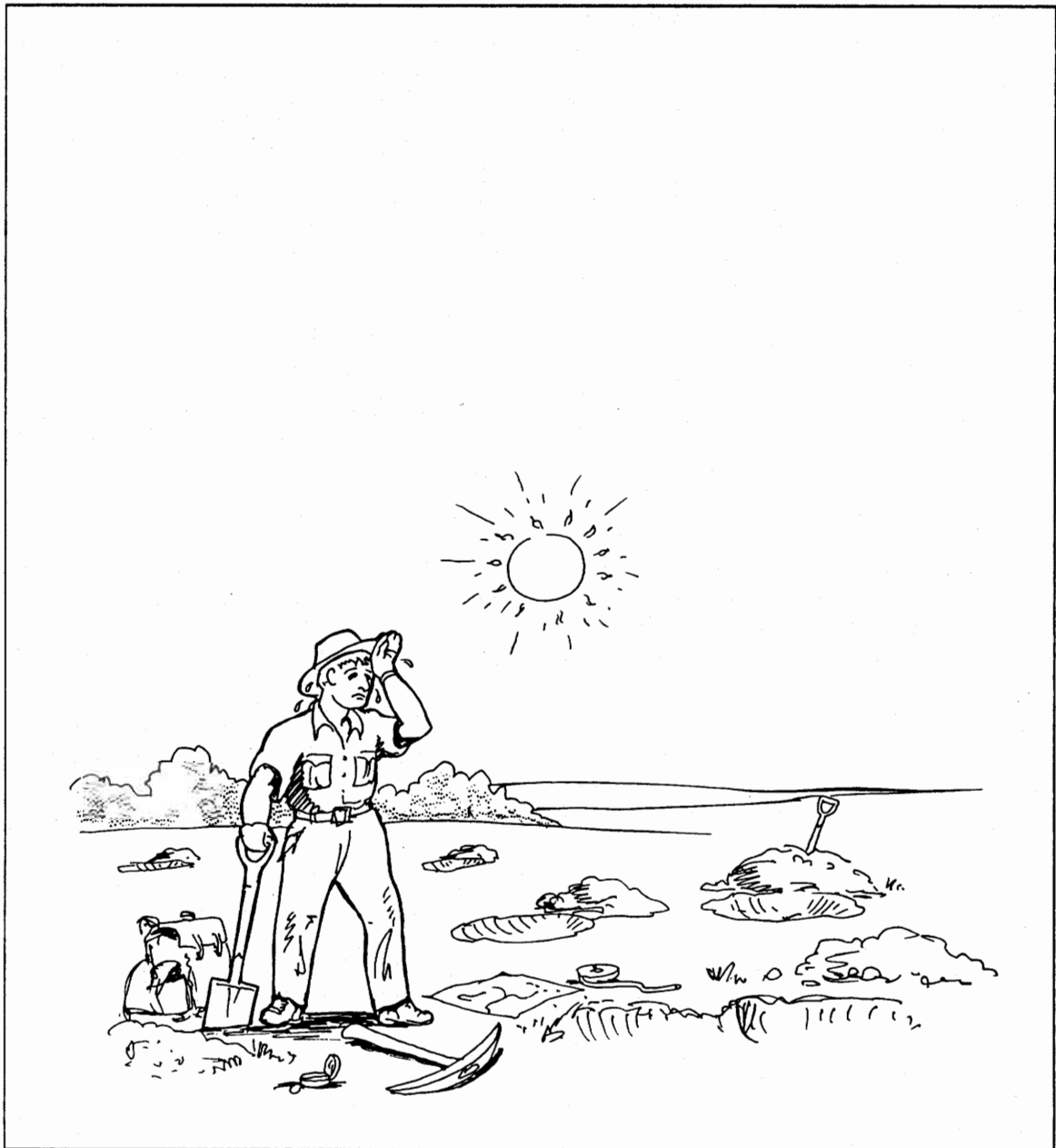
Animals are skinned, gutted and defleshed as above, and put (with labels!) into mesh sacks so that bones are not lost. It is important that the mesh used will survive two or three years of burial. Nylon curtain mesh can be used but isn't really strong enough for very large animals (and it's hard to find plain mesh); we use mesh manufactured for use in parachutes ('Quality 186', available from Swiss Net UK, Hartley House, Hucknall Road, Nottingham NG5 1FD, U.K.; telephone: 0602 692500). Very large animals can be cut up and buried in sections. If flies are active, it's worth leaving the defleshed carcass exposed for an hour or two to encourage fly-strike before burial; the maggots will hatch out after burial and do a good job cleaning the skeleton.

#### *Burial:*

The mesh sacks are then buried in piles of well-rotted leaf mould (or in pits full of leaf mould), open to the rain. Possible substitutes for rotted leaf mould include well-rotted compost and coconut peat. Fresh leaves, fresh

green matter and sawdust should be avoided as they are acid and will slow decomposition and attack the bones. Don't let plants get established on the leaf mould as roots will grow down through the pile and may damage the sacks and the bones; and be careful to cover sacks with at least a foot of leaf mould, otherwise rats or foxes will be attracted and may dig the sacks up and do damage. Medium-sized animals buried during warm

weather may only take a few weeks; but larger animals and animals buried during the winter will take longer—perhaps as much as two years. Once a skeleton is ready (leaf-mould is so light that it's fairly easy to dig a sack up, look at its contents and rebury it), it should be soaked in water for a few hours, cleaned by brushing as needed, rinsed in clean water, and laid out to dry. (As above, don't dry too fast or in the sun.)



*Don't forget where you buried it*



Comments on other methods

*Chemical methods:*

In our experience these are not to be recommended. Sodium perborate tends to leave bone soft and 'chalky' unless very carefully controlled; sodium and potassium hydroxide damage bone. Maceration in warm dilute ammonia can give reasonable results but is antisocial and tends to produce a very fatty skeleton.

*Rotting in the sea:*

'She weighted her brother down with stones, and sent him off to Davy Jones. All they ever found were some bones and occasional pieces of skin.' (Tom Lehrer: *The Irish Ballad*)

This can give good results. Defleshed carcasses are put in mesh sacks or cages and placed in the sea so that small marine organisms can clean the bones. The main problem is to secure sacks or cages so that they are safe from storms, tides and disturbance by people. A cat prepared in this way in Greece, in a sack tied to the anchor chain of a disused mooring buoy, took about three weeks. This method may, however, take considerably longer in colder water.

*Burial:*

Burial in earth gives rather variable results, depending mainly on soil conditions; it's worth experimenting with if you have a reasonably neutral silty soil, but less likely to give good results with acid or shallow alkaline soils, or with clays. We are experimenting at present with burial in silver sand to which some crushed calcite or apatite has been added to buffer any acidity; crushed shell might also be used. Burial in blown shell-sand would probably also give good results. Again, plants should be discouraged to avoid damage by rootlets. Make sure that burials are clearly marked or, if vandals might be a problem, that their positions are accurately recorded. One of us once spent two days fruitlessly digging holes in a Turkish floodplain in search of a buried cow . . .

De-fatting

Greasy skeletons are unpleasant to work with (and possibly also present a minor health hazard). Acid breakdown products of fats and

oils may also attack and weaken bone. De-fatting is therefore desirable. Our experience of alkaline hydrolysis is that it is either ineffective or too aggressive to bone. The best solvent we have found is a mixture of three parts of 1,1,1 trichloroethane and one part of methanol, which is able to de-fat small bones in a few days and large bones in a few weeks. We use a sequence of jars of solvent, placing the skeleton in a mesh bag and putting it first in the 'dirty' solvent jar, then in a 'cleaner' jar, and then in the 'clean' jar, each time for a few days (or longer if the bones are large), then removing the sack and letting it drain and then dry. As the solvent mixture is hazardous, everything has to be done in a fume cupboard and gloves have to be worn in case of splashes. To reduce solvent loss, use jars with lids that fit well. When solvent levels go down, the 'dirty' jar is topped up from the 'cleaner' jar, then the 'cleaner' from the 'clean', and finally the 'clean' jar from fresh stock. Alternatively, acetone can be used; it is less effective in removing old grease, but probably to be preferred in dealing with newly-prepared skeletons as it is cheaper, less toxic, and less ozone-unfriendly.



*Staining bones with tea*

Bleaching and tea-staining

Most preparation manuals will tell you that the final step in preparing a skeleton is to

bleach it with hydrogen peroxide. This may produce a more clinical specimen for museum display, but we have found that it isn't as easy to see shape on a dead-white bone (especially under a microscope), and we think that bleaching probably also weakens bones.

Instead, we prefer our skeletons to be a fairly uniform pale or mid-brown, produced by staining them with tea (after de-fatting). Strong Indian tea is best, and should be freshly-brewed; pour hot tea over the bones and then leave for a few minutes before draining, rinsing and drying. Left and right may be differentiated by staining one side and not the other.

### Storage

Bones should be stored dry: residual moisture encourages fungal attack, which can seriously damage specimens. We have noticed this to be a problem in bones stored in airtight containers. Extremes of temperature and humidity should be avoided as far as possible, and bones and bone containers should not be stored in direct sunlight.

### Further reading

Harris, R. H. (1951). The use of enzymes in the osteological preparation of the emperor penguin. *Museums Journal* 51, 97.

Luther, P. G. (1949). Enzymatic maceration of skeletons. *Proceedings of the Linnaean Society of London* 161, 146-7.

### Acknowledgements

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Disk copy received: November 1991

*Figures 18 (opposite) and 19 (overleaf). Sample catalogue sheets as used by the authors. Figure 18—blank form for reproduction; Figure 19—'mock-up'. Note that the top line comprises basic information, some of it duplicated in entries elsewhere in the sheet. Abbreviations: Loc—Locality of collection; H+B—head and body length; OAL—overall length; HF/Wing—hind foot or wing length; Intention—those parts of the skeletons required, for example: 'whole skeleton' or 'feet only'.*



AML No: Identification: Sex: Age: Loc:

**OBSERVATIONS AT TIME OF COLLECTION**

Collected by: Date: Weight:  
Locality, habitat: H+B: OAL:  
Tail: HF/Wing:  
Ear:  
Condition: Sex, reproductive condition:  
(Date of birth: )  
Date of death or estimate: Breed:  
Cause of death: Field/Flock/Ring No:  
Notes: History:

**IDENTIFICATION**

Identified by: Photo:  
Reasons for identification:

**PREPARATION DETAILS**

Intention: Date: Leaf mould/Neutrase/Biotex  
De-fatted:  
Notes:

State after preparation:

Date:  
General: Damage: Missing parts:

**SUBSEQUENT ACTIONS/NOTES**

AML No: 999 Identification: Mustela nivalis

Sex: ♂ Age: — Loc: Cambridge,  
Cambs, U.K.

#### OBSERVATIONS AT TIME OF COLLECTION

Collected by: S. Payne

Date: 30.2.92 Weight: 122 g.

Locality, habitat: 9 Wilberforce Rd., Cambridge.  
Suburban garden, lawn &  
rough grass etc. along ditch.

H+B: 205 mm. OAL: —

Tail: 47 mm. HF/Wing:

Ear: —

Condition: Back of head damaged

Sex, reproductive condition:  
adult ♂

(Date of birth: — )

Date of death or estimate: 30.2.92

Breed: —

Cause of death: Killed by cat

Field/Flock/Ring No: —

Notes:

History: —

#### IDENTIFICATION

Identified by: S. Davis

Photo:

Reasons for identification: Small mustelid, upper parts bright brown, underparts  
white, junction wavy, no black tip to tail.

#### PREPARATION DETAILS

Intention: whole skeleton

Date: 31.2.92 ~~Leaf mould~~ Neutrase Biotex

De-fatted: Trichloroethane

Notes: Simmered 10 mins before neutrase

State after preparation:

Date: 10.3.92

General: Good Damage: Slight damage to  
back of skull

Missing parts: —

#### SUBSEQUENT ACTIONS/NOTES