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The oldest archeological data evidencing the relationship of *Homo sapiens* with psychoactive plants: A worldwide overview

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Modern sophisticated archeometric instruments are increasingly capable of detecting the presence of psychoactive plant sources in archeological contexts, testifying the antiquity of humanity's search for altered states of consciousness. The purpose of this article is to provide a general picture of these findings, covering the main psychoactive plant sources of the world, and identifying the most ancient dates so far evidenced by archeology. This review is based on the archeological literature identifying the presence of psychoactive plant sources, relying on original research documents. The research produced two main results: (a) a systematization of the types of archeological evidence that testify the relationship between *Homo sapiens* and these psychoactive sources, subdivided into direct evidence (i.e., material findings, chemical, and genetic) and indirect evidence (i.e., anthropophysical, iconographic, literary, and paraphernalia); and (b) producing a list of the earliest known dates of the relationship of *H. sapiens* with the main psychoactive plant sources. There appears to be a general diffusion of the use of plant drugs from at least the Neolithic period (for the Old World) and the pre-Formative period (for the Americas). These dates should not to be understood as the first use of these materials, instead they refer to the oldest dates currently determined by either direct or indirect archeological evidence. Several of these dates are likely to be modified back in time by future excavations and finds.

Keywords: archeology, archeobotany, psychoactive plants, oldest find

INTRODUCTION

The hypothesis that the human search for altered states of consciousness through the intake of psychoactive plant sources has very ancient roots is repeatedly confirmed by archeological finds. The present review focuses on the most ancient dates so far identified by archeological research on the relationship of humans with the main psychoactive plant sources – listed in Table 1. Before this, some methodological and systematical aspects are discussed.

The initial problem that arises whenever remains of a plant (whether psychoactive or not) are found within an archeological context concerns whether or not they were introduced by humans. For this reason, a distinction between *anthropic* and *environmental* plant remains is usually taken into consideration, assigning them two different terms; however, there is no unanimous agreement among scholars about the nomenclature. Some scholars call the environmental finds *paleobotanical*, and the anthropic finds *archeobotanical*, starting from the assumption that archeology deals with everything related to humans and the anthropic environment (Day, 2013). Other scholars consider the terms *archeobotanical* and *paleoethnobotanical* to be synonymous, both associated with human activity, whereas yet other scholars consider them distinct, indicating, respectively, the environmental and the anthropic findings. Still others exclusively employ the term *archeoethnobotanical* to indicate the agricultural activity of ancient humans (for a discussion of these terms, see A-Magid, 2004). More generally, the term *paleoethnobotany* seems to be used mainly in New World archeology, whereas *archeobotany* is commonly used in Old World archeology, with mostly interchangeable meanings (VanDerwaker et al., 2016, p. 126). In Mediterranean archeology, the distinction between *archeobotanical* and *archeothnobotanical* finds is frequently adopted, here giving emphasis to the prefix *ethno-* to denote the causal relationship with anthropic activities (Marguerie, 1992, p. 46).

Once the anthropic causality of the plant find has been established, a second type of problem concerns the identification of the purpose of use of the plant, especially when it concerns remains of psychoactive plants. These plants have often been used, and continue to be used, not only to achieve altered states of consciousness, but also for medicinal, edible, manufacturing or utilitarian purposes, and it is not always possible to determine the precise purpose of use in the archeological contexts.

The archeological evidence attesting utilization of psychoactive plants can be classified into the two general groups of *direct evidence* and *indirect evidence.*

The direct evidence concerns:

Material finds: these occur when macroscopic or microscopic (pollen, phytoliths, lipids, etc.) botanical remains

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Table 1. Oldest evidence of anthropic psychoactive plant use

Old World	
Beer (from *Hordeum* spp.)[a]	11000 BC (Israel)
Hemp (*Cannabis*)[a]	8200 BC (Japan)
Betel (*Areca catechu*)[a]	7000 BC (Thailand)
Henbane (*Hyoscyamus* spp.)[a]	6000 BC (Egypt)
Waterlilies (*Nymphaea* spp.)[a]	6000 BC (Egypt)
Psilocybian mushrooms[b]	6000 BC (Sahara)
Wine (from *Vitis vinifera*)[a]	5800 BC (Georgia)
Opium poppy (*Papaver somniferum*)[a]	5600 BC (Italy)
Deadly nightshade (*Atropa belladonna*)[a]	4500 BC (Romania)
Mead[a]	4200 BC (Spain)
Harmel (*Peganum harmala*)[a]	4000 BC (Caucasus and Egypt)
Tea (*Camellia sinensis*)[a]	3500 BC (Zhejiang, China)
Lettuce (*Lactuca serriola*)[b]	2500 BC (Egypt)
Cider (from *Pyrus* sp.)[a]	2500 BC (Spain)
Ephedra spp.[a]	2000 BC (China)
Boophone disticha[b]	2000 BC (South Africa)
Jimsonweed (*Datura stramonium*)[a]	1700 BC (Andorra)
Fly-agaric (*Amanita muscaria*)[b]	1500 BC (Asia)
Mandrake (*Mandragora* spp.)[a]	1400 BC (Egypt)
Ergot (*Claviceps* spp.)[a]	300 BC (Spain)
Kava (*Piper methysticum*)[a]	850 AD (Oceania)
New World	
San Pedro (*Trichocereus* spp.)[a]	8600 BC (Peru)
Mescalbean (*Sophora secundiflora*)[a]	8440 BC (Texas)
Coca (*Erythroxylum* spp.)[a]	6000 BC (Peru)
Peyote (*Lophophora williamsii*)[a]	3200 BC (Texas)
Cebil (*Anadenanthera* spp.)[a]	2100 BC (Argentina)
Cocoa (*Theobroma cacao*)[a]	1900 BC (Mexico)
Tobacco (*Nicotiana* spp.)[a]	1500 BC (North America)
Psilocybian mushrooms and/or fly-agaric[b]	1000 BC (Guatemala)
Chicha (from *Zea maydis*)[a]	800 BC (Bolivia)
Mate (*Ilex paraguariensis*)[a]	650 BC (Argentina)
Jimsonweed (*D. stramonium*)	300 AD (Chile)
Guayusa (*Ilex guayusa*)[a]	375 AD (Bolivia)
Ololiuhqui (*Turbina corymbosa*)[b]	600 AD (Mexico)
Ipomoea spp.[a]	800 AD (Texas)
Black drink (*Ilex vomitoria*)[a]	1050 AD (IL, USA)

Note. [a]Direct evidence. [b]Indirect evidence.

are revealed in archeological excavations associated with anthropic contexts;

Chemical evidence: this concerns the identification of the active ingredients of plants in human organic tissues (hair, bones, etc.) or in material finds such as ceramics, mortars, and pestles. In addition to the active ingredients, their metabolites may also be found in organic tissues. This is the case with benzoylecgonine, a cocaine metabolite, or cocaethylene, a metabolite that the human body creates only in a context of simultaneous cocaine and alcohol intake; both compounds have been detected in the hair of South American mummies (Wilson et al., 2013). Chemical evidence also comprises the presence of specific marker compounds on the internal surface of liquid containers, such as tartaric acid, malvidin, and syringic acid attesting the original presence of grape wine (Barnard, Dooley, Areshian, Gasparyan, & Faull, 2010), or oxalic acid for barley beer (Michel, McGovern, & Badler, 1993); and

Genetic evidence: this is based on genetic studies of the plant populations of different geographical areas, with the aim of identifying the original areas of their anthropic diffusion; this technique has been used, for example, in the identification of the area of origin of cocoa tree cultivation (Matamayor et al., 2002), and in the ascertainment of a multilocation origin of grapevine domestication (Arroyo-García et al., 2006).

The indirect evidence concerns:

Anthropophysical evidence: this is based on the identification of specific transformations or malformations in the human remains that are formed as a result of the assiduous use of certain psychoactive sources. This is the case of certain mandibular and dental malformations among South American coca-leaf consumers (Indriati & Buikstra, 2001), or the blackish coloring in the teeth of betel masticators (Oxhenam, Cornelia, Cuon, & Thuy, 2002);

Paraphernalia: this refers to the instruments used for consumption of psychoactive sources, and are categorized as paraphernalia used in processing (pestles, mortars, presses, vats, etc.), conservation (*dolia*, etc.), transport (amphorae, etc.), and intake (pipes, snuff-trays, glasses, etc.);

Iconographic evidence: this concerns images of psychoactive plants, or of contexts of their use, as reported in ancient art. This type of documentation is frequently uncertain, given that the iconography of ancient plants and fungi is not generally reported with an abundance of morphological details that can safely allow the identification of the botanical species; and

Literary evidence: this concerns the terminology associated with use of psychoactive sources that can be identified in the ancient hieroglyphic, and cuneiform writings. Regarding this type of documentation, and similarly to iconographic sources, there are numerous uncertainties.

Some plant species that represent direct or indirect sources of psychoactives did not exist in nature, and were created by *Homo sapiens* through diligent cultivation and selection starting from wild species. The best known cases are opium poppy, wine vine, coca, and kava (Samorini, 2017a, 2017b).

In Table 1, the data have been divided in Old and New World sources, and have been presented in chronological order, indicating for each plant source the country with the oldest finds so far registered. The oldest date, whether for direct or indirect evidence, is presented, without reference to the more recent dates for the other form of evidence or more recent finds in other regions.

It should be recognized that these archeological finds do not always definitively establish that they reflect use as entheogens. Nonetheless, most of these evidence can be considered as indicative of entheogenic uses in the past because their discovery is generally in association with grave goods, items that were deliberately placed with deceased persons, or ceremonial sites that have apparent religious functions. The placement of plant material as grave goods, as is the case with burial itself, attests to a supernatural orientation and attitude. Similar arguments apply to finds within ceremonial structures; the default hypothesis for psychoactive plants in ceremonial structures is that they were involved in producing entheogenic experiences. These relationships justify treating the broad range of data involving deliberate interment of psychoactive plant substances as indicating that they were related to supernatural issues and consequently entheogenic concerns.

The following sections of the paper provide a succinct description of the oldest archeological data for each plant source (Table 1), grouped by geographical area (Old and New World) and following a mixed layout between kind and geographical distribution of the psychoactive sources.

OLD WORLD EVIDENCE

Alcohol sources

When it comes to the origin of the human relationship with alcohol, it is worth noting to mention the "drunken monkey hypothesis," proposed by Dudley (2004) and based on the observation that primates have been in contact with this drug since time immemorial, as it occurs naturally in fermenting fruits, meaning this association long precedes the origin of the human species. Following this, it can also be argued that alcophilia among humans is likely rooted deep in the evolutionary history of primates; the scent of alcohol indicates sources of desirable ripened fruit.

Throughout the world, people have learned to make alcoholic fermented beverages from the most disparate plant sources. In Eurasia, the best known of these products is grape wine, while ancient Mexican populations learned to get an alcoholic beverage – *pulque* – from the agave's sap. Another very ancient alcoholic product is mead, obtained by combining honey with water. With numerous types of fruit, even those found in the wild, it is possible to process fermented alcoholic brews, which are designated as ciders. Wine, mead, and ciders are all *leavened fermented beverages*. Humans acquired a second way of producing alcoholic brews using cereals, and these are classified as *malted fermented beverages*, giving rise to those drinks known as beers, and which were historically and technologically preceded by *saliva-fermented drinks* (Lima Gonçalves, 1990).

Beers

The widespread hypothesis that cereal beers originated subsequent to the achievement of cereal cultivation is increasingly rejected by scholars, who are moving toward a model of opposite technological evolution, that is, the acquisition of the production techniques of alcoholic drinks was the driving force of cereal production, which was only later adopted and perfected for the use of cereals as a food source. This would have occurred both in the context of the Eurasian beers (Joffe et al., 1998) and in the case of the Amerindian *chicha* made from corn (Smalley & Blake, 2003).

The oldest cereal beer appears to have been dated to 13,000 years ago, and its processing was established at Mount Carmel (Israel), in the Natufian site of the Raqefet Cave. The analysis of the starch granules found on the internal surfaces of some mortars revealed morphological malformations typical of those formed during the stages of brewing (germination, crushing, and enzymatic hydrolysis; Liu et al., 2018). The production of another ancient beer, dated to the 7th millennium BC, has been identified in China (Jiahu, Henan); the drink consisted of rice, honey, and a fruit (McGovern et al., 2004).

Regarding Mesopotamia, chemical analyses have outlined the preparation of barley beer at the Godin Tepe site (Zagros Mountains, Iran), at a level corresponding to the Late Uruk (3500–2900 BC; Michel et al., 1993). This direct confirmation of the existence of an ancient Mesopotamian beer would agree with the extensive evidence of beer in both administrative and mythological texts of proto-cuneiform writings, dated to 3200–3000 BC. The cuneiform texts show the production of at least nine different types of beer (Damerow, 2012, p. 4).

In Egypt, the pre-Dynastic brewery of Hierakonpolis was able to produce 1,100 L of beer a day. In addition, the excavations at Abydos, Mahasna, Badari, Ballas, and other pre-Dynastic sites have outlined elements that show the preparation of beer was a widespread practice in the phases of Naqada I–III of the 4th millennium BC (Geller, 1993).

For Europe, the presence of calcium oxalate and barley phytoliths has been evidenced in Neolithic ceramics and millstones dated to 3800–3500 BC found in the Can Sadurní cave (Barcelona, Spain; Blasco, Edo, & Villalba, 2008). In Scotland, in the Machrie Moor's stone circles site (Isle of Arran), on pottery fragments of which the oldest were dated to 3500 ± 70 BC, organic material was found with traces of hazelnuts, cereals, and honey; a fact that suggests a kind of beer was prepared (Dineley & Dineley, 2000, p. 138). In the Aegean area, the earliest references to the production of a cereal beer, dated to 2200 BC, come from the Minoan site of Myrtos (Crete; Tzedakis & Martlew, 1999, pp. 159–161).

Wine

The vine from which modern grape wines are obtained – *V. vinifera* L. subsp. *vinifera* – was created by selection from a wild vine species, recognized as *V. vinifera* subsp. *sylvestris* (*Vitaceae*; Renfrew, 1995, p. 255). In different geographical areas, wines obtained from wild vines preceded those obtained from cultivated vines, a fact that provides evidence of how viticulture was not a prerequisite for the production of wine (Valamoti, Mangafa, Koukouli-Chrysanthaki, & Malamidou, 2007, p. 58).

The oldest evidence of production of wild grape wine is currently dated around 5800 BC, found at the Godachrili Goa site (Georgia; Kvavadze, Jalabadze, & Shakulashvili, 2010). Another ancient piece of evidence, dated to 5400–5000 BC, is located in a Lake Urmia basin site (Iran); a millennium later, the wild vine was cultivated, and the domesticated form appeared a little later still (McGovern, Glusker, Exner, & Voigt, 1996).

Recent studies suggest a multilocality of genetic selection in the process of vine domestication. Over 70% of the cultivars of the Iberian Peninsula show chlorotypes that are compatible with wild vine populations originating in the western Mediterranean region (Arroyo-García et al., 2006). A secondary vine domestication center was identified in Sardinia (Italy), following the discovery of vine seeds in the Sa Osa site, dated to the Bronze Age (1350–1150 BC; Ucchesu et al., 2015). Even more recently, the genetic analysis of vine seeds found in Neolithic horizons of the Serratura Cave (Salerno) seems to confirm a domestication of the wild vine in southern Italy, independent of the Caucasian one (Gismondi et al., 2016).

In the Anatolian region, the oldest evidence dates back to 3500–3100 BC, located in the Warka site (the ancient Uruk, Irak), consisting of the residue in a ceramic container in which the presence of tartaric acid was confirmed (Badler, McGovern, & Glusker, 1996).

In Greece, the most ancient evidence for wine-making is located in the Neolithic site of Dikili Tash/Philippoi, Macedonia, where on the floor of a house numerous grape seeds and pressed grape skins have been found, dated to 4460–4000 BC, and recognized as belonging to the wild form of the vine. Specific chemical investigation evidenced that these grapes had been pressed to obtain the juice for the preparation of wine (Garnier & Valamoti, 2016).

In Egypt, the grapevine was not a native species, and the first wine was imported from the Levant, as evidenced by the discovery of 700 jars in the Tomb U-j of the king Scorpio I of Dynasty 0, dated to the Naqada IIIA2 period, ca. 3150 BC. The analysis of the residue in three of these jars showed the presence of tartaric acid and a resin, probably terebinth (McGovern, Mirzoian, & Hall, 2009). Viticulture originated during the First and Second Dynasties, as evidenced by the finding of wine jars made from Nile alluvial clay and grape remains in the Abydos and Saqqara cemeteries (McGovern, 2001, p. 402).

Mead

The oldest archeological evidence concerning mead is associated with Neolithic huts excavated beneath the Azután megalith (Toledo, Spain) and dated to 4220–3970 BC. The analysis of a ceramic sherd evidenced the presence of altered pollens of heather, cistus, and oak, in addition to cerotic acid, beeswax esters, glucose, and diatoms; a combination of elements that made it possible to identify the residue as honey diluted in water (Juan-Stresserras & Matamala, 2005). The analysis of a clay pot belonging to the necropolis of Valle de las Higueras, in the same Toledo region and with a chronology close to the previous one, also suggests the identification of a residue of mead (Bueno Ramírez, Barroso Bermejo, & Balbín Behrmann, 2005). In connection with this practice, it should be noted that the oldest documentation attesting the collection of honey from bees was also found in Spain, based on depictions in prehistoric paintings from the Mesolithic period (Dams & Dams, 1977).

Ciders

In a ceramic sherd from the Los Dolientes I site, located in the Ambrona Valley (Soria, Spain), belonging to the Bell Beaker culture of the middle of the 3rd millennium BC, a residue that would seem to correspond to a wild pear cider has been detected (Rojo-Guerra, Garrido-Pena, & García-Martínez de Lagrán, 2008, p. 98).

Kava (*P. methysticum*)

Kava is the name of both the plant and the psychoactive drink made from its roots, whose use is widespread in New Guinea and in large areas of the Pacific Ocean. The active ingredients are the kavalactones.

There is a general agreement among scholars that the kava plant – *P. methysticum* G. Forst, *Piperaceae* – was created from a wild species, *Piper wichmannii* C. DC., and an interesting confirmation of this botanical genesis is found in some traditional myths about the origin of kava (used today), which refer to a "kava of the ancestors" (Samorini, 2016b, pp. 152–153). Kava was once taken by chewing its roots and swallowing their juice, and this method is probably the oldest one, as well as being one that left no archeological traces. At a later stage, the pre-masticated boluses of the roots were extracted from the mouth and placed in containers with the addition of water. Another technique, which is the basis of today's preparation of the kava drink, involves crushing the roots using mortars and pestles.

The archeological evidence concerning kava is scarce. Samples of the domesticated species, dated to before 850 AD, have been found in some archeological sites in Remote Oceania, including the Vaito'otia site (Huahine, Society Islands; Sinoto, 1983, p. 59). Other indications, with more recent dates, have been obtained through the identification of kavalactones in archeological finds (Hocart, Fankhauser, & Buckle, 1993) and the observation in skeletons of a degeneration of the mandibular joint attributable to assiduous chewing of kava roots (Visser, 1994).

It has been suggested that a set of stone mortars and pestles endowed with characteristic ornamentations, of which the oldest are dated to 3400 BC, and which are widespread in New Guinea, were used for the preparation of the "ancestors' kava," because of a significant geographical correspondence between the spread of these finds and the geographical range of the wild species of kava (Ambrose, 1991).

Betel (*A. catechu*)

Betel consists of three ingredients: *Piper betle* L. leaf (*Piperaceae*), pieces of the nut of *A. catechu* L. (*Arecaceae*), and slaked lime. These three products are joined together in a bolus that is kept in the mouth, where the active principles of the two plant sources react with slaked lime in order to be absorbed through the buccal mucosa, synergistically producing a stimulating effect.

The use of betel is widespread in three continents: Asia, Oceania, and Africa. It spread to the latter of these during a relatively late period, perhaps around the 7th century AD, following the migration of Austronesian-speaking people that brought this habit with them (Zumbroich, 2007–2008, pp. 120–121).

There are several kinds of archeological evidence concerning the areca nut, but there are still no significant data specifically for *P. betle*. The most ancient finds, dated to the 8th millennium BC, are areca fragments excavated at the Spirit Cave (Thailand), which was inhabited by people belonging to the Hoabinhian Culture (Gorman, 1970). However, in Indochina, the tree is not present in the wild form, and botanical and linguistic data favor an origin of areca nut use in Malaysia (Rooney, 1993, p. 14); therefore, the origin of its use as a psychoactive is likely to precede this date.

A second type of evidence is based on the observation in skeletons of teeth with the typical coloration caused by the combined mastication of areca nut with slaked lime. The oldest find of this type is the skeleton of a man from the site of Duyong Cave (Palawan Island, Philippines), dating to 2600–2800 BC. Some shells that served as lime containers have been found next to this burial; a datum that appears to fix an *ante quem* date for the addition of slaked lime to areca (Fox, 1970).

Tea (*C. sinensis*)

The tea shrub – *C. sinensis* (L.) Kuntze (*Theaceae*) – is native to China. For some time, it was believed that tea cultivation's place of origin was to be found in the southern Chinese region of Yunnan (Berlie, 1995), but the oldest archeological data referring to this plant are instead found on the east coast of China. During archeological excavations of a Hemudu Culture site – a Neolithic population with matriarchal social connotations – in the Yueyao county, along the Zhejiang coastal region, a dozen tea roots came to light in an excellent state of conservation, arranged in what appears to have been the original cultivation position. Radiocarbon analyses dated the roots to 3526–3366 BC, and chemical analyses have revealed the presence of theanine, an amino acid typically synthesized in the roots of the tea plant, which is then transferred to its aerial parts (Nakamura, 2009).

Ephedra (*Ephedra* spp.)

Several Eurasian species of *Ephedra* (*Ephedraceae*) possess stimulating properties, due to the presence of the alkaloid ephedrine.

Many authors continue to report the case of the burial found in the Shanidar cave (northern Iraq) relating to a Neanderthal man dating back to 60,000 years ago, as the earliest documentation of the human relationship with ephedra. Around the skeleton, an unusual concentration of pollens of different plants was identified, including *Ephedra altissima* Desf.; a fact that led to the hypothesis that a bunch of flowers had been deposited on the tomb (Leroi-Gourhan, 1975). However, in 1999, Sommer interpreted this accumulation of pollens as the result of the activity of a small rodent, the Persian gerbil, which is known to accumulate large quantities of seeds and flowers in its burrows. During the excavations of the Shanidar cave, many burrows of this animal were encountered, and the polynimetric spectrum of these burrows was similar to that found around the burial studied earlier (Sommer, 1999). Verified its dubious validity, the finding of Shanidar has not been included in Table 1.

The oldest archeological findings are associated with the mummies of Ürümchi, in the Tarim basin (Sinkiang, China), dating back to 2000 BC. *Ephedra* twigs have been found above the inhumations or sewn between the fabrics that wrap the mummies. Most of these mummies belong to the physical Caucasoid group, a fact that confirms a European origin of this ancient population of Central Asia (Barber, 1999). In 36 graves of the Gumugou cemetery (Taklamakan desert, Tarim), dated to 1800 BC, small packets of *Ephedra* were found, invariably placed on the right side of the chest of each body (Xie, Yang, Wang, & Wang, 2013).

Indicating a European use of ephedra as a psychoactive, a concentration of ephedra pollen was identified at the bottom of some amphorae dated between the 3rd and the 2nd century BC and found in the pre-Roman village of Puntal dels Llops (Valencia, Spain). The amphorae came to light in the main residential structure of the town, where cult activities were carried out, suggesting a ritual use of this plant for its psychoactive properties (Dupré Ollivier, 1988, p. 78).

Hemp (*Cannabis* spp.)

Questions surrounding the origins of the human relationship with *Cannabis* continue to provoke much discord between scholars and for various reasons: from the still contested problem of speciation within the genus *Cannabis* (whether it is one, two, or three species); to the difficulty of distinguishing between paleobotanical finds of *Cannabis* and *Humulus* pollen (as both genera belong to the same family of the *Cannabaceae*); to the difficulty of distinguishing the archeological finds of hemp and linen fabrics. Another problem concerns the ascertaining of the use of cannabis, whether for psychoactive, medicinal, or manufacturing purposes.

A fact that now appears certain, as testified by numerous paleobotanical finds, is the presence of *Cannabis* in Europe from preglacial times, perhaps since the late Miocene. Another matter subject to modern revision concerns the origin of hemp cultivation, which would not have occurred during the Neolithic periods, as previously asserted by many researchers, but only starting from the Copper Age, then more widely in the Bronze Age (McPartland, Guy, & Hegman, 2018), while the Iron Age's Scythians would have introduced hemp cultivation to the European Celtic, Slavic, and Finno-Ugric cultures. Moreover, the hypothesis of a multilocation of the origin of the human relationship with this plant appears to be more and more plausible, there being at least one present in Europe and another in East Asia (Long, Wagner, Demske, Leipe, & Tarasov, 2017).

Despite the hypothesized late, post-Neolithic, advent of hemp cultivation, people began to interact with this plant in earlier times. The oldest evidence attesting this report is recognized by several authors in Japan, at the Okinoshima (Boso) site of the Jomon culture, where plant macrofossils, including fruits of *C. sativa*, have been identified adhering to fragments of pottery with a date of 8200 BC (Kudo et al., 2009). Although external contamination has been suspected for these archeological finds (Okazaki et al., 2011), the most recent revisions of hemp-related archeobotanical data favor the validity of this Japanese anthropic evidence (Long et al., 2017; McPartland & Hegman, 2017), and for this reason it has been included in Table 1.

Regarding the oldest human relationship with *Cannabis* in Europe, achenes of this plant have come to light at the Frumuşica site, Oneçti region (Romania), belonging to the Cucuteni B Neolithic culture, dated to the 7–6th millennium BC (Matasă, 1946, p. 39). An anthropic finding of achenes at the Thayngen-Weier site in Switzerland belongs to the same chronological horizon (Willerding, 1970).

Harmel (*P. harmala*)

The seeds of this Eurasian and North African plant (*P. harmala* L., *Zygophyllaceae*) contain the same compounds found in the ayahuasca vine (*Banisteriopsis caapi*) – harmine and harmaline – but in higher concentrations. Its identification with *haoma*, the drink of immortality of the Zoroastrian religion, has been suggested (Flattery & Schwartz, 1989).

The most ancient archeological finds date from the 5th millennium BC and come from Neolithic sites of the Caucasus (Merlin, 2003, p. 301). *Harmal* seeds have also come to light in a pre-Dynastic Egyptian site (Maadi, Cairo) dating back to 3700–3500 BC (Zeist & De Roller, 1993).

Regarding the iconographic aspects, it has been hypothesized that the representation of this plant can be seen among the findings of the ancient Mesopotamian Jiroft culture (Kerman, Iran), dated to the 3rd millennium BC. In the decorations of some chlorite vessels encountered in funerary contexts, a plant is frequently represented which Amigues (2009) identified as *P. harmala*.

Waterlilies (*Nymphaea* spp.)

Several species of water lilies (*Nymphaea* spp., *Nymphaeaceae*) are endowed with psychoactive compounds found in the petals and rhizomes. These psychoactive properties, which are due to the presence of aporphine alkaloids, were discovered by two great ancient cultures – the Egyptian and Mayan.

In ancient Egypt, the earliest remains of water lilies were found in the Neolithic Nabta Playa site, dating back to 6000 BC (Hather, 1995). The exact kind of causality of human interaction with this plant – whether for food or for psychoactive purposes – could not be determined, but since the psychoactive effects occur with the simple ingestion of the petals, this property will likely have been discovered concurrently with its use as a source of food. We are more certain of the use of the blue water lily – *Nymphaea nouchali* var. *caerulea* (Savigny) Verdc. – as a psychoactive plant during the Pharaonic periods, as expressed in iconography and hieroglyphic texts (Harer, 1985). Flowers of this plant have been found in abundance in the garlands and among the bandages of mummies of numerous pharaohs and court dignitaries (Germer, 1985, pp. 37–39).

Lettuce (*Lactuca* spp.)

The species of wild lettuce – of which the most common in the Mediterranean basin are *L. serriola* L. and *Lactuca virosa* L. (*Compositae*) – are endowed with psychoactive properties, specifically in the white latex that exudes profusely from the stem when it is cut. The fresh latex is toxic, but when it is dried it transforms into *lactucarium*, a narcotic-sedative medicine used until the 20th century in Europe as a substitute for opium. At higher doses, *lactucarium* yields more stimulating and visionary experiences, and at even higher doses it becomes toxic (Harlan, 1986). It has been speculated that the common lettuce of the vegetable garden – *L. sativa* L. – was created by selection from *L. serriola* by the ancient Egyptians (Lindquist, 1960).

Wild lettuce was widely depicted in ancient Egyptian art since Dynasty V, which began around 2500 BC (Keimer, 1924, p. 6); it became the plant attribute of the ithyphallic God Min (Defossez, 1985), and refers to the *L. serriola* species. In Egyptological studies, another species, *L. virosa*, is often indicated but this seems to be a case of mistaken identification, as this last species was not present in the Egyptian flora (Samorini, 2003–2004, p. 79).

As far as direct evidence is concerned, few remains are known; seeds of undetermined species of *Lactuca* have been found in Egyptian excavations, but are younger in age (Germer, 1985, p. 185). In the 7th century BC, sanctuary of the Goddess Hera in Samo (Greece), *L. serriola* seeds have come to light next to *P. somniferum* seeds, and the context leads to the hypothesis that both plants were used as psychoactive sources (Kučan, 1995, pp. 31–33).

Opium poppy (*P. somniferum*)

The opium poppy did not exist in nature and was created by human cultivation and selection of a wild species (Merlin, 1984, pp. 54–58). The most likely wild candidate is *P. setigerum* (*Papaveraceae*), and today most taxonomists recognize the existence of only one species, *P. somniferum* L., differentiated into the two subspecies *somniferum* Kadereit (the cultivated form) and *setigerum* (DC.) Corb. (the wild form; Hammer & Fritchs, 1977).

The opium poppy was considered to have originated in the Eastern regions of the Eurasian territories, but current scholars tend to put its origins during the 6th millennium BC in a region of the western Mediterranean.

The oldest opium poppy remains thus far have come from this region, including in Italy, from the pile-dwelling site of La Marmotta (Rome), dating back to 5600 BC. In this Neolithic site, intermediate forms between the wild and the cultivated poppy species have been found, which would testify in favor of this area of central Italy as the place of origin for the domestication of the opium poppy (Rottoli, 1993).

Large quantities of seeds and opium poppy capsules have come to light in the Neolithic sites of the Alpine Arc, dated to 4800–3200 BC. For example, more than 120,000 plant elements belonging to the *P. somniferum* cultivated subspecies came to light at the site of Schicht 3 (Switzerland), dated to 3200 BC (Jacomet, 2006).

In the Cueva de los Murcielagos (Córdoba, Spain), poppy remains were found dated to 5360 BC (González Urquijo et al., 2000). Other remains have come to light in several sites of the Linear Band Ceramic Neolithic culture, widespread in Central Europe, whose most ancient findings date back to 5200 BC (Schultze-Motel, 1979).

Tropane-containing solanaceous plants

Tropane *Solanaceae*, those producing the hallucinogenic tropane alkaloids (atropine, scopolamine, hyoscyamine, etc.), is widespread throughout the world. The archeological data for the *Mandragora*, *Datura*, *Hyoscyamus*, and *Atropa* genera are reported in this study.

*Mandrake (*Mandragora *spp.)*

Mandrake is strangely absent in the Eurasian archeological finds. The oldest record is located in Egypt. Mandrake did not belong to the Egyptian flora, and at the beginnings of Dynasty XVIII, it was imported from the regions of Palestine or Syria, and was cultivated in the gardens of the Pharaonic nobility (Bosse-Griffiths, 1983). *Mandragora* fruits have been identified in the floral garlands of the Tutankhamun mummy, and images of the plant are present in the paintings of Dynasty XVIII, dating back to 1400 BC (Germer, 1985). A recent phylogenetic analysis inside the genus *Mandragora* has evidenced a definitive distinction between the two species *Mandragora autumnalis* and *Mandragora officinarum*, and a possible ancient human assisted migration of this latter from Israel to Persia, giving form to the Asian species *Mandragora turcomanica* (Volis, Fogel, Tu, Sun, & Zaretsky, 2018).

*Jimsonweed (*Datura *spp.)*

This genus consists of about a dozen species spread on different continents. Although there has always been a general propensity of scholars to assert a long-standing presence of some species in Eurasia; Symon and Haegi (1991) proposed that no species of *Datura* was present in the Old World before Columbus, and this last thesis continues to meet agreement among scholars. One of the proofs given by Symon and Haegi is based on the consideration that only in the Americas, ants collect *Datura* seeds, evidencing an American origin of the relationship of ants with these plants. Indeed, observations of *Datura* seeds collected by ants are common in the European countries (Samorini, 2017c). Furthermore, some archeological findings, together with modern iconographic and ancient written sources studies, appear to contradict the hypothesis of a pre-Columbian the lack of presence of Daturas outside the Americas prior to modern contact (post 1500 AD).

A find of *D. stramonium* L. dated more than 3,000 years before Columbus appears to come from a Bronze Age site located at Prats (Pyrenees, Andorra). In a terracotta pot, eight seeds of stramonium and remains of the fruit that contained them were found. The radiocarbon dating was found to be 1700 BC (Yáñez, Burjachs i Casas, Juan i Tresserras, & Mestres, 2001–2002). The remains of *D. stramonium* also came to light in an ancient Bronze Age site (Pécs) in Hungary (Guerra Doce, 2006a, p. 294).

A species of *Datura* may be depicted in the headgear of Shiva's statuary from the 9th century AD, and both the iconography and the description of its effects would lead to a *Datura metel* L. identification (Geeta & Gharaibeh, 2007). Furthermore, several studies suggest evidence for the presence of Eurasian daturas in ancient literature (Scarborough, 2012; Siklós, 1994; Touwaide, 1998). All this leads to the pre-Columbian presence of *D. stramonium* in Europe and, with less certainty, *D. metel* in Asia.

*Henbane (*Hyoscyamus *spp.)*

Henbane species are widespread in Eurasia and North Africa. The most ancient findings belong to Egypt, where in the Farafra oasis – a site of the Middle Neolithic dating back to the 7–6th millennium BC – some seeds of an indeterminate species of *Hyoscyamus* have come to light (Fahmy, 2001).

Since ancient times, the practice of adding henbane seeds to beer to strengthen its effects was widespread in Europe. The oldest evidence is dated to 2340 BC and concerns a pottery offering deposited in a sepulchral cave of Calvari d'Amposta (Tarragona, Spain), and in which the presence of beer and hyoscyamine, one of the alkaloids present in henbane, was determined (Guerra Doce, 2006b). In more recent times, at the Celtic site of Hochdorf (Stuttgart, Germany), dated to 600–400 BC, remains of a brewing of malt have been discovered, and among the remains of barley, 15 seeds of black henbane (*H. niger* L.) were present (Stika, 1996).

Deadly nightshade (A. belladonna)

For deadly nightshade (*A. belladonna* L.), only a single documented piece of evidence is known. However, it is significant both for its antiquity and for the context of the discovery. In the Măgura Gorgana site, located along the Romanian side of the Danube and dated to 4500 BC, a village consisting of a hundred houses and a necropolis with a hundred graves, belonging to the Neolithic Gumelnita culture, have been excavated. Thousands of nightshade seeds have been found in several parts of the housing area; a finding that attests an intensive use of this plant, probably for religious purposes (Toderaş, Hansen, Reingruber, & Wunderlich, 2009).

Fungi

The archeology of psychoactive mushrooms tells us very little as far as direct evidence is concerned, due to the rapid deterioration of fungal tissue. Those prehistoric people integrated mushrooms into their diet would seem to have been recently confirmed by the discovery of microscopic fragments of a superior mushroom – perhaps a *Boletaceae* species – in the dental calculus of a woman who lived 18,700 years ago, found in the Cave El Mirón, in northern Spain (Power, Salazar-García, Straus, Gonzalez Morales, & Henry, 2015). Two main pharmacological classes of hallucinogenic mushrooms are recognized: the small group of isoxazole mushrooms, mainly pertaining to the genus *Amanita* (*Amanitaceae*), and the larger group of psilocybin mushrooms, mainly of the *Psilocybe*, *Panaeolus*, and *Copelandia* genera (Samorini, 2001).

Psilocybian mushrooms

The oldest archeological documentation attesting to the use of psychoactive mushrooms appears to have been identified in a geographical area where today it is difficult to find mushrooms: the Sahara Desert. These depictions of mushrooms are present among the prehistoric paintings belonging to the "Round Heads" pictorial phase, dated between 6000 and 4500 BC in the Tassili n'Ajjer (Algeria) and in other mountainous areas of the Sahara. The compelling evidence for an entheogenic interpretation of the paintings is in the human figures holding mushrooms in their hands, from which dotted lines extend to the head. This detail would seem to indicate that the artist was intending to convey a statement regarding the psychoactive effects that the fungus has on the human mind. Other large anthropomorphic figures, probably of divine nature, are entirely surrounded by mushrooms (Samorini, 1992). Another ancient iconographic documentation concerning psilocybian mushrooms has been proposed for a rock-painting in the Selva Pascuala site (Spain), dated to around 4000 BC (Akers, Ruiz, Piper, & Ruck, 2011).

Fly-agaric (A. muscaria)

On the rocks of central and northern Asia, depictions of anthropomorphs characterized by heads in the shape of a mushroom hat, or bearing a showy mushroom-shaped object above the head, are engraved. The scholars call these figures "mushroom-men," and the areas where their presence is most frequent are in Tuva, along the Yenisei, Altai, Siberia, and the Kazakhstan rivers. They are dated to 1500–1000 BC (Molodin & Cheremisin, 1999). Typically depicted in a position with their legs bent, as if they were dancing or jumping, in many cases the "mushroom-men" are endowed with a round protuberance at the height of the pelvis. This object would correspond to the "medicine bag" of leather containing the *mukhomor* (the Russian term for fly-agaric), which is kept by the shamans, an object that was actually reported in the ethnographic descriptions of modern Siberian shamans (Dikov, 1971, p. 118).

A second iconographic scheme is observed in the prehistoric art of Siberia and concerns human figures who have a real mushroom on their heads. One of the most studied cases concerns the rock art of the Pegtymel river, the work of ancient Chukchi populations of the local Bronze Age, with an average dating of 1500 BC (Dikov, 1971).

*Ergot (*Claviceps *spp.)*

Ergot (*Claviceps* spp., *Clavicipitaceae*) is a parasitic lower fungus of many wild grasses and cereals. Its sclerotia are a crucible of alkaloids, partly toxic, and partly psychoactive, many endowed with important medicinal properties. It was from the ergot alkaloids, in 1938, that the Swiss chemist Albert Hofmann synthesized lysergic acid diethylamide. Given its potential as a psychoactive source, ergot has been suggested as the key ingredient of *kykeon*, the visionary drink of the Eleusinian Mysteries of ancient Greece (Wasson, Hofmann, & Ruck, 1978), as well as the cause of the disease called St. Anthony's Fire (ergot poisoning).

As a parasite of grasses, ergot has been present in the anthropic environment ever since humans began to be interested in wild grasses, placing them in cultivation and transforming them by selection into cereals – barley, rye, wheat, etc. The ingestion of ergot sclerotia, which remain mixed among cereal grains, causes a state known as ergotism, which can occur with different symptoms, depending on the proportions of the most toxic or most psychoactive alkaloids (Bové, 1970).

Archeological finds have highlighted the presence of ergot in anthropic sites starting from at least 18,000 years ago in the Middle East and 5,400 years ago in Europe (Aaronson, 1989), although it is not possible to determine whether they are anthropic (intentional) or environmental (accidental) presences, and for this reason, these data are not included in Table 1.

A surprising fact regards the discovery of fragments of *Claviceps purpurea* (Fr.) Tul. sclerotia in a temple of the 4th–2nd century BC dedicated to the two Eleusinian Goddesses, Demeter and Persephone, excavated at the Mas Castellar site (Girona, Spain). Ergot sclerotia fragments were found inside a vase along with remains of beer and yeast, and within the dental calculus in a jaw of a 25-year-old man, providing evidence of their being chewed (Juan-Stresserras, 2002). This finding seems to strongly support the hypothesis of ergot as an ingredient of the Eleusinian *kykeon*.

Boophone disticha

In Southern Africa, the hallucinogenic bulb of *B. disticha* (L.f.) herb (*Amaryllidaceae*) is employed by different ethnic groups as a visionary, divinatory, and initiatory agent (Sobiecki, 2002, p. 3). Archeological data attest to a human relationship with this plant of at least 4,000 years. Regarding the material findings, a mummified body found in a rock shelter of Kouga Mountains, in the South African Province of Eastern Cape, dated to 2,000 years ago, was covered with a thick layer of *B. disticha* leaves (Steyn, Binneman, & Loots, 2007). Archeologists tend to interpret the presence of these leaves solely on the basis of their antiseptic properties (Binneman, 1998), but it appears reductive to ignore the vast traditional use of this plant not only as a medicinal product, but also as a psychoactive. Remains of this plant have come to light in other subrock shelters: in the Kleinpoort Shelter and in the Havens cave of Valle Cambria, both located in the Cape Province and dating back respectively to about 2,000 years ago and 700–800 AD. In the Melkhoutboom cave of the Eastern Cape, findings of the plant have been dated to 900 BC (Binneman, 1998; Lombard, Wadley, & Deacon, 2012). *Boophone* has been identified among the plants painted in the prehistoric rock art of Lesotho, in the Thaba Bosio National Monument, and among the rock paintings of the Zastron area in the Free State, with dates starting from the 2nd millennium BC (Mitchell & Hudson, 2004, pp. 49–51).

NEW WORLD EVIDENCE

Alcohol sources

Chicha (from Z. maydis*)*

Chicha is mainly prepared from corn, and the archeological data similarly support a probable precedence of the use of corn as a source of alcoholic beverage compared to its use as a food source (Jennings, 2005). The first data of corn cultivation come from 4200 BC in the Mexico region, while its role in the diet as food became a priority only after 1000 BC (Piperno, Ranere, & Hansell, 2000). Consequently, we can hypothetically place this archaic date as the oldest for the production of *chichi*, although the oldest direct evidence to date identified is at Lake Titicaca (Bolivia), dating to 800–250 BC (Logan, Hastorf, & Pearsall, 2012). Later, more certain date has been chosen for Table 1.

Mescalbean (*S. secundiflora*)

The natives of the Great Plains of North America held elaborate rites that included ingesting the seeds of the leguminous plant *S. secundiflora* (Ortega) DC., known as *mescalbean* or *frijol rojo*. This cult has long since disappeared and was replaced by the peyote cult (Campbell, 1958).

Archeological data from Texas and New Mexico have outlined a relationship of mescalbean with people from at least the middle of the 9th millennium BC, with the oldest date from 8440 BC (Adovasio & Fry, 1976). The most significant find came to light in a Cave of Horseshoe Ranch, located near Comstock, where a "medicine bag" was found, filled with various objects used for magical and ritual purposes, along with mescalbean seeds and seeds of *Ungnadia speciosa* Endl. (*Sapindaceae*) (Merrill, 1977). The latter species could possess psychoactive properties, although the biochemical data indicate that it would be toxic. In the archeological finds, it is invariably found associated with mescalbean, and in the most ancient contexts, the majority of the seeds are *Ungnadia*, while in the following periods, *Sophora* prevails. In addition, in Mexico, in caves of the Cuatro Cienegas Basin (Coahuila), mescalbeans were found, again together with *Ungnadia* seeds. The oldest dates reach 7500 BC (Taylor, 1956).

Peyote (*L. williamsii*)

Archeological data have highlighted the antiquity of the human relationship with this hallucinogenic cactus – *L. williamsii* (Lem. ex Salm-Dyck) J.M. Coult., *Cactaceae* – of at least 5,700 years. Peyote samples were found in several prehistoric sites in Texas and Northern Mexico. The most studied case concerns the "buttons" of peyote that came to light in the Shumla Cave 5 of the Rio Grande, located at the confluence with the Pecos river. Chemical analyses performed on two of these buttons have shown that they still contained mescaline in a concentration of 2% (El-Sheedi, De Smet, Beck, Possnert, & Bruhn, 2005). After a more careful analysis, it has been determined that these plant findings, previously classified as peyote buttons, were in reality aggregates of ground cactus along with other unidentified plants, which were given a similar rounded and flattened shape and size to those of real peyote buttons. Chronological analyses performed on three of these conglomerates have enabled a dating to the Eagle Nest subperiod of the Middle Archaic Period of the Texan tradition, with absolute ages of around 3200 BC (Terry, Steelman, Guilderson, Dering, & Rowe, 2005).

The visions achieved by the ingestion of peyote may have influenced the Texas and California prehistoric cave paintings, which may depict themes related to the symbolic universe of the peyote. This art is dated between 2200 and 750 BC (Boyd & Dering, 1996).

Tobacco (*Nicotiana* spp.)

The oldest archeological evidences concerning tobacco dates back to 1500 BC, located in North America sites and concern the species *N. quadrivalvis* Push. (*Solanaceae*). The use of this species was later abandoned with the arrival of *Nicotiana rustica* L. from South America (Pauketat et al., 2002).

As direct evidence, organic tissue analysis of South American mummies shows the presence of nicotine and its metabolite cotinine (Brown, 2012, p. 114). Nicotine was also found in the hair of 62% of the sample of mummies analyzed that had come from San Pedro de Atacama (Chile) and were dated between 100 BC and 1450 AD (Echeverría & Niemeyer, 2013). Cartmell, Springfield, and Weems (2001) studied the presence of nicotine and cotinine on a sample of 144 South American mummies of different archeological origins, with 97% positive results. In a couple of children younger than 2 years, a concentration of these compounds greater than in children aged 3–14 years were found. This was explained by the transfer of nicotine via transplacental passage and via breast milk. In Chile, at the Las Morena 1 site and dated after 500 BC, one hundred seeds of the species *Nicotiana corymbosa* Remy have been identified (Planella, Collao-Alvarado, Niemeyer, & Belmar, 2012).

Cocoa (*T. cacao*)

The cocoa drink, obtained from the fruits of the tree *T. cacao* L. (*Malvaceae*), was prepared with different techniques. The most primitive one comprised alcoholic fermented drinks made from the fruit pulp, with alcohol content that reached 5%–7%. Only later did attention focus on the large seeds, which contain the active ingredients theobromine, caffeine, and theophylline (Powis, Valdez, Hester, Hurst, & Tarka, 2002).

Regarding the place of origin of the cocoa tree and the genesis of its cultivation and domestication, contrasting theses have been presented, apparently solved only recently by specific genetic studies. For some decades, the most followed thesis postulated two cocoa subspecies that developed separately in North and South America, and that the wild plants found in the Lacandonian forest of southern Mexico could have been the ancestors of the domesticated cocoa as we know it today (Cuatrecasas, 1964). However, genetic studies (Matamayor et al., 2002) have shown that the trees of the Lacandonian forest are not wild, but represent made-wild forms of ancient Mayan crops, and have confirmed an Amazonian and Orinoco basin origin of the cocoa plant, this being the only geographic area where wild trees are present (Barrau, 1979).

Cocoa seeds have come to light at various Mayan sites. One of the oldest, 400 BC–250 AD, is the Cuello site, in Belize (Hammond & Miksicek, 1981). Much older dates have been provided by chemical analyses of pottery residues, aimed at identifying caffeine alkaloids. In the Paso de la Amada site, in the southern Mexican region of the Pacific Coast, theobromine was found in a clay pot dated from 1900 to 1500 BC and belonging to the pre-Olmec phase Mokaya Barra (Powis et al., 2008). Other findings concern ceramics from San Lorenzo (Vera Cruz), of which the oldest are dated to 1800 BC, and which were found to be positive for theobromine (Powis, Cyphers, Gaikwad, Grivetti, & Cheong, 2011). Having verified that the cocoa tree is native to South America and was brought to Mexico by man, the original date of the human relationship with this plant is consequently older than 1900 BC.

Convolvulaceae

Archeological finds concerning the psychoactive species of *Convolvulaceae* – *Ipomoea*, *Turbina*, *Argyreia*, etc. – are quite rare, and frequently the exact species is not specified in the *Ipomoea* findings; this deficiency does not allow identification of the presence of a psychoactive species, since only one group of *Ipomoea* taxa produces psychoactive seeds, whose active ingredients are lysergic acid derivates.

Among the North America findings, *Ipomoea* seeds were found in two wells of the Spoonbill site (Texas) belonging to the Ancient Caddo period (800–1300 AD). The context of the finding suggested these seeds had been prepared for some purpose, possibly for their psychoactive properties (Crane, 1982, p. 86). Depictions of the *dondiego*, the *ololiuhqui* of the ancient Aztecs – *T. corymbosa* (L.) Raf. – have been identified in the frescoes of Teotihuacan (Mexico), dating back to the 7th or 8th century AD (Furst, 1974).

Waterlilies (*Nymphaea* spp.)

The ancient Maya employed *Nymphaea ampla* (Salisb.) DC. as a psychoactive (Emboden, 1983). It is extensively represented in iconography since the dawn of this Mesoamerican culture, starting from at least 750 BC (McDonald & Stross, 2012). Recently, the identification of the Maya Cosmic Tree, widely diffused in the Mayan art, has been revised. Generally identified with the kakop tree (*Ceiba pentandra*) or with the corn (*Z. maydis*), McDonald (2016) suggested it has to be identified with *N. ampla*.

Mushrooms

As far as the Americas are concerned, the mushroom stones of the Mayan culture must be mentioned, the oldest of which date back to 1000 BC (Mayer, 1977). It is not clear if these effigies refer specifically to the psilocybian mushrooms and/or to fly-agaric, and the natural presence and ethnographic and/or linguistic data of their use in those regions have been evidenced (Wasson, 1980).

One of the most sensational discoveries occurred at the Kaminaljuyu site (Guatemala): nine small mushroom-shaped stones were found inside a hiding place, found together with nine *metates* (millstones) and nine *mano* (pestles). It would seem that each stone mushroom was associated with a pair of *metate* and *mano*. This curious set of mushroom stones belongs to the Verbena Phase of the Mayan culture and is dated to around 1000 BC. The number nine has been associated with the nine night divinities of the Maya pantheon (Borhegyi, 1961).

In South America, to date, we know only one case of iconographic evidence: the so-called Darien's pectorals (Torres & Repke, 2006). Diffused mainly in Colombia, Panama, and Costa Rica, the classic form of these gold artifacts shows an anthropomorphic structure with zoomorphic features, endowed with wing-like side ornaments, and bearing on their top two hemispherical protuberances. The most ancient finds date back to the 1st century BC (Falchetti, 2008). Several authors have interpreted the hemispherical protuberances, almost always supported by a stem, as depictions of hallucinogenic mushrooms (Schultes, 1979).

Coca (*Erythroxylum* spp.)

Two species of coca are used in South America: *Erythroxylum coca* Lam. (with the two varieties *coca* and *ipadu*) and *Erythroxylum novogranatense* (D. Morris) Hieron (with the two varieties *novogranatense* and *truxillense*) (*Erythroxylaceae*). It has been hypothesized that *E. coca* var. *coca* is the wild species, from which the other varieties originated through cultivation and selection (Plowman, 1986, p. 13).

Archeological finds attesting to the use of coca leaves among the South American populations are numerous and of various types, including the analysis of biological tissues aimed at identifying cocaine and its metabolites – mainly benzoylecgonine (Cartmell et al., 1994) and cocaethylene (Wilson et al., 2013), the latter being produced in the context of concomitant intake of alcohol and cocaine, and the observation of particular bone and dental pathologies associated with the assiduous consumption of coca leaves in combination with alkaline sources (Indriati & Buikstra, 2001).

The oldest direct evidence came to light in an anthropic context, recorded in the Nanchoc Valley in northern Peru, where coca leaves have been found on the floors of a house, and dated to the end of the Las Pircas phase 6000–5800 BC. In the same excavation context, spheroidal balls of compressed slaked lime were found, which can be associated with the consumption of coca leaves, and this should be considered a confirmation that since that period coca was taken together with slaked lime (Dillehay, Rossen, Ungent, & Karathanasis, 2010).

As for iconographic evidence, images of *coqueros* – individuals who highlight the swelling induced by the introduction of coca bole on a cheek – are present in several pre-Inca artistic productions, including Nasca, Moche, Quimbaya; the oldest ones appear among the artifacts of the Valdivia Culture, in Ecuador, with a date of around 2000 BC (Lathrap, Collier, & Chandra, 1975).

Jimsonweed (*Datura* spp.)

Concerning the American archeological findings of *Datura* spp., *D. stramonium* charred seeds were found in vases and funeral urns of the El Mercurio site, belonging to the Llolleo culture of central Chile, dating back to 300–1000 AD. The datura seeds were found in association with children's graves (Planella, Peña, Falabella, & McRostie, 2005–2006). In addition, in some pipes from the same Llolleo culture, findings of *D. stramonium* have been identified (Planella et al., 2018). These data are the most ancient in the Americas. The first evidences of *Datura* in the North American archeology date back to the beginnings of the II millennium AD, and are localized in the Pueblo areas of New Mexico and Arizona (Yarnell, 1959).

Hallucinogenic snuffs (*Anadenanthera* spp.)

The practice of inhaling psychoactive snuff powders was widespread in Central and South America and diffused to the Caribbean where it played an important role in ritual activities. In addition to tobacco, hallucinogenic powders are today used in various regions, mainly obtained from the seeds of *Anadenanthera* spp., large trees of the *Leguminosae* family, or from the bark of the species of *Virola*, trees of the *Myristicaceae* family. The powders obtained from these trees contain hallucinogenic tryptamines.

Despite the widespread practice of inhaling the powders of *Anadenanthera* seeds, the most ancient finding, dated to 2130 BC, concerns the practice of smoking these seeds, and is located in the Inca Cueva site, in the Puna de Jujuy, in the northernmost part of Argentina. Leguminous remains have been recognized in two pipes, including *Anadenanthera colubrina* seeds, and chemical analyses have shown the presence of tryptamines (Fernández Distel, 1980, p. 65).

For the practice of inhalation, the most ancient findings concern paraphernalia of use, that is, snuff-trays and inhalation tubes, dated to 1200 BC and located at the Huaca Prieta site, along the central Peruvian coast. In the valley of Asia, located in the same geographic area, an even greater number of inhalation implements of the same period was found, including a pumpkin containing a pulverized mixture of black seeds, most probably *Anadenanthera* seeds (*cebil*) (Torres & Repke, 2006, p. 32).

Although the archeological record is mainly spread along the Andes and neighboring regions, there is a general tendency to see the origins of the inhalation practice in the northern Amazon basin. The hypothesis of a cultural movement from the lowlands to the highlands seems corroborated by various archeological, ethnographic, and linguistic evidence, and reflects the more general view of ancient tropical forest cultures existing prior to those of the central Andes. A decisive confirmation appears from the adoption of the jaguar – a feline of the tropical lowlands – as an animal widely represented in Andean symbology and iconography by the Chavín, Tiwanaku, and other ancient pre-Columbian cultures of the highlands, following religious-shamanic influences of populations of the Amazon forests (Zerries, 1985). The fact that the most ancient finds were found in the highlands and not in the Amazon basin could be explained by the more rapid decomposition in the forest of snuff paraphernalia, since even today they are mostly made of plant material.

In many cases, the geographic range of snuff paraphernalia does not match the diffusion of the plant source, in particular *cebil* – *A. colubrina* (Vell.) Brenan var. *cebil* (Griseb) Altschul – as in the case of San Pedro de Atacama in Chile and more generally the Andean area; this highlights a distribution system, of a commercial or exchange type, that supplied regions far from the area of the drug's presence (Zelada & Capriles, 2004). The iconographic evidence is found in depictions of *Anadenanthera* trees and pods that have been identified in ceramics of different cultures of the 1st millennium AD, including Tiwanaku (Berenguer, 2001), Moche (Furst, 1974, pp. 84–85), Wari (Knobloch, 2000), and Aguada (Marconetto, 2015).

Ilex spp.

Some species of the genus *Ilex* (*Aquifoliaceae*) produce caffeine alkaloids; the most powerful are found in the Americas. The archeological data for guayusa, mate, and black drink are reported in the following.

Guayusa (I. guayusa Loes)

In the Niño Korin site (La Paz, Bolivia), the tomb of a probable medicine–man has been excavated, with a rich set of instruments and plants related to his profession, including some bunches of guayusa leaves. The inhumation belongs to the cultural phase Classic Tiahuanaco (Wassén, 1972). The analysis of *Guayusa* leaves, dated to 375 AD, highlighted caffeine as still present (Holmstedt & Lindgren, 1972).

*Mate (*I. paraguariensis *A.St.-Hil)*

In a pipe of the La Puntilla site (Catamarca, Argentina), dated to the Lower Formative Period (650 BC–500 AD), microscopic fragments of *I. paraguariensis* were identified, together with *Nicotiana* and *E. coca*. The intake by aspiration of mate is reported in modern ethnographic literature, for example, among the Tehuelches of Patagonia (Capparelli, Pochettino, Andreoni, & Iturriza, 2006).

*Black drink (*I. vomitoria *Aiton)*

This species was used by the North American southeast natives for the preparation of a drink – called Black Drink – utilized ritually as a stimulant and emetic. Its leaves contain low amounts of caffeine and theobromine, but not theophylline. In the pre-Hispanic Cahokia site (IL, USA), whose phase of the greatest development is dated between 1050 and 1250 AD, biochemical analyses of the residues of some glasses have highlighted the presence of caffeine and theobromine in a ratio corresponding to that present in *I. vomitoria*. Cahokia is more than 500 km away from the natural range of this plant, and this has led to the hypothesis of its long-distance trade or local cultivation (Crown et al., 2012).

San Pedro (*Trichocereus* spp.)

The term San Pedro refers to two mescaline-bearing cacti, which have suffered a difficult taxonomic remodelling in recent decades, and currently some authors places them both as belonging to the species *Trichocereus macrogonus* (Salm-Dyck) Riccob. (*Cactaceae*), one as subsp. *pachanoi*, called by the natives "San Pedro legitimate," and the other as subsp. *peruvianus*, known as "San Pedro cimarrón," where *cimarrón* means "wild" (Lodé, 2015). The archeological record has shown a human relationship with San Pedro, including both *pachanoi* and *peruvianus*, which is at least 10,000 years old, a fact that, for now, makes San Pedro the most ancient psychoactive from an American source.

Regarding material remains, the oldest find was located in the Cueva del Guitarrero, in the Peruvian department of Ancash. In this cave, inhabited continuously since 8600 BC, a high concentration of pollen of *T. peruvianus* has been detected from the oldest phase of human occupation, as well as some fragments of cacti, which would testify the intentional introduction of this plant inside the cave (Lynch, 1980, p. 101). The dates of these findings have recently been reconfirmed by Lynch (2013), who however did not understand the ethnobotanical importance, since he did not associate *T. peruvianus* to San Pedro, and it was only the study by Feldman Gracia (2006) that led to a more complete evaluation of this discovery.

Regarding iconographic documentation, the most ancient finds would appear to be those of the Cupisnique culture, where the cactus is associated with felines or snakes. These findings seem to belong to the phase of the Middle Formative, dated between 900 and 400 BC (Sharon, 2001). The most famous iconographic find, the so-called "San Pedro-bearing stele," in Chavín de Huantar, has been dated to 750 BC. The cactus is depicted in other lithic reliefs of the same site (Feldman Gracia, 2006, p. 33), including a fragment of pottery, dated to 500 BC (Mesía, 2014, pp. 328–329). Depictions of San Pedro also appear in the exhibits of the Salinar, Nazca, Moche, Lambayeque, Chimú, Wari, Inca (Sharon, 2001), and perhaps Tiwanaku (Mulvany de Peñaloza, 1994) cultures.

DISCUSSION

Table 1 lists the earliest known dates of the relationship of *H. sapiens* with the main psychoactive plant sources. These dates are not to be understood as the most ancient ones; they refer to those determined thus far by archeological evidence, direct or indirect, and several of these are likely to be modified back in time with future finds.

For some psychoactive sources, there would appear evident a discrepancy between the oldest dates of archeological finds and the probably much older dates concerning the origin of their human use. This is the case, for example, of psychoactive mushrooms, in particular fly-agaric, a widespread showy mushroom for which it is plausible to suspect a very ancient relationship with *H. sapiens* – if not with preceding *Homo* species; eventually, what was initially an accidental or incidential use subsequently became an intentional relationship.

Despite these limitations due to archeological gaps, Table 1 indicates with a degree of certainty a general plant drug use already attested during the Neolithic (for the Old World, around 11000 BC) and the pre-Formative (for the New World, around 8000 BC) periods. It is my opinion that, with the current state of our knowledge, and given the difficulties of identifying the purpose and kind of use of psychoactive sources for many archeological finds, it is not possible to reach further certain conclusions.

Several psychoactive sources continue to be "silent" in the archeological excavations. This may be due to a lack of archeological findings, but in some cases, the reason may lie in their recent discovery – as could have been the case for ayahuasca (Samorini, 2016a). Specifically, to date, it has not been possible to identify any credible archeological evidence for the following psychoactive plants: coffee (*Coffea arabica*), kratom (*Mitragyna speciosa*), pituri (*Duboisia hopwoodii*), betel (*P. betle*), kat (*Catha edulis*), iboga (*Tabernanthe iboga*), *Salvia divinorum*, ayahuasca (*B. caapi*), *Psychotria viridis*, *Virola* spp., jurema (*Mimosa* spp.), and guarana (*Paullinia cupana*).

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