Physical evidence for the antiquity of *Cannabis sativa* L.

Michael P. Fleming[1] and Robert C. Clarke[2]

[1] Brooklyn Botanic Garden, 100 Washington Ave., Brooklyn, NY, USA 11225-1099
Tel: +1 (718) 941-4044 ext. 219, Fax: +1 (718) 941-4774; e-mail: michaelfleming@mail.bbg.org

[2] International Hemp Association, Postbus 75007, 1070 AA Amsterdam, The Netherlands
Tel/Fax: +31 (0)20 618-8758; e-mail: iha@euronet.nl

Fleming, M. P. and R. C. Clarke 1998. Physical evidence for the antiquity of *Cannabis sativa* L. (Cannabaceae). *Journal of the International Hemp Association* 5(2): 80-92. *Cannabis* has been an important economic crop plant for six millennia. Its uses for fiber, food, oil, medicine, and as a recreational/religious drug have been prevalent throughout this period. Recent palynological research into the agricultural and environmental history of *Cannabis* has produced curves for Cannabaceae pollen at a number of sites in Europe and America. Additional archaeological remains and written records provide evidence for both Old and New World occurrences. This paper discusses the origin, domestication and migration of hemp as a crop plant as documented by palynological and archaeological evidence. In addition, the comparative morphology of *Cannabis* and *Humulus* pollen grains is described, and the problems of interpreting Cannabaceae pollen in the stratigraphic record are discussed.

Introduction

Since prehistoric times, *Cannabis* has been with us in one form or another. As an adaptable weedy annual, it has, under human tutelage, successfully extended its range, both latitudinally and longitudinally (Li 1974). Paleobotany, and in particular palynology, offer the most accurate evidence of the growth of a plant in a particular region, even though plant remains can be carried by water and wind over great distances before they are deposited. Several types of paleobotanical physical evidence of *Cannabis,* such as pollen grains, fibers, seeds, fiber and seed impressions, trichomes, carbonized remains and cannabinoid compounds, have been recovered from dated archeological contexts. Pollen evidence has proven very useful in establishing the early range of *Cannabis* in Europe. Cord and textile scraps as well as fiber impressions in pottery and bronze figures have been cited as early evidence of hemp in Asia. Seed remains have been recovered from both Europe and Asia. *Cannabis* trichomes (plant hairs) are resistant to decay and burning and are also occasionally recovered. Carbonized remains are relatively rare and are confined to eastern Africa and southern Europe. Cannabinoid compounds unique to the genus *Cannabis* are also occasionally identified. These various types of physical evidence allow us to substantiate or refute historical records concerning the origin and early diffusion of *Cannabis*. The various classes of physical evidence are discussed below in more detail.

Pollen

Hemp (*Cannabis sativa* L.) and hop (*Humulus* spp.) had previously been classified into the Moraceae and the Urticaceae, but are now widely accepted as belonging to their own family, the Cannabaceae (sometimes incorrectly called the Cannabinacaeae). The taxonomy and classification of the Cannabaceae have always been disputed (Schultes 1970), but current classification schemes recognize only one species *Cannabis sativa* L. with various subspecies and varieties (Chrtek 1981, Small and Cronquist 1976), three species of *Humulus* (*H. lupulus, H. japonicus and H. yunnanensis*) (Small 1978), and a recently described new genus and species, *Humulopsis scandens* (Lour.) I. A. Grudzinskaya (Grudzinskaya 1988). Cannabaceae pollen grains are most often recovered in sediments from the bottom of lakes, ponds and wells.

The pollen grains of the family have been sketched and described by several authors (Walker 1955, Godwin 1967a, French and Moore 1986, Whittington and Gordon 1987, Whittington and Edwards 1989). Cannabaceae pollen consists of trizonoporate grains typically less than 50 microns in diameter. The pore complex is generally not greater than 3-4 microns in diameter.

French and Moore (1986) described Cannabaceae pollen in detail, noting that,

"...at the break of the slope the sexine and nexine separate as if to form a vestibulum. The nexine continues to follow the circumference of the grain for approximately 0.5 microns. In some grains it is seen to taper out, whilst in many grains it is not discernible. The tectum rises away from the nexine to form the pore annulus before steeply penetrating below the level of the endexine. The diameter of the pore cavity is 1.0 to 1.5 microns and is often slightly larger at the base. Underneath the annulus is a void, sometimes referred to as 'the hollow internal annulus.' Away from the pore the exine is thin."

Due to the close resemblance between *Cannabis* and *Humulus* pollen grains, the similar flowering times for both genera, and the fact that both genera shed buoyant pollen in vast quantities (Lewis *et al.* 1983) there have been difficulties in accurately interpreting the Cannabaceae pollen records from past site analyses. The desirability of separating these two species has encouraged researchers to designate several characteristics which can be used to determine whether a Cannabaceae pollen grain came from a hemp or hop plant (Whittington and Edwards 1989). Godwin (1967a) examined the pore complexes of *Cannabis* and *Humulus* pollen and noted differentiating factors between the two, based on several minute details in these complexes. Described later in independent studies by French and Moore (1986) and Whittington and Gordon (1987), these factors include the grouping of the scabrae as revealed by scanning electron microscope (SEM), the virtual absence of the hollow internal annulus in hop grains, the rise and arch of the tectum over the rim of the pores, and the steep slope of the annulus of *Cannabis* versus the low slope of *Humulus* pore complexes.

Godwin's criterion of whether or not the tectum penetrates beneath the endexine was judged too cumber-some. French and Moore (1986), Whittington and Edwards (1989), Whittington and Gordon (1987) and Paahlson (1981) have all concluded that statistically significant values for separation can be achieved by noting pollen grain diameter and the degree of pore uplift. Of course, these methods may be supplemented by observing the aforementioned details of the pore complexes. French and Moore (1986) noted that greater than 60% of Cannabaceae pollen can be differentiated by the degree of pore protrusion alone, noting that the pore protrudes proportionately much more on *Cannabis* grains than on those of hop. However, their calculations

were based on a small sample size, and some of their samples were distorted by size increases in the grains due to prolonged acetolysis and storage in glycerol jelly. Whittington and Gordon (1987) reduced the time of acetolysis and substituted silicone oil for glycerol. Their data showed that by noting pore protrusion and pollen grain diameter, one can estimate the proportion of *Humulus* and *Cannabis* grains in a mixed sample. Their study was based on the assumption that "the proportion of pollen grains falling into each category of the pure populations are assumed to be relevant figures for the analysis of mixtures of pollen grains." Whittington and Edwards (1989) also addressed the problem of hemp and hop pollen differentiation based on pollen diameter and pore protrusion. They showed that while the pollen of *Cannabis* is generally larger than that of *Humulus*, this in itself was an unreliable criterion for separation and must be supplemented with data on pore complex protrusion.

These conclusions do not necessarily indicate that all previous attempts at interpreting Cannabaceae pollen curves and separating the two genera are incorrect, but it does mean that less confidence can be attached to earlier studies. It should also be remembered that 'pore protrusion' and 'pollen grain size' methods of separation are based on statistical methods and are dependent on a sufficiently large population of measurable grains. The tendency for palynologists to ascribe a marked expansion of the Cannabaceae curve to *Cannabis sativa* may be reasonable and correct, but local occurrences of *Humulus lupulus* may mean that the presence or importance of hop is being underestimated. Also, it is important to consider that *Cannabis* produces copious amounts of pollen, where *Humulus* tends to shed relatively much less pollen (Lewis *et al.* 1983). According to Whittington and Edwards (1989):

"Given the notoriety which surrounds the present day use of *Cannabis* crops in drug production, it seems unlikely that pollen trapping experiments from Europe and North America can be carried out on the scale necessary to provide convincing analogues for past patterns of production".

All the ambiguity interpreting the *Cannabis* pollen record also means that it is not yet possible to suggest that a certain proportion of *Cannabis* pollen would indicate on-site retting (*i.e.*, the process in which stems are soaked in water for prolonged periods to free their bast fibers) rather than, or along with, local cultivation. *Cannabis* in the fossil pollen assemblages recovered from lake sediments may come from locally growing hemp whose pollen has been aerially transported to the lake or from hemp of local or foreign origin transported to the lake for retting. The existence of known retting sites, however, are certainly worthy of more palynological investigation. The pollen method could also be used to verify the use of such sites for hemp retting purposes. Finally, awareness on the part of analysts that hop or flax (*Linum*), another major crop plant utilized for its fibers, that may have been locally cultivated or retted prior to, during, or after *Cannabis*, may produce more comprehensive data and would be of both palynological and historical interest (Whittington and Edwards 1989).

Flax may be underrepresented in the pollen record because it is insect pollinated rather than wind pollinated and therefore it does not produce as much free pollen as either hop or hemp. However, flax pollen does show up in spikes concurrent with other signs of human settlement (such as charcoal layers signifying clearing of the land) and the cultivation of other indicator species such as cereals.

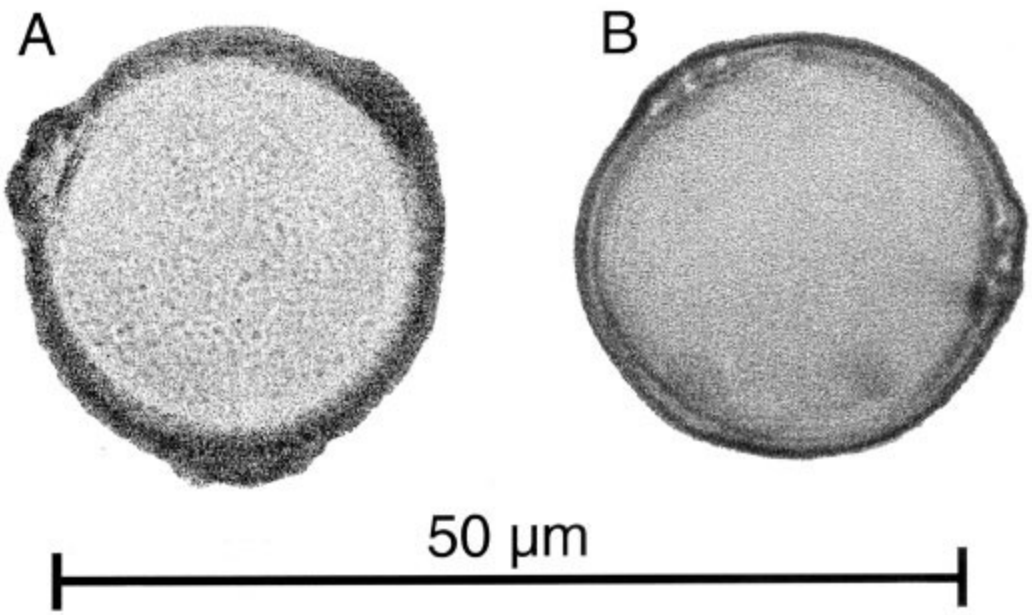

Figure 1. Pollen grains of (A): *Cannabis sativa* L and (B): *Humulus lupulus* L. Modified from photos taken by Keith Bennett. Used with permission.

Fibers

Schultes and Hofmann (1992) provided an overview of macrofossil evidence of the migration of *Cannabis* through the Old World. Fiber remains of *Cannabis* are usually found as scraps of cordage, textile fragments or pieces of paper. Mats of loose fibers have also been recovered from lake sediments in Europe. The vast majority of *Cannabis* fiber remains have been recovered from sites in China. The identity of fibers as *Cannabis* is often based on the context in which the fiber remains were found. Although it is possible to differentiate commercially available hemp fiber from other bast fibers by microscope techniques and chemical analysis, there is still much confusion surrounding the positive identification of degraded fibers recovered from archeological sites. In almost all cases, no actual laboratory identification of the plant fibers is provided and they are called "hemp" largely because of their context in early Chinese remains. If these same fiber samples had been recovered in western Europe rather than China, they might very well have been assumed to be flax rather than hemp, as flax also had a long history in ancient Europe.

Well preserved cord and fabric samples recovered from several important excavations may be made of hemp, but no definitive fiber identity has been reported in the literature. What fiber was used to twist the cord skirt of the Danish Bronze Age (*ca*. 3250 BP) Egtved girl or the rope noose around the neck of the well preserved Tollund Man's body recovered from a Danish bog? What fiber was used to weave the burial textiles of the Celtic chief buried at Hochdorf (*ca*. 2550-2500 BP), the tunics of the Iron Age (*ca*. 2400 BP) Pazyryk nobles and Ukok Princess (Bahn 1996) or the hunting nets of early (*ca.* 26,980 to 24,870 BP) Gravettians (Pringle 1977). It would be interesting to examine these archeological remains with more modern analysis techniques in order to accurately determine fiber identity.

Figure 2. Modern 'Novosadska' hemp, Pazyryk Iron Age and British medieval *Cannabis* seeds.

Seeds

Cannabis achene fruits, commonly known as seeds, have been found at many sites. *Cannabis* seeds are much easier to positively identify in archeological contexts than pollen grains or fibers. The characteristic shape of *Cannabis* seeds is not easily confused with other genera. Even when partial seeds are recovered, they often are half seeds and can still be identified (Figure 2). Dörfler (1990) published a review article of *Cannabis* seed and pollen remains from continental Europe, where the majority of *Cannabis* seed remains have been recovered. *Cannabis* seed remains are often considered indicative of hemp retting, especially in the presence of Cannabaceae pollen. Gaillard (pers. comm. 1997) interpreted high amounts of *Cannabis* pollen along with only a few seeds in retting ponds as evidence that predominantly male (pollen) plants were used for fiber production rather than female (seed) plants.

Fiber and seed impressions

Impressions of plant parts, such as fibers and seeds, are often recovered from archeological sites. Fiber impressions attributed to *Cannabis* have been found in earthen floors and clay pottery and as well as in the corroded surface of metal objects. Plant fiber impressions most often appear as cord marks either intentionally pressed into the exposed surface of pottery as a decoration, or as cord or textile patterns in the bottom of pottery, resulting from drying it on a woven cloth or cordage mat. Another type of textile impression is found in the corroded surface of bronze artifacts that were wrapped in cloth.

Fiber impressions in clay pottery, soil and metal objects present only circumstantial evidence for the antiquity of *Cannabis* (or other plant genera), because the fibers themselves are subject to decay. The context in which the fiber impressions are recovered is very important in deciding the identity of the plant fiber represented by the impressions. Even when cordage and textile imprints are found along with *Cannabis* seed or pollen remains, indicating that *Cannabis* grew nearby and was used for food, the imprints do not necessarily mean that they were made by hemp fibers.

Barber (1991) points out that,

"Archeologically, the earliest known candidates for hempen cloth occur in the form of impressions on East Asian Neolithic pots . . .. Although it is not possible to prove directly that the fiber that made these impressions was hemp, the circumstantial evidence is strong for northern China. The fibers are too coarse to have been silk; no other fiber-producing source was known to have existed in northern China until the much later introduction of ramie and cotton from the south; and fair quantities of what is probably hemp pollen have been found at Pan-p'o; one of the sites with these early textile impressions (Li 1974b)."

Pringle (1997), reporting on Gravettian sites in the Czech Republic dated at *ca*. 26,980 to 24,870 BP, refers to impressions of plant fiber cordage in clay fragments from the floors of dwellings,

"Adovasio, one of the world's experts on prehistoric fiber technology, quickly recognized the imprints of basketry or textiles on four fragments . . .. Almost certainly, says Adovasio, the impressions were created from fabrics woven of fibers from wild plants, such as nettle or wild hemp, that were preserved by accident."

"Hyland [another researcher investigating the remains] also discovered impressions of cordage ranging in diameter from 0.31 to 1.15 millimeters and bearing weaver's knots, a technique for joining two lengths of cords that is commonly used to make nets of secure mesh."

The estimated mean mesh diameter was 4 mm. and the nets were probably used for trapping birds and small game. If these impressions could be positively identified as those of *Cannabis* they would be by far the oldest archeological evidence for *Cannabis'* antiquity. However, without further substantiation, the researchers are only speculating.

We also consider impressions of seeds to be circumstantial evidence, if the actual seed no longer remains. However, the shape and size of the *Cannabis* achene is more distinctive than the impression left by a bundle of plant fibers, and is easier to identify.

Carbonized and chemical remains

The distinctive shape of *Cannabis* trichomes (hairs) allows their identification even in semi-combusted material (Nordal 1970) In addition, carbonized remains can be analyzed for the presence of the stable cannabinoid Δ^{6}-tetrahydrocannabinol (Δ^{6}-THC = Δ^{8}-THC) a compound unique to *Cannabis*. The presence of Δ^{6}-THC results from the acid catalysis of Δ^{1}-THC (Δ^{1}-THC = Δ^{9}-THC) and cannabidiol (CBD) to Δ^{6}-THC during the burning process (Zias *et al.* 1993). In certain instances, cannabinoid com-pounds can also be isolated from non-carbonized remains.

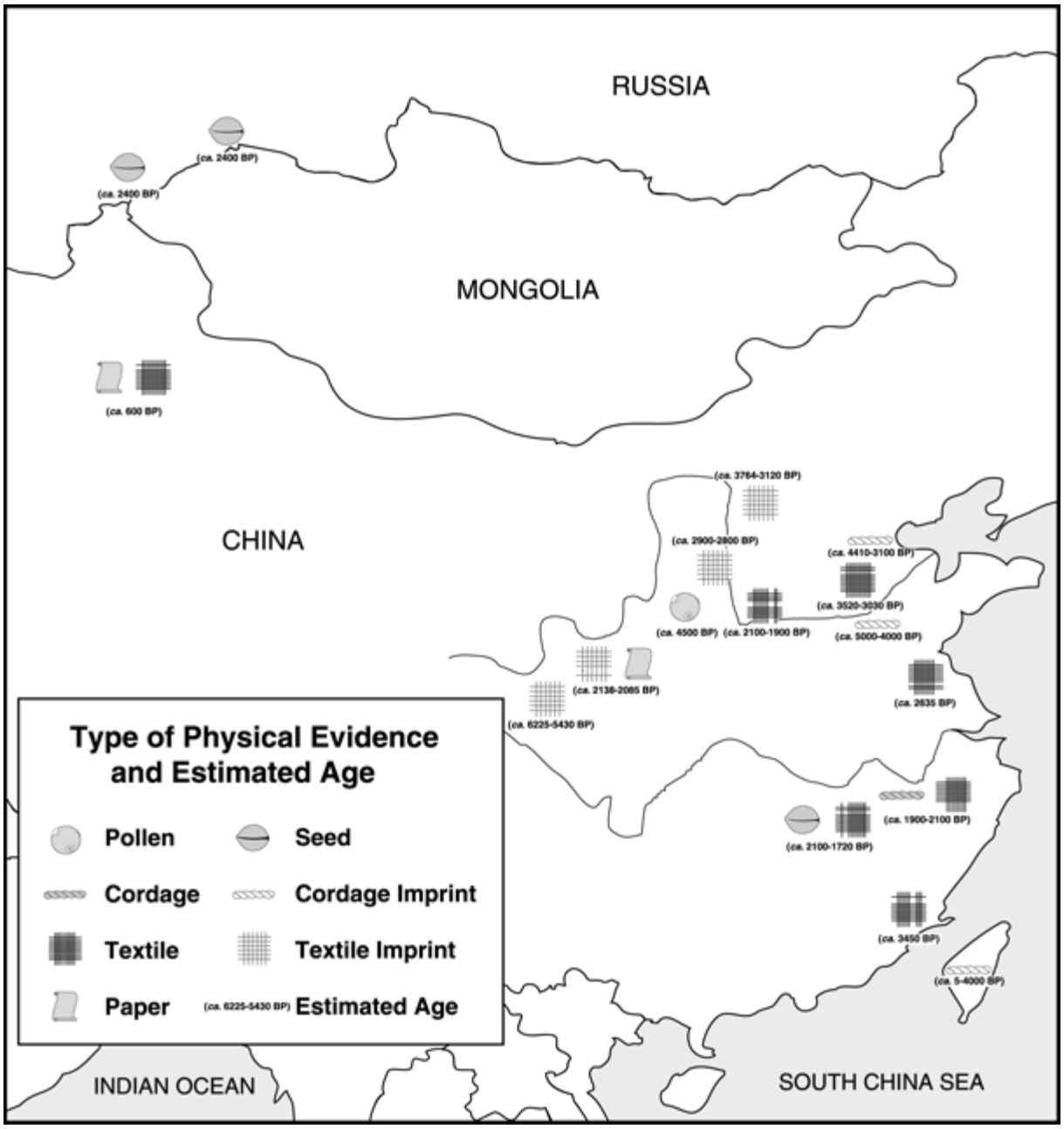

Figure 3. Asian *Cannabis* remains and approximate ages.

Physical evidence for the origin and diffusion of *Cannabis* in Asia

"Many cultivated plants are so changed from their ancestral types that it is not possible to unravel their evolutionary history. Such is not the case, however, with *Cannabis*. Yet, despite its long history as a major crop plant, *Cannabis* is still characterized more by what is not known about its biology than what is known (Schultes and Hofmann 1992)."

This situation, however, is changing. Work by Vavilov (1987) has shed light on how *Cannabis* may have been originally domesticated. It is well known that *Cannabis* requires soil

with a high nutrient content, either artificially fertilized or naturally occurring. By working with wild hemp growing in Mongolia, Vavilov imitated the process of selection and domestication of hemp as it may well have occurred 6500 years ago.

Vavilov postulated four stages in the domestication of *Cannabis*: (1) existence of plants entirely in their wild state, (2) initial colonization of the wild plant on nutrient-rich dump heaps, (3) utilization of the weed by local inhabitants, and (4) intentional cultivation (Vavilov 1992). Unlike oats and rye, which required an intentional effort to locate and utilize, hemp was very likely only circumstantially domesticated. Domestication probably occurred independently in several centers in northeast Asia around six millennia ago (Vavilov 1987, Schultes 1970, Li 1973 and 1974).

Due to biological data in English translation being recently released from China and India (Harlan 1986), details of the centers and exact dates of *Cannabis* domestication vary. We were able to locate little palynological data for the Asian continent (Figure 3). Only Chou (1963) reveals a pollen curve for what he interpreted as *Humulus* at Pan-p'o, China dated to *ca*. 4500 BP. Recently, Garg (1996) has found *Cannabis* pollen in the pollen loads of bees in present-day northeastern India. As a result, we rely largely on archaeological evidence. It is widely accepted that the Chinese were the first to domesticate this native Asian plant. There is strong archaeological evidence of its widespread use as an economic crop by *ca*. 6500 BP. Existing records place its major center of domestication in present-day northern China where there is a continuous record of its use from the Neolithic to the present (Li 1973). While its use as a food source probably resulted in its initial domestication, *Cannabis* fiber was discovered not long thereafter.

In ancient China, hemp cords were used to form the core of clay temple statues. Remains of Song Dynasty (*ca*. 1040 to 720 BP) statuary made with hemp cordage have been excavated near Chin-Ch'eng in Shanxi Province (Kao 1978). Hemp textile, rope and thread remains were also reported from a Liang-Chu culture site in Zhejiang Province (Cheng 1966). Hemp textile remains have been discovered at a Shan Kingdom (ca. 3520 to 3030 BP) site in Anyang in Henan Province (Chang 1963). Zhou Dynasty (*ca*. 3200 to 2219 BP) cemeteries in Anyang, and also Changsha in Hunan Province, yielded thousands of funerary objects, and the inventories listed included hemp textiles (Cheng 1963). A Zhou Dynasty tomb in Shanxi Province contained hemp cloth of a light weave, indicating that hemp weaving had reached a fairly high standard (Li 1974). Excavations of Han Dynasty (*ca*. 2100 to 1900 BP) tombs in Gansu Province produced complete specimens of hemp cloth used to cover corpses. The coverings were wrapped around silk dresses and were tied with hemp ropes. Hemp fibers were also used for reinforcing the plaster covering of the brick walls of the crypt (Kansu Museum 1972). Laquerware winged cups constructed over hemp cloth cores were recovered from a Han Dynasty (*ca*. 2100 to 1900 BP) wooden pit burial near Nanchang city, Jiangxi Province (Kuo 1978). A boat coffin recovered from the Wuyi mountains in Fujian Province and carved from a single tree trunk contained the body of an old man wrapped in cloth funeral shroud said to be made of jute, hemp, silk and cotton. The coffin was dated at *ca*. 3600 to 3300 BP (Li 1984). Fragments of both silk and hemp textiles dated to *ca*. 2655 to 2615 BP were found in a tomb excavated in Anhui Province adhering to the outer surface of bronze sculptures indicating that the bronzes had been wrapped in cloth (Yin 1978). Many other textile samples identified as "hemp" have been recovered from additional sites across China, but these are undated and have been omitted from this survey.

China is the original home of paper making, and paper scraps containing hemp fibers have been discovered at Chinese archeological sites. Li (1974) and Temple (1988) both report on the

1957 discovery of a scrap of paper in a tomb near Xi'an in Shaanxi Province dated at *ca*. 2138 to 2085 BP. This is considered to be the oldest surviving piece of paper ever recovered from a dated site. Temple (1988) describes the piece of paper and explains its fabrication,

"It is about 10 cm square and can be dated precisely between the years 140 and 87 BC [*ca.* 2138 to 2085 BP]. This paper and similar bits of paper surviving from the next century are thick, coarse and uneven in their texture. They are all made of pounded and disintegrated hemp fibers. From the drying marks on them, it is evident that they were dried primitively on mats woven as pieces of fabric [also likely hemp], not on what we know as paper molds. In these early days, the water just drained slowly through the underlying mat of fabric, leaving the paper layer on top. This was then peeled off and dried thoroughly. But so thick and coarse was the result, that it could not have been very satisfactory for writing."

Li (1974) describes a much later find of hemp paper along with other hempen artifacts at Turfan in Xinjiang Province in western China,

"In one grave was found a rare fragmentary script of the *Lun Yü* (Analects of Confucius) written in 716 AD [*ca*. 1282 BP] on white hemp paper. Also found were paper shoes made of pasted layers of white hemp paper sewn together with white hemp threads. In the same grave was a complete cloth sheet of hemp fabric.

"In another grave dated 721 AD [*ca*. 1277 BP], there was hemp cloth as well as hemp shoes. The latter were of two kinds, one woven of hemp fibers and the other sewn in a fine yellow cloth."

China has produced fewer seed remains than fiber remains and fiber impressions. Li (1974b) describes the tomb of a woman from Han Dynasty Tomb No. 2 (*ca*. 2100 to 1900 BP) at Changsha, Hunan Province,

"Besides fruits such as pears, peaches and jujubes, there were grains such as rice, wheat, millet, hemp seed, and mustard seed. Hemp seed was clearly used in early Han times as a common grain along with the other cereals."

The most well publicized, as well as the most controversial, *Cannabis* seed remains (Figure 2) were recovered from the frozen tomb of Iron Age (*ca*. 2430 BP) nobles of eastern Siberia discovered by Sergei Rudenko in 1929 (Rudenko 1970). We have included Rudenko's account of the occurrence of *Cannabis* seeds in the tomb, even though much of it is highly conjectural.

"Thus in barrow 2, two smoking sets were found: vessels containing stones that had been in the fire and hemp seeds; above them were shelters supported on six rods, in one case covered with a leather hanging and in the other case probably with a felt hanging, large pieces of which were found in the southwest corner of the tomb. Finally, there was a [leather] flask containing hemp seeds [Figure 2] fixed to one of the legs of a hexapod stand. Consequently we have the full set of articles for carrying out the purification ritual, about which Herodotus wrote in such detail in his description of the Black Sea Scyths. There had been sets for smoking hemp in all the Pazyryk barrows; the sticks for the stand survived in each barrow although the censers and cloth

covers had all been stolen except in barrow 2. Hemp smoking was practiced evidently not only for purification, but in ordinary life by both men and women.

"In each vessel besides the stones, as already mentioned above, there was a small quantity of seeds of hemp (*Cannabis sativa* L. of the variety *C. ruderalis* Janisch.). Burning hot stones had been placed in the censer and part of the hemp seeds had been charred. Furthermore the handle of the cauldron censer had been bound round with birch bark, evidently because the heat of the stones was such that its handle had become too hot to hold in the bare hands."

Rudenko's speculations on the smoking of *Cannabis* by these Iron Age nobles, based largely on Herodotus' accounts of the Scythians of the Black Sea region, have led to many claims that the Scythians smoked *Cannabis*. Clarke (1998) provides a more complete rebuttal of these claims. All that we know with certainty is that *Cannabis* seeds were found in the Pazyryk tombs. Woven textiles were also recovered, but the identity of the fibers has yet to be determined (Clarke 1995).

Cannabis remains may also have been recovered from more recently excavated Iron Age tombs similar to the Pazyryk tombs discovered by Rudenko. In 1993, a tomb containing the preserved body of a young woman nicknamed "The Lady" or the "Frozen Princess" was discovered by a Russian team headed by Natalia Polosmak. The tomb dated at *ca*. 2400 BP reportedly contained many grave goods, including either *Cannabis* remains in a small pot (Anon. 1994) or coriander seeds in a stone dish (Polosmak 1996). It is not clear if the seed remains were of *Cannabis* or coriander or both. Polosmak (1996) also echoes Rudenko's (1970) theory that the Pazyryk people may have breathed the fumes of burning *Cannabis*.

Nearly all of the remaining early fiber impressions attributed to *Cannabis* hemp originate from China. Li (1974b) mentions several sites in China where cordage impressions deduced as being *Cannabis* were recovered from various sites of the Yang-Shao culture in northern China dated *ca*. 4410 to 3100 BP and from a late Neolithic age (*ca*. 5000 to 4000 BP) site in Henan Province in eastern China.

Additional evidence of cord impressions have been recovered from early Neolithic (*ca*. 6000 to 5000 BP) sites on Taiwan island. According to Cheng (1959), referring to the lower stratum of Yuan Shan, the richest and most important site on the island,

"The characteristic remains here as elsewhere on the island, are the cord-marked pottery, a coarse sandy ware, handmade, thick-walled, with a plain surface covered with cord marks and, occasionally, with lineal impressions. . . . There is also a stone beater, a rod-shaped implement with incisions, which might have been used for the lineal impressions in pottery decoration, or for pounding hemp fiber, a common raw material for rope and textile."

Textile imprints have been found in pottery shards, clay layers and bronze objects. Anderson (1923) surmised that woven textile impressions found on Neolithic (*ca*. 6000 to 4000 BP) pottery shards at Yangshao in Henan Province represented hemp cloth. Li (1974b) cites many finds of *Cannabis* textile impressions from China. At the early Neolithic Yang-shao site at Pan-p'o, near Xi'an in Shaanxi Province, imprints of textiles were found on many pottery shards dated to *ca*. 6225 to 5430 BP. Another Yang-shao site in Shaanxi Province yielded pottery spinning whorls, fine bone needles and textile impressions in the dirt of one grave and were interpreted as hemp re-mains. Bronze weapons of the Shang Dynasty (*ca*. 3764 to 3120 BP)

recovered from excavations at Anyang, Henan province, have impressions left by cloth wrappers thought to be hemp. A dagger recovered from a *ca*. 2900 to 2800 BP burial at Ning Xian, Gansu Province was apparently wrapped in hemp or a similar coarse fabric as indicated by fiber impressions (So and Bunker 1995).

By *ca*. 3000 BP, *Cannabis* had most likely migrated west and south over the Himalayas and into India, probably coming with nomads and traders over the trade routes that crossed the region. In light of the accepted antiquity of *Cannabis* in India, it is noteworthy that no *Cannabis* re-mains have been recovered from archeological sights there.

Although archaeological and historical data provide a foundation for our understanding of *Cannabis* dispersal in Asia, there remains a severe lack of palynological and archeological references with which to correlate these data. We were not able to find many references dealing with analytic evidence of *Cannabis* pollen for the entire Asian region and no archeological finds of *Cannabis* remains at all from southern India. Certainly, archeological sites have been investigated, but translations of foreign studies appear to be rare. This may simply be the result of researchers focusing their investigations on other topics besides *Cannabis* remains. Many early excavations overlooked botanical evidence in their search for cultural objects. Long core samples dating further back in time may reveal *Cannabis* pollen grains giving us a much earlier time scale for the origin, evolution and migration of *Cannabis*. This is an area worth pursuing and will help broaden our biological and historical knowledge of this important crop plant.

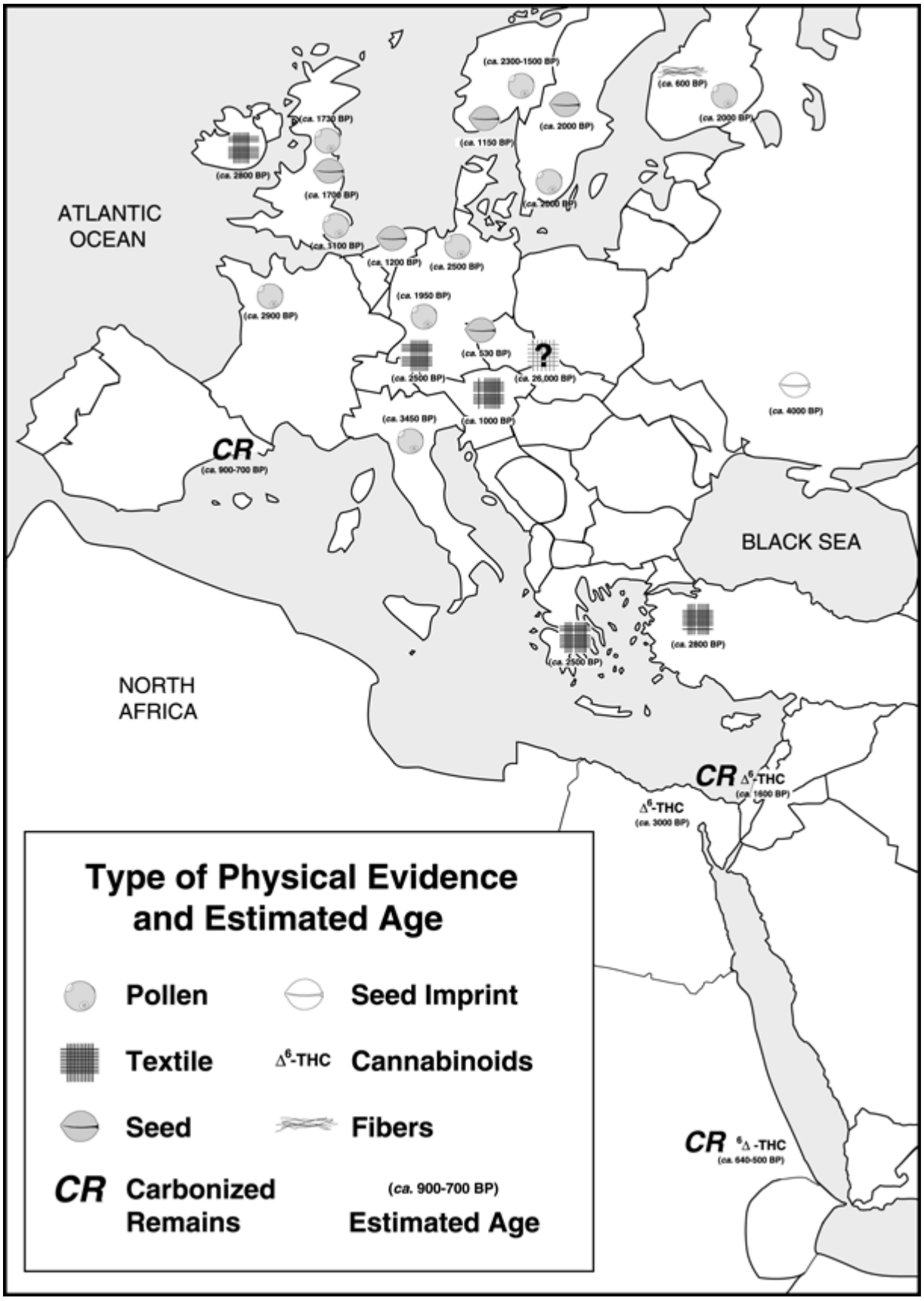
ATLANTIC OCEAN
NORTH AFRICA
BLACK SEA
(ca. 2300-1500 BP)
(ca. 600 BP)
(ca. 2000 BP)
(ca. 1730 BP)
(ca. 2000 BP)
(ca. 1150 BP)
(ca. 2800 BP)
(ca. 1700 BP)
(ca. 2000 BP)
(ca. 3100 BP)
(ca. 1200 BP)
(ca. 2500 BP)
(ca. 1950 BP)
(ca. 2900 BP)
(ca. 530 BP)
?
(ca. 2500 BP)
(ca. 26,000 BP)
(ca. 4000 BP)
(ca. 3450 BP)
(ca. 1000 BP)
CR
(ca. 900-700 BP)
(ca. 2800 BP)
(ca. 2500 BP)
CR Δ6-THC
(ca. 1600 BP)
Δ6-THC
(ca. 3000 BP)
CR 6Δ -THC
(ca. 640-500 BP)
Type of Physical Evidence and Estimated Age
Pollen
Seed Imprint
Textile
Δ6-THC
Cannabinoids
Seed
Fibers
CR
Carbonized Remains
(ca. 900-700 BP)
Estimated Age

Figure 4. European *Cannabis* remains and approximate ages.

Evidence for the diffusion of *Cannabis* in Europe and the Middle East

The most comprehensive English language survey of the archeological evidence for *Cannabis* early history in Europe is by Godwin (1967b). Dörfler (1990) provides a more recent German language overview of both macro-fossil and pollen evidence for the early distribution and diffusion of *Cannabis* in Europe.

According to the pollen record, the spread of *Cannabis* throughout Europe was a two-pronged migration. After its establishment in the Balkan states and Italy during the time of the Greek and Roman empires, it spread both north and west through eastern and southern Europe. Trade between the Vikings and various Mediterranean cultures resulted in its early establishment and cultivation in Scandinavia and its subsequent spread into the rest of northwestern Europe (Figure 4).

There is little palynological evidence of the occurrence of cultivated *Cannabis* from Greek or Roman classical sites, but its use as a foodstuff, fiber, oil, medicine, and drug is often noted in the literature of the time. *Cannabis* occurrence in the northern provinces of Italy was rare (Godwin 1967b), but Caramiello *et al*. (1992) did find pollen of both *Cannabis* and *Humulus* at sites in southern Italy dating to *ca*. 2500-2200 BP.

Willis (1992) studied the pollen stratigraphy of late Quaternary deposits in northwest Greece and noted no occurrences of *Cannabis* or *Humulus* and only minute quantities of Cannabaceae indicator species (described below). He suggested that the region was not suitable for agriculture and local tree clearances reflected in the pollen record were made to support animal husbandry. This hypo-thesis seems to agree with historical evidence for the area.

Godwin (1967b) further noted that,

"Etymological evidence seems to indicate that knowledge of the plant and its cultivation were carried to western Europe by the migrating Teutonic peoples. For the purpose of checking this assumption, we may most usefully turn to pollen analytic evidence, for whereas ropes and textiles may well have been imported, cultivation of hemp will be directly registered in the pollen rain."

Cannabis pollen values tend to be strongly associated with other indicators of arable cultivation (*Plantago*, *Rumex*, *Artemisia*, several species of the Chenopodiaceae) and often with flax (*Linum*), and with high frequencies for rye (*Secale*) as well as certain specific tree clearances, generally deciduous trees and sometimes *Pinus*. This is well documented in pollen studies throughout continental Europe, Scandinavia and England. Miotik-Szpiganowicz (1992) documented high Cannabaceae pollen curves in Bory Tucholskie in northwest Poland. Taking three cores from the lake, she noted the first *Cannabis/Humulus* pollen appearance at *ca*. 5500 BP correlated with radio-carbon dating and varve analysis (*e.g.* an examination of different layers of sediment). During this time, there was also an increase of ash (*Fraxinus*) and a decrease in hazel (*Corylus*) pollen deposits, certainly the results of the first Neolithic human influences in the region. She similarly noted the elm (*Ulmus*) decline in the area that she dated to *ca*. 5100 BP, and which has been documented throughout all of northern Europe. A warm climate for the time period was confirmed by significant values of mistletoe (*Viscum*) and ivy (*Hedera*) pollen curves. (Note: These curves are not shown on her pollen diagrams, but they are discussed in her text.) By *ca*. 3200 BP, millet (*Setaria*), barley (*Hordeum*), wheat (*Triticum*), and rye (*Secale*) are

all present in the diagram, and by the end of the Roman period (*ca*. 1800 BP) hemp, flax, and vetch (*Vicia*) are indicated. The local *Cannabis* maximums do not show in-disputable evidence of cultivation until *ca*. 1000 BP where there is a subsequent increase in hemp, plantain (*Plantago*), ragweed (*Artemisia*), rye, wheat, and cereal pollen curves and a decrease in oak (*Quercus*), elm, birch (*Betula*) and alder (*Alnus*) pollen. The high Cannabaceae percentages continue into the last century, then disappear; dioecious tree pollen is still infrequent although pine pollen increased gradually over time.

This study has been supported by other studies in Poland and the former Czechoslovakia by Balaga (1990), Latalowa (1992) and Ralska (1992). Balaga studied areas in southern Poland and northern Czechoslovakia and mentioned the "invasion of the Scyths into the Lusatain" region *ca*. 2000 BP. He discussed in his studies many anthropogenic indicators of hemp cultivation, but showed no *Cannabis* pollen. Decreases in oak, elm, hazel, and linden (*Tilia*) with corresponding increases in plantain (*Plantago*), dock (*Rumex*), and the cereals were shown. Latalowa's study on Wolin Island in the Baltic Sea showed "much hemp pollen occurring from 1000 BP to [the] present" with high values of winter rye and barley, possibly indicating crop rotation, a method practiced in Asiatic cultivation of *Cannabis*. Ralska's study revealed Cannabaceae pollen in small, but constant occurrences from *ca*. 7000 to 3900 BP in central Poland. This curve was interpreted to be that of *Humulus*, due to its antiquity and slight occurrence.

Delusina (1991) investigated Holocene pollen stratigraphy in Lake Ladoga near St. Petersburg, Russia in an attempt to correlate pollen zones of the area with those of the neighboring Russian region of northern Karelskaya and southern Finland. She found no Cannabaceae pollen, but noted great quantities of pondweed (*Potamogeton*), an indicator of many retting sites in England (Bradshaw *et al.* 1981).

Central, southern and western Europe have also yielded some interesting palynological evidence for hemp and hop occurrence. Lutgerink (1989) documented local occurrences of both *Cannabis* and *Humulus* in east-central France. Unfortunately, the study was not correlated with radiocarbon dating, and birch was the sole source of arboreal pollen. This study took place in an elevation zone of 1300-1700 meters that showed no arable cultivation. From northwestern France, Corillion and Planchas (1963) reported high values for Cannabaceae pollen associated with rye and weeds of arable ground from *ca*. 2000 BP. They furthermore note historical accounts of widespread hemp cultivation from the 11th through the 18th centuries. Further west in France, van Zeist (1964) showed high Cannabaceae values also associated with rye cultivation. Radiocarbon dating showed that continuous curve to be low from *ca*. 2900 BP, but with high occurrences after *ca*. 2600 BP. Welten (1952) was able to date *Cannabis* pollen to *ca.* 2200 BP in Spitzierbucht, Switzerland, but wide-spread cultivation there occurred during the 12th through the 17th centuries. His studies showed the *Cannabis*/ *Humulus* maximum to reach 10-13% of the total pollen, and showed occurrences of the usual indicator species. From Sehestedt on the northwestern German coast, Wiermann (1965) reported a substantial *Humulus* curve paralleled by clearance indicators, especially those of arable ground (*i.e.*, cereals, Cruciferae, and *Centaurea cyanus*). His studies showed intermittent occurrences from *ca*. 2500 BP, continuous but low values from *ca*. 1600 BP, and high values after *ca*. 600 BP. Hölzer and Hölzer (1995) documented *Cannabis* pollen near Stuttgart, Germany from *ca*. 1950-250 BP.

The most recent recovery of *Cannabis* pollen is from the Po Plain in northern Italy, a region famous for hemp cultivation during the historical period. Ravazzi (pers. comm. 1998) reports *Cannabis* pollen (positively identified based on pore structure and grain size) from a Middle Bronze Age (*ca*. 3500-3400 BP) village site. *Cannabis* pollen percentages reach 30% near the

river and 8% far from the river. These layers also contain pollen of several cultivated and weed plants.

The literature on palynological studies from Scandinavia, Denmark, and Great Britain is overwhelming. Godwin (1967a,b) has studied the vegetational history of the region and local occurrences of Cannabaceae are well documented. Godwin (1967a,b) summarized the work of several authors on the history of Cannabaceae occurring in England and Europe, in addition to providing his own data from Old Buckenham Mere, which is often cited. Based on his information, he concluded that hemp was not cultivated in England before *ca*. 2000 BP. Indeed, his data show that hemp was not cultivated in the area until the end of Roman times when the Anglo-Saxons invaded the island (*ca*. 1500 BP), bringing with them the ox-drawn plow. His Cannabaceae curve is mirrored by increases in *Secale*, *Linum*, and *Triticum*. The increased emphasis on arable cultivation during Anglo-Saxon and Norman times is evident, showing continuous curves for the arable crops. *Cannabis* maximums appear to occur from *ca*. 1200-800 BP and suffer a considerable setback around the 14th century.

Bartley *et al*. (1976) shows *Cannabis* pollen from the Durham lowlands that comprise 19% of the total pollen count in a continuous curve from 1730 to 852 BP. Birks (1965) shows a *Cannabis* occurrence from Cheshire Moss dating to *ca*. 1350 BP. Peglar (1993) studied the vegetational history around Diss Mere on the eastern English coast and revealed an almost continuous *Cannabis* pollen curve for the area from *ca*. 1100-150 BP. Using a pollen percentage diagram, she showed the almost mirror-like occurrence of hemp with cultivated rye, flax, barley, and mustard (*Brassica*) as well as the near omnipresence of plantain and nettle (*Urtica*). Historical records show the area was the center of the hemp industry in England. Pursehouse (1961) noted that 15% of all sown areas in the Waveney valley supported hemp, and her study correlates with this information nicely. Her diagram showed a very rich pollen assemblage, and there are good records of the flora and climatic conditions around the area, but her study had some potential weaknesses. First, the sediments she studied were calcareous, which can skew carbon-14 dating (Peglar 1993), making pollen-influx diagrams and rates of palynological change impossible to accurately document. Secondly, she admitted that sedimentation rates for the area may also show marked changes, and local disturbances are likely to have re-deposited pollen grains in the study site.

A study from Kentmore in Westmoreland, Wales by Walker (1955) sampled calcareous and detritus mud for Cannabaceae pollen. Using Godwin's (1940) British numbering system, he noted occurrences of Cannabaceae pollen corresponding with decreases in oak, elm, birch, alder and increases in plantain, ragweed, and Cyperaceae. He also noted a large curve for pondweed, a retting site indicator as noted by Bradshaw *et al*. (1981). Walker was unable to distinguish between hemp and hop pollen, and attempts at verification by other scientists could not distinguish the two genera.

A brief discussion on hop's occurrence is in order here. Wilson (1975) discussed the occurrence of *Humulus lupulus* in central Europe and noted that its natural range extends throughout most of Europe (except the islands of Crete, Iceland, and Spitzbergen) over the Caucasus and Altai Mountains into Siberia, north up to the Arctic Circle and south into Morocco and Palestine. Based on this early evidence, Wilson concluded that "Cannabaceae pollen curves from Zone VIIb and earlier in northern Europe are assumed to be that of hop only," using the occurrence of *Cannabis* grains as post-Roman indicators. The first written evidence of hop cultivation in Europe was *ca*. 1140 BP (DeLyser and Kasper 1994). Increases of Cannabaceaen pollen curves could not be attributed to increases in hop cultivation until after 1100 BP.

Cannabaceae pollen grains and *Cannabis* seeds were observed by Bradshaw *et al*. (1981) in Flandrian deposits in eastern England. His studies showed the pollen curve to reach up to 50% of the total land pollen in places and similarly noticed much pondweed pollen and many molluscan shell fragments, indicating that his samples came from sediments that once stood underwater. His pollen diagram also showed a drying-out period evidenced by a decrease in Cannabaceae pollen and local maxima of *Equisetum*, *Sphagnum*, and *Cyperaceae* pollen. Evidence from his earlier studies in other areas revealed that Cannabaceae maximums in those samples never exceeded 25% and lacked shell fragments and pondweed grains. Bradshaw concluded that this site was a retting site, but could not decide if local hemp cultivation had occurred or not.

French and Moore (1986) refuted Bradshaw's hypo-thesis with an independent study from Cors Llyn in central Wales. Historical evidence documents the cultivation of *Cannabis* around the lake, first on the eastern side, later on the western side. Their pollen data showed extensive *Cannabis* cultivation around the area and indicate that retting did not occur at this site based on the following facts: (1) retting involves considerable disturbance of a site, both of sediments and pollen profile and neither disturbance was observed at the study area; (2) *Cannabis* pollen was still observed after the beginning of a schwingmoor (boggy peat land) formation and the lake would be unsuitable for retting at this stage; (3) if retting had occurred, one would expect a substantial *Cannabis* curve like that seen in Bradshaw's study, but the pollen percentages reported by French and Moore (1986) never exceeded 12% of the total land pollen; (4) an agricultural survey of southern Wales in 1815 indicated that the region was damp enough to allow for retting by simply laying the hemp plants outside over the winter; (5) a calculation of diversity of pollen types from the pollen diagram indicated an increase of pollen-type diversity during the *Cannabis* stages, not a decrease, as retting would reveal. Further studies, and a re-examination of previous palynological studies using the criteria mentioned by French and Moore (1986), will help to give more detail to the emerging picture of hemp cultivation and processing.

Other evidence for *Cannabis*/*Humulus* comes from Scandinavia and Denmark. These data help make clear that the Vikings were responsible for the introduction of hemp into northwestern Europe. Hafsten (1956) showed data from the inner Oslo Fjord area of Norway that indicate the probable occurrence of cultivated hemp from *ca*. 2300-1500 BP. His pollen curves showed maxima for Cannabaceae to be 45% in some spots, but later evidence from Bradshaw *et al*. (1981) indicate that this high percentage may be due to retting (as previously discussed) and we therefore must also note that possibly, the Vikings could have been introducing foreign-grown hemp for retting, although, hemp is much easier to transport after it is retted and peeled from the stalks.

In Sweden, Fries (1962) has done pollen studies near Osbysjo and shown a *Cannabis*/*Humulus* type pollen curve that begins with low occurrences *ca*. 1850 BP and reaches 13% during the Viking period of *ca*. 1150-800 BP. It should be noted that his curve was not correlated with other arable cultivars, but a curve for rye does appear from *ca*. 2000 BP with high values after *ca*. 900 BP. Lageras (1995) showed *Cannabis* pollen from multiple sites in southern Sweden from *ca*. 600-200 BP. Godwin (1967a) found *Cannabis* pollen in southeastern Sweden, associated with rye pollen, dated from *ca*. 1600-800 BP. Tolonen (1978) showed Cannabaceae pollen curves from southern Finland. He interpreted *Humulus* pollen from *ca*. 3530-2639 BP and *Cannabis* pollen from *ca*. 2000-500 BP. Studies done by Anderson (1954) in southern Jutland show a significant Cannabaceae maximum dated to *ca*. 400 BP. However, as *Cannabis* is easily confused with *Humulus* pollen, *Cannabis* macrofossils (*e.g*., fibers, seeds, trichomes) may prove to be more definitive than, or at least a valuable supplement to, pollen

evidence.

Early European and Middle Eastern finds of *Cannabis* fibers are much less common than in China. Barber (1991) reports that hemp and linen fibers were found snagged in a bone tool recovered from a late Neolithic (*ca*. 4000 BP) site at Adaouste in southern France and also mentions the recovery of hemp fabric scraps from the ruins of Gordium, Turkey dated at *ca*. 2800 BP and Trakhones, in the Attiki Province of Greece dated at *ca*. 2500 BP. None of these fiber analyses have been substantiated. Brown layers containing *Cannabis* fibers found on lake bottoms in Finland have been interpreted as indicating the soaking of hemp after *ca*. 600 BP (Saarnisto *et al*. 1977). *Cannabis* fibers recovered from lake sediments provide more certain evidence of local hemp retting than that provided by pollen grains.

Hemp string and fabric specimens were recovered from a Bronze Age (*ca*. 2800 BP) site at St. Andrews in Scotland (Ryder 193). Identification was based on measurements of fiber diameter and comparisons were made with flax samples. Delaney (1986) refers to a Celtic "princely tomb" dated from the late Hallstatt period (*ca*. 2550 to 2500 BP) in Hochdorf, Germany excavated in 1978-1979 by Jorg Biel,

"Here the people of prehistoric Hochdorf buried a Celtic chieftain who merited a great mausoleum. He lay on a bronze, high-backed couch embossed with ritual dancing figures and horses pulling a cart. . . . Dr. Biel's fiber analysis revealed, imbedded in the bronze, horsehair, hemp, wool, and the fur of badgers, on which the dead prince had reposed."

Textile fragments from an early Magyar graveyard (*ca*. 950 BP) at Halimba-Cseres in Hungary were made of either hemp or flax (Török 1954). The hemp fibers were differentiated by microscopical observation.

In continental Europe, seed remains have been report-ed from two pre-Roman Iron Age (*ca*. 3000 to 2500 BP) sites (Willerding 1979), a water well dated at *ca*. 530 BP in the Bohemian region of Czechoslovakia (Opravil 1979), and many sites dating from *ca*. 1200 - 350 BP in the Netherlands (Pals pers. comm. 1997). In Britain, *Cannabis* seeds have been recovered from a Roman era (*ca*. 1800 to 1600 BP) well (Figure 2) at Skeldergate (Hall *et al*. 1980) and Medieval pits and watercourses at Sewer Lane, both in York (Williams 1977). Scandinavian seed remains have been recovered from a few sites in Sweden dating from as early as *ca*. 2000 BP (Påhlsson 1982 and Gaillard pers. comm. 1997). Although no hemp ropes or textiles were reported from the famous Oseberg ship burial of a woman (*ca*. 1150 BP), four *Cannabis* seeds were recovered (Holmboe 1927) and are now believed to be connected with the woman's priestly functions (Christensen 1992).

Fruits of *Cannabis* have also been found in Viking settlements in Denmark (Godwin 1967a,b). Rather surprisingly, there is no solid historical or etymological evidence that hemp was known to Iceland until quite late in medieval times, first noted in the *Kornungs Skuggsja* written in *ca*. 1240 AD (Godwin 1967b). As Godwin (1967b) points out,

"The historical evidence as a whole clearly points to cultivation of hemp in the Middle East...It spread rapidly in the Mediterranean area in classical times but there is very little evidence that its cultivation was extended northwards within the Roman empire".

Seed impressions attributed to *Cannabis* have been found in several clay shards recovered from one middle Neolithic (*ca*. 5000 BP) site of the Linearbandkeramik Culture north of the

Black Sea. Imprints of peas (*Pisum sativum*) and a vetch (*Lathyrus sp.*) were also found. Some charred remains or imprints of *Cannabis* seeds are also associated with Iron Age (*ca*. 2800 to 2400 BP) Scythian remains from the Ukraine (Yanushevich 1989).

Israeli researchers discovered carbonized material in the tomb of a 14 year old girl excavated near Jerusalem and dated at 1600 BP. Initial microscopic investigation indicated that the material possibly resulted from burning a mixture of *Cannabis* and other plants. Subsequent chemical analysis revealed the presence of Δ^6-THC. Researchers concluded that *Cannabis* had been burned to facilitate the birth process (Zias *et al.* 1993).

Evidence for the diffusion of *Cannabis* in Africa

Cannabis was introduced into Africa at an early date, although accounts of this differ greatly and no certain date has been agreed upon. Schultes (1970) estimates that the period of *ca*. 4000-3000 BP saw the first introduction of *Cannabis* into Africa, but the first physical evidence that the plant reached the African continent is not given until the *ca*. 640-500 BP (van der Merwe 1975). Whichever the case, its use in Morocco for drugs was firmly established by the early 1800's (Clarke 1998). The only pollen record we were able to locate from Africa was modern pollen trapping in Durban, South Africa (Cadman and Dames 1993). The authors tested aerial pollen for three years in the late 1980s and *Cannabis* pollen accounted for an average of 20% of the total pollen count over the test period. The authors concluded that this count indicated local cultivation.

Pipes thought to have been used for smoking *Cannabis* have been recovered from both Ethiopia and southern Spain. Remains of two ceramic water pipe bowls excavated from Lalibela cave in Ethiopia were dated at *ca*. 640 - 500 BP. Both contained trace amounts of ^{3}6-THC. This evidence was interpreted to indicate that psychoactive *Cannabis* containing THC was smoked in these pipes (van der Merwe 1975). Juan i Tresserras (pers. comm. 1998) claims to have identified charred *Cannabis* remains (*i.e*., parenchyma tissues, siliceous hairs and calcium oxalate crystals) from an Arabian pipe recovered from the medieval Christian castle site of Cornellà de Llobregat, Barcelona and dated at *ca*. 900-700 BP. The methods used to identify the charred remains as *Cannabis* were not disclosed. These reports are controversial, as both these dates precede the exploration of the New World by Spain and the supposed first date of introduction (*ca*. 400 BP) of tobacco, pipes and smoking from the New World into Europe. We hope for more substantive data in the near future.

Additional archeological evidence attributed to *Cannabis* use were found in the body tissues of several Egyptian mummies chemically determined to contain cannabinoids (Balabanova *et al*. 1992). According to their published reports,

"The immunological determination of cocaine and hashish (THC) showed the presence of these drugs in all nine samples."

"This is the first study which shows the presence of cocaine, hashish and nicotine in Egyptian mummies, dating back to about 1000 BC. This means that these three organic substances are capable of surviving in hair, soft tissue and bones for *ca.* 3000 years under favorable conditions. However, it cannot be deter-mined at present whether the concentrations measured represent the original amount of these drugs during life or immediately after death, or what kind of decomposition might have taken place in the past 3000 years."

This is the only archeological study linking *Cannabis* with ancient Egypt. Historically, the ancient Egyptians used flax (*Linum*) and cotton (*Gossypium*) for spinning and weaving and there is no mention of *Cannabis* use for any purpose. The presence of cannabinoids in the tissues of Egyptian mummies brings up the possibility that *Cannabis* was used recreationally/religiously or medicinally by the early Egyptians. However, most of the controversy centers around the reports of cocaine and nicotine contents in these Egyptian mummies predating Columbus' "discovery" of the New World. The plant genera *Erythroxylum* (the sole source of cocaine) and *Nicotiana* (the sole source of nicotine) are both considered to have only a New World distribution prior to European contact during the 15th century, much later than the dates (*ca.* 3000 BP) of the mummies analyzed by Balabanova *et al.* (1992). These results are so unusual that they cast some doubt over the cannabinoid findings as well.

Claims from the same research team add even more mystery. According to Wills (1998),

"In 1993, a team of German anthropologists published the results of an analysis of various tissues from 72 Peruvian mummies dated *ca*. 1800-500 BC (Parsche *et al*. 1993). Bones from 20 of them were shown to contain cannabinoids. In the same study, ten bodies from the German Bell Culture (*ca*. 4500 BP) did not contain cannabinoids. In addition, two African mummies from the Sudan (dated at *ca*. 7000 to 6000 BP) and 1600 to 600 BP) also did not contain *Cannabis*."

Diffusion of hemp in the New World

Haney and Kutscheid (1973) documented the spread of *Cannabis* from the east coast westward into Missouri (1835), Illinois (1875), Nebraska (1887), California (1912) and Michigan (1922), and van Zant *et al.*, (1979) studied *Cannabis*-bearing deposits at Lake West Okoboji, Iowa. The rise of Cannabaceae pollen in this study is presumed to reflect the planting of hemp crops there in 1910. MacQuiddy (1995) showed significant pollen counts near Omaha, Nebraska in air trapping studies of pollen there, and Basset *et al*. (1978) caught large amounts of *Cannabis* pollen on exposed slides in Ottawa, Canada. Although these last two studies were not of pollen cores taken from the soil, they may be useful in that they provide a comparative baseline of data to use in studies of past *Cannabis* diffusion.

Conclusion

The positive identification of the physical remains of hemp textiles, cordage, pollen grains, fruits, stalks and trichomes, combined with chemical analysis for trace remains of cannabinoids are techniques used to establish a prehistoric distribution for *Cannabis*. Palynological and other archaeological evidence substantiate much of the historical evidence for the origin of *Cannabis* in Asia and its migration around the globe. Further study is needed to clear up the lack of corroborating physical data for many regions.

References

- Anderson, A. 1954. Two standard diagrams from south Jutland. *Danmarks Geol. Untersolgelse* II 80: 188-209.
- Andersson, J. G. 1923. An early Chinese culture. *Bull. Geog. Survey China* 5(1): 26.
- Anonymous 1994. Scientists' bid to save ancient princess. *China Daily* 14(4126): 1.

- Bahn, P. G. 1996. *Tombs, Graves and Mummies.* Weidenfeld & Nicholson, London: 96, 106, 146, 164.
- Balabanova, S., F. Parsche and W. Pirsig 1992. First identification of drugs in Egyptian mummies. *Naturwissenschaften* 79: 358.
- Balaga, K. 1990. The development of Lake Lukcze and changes in the plant cover of the south-western part of the Lenczna-Wlodawa lake district in the last 13000 years. *Acta Palaeobot.* 30(1,2): 77-146.
- Barber, E. J. W. 1991. *Prehistoric Textiles - The development of cloth in the Neolithic and Bronze Ages with special reference to the Aegean*. Princeton University Press, Princeton: 16-18.
- Basset, I. J., C. W. Crompton and J. A. Parmalee 1978. *An Atlas of Airborne pollen grains and common fungus spores in Canada*. Monograph 18. Canada Dept. of Agriculture, Ottawa: 321 pgs.
- Birks, H. J. B. 1965. Pollen analytical investigations at Holcroft Moss, Lancashire and Lindlow Moss, Cheshire. *Journal of Ecology* 53(2): 299-314.
- Bradshaw, R. H. W. *et al*. 1981. New fossil evidence for the past cultivation and processing of hemp (*Cannabis sativa* L.) in eastern England. *New Phytol*. 89: 503-510.
- Cadman, A. and J. F. Dames 1993. Airspora of Durban: a sub-tropical, coastal South African city. I. Pollen component. *Grana* 32(6): 372-375.
- Caramiello, R. *et al*. 1993. Palynological findings in the Centocamare and Marasà Sud sites (Locri Epizephyrii) and their relation to the historical and archeological hypotheses. *Alloionia* 31: 7-19. [in Italian]
- Chang, K. 1963. *The Archeology of Ancient China.* Yale Univ. Press, New Haven and London: 120, 173.
- Cheng, T.-K. 1959 *Archeology in China, Vol. 1 - prehistoric China.* W. Heffer and Sons Ltd., Cambridge: 11-168.
- Cheng, T.-K. 1963 *Archeology in China, Vol. 3 - Chou China.* W. Heffer and Sons Ltd., Cambridge: 36-37.
- Chou, K. 1963. *Analysis of pollen from the Neolithic site at Pan-p'o. App. 3, Si-an Pan-p'o.* Peking.
- Christensen, I. M. 1992. *Osebergdronningens gravvaar arkeologiske nasjonalsskatt i nytt lys.* Oslo, Schibsted. [in Norwegian]
- Chrtek, J. 1981. Bemerkungen zur verbreitung der art *Cannabis ruderalis* in Böhmen und Mähren [Remarks on the distribution of the species *Cannabis ruderalis* in Bohemia Czechoslovakia.] *Casopsis Narodniho Muzea* 150(1,2): 21-24. [in German]
- Clarke, R. C. 1995. Scythian *Cannabis* verification project. *Journal of the International Hemp Association* 2(2): 104.
- Clarke, R. C. 1998. *Hashish!*. Red Eye Press, Los Angeles: 387.
- Corillion, R. and N. Planchais 1963. Recherches sur la vegetation actuelle et passee d'une lande torbeuse Armoricaine: Malingue (Meyenne). *Pollen Spores* 5: 273-286.
- Delaney, F. 1986. *The Celts* BBC Publications, London: 19, 22.
- Delusina, I. V. 1991. The Holocene pollen stratigraphy of Lake Ladoga and the vegetational history of the surroundings. *Ann. Acad. Sci. Fennicae* 153(3): 1-66.
- DeLyser, D. Y. and W. J. Kasper 1994. Hopped beer: The case for cultivation. *Economic Botany* 48(2):166-170.

- Dörfler, Walter 1990 Die geschichte des hanfanbaus in Mitteleuropa aufgrund palynologischer untersuchungen und von Großrestnach-weisen *Praehistorische Zeitschrift* 65:218-244. [in German]
- French, C. N. and Moore, P. D. 1986. Deforestation, *Cannabis* cultivation, and schwingmoor formation at Cors Llyn (Llyn Mire), central Wales. *New Phytol.* 102: 469-482.
- Fries, M. 1962. Studies of the sediments and the vegetational history in the Osbysjo Basin, north of Stockholm. *Oikos* 13: 76-96.
- Gaillard, M.-J. 1997. personal communication.
- Garg, A. 1996. Palynocontents of bee-collected pollen loads of autumn season in Bhimal, India. *Taiwania* 41(3): 197-207.
- Godwin, H. 1940. Pollen analysis and forest history of England and Wales. *New Phytol*. 39: 370.
- Godwin, H. 1967a. Pollen-analytic evidence for the cultivation of *Cannabis* in England. *Rev. Palaeobot. Palynol.* 4: 71-80.
- Godwin, H. 1967b. The ancient cultivation of hemp. *Antiquity* 42: 42-49.
- Grudzinskaya, I. A. 1988. On the taxonomy of Cannabaceae. *Bot. Zhurn.* 73(4): 589-593.
- Hafsten, U. 1956. Pollen analysis investigations on the Late-Quaternary development in the inner Oslo Fjord area. *Arbok. Univ. Bergen, Mat. Naturv.* Ser. 8: 1-162.
- Hall, A. R., H. K. Kenward and D. Williams 1980. Environmental evidence from Roman deposits at Skeldergate. in Addyman, P. V. (Ed.) *The Archeology of York* 14(3):101-156.
- Haney, A. and B. B. Kutscheid 1973. Quantitative variation in the chemical constituents of marihuana from stands of naturalized *Cannabis sativa* L. in east central Illinois. *Econ. Bot.* 27: 193-203.
- Harlan, J. R. 1986. Plant domestication: diffuse origins and diffusions. in Barigozzi, C. (Ed.) *The Origin and Early Spread of Agriculture in the Old World*. New York: Elsevier.
- Holmboe, J. 1927. Osebergfundet. in *Den norske.* Stat. Oslo. [in Norwegian]
- Hölzer, A. and A. Hölzer 1995. Studies on the vegetation history of the Hornisgrinde area in the northern Black Forest (SW Germany) by means of pollen, macrofossils and geochemistry. *Carolinea* 53: 199-238. [in German]
- Juan i Tresserras, J. 1998. Personal communication.
- Kansu Museum 1972. Preliminary report on the excavation of 3 Han tombs at Ma-tsu-tze, Wu-wei. *Wen-wu* 12: 9-21.
- Kuo, Y. 1978. The Western Han wooden-chambered tomb of Lao-fu-shan, Nan-ch'ang, Kiangsi province *KK* 1965/66: 268-272, 300, pl. II, III in Rudolph, R. C. (Ed.) *Chinese Archeological Abstracts*. UCLA Inst. of Archeology, Los Angeles: 252.
- Joseph, R. 1973. Economic significance of *Cannabis sativa* in the Moroccan Rif. *Econ. Bot*. 27: 235-240.
- Lagerås, P. 1996. Long-term history of land-use and vegetation at Femtingagölen - a small lake in the Småland Uplands, southern Sweden. *Veget. Hist. Archeobot.* 5: 215-228.
- Latalowa, M. 1992. Man and vegetation in the pollen diagrams from Wolin Island (NW Poland). *Acta Palaeobot.* 32(1): 123-249.
- Lewis, W. H., V. Prathiba and V. E. Zenger 1983. *Airborne and allergenic pollen of North America*. Johns Hopkins Univ. Press, Baltimore: 150-153.
- Li, H. L. 1973. The origin and use of *Cannabis* in East Asia: linguistic and cultural implications. *Econ. Bot.* 28: 293-301.

- Liou, S. Z. 1988. Moraceae. in Li, S. X. (Ed.) *Flora Liaoningica* 1: 281-292.
- Li, H. L. 1974. An archaeological and historical account of *Cannabis* in China. *Econ. Bot.* 28(4): 437-448.
- Lutgerink, C. A. *et al*. 1989. Regional pollen assemblages versus landscape regions in the Monts du Forez, Massif Central, France. *Pollen et Spores* 31(1,2): 45-60.
- MacQuiddy, E. L. 1955. Northern prairies and plains (Iowa, Nebraska and the Dakotas) in Samter, M. and O. C. Durham (Eds.) *Regional Allergy of the United States, Canada, Mexico and Cuba*. C. C. Thomas, Springfield, Illinois: 183-195
- Miotik-Szpiganowicz, G. 1992. The history of the vegetation of Bory Tucholskie and the role of man in the light of palynological investigations. *Acta Palaeobot.* 32(1): 39-122.
- Nordal, A. 1970. Microscopic detection of *Cannabis* in the pure state and in semi-combusted residues. in Joyce, C. R. B. and S. H. Curry (Eds.) *The Botany and Chemistry of* Cannabis. J. & A. Churchill, London: 61-68.
- Opravil, E. 1979. *Hedera helix* L. aus der mittelalterlichen Stadt Most (Tschechoslowakei). in Ludwig, M. (Ed.) *Veröffentlich mit Mittelen des Land-schaftsverbandes Rheinland*. Rheinisches Landesmuseum, Bonn: 209-215.
- Påhlsson, I. 1982. *Cannabis sativa* in Dalarna. *Striae* 14: 79-82.
- Parsche, F., S. Balabanova and W. Pirsig 1993 Drugs in ancient populations (letter). *Lancet* 341: 503.
- Peglar, S. M. 1993. The development of the cultural landscape around Diss Mere, Norfolk, UK during the past 7000 years. *Rev. Paleobot. and Palynol.* 76: 1-43.
- Polosmak, N. 1996. A mummy unearthed from the pastures of heaven. *National Geographic* Sept.: 82.
- Pringle, H. 1997. Ice age communities may be earliest known net hunters. *Science* 277: 1203-1204.
- Pursehouse, E. Hemp: A forgotten Norfolk crop. *Eastern Daily Press*. 25 Feb. 1961.
- Ralska-Jasiewiczowa, M. and B. van Geel 1992. Early human disturbance of the natural environment recorded in annually laminated sediments of Lake Gosciaz, central Poland. *Veget. Hist. Archeobot.* 1: 33-42.
- Ravazzi, C. 1998. (personal communication)
- Rudenko, Sergei I. 1970. *Frozen Tombs of Siberia - the Pazyryk burials of Iron Age horsemen* University of California Press, Berkeley and Los Angeles: 34-36, 62, 197, 199-200, 284-285, Plates 35, 61c, 62, 63.
- Ryder, M. L. 1993. Probable hemp fibre in Bronze Age Scotland. *Archeological Textiles Newsletter* 17: 10-13.
- Saarnisto, M., P. Huttenen and K. Tolonen 1977. Annual lamination of sediments in Lake Lovojärvi, southern Finland, during the past 600 years. *Ann. Bot. Fennici* 14(1): 35-45.
- Schultes, R. E. 1970. Random thoughts and queries on the botany of *Cannabis*. In: Joyce, C. R. B. and S. H. Curry (eds.) The *Botany and Chemistry of Cannabis.* London: 11-38.
- Schultes, R. E. and A. Hofmann 1992. *Plants of the Gods: sacred, healing and hallucinogenic properties*. Rochester, VT: Healing Arts Press: 92-102.
- Simpson, B. B. and M. Conner-Ogorzaly 1986. *Economic Botany: plants in our world*. San Francisco: McGraw-Hill: 385-391.
- Small, E. 1978. A numerical and nomenclatural analysis of morpho-geographic taxa of *Humulus*. *Systematic Botany* 3(1): 37-76.

- Small, E. and A. Cronquist 1976. A practical and natural taxonomy for *Cannabis*. *Taxon* 25(4): 405-435.
- So, J. F. and E. C. Bunker 1995 *Traders and Raiders on China's Northern Frontier* Arthur M. Sackler Gallery, Smithsonian Institution, University of Washington Press, Seattle and London: 126.
- Soják, J. 1980. Fragmenta phytotaxonomica et nomenclatorica (I.) *Casopis Narodniho Muzea* 148(2): 77-80.
- Temple, Robert K. 1986. *China- Land of discovery and invention.* Patrick Stevens, Wellingborough, UK: 81-82.
- Tolonen, M. 1978. Paleoecology of annually laminated sediments in Lake Ahvenainen, S. Finland. I. Pollen and charcoal analyses and their relation to human impact. *Annales Botanici Fennici* 15: 177-208.
- Török, G. 1954 Graveyard of Halimba-Cseres dating from the X-XIIth centuries. *Folia Archaelogica* 4: 95-105, 207-208. [in Hungarian]
- van der Merwe, N. J. 1975. *Cannabis* smoking in 13th-14th century Ethiopia: Chemical evidence in Rubin, V. (Ed.) *Cannabis and Culture*. Mouton, The Hague: 77-80.
- van Zant, K. L., *et al*. 1979. Increased *Cannabis* and *Humulus* pollen, an indicator of European agriculture in Iowa. *Palynology* 3: 227-233.
- van Zeist, W. 1964. A paleobotanical study of some bogs in western Brittany (Finistere), France. *Palaeohist*. 10: 157-180.
- Vavilov, N. I. 1987. *Origin and Geography of Cultivated Plants.* Cambridge University Press, Cambridge, 1992. [English translation].
- Walker, D. 1955. Studies in the post-glacial history of British vegetation. XIV: Skelsmergh Tarn and Kentmore, Westmoreland. *New Phytol.* 54(2): 222-254.
- Welten, M. 1952. Uber die spat- und postglaciale Vegetationsgeschichte des Simmentals. *Veroffentl. Geobotan. Inst.* Rubel, Zurich 26: 1-135. [in German]
- Whittington, G. and K. J. Edwards 1989. Problems in the interpretation of Cannabaceae pollen in the stratigraphic record. *Pollen et Spores* 31(1,2): 79-96.
- Whittington, G. and A. D. Gordon 1987. The differentiation of the pollen of *Cannabis sativa* L. from that of *Humulus lupulus* L. *Pollen et Spores* 29(1): 111-120.
- Wills, S. 1998 *Cannabis* use and abuse by man: An historical perspective. In: Brown, P. T. (Ed.) Cannabis - *The genus* Cannabis. Harwood Academic Pubs., The Netherlands: 1-27.
- Wiermann, R. 1965. Moorkundliche and vegetations geschichtliche Betrach-tungen zum Aussendeichsmoor bei Sehestedt (Jadebusen). *Ber. Deut. Botan. Ges.* 78: 269-278.
- Willerding, U. 1979. Zum Ackerbau in der jüngeren vorrömischen Eisenzeit. in Ludwig, M. *Veröffentlicht mit Mittelen des Landschafts-verbandes Rheinland.* Rheinisches Landesmuseum, Bonn: 309-330. [in German]
- Williams, D. 1977. The plant macrofossil contents of medieval pits at Sewer Lane, Hull. in Armstrong, P. Excavations in Sewer Lane, Hull, 1974. *East Riding Archeologist* 3, *Old Town Report Series* No. 1: 18-32.
- Willis, K. S. 1992. The late Quaternary vegetational history of northwest Greece. I. Lake Gramousti. *New Phytol*. 121: 101-117.
- Wilson, D. G. 1975. Plant remains from the Graveney boat and the early history of *Humulus lupulus* L. in western Europe. *New Phytol.* 75: 627-648.

- Yanushevich, Z. V. 1989. Agricultural evolution north of the Black Sea from the Neolithic to the Iron Age. in Harris, D. R. and G. C. Hillman (Eds.) *Foraging and Farming - The evolution of plant exploitation*. Unwin Hyman, London: 611, 614, 646.
- Yin, T. 1978. The bronzes unearthed at Shu-ch'eng, Anhwei. *KK* 1964/10: 490-503, pl. I, VI in Rudolph, R. C. (Ed.) *Chinese Archeological Abstracts* UCLA Institute of Archeology, Los Angeles: 116.
- Zias, J. *et al*. 1993. Early medical use of *Cannabis*. *Nature* 363: 215.