Journal of Forensic and Legal Medicine 34 (2015) 73–80

Contents lists available at ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Original communication

# Light microscopy can reveal the consumption of a mixture of psychotropic plant and fungal material in suspicious death

Patricia E.J. Wiltshire [a, b, *], David L. Hawksworth [b, c, d], Kevin J. Edwards [a, e]

[a] Department of Geography and Environment, School of Geosciences, University of Aberdeen, Elphinstone Road, Aberdeen AB24 3UF, UK
[b] Mycology Section, Royal Botanic Gardens, Kew, Surrey TW9 3DS, UK
[c] Departamento de Biología Vegetal II, Facultad de Farmacia, Universidad Complutense de Madrid, Plaza Ramón y Cajal, Madrid 28040, Spain
[d] Department of Life Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK
[e] Department of Archaeology, School of Geosciences, University of Aberdeen, Elphinstone Road, Aberdeen AB24 3UF, UK

ARTICLE INFO

*Article history:*
Received 28 January 2015
Received in revised form
24 May 2015
Accepted 25 May 2015
Available online 4 June 2015

*Keywords:*
Ayahuasca
*Cannabis*
*Papaver*
*Psilocybe*
Palynology
Mycology

ABSTRACT

Light microscopical examination of plant and fungal remains in the *post mortem* gut may be capable of demonstrating the ingestion of unexpected natural psychotropic materials. This is demonstrated here in a case in which a 'shaman' was accused of causing the death of a young man. The deceased had participated in a ceremony which involved the drinking of ayahuasca in order to induce a psychotropic experience. Ayahuasca is an infusion of *Banisteriopsis caapi* (ayahuasca vine), which produces a monoamine oxidase inhibitor, and one or more additional tropical plants, generally *Psychotria viridis* (chacruna) which produces dimethyltryptamine (DMT). The monoamine oxidase inhibitor prevents DMT from being broken down in the gut, so enabling its passage into the bloodstream and across the blood/brain barrier. Toxicological tests for DMT demonstrated the presence of this compound in the body. The deceased was reported to be in the habit of using *Psilocybe semilanceata* (liberty cap). This fungus (popularly called magic mushroom) contains psilocybin which is hydrolysed in the gut to psilocin; this compound mimics a serotonin uptake inhibitor, and also invokes psychotropic experiences. Microscopical examination established that the ileum and colon contained spores of *Psilocybe* and, in addition, pollen of *Cannabis sativa* and seeds of *Papaver* cf. *somniferum* (opium poppy). Both the plant species yield psychotropic substances. Palynological and mycological analysis of containers from the deceased person's dwelling also yielded abundant trace evidence of pertinent pollen and spores. The police had requested analysis for DMT but there was no screening for other psychotropic substances. Investigators were surprised that a mixture of hallucinogenic materials had been consumed by the deceased. The charge was modified from manslaughter to possession of a 'Class A' drug as the deceased had been consuming psychotropic substances not administered by the 'shaman'. Where death involving drugs from plants or fungi is suspected, microscopical examination of samples from the gut can provide a rapid and effective method for assessing, in a temporal context, the presence of ingested materials that may not have been previously suspected. The example presented here also demonstrates the need for caution in interpreting toxicological results where screening for unusual compounds has been limited.


## 1. Introduction

In cases of suspicious death by poisoning, the presence of one or more toxic substances is tested for by various techniques of chemical analysis of body fluids and other material from the corpse. Initial screening is usually limited to the most commonly-encountered toxins, and the library of reference samples to which the toxicologist has access. Plants and fungi produce a vast array of potentially toxic compounds, and in the absence of special intelligence, the process of identification of specific substances could be prolonged and costly. The light microscope is rarely used where poisoning is involved, but in the case of ingested material, gut contents and faeces can be examined directly, and plant and fungal material can be identified, often to species. This is illustrated here by the death of a healthy young man in south-west England in 2008, where microscopical analysis of gut contents yielded information that might otherwise have been missed; the findings had implications for

* Corresponding author. Department of Geography and Environment, School of Geosciences, University of Aberdeen, Elphinstone Road, Aberdeen AB24 3UF, UK. Tel./fax: +44 1372 272087.
*E-mail address:* patricia.wiltshire1@btinternet.com (P.E.J. Wiltshire).

http://dx.doi.org/10.1016/j.jflm.2015.05.010
1752-928X/

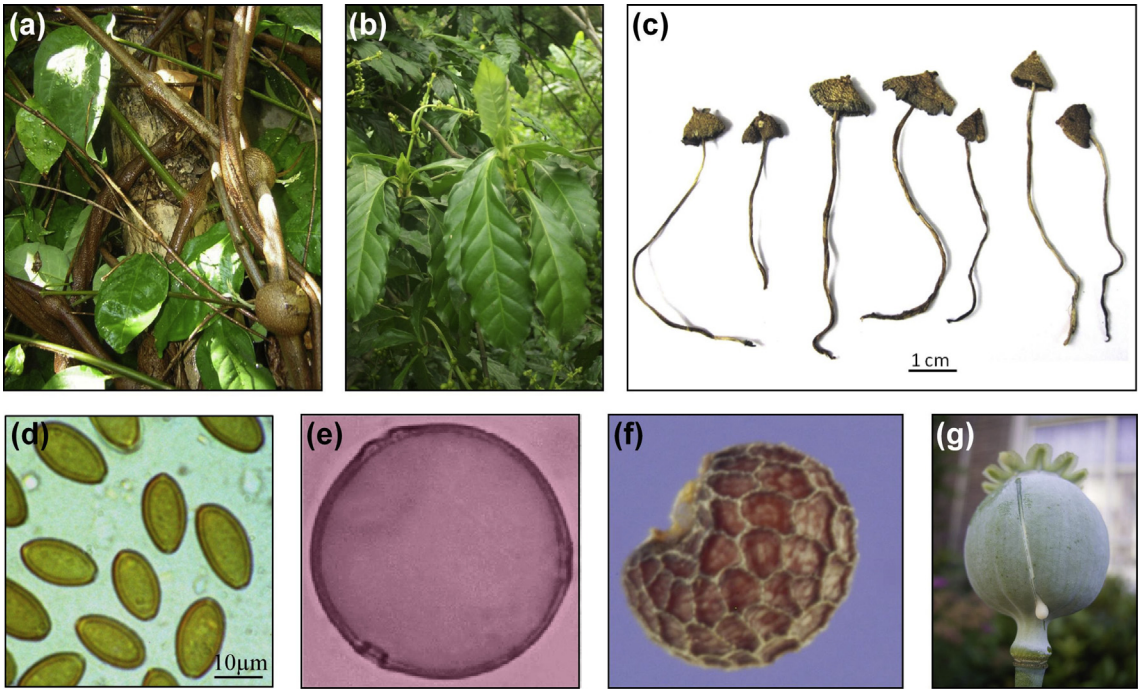


**Fig. 1.** (a) *Banisteriopsis caapi* (part of climbing stem with leaves; both are used to obtain active substances); (b) *Psychotria viridis* (part of plant showing stem, leaves, flowers, and unripe fruit); (c) *Psilocybe semilanceata* sporophores; (d) *Psilocybe semilanceata* spores; (e) *Cannabis sativa* pollen grain (19 μm in diameter); (f) *Papaver somniferum* seed (longest axis ~0.7 mm); (g) *Papaver somniferum* fruit (capsule): latex-containing opiates oozes from a cut. (a) Courtesy of Rafael Guimarães dos Santos, PhD; (b), (f), and (g) courtesy of Wikipedia Commons; (c), (d), and (e) photographs obtained from reference collections.

criminal charges and sentencing of a defendant. This approach to the detection of psychotropic substances throughout the length of the gut of a corpse, and items associated with the deceased, represents a new application of botany, palynology (the study of palynomorphs, i.e. pollen, many kinds of spore, and other microscopic entities), and mycology (the study of fungi). They were applied to the identification of a fungal sporophore (spore-bearing body), fungal spores, pollen grains, and seeds, in a variety of containers, as well as in the deceased man's gut. The disciplines provide a powerful approach in forensic investigation[1] and, in this case, provided intelligence which affected the final court case and its outcome.

## 2. Background

### 2.1. Psychotropic substances

Plants and fungi have been exploited for their psychotropic effects[1] since prehistoric times. A shaman, witch doctor, priest, or 'wise elder' would usually be responsible for dispensing and supervising their consumption, and this tradition continues today. The tropical rainforest has a species-rich and highly diverse flora, with many plant families yielding arrays of complex compounds possessing medicinal and/or psychotropic properties (e.g. mescaline, cardiac glycosides, ergot alkaloids, morphine, tryptamines, cocaine, caffeine, coumarins).[2] Many of the substances provide feelings of well-being and euphoria, and these may contribute to their therapeutic value,[3] while others elicit religious and hallucinogenic experiences, and may have played a role in human history.[4] The tropics are the main sources of psychotropic plants and fungi, but some occur naturally and are imported into, or cultivated in, temperate regions where they are used as 'recreational' drugs.

South American tribes have long been combining infusions of one or more species (or varieties of species) for healing and for inducing hallucinations and religious experiences. They also have extensive knowledge of individual plant species which are used for particular purposes. Depending on the recipe, stem, bark, and leaves of the required plants are cut into appropriate pieces and steeped in boiling water for various lengths of time. The resulting infusions, containing medicinal and/or psychotropic substances, are termed 'ayahuasca'. At least 44 families, 87 genera, more than 113 species of plant, as well as some that have eluded identification, are known to be components of various kinds of ayahuasca.[2] Experienced shamans may use as many as 100 admixtures to obtain their desired and specific effects.[2] Recipes differ, depending on tribe and geographical area, but the stem and bark of the lianes, *Banisteriopsis* species (Malpighiaceae) (Fig. 1a), known as ayahuasca vines, form the basis for all ayahuasca recipes. *Banisteriopsis caapi* is the most commonly used liane, and it contains harmala alkaloids which are powerful monoamine oxidase inhibiting beta-carbolines: harmine, harmaline, and tetrahydroharmine. The former two selectively and reversibly inhibit monoamine oxidase A, and tetrahydroharmine is a serotonin uptake inhibitor. The leaves of *Psychotria viridis* (Rubiaceae) (Fig. 1b),[2,3] 'chacruna', are invariably added when a strong psychotropic experience is desired. The leaves of this liane contain harmine and other beta-carboline alkaloids, but also, significantly, the alkaloid dimethyltryptamine (DMT). The monoamine oxidase inhibitors in *B. caapi* prevent gut enzyme activity, so that any endogenous DMT, or that from *P. viridis*, passes unchanged from the gut into the bloodstream. It can then cross the blood-brain barrier to activate receptor sites and cause hallucinations and other psychotic effects.[5]

Various 'magic mushrooms' have also long been used for inducing hallucinations and religious experiences, and representations of them appear in Palaeolithic cave paintings in Siberia and Algeria; more recently, a pre-Neolithic site in Spain showed that mushrooms were of cultural significance.[6] Species of *Psilocybe* produce the alkaloid psilocybin (4-phosphoryloxy-N, N