

Identification of archaeological remains of wheat: the 1992 London workshop

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Summary

This report summarizes issues discussed at a meeting whose aim was to discuss the current extent of agreement on critical issues in the taxonomy and identification of archaeological remains of wheat (Triticum L.). Discussions focused on taxonomy and nomenclature, and identification criteria for chaff and grain remains of glume and free-threshing wheats. Recommendations are made here for good practice and for areas requiring further research.

Introduction

Wheat (*Triticum* L.) is of particular interest to archaeobotanists for two reasons. Firstly, it has been a staple crop in much of Eurasia since the beginnings of agriculture, and its remains therefore form a major component of the assemblages studied by archaeobotanists. Secondly, ancient farmers grew a range of forms with varying agronomic and nutritional qualities. Understanding regional or diachronic differences in the relative abundance of the different wheat taxa can therefore make a useful contribution to the investigation of changes in ancient agricultural practices and diet, and offer a means of detecting patterns of exchange or diffusion of agricultural products. However, the wide range of closely related taxa, and their complex evolution involving hybridization, polyploidy and millennia of human selection, makes the identification of archaeological specimens unusually difficult.

Discussion of these problems by Dominique de Moulins and Mark Nesbitt coincided with the funding by the Leverhulme Trust of preparation of an archaeobotanical guide to criteria for the identification of wheats by Gordon Hillman and Sarah Mason. It seemed that the time was right to organize a meeting of archaeobotanists to compare notes on approaches to wheat identification and nomenclature, including problems encountered with the use of the classical criteria defined by earlier workers such as Schieman (1948), Helbæk (1952; 1970) and van Zeist (1968-70). More recent guides include Jacomet (1987; 1989), and Hillman's

unpublished but widely circulated student guides to wheat identification, which advocate the use of a range of alternative criteria and have been in use in the UK and elsewhere for well over a decade.

About 25 archaeobotanists, together with a wheat cytogeneticist, Terry Miller, met at the Institute of Archaeology in London on 17 and 18 December 1992. Our intention was not to arrive at a definitive guide as to how wheats should be treated, but rather to explore the extent to which our approaches were similar, to discuss areas in which there were major disagreements, and to identify topics on which further research was urgently required. The discussion centered largely on criteria which participants had found useful in the identification of charred remains of wheat, and largely on domesticated taxa. This account of our discussion does not, therefore, set out to be a guide to wheat identification; rather, a representation of the consensus view on what those at the meeting found to be useful approaches. We here assume a basic knowledge of wheat taxonomy and nomenclature (Miller 1987; 1992), and we likewise assume familiarity with the structure of the wheat plant (Fig. 54; see also Charles 1984; Hervey-Murray 1980; Renfrew 1973).

We wish also to draw attention to a recent Ph.D. thesis by Laura Morrison (1994). This thorough investigation of dispersal mechanisms in the wheat group also includes a useful discussion of wheat taxonomy and nomenclature (cf. Morrison 1993).

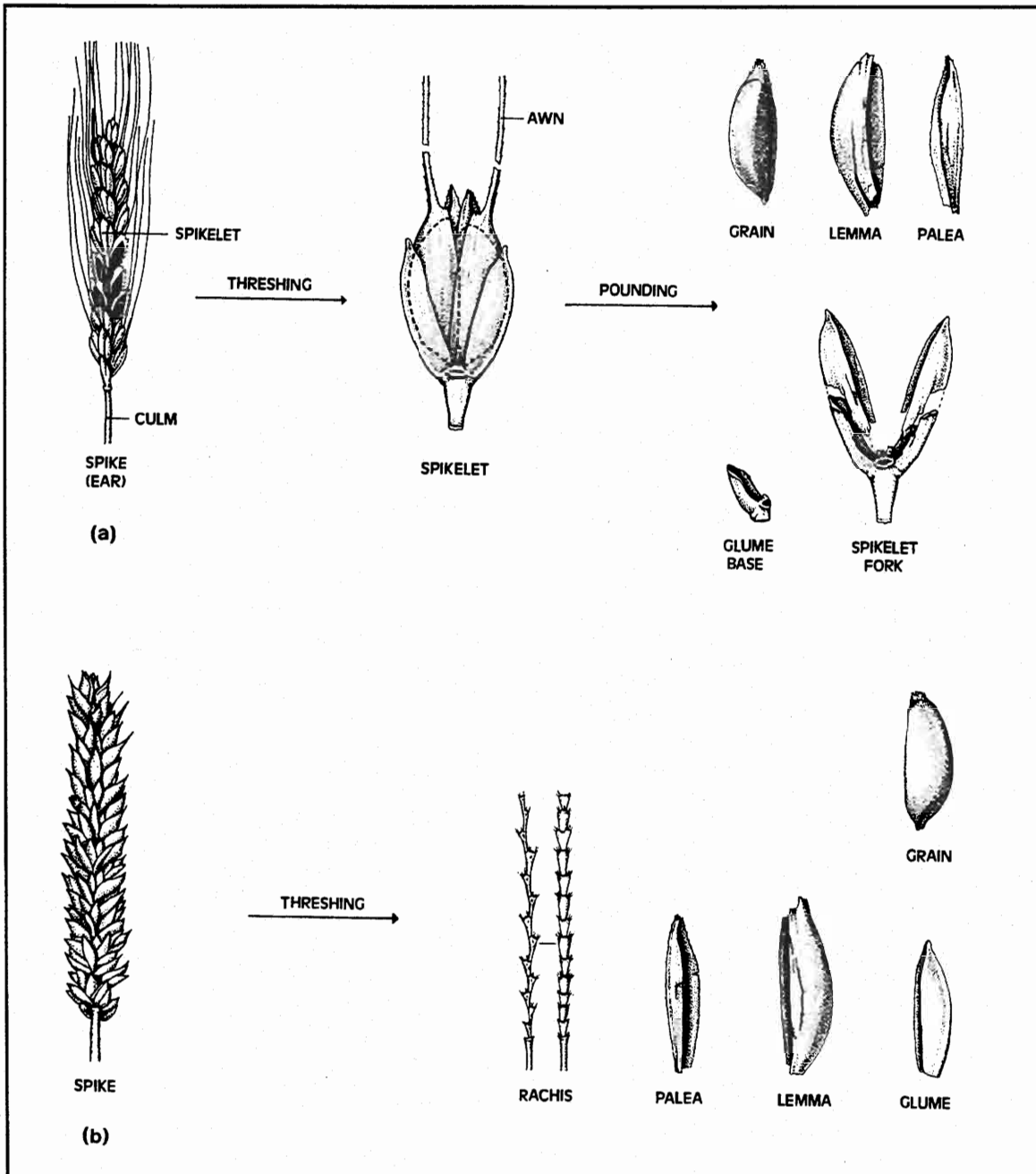


Figure 54. The major components of the wheat ear, (a) in a stylized glume wheat, in the intact state, after threshing and after pounding; (b) in a stylized free-threshing wheat, in the intact state and after threshing. (Redrawn from Charles 1984).

Wheat taxonomy and nomenclature
(Convenor: Terry Miller, Cereals Research Department, John Innes Centre, Norwich, U.K.)

1. Modern wheat nomenclature

Two fundamentally different concepts of wheat nomenclature are currently applied in the

scientific literature. The first is the traditional system of Latin binomials. About 20 species are recognized in the wheat genus *Triticum*, and each has a different species name. For example, emmer wheat is *Triticum dicoccum* (Schrank) Schübl.; macaroni wheat is *Triticum durum* Desf. The second system is based on the biological species concept and aggregates within a single

biological species all wheat taxa that readily interbreed (for further discussion of the definition of species see Cronquist 1978; Gupta and Baum 1986; Mayr 1992; Miller 1987). For example, wild emmer and domesticated emmer are interfertile, and are thus considered subspecies of the one species. In the tetraploid free-threshing wheats, virtually all the traditional species with the genomic complement AABB are accorded only subspecies or varietal status within one species: in MacKey's (1966) system *Triticum turgidum* (L.) Thell. Thus under MacKey's system domesticated emmer is known as *Triticum turgidum* (L.) Thell. ssp. *dicoccum* (Schrank) Thell. and macaroni wheat as *Triticum turgidum* (L.) Thell. ssp. *turgidum* conv. *durum* Desf. Mk.

Overall there was agreement on the following:

(a) Both systems offer advantages in that they emphasize different characteristics which are useful in different roles. The biological species system better reflects the genetic and evolutionary relationships, and thence patterns of variation in morphology. The traditional binomial system is much more conveniently expressed in writing, and continues to be the system most familiar to most archaeobotanists.

(b) Whichever system is chosen, it should be used consistently and accurately, with reference to a specified published checklist. Miller (1987) offers a convenient synopsis of a range of nomenclatural systems; Zohary and Hopf (1993) present a streamlined version of the biological species system.

(c) Most participants noted that, for most of their publications, they used the traditional species system and would probably continue to do so.

(d) It was also agreed that in publications in which it is important to stress the nature of evolutionary relationships or the pattern of manifestation of specific features within single biological species, the biological species system could be an appropriate format (e.g. Hillman and Davies 1990; 1992; Zohary and Hopf 1993).

For the purposes of the present paper we are using the version of the traditional binomial system outlined by Miller (1987, 18).

2. Applicability of modern taxonomies to ancient specimens

The question next arose of whether there was any justification for applying the names of

present-day wheat taxa to ancient forms. In some cases this is satisfactory: there is a clear similarity between, for example, modern emmer wheat spikelet and grain morphology, and that of many ancient tetraploid glume-wheat remains, so these can be justifiably named as emmer. Further, the use of familiar Latin names means that we are using nomenclature easily understood in different languages, and allows ancient plant remains to be linked to the wider agronomic and botanical literature.

Nevertheless, concern was expressed on two grounds:

(a) Our view of the range of taxa in ancient assemblages could be overly narrowed by the limited number of taxa surviving today. Obviously archaeobotanists have to start with known modern taxa and work back to identifying ancient unknowns, but we should consider the possibility that taxa which are no longer extant were present in the past. Furthermore, assemblages are likely to have derived from far more complex mixtures of landraces and species than are known today.

(b) Use of modern names for ancient wheats might appear to indicate that they share not just morphological but also ecological characteristics with their modern counterparts. It was agreed that any such assumptions should be discouraged for several reasons.

(i) Any one species (even the narrower classical species of the traditional system) embraces a broad spectrum of ecological tolerances which overlap massively between the different species. Although the modes and medians of the frequency-distributions of values for any one aspect of their ecology are doubtless different in each of the species, the overlap of the respective distributions is so great that archaeological remains assignable to a named species on the basis of morphology cannot be assumed to exhibit a known set of ecological tolerances (Davies and Hillman 1988, 603).

(ii) All ancient wheat populations, like their present-day progeny, are likely to have experienced intense selection pressure on those features of physiology which determine their ecological tolerances. The range of ecological tolerances represented in each population will have changed through time, and these changes will have accelerated when seed-stocks were sown in new areas. See, for example, the classic experiment of Harlan and Martini (1938).

(iii) Our knowledge of the ecology of archaic wheats is based on such a narrow range of surviving populations as to be hardly representative of the galaxy of forms which existed in the past. For example, emmer was (and is) basically a winter wheat (Miller 1992, 251), but once it ceased to be the principle wheat of arable farmers, atypical, spring-sown forms were particularly advantaged. These could be sown at the last minute as an optional extra if farmers found they had spare land and time after planting more important spring crops such as legumes (Hillman 1981, 146-8). The samples of emmer obtained by Percival for his classic monograph (1921, 188) came from just such areas where emmer had become a marginal crop, and it is hardly surprising that these are listed as spring-sown.

There was general agreement that we should be extremely careful about extrapolating ecological characteristics from a limited range of modern examples to ancient populations.

3. Systematic application of botanical names

In concluding discussion of this point, consensus was reached that applying a name to ancient assemblages of wheat should follow three steps:

- (a) The separation of clearly defined morphological groups in the material.
- (b) Referral of the groups to (i) ploidy level and (ii) free-threshing or glume wheat status.
- (c) Application of a botanical (Latin) name to each group, or the indication of an intermediate status between two or more known taxa.

However, it was particularly emphasized that botanical (Latin) names should be used only as shorthand for specified groups of character combinations (i.e. ploidy level and glume wheat/free-threshing status), *except in those rare cases where a more specific identification is possible*. It was generally felt that identification tables should contain both groupings (as in (b)) and Latin names. For the most common domesticated wheats, following the binomial system suggested by Miller (1987), the referral of names would be as in Table 83.

Thus the term '*T. durum/turgidum* group' would be applied to all tetraploid, free-threshing wheat remains, except for *T. carthlicum*. It would not imply (or rule out) any more specific identification to, say, *T. durum*, *T. turgidum*, *T.*

turanicum or *T. polonicum*. As stressed further on, any more detailed level of identification would require explicit justification. Such more detailed identifications are in practice rarely possible in ancient specimens.

Where we are unable to determine either of the key characters—ploidy level and free-threshing/glume wheat status—we should make this clear. For example, if we can say that some grain is free-threshing, but its ploidy level cannot be determined, it should be named simply as 'free-threshing wheat'. The custom in older publications of naming all free-threshing wheat as '*T. aestivum*' or 'bread wheat' should obviously be avoided. Most identifications to ploidy level of free-threshing wheats prior to the early 1980s are highly suspect.

With regard to the use of terms relating to free-threshing and glume wheats, we have yet to confront fully the problems caused by the existence of intermediates between glume wheats and free-threshing wheats in both the tetraploid and hexaploid series. These include forms of *T. durum* collected in Turkey by GCH in which the top half of the ear shatters like emmer, and the speltiform *T. aestivum* collected by Kuckuck (1964) in Iran and by GCH in east Anatolia, in which parts of many of the ears shatter on threshing, as in *T. spelta*.

4. Use of geographical and ecological distributions in identification

Identification of wheat remains on geographical or ecological grounds has long been made by archaeobotanists: for example, the long-held assumption that prehistoric free-threshing wheats in central Europe must be hexaploid—now overturned by Stefanie Jacomet's work on the mainly tetraploid Swiss Lake Village material (Jacomet *et al.* 1989, 327; Jacomet and Schlichtherle 1984), and the automatic identification by some archaeobotanists of free-threshing wheats from the Indian subcontinent as *T. sphaerococcum*, rather than simply to the *T. aestivum* group.

Another common example of this practice is the automatic identification of free-threshing wheats from the Mediterranean area as tetraploid, even though hexaploid wheats are cultivated widely in the area today. In view of the wide ecological ranges of wheat both within the traditional species, and within ploidy level, this kind of assumption is inappropriate. Wheats of *all* ploidy levels will grow in virtually all parts of the world in which wheat grows.

Ploidy level	Free-threshing/ glume wheat	English name	Botanical name and authority
Diploid	Glume	Domestic einkorn	<i>T. monococcum</i> L.
Tetraploid	Glume	Domestic emmer	<i>T. dicoccum</i> (Schrank) Schübl.
Tetraploid	Free-threshing	Macaroni/ Rivet wheat	<i>T. durum</i> Desf./ <i>T. turgidum</i> L. group
Hexaploid	Glume	Spelt wheat	<i>T. spelta</i> L.
Hexaploid	Free-threshing	Bread wheat	<i>T. aestivum</i> L. group

Table 83. Naming system for archaeological remains of domesticated wheats.

The ploidy levels of wheats growing in a particular area must always be demonstrated by application of rigorous identification criteria. Even where wheats of one period are generally found to be of only one ploidy level, it cannot be assumed that other finds of this period are the same.

Similarly, identifications are sometimes made *within* ploidy level on regional/ecological grounds. For example, rachis remains that are otherwise similar are often identified to *T. durum* in Mediterranean areas, and to *T. turgidum* in northern Europe (see Moffett 1991 for a useful discussion of tetraploid wheats). Identifications made in such a way are generally insecure unless it is clear they are made in a wide inclusive sense meaning 'free-threshing tetraploid wheat', as recommended in this paper. We recommend that the botanical name applied to such rachis remains is '*T. durum/turgidum* group'.

Some cultivated wheats that today have very local distributions—for example *T. macha* and *T. carthlicum*—may have been more widespread in the past; in the case of taxa such as *T. carthlicum*, distinguished by small genetic differences, they may have arisen by mutation more than once. For the wild wheats our knowledge of distribution is still highly uncertain, and again may not in any case reflect past distribution. For example, *Aegilops squarrosa* L. (also known as *Ae. tauschii* Coss.), a wild ancestor of *Triticum aestivum*, has recently been found in China, where it was previously unknown (Yen *et al.* 1983, 55-6). The ecology and distribution of remaining populations is likely to have changed over the millennia, as many of the areas in which wild wheats may have grown are now under intensive cultivation. The consensus of the meeting was that assumptions about the presence of species based on assumed past

geography and ecology are potentially misleading.

5. Conclusions: wheat taxonomy and nomenclature

(a) Application of modern wheat taxonomy to ancient material should be undertaken with care, and should be accompanied by full morphological characterization and justification. The possibility that plant remains may include other, less widely-distributed taxa, or those for which there are no modern analogues, must be allowed for.

(b) Both the traditional binomial system and biological species system of naming have advantages. The binomial system has the advantage of being well known and simple. The biological species system is appropriate when the emphasis is on the study of the evolution and genetics of wheats or precise patterns of morphological variation. Whichever is chosen, explicit reference should be made to the system of nomenclature used, as well as to the identity of accessions of modern reference specimens used for comparison.

(c) Latin names of modern wheat taxa can usually be applied to ancient remains only in a broad sense; identifications to a more specific level must be fully justified. Tables of identifications should include both descriptive characters (glume wheat/free-threshing status; ploidy level) and any botanical names used.

(d) Use of geographical and ecological distributions to identify plant remains is inappropriate; equally, identifications of wheat remains should be used to infer past growing conditions only with extreme caution.

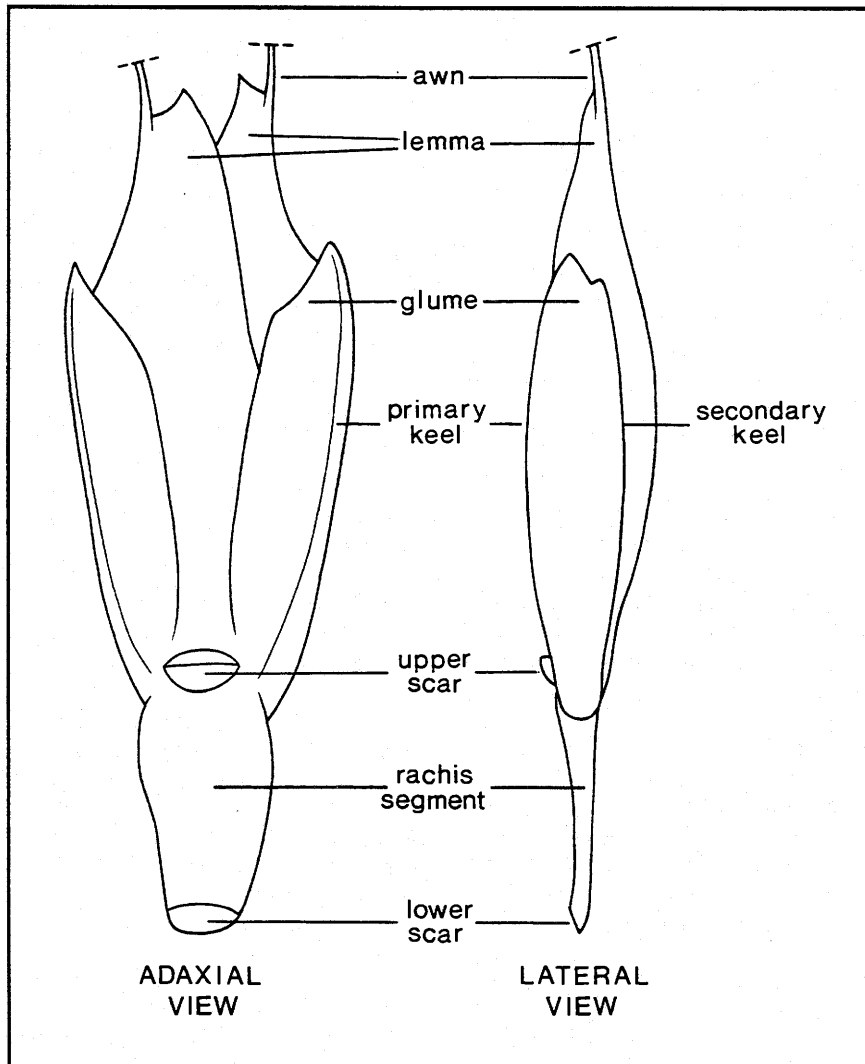


Figure 55. The principal diagnostic features of a stylized spikelet of a glume wheat. (From Nesbitt 1993).

(e) This session ended by discussing our incomplete state of knowledge of the taxonomy of present-day wheats. Work on morphological characterization has not progressed in the same way as that on genetics, particularly with regard to the rarer taxa. Reference material is often incorrectly identified and, when grown on to increase stocks, has often hybridized with other taxa.

Glume wheat chaff

(Convenor: Stefanie Jacomet, Botanical Institute, University of Basel)

This primary concern of this session was the separation of spikelet forks and glume bases of einkorn, emmer and spelt. Terminology of spikelet parts is shown in Fig. 55. Stefanie

Jacomet first presented a synopsis of the characters (particularly the prominence of veins on the glumes and the shape of the glume shoulder and apex) which have proved diagnostic in investigations of Swiss waterlogged assemblages where material such as whole ears (including parts that often do not survive in charred material) have been preserved (Jacomet 1987; 1989, table 13; Jacomet *et al.* 1989, 325). Gordon Hillman then summarized additional criteria that he had isolated from studies of modern wheats which can be used with more fragmentary remains, as outlined in his 1978 student guides. These include the relative width of the rachis scar (expressed as a percentage of spikelet width at the level of the scar); features of the rachis internode (see next section); the prominence of (and angle at) the secondary nerve (secondary

keel) of the glume; the pattern of tertiary venation on all glume surfaces, and the angle and prominence of the primary keel (Jacomet's 'Hauptkiel'). After warning of the variation within single ears which occurs in several of his chaff characteristics, he went on to outline features (commonly surviving in charred chaff) which provide clues to the part of the ear from which the spikelet derived, and which thereby permit more exact use of the species-diagnostic criteria.

Of Hans Helbæk's criteria (1970, 204-5), the absolute width of the glume base has been found useful (for example, Nesbitt 1993, 83-6), but *relative* width of the upper rachis disarticulation scar is more reliable than the absolute width. The third of Helbæk's features (absolute spikelet width) was usually unreliable. In addition, when confronted with fragmentary remains of glume bases, most agreed that as primary determinants, they used the features of glume venation and the angle at primary and secondary nerves (keels), as outlined by Hillman in his student guides.

However, it was also agreed that most of these features varied between the different populations of any one species as represented by the assemblages from different sites, and that we should not expect them to have universal validity through time and space. These criteria are most effectively used in the analysis of large assemblages to isolate internal groupings which might then be seen to have affinities with modern species. It was agreed that these criteria cannot always reliably identify individual specimens.

Other features which were agreed to be of some value were the robustness of the lower part of the glume in transverse section (although this varies between populations within species); the glossiness or otherwise of the surface of the glumes, which can clearly distinguish well-preserved einkorn and emmer; and the hollowness of the culm two centimetres below the spike as a distinguishing feature between hexaploids and tetraploids, although this part of the plant rarely survives. Participants were reminded that if they find remains of terminal spikelets (rotated through 90°) these cannot derive from einkorn, as the terminal spikelet in the diploid taxa is a tiny sterile appendage, as noted by Schieman (1948, 8).

There was incomplete unanimity on the utility of the prominence of primary keels of glumes, although it had sometimes proved useful in

separating keeled domestic einkorns from unkeeled domestic emmers in continental Europe (Knörzer 1971, 14-6). Terry Miller stressed that both the wild emmers and wild einkorns have strong primary keels, so prominent keels are likely to have characterized many of the domestic derivatives of both species, particularly the more primitive forms. In support of this, Leonor Peña-Chocarro was able to confirm that all the cultivated emmers she has recently collected in Spain are strongly keeled. This point was reinforced when ancient European and Near Eastern spikelet forks were compared under the microscope in the practical session. On Central European forks the primary nerve is very strong in einkorn and weak in emmer; in Near Eastern and Spanish forks it is strong in both taxa. As is often the case, a character that is useful in one region does not work in another. Another variation is the exceptionally heavily-veined glumes of what appear to be a distinct group of glume wheats (tentatively assigned to the tetraploids) from Neolithic and Chalcolithic sites in the Near East and southeast Europe. The past distribution of this form remains uncertain.

A further character which was rejected for general use is the angle between the glumes as viewed from the abaxial or adaxial side. This feature can be radically affected by charring and is therefore more likely to be useful on desiccated or waterlogged material. It also overlaps between diploid and tetraploid wheats, and thus has been found more useful for separating emmer from spelt. Even in this case its usefulness varies between assemblages.

It was agreed that the breakage pattern of the rachis ('barrel break' in spelt; 'wedge break' in emmer) as a character for distinguishing spelt should be used with circumspection and only in combination with more reliable criteria. Modern-day spelt often breaks up into both barrel- and wedge-shaped spikelets (e.g. Percival 1921, fig. 207). In southwest Asia care is also needed to ensure that chaff remains of *Aegilops crassa* Boiss. are not confused with the more heavily indurated forms of spelt (*Aegilops crassa* chaff is illustrated by Bor 1968, 181).

Quantification

A brief discussion on how best to present numerical data relating to glume wheat chaff followed. It was agreed that scoring the number of glume bases present in a sample (with one spikelet fork scored as two glume

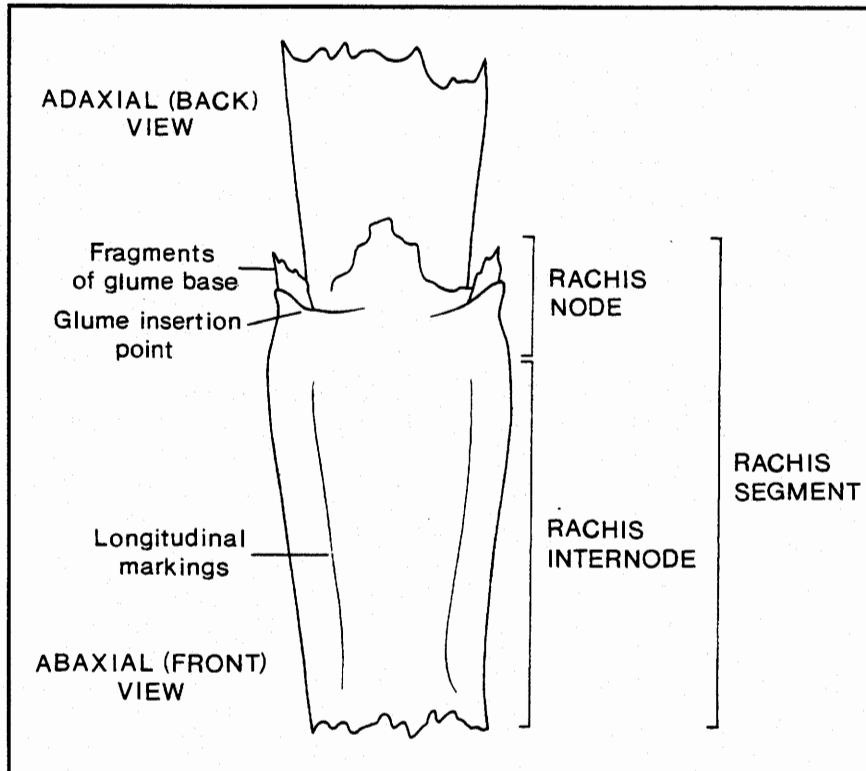


Figure 56. The principal diagnostic features of a portion of rachis of a free-threshing wheat. Note the distinction between 'rachis segment' and 'internode'.

bases) was preferred as, with the exception of one-grained einkorn, the figures are then readily comparable with the number of grains present. Spikelet forks are easily recognized and scored in archaeological material. Glume bases are more difficult as they can be confused with sturdier pieces of glume. Glume bases should only be scored if pieces of rachis node still adhere, as in the glume base illustrated in Fig. 54(a). It is important that simple pieces of glume are not scored as glume bases, as this will leave to overestimation of spikelet remains.

Conclusions: glume wheat chaff

Identification of spikelet forks and glume bases is fairly straightforward in well-preserved specimens which offer a range of independent criteria. While some characters are relatively secure, it was emphasized that a combination of characters should always be used, and that in different assemblages different combinations might prove useful. In using measurements of any kind relative size differences within any one assemblage are often useful, but absolute measurements should not be relied upon.

Where sufficiently large numbers of measurements can be made, width of glume bases is often a highly effective tool for checking identifications made on the basis of qualitative characters (Nesbitt 1993, 83-6).

Introgression between taxa of different ploidy levels means that even criteria which are generally regarded as ploidy-specific may sometimes be insecure. Marked regional variation suggests each site should be approached afresh; as ever, identification criteria that work in one place should not be applied uncritically to others.

Free-threshing wheat chaff

(Convenor: Gordon Hillman, Institute of Archaeology, University College London)

Until recently it was believed that rachis fragments of tetraploid and hexaploid free-threshing wheats could not be separated. Since the mid-1970s unpublished, but widely circulated, criteria from Gordon Hillman (also outlined in an unpublished paper given at the 1983 International Workgroup for Palaeo-ethnobotany meeting in Groningen, in the

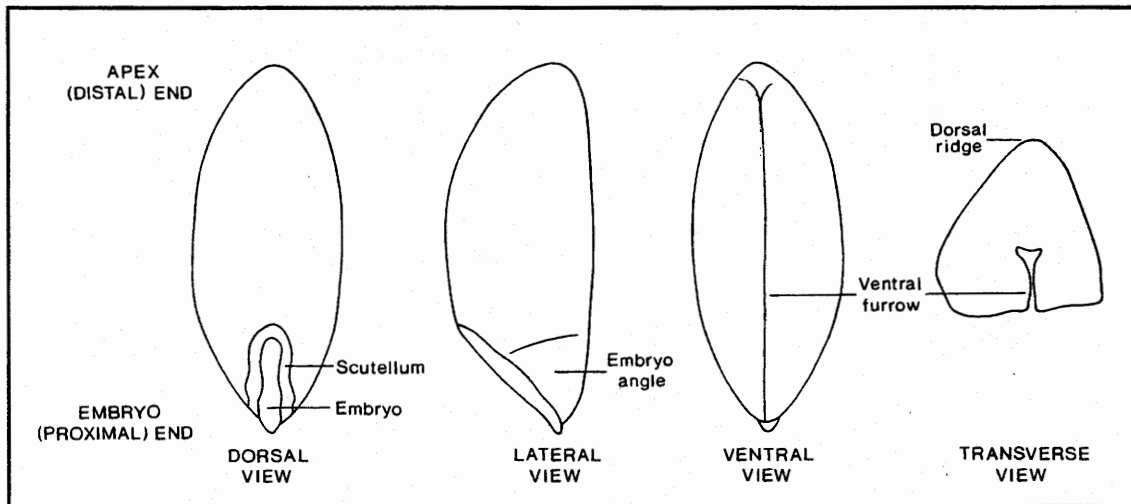


Figure 57. The principal diagnostic features of a stylized wheat grain.

Netherlands) have been tested and found effective by a wide range of users on diverse modern and ancient internodes. The testing has involved independent identifications using chemical criteria applied by Frances McLaren which, so far, have affirmed Hillman's criteria in both modern and ancient specimens (Hillman *et al.* 1993; McLaren *et al.* 1991). These criteria have been successfully applied by, amongst others, Jacomet (1987; 1989), Jacomet *et al.* (1989, 327-9), Jacomet and Schlichtherle (1984, 174), Maier (1995, 202-11; 1996), Moffett (1991) and Nesbitt (1993, 80-3). All these references include illustrations, but we would, as usual, stress the necessity for study of authenticated modern reference material prior to any work on ancient material.

Characters which serve to distinguish chaff at the level of ploidy include the presence of striations or lines of dots running down the abaxial ('front') surface of the rachis. These are often clearest on the lower internodes of an ear, which are more heavily built and thus more likely to survive charring (the absence of such striations is not a reliable character); the shape of the rachis in abaxial view, in all but short internodes; the robustness of the fragments of glume bases remaining at the node together with the presence or absence of a heavily thickened keel at the base of the glumes; the presence or absence of a fold at right-angles to the primary vein around the base of the glume and across the primary nerve itself (the '*am Grunde faltig eingezogen*' glumes described by Schieman 1948, 17); the degree of swelling ('lumps') on the rachis node immediately below the point of glume

insertion, and the shape of the rachis internode in transverse section (for terminology see Fig. 56). Delwen Samuel pointed out that the degree of swelling below the point of glume insertion can also be seen clearly from the adaxial ('back') side of the node. The swellings below the point of glume insertion appear to be the same as the '*Wulst*' identified in early German literature (Schroder 1931; Zimmerman 1934). The glumes themselves also offer other characters of potential value, but rarely survive intact.

Discussion also centered on those genetic or environmental factors that complicate the use of diagnostic characters. The problems introduced by the study of some of the less well-known taxa, and in the identification of compact forms of wheat were also raised. In the latter case Terry Miller emphasized the difference between truly compact wheats and forms which were merely dense-eared. The morphological distinction between these is difficult. The truly compact forms bear the C allele and have a zigzag rachis. Thus *T. compactum*, which carries the C allele, is a true compact wheat, as is *T. paleocolchicum*. Unlike *T. compactum* which has a very short ear, *T. paleocolchicum* has a long ear. *T. macha* also carries the C gene and is thus compact. However, because it is a glume wheat with a semi-brittle rachis, multiple-jointed rachis segments are unlikely to appear as archaeological specimens and the zigzag character will be less clear than with *T. compactum*. The same is only partly true for *T. paleocolchicum*, in which part of the rachis is often tough, especially at the base of the spike.

The situation regarding *T. sphaerococcum* is unclear. Percival claims that all the forms of this species have dense ears, but this was queried by Terry Miller, who pointed out that some undoubtedly have zigzag rachises. These are clearly shown in Percival's illustrations (1921, figs. 205, 206). Terry Miller stressed that single characters could not be relied on to identify archaeological specimens. For example, a zigzag rachis could derive from *T. compactum*, *T. sphaerococcum* or even from less fragile *T. paleocolchicum* or *T. macha*.

It is clear that more work on the compact wheats is needed. Any claim that truly compact wheats have been found in archaeological remains would need to be backed by full explanations, and clear illustration of true zigzag rachises. Where wheat remains can be demonstrated to have unusually short internodes, but there is no evidence for zigzag rachis, the term 'dense-eared' is appropriate. However, given the variability in length of rachis segments within the ear, and the ability of charring to greatly shrink rachis segments (Villaret-von Rochow 1967, 33-7), any claim for a 'dense-eared' wheat would need to be supported by measurements and illustrations.

Most past identifications of ancient material as *T. sphaerococcum* have been made on geographical grounds rather than on clearly defined morphological criteria, and are therefore highly suspect. The morphological characters that distinguish this species from *T. compactum* are poorly defined (Percival 1921, 321-4) and it is unclear to what extent these will be visible in archaeological plant remains.

It was agreed that, at present, awn remains could be identified only at the generic level or above, for example wheat/rye as against barley. Identification below genus level needs further work.

Quantification

On scoresheets, rachis segments should be scored by the number of nodes present (see Fig. 56 for the terminology): for example, an intact length of four nodes and internodes would be scored as four rachis segments. Presence of intact lengths of more than one rachis segment should, of course, also be separately scored. As with rachises of glume wheat chaff, rachis fragments should generally only be scored if they bear a rachis node.

It was agreed that Jacomet's (1987; 1989, fig. 5; see also Nesbitt 1993, 80) system of measurements for free-threshing wheat chaff should be used as standard, consistently taking measurements from one side (e.g. the left) of internodes.

Conclusions: free-threshing wheat chaff

(a) Useful criteria do exist for separating tetraploid and hexaploid wheats. However, these characters should only be used when strongly-developed and, like those for the glume wheats, should always be used in combination. In many modern and ancient specimens the critical characters are poorly developed. As with many spikelet forks of glume wheats, a proportion of free-threshing internodes cannot be identified using morphological criteria.

(b) Measurements of certain rachis features may offer some potential in separating free-threshing species such as *T. durum*, *T. turgidum*, *T. turanicum* and *T. polonicum*, but the pattern of continuous variation in rachis and other criteria between such taxa suggests that investment of a great deal of effort in this area is probably pointless, except where material is exceptionally well preserved. However, with genetically disjunct taxa such as *T. carthlicum* in the tetraploids and *T. sphaerococcum* in the hexaploids, useful criteria do exist, and in the case of *T. carthlicum* have already been applied (but not yet published) by Hillman. However, any identification beyond the basic level of tetraploid or hexaploid requires full justification in publication, and most such identifications extant in the literature have little value.

(c) The biases introduced by charring, resulting in dramatic shrinkage of rachises (Villaret-von Rochow 1967, 33-4), the preferential preservation of internodes from the lower part of the ear, and the variation in spike features induced by climate, mean that attempts at identifying dense, compact or pyramidal forms should be treated with caution.

Wheat grains

(Convenor: Glynis Jones, Department of Archaeology and Prehistory, University of Sheffield)

Identification of grains was agreed to be the most difficult area. In part this is because

Dorsal view	Ventral view	Lateral view	Transverse section
Apex (distal) bluntness/attenuation	Flatness of ventral face	Apex bluntness/attenuation	Presence of a ridge
Asymmetry of the grain	Compression lines	cross-section	Curved <i>vs</i> angular
Presence of a ridge		Embryo angle	Depth and shape of the ventral furrow
Parallel-sidedness		Presence of a hump above the embryo	
Attenuation or roundness of the embryo (proximal) end			
Position of greatest width of the grain			

Table 84. Grain characters of potential value for identification of archaeological wheat remains.

charring affects the morphology of grains more than that of chaff; in part because of wide intra- and inter-specific variation in grain characters today; and in part because characters tend to be more subjective, unlike the present/absent characters used for chaff. The potentially useful characters are listed in Table 84; terminology is shown in Fig. 57.

Grains present some of the clearest cases of different characters being effective in different geographical regions. For example, Mark Nesbitt found distinguishing between grains of glume wheats and free-threshing wheats to be a straightforward matter on most of the archaeological Turkish material he had examined. In contrast, Gordon Hillman and others found that making this distinction presented great difficulties in the case of Romano-British spelt and bread wheat. Similarly, Stefanie Jacomet pointed out that in the case of Swiss Lake Dwelling wheats, grain extracted from intact emmer and spelt spikelets proved to be identical in appearance, while others found that it was possible to distinguish at least some of the more extreme forms of spelt from emmer in Wales and northern England.

Because of this great variability there was no general agreement on the usefulness of different characters; it is suggested here that grain has to be considered on a site-by-site basis, and that any linkage between internal groups and modern taxa would require

justification in each case. Where the much more diagnostic chaff remains are present, and indicate that there is only one taxon present, this can obviously be extremely helpful in suggesting possible identities of the grain. However, it is far more common for taxa to be mixed, or for the amounts of chaff present in grain samples to be too small to permit any inferences.

Some specific cases were discussed. It was agreed that a high back or hump above the embryo, a character used by earlier archaeobotanists to indicate tetraploidy, was not a universally reliable character as it can also occur in some forms of *T. spelta* and *T. macha*. Gordon Hillman suggested that hexaploid wheats could often be reliably distinguished from diploid and tetraploid wheats (with the exception of *T. carthlicum*) by the degree of attenuation or roundness of the embryo end and from the depth of the ventral furrow relative to the height of the grain at the same point. It was agreed that applying the term 'compact' to grains could be misleading, as it suggests an automatic link with compact-eared wheats; it would be better simply to use neutral terms such as 'short and round-grained'.

Within the glume wheats, difficulties still exist in separating grain of one-grained einkorn from grain in one-grained spikelets of emmer: although most emmer spikelets are two-grained, the terminal spikelets are almost

always one-grained, and there are both modern and ancient populations of emmer in which the spike contains a mixture of one- and two-grained lateral spikelets. The same is true of spelt. It was also agreed that distinguishing grains from two-grained spikelets of emmer and einkorn presents difficulties that we are equally far from resolving, although there are several characters useful for separating extreme forms of either type.

Quantification

There are two approaches to counting grains. One is to select a number of grains and embryo-end bearing grain fragments, and to attempt identification of all, irrespective of preservation or size. The other is to select a number of whole grains and to identify these, and then to assume the relative quantities in these reflect those in the fragments. Checks are needed to ensure that this is in fact true. Naturally, in the case of very small samples all surviving material must be identified. In the case of larger samples, the method used is a matter of choice that must be recorded in the publication.

Conclusions: grain identification

Overall there was agreement on the kind of characters that could be used in separating taxa, but little agreement on what combinations of characters were consistently successful in separating specific taxa. Grain morphology seems to vary greatly between different regions and periods. Although it is usually possible to distinguish groups of grain and tentatively refer some of them to modern taxa, problems are much greater than with chaff. Often identification will only be possible for a proportion of grains, and identification may be possible only to ploidy level or free-threshing/glume wheat status. Regional variations in the degree to which grains can be identified may as much reflect our degree of self-certainty in making identifications as any real patterns of morphological variation. Adequate explanation of how specimens have been identified, and suitable illustrations should be a routine part of publication.

Overall conclusions

Our conclusions were encouraging: broadly similar approaches are used by all present at the meeting; in part this reflects the

widespread adoption during the last two decades of Gordon Hillman's criteria, which in turn, owe much to his early training with Maria Hopf.

It was agreed that both the traditional system of nomenclature and the biological species system have advantages in different situations, but that it is most important that whichever system is used is applied accurately, consistently, and with reference to a published checklist.

Consistent, repeatable identifications are only possible when a combination of characters is preserved; such character combinations have proved more elusive for grains than for chaff, and their identification is often difficult to confirm. Grains require greater caution in identification, and urgently need further comparative studies.

In the case of glume wheat chaff, separation of einkorn, emmer and spelt is often straightforward for well-preserved material, especially if enough spikelet forks are present at the site to allow metrical criteria to be applied in addition. However, the criteria we use at present take little account of the possible admixture of rarer taxa such as *T. paleocolchicum*, *T. timopheevi* and *T. macha*, although combinations of more cryptic criteria have now been isolated by Mason and Hillman which offer the possibility of distinguishing the more extreme forms of *T. paleocolchicum* and *T. macha*. Rachis internodes from free-threshing wheat can usually be divided into tetraploid and hexaploid groups, but intermediate specimens do exist even in modern populations. In both areas, further work is badly needed to achieve reliable identification at the classical species level.

All criteria would benefit greatly from studies of a wider range of modern populations. This raises a constant theme of the meeting: our poor knowledge of even the modern wheats, particularly those taxa that are relatively rare today. Equally worrying is our lack of familiarity with a sufficiently broad range of the forms that can exist within any one classical species, or even within one landrace. This frequently reflects inadequate reference collections which often have very few accessions of each species. Such deficiencies have doubtless been the cause of several cases where widely used criteria have wrongly been assumed to have diagnostic potential. This problem is exacerbated by the fact that wheats in many reference collections are commonly

either misidentified at source, and/or are the products of hybridization in botanical gardens. Even specimens obtained directly from genebanks have often been misidentified at source. Our incomplete knowledge of morphological variability is compounded by our lack of familiarity with recent advances in studies of wheat origins, hybridization, introgression and phenotypic plasticity, and by the fact that such studies are still far from resolving some of the major issues.

Another constant theme of the meeting was that different identification criteria or groups of criteria are effective in different areas, often to a radical extent. For wheat identifications to be fully intelligible to those working in other areas—or even other sites—it is essential that we provide the reasoning by which each morphological group has been named. We must be sure to describe both 'normal' types and also unusual or unreferrable types. Descriptions should be supported by illustrations (the publications of Willem van Zeist in *Palaeohistoria* set the standard for this), and where identifications include a quantifiable element—for example, 'short and rounded' grains or 'dense' internodes—these must be supported by measurements.

New techniques

An encouraging development is the growth of new techniques that offer independent criteria for identification. Of these, infra-red spectroscopy is already giving good results for both grain and chaff (McLaren *et al.* 1991; Hillman *et al.* 1993), while ancient DNA holds promise for the future (Allaby *et al.* 1994; Brown *et al.* 1993; 1994).

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