Review Article

International Journal of Forensic Science
Volume 4 Number 1, January–June 2021

Forensic Palynology: Pollen Spectra as Cogent Evidence for Crime Investigation

Shyam Sundar Jangir[1], R.K. Kumawat[2], Rajesh Singh[3], Ajay Sharma[4]

How to cite this article:
Shyam Sundar Jangir, R.K. Kumawat, Rajesh Singh et al./Forensic Palynology: Pollen Spectra as Cogent Evidence for Crime Investigation International Journal of Forensic Science. 2021;4(1): 27–30.

Abstract

Forensic palynology, one science of plant's pollen and spores, has been developing to be a new frontier discipline in scientific toolkit of forensic science.There are approximate half million plants that produce pollen grains and spores. Each and every species of plant is unique. Each biogeographical region produces a unique 'pollen spectra' or 'pollen print' that can be very useful in linking things to the exact location. Due to characteristicsfeatures of pollen and spores, such as small size, light weight, large amount, and difficult to be found, they can leave trace evidence and provide new crime detection tool. Pollen spectra give relevant information about of vegetation of particulargeographical location. Many scientific studies have been proven potential values of forensic palynology in both criminal and civil cases. Forensic palynology studies and their use in crime detection are very rarely attempted in India. Therefore palynology has a good prospect for practical application in forensic botany. The paper intends to analyze the advantage and limitation of palynology in forensic science by reviewing its general characteristics, morphology, and disseminating circadian rhythm.

Key words: Forensic Palynology; Pollen spectra; Criminal and civil cases; Morphology.

Introduction

Forensic palynologyis a branch of Forensic Botany, which deals in pollen grains and spores studies for the purpose of law. Since last seven decades pollens and spores have been proven the potential valuesin crime investigation. Forensic palynology has been developing to be a new frontier discipline in scientific toolkit of forensic science (Zhang et al. 2007). It has been used as a crime detection weapon since the 1950's and is the utilization of pollen and spores in solving criminal issues. (Bryant, 2013) Pollens can also be transferred by direct contact with a part of a plant containing spores or pollen. Pollen grains are ideal forensic trace evidence since they are small, highly variable and found on things that have been exposed to or interact with the air, water and insects. Such samples may include soil, ropes and twines, clothing and fabrics, drugs, air filters, plant material, and animal and human material, such as fur, hair and stomach contents (Milne et al., 2005) Pollen grains could be resided in the intestinal for more than 20 days. Therefore, pollen analysis is an important avenue of forensic investigation and research dimensions (Arguelles et al., 2015). Forensic palynology is increasingly being used to determine the region of origin, or geolocation, for persons and items of interest. In most countries that use forensic palynology, microscopic pollen grains and spores are traditionally used in criminal investigations to link suspects or items (Laurence et al. 2019). Palynological evidence can provide very powerful

Author's Affiliation: [1]Forensic Assistant, Biology Division, [2]Senior Scientific Officer, DNA Division, [3]Assistant Director, Biology Division, [4]Director, State, State Forensic Science Laboratory Rajasthan, Jaipur 302016, India.

Correspondence: R.K. Kumawat, Senior Scientific Officer, DNA Division, State Forensic Science Laboratory Jaipur 302016, Rajasthan, India.
E-mail: ramkishankmwt@gmail.com

investigative and associative evidence. Despite this, the application of palynology to forensic science has had mixed success. There are many anecdotal stories where pollen evidence has had spectacular successes(Walsh et al. 2008).

Types of pollenand its characteristics

Pollen grains are usually categorized largely on the basis of their shape, size, apertural types, symmetry, polarity and exine sculpturing. However, from a phylogenetic and evolutionary point of view, polarity, symmetry, apertural types and exine sculpturing are the most important pollen characters to the morphological identification. (Walker and Doyle, 1975).

1. *Spectra of possible pollen types:* Every biogeographical region or location has a own pollen prints or pollen spectra. There are many types of pollen grains such as monolete, trilete, poliplicate, vesiculate, saccate, inaperturate, monocolpate, monoporate, dicolpate, diporate, triporate, tricolpate, tricolporate, zonocolpate, zonoporate, zonocolporate, pantocolporate, pantoporate, pantocolporate, heterocolpate, fenestrate, syncolpate, dyad, tetrad etc. (Figure 1).

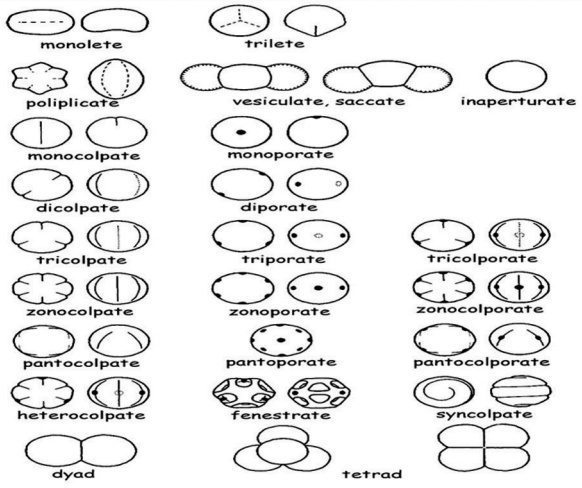

Fig. 1: Spectra of possible pollen types (Pollen print).

2. *Pollen unit and dimensions:* The pollen grains at anthesiswere foundto be solitary (monads) in all the studied taxa. Pollen can be categorized into small sized (10-25 µm), medium sized (25-50 µm), large sized (50-100 µm) and very large sized (100-200 µm) (Kermp, 1965) and inthis context many Palynologists suggested that small sized pollen enhances the insect pollination whereas large sized pollen enables moth or bat pollinations (Ramamorthay, 1991).
3. *Shape class:* Accordingto the literature suggested by the Erdtman, the morphology of pollen grains is measured by the ratio of the length of the polar axis (an imaginary straight line connecting the two poles) to the equatorial diameter (P/E) (Erdtman, 1952). Major shapes of pollen grains are spheroidal, prolate spheroidal, oblate spheroidal, triangular, subporate, prolate, elongated
4. *Polarity and symmetry of pollen grains:* The pollen grainsare usually examined based on their polarity and symmetry and most of the pollen grains are radially symmetrical, apolar, isopolar and heteropolar. Pollen grains of dicot families are commonly apolar and isopolar whereas heteropolar are found in monocotyledonous families(El-Amier,2015).
5. *Aperture Class:* The apertural types and their phenotypic characters are most important features of pollen grains and the first feature to be considered when identifying pollen are the aperture. An aperture is a thin or missing part of the exine, which is independent of the pottering of the exine. On the basis of aperture, pollens are mostly colporate, colpate, porate and rarely non aperturate type. As the majority of the studied taxa have porate or inaperturate, rarely colpate and colporate pollen grains, thus are considered the line of evolution between the primitive type and advanced pores. The pollen in monocots are less specialized than that of dicots, particularly in their apertural types (El-Amier,2015), (Perveen,2000).
6. *Pollen surface sculpture:* The difference in the structure and sculpturing of the exine of pollens are very significant phenotypic characteristics for the identification of origin. The sculpturing of the pollen grains is the ornamentation of the exine surface which can be psilate, foveolate, frustillate, gemmate, clavate, verrucate, buculate, regulate, reticulate etc.

Wide range of application and fighting crime with pollen:

There are many circumstances in which pollen grains and spores could help in a criminal investigation as given below.

1. Establish linkage between primary and secondary crime site.
2. Establish linkage between suspect and victim.
3. Establish linkage between objects which are present at crime site and suspect.
4. Determination of biogeographical location

(region of origin)– as corroboratory evidence in reference of victims account

5. Establish linkage between –suspect, victim, different articles such as vehicles, clothing's etc.
6. Establish linkage on the basis of articles which are in possession under victim/suspect such as vehicles, clothing's, jackets, wrist watch, Goggles, brash lets, ornaments etc.
7. Generate a profile of the suspect with the help of pollen found at crime site
8. Narrow the list of potential suspects which can speed up the investigation.
9. Determine of point the investigation in the correct direction.
10. Determine the source of origin or travel history of articles such as drugs, narcotic plants, weapon, tools, currency, explosive devices, stolen vehicles etc.
11. Determine the biogeographic contents and origin of food products.
12. Determine the season in which crime was commuted.

Combined approach with Forensic entomology

Currently, some case reports and studies belongs to many actual crime cases, combined application of forensic entomology and palynology (Botany) plays very important role in crime detection. Due to wide range of multidimensional approach, gradually popular to answered many medico legal questions in complicated and highlighted cases. It's all about close observation of forensic entomofauna developmental stages and endemic plant species. Together, forensic botany and entomological techniques shows impressive possibilities in solving both criminal and civil cases.

Recent advancements and molecular approach

There are many reasons to becoming popular DNA based molecular identification in forensicpalynology, such as difficulties in the identification of plant species, the limited number of experts in the field and the shortage of information and database. The identification of plant family or genus level (taxonomic resolution) is the most difficult. But among the accelerating development of DNA technology, there are two main benefits of using a DNA barcoding method in forensic palynology field. First, this method is able to identify multiple taxonomies groups, and secondly, it more efficiently identifies parts of the organism that do not appear in the morphology (Bell et al., 2016). DNA barcoding is the fastest way to differentiate between pollens (Galimberti et al., 2014). Therefore DNA based molecular identification is must for accurate identification and build a regional data base of pollen print or pollen spectra.

Indian Perspectives

Forensic palynology studies, research and their use in crime detection are very rarely attempted in India. There is no funding for research and development in this emerging field. Now a day, major challenges in India is that there are very few forensic scientists and forensic botanists or forensic palynologists who are trained to do forensic pollen studies at their own effort. Therefore, Forensic Palynology, despite being an emerging trend from toolbox of forensic science, is becoming a vast avoidable filed.

Conclusions

The value of pollen evidence in forensic investigation depends on careful collection, documentation and preservation for later forensic analysis of the collected sample. To obtain accurate results the forensic samples are collected and careful examination. Forensic palynologists collect, store and analyze the samples with great precision. Precautions are taken throughout all the steps to avoid contamination from atmosphere or other sources. The source material of forensic pollen may be almost anything that is exposed to or in contact with air. Even the packaged food and dry food like prunes, sultanas etc. contain pollen from where the food originated. The source material of forensic pollen is different for each case. The utilization of pollen evidence as forensic indicator or detective has been grown and we can apply pollen analysis techniques and methods in proper way to explore full potential of the field and fulfill the vacuum of this emerging stream. Now a day's forensic palynology is becoming a strong pillar of forensic science to solve criminal cases and due to there is a solid foundation of scientific literature, analysis methods, characteristics as forensic indicator, advancement such as DNA based identification, software based analysis must be employed to investigation process to help criminal justice system. Forensic palynology practices should increase by scientific community of India for betterment of this sphere in special context of Indian enforcement agencies and judicial platform.

References

1. V.M. Bryant (2013) Analytical techniques in forensic Palynology S.A. Elias (Ed.), The Encyclopedia of Quaternary Science, vol. 4, Elsevier, Amsterdam (2013), pp. 556-566.
2. L. Milne, V.M. Bryant Jr, D.C. Mildenhall (2005) Forensic PalynologyH.M. Coyle (Ed.), Forensic Botany: Principles and Applications to Criminal Casework, CRC Press, Boca Raton, USA (2005), pp. 217-252.
3. P. Arguelles, K. Reinhard, D.H. Shin (2015) Forensic palynological analysis ofintestinal contents of a Korean mummyAnat. Rec., 298 (6) (2015), pp. 1182-1190.
4. Zhang DY, Zhang DM, Hou YP. (2007)The application of palynology in forensic medicine. Fa Yi Xue Za Zhi. 2007 Dec;23(6):457-9. Chinese. PMID: 18402121.
5. Laurence AR, Bryant VM. (2019) Forensic palynology and the search for geolocation: Factors for analysis and the Baby Doe case. Forensic Sci Int. 2019 Sep;302:109903. doi: 10.1016/j.forsciint.2019. Epub 2019 109903. Jul 27.
6. Walsh KA, Horrocks M. Palynology: its position in the field of forensic science. J Forensic Sci. 2008 Sep;53(5):1053-60. doi: 10.1111/j.1556-4029.2008.00802.x. Epub 2008 Jul 11. PMID: 18636981.
7. G.O.W. Kermp (1965)Encyclopedia of pollen morphologyUniv. Arizona Press, Tuscon, U.S.A.
8. T.P. Ramamoorthy (1991) Ruellia section Chiropterophila (Acanthaceae): a novelty from Mexico Bot J Linn Soc, 107 (1991), pp. 79-88.
9. G. Erdtman (1952) Pollen; morphology and plant taxonomy angiospermsAlmqvist & Wiksell, Stockholm (1952).
10. J.W. Walker, J.A. Doyle (1975)The basis of Angiosperm phylogeny: Palynology Ann Bot Gard, 62 (1975), pp. 666-723.
11. Y.A.El-Amier (2015) Morphological studies of the pollen grains for some hydrophytes in coastal Mediterranean lakes, EgyptEgyptian Journal of Basic and Applied Sciences, Volume 2, Issue 2, June 2015, Pages 132-138.
12. A. Perveen (2000)Pollen characters and their evolutionary significance with special reference to the Flora of Karachi Tur J Biol, 24 (2000), pp. 365-377.
13. Galimberti, A., De Mattia, F., Bruni, I., Scaccabarozzi, D., Sandionigi, A., Barbuto, M.,Casiraghi, M., Labra, M., (2014). A DNA barcoding approach to characterize pollencollected by honeybees. PLoS One 9 (10), e109363.https://doi.org/10.1371/journal.pone.0109363.
14. Bell, B.,de vere, N., Keller, A., Richardson, R., Gous, A., Burgress, K and Brosi, B (2016) pollen DNA barcoding : current application and future prospects Genome, 59 (9), 629-640.
15. Lang, G., (1994) Quartare vegetations geschichte Europas. Gustav Fischer Verlag Jena, Stuttgart, New York: 462 S.