Human Ecology
https://doi.org/10.1007/s10745-024-00501-9

Arundo/Phragmites: Identification and Uses of Essential Plants in Mediterranean Civilizations

Régine Verlaque[1] · Marc Verlaque[2] · Guillaume Renoux[3] · Laurent Hardion[4] · Bruno Vila[1]

Accepted: 27 April 2024

Abstract
Using iconography and ancient texts, we list and discuss *Arundo* and *Phragmites* taxa (canes and reeds, respectively), their uses, such as writing, units of measurement, medicines, fuels, food, fodders, rural lifestyles, construction materials, ship building, musical wind instruments, throwing weapons, and sacred symbols. These plants that were essential in the daily life of Mediterranean civilizations for millennia could still play a very useful role (bioremediation, CO_2 fixation, biogas), for future generations.

Keywords Poaceae · *Arundo* · *Phragmites* · Cane · Reed · Macro- and microscopic characters · Past and present uses · Mediterranean civilizations

Introduction

The origin of this research is related to the proximity between the stands of some *Arundo* species and several ancient Mediterranean cities (e.g., Antibes, Fréjus, Cartagena, Carthage, Narbonne). In the Iliad (canto 10, 467), Homer described a field of '*donax*' beneath the walls of Troy, attesting to its ancient occurrence (Amigues, pers. com.). We address the questions: (1) did humans introduce them, or did they choose to build cities close areas where they naturally occur? and (2) if they were introduced, where did they originate and when and for what purposes were they introduced? These questions are complicated because the genera *Arundo* L. and *Phragmites* Adans. are perishable under normal conditions, except phytoliths (Albert et al., 2012), and imprints of plants (Romano et al., 2021) and few large artifacts have survived, except in dry (pyramids, desert areas) or anoxic (marine or freshwater muds) environments. Research into their uses requires different sources of information, such as cylinder seals (L = 3–5 cm) (~4100 BC), which left the imprint of the owner's mark on soft clay and served as proof of identity, jewelry, talismans, and ex-voto offerings. They provide information on everyday life, religion, architecture, banquets, battles, and crafts (Amiet, 1980). Cuneiform writing emerged in Mesopotamia (3300 BC to 100 AD), and alphabetic writing in Phoenicia. While countless Greek and Levantine texts on papyrus have disappeared, ancient clay tablets (ca. 500 000) survived attesting to the huge Mesopotamian influence on the Levant. It is possible to access online Sumerian texts (ETCSL, 2003–2007) and the Assyrian dictionary (CAD, 1956–2010). Mesopotamian sculptures and bas reliefs also depict canes and reeds in pastoral, hunting, and warfare scenes.

In the Greco-Latin world, the major texts are those of the first century encyclopedist Pliny the Elder, who devoted several chapters to the uses of reeds, and the texts of Ovid, Vitruvius, Columella, and Strabo; followed by those of Cato (third century BC), the botanist Theophrastus and Xenophon (fourth century BC), the historian Herodotus and Heraclitus (fifth century BC), and the Greek poet Homer (ninth-eighth century BC). These texts illustrate the difficulties of naming these *Arundo* L. and *Phragmites* Adans. plants, and how botany can help identify them, as well as artifacts made from them. We present the inferences that can be drawn from the study of iconography and ancient texts.

✉ Marc Verlaque
marclouis.verlaque@gmail.com

[1] Aix Marseille University, IRD, LPED, Marseille, France

[2] Aix Marseille University and Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), UM 110, Marseille, France

[3] Université Toulouse Jean Jaurès, Laboratoire TRACES-UMR 5608, Toulouse, France

[4] University of Strasbourg, CNRS, Laboratoire Image Ville Environnement, UMR 7362, Strasbourg, France

Published online: 07 June 2024

Arundo and *Phragmites* were included in the same genus until 1950, and their vernacular names reflect the confusion between the cane/reed taxa (Fig. 1). Nowadays, the usual names of *Phragmites* are common reed (English), *roseau à balai* (French), *agmôn* (Hebrew), *qassab, hagna* (Arabic). *Arundo donax* L. is called giant reed, cane (English), *canne de Provence* or *canne à palissades* (French), *qanéh* (Hebrew), *ghab*, Spanish or Persian reed (Arabic). *Arundo plinii* Turra is rarely cited: we found *canne de Pline* (French) and arrow reed; the other taxa have no vernacular names.

The words *canna* (Italian), *caña* (Spanish), *canne* (French), cane (English) are direct borrowings from Greek derived from Akkadian *qanû*, and its Phoenician or Hebrew derivative *qn* (Hemmerdinger, 1966). However, the name reed (English) of German origin (*raus, rohr*) is used worldwide in the literature, except in the Mediterranean region. In Greek, *phragmites* is a barrier, *kalamos* or *kanna* is a pipe of small diameter (torch, arrow, flute, stylus), and *donax* is used for large diameters. In Latin, *harundo/arundo* is used for large-diameter plants and objects (fishing rod, stick). In the ancient texts, the term *calamos* seems more poetic than *arundo*, which is preferentially used for agriculture and weapons (Renoux, 2006).

In Mesopotamia, the names of these plants were synonymous with the objects produced: arrow, tube, musical pipe, measuring rod (CAD, 1956–2010). In Hebrew, other functions are added: stem and branches of the menorah, humerus bone and balance beam (Botterweck et al., 2004). This brings us back to the Bible and everyday language: reeds symbolize the flexibility, the weakness and fragility of mankind, while canes represent rigidity, support (stick), canon law, the rule, and the norm (Paquereau, 2013).

Fig. 1 Reedbed in winter (Sausset-Les-Pins, France), *Phragmites australis* with one-sided leaning panicles in the foreground, and *Arundo donax* with straight panicles in the second plane. For color figures, the reader is referred to the web version of this article

Botanical Study

The genera *Arundo* and *Phragmites* (Poaceae), similar in appearance, belong to the Arundinoideae subfamily, but within two distinct tribes (Hardion et al., 2017). Both are perennial strongly rhizomatous, with tall erect culms (1–6 m), long cauline leaves, and large plumose panicles (Fig. 1). These tallest Mediterranean grasses are used in a similar fashion to Asian tropical bamboos. To interpret the iconography, texts, and artifacts, we first identify the two genera based on Greiss (1957). *Phragmites* spp. live in wetlands forming extended, dense stands called reed-beds, while *Arundo* spp. with greater height thrive in terrestrial environments in smaller areas, called canebrakes.

Morpho-genetic studies showed that the Mediterranean *Phragmites* include three native species: *P. australis* (Cav.) Trin. ex Steud. (Cosmopolitan in temperate to cold regions), and two thermophilic taxa: the rare *P. frutescens* Scholz (Crete, Greece, SW-Turkey), and the common *P. altissimus* (Benth.) Mabille (S-Mediterranean to Central Asia) (Lambertini et al., 2006; Verlaque et al., 2023). The genus *Arundo* includes four taxa: (1) the giant reed *A. donax* L., a subtropical invasive clone (Ahmad et al., 2008) whose closest phylogenetic relatives occur in the Indus Valley (Hardion et al., 2014), and the complex of three smaller taxa (*A. plinii s.l.*) with (2) the introduced circum-Mediterranean clone *A. micrantha* Lam. of unknown origin, and two native species, (3) the fertile Italo-Balkan *A. plinii* Turra, and (4) the rare endemic Ligurian *A. donaciformis* (Loisel.) Hardion et al. (Hardion et al., 2012). The complementarity of their ranges suggests extensive past uses (Fig. 2).

The material and methods are described in Hardion et al. (2012) and Verlaque et al. (2023), which, along with

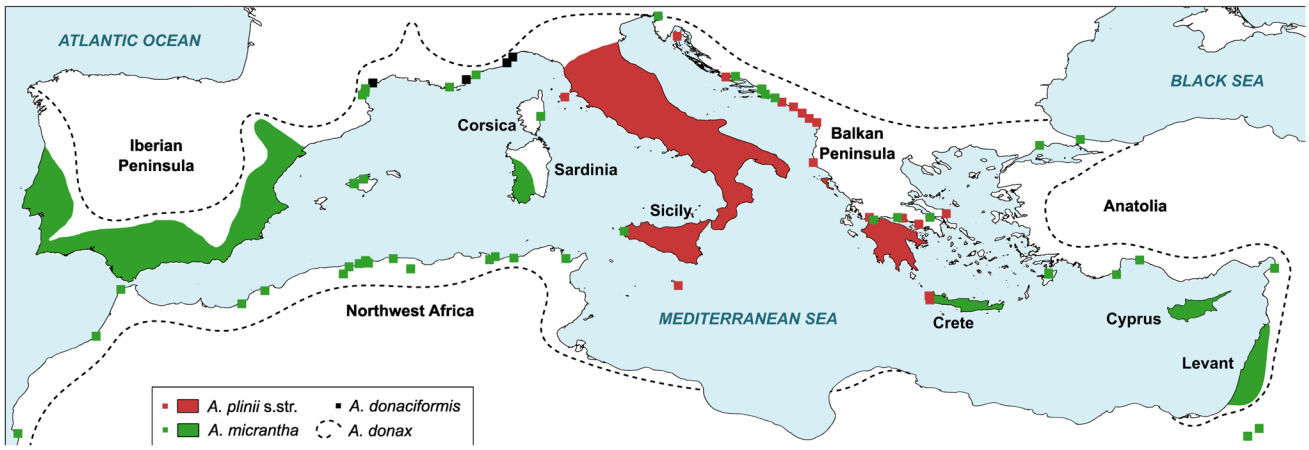

Fig. 2 Mediterranean distribution of *Arundo* taxa

new results show that both genera are strongly distinct whichever criteria are used. In each of them, one species is clearly distinguished: *P. australis* within *Phragmites* and *A. donax* within *Arundo*. We will consider first the classic floral macroscopic traits, present only in autumn, with one-sided leaning panicles in *Phragmites*, and symmetric straight panicles in *Arundo*, and lemmas as major characters (Supplementary Box 1, Fig. 3a–c). We then address the vegetative traits, present all year round, with the ones most useful for artifacts, charcoals, and imprints: rhizomes (with aerenchyma or not; hollow or solid), culms (height and diameter), and nodes (Supplementary Box 2, Fig. 3d–j).

Microscopic traits are the most discriminating in Poaceae (Metcalfe, 1960). These elements are preserved for a long time in sediment and artifacts (Greiss, 1957; Täckholm et al., 1973; Albert et al., 2012). Leaf and culm epidermal traits are useful, notably the short silica bodies of both genera mainly found in tropical grasses, and so very rare in Mediterranean and European taxa.

The epidermis keeps well due to its thick waxy cuticle, and many silicified cells: silica bodies, bulliform cells, stomata, prickles, hooks, that become phytoliths. The distinction between the two genera is easy with short silica bodies of abaxial leaf epidermis: saddle shaped in *Phragmites*, and bilobate in *Arundo* (Supplementary Box 3, Fig. 4a, b). In *Phragmites* culm epidermis, each short-cell pair includes a globular silica body and a reniform cork-cell, while in *Arundo* they are bilobate and cubic, respectively. These traits enabled us to identify reed and cane in Roman shipwrecks (Supplementary Box 4, Fig. 4c–f). In agreement with previous works (Greiss, 1957; Metcalfe, 1960; Crivellaro & Schweingruber, 2013), for mature culm anatomy (ø = 6 mm), major traits are its thickness and forms of vascular bundles (Supplementary Box 5, Fig. 5a–d). These features allow charcoal identification.

Historical and Current Uses

'Where there are no reeds, it is the worst of all poverty'. Sumerian proverb (ETCSL, 2003–2007).

Glyptic Art and Writing

Oriental history traced with cylinder seals (from 4100 BC, Amiet, 1980) and the first Sumerian pictograms (~3300 BC) attest to the importance of reeds, with a *Phragmites* close to a river (Fig. 6a). In Egyptian hieroglyphs (~3100 BC), the single reed panicle is the sound *'i'* or '*e*', and the pair '*y*' (Fig. 6b). These drawings reflect the observations of scribes of leaning and one-sided panicles of *Phragmites* distinct from the straight and symmetrical ones of *Arundo* (Täckholm et al., 1973). The 1500 Sumerian pictograms were quickly replaced by 500 cuneiform ideograms, better adapted to reed-pens on clay tablets (Fig. 6c, d). This writing became syllabic (150–300 signs, civilization of Akkad ~ 2700 BC) (Bottéro, 1987).

The Sumerian scribes wrote on tablets with *Qalam*: "reed" culm obliquely cut (Joannès et al., 2001). In many hymns to the vegetation and writing goddess, we find '*Nisaba who holds a holy reed-stylus (or golden stylus) and the shining measuring rod*'. This is reminiscent of the golden color of *Arundo* culms. The Assyrians deified *qalam* and tablets inherited from Sumer and Babylon (Fig. 6e). In Palestine, Linnaeus described *A. scriptoria* (Post, 1933, probably *A. micrantha*). Finally, a notable fresco from the Dura-Europos synagogue (~250 AD) shows Moses with a grass (not a burning bush) that looks like *A. micrantha*; maybe to suggest his role as the Torah writer (Fig. 6f).

The Phoenicians played a major role with the invention of the alphabet in Byblos (12th c. BC) that could be written in ink on papyrus. According to legend, this alphabet was offered to the Greeks by Cadmus (son of the king of Tyre),

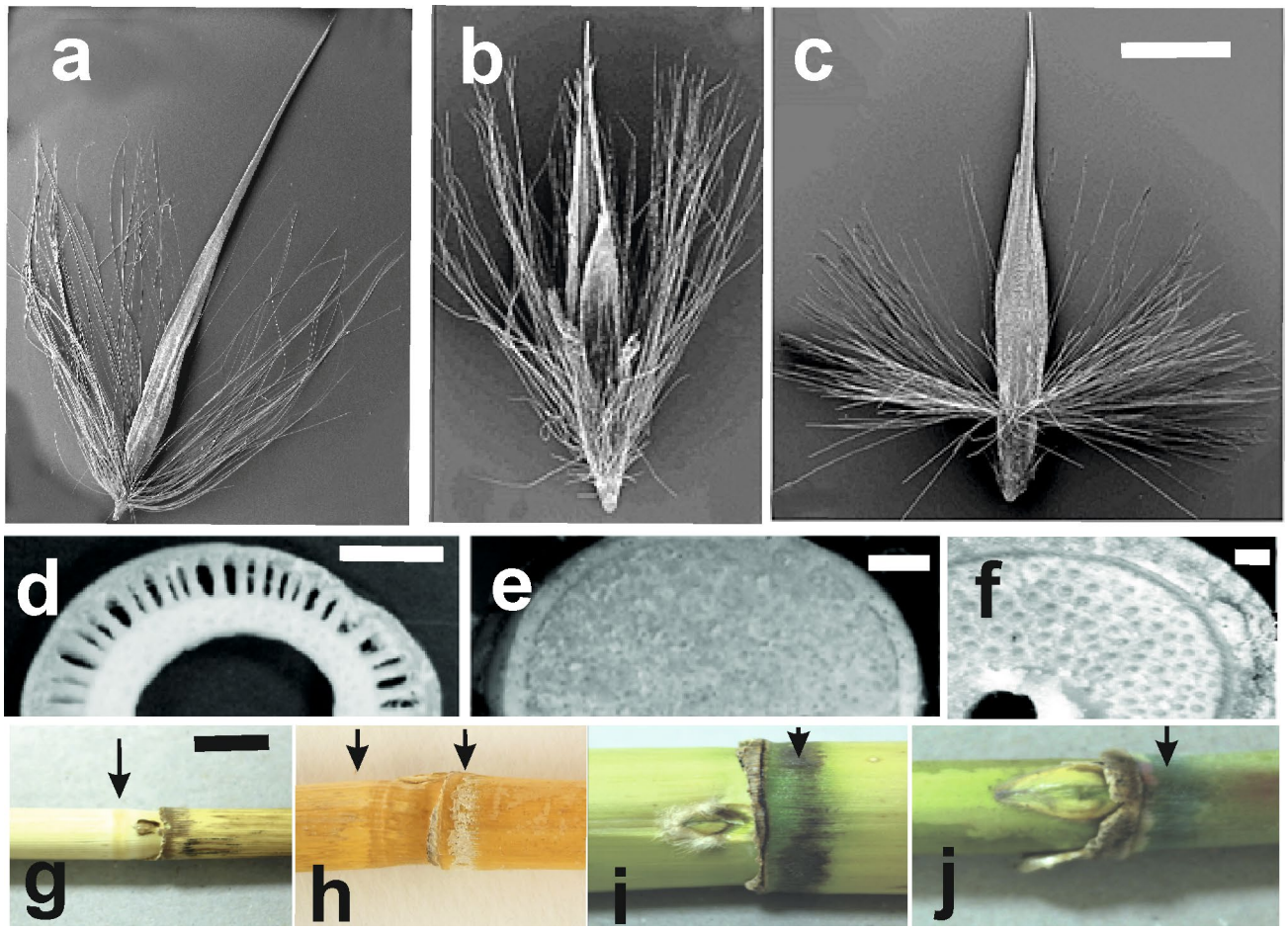

Fig. 3 Lemmas: **a** *P. australis* (glabrous lemma, hairs on the rachilla), **b** *A. donax* (villous lemma, hairs oblique on the lower quarter), **c** *A. plinii* (hairs perpendicular on a ring). Rhizomes: **d** *P. australis* (hollow with peripheral aerenchyma), **e** *A. donax* (solid without aerenchyma), **f** *A. plinii* (hollow, without aerenchyma) (Jiménez-Ruiz et al., 2021, modified). Culm nodes: **g** *P. australis* (arrow: thickened clear band above), **h** *P. frutescens* (arrows: thickened clear band above and waxy band below), **i** *A. donax* and **j** *A. micrantha* (arrows: large dark ring below). **a**–**c**: scale = 2 mm, **d**–**f**: scale = 5 mm, **g**–**j** scale = 1 cm

founder of Thebes (Boeotia), during his search for his sister Europa who had been kidnapped by Zeus and subsequently bore Minos, the founder of the Minoan civilization in Crete (Briquel-Chatonnet & Gubel, 1998). As this consonantal alphabet resulted in highly complex texts, the Greeks added vowels. Ausone (1843) (fourth century AD) describes this: "*Muse, suspend your march in these fields of papyrus. Let us stop there the furrow traced by the reed* (harundinis) *of Cnidus* (Turkey) *with its split foot, which goes to draw the blackish signs of Cadmus' daughters."* In Europe, although the name *qalam* persists, the object was replaced by the quill pen in the Middle Ages, by pencils and metal nibs (nineteenth century. AD), then by ballpoint pens.

Unit of Measure

Units of length, weight, area, and capacity were created in Sumer before writing in the fourth millennium, then unified and extended to the Near East (Joannès et al., 2001). The length unit equal to three meters was called *qanû* (cane). It became a reference (e.g., in the Bible, Paquereau, 2013) throughout Europe, and was used until the French Revolution (e.g., Girardin, 1729) (Fig. 7).

Medicine

Arundo donax is one of the 30 plants listed in ancient medical oriental remedies (Mazars, 2002). According to the principle of analogy: "the strong joints of culms can also repair the damaged ones of the men" (Lieutaghi, 2006), and it was used to remove arrows and thorns (Pliny the Elder, 1981) as well as to make arrows. Their "ashes in vinegar prevented alopecia" and the fresh rhizomes crushed in wine gave "*a drink with a powerful attractive virtue which excites Venus*" (Pliny the Elder, 1981), probably due to donaxine and bufotenine: hallucinogenic and euphoric alkaloids (Paris &

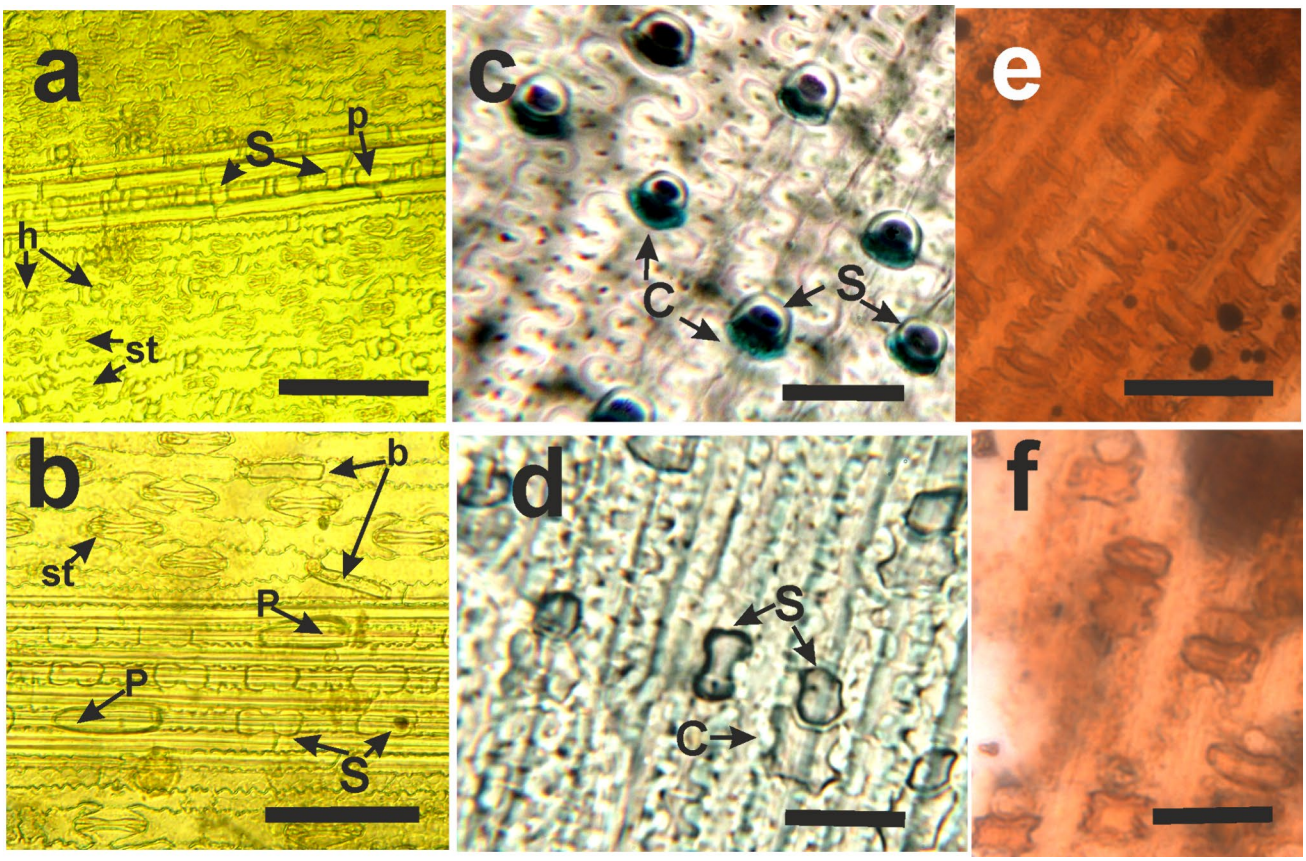

Fig. 4 Leaf epidermis: **a** *Phragmites*, ribs with saddle-shaped silica bodies (S) and short prickles (p), intercostal zone with hooks (h) and small stomata (st). **b** *Arundo*, ribs with bilobate silica bodies and long prickles, intercostal zone with microhair bases (b) and taller stomata. Culm epidermis. Fresh plants: **c** *Phragmites*, short pairs with reniform cork-cells (c) and globular silica bodies (S). **d** *Arundo*, short pairs with cubic cork-cells and bilobate silica bodies. Caulking material of shipwrecks. **e** *Phragmites*. **f** *Arundo*. **a**, **b**: scale = 100 µm; **c**–**f**: scale = 20 µm

Moise, 1981). Moreover, in glyptic art of banquets, the leafy branches of cane represent "joy" (Amiet, 1980). Works on medicinal plants also indicate diuretic, febrifuge, anti-milky properties of *A. donax*, and diuretic and anti-emetic uses for *P. australis* (Fournier, 1947).

During the Spartan military campaigns, Xenophon (1967) described "*those who lodge with the king: the soothsayers, the doctors, the pipers, the commanders*" (Grumberg, 2011: 73). Doctors in the Middle East had musicians and exorcists as assistants who burned torches and portable altars made

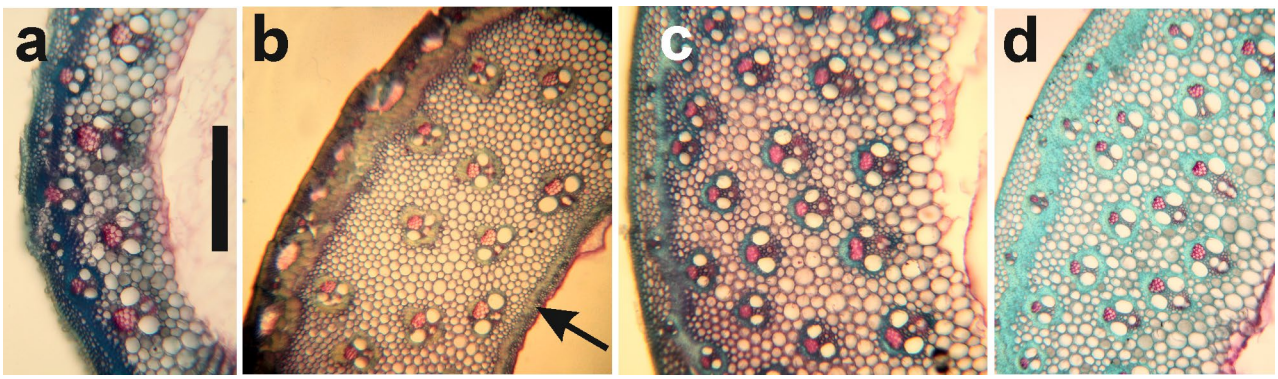

Fig. 5 Culm anatomy. *Phragmites*: vascular bundles wider than tall. **a** *P. australis*, **b** *P. frutescens* with internal layer of sclerenchyma (arrow), and peripheral aerenchyma. Arundo : vascular bundles taller than wide: **c** *A. donax*, **d** *A. plinii*. Scale = 500 µm

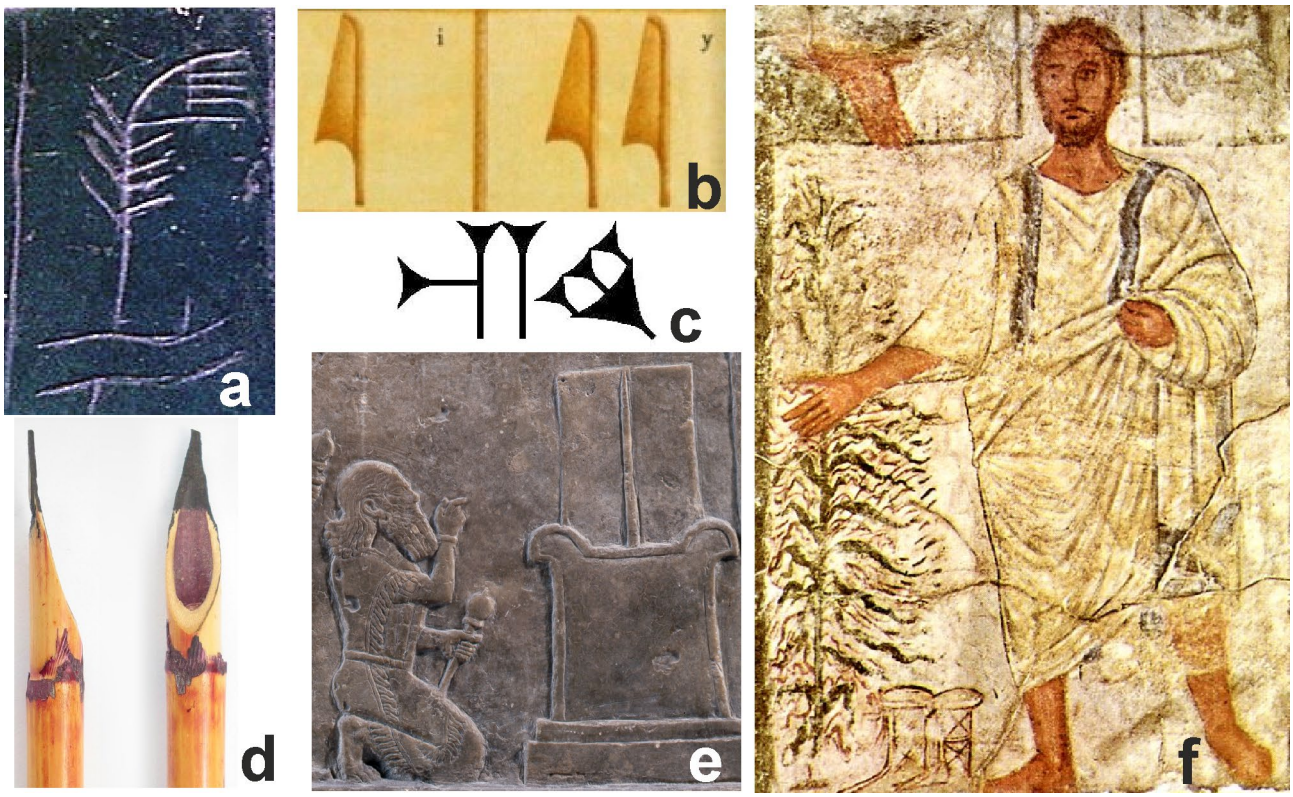

Fig. 6 *Phragmites* with one-sided panicles: **a** Sumerian pictogram and **b** Egyptian hieroglyphs. **c** Cuneiform sign of GI (Sumerian) or Qanû (Akkadian). **d** *Qalams* of *Arundo donax*. **e** Low relief of an Assyrian king in prayer in front of the tablet with *qalam* (1220 BC, © *Staatliche Museen zu Berlin – Vorderasiatisches Museum*, photo: VA 8146_VAMF1090_bs). **f** Dura-Europos Synagogue fresco (250 AD) with Moses near a grass resembling *A. micrantha* (© Wikimedia Commons)

of reeds and cast them into a river during purification ceremonies. They could also blow to put the 'evil' in a culm (probably *A. donax*) to burn it (Bottéro, 1987; Heckel, 2003).

Canes have always been used as a walking aid. The treasures of Tutankhamun (1336 – 1327 BC, 18th dynasty), include one engraved cane with: "*Reed which His Majesty selected and cut with his own hand from the thicket of reeds-of-Djapur, which lies in the Iounsès court at the location of the arrow makers*" (Gabolde, 2012). Judging by the diameter (2 cm, Gabolde, 2012) and the dark mark under the nodes (pers. obs.), the species seems to be *A. donax*, which would have been a rare plant in Egypt, where only the common native reed is *P. altissimus* (= *P. australis* var. *isiacus*). It would be still rare after its probable introduction during the Hyksos invasion (Canaanites, 1650 – 1550 BC), and this harvest took place near the capital Avaris in the NE-Delta. Note that the first *Arundo* artifact identified in Egypt dates from this same period (Greiss, 1957).

Fig. 7 The 'canna Volterrana' (arrow) in the Palazzo dei Priori (Volterra, Italy, © N. Castelbon)

Fuel, Food, and Fodder

In poor rural Mediterranean areas, tender young shoots of reeds are used as fodder for cattle, and can be chewed like sugar cane (Ochsenschlager, 1992). The large rhizomes of *A. donax* have a "bitter and vanilla taste" (Chevalier, 1817), with maximum sugar content before flowering (Lieutaghi, 2006). In the Middle East, reeds or canes were used as straws to drink beer or wine.

In wood-poor areas, reeds are a vital fuel. In Sumer, the fire god Gibil was called "arsonist of reeds," and reed harvesting was a daily chore (Kramer, 1957) because *Phragmites* are weeds in irrigation channels. Akkadian tablets (2400 – 2100

BC) record the number of reed bundles needed to cook meat for banquets (Grandjean et al., 2013). With the rise of metallurgy in Middle East (Copper age, mid-fifth millennium BC), fuel requirements involved huge quantities of reeds (Margueron, 1991). In China, the common name of firewood reeds is *Luchai*. '*Shui Luchai*' refers to wetlands of *P. australis*, and '*Yang Luchai*' refers to terrestrial *A. donax* (Zhang et al., 2016). In Egypt, charcoals identified as *Arundo/Phragmites* in Greco-Roman baths are *A. donax* (Photo in Bouchaud, 2012).

Canes symbolized pastoral life in glyptic art (~ 2600 BC, Amiet, 1980: Fig. 8a). Sumerian texts report the construction of 13 km of palisade (2150 BC), with words referring to the cut canes, e.g.,"canisse" (Joannès et al., 2001). In Mediterranean areas, *A. donax* was also used to make live and dry fences, windbreaks, sunshades, huts, enclosures, supports for plants, traps, fishing rods, cattails, hurdles (fruit drying), beehives, floats, to mark the edges of fields and water points, to prevent erosion or the silting up of banks and coastlines, and to improve drainage and sanitation (Lieutaghi, 2006; Täckholm et al., 1973). We may also mention shepherd's canes, sticks, games (kites, blowguns, etc.), and boxes for: *kôhl* (Egypt, 18th dynasty, Fig. 8j), salt, spice, or "cane to put the Gold" (Herodotus, 1850).

Egyptian and Roman basketry using the flexible *Phragmites* has been well-documented (Cullin-Mingaud, 2015; Wendrich, 2000). Charred stems found at a basket maker in Pompeii were attributed to "two grasses" (Figueiral, 2015) that match the two anatomical types of *P. australis* culms (base and middle). "*The thick and hairy tuft employed for filling the beds used in taverns*" (Pliny the Elder) were *Phragmites* panicles. Reed ashes were also used as soap, ointment (added oil), toothpaste (Brillaud, 2011), and bleaching textiles (Joannès et al., 2001).

Vineyards

The origins of wine are complex and still debated, with increasingly early and scattered archaeological sites in Transcaucasia (eighth millennium BC), Greece (fifth millennium BC; Pagnoux et al., 2021), and Sicily (fourth–third millennium BC; De Michele et al., 2019). From these regions, viticulture spread with Canaanite, Phoenician, Greek, Etruscan, and Roman trade. One of the reasons for the introduction of *A. donax* into the Mediterranean could be viticulture in vine arbors supported by cane stakes, hence its name vineyard cane. The high quantity of *Arundo* charcoals found in a Gallo-Roman vineyard in Languedoc argues in favor of this use (Figueiral et al., 2010).

In addition, the distribution of *A. donax* matches with those of grapevines and olive trees. There is a rich

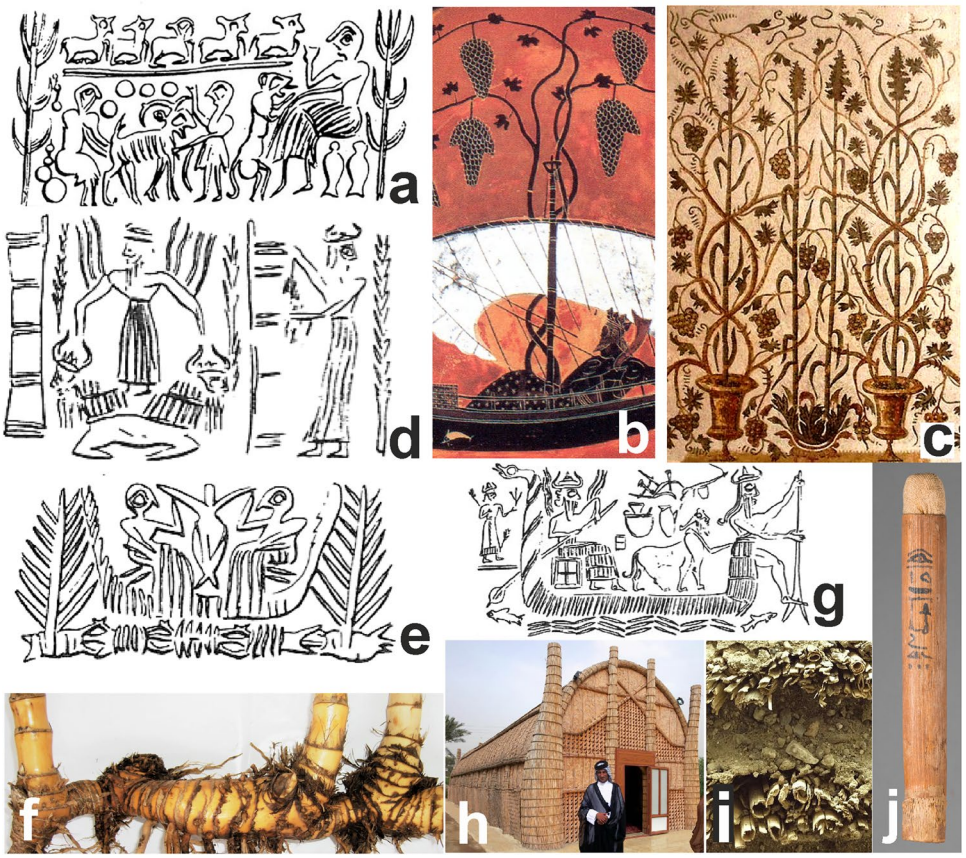

Fig. 8 **a** Canes symbolizing the pastoral life. **b** Dionysus wine god in a ship with a cane mast on which a vine grows (Attic black-figure kylix from Vulci, ~ 530 BC, Munich Museum, © Wikimedia Commons). **c** Roman mosaic of vines growing on canes (© Bardo Museum, Tunis). **d** Pillars ("horizon doors") of temple looking like canes. **e** 'Sacred Boat' made in *A. donax*. **f** Tuberculate rhizome of *A. donax*. **g** 'Boat God'. **h** Traditional South-Iraq reed hut (*mudhif*, © Wikimedia Commons). **i** Reed bundles layers between mud (Chinese Great Wall, Gobi ~ 120 BC, © Bairuilong, Wikimedia Commons). **j** Kôhl boxes (Egypt, 18th dynasty, © *Museo Egizio, Torino*) (Cylinder seals, 2900 – 2300 BC, Amiet, 1980)

iconography of this: e.g., the Sennefer tomb of vine arbor in Luxor (Egypt, ~ 1420 BC), Assyrian bas reliefs (Ashurbanipal banquet under the vine arbor at Nineveh ~ 650 BC), Greek ceramics, and Roman mosaics (Fig. 8b, c). Many Latin texts document the cultivation and use of *A. donax* in agriculture, e.g., Pliny the Elder (1981): "*The reed is employed more particularly, as vine supports*." Cato the Elder (1975) recommends that "*it should be planted in a damp situation, the soil being first turned up, and a distance of three feet left between the young shoots of reeds* (harundinetum)." Columella (1864) notes: "*This perennial plant adapts to all soils. It is propagated by cutting, or by laying down its stem, after the winter solstice. For a vineyard, a juger (25 acres) of reeds* (arundineti) *produces enough to erect the stakes of 20 jugers of vine*."

Ship Building

In the Mediterranean, navigation dates to the early ninth millennium BC, as evidenced by Cypriot obsidian artifacts originating in Turkey (Cauvin & Chataigner, 1998). The Neolithic expansion from the Levant to Europe (~ 5700 BC) would have involved boats capable of transporting people and animals (Guilaine, 2003). In Mesopotamia (~ 4000 BC), boats of wood, leather, and reeds (2–90 tons) travelling the rivers were dismantled on arrival. Sumerian tablets document deliveries of reeds (up to 23 000 bundles) to shipwrights (Joannès et al., 2001). According to Pliny the Elder (1981): "*when it has assumed a more ligneous consistency, it is pounded, as we see done among the Belgæ, and inserted between the joints of ships, to close the seams, a thing that it does most effectively, being more tenacious than glue, and adhering more firmly than pitch*." At Caska and Pakoštane (Croatia), we identified reed and cane in caulking material of Roman shipwrecks (*leg*. S. Wicha, unpubl. data, Fig. 4).

In South Iraq, the construction of reed ships (cited by Herodotus, 1850) has persisted from 4000 BC to the present day. These boats of strong symbolic value often appear in glyptic art (Amiet, 1980) as the "Boat God" in annual pilgrimages of gods, and the "Sacred Boat" that evoked the Ark of the Great Flood. On a cylinder seal, the engraver drew the plant used to make them; *A. donax* can be clearly recognized with its typical leafy stems and tuberculate rhizomes (Ur 2400 BC, Fig. 8e–g). The Flood texts differ according to region, but all relate the same order of the god Ea (creator of men) to the Great Sage (Atra-Hasis), through a "reed palisade." The Babylonian version from the holy city of Nippur (1500 BC) says "*destroy your house and make a rescue boat… let the boat's structure be of good reeds*" (Finkel, 2015). The temples managed the reeds, and often cultivated "the pure reed" (Cunningham, 1997), i.e., *A. donax*.

Construction

Traditionally, huts have been made of reeds, and this practice continues in the South-Iraq marshes (called *mudhif*), (Fig. 8h). The neolithic houses were built of raw bricks made with a mixture of mud and straw to avoid cracks, with roofs and light ceilings made of reeds (Michel, 2015). From 2700 to 2000 BC, documents cite the purchase of thousands of reed bundles for construction of temples, ziggurats, and palaces (Joannés et al., 2001; Margueron, 1991). To consolidate the buildings and prevent slippage and humidity, reeds were layered as crisscrossed bundles between the raw brick beds (still visible today). Similar techniques are found in Egyptian mud-brick mastabas (Postgate, 1980), in the legendary Babylon hanging gardens and the Chinese Great Wall (Gobi and Mongolian deserts ~ 120 BC). On several cylinder seals (Akkad, 2300 BC) at the temple entrance the two large pillars, symbolizing "the horizon doors" resemble canes (Amiet, 1980) (Fig. 8d).

From the Southern Mediterranean to the East, these constructions involved *P. altissimus* (common) and *A. donax* (cultivated). In Assyrian texts (~ 700 BC), the king Sennacherib wrote "*I created a pond and planted a canebrake* (sušu)," and "*The canebrakes* (appâru) *planted around Nineveh flourished greatly*" (CAD, 1956–2010, vol. 16: 262 and vol. 2: 179–181, respectively). The two infrequent and poetic terms *sušu* and *appâru* relate specifically to *A. donax*, also called "pure," "clean," or "great" reed.

In Ugaritic (Pardee, 2000) and Sumerian texts, we found reed bundles with different prices (van Driel, 1992; van de Mieroop, 1992). Reed artifacts also exhibit distinct aspects that puzzle archaeologists (Postgate, 1980), as some collapse, degrade, and turn pale (*P. altissimus*), while others remain nearly intact and golden (*A. donax*). Herodotus (1850) points out the importance of these plants in the Middle East: "*houses and mats of canes and reeds."* Vitruvius (1986) reports the same uses in Roman architecture (ceilings, partitions), and specifies: "*If the Greek reed* (arundinis) *were lacking, one could have recourse to thin reeds of the marshes, in bundles*." Until recently, these practices were still observed in Mediterranean houses.

Musical Wind Instruments

Flutes made with various bones date back 40 000 years. Single flutes are attested by paintings in Egyptian tombs of the Old Kingdom, and in Mesopotamia on a cylinder seal from Ur (2400 BC, Amiet, 1980). One of the earliest illustrations of a double flute or *aulos* is the famous marble statue from the Cycladic islands (2800 – 2300 BC). There is a statue of a flutist in the Ugarit temple of Baal (fourteenth-thirteenth century BC: Caubet, 1987) and, in Egypt, a painting shows a flutist seen exceptionally from the front (eighteenth dynasty

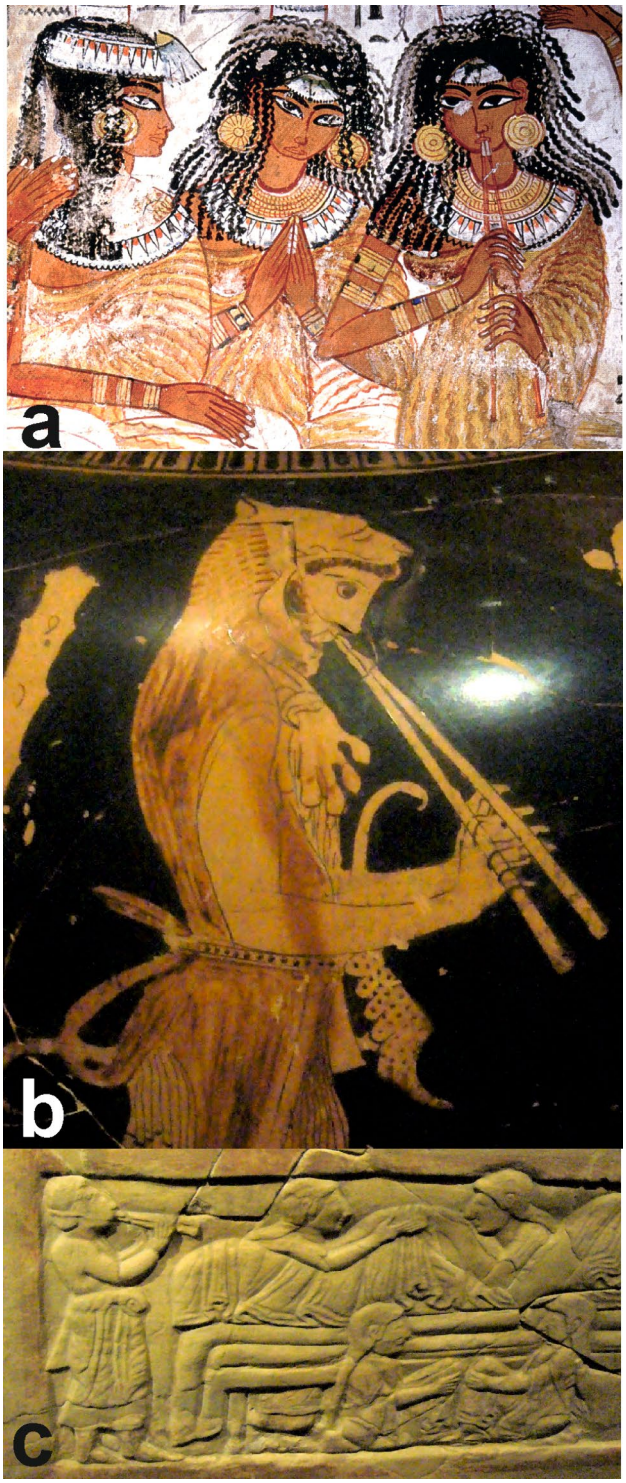

Fig. 9 Aulos. **a** flutist seen exceptionally from the front (Egypt, 18th dynasty, ~ 1350 BC, © Wikimedia Commons). **b** Heracles (Greek red-figure vase, © *Musée de la Romanité de Nîmes*). **c** Etruscan cinerary urn (Chiusi, 6 c. BC, © *Musée de la Romanité de Nîmes*)

tomb, after the Hyksos invasion, ~ 1350 BC) (Amin, 2016; Fig. 9a). In the first millennium BC, the mythic aulos of Athena enjoyed a great success in Mediterranean (Fig. 9b, c).

In a chapter on reeds, Theophrastus (1989) reports the harvesting of a rare plant used to make the aulos on the shore of Lake Orchomenus (now dried up) near Thebes (where the Muses bathed). Strabo (1966) adds "*the Aulos Fountain*" near the source of the Meander River (Phrygia, site of the musical duel between Apollo and Marsyas). If this reed was so rare, it could not be the common *A. donax, A. plinii*, and *Phragmites*. For its identification, it is necessary to read the text of Theophrastus (1989):

> '*It is said that there are two genera of reeds: the Aulos reed and the others…the species are differentiated by their strength and thickness, or by their thinness and weakness…One is called palisade reed that which is solid and large* (A. donax), *and the other the reed of basket weavers* (P. australis). *The latter would grow on floating islands, the palisade species in the cane-brakes…The one that has grown is suitable for double lamellas, the one that has not been permanently bathed in water, for the pipes…The reed even has a female aspect…The plume (panicle) shorter than the others, and totally absent in certain subjects qualified as eunuchs*.'

Therefore, there were several taxa in Greece, hence the difficulty for translators. According to the present study, eunuchs match *Arundo micrantha*, rarely flowering and not fructiferous. The canes were cut in early summer for a harmonious sound (soft tissues), and in September (lignified tissues) for a piercing sonority (the cries of Gorgons at the death of Medusa).

It is worth noting the relation between the distribution of *A. micrantha* (Fig. 2) and Phoenician-Punic ports (Carayon, 2008). An inscription from a Carthage Tophet mentions '*canna pura*' (Guzzo, 1995), and in Andalusia *A. micrantha* is called '*caña Judia*' i.e., Jewish cane (Balibrea et al., 2015). If the link with the music is obvious, one wonders what activity required accompaniment by these flutes. In antiquity, they were played on all occasions, especially those dedicated to sacrifices and burials. *Arundo micrantha* is often found near temples, such as at Delphi (Temple of Apollo, the archer god of music), or in Western Sicily at Motya (Vila, unpubl. data). The Bible cites this instrument many times in the activities of the temple. Flavius Josephus (1975–1982) (first century AD) notes that after one Hebrew defeat "*for 30 days lamentations did not cease in the city and the flutists were disputed to accompany the hymns*". Currently, in Northern Africa and the Levant, craftsmen produce various flutes. In Southern Sardinia, the launeddas, a triple clarinet (two melodic pipes *'kanna masku'* and one tumbu *'kanna femina'*) are made with *A. micrantha* (Fridolin & Bentzon, 1969).

Arundo donax supplies the large pipes of wind instruments, and lamellas or reeds (thin tongues of material that vibrate to produce a sound) (Bucur, 2019). The origin of

the invention of lamellas is unknown, perhaps concomitant with that of the aulos. Their use persists: simple (clarinets, saxophones), or double lamella (oboes, bassoons). The pipes were made of metal from the beginning of our era (Pliny the Elder), except for traditional or rustic instruments (pipes, whistles, kazoos). Pan-flutes are made with *A. donax* and date from 2000 BC. The Southern France (Var) was for a long time the world center for lamellas production. To compete with this monopoly, many plants were introduced to America in the last century. The operation ended in commercial failure, but the worldwide invasion of *A. donax* had begun (Perdue, 1958).

Throwing Weapons

Many types of weapons have been described (Aurenche & Kozlowski, 1999; Cauvin, 2013; Gernez, 2008). Like ceramics, they constitute a cultural signature for civilizations, and mark technical progress and spheres of influence. Generally, the forms have persisted for a long time, from stone to metal.

Spears, javelins, and pikes are typical weapons since the Paleolithic (~400 000 BC) and consist of a pointed head inserted into a handle, usually made of wood. In the Levant (origin of Neolithic), the 8000 – 6600 BC period, called the 'Big Arrowheads Industry'age (Aurenche & Kozlowski, 1999) matches a rapid climate change and the first major post-glacial warming, the 'Levantine moist Period' (Weninger et al., 2009). Succeeding the earlier microliths (adapted to temperate-cold *P. australis*), these new points (L = 5–10 cm) suggest the development of more robust thermophilic species: *P. altissimus* and perhaps *Arundo*. This period is marked by the circulation of materials and innovations, such as tanged points that involved fitting into a hollow shaft (Arimura, 2007) (Fig. 10a). The earliest images of phalanxes armed with short spears date from Sumer (~2500 BC, Fig. 10b). Gernez (2008) reports some bamboo traces (node imprints) on metallic sockets of javelins and pikes (Ur royal cemetery, ~2600 BC). Since tropical bamboos have only recently been introduced, these may be *A. donax*, whose large diameters were suited for the handles of throwing weapons and Minoan ceremonial double axes (Fig. 10c).

The main use of reeds as weapons was in making arrows. The first bone or stone points (L < 5 cm) date from the Upper Paleolithic (~35 000 BC). The origin of the bow is Mesolithic (~10 000 BC), e.g., artifacts in German bogs, Valltorta cave paintings (Spain). They were used until the arrival of firearms (Renoux, 2006). Shafts can be in rigid, straight, and isodiametric woods; but production requires time and skill. The easiest way was using cane or reed culms. Those of *Arundo* are 'ready to use', while the less straight and less lignified *Phragmites* culms require straightening and hardening on hot grooved stones found in many sites (Cauvin, 2013; Pichon & Abbès, 2019, Fig. 10d).

Pliny the Elder (1981) wrote texts of particular interest:

> *'It is by the aid of the reed* (calamis) *that the nations of the East decide their wars…With these missiles the warriors darken the very rays of the sun…Together with all the many peoples of the East, one-half of the whole world live under a dominion imposed by the agency of the arrow.'*

Except *P. australis*, cosmopolitan in temperate or cold zones, all other *Phragmites* and *Arundo* are thermophilic and often Mediterranean. Pliny the Elder also specified:

> '*…though in this respect, as well as in all others, Italy has gained the mastery; there being no reed in existence better adapted for making arrows* (calamis spicula) *than that found in the Rhenus* (Reno), *a river of the territory of Bononia* (Bologna*), filled with a greater quantity of pith than any of the others, it is light, and easily cleaves the air, while at the same time it has sufficient weight to resist the action of the wind'.*

This reed matches the Italo-Balkan *Arundo plinii*, dedicated to Pliny by Turra (1765) with Bologna as *locus classicus*. During their expansion, the Romans probably also used *A. donaciformis* (Liguria and Languedoc) to make arrow-shafts (also called *sagitta*).

Theophrastus (1989) wrote "*Let us point out a peculiarity of the reed suitable for making bows* (probably arrows, Renoux, 2006), *called Cretan reed*.". This is *A. micrantha* (and not the rare *P. frutescens*), whose stands match sites frequented by the Phoenicians who introduced it (Fig. 2). These great sailors founded 183 ports around the Mediterranean, including Carthage; their westward expansion mainly occurred after the Sea Peoples raids (thirteenth-twelfth centuries BC) and the Mycenaean civilization collapse (Carayon, 2008). In the Balearic Islands and Southern Spain, the discovery of their typical arrowheads coincides with their arrival (Elayi & Planas Palau, 1995). Nowadays, the most extensive *A. micrantha* populations still thrive in Crete, Southern Spain, and Levant.

Unlike the Minoans and Mycenaeans, Helladic Greeks adopted the tactic of fighting in phalanxes. This contempt for the bow perhaps stems from the mythical Trojan War, where Paris killed the Achaean hero Achilles with an arrow (Reboreda Morillo, 1996). However, the Greeks engaged Cretan archers during the Persian Wars (fifth century BC). Similarly, in 217 BC, after several defeats against Carthage, the Romans enlisted Cretan (*calami spicula gnossi*) and Iturean (Lebanon, Bekaa plain) archers who used poisoned and incendiary arrows (Renoux, 2006). Emperor Augustus organized cohorts of auxiliary archers, essential elements

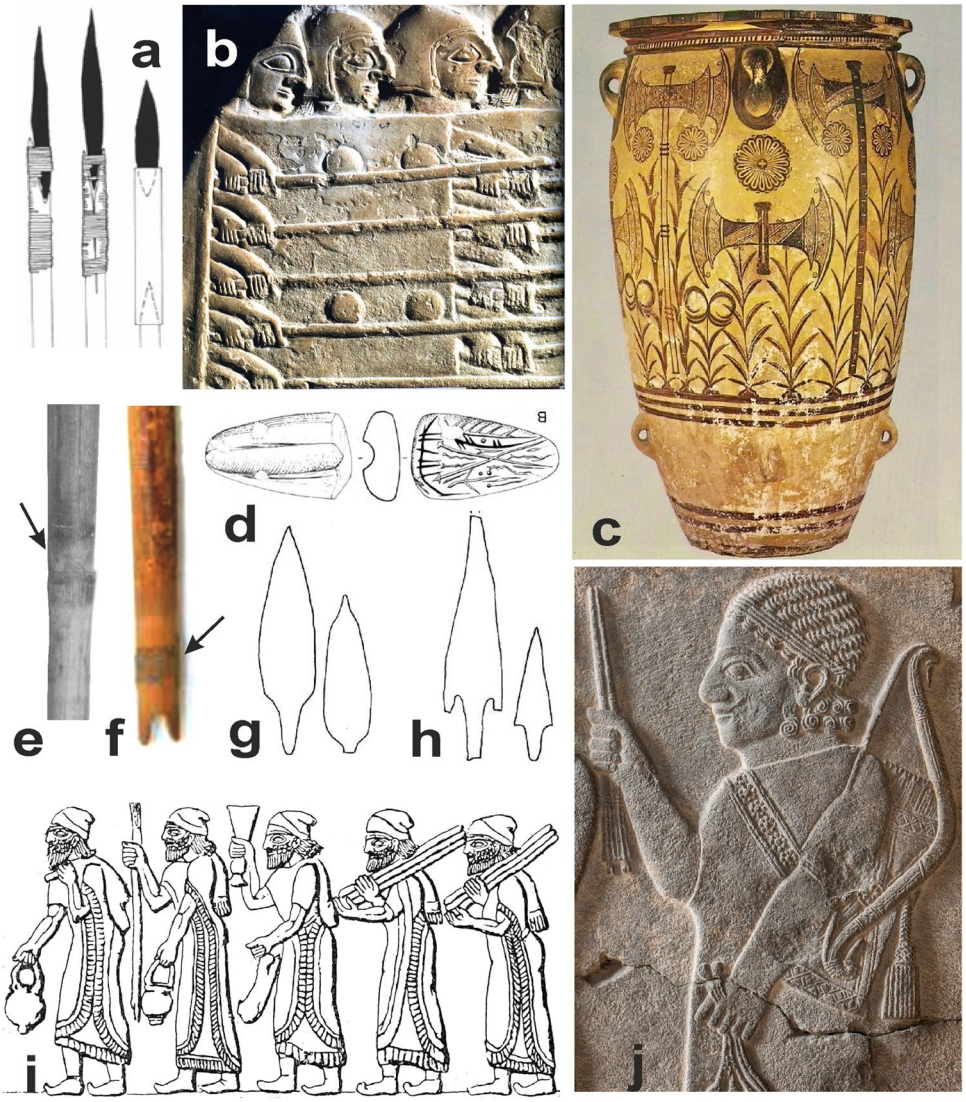

Fig. 10 **a** Fitting of weapon points (Syria, 8500 – 6000 BC, Arimura, 2007). **b** Sumerian phalanxes (The Vultures stele, 2450 BC, © Wikimedia Commons). **c** Minoan labrys (double axe, Crete, © Wikimedia Commons). **d** Grooved stone to straighten reed culms (Cauvin, 2013). **e** Egyptian *Phragmites* shaft (© *Musée d'Archéologie de Marseille*). **f** *Arundo* shaft (Dura-Europos, ~255 AD, Brown, 2007) (e, f: black arrows: distinctive traits) **g** Byblos type points and **h** Jericho type points (Arimura, 2007). **i** Hebrews bringing war tributes (Shalmaneser black Obelisk, 825 BC, © Wikimedia Commons). **j** Assyrian archer (© *Staatliche Museen zu Berlin – Vorderasiatisches Museum*, photo: VA 3000__001b)

of Roman war strategy. Cretan archers and composite bows were used until the fifteenth century AD.

Sumerian phalanx defeats were attributed to Akkadian archers equipped with composite bows (2350 BC). It was a major turning point in the art of war, acting from a distance, ambushing, and breaking through the enemy ranks (Joannès et al., 2001). In fact, the composite bow appears in Susa around 3000 BC (cylinder seal, Amiet, 1980), and the engraving of an Akkadian king says: '*I took away the weapons of Elam as tribute*' (Roux, 1995: 166). The simple bow, made from a single piece of wood, had a short range, and used small arrows (L = 48–56 cm, diameter < 1 cm) (Gernez, 2008). The composite bow, made of several pieces of wood reinforced with horn and tendons, had better elasticity, solidity, and efficiency, with a longer range (~300 m), and used long rigid arrows (L = 72–90 cm, diameter 0.8–1.5 cm) (Gernez, 2008). A Babylonian prayer says: '*return the arrow that came from the reed, your bow to the woods, cord to the tendon of the sheep heel*' (Attia, 2000: 48). These long arrows seem to correspond to the replacement of *Phragmites* by *Arundo*. Herodotus (1850) indicated in the Middle East: '*canes used to make short javelins, large bows and long arrows*.'

During battles, a good archer shot 10–12 arrows/min, requiring vast resources of equipment and the probable cultivation of canes, as confirmed by Assyrian texts (~1600 BC) (Miller et al., 1986). A few traces of this material remain, e.g., (1) weapons from an Egyptian tomb (~670 BC), with reed arrows, simple Egyptian bows (Fig. 10e), and Assyrian composite bows (Balfour, 1897); and (2) arrows of Dura-Europos (Northern Syria, ~255 AD) qualified as reed cane (Brown, 2007), and identified as *Arundo* by the dark mark under the node (Fig. 10f). In contrast, the points become increasingly widespread over time, especially in tombs. In the Levant, we can see the evolution from earliest microliths, to tanged points (adapted to hollow shafts) known as Byblos

type (~ 8000 BC), then the Jericho type with lateral barbs (~ 7500 BC) (Fig. 10g, h). The obsidian and flint points were slowly replaced by metal with a tang (~ 3500 BC), then with a socket (~ 2200 BC). Many bas reliefs with archers show scenes of unrivalled cruelty, especially in Assyria (fourteen-seventh century BC), and on several victory steles we see that the shaft bundles were part of war tributes at Susa, Byblos, Israel (Fig. 10i, j). The lament for Sumer and Ur (2000 BC) describes: "*The good reeds, which grew in the sacred place, were uprooted. The great tribute that the enemies had collected was hauled off in foreign countries.*"

The type of points marks the Neolithization of the Western Mediterranean. In Southern France, in the Chalcolithic (3500 – 2500 BC), the Byblos points arrive, and in the Bell Beaker culture (2500 BC) the Jericho points appear (Courtin, 1974). Paradoxically, this last type with tang and barbs, corresponding to the Western European and Mediterranean conception of the arrow design, is very rare elsewhere in Europe and in the East (Dias-Meirinho, 2011).

Symbols and Religions

How not to see the divine in these giant grasses, remaining green almost all year round, flowering after the autumn rains, and with so many uses? During Antiquity, myths and reality constantly merge. The Mesopotamian Genesis begins: "*When on high no word was used for heaven…no canebrake was to be seen…In water gods were created*" (Roux, 1995: 119); the order of creation was the sky, the earth, and the reeds. In Sumer, the fertility goddess Inanna was symbolized by a streamer reed stem (i.e., *P. altissimus*), while the straight cane was a male symbol (Amiet, 1980) (Fig. 11a, b) that matches *A. donax*. The Levantine storm god Adad is also drawn with reeds (Fig. 11c).

Everywhere, since the Paleolithic the waterways were sacred and in Mesopotamia the passage to the afterlife was via water. Enki, the Sumerian god of fresh water and wisdom, was the creator and savior of men. The dead was buried rolled up in reed mats, but the kings "went to the reeds of Enki." Thus, urinating or vomiting in the river and to pull up reeds were sins (Bottero, 1987). In Egypt, reed beds represented Paradise. In Roman times, we find funerary garlands of reeds, and *Arundo* under the heads of mummies or used as wrappings (Täckholm et al., 1973). For the Greco-Romans and first Christians these plants bordering the waters personified the river god with a reed in his hand (Fig. 11d).

The bow, attribute of deities and chiefs, illustrates the syncretism of religions: the names change, but functions remain. In Sumer, the homophone *TI* means both arrow and life (pictograms transition to syllabic writing around 2700 BC). The archer god Rašap (Syria, third millennium BC) spread plague or disorder and could also heal them. Brown (1993) cites Heraclitus' pun '*The name of bow is life; its work is death*' because in Greek '*bios*' designates the both. He also insists on the arrow as a symbol of male vigor and sexual energy; arrows pierce bodies and hearts: '*the arrow* (*harundine*) *that excites Love is golden*' (Ovid, 2005). Several myths link canes to sex and music: the arrows of the musician god Apollo also brought plague or healing. In legend, the nymph Syrinx was transformed into reeds to

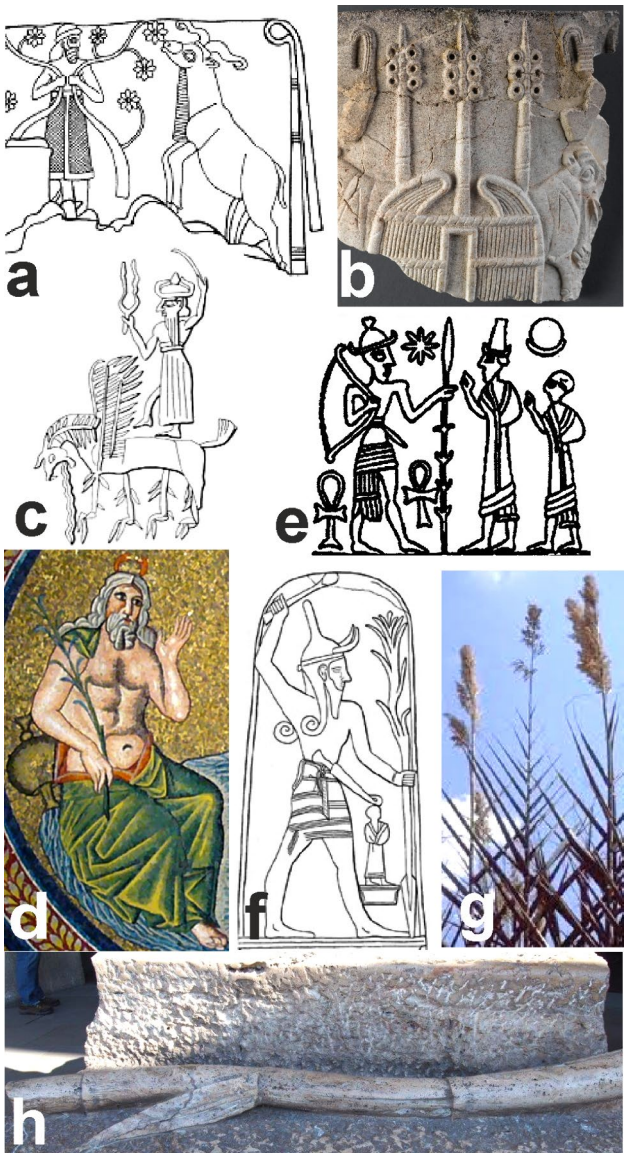

Fig. 11 **a** Goddess Inanna symbol: a streamer reed stem (Amiet, 1980). **b** Male straight symbol evoking *A. donax* (Sumer barn, 3rd mill. BC, © *Musée du Louvre*: photo AO884206-531367 NU). **c** Storm Levantine god Adad with reeds (Joannès et al., 2001). **d** Jordan river God holding a reed (Arians Baptistery, Ravenna, Italy, © N. Castelbon). **e** Archer God Rašap with defoliated *Arundo* culm (Daccache, 2010). **f** God Baal holding a spear with an enigmatic leafy culm evoking *A. micrantha* (Ugarit stele, 14th c. BC © Wikimedia Commons). **g** *Arundo micrantha.* **h** *A. donax* culm symbolizing the Way of the Cross (*Sagrada Familia*, Barcelona, Spain; (© A. Aboucaya)

escape the lustful god Pan. Disappointed, he cut them and made his Pan flute to preserve her memory. Until 1900, pig castrators were identified with Pan pipes in the countryside (Fabre-Vassas, 1983). On a cylinder seal, we see Rašap with his bow and a partly defoliated culm that looks like a cane (Daccache, 2010). Similarly, on the famous Ugarit stele, the god Baal holds a mace in one hand and a spear ending in an enigmatic leafy culm in the other: flame or lightning (Benoit, 2003: 309), perhaps *A. micrantha*. The resemblance is striking, especially the thin and stiff leaves (Fig. 11e–g).

Since the Neolithic, robust sticks were a symbol of power. According to a Sumerian text, the Uruk king (Enmerkar) cultivated a cane with two tint foliage (*A. donax* var. *versicolor*) to impress the lord of Arrata (Jiroft, Iran): '*then cuts it with an axe to turn it into an exceptional shining scepter*' (Kramer, 1957: 52). During the judgment of Christ, soldiers place in his hand a reed as the scepter of the "King of the Jews," which matches *A. donax* in paintings (e.g., Caravaggio's Ecce Homo). In the *Sagrada Familia* (Barcelona) a piece of *A. donax* symbolizes the Way of the Cross, and the Holy Spear that killed the Christ (Fig. 11h). Nowadays, in Morocco, *A. donax* is considered a mythical species, the last bastion against the advance of the desert, also serving as a knife for ritual sacrifices, and used as a partition separating young girls and boys (Gélard, 2007).

Conclusion

Due to their countless uses (writing, measurement, medicine, fuel, fodder, construction, shipbuilding, musical instruments, weapons…), reeds and canes share a long history with mankind. In most archaeological studies, the two genera are not distinguished, plants being called '*Arundo*/*Phragmites*'. Analyses of glyptic, sculptures, basreliefs and ancient texts show that craftsmen knew which plants to choose according to the uses. Botanical studies of fresh plants (micro- and macro-characters), and comparisons with artefacts (manufactured objects, fragments, and imprints) allowed us to identify the genus, and in some cases the species.

Since the Neolithic, Mediterranean villages have been established near watercourses, i.e., near reeds and canes, and humans have also introduced the most useful taxa: i.e., *A. donax* (towards the third millennium BC) that became the symbol of the Mediterranean rural world, and later *A. micrantha* (Iron Age) with Phoenician expansion.

Currently the range of their uses has declined significantly (with the exceptions of *qalams*, narghiles, thatched roofs, and lamellas), as have most of the taxa themselves. Faced with global change and worldwide regression of wetlands, *Phragmites* spp. and the *A. plinii* complex are highly threatened (geophytes linked to wetlands and/or coasts, strict outbreeding, almost exclusive vegetative multiplication) (Verlaque et al., 2001). For example, *A. donaciformis* lost 60% of its distribution in 20 years (Vila et al., 2016). However, thanks to their strong phytoremediation power, and their high energy potential (calorific value higher than woods, biogas, ethyl alcohol), reeds and canes could soon become very useful again.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10745-024-00501-9.

Acknowledgements We are grateful to Stéphanie Wicha for providing material and photos of shipwrecks. We also thank the *Musée d'Archéologie de Marseille*, the Bardo Museum of Tunis, the *Museo Egizio di Torino*, the *Musée du Louvre*, the *Musée de la Romanité de Nimes*, the *Staatliche Museen zu Berlin*, Wikimedia Commons, Nicole Castelbon and Annie Aboucaya for their permission of photo reproduction, Alain Tonetto for his SEM assistance, and Michael Paul for proofreading the text. Finally, the authors are indebted to Claudia Speciale, Judith Tucker, and the anonymous reviewers for their valuable suggestions.

Author Contributions R. Verlaque and M Verlaque wrote the main manuscript text, G. Renoux researched ancient texts, B. Vila did field work, L. Hardion and M.Verlaque prepared figures. All authors reviewed the manuscript.

Funding No funding.

Data Availability All secondary data are available from the corresponding author.

Declarations

Ethical Approval Not applicable.

Competing Interests The authors declare no competing interests.

References

Ahmad, R., Liow, P., Spencer, D., & Jasieniuk, M. (2008). Molecular evidence for a single genetic clone of invasive *Arundo donax* in the United States. *Aquatic Botany, 88*, 113–120.

Albert, R. M., Berna, F., & Goldberg, P. (2012). Insights on neanderthal fire use at Kebara Cave (Israel) through high resolution study of prehistoric combustion features: Evidence from phytoliths and thin sections. *Quaternary International, 247*, 278–293.

Amiet, P. (1980). *La Glyptique mésopotamienne archaïque* (2nd ed., p. 542). CNRS Editions.

Amin, O. S. M. (2016). The Egyptian Tomb-chapel scenes of Nebamun at the British Museum. *Ancient History Et Ceterea*. https://doi.org/10.13140/RG.2.2.34134.04160

Arimura, M. (2007). *La Néolithisation de la Syrie du Nord-Ouest: l'évolution des industries lithiques à Tell Ain El-Kerkh (Bassin du Rouj, 8500–6000 Cal. BC)*. Thesis, Lyon 2. http://theses.univ-lyon2.fr/documents/lyon2/2007/arimura_m#p=0&a=top

Attia, A. (2000). A propos de la signification de ser'ânu dans les textes médicaux mésopotamiens: Question d'anatomie. *Histoire des Sciences médicales, 34*(1), 47–56.

Aurenche, O., & Kozlowski, S. (1999). *La naissance du Néolithique au Proche-Orient* (p. 256). Paris: Éditions Errance.

Ausone. (1843). *Lettres, VII à Créon*. Texte traduit par E.F. Corpet & C.L. Panckoucke. https://remacle.org

Balfour, H. (1897). On a remarkable ancient bow and arrows believed to be of assyrian origin. *The Journal of the Anthropological Institute of Great Britain and Ireland, 26*, 210–220. https://doi.org/10.2307/2842351

Balibrea, J. M., Gallego, P. P., Sanabria, M. I., Pedauyé, H., Gimeno, R. R., Lumbreras, E. L., & Mateo, G. (2015). Sobre la presencia de *Arundo Micrantha* Lam.(Poaceae) en el levante peninsular ibérico. *Flora Montiberica, 61*, 79–89.

Benoit, A. (2003). *Les civilisations du Proche-Orient ancien* (p. 678). Réunion des Musées - Nationaux, Manuels de l'Ecole du Louvre.

Bottéro, J. (1987). *Mésopotamie. L'écriture, la Raison et les Dieux* (p. 556). Folio Histoire, Gallimard Ed.

Botterweck, G. J., Ringgren, H., & Fabry, H. J. (Eds.). (2004). *Theological dictionary of the Old Testament* (Vol. 13, p. 647). Wm. B. Eerdmans Publ. Co.

Bouchaud, C. (2012). *Recherches sur le combustible des bains d'Egypte gréco-romaine. (approche archéo-botanique)*. Rapport sur les analyses botaniques effectuées en février 2012. In Rapports des opérations balnéorient. https://balneorient.hypotheses.org/2357

Brillaud, R. (2011). Soin, prévention, contamination. Le paradoxe d'Hygie. In Naissance de la Médecine. *Les Cahiers de Science et Vie, 121*, 90–95.

Briquel-Chatonnet, F., & Gubel, E. (1998). *Les Phéniciens Aux origines du Liban* (p. 159). Gallimard Ed.

Brown, J. P. (1993). Archery in the ancient world: 'Its name is life, its work is death.' *Biblische Zeitschrif, 37*, 26–42.

Brown, P. (2007). *The roman military research society – Roman arrows*. From www.romanarmy.net/arrows.shtml

Bucur, V. (2019). Physical, mechanical and acoustical properties of cane for reeds. *Handbook of materials for wind musical instruments* (pp. 167–265). Springer.

CAD. (1956–2010). *Chicago Assyrian dictionary*. Vol. I – XXI. A. Oppenheim, E. Reiner et al. (Eds.), Chicago oriental institute. https://isac.uchicago.edu/research/publications/chicago-assyrian-dictionary

Carayon, N. (2008). *Les ports phéniciens et puniques. Géomorphologie et infrastructures* (p. 1385). Thesis, sciences de l'Antiquité – Archéologie. Univ. Strasbourg II. https://theses.hal.science/file/index/docid/283210/filename/3vol.pdf

Cato the Elder. (1975). *De l'agriculture* (p. 364). Paris, PUF, Les Belles Lettres. Traduit par R. Goujart.

Caubet, A. (1987). La Musique à Ugarit. *Comptes rendus des séances de l'Académie des Inscriptions et Belles-Lettres, 131*(4), 731–754. https://www.persee.fr/doc/crai_0065-0536_1987_num_131_4_14552

Cauvin, J. (2013). *Naissance des divinités, naissance de l'agriculture* (p. 312). CNRS Editions.

Cauvin, M. C., & Chataigner, C. (1998). Distribution de l'obsidienne dans les sites archéologiques du Proche et Moyen Orient. *British Archeological Reports International Series, 738*, 325–350.

Chevalier, P. (1817). Analyse de l'*Arundo donax* (canne de Provence). *Journal De Pharmacie et des Sciences Accessoires, 3*, 244–248.

Columella. (1864). *Les agronomes latins sous la direction de M. Nisard* (pp. 165–517). Paris: Firmin Didot Frères.

Courtin, J. (1974). *Le néolithique de la Provence* (p. 359). Klincksieck.

Crivellaro, A., & Schweingruber, F. H. (2013). *Atlas of wood, bark and pith anatomy of Eastern Mediterranean trees and shrubs*. Springer Science and Business Media.

Cullin-Mingaud, M. (2015). *La vannerie dans l'Antiquité Romaine; Chap. 1 & 2*. (pp. 207–228). Publications du Centre Jean Bérard. https://books.openedition.org/pcjb/710?lang=fr

Cunningham, G. (1997). Deliver me from evil: Mesopotamian Incantations, 2500 – 1500 BC. *Studia Pohl: Series Maior Dissertationes Scientificae De Rebus Orientis Antiqui, 17* Editrice Pontificio Istituto Biblico., 203 p.

Daccache, J. (2010). La figure d'un Dieu du Levant Antique, Rašap: Dieu malfaisant, Dieu guérisseur. *Camenulae, 5*, 1–13.

De Michele, R., La Bella, F., Gristina, A. S., Fontana, I., Pacifico, D., Garfi, G., Motisi, A., Crucitti, D., Abbate, L., & Carimi, F. (2019). Phylogenetic relationship among wild and cultivated grapevine in Sicily: A hotspot in the middle of the Mediterranean Basin. *Frontiers in Plant Science, 10*, 1506.

Dias-Meirinho, M. H. (2011). *Des Armes et des Hommes. L'archerie à la transition fin du Néolithique/Age du Bronze en Europe occidentale*. Thesis Toulouse le Mirail-II. https://theses.hal.science/tel-00674601

Elayi, J., & Planas Palau, A. (1995). *Les pointes de flèches en bronze d'Ibiza dans le cadre de la colonisation Phénico-Punique* (Vol. 2, p. 350). Paris: Gabalda.

ETCSL. (2003–2007). *The electronic text corpus of Sumerian literature*. Faculty of Oriental Studies, University of Oxford. https://etcsl.orinst.ox.ac.uk/

Fabre-Vassas, C. (1983). Le Charme de la Syrinx. *L'Homme, 23*, 5–39.

Figueiral, I. (2015). Chapter 3: Les restes végétaux. In M. Cullin-Mingaud (Ed.) *La vannerie dans l'Antiquité Romaine* (pp. 255–261). Publications du Centre Jean Bérard. https://books.openedition.org/pcjb/710?lang=fr

Figueiral, I., Bouby, L., Buffat, L., Petitot, H., & Terral, J. F. (2010). Archaeobotany, vine growing and wine producing in Roman Southern France: The site of Gasquinoy (Béziers, Hérault). *Journal of Archaeological Science, 37*(1), 139–149. https://doi.org/10.1016/j.jas.2009.09.024

Finkel, I. (2015). *L'Arche avant Noé. Les origines de l'histoire du déluge déchiffrées* (p. 445). J.C. Lattès Publ.

Fournier, P. (1947). *Dictionnaire des plantes médicinales et vénéneuses de France* (p. 1047). Lechevalier.

Fridolin, A., & Bentzon, W. (1969). The Launeddas: A sardinian folk-instrument. *Acta Etnomusicologia Danica, 1*, 11–158.

Gabolde, M. (2012). Toutânkhamon et les roseaux de Djapour: Pi-Ramsès avant Pi-Ramsès? In C. Zivie-Coche & I. Guermeur (Eds.), *Parcourir l'éternité. Hommages à Jean Yoyotte, Tomes I et II* (pp. 483–504). Brepols.

Gélard, M.-L. (2007). Le Roseau protecteur: Techniques et symboliques d'une plante dans le sud marocain. *Technique et Cultures, 48–49*, 61–84.

Gernez, G. (2008). *L'armement en métal au Proche et Moyen-Orient. Des origines à 1750 av. J.C* 4 volumes. Thesis Archéologie. Université Paris 1 Panthéon-Sorbonne. https://theses.hal.science/tel-00339404/

Girardin, J.-F. (1729). *Histoire de la ville et de l'église de Fréjus* (Vol. 1, p. 604). La veuve Delaulne.

Grandjean, C., Hugoniot, C., & Lion, B. (2013). *Le banquet du monarque dans le monde antique*. Introduction (pp. 13–28). Presses universitaires de Rennes. https://journals.openedition.org/syria/2364

Greiss, E. A. (1957). Anatomical identification of some ancient Egyptian plant materials. *Mémoires de l'Institut d'Egypte, Le Caire, 55*, 1-165, Figs. 1–138.

Grumberg, P. (2011). Médecine militaire. A la pointe de l'art. In Naissance de la Médecine. *Les cahiers de science et Vie, 121*, 70–74.

Guilaine, J. (2003). *De la vague à la tombe. La conquête néolithique de la Méditerranée* (p. 375). Seuil.

Guzzo, M.-G. (1995). Note sur un 'venditore di canna pura.' *Studi Epigrafici E Linguistici Sul Vicino Oriente Antico, 12*, 3–11.

Hardion, L., Verlaque, R., Baumel, A., Juin, M.-A., & Vila, B. (2012). Revised systematic of Mediterranean *Arundo* (Poaceae) based on AFLP fingerprints and morphology. *Taxon, 61*, 1217–1226.

Hardion, L., Verlaque, R., Haan-Archipoff, G., Cahen, D., Hoff, M., & Vila, B. (2017). Cleaning up the grasses dustbin: Systematics

of the Arundinoideae subfamily (Poaceae). *Plant Systematic and Evolution, 303*, 1331–1339. https://doi.org/10.1007/s00606-017-1451-6

Hardion, L., Verlaque, R., Saltonstall, K., Leriche, A., & Vila, B. (2014). Origin of the invasive *Arundo donax* L. (Poaceae): A trans-asian expedition in Herbaria. *Annals of Botany, 114*(3), 455–462. https://doi.org/10.1093/aob/mcu143

Heckel, A. (2003). *Emergence de la médecine en Mésopotamie* (p. 153). Nancy: Thesis Médecine. https://hal.univ-lorraine.fr/hal-01732845

Hemmerdinger, B. (1966). Trois notes: I. Kadmos. II. Emprunts du Grec mycénien à l'akkadien. III. L'infiltration phénicienne en Béotie. *Revue des Études Grecques, 79*(376–378), 698–703.

Herodotus (1850). *Histoire*. Texte traduit par Larcher. https://remacle.org

Jiménez-Ruiz, J., Hardion, L., Del Monte, J. P., Vila, B., & Santín-Montanyá, M. I. (2021). Monographs on invasive plants in Europe N° 4: *Arundo donax* L. *Botany Letters, 168*(1), 131–151. https://doi.org/10.1080/23818107.2020.1864470

Joannès, F., Michel, C., et al. (2001). *Dictionnaire de la civilisation Mésopotamienne* (p. 974). Laffont.

Josephus, F. (1975–1982). *La Guerre des Juifs* (p. 360). Les Belles Lettres. Traduit par A. Pelletier.

Kramer, S. N. (1957). *L'Histoire commence à Sumer* (p. 316). Arthaud.

Lambertini, C., Gustafsson, M., Frydenberg, J., Lissner, J., Speranza, M., & Brix, H. (2006). A phylogeographic study of the cosmopolitan genus *Phragmites* (Poaceae) based on AFLPs. *Plant Systematic and Evolution, 258*, 161–182. https://doi.org/10.1007/s00606-006-0412-2

Lieutaghi, P. (2006). *Petite ethnobotanique méditerranéenne* (p. 336). Actes Sud.

Margueron, J.-C. (1991). *Les Mésopotamiens. 2 tomes*. Collection Civilisations. Colin. 331 p and 237 p.

Mazars, G. (2002). Pharmacopées du Proche-Orient Antique. In J. Fleurentin, J.-M. Pelt, & G. Mazars (Eds.), *Des sources du savoir aux médicaments du futur* (pp. 55–66). 4th European Congress on Ethnopharmacology, Paris, IRD Editions, Marseille.

Metcalfe, C. R. (1960). *Anatomy of monocotyledons: I. Gramineae* (p. 731). Oxford: Gramineae.

Michel C. (Ed.) (2015). De la maison à la ville dans l'Orient ancien: la maison et son mobilier. In *Archéologies et Sciences de l'Antiquité*, XII, p. 157, 2015, Cahier des Thèmes transversaux, CNRS Editions.

Miller, R., McEwen, E., & Bergman, C. (1986). Experimental approaches to ancient Near Eastern Archery. *World Archaeology Weaponry and Warfare, 18*(2), 179–194. https://doi.org/10.1080/00438243.1986.9979997

Ochsenschlager, E. (1992). Ethnographic evidence for wood, boats, bitumen, and reeds in southern Iraq: Ethnoarchaeology at Al-Hiba. *Bulletin on Sumerian Agriculture Cambridge, 6*, 47–78.

Ovid, N. (2005). *Métamorphoses*, Livre I. Traduit par A.-M. Boxus & J. Poucet, Bruxelles. http://bcs.fltr.ucl.ac.be/METAM/Met00-Intro.html

Pagnoux, C., Bouby, L., Valamoti, S. M., Bonhomme, V., Ivorra, S., Gkatzogia, E., Karathanou, A., Kotsachristou, D., Kroll, H., & Terral, J. F. (2021). Local domestication or diffusion? Insights into viticulture in Greece from Neolithic to archaic times, using geometric morphometric analyses of archaeological grape seeds. *Journal of Archaeological Science, 125*, 105263.

Paquereau, J. (2013). *Au jardin des plantes de la Bible. Botanique, Symboles et usages* (p. 416). CNPF-IDF.

Pardee, D. (2000). Trois comptes Ougaritiques (RS 15.062, RS 18.024, RIH78/02). *Syria, 77*, 23–67.

Paris, R. R., & Moyse, H. (1981). *Précis de matière médicale* (p. 511). Masson: Tome II.

Perdue, R. (1958). *Arundo donax*, source of musical reeds and industrial cellulose. *Economic Botany, 12*(4), 368–404. https://doi.org/10.1007/BF02860024

Pichon, F., & Abbès, F. (2019). L'archerie préhistorique au proche-orient. Fabrication expérimentale de flèches néolithiques. From https://www.fondationfyssen.fr/wp-content/uploads/2019/03/PICHON_Fiona.pdf

Pliny the Elder, G. (1981). *Histoire Naturelle* (vol. XII-XXVII). Les Belles Lettres. Texte traduit par J. André. https://www.lesbelleslettres.com/livre/9782251011721/histoire-naturelle

Post, G. (1933). *Flora of Syria, Palestina and Sinai* (p. 919). Beirut: American Press.

Postgate, J. (1980). Palm-trees, reeds and rushes in Iraq Ancient and Modern. In M. T. Barrelet (Ed.), *L'archéologie de l'Iraq. Perspectives et limites de l'interprétation anthropologique des documents* (pp. 99–109). Paris: CNRS Editions.

Reboreda Morillo, S. (1996). L'arc et les flèches en Grèce à la fin de l'Âge du bronze et au début de l'Âge du Fer. *Dialogues d'Histoire Ancienne, 22*(2), 9–24. https://www.persee.fr/doc/dha_0755-7256_1996_num_22_2_2294

Renoux, G. (2006). Les archers de César. *Recherches historiques, archéologiques et paléo-métallurgiques sur les archers dans l'armée romaine et leur armement dans l'armée romaine de César à Trajan.* (Vol. 2). Thesis Toulouse. https://theses.hal.science/tel-00545245 410 p and 138 p.

Romano, L., Celant, A., & Montorfani, M. V. (2021). Chapter 3. Reed-swamps in the sumerian material culture: Archaeological, archaeobotanical and experimental insights from the Abu Tbeirah excavations. In L. A. Jawad (Ed.), *Southern Iraq's Marshes: Their Environment and Conservation* (pp. 33–54). Coastal Research Library, Springer International Publishing.

Roux, G. (1995). *La Mésopotamie* (2nd ed., p. 608). Seuil: Collection Points Histoire.

Strabo. (1966). *Géographie* (p. 404). Tome II, Livres III - IV, Les Belles Lettres. Texte traduit par F. Lasserre.

Täckholm, V., Täckholm, G., & Drar, M. (1973). *Flora of Egypt* (Vol. 1, p. 1765). Koeltz Scientific Books Pub.

Theophrastus. (1989). *Recherches sur les plantes, Livres III-IV* (p. 423). Les Belles Lettres. Texte traduit par S. Amigues.

Turra, A. (1765). *Farsetia, novul Genus*. Venetiis.

van de Mieroop, M. (1992). Reed in the old babylonian texts from Ur. *Bulletin on Sumerian Agriculture Cambridge, 6*, 147–153.

van Driel, G. (1992). Wood, Reeds and Rushes: A Note on Neo-Babylonian Practical Texts. *Bulletin on Sumerian Agriculture, Cambridge, 6*, 171–176.

Verlaque, R., Hardion, L., Lambertini, C., Canavan, K., Verlaque, M., & Vila, B. (2023). New highlights on Old World giant *Phragmites* (Poaceae) using leaf and floral bract microscopic characters. *Aquatic Botany, 184*, 103591.

Verlaque, R., Médail, F., & Aboucaya, A. (2001). Valeur prédictive des types biologiques pour la conservation de la flore méditerranéenne. *Comptes Rendus de l'Académie des sciences-Series III-Sciences de la Vie, 324*(12), 1157–1165. https://doi.org/10.1016/S0764-4469(01)01406-8

Vila, B., Barthelemy, C., Consalès, J., Lizet, B., Renoux, G., Verlaque, R., en collaboration avec, Goiffon, M., Lizée, C., & Geneys, C. (2016). La canne de Pline à Fréjus: préserver l'héritage antique. In S. Barles & N. Blanc (Eds.), *Ecologies urbaines sur le terrain* (pp. 303–323). Economica Anthropos.

Vitruvius, M. (1986). *De l'Architecture, Livre X* (p. 360). Les Belles Lettres. Texte traduit et commenté par L. Callebat.

Wendrich, W. Z. (2000). Chapter 10. Basketry. In P. Nicholson & I. Shaw (Eds.), *Ancient Egyptian materials and technology* (pp. 254–267). Cambridge University Press.

Weninger, B., Clare, L., Rohling, E., Bar-Yosef, O., Böhner, U., Budja, M., & Zielhofer, C. (2009). The impact of rapid climate change on prehistoric societies during the Holocene in the Eastern Mediterranean. *Documenta Praehistorica, 36*, 7–59.

Xenophon. (1967). *Œuvres complètes* (p. 508). Texte traduit par P. Chambry, Garnier-Flammarion.

Zhang, S. C., Lin, S., Shen, A., Chen, H., Wang, F., & Huai, H. Y. (2016). Traditional knowledge on Luchai [*Phragmites australis* (Cav.) Trin. Ex Steud. And *Arundo donax* L.] and their dynamics through urbanization in Yangzhou area, East China. *Indian Journal of Traditional Knowledge, 15*(4), 580–586.