

## COMPUTERIZED KEY OF GRASS GRAINS OF THE MEDITERRANEAN BASIN

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### Abstract

The Computerized Key of Grass Grains helps researchers to identify easily and definitively grains of the *Gramineae* species that grow in the Mediterranean basin. Archaeobotanists, ecologists, taxonomists and agronomists will find the Key useful. Its application simply requires measurement of grain dimensions - preferably of a number of grains - and description of several of its features.

When an unknown grain is measured and described and the information is fed into the computer, all possible species whose dimension ranges and physical features are compatible with the measured grain appear on the screen.

It is advised, in practice, to modify grain dimensions by 20%, thereby decreasing the sensitivity of the Key and obtaining a larger variety of possible candidates. Then, with the aid of image files of various grains, a visual selection of the candidates can be carried out. The final identification of the precise species is made by comparison to a good reference collection. We plan to continue incorporating all new data accumulated in our laboratory and to release updated and expanded versions of the Key every two years or so.

The "Computerized Key for Grass Grains of Israel and its Neighbouring Countries" (KISLEV & al., 1995) has been greatly improved since its original presentation in 1991 at the Kiel 9th Symposium in archaeobotany. The geographical range has been expanded to include most of the countries in the Near East as well as Libya (SHERIF & SIDDIQI, 1988) and the six largest islands in the Mediterranean basin (TUTIN & al., 1980). Turkey is represented by its Mediterranean parts: West Anatolia, South Anatolia and the East Aegean Islands (DAVIS, 1985) which are equal to districts WN, W, Is, SW, S and SE (HELLER & HEYN, 1991) (Table 1). The grasses of Greece are now being processed.

The grass family was chosen as a model for the first computerized key because of its importance, the large number of species, and the often extreme difficulty of distinguishing between the grains. It is worth quoting Bor who wrote: "The grasses are the most widely distributed of all flowering plants and form a prominent feature of the flora of every continent. In the temperate regions, the Asterales lead in number of species; in the tropics, the Leguminales are the leading order, closely followed by the Orchidales and the Gramineales in second and third place respectively. But, in number of individual plants and coverage, the grasses lead in both regions". It should be emphasized that the family *Gramineae* is one of the most difficult of families (BOR & GUEST, 1968: 14f).

It is well known that the published Floras of different countries are not of equal quality nor are all of them regularly updated. To take only three extreme examples, the grass flora of Egypt was published this decade (COPE & HOSNI, 1991), that of Syria and Lebanon (MOUTERDE, 1966) needs revision, while only mountainous Greece was

Symbol	Country	Grasses	Grasses in the key	
Ar	Saudi Arabia	267	209	78
BI	Balearic Islands	149	127	85
Co	Corsica	225	165	73
Cr	Crete	168	162	96
Cy	Cyprus	177	170	96
Eg	Egypt	266	255	96
Gu	Kuwait, Bahrain & Qatar	130	118	91
IJ	Israel & Jordan	341	334	98
Iq	Iraq	299	259	87
Li	Libya	219	198	90
LS	Lebanon & Syria	302	291	96
Sa	Sardinia	201	157	78
Si	Sicily	244	185	76
Tu	Mediterranean Anatolia	346	266	77

Table 1. Grasses of Mediterranean & Near Eastern floras found in the key. (Updated to summer 1996).

recently published (Strid & Tan, 1991). Besides, it was not easy to decide which species should be included in the key, because sometimes the flora is overrepresented. Take, for example, Flora of Iraq. *Agropyron caespitosum* was found only once in the country, and therefore is included in the key. But, *A. cristatum* is not included as it was not yet found, although "it occurs over the frontiers and should be looked for in the mountains". Similarly, some experimentally cultivated grasses in Egypt, such as *Cymbopogon citratus*, were excluded. A conspectus of the grasses of the Mediterranean basin could considerably help us in this respect. Latin names, which change so quickly, are given in the key according to the latest Floras (e.g. HELLER & HEYN, 1991; STRID & TAN, 1991; TURLAND & al., 1993), as well as the keystone of grass taxonomy by CLAYTON & RENVOIZE (1986).

The aims and principles underlying the Key are: 1. Rapid identification. 2. More reliable identification. 3. Coverage of all local grass species. 4. Ancient cereals found in archaeological sites, whose grains have generally smaller dimensions, are considered as separated species. 5. Use of all available morphological grain characters. It is recommended that a maximum number of characters is used, but it is not necessary to use all of them. The Key is user friendly and was built with Microsoft Access software. It can, therefore, be routinely used by anyone needing assistance in grass identification. However, the user must be acquainted with the details of grain morphology as well as being somewhat experienced in the field. The Key will be most effective when finds come from a country that has more than 85% of its grass flora in the database. When a country is represented by smaller percentage of its grass flora, the Key may still be used, but with some reservations. Here its identification will be done in two steps: first, the usual procedure will be used to identify the grain. Then, the researcher will have to consult a list of local species that their database is not included in the key.

The Key itself is not designed for absolute identification, the computer producing a rather limited list, generally of less than 10 species. (But it sometimes provides a small number of suggestions or even a single species.) Using the image files, which are planned to include in the first stage one or two species for each genus, the list can be considerably reduced by visual selection of the candidates. With this restricted number of candidates, final identification can be easily made with the aid of a good reference collection. The Key is, therefore, more of a computerized determination aid than a computerized key in the absolute sense.

The database includes now (summer 1996) over 1600 samples from about 550 species. For this purpose we made field trips in Israel as well as in Cyprus, the Greek mainland and to Crete. Additional data were obtained from gene banks, herbaria and collections of many colleagues. Indeed, not all grasses from each country are included in the database. This is because of the difficulty of gathering during the ripening season before the plants shed their fruits and of collecting the grains on the ground. Most of the missing species, however, are rare (e.g. *Bromus javorkae*) or with very low rates of fertility or absolute sterility (e.g. *Arundo donax*). The missing species would therefore have little chances of being found in archaeological excavations.

Today, 12 grain features are included in the input screen, namely the three dimensions, four features of the hilum (a scar formed by detachment of the grain from the ovary), its location along the grain, its length, shape and size, the embryo length, grain surface and hairiness, shape of its ventral side, and adherence of the grain to its hulls. Some of these features can be observed only by the aid of a stereomicroscope. It should be emphasized that it is not necessary to enter all features for identification. On the other hand, a single charred grain does not always exhibit clearly all relevant features. Then, if several grains (of the same species) are available, it is useful to measure and enter measurements of a few of them, and the computer will automatically calculate their average. With data of several heterogenous grains (of the same species), e.g. belonging to *Aegilops* or *Avena* which exhibit various types of venter shape, the list will be smaller, including only species which have those alternatives.

When the archaeological grains are charred, the possible dimensional changes due to heat can be automatically corrected for. The search can be limited to the country in which the grain was found, or neighbouring countries can also be included. Symbols of European countries follows *Flora Europaea* (TUTIN & al., 1980), except Tu which refers to Mediterranean Anatolia. This enables a more reliable identification from the morphological point of view and the output of a relatively short list of candidates. If it is desired to further shorten the list, it is possible to choose a particular region(s) and consequently to obtain species growing in a restricted area. This is especially important when dealing with large countries with rich floras, such as Turkey. Also, when an archaeological site is located near the border, it is useful to choose the nearest regions from the relevant countries. The use of regions not only reduces the number of candidates, but also reduces the number of closely related species. This often makes possible more reliable identifications. However, it should be noticed that the occurrence of species in regions is not as well documented in Floras as are countries as a whole.

One of the reasons is that an international border is also a geographical barrier. Updated Floras may provide improved data of countries and regions. In this connection,

Plant name		Quantity
1991	1996	
<i>Aegilops geniculata/peregrina</i>	<i>Aegilops geniculata/peregrina</i>	9
	cf. <i>Agrostis</i>	1
	<i>Alopecurus utriculatus</i>	45
* <i>Avena barbata</i>	<i>Avena</i> sp.	84
<i>Avena sterilis</i>	<i>Avena sterilis</i>	63
<i>Avena wiestii</i>	<i>Avena wiestii</i>	16
*cf. <i>Brachypodium distachyum</i>		
* <i>Cutandia</i> sp.		
* <i>Echinaria capitata</i>		
	<i>Hordeum geniculatum/marinum</i>	11
<i>Hordeum glaucum</i>	<i>Hordeum glaucum</i>	22
<i>Hordeum spontaneum</i>	<i>Hordeum spontaneum</i>	556
	<i>Hordeum spontaneum/bulbosum</i>	638
	<i>Imperata/Saccharum</i>	1
* <i>Lolium</i> sp.		
	<i>Melica persica</i>	2
* <i>Phalaris minor</i>	<i>Phalaris</i> sp.	4
<i>Stipa barbata</i>	<i>Stipa barbata/holosericea</i>	1
<i>Stipa capensis</i>	<i>Stipa capensis</i>	63
	<i>Stipa/Stipagrostis</i>	64
<i>Stipagrostis obtusa</i>	<i>Stipagrostis obtusa</i>	7
	<i>Stipagrostis plumosa</i>	3
<i>Triticum dicoccoides</i>	<i>Triticum dicoccoides</i>	27
Incomplete & damaged grains		622
Total grass grains		2239
Spikelet parts, bulbils, etc.		5007
Total gras remains		7246

Table 2. Grass grains identified at Netiv Hagdud (After BAR-YOSEF & al., 1991 and KISLEV, 1996). (Names with \* were proved to be misidentified).

it should be stressed that not always the grasses still grow today in the same region. The reasons may be changes in plant distribution or international or even local trade from other regions.

Before turning to a reference collection, it will be possible to examine the image files. For each genus one or two representative species will be present, each with three images, namely dorsal view, side view and cross section. Comparing the identified grain to the images of the candidates (or of related species), the list of candidates will be reduced to about half. Thus, it may sometimes cut down choices to only one or two species. The image files are especially important when a reference collection is not available or its scope is unsatisfactory.

In the last few years, some thousands of grains belonging to dozens of grass species from several local archaeological sites were identified by us with the help of the

Computerized Key. Among them, an early Neolithic site - Netiv Hagdud, dated to 9,700  $\pm$ 200 B.P. (in radiocarbon years), where out of 16 grass species some four species were reidentified. It is more difficult to identify a single grain than several belonging to the same species. It worth noting that some of the grass species do not grow today in the surrounding regions. Indeed, almost 30% of the grains could not be determined because of their bad state of preservation, and all the grains in this site constitute only some 30% of the grass remains (Bar-Yosef & al., 1991; Kislev, 1996) (Table 2). In addition, our colleagues often send us archaeobotanical material, e.g. from Egypt, as well as grains from their reference collection, for identification or confirmation. Measured grains should be complete - though not necessarily with the embryo - or at least almost complete. We are sure that a considerable part of our reported grains would have never been identified without the help of the Computerized Key, despite the reasonably good reference collection of grasses at our disposal. This is because it is not easy, from both the psychological or practical points of view, to go through more than 1000 samples from the reference collection to identify a single, charred, somewhat puffed grain! This is particularly true when single charred grains belonging to different species are submitted for identification at least once a month!

Some disadvantages of the Key should be mentioned. Unfortunately, at this stage, the researcher cannot take a plastic bag full of excavation earth, pour it onto a moving belt passing beneath a computerized detector, take a coffee break, and obtain the whole list of plants found (with their quantities) when he returns!. In addition, for a reliable identification, the grain in question should be in a good, or at least in a satisfactory state of preservation. Even an experienced user of the Key may require several hours to successfully identify a stubborn grain sample. It should be emphasized that only grains can be identified and not other parts frequently uncovered, such as rachis parts, glume bases or bulbs. Another problematic area is plants belonging to large, or well presented genera in the Mediterranean basin, such as *Aegilops*, *Bromus*, or *Festuca*, because their grains are too similar. It might be useful to identify, e.g. the species of *Festuca*, to their aggregate level.

Our future plans include: 1. Increasing the number of species by extending the Key's geographical range to all Mediterranean countries (in France and Spain it will be difficult to put a border between the Mediterranean and the neighbouring floras) and by incorporating the rest of the Near Eastern countries, or at least those regions that do not sustain tropical floras. 2. Enlarging the image file. 3. Increasing the Key's reliability. (At this stage, it seems that the emphasis should be on varieties from other countries, which may enlarge the range of measurements in the database. 4. Updating the list of new adventive weeds to benefit those needing help in modern grain determinations, such as farmers and quality control of cereal commercials which include certain amounts of weeds. 5. Growing the collected wild grasses in order to provide well identified grains for reference collections.

We feel that the Key will open a new era in archaeobotany - computerized help in grain identification. In our laboratory in Bar-Ilan University, we are in the initial stages of preparing keys for another one or two families. We invite other groups to use our experience for preparing keys of other families or large genera. We also hope that the Key will break a vicious cycle. When grasses are difficult to identify, either as whole

plants or as single grains in the laboratory, most botanists will be dissuaded from preparing a complete reference collection of the family members for foreign countries he might need data for his work. Now, there is hope that the grass family determination will be simpler and cooperation between colleagues in providing grain samples should be intensified.

The key is free, except for the diskette itself. In the future, we plan to routinely incorporate the new data accumulated in our laboratory and every two years or so to prepare a new version for distribution. However, we realize that some errors or missing data may be noticed by users during the procedure of identification. We shall be grateful for any suggestions by colleagues for improving the Key for drawing our attention to faults they may uncover. We will also be grateful if any colleagues could spare some of their grass grain samples for increasing the reliability of the Key.

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