PERSPECTIVE ARTICLE

Fossil or non-fossil? A best-practice guide for archaeobotanical taxa

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Abstract Can archaeobotanical material be treated as a nomenclatural type of a fossil taxon? Here we show that archaeobotanical taxa should be named according to the rules for non-fossil taxa. Examples of archaeobotanical taxa are summarized and discussed. A best-practice guide for the correct treatment of archaeological plant remains as the type of a new name is presented.

Keywords archaeobotany; fossil; herbarium; museum; nomenclature; non-fossil; palaeoethnobotany; typus

■ INTRODUCTION

The terms archaeobotany or archaeobotanical research, whose content is undoubtedly the paleobotanical investigation of plant remains (fruits, seeds, wood, tubers and others) found in archaeological contexts, appear in the scientific literature since the middle of the 20th century (Opravil, 1969). With the examination of plant remains in connection with archaeological excavations, archaeobotany makes a contribution to the life picture of past human epochs (Kalis & al., 2003) and, together with many other techniques of a historical or biological nature, contributes to resolve the origin of cultivated plants (Candolle, 1883a). In parallel, the term palaeoethnobotany was defined as the study of the remains of plants cultivated or used by humans in ancient times that have survived in archaeological contexts (Helbaek, 1960; Renfrew, 1973; Knörzer, 1975; Ford, 1979).

Nevertheless, this type of research predates the appearance of the terms archaeobotany and palaeoethnobotany. Since the beginning of the 19th century, archaeobotanical studies have been devoted to the identification of plant remains, especially the fruits and seeds of cultivated plants. As a result, thousands of archaeobotanical papers have been published (Helbaek, 1959; Renfrew, 1973; Vartavan & al., 2010; Schultze-Motel & Hammer, 2021).

In his seminal work, Kunth (1826a,b) adopted the "principle of parsimony", which assumes that the most acceptable approach for identifying and naming the recovered remains was the simplest, namely recognized living taxa. As an example, he writes, "The fruits and plant fragments discovered [by M. Passalacqua] in the tombs of ancient Egypt, almost all belong to plants that are still found today in these regions" (Kunth, 1826b: 418; all translations are ours). The basic approach invoked by Kunth (1826a,b) is morphological: "The most scrupulous comparison of analogous parts has allowed me to perceive no difference. It seems to me therefore proved that the vegetation of these two epochs is perfectly identical, and that, for so many centuries, plants have not experienced any perceptible change in their form and structure" (Kunth, 1826b: 418).

In addition, Kunth (1826a: 418–419) established his second rule for archaeobotanists: "If I could not relate to their species two or three of these [found] objects, we must blame the incomplete knowledge that we have of the families to which these plants belong." Therefore if the available archaeological material presents distinct characters, it can be described in terms of a novel living taxon: This is the case for *Areca passalacquae* Kunth (Kunth, 1826a).

The first outstanding archaeobotanical publication is the work of Heer (1865), commonly considered as the birth of archaeobotany, which is also called palaeoethnobotany, phytoarchaeology, or archaeoethnobotany (Schultze-Motel & Hammer, 2021). With regard to his finds, Heer (1865, 1866) claims that "the charring process has not changed their

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shape significantly" (Heer, 1865: 3). Accordingly, he was able, using the parsimony principle and non-fossil taxa, to identify *Corylus avellana* L., *Fagus sylvatica* L., *Reseda luteola* L., and others. It is important that the support for the approach was early expressed by such an authority as Alphonse de Candolle: "The wish expressed by geologists to have a special code for the nomenclature of fossils had alarmed both botanists and zoologists, for whom fossil plants, and animals, belong to both kingdoms. They saw no advantage and feared disadvantages in introducing special rules for the description of beings that are only anterior to those of the present time […]" Candolle (1883b: 3).

"It would be useful, it seems to me, to add an article [to the Laws of Botanical Nomenclature approved in 1867] worded as follows: 7 bis. The rules of botanical nomenclature apply to all classes of the plant kingdom and to fossil plants as well as to those now living" (Candolle, 1883b: 46).

"In addition, there is a higher reason for not making palaeontology a separate science, with its own laws and uses in nomenclature. The further we advance, the more the fossils of a kingdom are mixed up in the classifications with the currently living species […]" (Candolle, 1883b: 47).

Since then this was the prevailing approach for identifying prehistoric food plants (Renfrew, 1973).

Reviews and databases. — Between 1968 and 1991, Jürgen Schultze-Motel published the series "Literatur über archäologische Kulturpflanzenreste" that provides printed lists of publications on archaeological remains of cultivated plants from 1965 to 1990 (Schultze-Motel & Hammer, 2021). The online "Archaeobotanical Literature Database" (ArchbotLit: https://www.wikis.uni-kiel.de/archbotlit/), built upon the efforts of Jürgen Schultze-Motel and Helmut Kroll, was transferred into referenced plant lists that were published annually from 1992 to 2001, entitled "Literature on archaeological remains of cultivated plants". The adopted nomenclature in these databases and reviews, and the reviewed papers were based on non-fossil taxa. ArchbotLit was recently converted into a wiki-platform hosted at Kiel University (Kirleis & Schmütz, 2018). The most important backbone for the ArchbotLit database is its list of taxa and synonyms. The predetermined taxa list is based upon the catalogue, "Mansfeld's World Database of Agricultural and Horticultural Crops", which contains information on 6100 non-fossil crop plant species (IPK, 2020; Kirleis & al., 2021).

Additional parsimony-principle examples. — Paleontologists often combine Holocene fossils with non-fossil taxa. In his study of the Burma Quarry deposits, Pregill (1988: 8) reports that, "apart from charcoal and a single unidentified seed, the only plant macrofossils recovered from the Burma Quarry deposits were seeds of *Celtis [Trema] micrantha*. This Neotropical species is found from Florida, the West Indies, and Mexico, south through Central America to much of tropical and subtropical South America. It grows as a large shrub or small tree in forests and at forest edges." Using this approach, Hall & al. (1978: 247) reports that "fossil leaf impressions obtained from raised lacustrine sediments above the shores of the present Lake Bosumtwi, radiocarbon-dated at one locality to around 10,000 B.P., include twenty species of trees and shrubs all of which are found in present-day Ghanaian forest of the type surrounding the lake. The most abundant fossil is *Canarium schweinfurthii*, a tree whose fruits were commonly eaten in Late Stone Age times; […]." The list of plant macrofossils recovered in sediments (12,500 to 8,500 BP) from Edgeøya, Svalbard, is composed of remains identified using non-fossil taxa, namely *Silene acaulis* (L.) Jacq., *Oxyria digyna* (L.) Hill., *Dryas octopetala* L., and others (Bennike & Hedenäs, 1995).

Distinguishing fossil from non-fossil taxa. — The field of archaeobotany thenceforth stands in the triple frontier between palaeontology, botany, and weed science. However, the names based on archaeobotanical material must not become a series of "zombie-taxa", namely dead species that can alternatively be considered fossil or non-fossil. Archaeobotanical-based taxa, either fossil or non-fossil, must comply with the rules of the *International Code of Nomenclature for algae, fungi, and plants* (Turland & al., 2018 – *Shenzhen Code*).

Thus, according to Art. 13.3 of the *Shenzhen Code*, "For nomenclatural purposes, a name is treated as pertaining to a non-fossil taxon unless its type is fossil in origin (Art. 1.2). Fossil material is distinguished from non-fossil material by stratigraphic relations at the site of original occurrence. In cases of doubtful stratigraphic relations, and for all diatoms, provisions for non-fossil taxa apply."

Desiccated, waterlogged and carbonized are the most common states of archaeobotanical finds (Table 1). Fossil-taxa must be based on a fossil type (*ICN* Art. 1.2) with a stratigraphic relationship to its locale (Art. 13.3). In other words, it would have to have originated within a single stratigraphic layer of rock. Only if charred plant materials belong to a taxon whose type originated within some (usually sedimentary) rock layer, can it be called a fossil-taxon. A charred fragment could be considered fossil if it comes from older stratigraphic units (e.g., Pliocene, Miocene, etc.). Whereas a plant fragment derived from a relatively recent carbonization, namely, of the Holocene, is considered a recent, non-fossil plant. In palaeobotany these fragments are sometimes called "subfossils" and are subordinate in nomenclature to recent non-fossil taxa.

Among the numerous wheat finds from archaeological sites, small-grained naked wheats pose a problem for taxonomists and archaeobotanists, as no similar live plants or herbarium specimens were known until recently. Thus, these wheats were described as new taxa, whose types are currently extinct (Heer, 1865).

Aims. — This article seeks to offer examples of the problems of archaeobotanical nomenclature that, among others, affect taxa of the *Hordeum* L., *Medemia* Württemb. ex H.Wendl., *Triticum* L. or *Vicia* L. genera; to provide a good practice guide for working with taxa whose types are archaeological material; and finally, to resolve the nomenclatural confusion surrounding the names of one of these small-grained archaeobotanical wheats, *Triticum parvicoccum* Kislev.

Table 1. The nomenclature of archaeobotanical finds.

Taxa	Original archaeobotanical material	Status	Related taxa	References
Amaranthaceae Juss.				
Chenopodium berlandieri subsp. *jonesianum* B.Sm. in Phytologia 57(7): 445–448. 1985	Type: U.S.A., Ohio, Hocking County, 3 miles southeast of Bloomingville, Ash Cave (33Hol), 1876, *Ebenezer Andrews s.n.* (holotype, US No. 3036256)	Holotype at US designated as specimen No. 3036256.	*Chenopodium berlandieri* Moq.	Smith, 1985; Smith & Funk, 1985; Smith & Cowan, 1987; Crawford & al., 2019
Arecaceae Bercht. & J.Presl, nom. cons.				
Areca passalacquae Kunth in Passalacqua, Catalogue Raisonné et Historique des Antiquités Découvertes en Égypte: 228–229. 1826 [and in Ann. Sci. Nat. (Paris) 8: 420. 1826]	Desiccated? Fruits. Possibly in the Passalacqua collection in the Egyptian Museum in Berlin?	Pending typification	*Medemia argun* (Mart.) Württemb. ex H.Wendl.	Kunth, 1826a,b; Buschan, 1895; Ibrahim & Baker, 2009; Vartavan & al., 2010
Fabaceae Lindl.				
Faba vulgaris var. *celtica-nana* Heer, Pfl. Pfahlbauten: 22–23, fig. 44–47. 1865 [or var. *celtica*]	Carbonized seeds. "[…] from the pile dwellings in Montelier at Murtnersee […] the Petersinsel and […] Parma; exactly the same form from a Roman settlement in Hungary can be found in the Museum of Industry in Lausanne" (our trans.) [cf. Fig. 1A,B in this paper]	Pending typification	*Vicia faba* L.	Heer, 1865, 1866; Deininger, 1892; Buschan, 1895; Jessen & Helbaek, 1944; IFPNI, 2014
Juglandaceae DC. ex Perleb.				
Juglans sieboldiana subsp. *hosenjiana* Krysht. in J. Geol. Soc. Tokyo 25(296): 248. 20 Mai 1918	Hosenji, Shimosueyoshi, Tsurumi, Yokohama City, Kanagawa Prefecture, Japan	Pleistocene remains doubtfully archaeobotanical	*Juglans mandshurica* var. *sachalinensis* (Komatsu) Kitam.	Kryshtofovich, 1918; IFPNI, 2014
Poaceae Barnhart, nom. cons.				
"*Hordeum lagunculiforme*" Bachteev in Dokl. Akad. Nauk. S.S.S.R., n.s., 110(1): 153. 1 Sep 1956	Carbonized grains, Tiritaki, near Kerch, Crimea Republic, … Teishebaini Castle, Karmir-Blur, left bank of Zanga River, below Erevan, Armenia; Uzerlik-Tepe & Kul-Tepe, near Nakhichevan, Azerbaijan [cf. Fig. 2A,B in this paper]	Not validly published (Russian)	*Hordeum vulgare* L.	Bachteev, 1956; IFPNI, 2014
Hordeum palaeoparalellum A.A.H.Schulz in Ber. Deutsch. Bot. Ges. 34(8): 617. Nov 1916	Desiccated? Spikes from the six-rowed barley remains found in Ani's grave in Gebelên	Pending typification	*Hordeum vulgare* L.	Schulz, 1916; IFPNI, 2014
Hordeum polystichum var. *densum* Heer ex Deininger in Wosinsky, Prähist. Schanzwerk Lengyel 3: 270. 1892	Based on "Die dichte sechszeilige Gerste (Hordeum hexastichum, densum). Fig. 9"; "Ich habe sie nur von Robenhausen, Montelier und Parma" (Heer, 1865: 13) [cf. Fig. 1E in this paper]	Valid publication questionable	*Hordeum vulgare* L.	Heer, 1865, 1866; Deininger, 1892; Neuweiler, 1924; IFPNI, 2014
Hordeum polystichum var. *pannonicum* Deininger in Wosinsky, Prähist. Schanzwerk Lengyel 3: 270–271, fig. 3. 1892	Carbonized grains, Lengyel	Pending typification	*Hordeum vulgare* L.	Deininger, 1892; Buschan, 1895

(Continues)

Table 1. Continued.

Taxa	Original archaeobotanical material	Status	Related taxa	References
Hordeum polystichum var. *sanctum* Heer ex Deininger in Wosinsky, Prähist. Schanzwerk Lengyel 3: 267. 8 Jun 1892	Based on "Die kleine Pfahlbautengerste (Hordeum hexastichumsanctum). Fig. 1 bis 8, vervollständigt S. 5 Fig. 3"; "von Robenhausen" (Heer, 1865: 12) [cf. Fig. 1E,F in this paper]	Valid publication questionable	*Hordeum vulgare* L.	Heer, 1865, 1866; Neuweiler, 1924; IFPNI, 2014
Hordeum spontaneum var. *lagunculiforme* Bachteev in Bot. Zhurn. (Moscow & Leningrad) 47: 847. 1962	Likely to be designated as epitype: "Turkmen SSR, Ashgabat region, 40–50 km to the south-east. from the city of Ashgabat, a deposit along the foothill slopes of the Kopet-Dag, in the wide valley of the Kelte-Chinar river, near the village of Manysh, May 26, 1960, herbarium sheets 1–9, collected by F. Kh. Bakhteev; herbarium sheet 10 was collected by Bakhteev and A. N. Belavskaya June 1, 1961 Stored in Leningrad" (Bachteev, 1962: 846–847; our trans.)	Pending typification	*Hordeum vulgare* L.	Bachteev, 1962; IFPNI, 2014
Hordeum vulgare var. *densum* Heer ex Neuweiler in Mitt. Antiquar. Ges. Zürich 29(4): 257 ["245"] (113). 1924	Based on "Die dichte sechszeilige Gerste (Hordeum hexastichum, densum). Fig. 9"; "Ich habe sie nur von Robenhausen, Montelier und Parma" (Heer, 1865: 13)	Valid publication questionable	*Hordeum vulgare* L.	Heer, 1865, 1866; Deininger, 1892; Neuweiler, 1924; IFPNI, 2014
Hordeum vulgare var. *palaeoaegyptiacum* A.A.H.Schulz in Ber. Deutsch. Bot. Ges. 34(8): 616. Nov 1916	Desiccated? Spikes from the barley remains found in Ani's grave in Gebelên. From the larger memory model in the grave of Rahotep at Mer near Kusijeh. Spikes in the Egyptian Museum (Berlin) …	Pending typification	*Hordeum vulgare* L.	Schulz, 1916; IFPNI, 2014
Hordeum vulgare var. *sanctum* Heer ex Neuweiler in Mitt. Antiquar. Ges. Zürich 29(4): 257 ["245"] (113). 1924	Based on "Die dichte sechszeilige Gerste (Hordeum hexastichum, densum). Fig. 9"; "Ich habe sie nur von Robenhausen, Montelier und Parma" (Heer, 1865: 13)	Valid publication questionable	*Hordeum vulgare* L.	Heer, 1865, 1866; Neuweiler, 1924; IFPNI, 2014
Triticum aestivum subsp. *compactum* var. *antiquorum* (Heer) H.Messik., Pfahlbauten Robenhausen: 81. Mar–5 Apr 1913	Carbonized spikes and grains, mainly from Robenhausen, but also, Moosfeedorf, Montelier and Olmuz …	Pending typification	*Triticum aestivum* L.	Heer, 1865, 1866; Messikommer, 1913; IFPNI, 2014
Triticum aestivum f. *antiquorum* (Heer) Neuweiler in Vierteljahrsschr. Naturf. Ges. Zürich 80(1–2): 104. 24 Mai 1935	Carbonized spikes and grains, mainly from Robenhausen, but also, Moosfeedorf, Montelier and Olmuz …	Pending typification	*Triticum aestivum* L.	Heer, 1865, 1866; Neuweiler, 1935; IFPNI, 2014
Triticum compactum var. *antiquorum* (Heer) Flaksb. in Izv. Glavn. Bot. Sada S.S.S.R. 29(1–2): 85. 1930	Carbonized spikes and grains, mainly from Robenhausen, but also, Moosfeedorf, Montelier and Olmuz …	Pending typification	*Triticum aestivum* L.	Heer, 1865, 1866; Flaksberger, 1930; IFPNI, 2014
Triticum compactum var. *globiforme* Buschan, Vorgeschichtl. Bot. Cultur-Nutzpfl. Alten Welt: 11, 16–17. 1895	Cf. *T. vulgare* var. *antiquorum* Heer	Pending typification	*Triticum aestivum* L.	Buschan, 1895
Triticum durum var. *trojanum* Wittm. in Monatsschr. Vereines Beförd. Gartenbaues Königl. Preuss. Staaten. Ges. Gartenfr. Berlins 22(10): 479. Oct 1879	Troy [Hisarlik, Turkey]	Pending typification	*Triticum turgidum* L.	Wittmack, 1879

(Continues)

Table 1. Continued.

Taxa	Original archaeobotanical material	Status	Related taxa	References
Triticum monococcum var. *trojanum* (Wittm.) Wittm. in Z. Ethnol. 22(6 [Verh. Berliner Ges. Anthropol., Ethnol. & Urgeschichte]): 615. 20–31 Dec 1890	Troy [Hisarlik, Turkey]	Pending typification	*Triticum monococcum* L.	Wittmack, 1890
"*Triticum parvicoccum*" Kislev in Israel J. Bot. 28(2): 97. Jun 1980	Carbonized grains and rachises from different sites, Bar-Ilan University	Invalid publication (English)	*Triticum turgidum* L.	Kislev, 1980, 1981, 1984, 2009; Tan, 1985; Kislev & Melamed, 2000; Kislev & al., 2006; IFPNI, 2014, Schultze-Motel, 2019
Triticum sativum var. *scythicum* Deininger in Wosinsky, Prähist. Schanzwerk Lengyel 3: 272–273, fig. 5. 1892	Carbonized grains, Lengyel	Pending typification	*Triticum aestivum* L.	Deininger, 1892; Buschan, 1895
Triticum vulgare var. *antiquorum* Heer, Pfl. Pfahlbauten: 13, fig. 14–18. 1865	Carbonized spikes and grains, mainly from Robenhausen, but also, Moosfeedorf, Montelier and Olmuz … [cf. Fig. 1C,D.1 in this paper]	Pending typification	*Triticum aestivum* L.	Heer, 1865, 1866; Dyer, 1886; Deininger, 1892; Buschan, 1895; Flaksberger, 1930; Jessen & Helbaek, 1944; IFPNI, 2014
Triticum vulgare var. *trojanum* (Wittm.) Wittm. in Ber. Deutsch. Bot. Ges. 4(11): xxxiii. 19 Nov 1886	Troy [Hisarlik, Turkey]	Pending typification	*Triticum aestivum* L.	Wittmack, 1886a,b
Polygonaceae Juss.				
Polygonum erectum subsp. *watsoniae* N.G.Muell. in Novon 25(2): 176. 2017	Type: U.S.A., Arkansas, Benton Co., Whitney Bluff rock shelter (3BE20), 1932, *W. Henbest & C. Finger Jr. 32-57-5c* (holotype, UARK barcode UARK 20121)	Holotype at UARK designated as specimen 20121; isotype at Arkansas Museum	*Polygonum erectum* L.	Mueller, 2017a,b, 2019

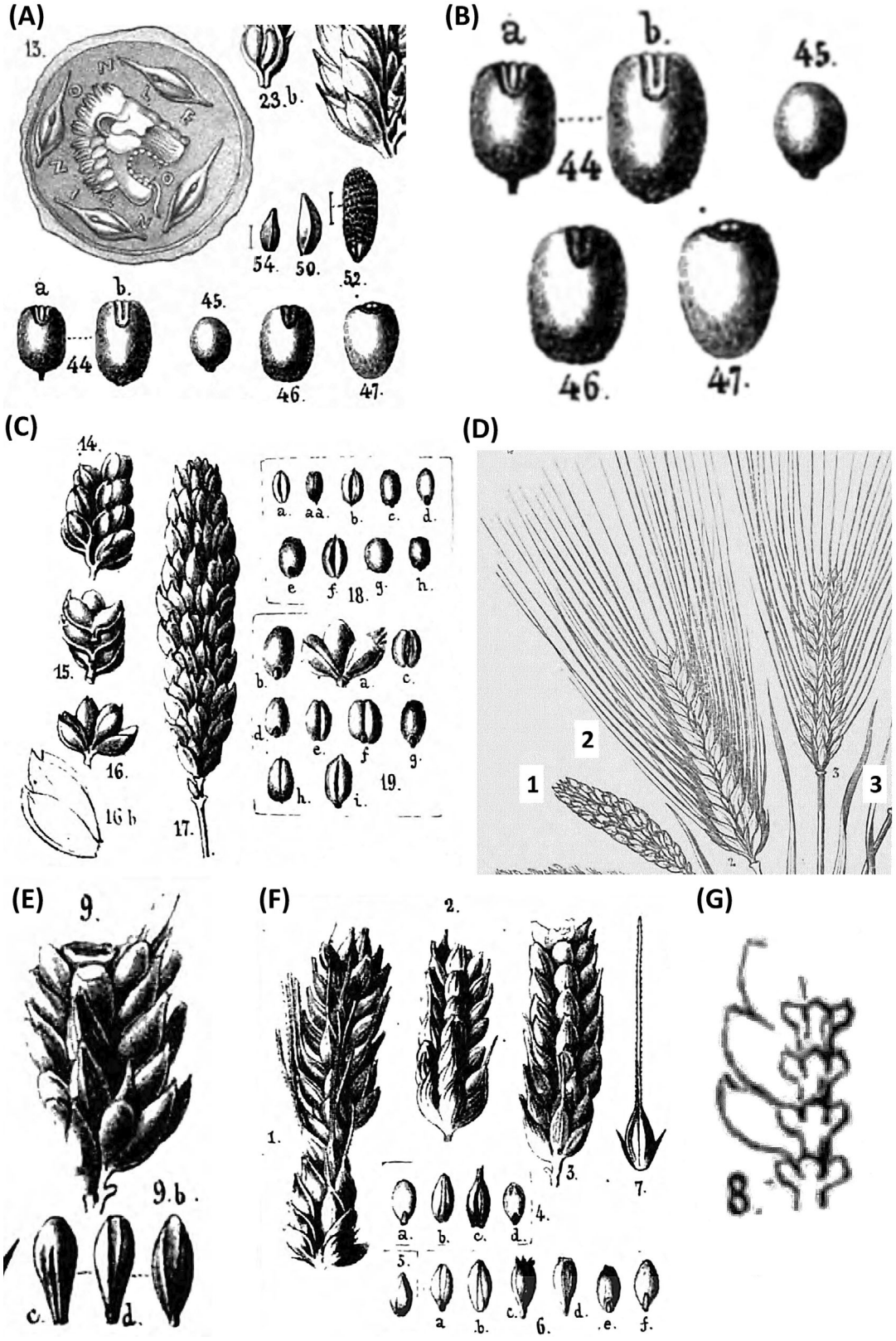

Fig. 1. Image of the original materials for Heer's different archaeobotanical taxa. **A**, *Faba vulgaris* var. *celtica-nana* Heer (Heer, 1865: fig. 44–47); **B**, *Faba vulgaris* var. *celtica-nana* Heer (Heer, 1866: fig. 44–47); **C**, *Triticum vulgare* var. *antiquorum* Heer (Heer, 1865: fig. 14–18); **D**, *Triticum vulgare* var. *antiquorum* Heer (Heer, 1865: "1" in text-fig. on p. 5); **E**, "Die dichte sechszeilige Gerste *Hordeum hexastichum, densum*" (Heer, 1865: fig. 9); **F**, "Kleine Pfahlbaugerste (Hordeum hexastichum, sanctum)" (Heer, 1865: fig. 1–7); **G**, "Kleine Pfahlbaugerste (Hordeum hexastichum, sanctum)" (Heer, 1865: fig. 8).

■ PROBLEMS OF ARCHAEOBOTANICAL NOMENCLATURE

The earliest known taxon based on archaeological material is *Areca passalacquae* Kunth (Kunth, 1826a). It was first discovered by archaeologists as fruits within ancient Egyptian tombs. A second species diagnosis published by Kunth (1826b) is slightly different. Here the genus is given with a question mark: "*Areca? passalacquae*". Later it became clear that *A. passalacquae* falls within the variability of *Medemia argun* (Mart.) Württemb. ex H.Wendl.; the discovery of the latter as a living palm occurred only in 1837. At that time, the "*argun*" palm was found growing in the Nubian Desert (N Sudan) by the German Prince Friedrich Paul Wilhelm von Württemberg and the botanist Theodor Kotschy. In 1845, based on specimens collected by Württemberg and Kotschy and ignoring Kunth's publication, the species was described by Carl von Martius (1845) as *Hyphaene argun*. Then, in 1859, these living specimens of *H. argun* were linked to the Egyptian tomb fruits by Franz Unger. Finally in 1881, based on a manuscript by the Prince of Württemberg, Wendland (1881) described the genus *Medemia*, differentiating it from *Hyphaene*, and published the combination *Medemia argun*, which today is generally accepted as the name of the species (Reichardt, 1859; Dransfield & Moore, 1982; Govaerts & Dransfield, 2005; Ibrahim & Baker, 2009; Cosiaux & al., 2020; IPNI, 2020; POWO, 2020a,b). The archaeological materials collected by Giuseppe Passalacqua were shown in the Gallery Marchoux (now Vivienne) of Paris in 1826. Later on, Passalacqua offered these for acquisition by the French Government, but eventually they were sold to Friedrich Wilhelm IV of Prussia, who deposited the collection in the Egyptian Museum in Berlin. It is not known whether these archaeobotanical materials are still extant or were destroyed.

Throughout the 19th and 20th centuries, other taxa based on archaeological materials were published, namely of the Arecaceae, Fabaceae and Poaceae families (Table 1). The taxonomic levels used were species, variety and form. In addition to Heer (1865), it is worth highlighting the publications of Deininger (1892), Buschan (1895), Schulz (1916), Bachteev (1956), and Kislev (1980, 2009). Some of these taxa were later combined within other genera or at other taxonomic levels, often without conforming to the rules of the *Code*.

Fig. 2. Images of the original materials mentioned in the invalid publication of "*Hordeum lagunculiforme*" Bachteev. **A**, Charred barley grains from the archaeological excavations of the Bosporan expedition of the Leningrad Region Institute of Mineral Resources of the U.S.S.R. Academy of Sciences (3rd–2nd centuries B.C.): a, the largest grains; b, middle grains; c, small and very small grains; h, hulled; n, naked (Bachteev, 1956: fig. 1); **B**, Two samples (a and b) of charred barley grains from the Karmir-Blur archaeological sites: (7th–6th centuries B.C.) (Bachteev, 1956: fig. 2).

Another factor to consider is the existence of names attributed to authors who apparently did not publish these combinations. These include *Hordeum hexastichum* var. *sanctum*, *H. hexastichum* var. *densum*, and *Triticum vulgare* var. *compactum-muticum*, which Deininger (1892), Buschan (1895) and Flaksberger (1930) attributed to Heer (1865, 1866). Although Heer (1865, 1866) published these names, he did not mark them as his own by using the abbreviation "m." (*mihi*, mine), something that he did with *Faba vulgaris* var. *celticanana* and *Triticum vulgare* var. *antiquorum* (Table 1).

The above justifies the need for a detailed taxonomic and nomenclatural review of these taxa. Obviously, a thorough review of the archaeobotanical literature would be necessary to find other names that may have been published and are not among those listed in Table 1. This is also necessary in order to avoid errors in the spelling of epithets such as that incurred by POWO (2023) and IPNI (2023) when mentioning as "*Hordeum* ×*lagunculciforme*" a taxon whose name is *Hordeum* ×*lagunculiforme*. We are not concerned here with the concept of the "botanically accepted name", which is becoming a mainstream idea, but with whether the name requires a review of the validity of its publication, or whether it requires typification, as it is impossible to decide on a name in the absence of such information.

■ BEST-PRACTICE GUIDE FOR ARCHAEOBOTANICAL-BASED TAXA

Preliminary remarks. — Botanical materials gathered at archaeologic sites are found in different situations that affect their analysis and naming. When found intact, such as *Areca passalacquae* from Egyptian tombs, the evaluator must first consider the morphological transformation produced in the sample by pre- and postdepositional processes (carbonization, cyclic hydration-dehydration, extreme desiccation, and others). These changes would differ from those produced by the mere drying of herbarium materials and are relevant to all archaeobotanical findings.

It is essential that the usual databases in the field of botany (GBIF, GRIN-Taxonomy, IPNI, POWO, and TROPICOS) include all plant taxa based on archaeological materials. For this purpose it is essential to proceed with their taxonomic study and typification where required.

On the rare occasions where DNA is preserved and extraction and sequencing of fragments from "fossil" plants can be successfully performed (Schlumbaum & al., 1987), it could be used for identification (Bilgic & al., 2016), but this is not a frequent case and the researcher must work without this information.

New taxa. — Although the last taxon based on archaeobotanical materials was published in the 1980s, it cannot be ruled out that others will be published in the future. To avoid the problems encountered so far, a number of considerations should be taken into account. The first is to exhaust all identification possibilities using extensive comparison collections and detailed morphometric analyses before embarking on the publication of a new taxon.

When the original material is exclusively composed of grain and fruit fragments, it could be difficult to determine the properties of a single specimen. Here we must follow the instructions in the *ICN* Art. 8.2: "[…] parts of one or several organisms […]".

Specimens are usually mounted on herbarium sheets. However, equivalent presentation, e.g., in a box, packet or jar, is acceptable, and because of their fragility, archaeobotanical material is typically stored this way.

The single-gathering requisite (Art. 8.2) is satisfied when the original material designated as type was collected from a single place (locus) and by a singular action during excavation (avoiding admixtures).

The optimal archaeobotanical deposits from which to choose the type of a taxon should be radiocarbon dated, morphometrically homogeneous, from culturally well-defined levels and preferably recovered from closed containers. For type designation, the best-preserved specimens should always be chosen, ideally whole, not fragmented or damaged, and with the greatest number of diagnostic characters. Heterogeneous assemblages, made up of dispersed materials, although recovered within an apparently sealed concrete level, are less reliable as they can consist of admixtures.

Traces or casts in ceramics, adobes or other materials are not eligible as type of a taxon of archaeobotanical origin, regardless of their quality. Findings must be actual plant material.

Sample components should be photographed and measured as thoroughly as possible (following the standardized descriptors for that plant or crop), with data deposited and made available online at the pertinent museum or herbarium site.

The repositories of archaeobotanical materials are usually various tpyes of archaeological museums and archaeobotanical or natural history collections. To facilitate consultation by researchers, they should be indexed in a special section of Index Herbariorum (http://sweetgum.nybg.org/science/ih/). Online access to data and images of archaeobotanical materials should be provided, as is being done at Penn Museum (2022) or the British Museum (2022). We strongly advise depositing archaeobotanical materials in specialized repositories that guarantee long-term preservation, preferably those that store in parallel a large repertoire of modern comparison samples of wild and cultivated plants and have facilities that allow researchers to work. Examples are the seed collection at Bar Ilan University (Weiss, 2018) and the Economic Botany Collection at Kew (RBGK, 2022).

Validation. — For already published names, the first step is to study the protologue and determine whether the publication is valid or not. Validation is particularly necessary in cases where the proposed but invalidly published taxon appears well differentiated within the range of variability of the genus or species to which it is ascribed.

Typification. — In the case of names validly published during the 19th and 20th centuries, original material is

mentioned but the holotype is usually not designated (Table 1), so typification is required. In our attempts to find original material for several of these taxa, we have found that while archaeobotanical remains have often been lost, published illustrations are available.

Epitypes should be designated from modern plant material (or illustration), provided that the taxon is not considered extinct, preserved as a herbarium specimen, and with adequate morphological, cytogenetic, and molecular characterization.

Finally, this interdisciplinary task should be carried out in collaboration between archaeobotanists, taxonomists, and nomenclaturists.

■ AUTHOR CONTRIBUTIONS

DR, Design and writing, photography for figures; PPFG, Nomenclatural analysis and consulted with specialists; CO, FA, EL & JV, Literature and text review; NPG, Poaceae taxonomy, and literature and text review; MK, Conception, selection of plant materials. — DR, https://orcid.org/0000-0001-6889-714X; PPFG, http://orcid.org/0000-0001-7595-9302; CO, https://orcid.org/0000-0002-0244-601X; FA, https://orcid.org/0000-0003-3254-2691; JV, https://orcid.org/0000-0002-4401-9884; EL, https://orcid.org/0000-0002-9674-2767

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