A TESTED SET OF TECHNIQUES FOR THE EXTRACTION OF PLANT AND ANIMAL MACROFOSSILS FROM WATERLOGGED ARCHAEOLOGICAL DEPOSITS

A.K. Kenward, A.R. Hall and A.T.G. Jones
Environmental Archaeology Unit,
University of York,
York, YO1 5DR,
England.

ABSTRACT

The principles and methods of extracting and concentrating plant and animal macrofossils from waterlogged archaeological deposits are briefly reviewed. Bait-testing (carried out on site), the extraction of plant macrofossils using a sieving-back, and paraffin-flotation for invertebrates are each described. Accounts designed to provide sufficient procedural detail to permit successful application of the methods are given.

Keywords

ENVIRONMENTAL ARCHAEOLOGY, PALEOECOLOGY, METHODOLOGY, WATERLOGGED DEPOSITS, PLANT MACROFOSSILS, SEEDS, INSECT REMAINS, METELES, BONES, SNAILS, EXTRACTION TECHNIQUES, WATER- SEPARATION, DI-LITE METHODS, BULK-LEVING, PARAFFIN-FLUTION, CONCENTRATION, RECORDING.

Introduction

Biological remains from archaeological sites are examined for three principal reasons: firstly, for their intrinsic interest to biologists and ecologists; secondly, in order to reconstruct human diet and activity, and thirdly, to reconstruct past environments, both local and regional and including human living conditions. A detailed discussion of the interpretative value of each of the groups of macrofossils which may be encountered is beyond the scope of this account, but to date animal bones, plant remains, molluscs and insects have been the most extensively investigated.

The present account is mainly concerned with arthropod remains, plant macrofossils and small bones, but some other groups are briefly considered. The set of techniques which have been found most satisfactory for waterlogged deposits of all kinds, and which is employed at the Environmental Archaeology Unit (EAD), York, is described in detail. While this account may occasionally appear to state the obvious, long experience in teaching the methods has underlined the need for a precise description. Tests demonstrating the efficacy of the techniques will be outlined elsewhere (Jones et al., in prep.).

Whatever the purpose of the investigation, if anything more than a mere catalogue of common species is required (it is desirable to examine very large numbers of specimens). There are two reasons for this: firstly, to obtain a reasonably representative sample of the assemblage in a deposit, and secondly, to provide numbers large enough for statistical manipulation of the data (see, for example, Kenward, 1978; in prep.; Waddell and Kenward, in prep.). This holds true whatever group of organisms is being considered.

Assemblages of 100 individual insects and 200 seeds from a single sample are probably the minimum for useful interpretation, although assemblages several times larger are preferable, and interpretations should ideally be based on groups of samples rather than single ones.

The concentration of insects and seeds in waterlogged deposits varies enormously, and 5 g to 10 kg or more of sediments may be needed to provide an adequate assemblage; typically, samples of 0.5 to 1 kg for seeds and 1 to 3 kg for insects are found to be suitable. The sample collected at site must, of course, allow for the worst contingency and should be at least 5 kg, but ideally over 10 kg. Samples of 10 kg will generally provide sufficient material for a variety of analyses. Sampling and sub-sampling strategies are complex and subject to many variables, and will be discussed elsewhere (Kenward et al., in prep.; Topsey et al., in prep.), but it is worth remarking here that single bags of sediment may not be representative of a large context (Hall et al., in prep.). There is much confusion as to the kinds of samples required for the investigation of particular groups of organisms; in the hope of alleviating this, suggestive sample sizes are given in Table 1, together with a standard non-claystone found useful at York.

Some common extraction methods

Since large quantities of sediment and large numbers of samples must generally be processed to obtain adequate biological material, some technique to reduce the labour of concentrating plant and animal remains is necessary. The simplest but most impractical way of recovering biological remains is sorting the raw sediment. It would be quite unreasonable to employ this method for a serious study, for it is immensely time-consuming and, since most fossils are coated with sediment, the vast majority would be overlooked. Almost all successful methods therefore involve sieving off...
the fine organic fractions. This makes the fossils much more easily recognizable, permitting efficient sorting. The technique is widely employed, and the authors regard the use of a gridded box of sleeves as the most satisfactory means of extracting plant macrofossils and smalls. The same technique can be employed for insect remains, but it is too time-consuming as larger samples are generally required and insect remains are very hard to recognize amongst plant debris, especially charcoal. A number of methods have been tried, but the only one considered to be practicable in terms of reliability and cost-effectiveness is paralysis-flotation. This technique has been developed from methods originally devised for the extraction of terrestrial arthropods (Southwood, 1964) and was adapted for work on Pleistocene insects (Coop and Olsufjev, 1968; Shorton, 1970). The method has been described by Speight (1974) as "strangely captivating", but this is directly at variance with experience at Birmingham and York. It is considered that it has the virtue of being cheap, straightforward and trustworthy. However, it has been found that students who have attempted the method without practical instruction, and with a poor understanding of the principles involved, have often met with failure. For this reason, a detailed description of the standard method employed at the EAU will be given; care has been taken to include all the nuances which can make the difference between success and failure. The method has been applied in a great variety of sediments and the results of tests will be presented elsewhere (Jones et al., in prep.).

Other techniques for concentrating biological remains vary in their value. The complicated fractionation machines are, in the authors' view, unsatisfactory. The writer is aware of the use of a large sorting system for most deposits from temperate regions, although a number of workers have found useful work in dealing with soils with a very low organic content, for example in the Peak District. However, the use of a bulb-leaching apparatus on site for processing large samples is regarded as an essential component of extraction. It is invaluable in the recovery of small artifacts overlooked by excavators. It is, however, not practicable for small bones (particularly those of fish), large molluscs and some large insect and plant material, for example fruits/trees. Such remains are generally too thinly distributed to be retrieved in useful numbers from "biological samples". However, it must be emphasized that many small remains are lost during bulb-leaching and that the fossils recovered are a biased sample (Jones et al., in prep.), so that it is completely unsuitable for detailed work on plant macrofossils and insect assemblages. Equally, bulk-leaching in the field is unsatisfactory in the writer's opinion. The writer has used exclusively for extracting sites (Benford, 1973). The efficiency of fraction-flotation for recovering sites requires further consideration. The fraction-flotation method (Newberry, 1974) can be used for very small arthropod remains, but this technique has not been adequately tested. A method of extraction involving a screened bail has been described (Speight, 1973); although the
present authors have not used this device, it appears to be unnecessarily complicated compared with the proven paraffin-floatation process and, moreover, to judge from the description, it is unlikely to be suitable for richly organic deposits.

A standard approach to the recovery of biological remains

The remainder of this paper describes the methods used at the BGR for the processing of biological samples. It varies in the amount of detail given, a fuller account being provided where difficulty is likely to be experienced.

Plant macrofossil and insect extract is typically carried out on pilot samples of 1 kg and further sub-samples processed as required to provide sufficient fossils for interpretation. Smalls are generally recovered from a separate sub-sample, using methods described by Evans (1972), but may conventionally be retrieved from the same sub-sample as plant macrofossils or insects, using banks of sieves. In either case, disaggregation must be gentle to prevent damage to the fragile shells, and, of course, no acids should be used.

Hand-picking on site

Biological remains are often recognised during excavation and recorded and sampled in the same way as small finds. Caches of seeds, large beetles, groups of fly puparia and of small bones may be treated in the same way, whilst large bones are typically processed as loose finds, bagged by context in the same way as pottery. A critique of this method of recovering bones is beyond the scope of this paper (but see, for example, Uehlinger, 1972, and papers in Cherry et al., 1970).

Bulk-sieving

Considerable confusion has arisen concerning the terminology applied to the various methods of processing large quantities of soil for small bones, large seeds and-charted grain, artifacts and the like. The authors prefer to adopt the terms 'bulk-sieving' or 'water-separation' for the method described below (which relies primarily on water currents for separation) and the term 'bulk sample' for the material processed by it. The expression 'flostation machine' is reserved for apparatus using air bubbles or organic liquids in addition to water currents (for example, the 'Cambridge Machine', Jenner et al., 1972).

The application of bulk-sieving to the whole of any archeological context likely to contain remains over 1 mm in diameter might be viewed as a routine excavation technique. However, in practice, bulk-sieving is seldom done, for a variety of reasons including traditional bias towards large artifacts and structural remains and the time necessary to carry it out and to sort the resulting material. Experience suggests that not only are large amounts of useful biological material recovered by this method, but that significant quantities of very small, small finds and technological products like slag may also be recovered (James et al., 1974). Bulk-sieving can be applied in two ways, which should be clearly distinguished. Firstly, bulk samples representative of a context may be processed to give a reliable sample of its inclusions, both biological and artificial. Such bulk samples should, of course, have nothing removed from them prior to sieving, and the quantity of material processed should be recorded. Secondly, the apparatus can be used to retrieve small objects and biological remains from the whole of the troubled spoil from Individual contexts; it has been shown that spoil often contains much material overlooked using traditional excavation techniques. Bulk-sieving also provides an opportunity to make a detailed examination of the gross composition of a deposit and its large and small-scale variations.

A suitable apparatus for bulk-sieving, modified from that described by Williams (1973), is shown in Figure 1. Soil is suspended upon a one-millimetre mesh within the tank and a current of water is run through the soil, carrying off the material such as wood and charcoal fragments. Small mineral particles fall through the mesh into the tank, which is periodically emptied. The water flow is directed onto a sieve (also one-millimetre mesh) where the floating material ("float") is collected. The clean residue on the mesh, and the float, are bagged separately after drying and may then be sorted in the laboratory.

There is, of course, no reason why bulk-sieving should not be carried out in the laboratory, providing a suitable pump is available.

Operation of the bulk-sieving apparatus

A Apparatus: A bulk-sieving tank (Figure 1): 1 m³ mesh sieve, about 30 cm diameter; 1 λ of 1 µm aperture nylon mesh; plastic labels: black, spirit-based waterproof felt-tip marker; recording sheets; drying trays; polythene bags (c. 0.5 m³); a supply of cold water; soup. A recyling pump and water-heater can readily be fitted to the apparatus, reducing the amount of water required and making operation less unpleasant in cold weather, although a stirring tank will then be necessary.

B Preparation: The tank, mesh and sieve are thoroughly cleaned, the hose is connected to the inlet pipe and the drain plug closed securely. While the tank is filling with water, the wire support for the nylon mesh is positioned. The mesh is secured into the weir by the V-shaped rod and spring-clips used to anchor it to the rim of the tank. It is necessary to plash the mesh to accommodate the bulk of soil. The float sieve is positioned beneath the weir and a steady flow of water established.

C Recording: A recording sheet (Figure 2) is completed and four labels are marked with the site code and context number. A separate code is used to distinguish the residue and float (K and F respectively are used at York).

D Operation: When water is flowing steadily through the sieve, a bucket of soil is introduced onto the nylon mesh, care being taken to avoid losses through splashing. The lumps of soil are gently disaggregated by hand, so as to minimize mechanical damage to fragile remains. Floating debris are encouraged into the float sieve by gentle stirring with a spatula. During washing, notes are made of the nature of the residue, incidents of types or categories: particular attention is paid to any possible modern vegetation, for example airborne pollen or insects. The process continues until all sand, clay and any clay have been washed through the nylon mesh.

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Figure 1. (a) Floor-plan of tank: A - 50-gallon oil drum; B - weldLicensed to: University of South Carolina for non-commercial use. For permission to copy or redistribute the material or further information, please contact: University of South Carolina Library System, Digital Library (https://library.sc.edu)
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**Notes:**
- Some macro remains; fly pupa abundant; some ants present; ascension not good, some added to ascension tent tube.
- No noticeable changes after 24 hours.
Plant Macrofossil Extraction

The most satisfactory technique for concentrating plant macrofossils from organic archaeological deposits involves disaggregation and separation in a graded bank of sieves. Methods of extraction described by Dickson (1970) for natural deposits will be useful in certain archaeological situations (Table 3). However, plant macrofossils encountered in towns are better treated by the technique given below. Some workers have used paraffin-flotation for the extraction of plant macrofossils, but it must be emphasized here that the flots from paraffin-flotation, by itself, does not provide an adequately representative assemblage of seeds and other plant remains. If paraffin-flotation is to be used to extract insect remains from the same material, it is essential that the sample be sorted by the method outlined here before flotation, on that both flot and residue are sorted for seeds.

Some aspects of the extraction of mesozoic remains of which are frequently present in samples, are discussed by Williams (1970).

A Apparatus: Drainage with sump (Figure 3); a tipped bucket, 0.10 litre capacity, plastic or metal; 500 micron micro-sieve; 300 micron micro-sieve; 150 micron micro-sieve; 100 micron micro-sieve; 50 micron micro-sieve. Fine mud must be filled with solder and label removed to prevent cross-contamination, see Figure 4); bank of brass sieves of mesh sizes 500 micron, 1 mm, 2 mm, 4 mm, etc (Figure 5), as dictated by the sample (rim crevice likewise sealed and labels removed); a supply of hot and cold water; 3 x 10" (7.7 x 2.6 mm) plastic stoppered glass vials; labels (in pencil, on card); alcohol-glycerine-formalin solution (approximate proportions are 60 parts glycerine: 30 parts industrial methylyated spirit: 2 parts 40% formalin).

B Preparation: All apparatus must be cleaned scrupulously, using hot water, detergent and a stiff scouring brush. A suitable quantity of sedi ment for processing is weighed out, and details of its lithology recorded, together with site code, context and sample details etc. on a laboratory processing sheet (Figure 2). The bucket should also be labelled with site code and sample number.

C Operation: The sample is placed in the bucket and hot water added.

The sediment is disaggregated by being gently agitated by hand and, when it has begun to break down, the bucket is tilted over the 300 micron mesh sieve so that a stream of water can flow over the sample and onto the sieve. The process is continued until little or no fine material passes the mesh, and the sample is thoroughly disaggregated. In extreme cases, for example compressed materials may be treated with 1-2% sodium hydroxide solution for days or weeks prior to processing (see also p.11 below). Boiling in water or mild reagents may also assist disaggregation. Next, the residue is returned to the bucket and the bank of sieves set up with the 300 micron mesh sieve at the base. The residue is placed in the top sieve and washed down the column with a gentle stream of water. Care must be taken to avoid loss of material from the top sieve by splashing, or from lower sieves if blockage of the mesh and overflowing occur. It is desirable that the sieves be as tight-fitting as possible, to minimize latter problem. The use of a large range of sieve sizes also facilitates rapid separation and, subsequently, sorting. A sprinkle nozzle may be fitted to the rubber hose, producing a diffuse, gentle stream of water. If there is a large mineral content the organic fraction may be extracted by the 'lashover' technique described below (p.11), before column-sieving.

D Sorting: When separation into fractions is complete, the contents of each sieve are sorted a little at a time under a low-power binocular microscope (x2.5), the material being spread in water on a glass or white ceramic dish. Remains are picked out using fine forceps and tweezers. Some practical aspects of sorting for plant remains, in particular the sorting of fine fractions, will be dealt with elsewhere (Jones et al., in prep.).

E Storage: Seeds and other plant remains picked out of the last fraction are stored either in alcohol-glycerine-formalin solution (ADF), in plastic-stoppered glass vials, enclosing a label written in pencil in the neck. The label may be also labelled externally, though alcohol-soluble media are to be avoided.

Insect extraction

The method of paraffin-flotation described here has been refined from that used on archaeolo gical material by P.J. Osborne at the Univer sity of Birmingham. It is reliable for the extraction of almost all insect and other arthropod remains, with the exception of dipterous (fly) puparia, strongly calcified cuticle (for example, woodlice), and charred or mineralized fossils. If these are to be recovered, the methods described above for plant macrofossils should be employed. Paraffin-flotation is carried out on 1 kg subsamples at the EAG these are of a convenient size for handling.

A Apparatus: A supply of hot and cold water; drainage with sump (Figure 3); tipped bucket (c. 0.10 litre capacity, plastic or metal; 20 cm diameter). 300 micron-mesh aperture brass sieve with rim crevice sealed and label removed (Figure 4); 5 - 10 ml stainless steel pipette (alumina is suitable if disaggregating reagents are not to be employed); boiling ring; washing water (hydrated sodium carbonate); liquid detergent; amesetic paraffin (hersons); a paraffin conforming to Science and Archaeology no.22 (1980)
Figure 3. Sieving, drainer and sump. A - supply of hot and cold water from rubber hoses; B - lipped bucket; C - sieve and retent; D - settling tank for coarse sediments; E - settling tank for fine sediments; F - outlet to drains. Scale: sieve diameter = 20 cm.

Figure 4. S'ewe rim sealing. A - sieve body; B - sieve rim bracing rod; C - solder.
Figure 5. Bank of sieves for macrofossil extraction. A = ribbed drainer; B = sieve; C = retent.

Figure 6. Simple filter for recycling paraffin. A = Buchner funnel (14 cm. diameter); B = coarse filter paper (serves only as white background for detritus particles carried over); C = glass wool; D = fine filter paper (larger than funnel diameter); E = rubber support; F = side-arm flash.
BS 2869C has been found highly satisfactory: filter for paraffin (Figure 6); industrial methylated spirits (IMS): 120 ml wide-mouthed storage jars; 3 x 1" (7.742 x 6 mm) plastic-stoppered glass vials; notebook or recording sheet; cord label; pencil.

8 Contamination: All apparatus must be kept scrupulously clean. Paraffin causes insect remains to adhere closely to surfaces and paraffin-alcohol-water mixtures produce a "waxy" material in which fragments become trapped and from which they are removed with difficulty. Sieves must have the cramp around the rim filled with solder and the riveted label removed; otherwise insect remains (as well as small seeds, etc.) may become trapped, resulting in cross-contamination between samples. It is very easy accidentally to introduce enough contaminant insect remains to distort interpretation, and any contamination will obviously invalidate the records of species in space and time.

9 Preparation and Recording: The condition, nature and storage history of the sample are recorded, with the sheet similar to that reproduced in Figure 2. The methods used and the response of the narcotic to them are also recorded, and any losses or contamination (observed or suspected) carefully noted, as they will obviously affect interpretation.

In the event of large spillages or contamination, the sub-sample may have to be abandoned.

The apparatus is cleaned using detergent, hot water and a scrubbing brush. A label is tied to the bucket, bearing sample and sub-sample numbers as well as site code or name, and the desired quantity of material is weighed out to the nearest gramme and placed in the bucket.

10 Disaggregation and sieving: The ease with which the sample is likely to be disaggregated is tested by passing a stream of water over it (using a rubber hose and water at 50 O C and onto a 300 micron mesh sieve (Figure 7). Now, as throughout, the cleanliness of the hose must be carefully checked. For this, the stage will depend on how the sample has behaved.

A few sediments will fall apart readily in the stream of hot water, with gentle mechanical agitation (for example by hand, or by swirling or tilting the bucket) and need no other treatment except, perhaps, for a few small resistant lumps which may be treated more harshly. The washing time for these easily disaggregated sediments is n. 10 × 30 minutes. Less friable samples may be soaked in water in the bucket for a day or so, then sieved. The bucket where it stood in a water bath at 40 °C to 90 °C, but in any case must be covered to prevent contamination and evaporation, and should not be let for more than three days without being well mixed, to prevent mould growth. M. Robinson (pers. comm.) has found extended freezing and thawing of the raw sediment to be an effective disaggregation technique especially for clays, although the effect of this method in damaging fossils has not been tested by the authors.

Most friable organic samples disaggregate more readily after being boiled in water for 15 × 30 minutes, or, exceptionally, for several hours as necessary, when it is usually at or near the 300 mesh, either before or after sieving, for boiling has the additional advantage of expelling gas from plant matter, resulting in a very flaky soil. The material is washed as described above (p. 8) after boiling; resistant lumps may be rebutted. Samples which do not wash down fairly easily after boiling in water may be soaked or boiled in a dilute (c. 10 g l-1) solution of sodium carbonate. Sample material will require some manual treatment to speed disaggregation. Such treatment may be gentle, or at least in the early stages, large lumps may be pulled apart (not crushed), the bucket tipped back and forth and swirled, and the material shaken through the fingers. It is reasonable to use harsher treatment for the last five per cent or so of the material, as this may involve washing time and will only have a small effect on the results. Automatic washing devices, using shower heads etc., have proved of little value for small samples.

Large stones, pot fragments, artifacts and bones are picked out during disaggregation; stones are returned after paraffin- flotation is complete, other remains labelled, sealed and dispatched to the appropriate specialist.

Most fine particles (clay, silt, fine sand and fine organic debris) will be carried through the sieve by the stream of water. During washing, the sieve may be cleaned of small particles trapped amongst the Carrier by gently running water onto its contents and by tapping it sharply on the drainer. When sieving is completed, the retained material ('retain' - that which is retained, 0.2 mm) is further cleaned by agitation the sieve in water, taking care not to immerse the rim. If this is not successful, the contents may be returned to the bucket and washed carefully. It may be necessary to empty the sieve at intervals, if the volume of retain becomes too great. A coarse sieve (typically 1 mesh) may be placed over the 300 µm sieve to catch large fragments of wood etc. The product should be of fine particles, and contain no lumps of matrix and not too much coarse material.

11 Summary: If there is a large quantity of inorganic matter, especially medium to coarse sand, the organic fraction may be separated from it by the method employed. For this, the sample is returned to the bucket and subjected to a moderate stream of cold water. When the bucket is about a third to a half full it is swirled and the supernatant, with its load of suspended organic particles, is decanted into the sieve. The process is repeated until no further organic particles are captured. If the quantity of inorganic material concentrated by this method is small, it may be sorted in its entirety. It may be desirable, however, to carry out paraffin-flotation on the inorganic fraction as a check.

12 Paraffin-flotation: If the sieving process produces more than a few cubic centimetres of organic matter, paraffin-flotation is necessary to concentrate it prior to palynology. Although this technique is reliable and effective, its success depends upon many factors. Failure to carry out the steps detailed below may lead to either too large a float or incomplete recovery. Nevertheless, with care it is possible to process large numbers of samples quickly and reliably (Jones et al., in prep.).

The thoroughly cleaned retain is drained of free water by tapping the sieve sharply a few times on the edge of the table. When dry, the float is placed in a 5 l Erlenmeyer, degrees for up to 30 minutes (the time depending on the water-retaining properties of the material). There, however, be no superficial drying, or very large floats will occur, since dry plant debris are wetted by paraffin, and contain air. Science and Archaeology no.22 (1980)
Figure 7. (a) Washing a sample. A – rubber hose delivering hot water; B – bucket containing sample; C – sieve with retent. (b) Paraffin flotation. A – float at paraffin-water interface; B – residue.
The grazed sample is tipped into a clean, tipped bucket; tapping the sieve sharply to evert as much of the sediment as possible. The sieve, with its small quantity of adherent material, is put aside (it should not be allowed to dry out, however). The material in the bucket is covered with paraffin and mixed by hand,-wrting the hand first to reduce the effect of paraffin in dissolving skin oils. If the volume of the sample material is large, it may be shaken through the fingers in handfuls to ensure thorough mixing. Other methods of mixing have been found to be ineffective or to damage fossils, and it is important to avoid crushing or grinding actions. It will be apparent if the material has been insufficiently drained, as a slurry will result. Disposable surgical latex gloves may be worn when mixing by hand; a suitable brand is "Micro-touch" (Armco). Domestic washing-up gloves have been found to be unsuitable. Excess paraffin is poured off, taking care that no solid particles are lost, and the material is mixed through glass wool (Figure 6) for re-use.

The next stage involves the addition of cold water and the separation of afloat at the paraffin-water interface, consisting of remains whose surfaces are paraffin-coated and which float up in a bead of paraffin. The procedure is as follows:

Firstly, the traces of sediment on the hands are washed into the sieve, and thence, together with the material left in the sieve, into the bucket. Any material adhering to the walls of the bucket is washed down; this will probably be enough to produce a slurry if not, more water should be added. The slurry is gently stirred to suspend the air and to dissolve the viscous propagent of paraffin-coated fossils. The opening of the rube hose is thrust beneath the surface of the slurry (after re-checking its cleanliness) and the water is poured into the bucket filled by a fast flow of cold water. It is essential that during the flow the water is not directed over the sieve, in case of spillage. It is also important to avoid swirling, for this causes insect remains to adhere to the walls of the bucket, and great care must be taken to keep the end of the hose below the water level. If the water is not entrained the air may cause excessive large float. However, if the bucket is filled, the water must be well-distributed by the water flow. With practice, it is possible to add water quickly but in such a way that turbulence is avoided. During filling, the hose is brought up, keeping it just below the water level, so that the bucket is filled to about one centimetre from the lip edge and the water turned off. As the hose is removed, a small amount of sediment may be drawn into it, and thus must be expelled into the bucket by moving on the taps briefly; traces of sediment adhering to the outside of the hose must also be washed into the bucket.

The use of cold tap water has been found to be essential as floaters in hot water are often very large. This seems mainly to result from the release of gas bubbles from hot tap water, but the decreased viscosity of paraffin when hot may also be responsible.

While the lighter fraction of the sediment is settling, the bucket is placed in the sun to dry directly on the paraffin surface to free debris which are floatin; the sediment is too wet, and, secondly, to tap the sides of the bucket sharply a number of times to release particles adhering to them. The bucket is left to stand for 5-30 minutes, as necessary for the residue to settle completely (Figure 7). After settling, the supernatant is carefully poured onto the clean sieve, taking care that no residue is disturbed by turbulence and so carried away. Floating particles may be encouraged towards the lip by gently blowing the surface. The bucket is refilled with water (as above) and the whole float process repeated twice. It is important to prevent floaters drying on the sieve between float; if necessary, each float may be cleaned and treated immediately. To clean the float of paraffin, paraffin is washed off one side of the sieve and covered with copious liquid detergent, shaking the sieve to ensure that all the material is treated. The detergent is rinsed off with very hot water (50°C to 60°C) if possible and all traces of paraffin and detergent removed by flushing with IMS. The float is then washed into a jar (with IMS) and internal and external labels added (in pencil), on card, ready for storage. It is extremely important that the floaters are thoroughly cleaned of paraffin, since paraffins-alcohol-water mixtures produce a "varnish" like above.

The residue in the bucket is now tipped into the sieve and drained, and the paraffin treatment repeated twice. Normally, three "paraffins" (PI-3), each followed by three "floats" (FI-3) are employed. Occasionally, however, multiple f's in PI may be advantageous, especially for some samples rich in plant debris; the latter tends to float in later f's. Where the fossil content is small, P2 and P3 may be carried out with one or two f's only. If insect material is still being recovered at P3, then further f's or P's may be worthwhile. P's and f's are ticked on the recording sheet (Figure 2) as they are carried out.

On rare occasions, problems will be encountered when carrying out flotation. The commonest is that excessively large floaters are obtained (rat's tail floaters from a cubicle) and the resulting sediments are too hot to touch (centimetre or so of solid matter). This may be due to a failure to follow the steps outlined above, but is sometimes an unavoidable consequence of the nature of the archaeological setting. The solutions which may be effective are, firstly, to boil the sieve sample for some hours and, secondly, to boil with strong acid (15 v/v HCl) to achieve a solution. All paraffin from the first treatment must be removed with boiling with detergent before boiling. Samples of modern sediments processed float as well as much trouble-some, since fresh plant cuticles are readily wetted by paraffin and will float; a reliable solution to this problem has yet to be found.

G Treatment of residue: If there is doubt as to the effectiveness of the process in a particular sample, the residue from paraffin flotation may be wholly or partly checked, by sorting it in water under the low-power of a binocular microscope. Occasional remnants of residue at random is desirable to be sure that the operator's technique has not deteriorated. If the sample is to be examined for plant macrofossils as well as insects, the residue should be washed and sieved by sieves and screens as described above (p. 11). The material should on no account be allowed to dry out before sorting. Plant remains must be recovered from the float as well as the paraffin-coated residue and the two both cleaned in separate work. When the plant residue is no longer required, it can be dried in an oven at 60°C and then sorted for bones, small artifacts etc. The stones and wood fragments picked out prior to paraffin-flotation should now be returned, and the complete residue stored dry.

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in a clearly labelled polythene bag. It is consi-
tered most undesirable to rely for interpretation
upon assemblages at scenes recovered from the
dry residues.

H Flot sorting: Flots are sorted in small
amounts in alcohol in a petri dish using the low
power of a binocular microscope (612.5: minute,
yet identifiable, insect remains will be overlook-
ied at lower magnifications). Sorting requires con-
tinuous training and patience, but a discussion of
sorting techniques is beyond the scope of this
paper. The sorted insect remains are stored in absolute
alcohol in 5 x 77.52 cm plastic-capped
glass vials and labelled internally and externally
(in pencil, on card).

Concluding remarks

If the "recipes" given here are followed, the
techniques should almost invariably prove successful,
producing reliable samples of biological remains
from archaeological deposits in the shortest prac-
ticable time. Some deposits will prove extremely
untractable, but with experience and impatience such
problems should be overcome. However, it is desir-
able that beginners seek advice and training from
experienced workers.

Paraffin-flotation and seed extraction should
never be carried out in the open air or in dirty
buildings, since the risk of contamination is
immense. Even in well-designed laboratories, it is
essential to take every precaution to prevent cross-
contamination and the introduction of modern material
into the samples. On the other hand, bulk-sieving is a
process specifically designed to be employed on
site.

Finally, it may be useful to give an indica-
tion of the time required to perform the various
processes described here. It is impossible to provide
more than a very approximate estimate; some of the
figures quoted by Hirst and Hay (1978) are at variance with
the authors' experience. The following figures can be
taken as a range of deposit from those most easily
dealt with to the most tractable (to offer an
average would, frankly, be misleading) and refer to
a 1 kg sample size unless otherwise stated:

- Disaggregation and sieving for plant macrofossils - 2
  hours; sorting for plant macrofossils - 1 to 12
  hours; disaggregation, sieving, and paraffin-
  flotation - 2 to 4 hours, plus time for soaking or
  boiling; sorting float from paraffin-flotation - 1 to
  12 hours; sorting dry residue from paraffin-flotation
  (for bones, artifacts, etc.) - 5 minutes to 1 hour;
  bulk sieving of five buckets at a time (approximately
  50-100 l, the minimum sample thought to be representative of a
  large context) - 1 to 6 hours; sorting residue and
  float from bulk-sieving - 1 to 20 hours.

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