International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(Review Article)

Check for updates

Botanical detectives: Harnessing plant evidence in criminal justice

Isha Vishnoi *

Department of Botany, Gargi College, University of Delhi, New Delhi, India.

International Journal of Science and Research Archive, 2024, 12(02), 806–812

Publication history: Received on 10 June 2024; revised on 15 July 2024; accepted on 18 July 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.12.2.1320

Abstract

Forensic botany is an interdisciplinary science that combines botanical principles with legal investigations to solve crimes. Forensic botany involves various subdisciplines of plant science, including palynology (study of pollen and spores), dendrochronology (study of tree rings), and plant anatomy and morphology.

Historically, plant evidence has been underutilized in forensic science, despite its potential to provide critical information. The field gained prominence in the mid-20th century, with pioneering cases where botanical evidence played a key role in criminal investigations.

This paper reviews procedures and recent cases where botanical evidence played a role in establishing either manner or time of death. Plant evidence can be useful for determining if the death was due to an accident, suicide, or homicide, or what time of year burial may have taken place. In addition, plant evidence can be used to determine whether a crime scene is a primary or secondary scene and to locate missing bodies.

Keywords: Forensic Botany; Case studies; Plant Evidence; Forensic Palynology; Crime scene Investigation

1. Introduction

The significance of botanical evidence in forensic examination ultimately depends on what happened or was missed in the crime scene. Researchers will not be able to utilize their plant analysis if the crime scene technician or investigator neglects the significance at the initiation of the process. This foundation's primary requirements are that researchers identify the significance of plant materials, accurately record plant locations, determine how plants relate to the environment, and use appropriate methods for plant collection and preservation.

Finding relevant evidence in a crime scene may seem simple; however, in reality, it can be one of the hardest tasks. The fact that something that is relevant in the current situation may not be relevant in the future is the root of this problem. Thus, checklists and institutional knowledge alone cannot provide a crime scene investigator with the necessary ability to identify all relevant evidence.

Furthermore, although experience is valuable, it cannot determine whether a certain piece of evidence is relevant to a given investigation on its own. This issue is worse in the case of botanical evidence because of the broad ignorance surrounding this topic.

The significance of plant evidence identification in "classical" forensic botany applications, such as crime scene investigations, is demonstrated by the following instances. However, the same principles can be applied to other fields, like drug investigations, wildlife conservation, and environmental protection (illegal activities that harm protected

* Corresponding author: Isha Vishnoi

Copyright © 2024 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution Liscense 4.0.

species and their habitats), food and pharmaceutical fraud (mislabeled or adulterated products), and national security (biological warfare, bioterrorism, and bio crime).

Despite being an underutilized tool, forensic botany can offer substantial supporting evidence for criminal investigations. Accurate identification, recording, gathering, and preservation of botanical evidence are critical for successful laboratory testing.

2. Collection and preservation of Plant evidences:

The identification of evidence in the criminal scene should come first. Pollen grains are tiny objects that evidence collection teams may overlook if a large branch of leaves or a piece of wood provides readily visible evidence. Investigators should be familiar with the distribution and quantity of a certain plant species in an ecosystem, as the main objective of forensic botany in criminal investigations is to establish links between the victim, suspect, and crime scene. Teams working on criminal investigations should be aware of the potential value of plant evidence. They should also share case studies and lessons learned from prior evidence collections in which this type of evidence was successfully used to conclude investigations. Prosecutors should also be aware of the evidence's ability to link certain crime scenes to specific people.

The second constraint relies on the fact that, like any other type of forensic evidence, all material collected should include all necessary control samples at the scene and adjacent areas and be documented to preserve the character and manner in which evidence was positioned and collected from a scene, showing the link between the plant evidence and other pieces of evidence. Including samples collected at the crime scene and from adjacent areas are crucial for accurate and reliable analysis of plant evidence. These two types of samples allow for baseline comparisons, studying environmental and seasonal variations, providing contextual significance, validating the methods applied, excluding coincidence, improving expert testimony and scientific rigor, improving reproducibility and peer review, and enhancing credibility and admissibility in legal proceedings. Proper documentation of the environmental setup, including both the crime scene and the adjacent area, requires a combination of visual, written, and possibly technological methods aiming to capture a complete and accurate representation of the crime scene's surroundings and the interpretation of plant evidence collected. These methods frequently include photographs and videos (overall crime scene, including the vegetation, soil, and other relevant features; using multiple angles and distances to provide a comprehensive view), detailed written notes (describing the time of year and the ongoing seasonal changes, the plants present, their phenological stages, anomalies, and the overall appearance of the vegetation), description of soil characteristics (soil type, colour, texture, and moisture levels), description of the weather conditions (temperature, humidity, wind speed, and precipitation), topography (elevation, slopes, and -water bodies), evidence markers (flags, cones, or others), sketched diagrams (the layout of the crime scene and the distribution of plants), and Geographic Information Systems (GIS) Technology (detailed maps that incorporate spatial and environmental information).

Only after the body has been removed is the botanist permitted to appear on the site alongside the coroner and police officers. As a result, to gather plant evidence during autopsy, several protocols must be followed. The coroner first checks the victim to confirm whether any visible plant material is present on the outside of the body, on clothing, in personal possessions, or inside the bodily orifices. If plant evidence is identified, the location, appearance, and condition of each item are recorded. The plant evidence is carefully retrieved using sterile forceps or tweezers, attempting to preserve the original state of the plant as much as possible if it is located outside the body, clothing, or personal possessions. If plant material is found within body orifices, it is collected using a sterile swab without trauma to the tissue or evidence.

Plant evidence should be preserved from further deterioration or contamination because it may dry out, decay, become contaminated with fungi, or change in various ways from its original location. To avoid bacterial development or excessive moisture, most botanical specimens can be dried. They can then be wrapped in paper or vials that allow air circulation to prevent moisture buildup and preserve evidence. Moreover, distinct substances must be packaged independently to prevent cross-contamination. Relevant information, including case number, date, time, collection location, evidence description, and examiner's name, should be prominently displayed on each container.

Finally, to establish a chain of custody, evidence must be collected and preserved. As a result, records need to be maintained from the time the evidence is collected until the case is resolved, and possibly even after that, for cold case revaluations. In addition, evidence transfers must be logged along with their location and flow, and they should only occur when necessary.

Evidence in forensic botany takes the form of legal and scientific disputes. High ethical and scientific standards are necessary for all forensic science disciplines. The results should be interpreted clearly, with no consideration for personal prejudice or other possible interpretations. In addition, analyses of hardly detectable traces must be performed using non-destructive techniques to preserve evidence for future analysis in disputes.

3. Case studies

3.1. Case 1: forensic botany and a victim's concealment location

During normal maintenance work in October 2011, the skeletal remains of a victim were accidentally found entangled in a bush along the overgrown banks of a river in a pre-Alpine valley in northern Italy. Forensic anthropologists and forensic pathologists employed numbered grid systems to arrange the evidence in accordance with forensic archaeological guidelines throughout the victim's recovery. Several plant components were found, documented, and collected above the skeletonized bones. The spontaneous vegetation in the vicinity was examined closely during the same inspection, and a sampling plan was implemented for later comparison with materials directly related to the remains. The remains that were eventually identified as those of a woman who had disappeared 3 months earlier presented no peri-mortem trauma that could clearly diagnose the victim's cause and manner of death. On the basis of circumstantial evidence, the woman's husband was identified as a suspect, subsequently charged with murder, and arrested.

After the vegetation was removed from above the victim, it was examined under a Leica Zoom 2000 episcopic microscope. The leaf and stem morphologies were compared with those of the reference material and dichotomous keys. Using the data from this analysis technique, *Prunus laurocerasus*, a shrub species not seen in the spontaneous vegetation sampled in the discovery region, was identified as the leaves and trimmed branches that were recovered directly above the remains. However, a pile of severed branches and leaves was discovered approximately 100 m from the discovery site. Although not of the same species as those found above the victim, the findings led experts to identify the general area as a clandestine dump site typically used for the disposal of garden waste. The experts concluded that the perpetrator had hidden the woman's body in a bush that was already growing in the area and had further concealed it by covering it with *Prunus laurocerasus* plant trimmings recovered from a nearby fly tip. Thanks also to the support of the botanical evidence presented above, the suspect was sentenced by the Court of Appeal and subsequently by the Cassation Court (Italy's supreme Court of Appeal) for both his wife's murder and the aggravated circumstance of the unlawful disposal of a dead body.

Figure 1 Human remains partially covered by plant components a, the *Prunus laurocerasus* leaves and branches collected during the on-site inspection b, and a close-up of the severed extremities of two branches c

3.2. Case 2: forensic botany and confirmation of Homicide or Suicide?

One case in Taipei, Taiwan, illustrates how plant material can be simply used to determine whether an unidentified body was a result of homicide or suicide. In this case report, the body of a young woman was found lying in a gutter in an urban section of Taiwan. Before autopsy, due to the lack of obvious bone fractures, the patient was believed to have died from a hit-and-run accident. She was visible on surveillance system tape, but after a truck passed by her, she was no longer visible on the tape. It was assumed that she was hit by the vehicle, and her body moved to the gutter to conceal the incident. Her body had already been relocated to the hospital by the time investigators reached the crime scene, so they decided to go to the hospital to examine it. Some plant material (a tiny berry and stem) was found in the victim's hair. This was an unusual flora for the area, possibly from the genus Solanaceae, based on limited morphological characteristics.

After searching the crime scene for plants belonging to the genus Solanaceae, part of a broken stem was found at the location where the body was discovered. The investigators looked upward and found potted plants on the edge of a railing above the gutter. These plants were identified as Solanum nigrum L., consistent with the botanical evidence from the victim's hair and the presence of a physical match between the stem on one plant and the stem fragment found in the gutter. Based on location and climate, wind force is not strong enough to break the stem, so investigators presumed that the plant had received a strong impact from something heavy, such as a body. In addition, the height of the railing at which the plants were found was 3.5 m; thus, they could not be reached by persons walking on the street. The likely scenario for this incident was that the female fell from the top of the building, her body came into contact with the plants during the fall, and some of the plant was transferred to the gutter and the victim's hair. Several days later, autopsy results showed her death to be a result of her impact injuries, and her relatives told the police that the young woman had suffered from depression and had attempted suicide previously.

Figure 2 A. Photograph of the alley where the victim's body was found and the buildings from where the victim jumped. B. A tiny berry and stem fragment found in the young woman's hair. C. Physical match between the broken end of the stem from the plant on the railing and the broken stem from the gutter

3.3. Case 3: forensic botany and confirmation of a primary crime scene

At the end of February 2011, the partially skeletonized corpse of a girl who had disappeared in November 2011 was found in a field in a sparsely populated industrial area in northern Italy. The authorities carried out a large and prolonged search campaign over a wide area that also included the discovery site. Due to this, when at last the victim was discovered, presenting evident signs of violence and foul play, the search operators and the authorities suspected that the victim may have been murdered elsewhere and subsequently transferred and deposited at the discovery site. During the initial inspection, the on-site pathologist and forensic archeologist who recovered the victim observed a deep interconnection between the human remains and plant specimens directly associated with the corpse. In the days following the victim's recovery, a forensic botanist carried out an on-site inspection to implement a sampling strategy to determine the vegetation species that occupied the surrounding area, the adjacent area, and the area directly beneath the profile of the victim's deposition.

It was subsequently discovered that the field was dominated by the presence of *Buddleja davidii*, *Rubus* sp., numerous large-sized forbs, such as *Epilobium hirsutum*, *Solidago gigantea*, and grasses, such as *Sorghum halepense* and *Panicum dichotomiflorum*. The vegetation that was clenched in the victim's right fist was identified as *Sorghum halepense* (prevalent species), *Epilobium hirsutum*, and *Rubus* sp*.* Moreover, it was noted that below the area previously occupied by the cadaver, Epilobium *hirsutum* seedlings were absent, which contrasted with the adjacent areas in which they grew extensively. Finally, a *Solidago gigantea* leaf was found directly beneath the victim's skull.

The absence of botanical evidence that could lead to other environments other than that of the discovery area along with the lack of any other environmental evidence in this sense supports the theory that the field in which the victim was found was indeed the primary crime scene and that the victim had not undergone any post mortem transferral. Based on other botanical findings, the post-deposition interval was also determined and was compatible with estimations made by other specialists. By observing the distribution pattern of Epilobium *hirsutum* seedlings that did not occupy the area directly beneath the victim's body, it was evident that the corpse had been in the same place and position before the seedlings sprouted. Because suitable temperatures for the germination of these seedlings were reached in that area only at the beginning of February, the minimum depositional interval was estimated to be 25–30 days prior to the victim's discovery. Regarding the maximum depositional interval and, in this case, the certain post-mortem interval, the estimation was reached through the analysis of the *Solidago gigantea* leaf recovered beneath the girl's skull. Being particularly well preserved and well laid out, unlike those exposed to atmospheric agents that appeared crumpled and damaged, it was assumed that the protection offered by the corpse directly above it allowed the leaf to remain stretched out and well hydrated. Since *Solidago gigantea* is a late summer-autumn flowering species whose leaves and stems gradually dry out from September to November, we concluded that the corpse was deposited on top of the leaf in late autumn. The determination of the chain of events and the chronological time span were perfectly consistent, not only with the date of the victim's disappearance but also with the hypothesis that the field that had already been searched in November was to be considered the primary murder scene.

Figure 3 The surface beneath the victim's body: in contrast to the adjacent areas, the seedlings of *Epilobium hirsutum* were absent. Diagram illustrating the detailed analysis of the distribution of botanical elements associated with the victim and the surrounding area. b

3.4. Case 4: forensic botany and estimation of time of death

Different tests, including body temperature, forensic entomology, and forensic botany, can be performed to establish the time of death. After death, the body will slowly cool to the surrounding temperature. Before the body reaches the equivalent ambient temperature, it is fairly straightforward to calculate the time since death by extrapolating back from the original average body temperature. Both forensic botany and entomology are useful tools for estimating the time of death. Entomology relies on predictable patterns of insect colonization in a corpse to estimate the time of death. Forensic bots can, however, be used to establish the time of death via pollen analysis or stomach contents analysis. A good example of pollen analysis and estimated time of death is a study of skeletons recovered from a mass grave in Magdeburg, Germany, in 1994. Because 32 male skeletons were recovered, we hypothesized that they died during military interactions. Two possible hypotheses were considered:

- That the men were victims of the Gestapo at the end of World War II in the spring of 1945, or
- That the men were Soviet soldiers killed by secret police after the German Democratic Republic revolted in the summer of 1953.

The remains were exhumed, and the nasal cavities were rinsed with a saline solution to remove any pollen that the men may have ingested prior to their death. Appropriate control samples from the soil were also analyzed for pollen species composition. Seven of the tested skulls contained high levels of plantain, rye, and lime tree pollen—all common for plants that flower in the summer months, thus supporting the second hypothesis. The analysis of stomach contents can also be used to estimate the time of death using simple microscopic methods. For example, in 1993, a man in Colorado was suspected of having been murdered by his wife. He was the eighth husband of Jill Caroll, and his body was found in her home. The victim was very habitual in that he always ate the same breakfast consisting of toast, hash brown potatoes, and eggs at the same restaurant every morning. At autopsy, his stomach contents were misidentified as noodles, which were later correctly identified as potatoes. Knowing the estimated di gestion time for this food, the victim must have died sometime between two and four hours after breakfast; a time frame that was not consistent with her wife's alibi. She was later convicted of the crime.

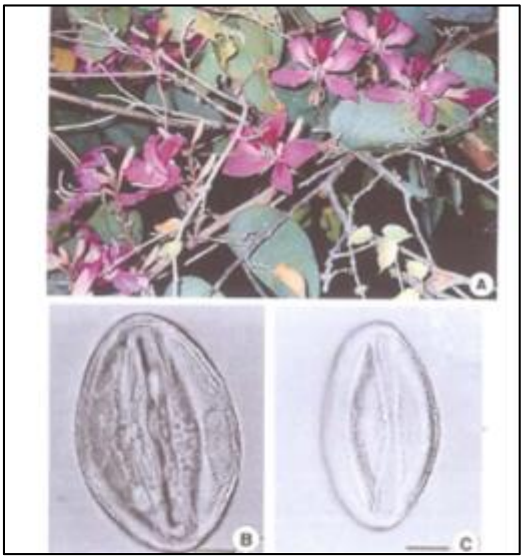

Figure 4 Pollen evidence from clothes Bauhinia purpurea L. (locality 14). A: Habit. B: A fresh pollen grain. C: An adhesive pollen grain. (Bar = 10 μm)

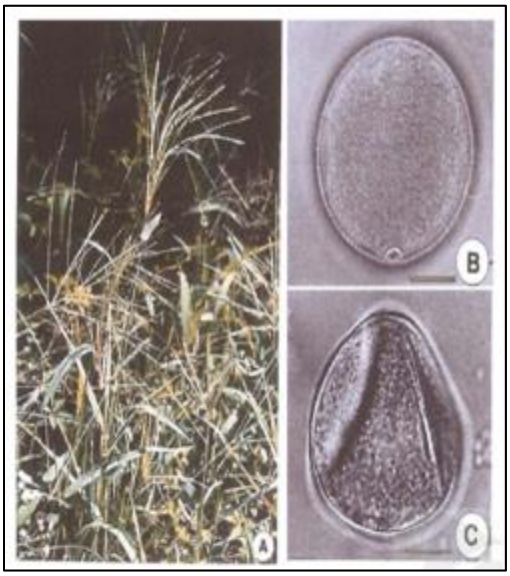

Figure 5 *Digitaria sanguinalis* (L.) Scop. (locality 26). A: Habit. B: A fresh pollen grain. C: An adhesive pollen grain. (Bar = 10 μm)

4. Conclusion

Undoubtedly, the field of forensic botany serves as a significant source of information for studying many forensic situations and frequently provides insightful and practical data for research projects. As these case studies have shown, forensic botany can be very helpful in determining the location of a victim, the length of time it took them to be deposed, and the possible events that transpired at a particular scene when dealing with skeletal or partially skeletonized human remains, cases in which other disciplines are simply ineffective.

However, only if botanical evidence has been collected by forensic experts or on-site staff who have at least a minimal level of training in the application of sampling protocols, accurate recording techniques, and the collection of background environmental data regarding a specific discovery location can forensic botany help the forensic pathologist or investigators.

The collection, identification, categorization, and preservation of botanical evidence can only be submitted to an investigating body or, in fact, a court of law, provided these initial on-site procedures are properly completed.

Forensic botany is a field that should be considered in any situation where botanical evidence is presented because of its potential. The information that can be presented, even if it is merely circumstantial, can certainly shed light on many of the classic questions that judicial investigators pose, as detailed and illustrated by the cases presented in this paper. It is true that botanical evidence has been used in court cases more frequently than not up to this point, and the topic has been hotly contested.

Therefore, members of the forensic science community should be more cognizant of the possibilities this field may offer in various situations.

References

[1] Heather Miller Coyle1, Cheng-Lung Lee2,3, Wen-Yu Lin4, Henry C. Lee1,5, Timothy M. Palmbach1 Forensic Botany: Using Plant Evidence to Aid in Forensic Death Investigation Croat Med J 2005;46(4):606-612

[2] Marco Caccianiga, Giulia Caccia, Debora Mazzarelli, Dominic Salsarola, Pasquale Poppa, Daniel Gaudio, Annalisa Cappella, Lorenzo Franceschetti, Stefano Tambuzzi, Lidia Maggioni, Cristina Cattaneo, Common and much less common scenarios in which botany is crucial for forensic pathologist and anthropologists: a series of eight case studies International Journal of legal medicine 2020

[3] Manuela Oliveira, Luísa Azevedo, David Ballard, Wojciech Branicki f g, Antonio Amorim. Using plants in forensics: State-of-the-art and prospects, Plant Science 2023

[4] Gabriele Margiotta, Giovanni Bacaro, Eugenia Carnevali, Simona Severini: Forensic botany as a useful tool in the crime scene: Report of a case, June 2015 Journal of Forensic and Legal Medicine 34:22-28

[5] Chun-Liang Wu (1), Chiou-Herr Yang (2), Tseng-Chieng Huang (3,5) and Su-Hwa Chen (4): Forensic Pollen Evidence from Clothes by the Tape Adhesive Method, Taiwania, 51(2): 123-130 (2006)