Melissopalynological Investigation and Preparation of a Seasonal Pollen Calendar of Malda District, West Bengal, India.

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***Abstract*—Melissopalynological investigation is an important tool for understanding the botanical origin of honey, floral resource availability, and seasonal variation in flowering plants. The present study aims to investigate the pollen composition of honey samples collected from different blocks of Malda district, West Bengal, India, and to prepare a seasonal pollen calendar based on the identified pollen types and their flowering periods. The study encompasses all 15 community development blocks of the district, namely Bamangola, Chanchal-I, Chanchal-II, English Bazar, Gazole, Habibpur, Harishchandrapur-I, Harishchandrapur-II, Kaliachak-I, Kaliachak-II, Kaliachak-III, Manikchak, Old Malda, Ratua-I and Ratua-II. Honey samples will be subjected to standard melissopalynological techniques for the extraction, identification and quantitative analysis of pollen grains using microscopic examination. The identified pollen types will be classified according to their botanical origin and frequency of occurrence. Seasonal flowering information of the identified nectariferous and polleniferous plants will be compiled to determine their flowering periods and seasonal availability. The resulting information will be used to develop a seasonal pollen calendar for Malda district, highlighting the major floral resources available to honeybees throughout the year. The study is expected to provide valuable baseline information on the botanical origin of honey, seasonal floral diversity and the availability of bee forage resources. Furthermore, the findings may contribute to sustainable apiculture, effective management of honeybee colonies and conservation of important melliferous plants in the region.**

***Index Terms*—Melissopalynology, Honey, Pollen Analysis, Seasonal Pollen Calendar, Floral Diversity, Malda District, Apiculture, West Bengal.**

I. INTRODUCTION

Honey is a natural biological product produced by honeybees from floral nectar and other plant-derived substances. Its botanical origin influences its quality, physicochemical properties and commercial value. Melissopalynology, the scientific study of pollen grains present in honey, is an effective method for identifying its floral sources through microscopic and quantitative pollen analysis.

Floral resource availability varies with seasonal changes, climatic conditions, vegetation and agricultural practices. These variations influence honeybee foraging activities and are reflected in the pollen composition of honey. A seasonal pollen calendar helps document flowering periods and the availability of floral resources throughout the year. Malda district of West Bengal, India, comprises three broad agroecological regions: Diara, Barind and Tal, which differ in their geographical features, vegetation and agricultural practices.

These variations provide an opportunity to investigate regional and seasonal differences in floral resources. Therefore, the present study aims to analyse honey samples collected from all 15 community development blocks of Malda district through melissopalynological investigations and prepare a seasonal pollen calendar based on pollen composition and flowering phenology. The study will provide baseline information on the botanical origin of honey and the potential for sustainable apiculture in the district.

II. STUDY AREA

Malda district, situated in northern West Bengal, India, exhibits considerable geographical and ecological diversity due to variations in topography, soil, drainage and agricultural practices. The district is influenced by the Ganga and Mahananda river systems and their associated floodplains. For the present

investigation, the district has been broadly divided into three agroecological regions: Diara, Barind and Tal.

Diara Region: The Diara region is characterized by fertile alluvial soil, low-lying plains and intensive agricultural and horticultural activities, particularly mango cultivation. It includes English Bazar, Manikchak, Kaliachak-I, Kaliachak-II, Kaliachak-III and parts of Old Malda.

Barind Region: The Barind region comprises relatively elevated terrain with red and lateritic soil patches, agricultural fields and scattered natural vegetation. It includes Gazole, Habibpur, Bamangola and the eastern part of Old Malda.

Tal Region: The Tal region is characterized by low-lying floodplains, wetlands, seasonal water bodies and waterlogged agricultural areas. Its landscape is strongly influenced by seasonal rainfall and fluctuations in water levels. It includes Chanchal-I, Chanchal-II, Ratua-I, Ratua-II, Harishchandrapur-I and Harishchandrapur-II.

Table 1. Agroecological classification of Malda district and corresponding community development blocks

Agroecological region	Community development blocks
Diara Region	English Bazar, Manikchak, Kaliachak-I, Kaliachak-II, Kaliachak-III and part of Old Malda
Barind Region	Gazole, Habibpur, Bamangola and part of Old Malda
Tal Region	Chanchal-I, Chanchal-II, Ratua-I, Ratua-II, Harishchandrapur-I and Harishchandrapur-II

The regional classification provides the geographical basis for the selection and comparative assessment of honey samples in the present investigation. Sampling across these three ecological regions is intended to facilitate an understanding of spatial variations in pollen composition and seasonal floral resource availability throughout Malda district.

III. MATERIALS AND METHODS

3.1 Study Design and Sampling Strategy

The present investigation was designed to evaluate the pollen composition of honey samples collected from different geographical locations of Malda district, West Bengal, India. The sampling strategy covers all 15 community development blocks representing the three major agroecological regions, namely Diara, Barind and Tal. Honey samples will be collected from selected localities within each block to ensure adequate geographical representation. The sampling programme will consider seasonal variations in honey production and floral resource availability. Each sample will be assigned a unique identification code indicating its collection location, block and sampling period.

3.2 Collection and Preservation of Honey Samples

Honey samples will be collected from local beekeepers, apiaries and other reliable sources using clean and dry containers. Approximately 50–100 g of honey will be collected from each sampling location, depending on availability.

Each sample will be transferred into a sterile, airtight container and labelled with relevant information, including sample identification number, collection location, block name and date of collection. Samples will be transported to the laboratory and stored under suitable conditions until further analysis.

Care will be taken to avoid contamination during collection, transportation and storage.

3.3 Preparation of Pollen Samples

The pollen content of each honey sample will be extracted following standard melissopalynological procedures. A measured quantity of homogenized honey will be dissolved in distilled water and thoroughly mixed to facilitate the separation of pollen grains from the honey matrix.

The resulting solution will be centrifuged to concentrate the pollen sediment. The supernatant will be carefully discarded, and the recovered sediment will be processed for microscopic examination. The prepared pollen material will subsequently be mounted on clean microscopic slides using an appropriate mounting medium.

3.4 Microscopic Examination and Identification of Pollen Grains

The prepared slides will be examined under a compound light microscope at suitable magnifications. Pollen grains will be identified based on their characteristic morphological features. The identification process will consider pollen size, shape,

aperture characteristics, exine ornamentation, wall structure and other diagnostic morphological features. Available pollen reference materials, standard palynological literature and relevant identification keys will be used for taxonomic identification.

Identified pollen types will be documented photographically wherever possible. The pollen taxa will subsequently be arranged according to their respective botanical families for comparative analysis.

3.5 Quantitative Pollen Analysis

Quantitative pollen analysis will be performed by counting the pollen grains present in prepared microscopic slides. The relative frequency of each identified pollen type will be calculated using the following formula:

$P = Ni/Nt * 100$

Where:

- P = Percentage frequency of a pollen type
- N_i = Number of grains of an individual pollen type
- N_t = Total number of pollen grains counted

Based on their percentage frequency, pollen types will be classified into different frequency categories to determine their relative representation in honey samples.

3.6 Determination of Botanical Origin

The botanical origin of honey samples will be interpreted based on the identification and relative frequency of pollen types present in each sample. The pollen composition will be evaluated to determine the possible floral associations and botanical characteristics of the collected honey.

The interpretation will consider the known pollen representation characteristics of different plant taxa, as pollen frequency in honey does not always directly correspond to the actual nectar contribution of the respective plants.

3.7 Documentation of Flowering Phenology

Information regarding the flowering periods of identified plant taxa will be collected through field observations, available botanical literature and relevant regional floristic information. Field observations will be conducted at selected locations representing the three agroecological regions. The flowering periods, seasonal occurrence and geographical distribution of important floral resources will be documented. The collected information will be organized month-wise to establish the flowering phenological pattern of the identified plants.

3.8 Preparation of Seasonal Pollen Calendar

A seasonal pollen calendar will be prepared by integrating the results of melissopalynological analysis with the documented flowering phenology of the identified plants. The calendar will represent the monthly occurrence of pollen types and the corresponding flowering periods of their probable botanical sources. It will cover the entire annual cycle from January to December.

Regional variations in flowering periods and pollen representation will also be considered to identify differences in seasonal floral resource availability among the Diara, Barind and Tal regions.

3.9 Comparative Regional Analysis

The pollen composition of honey samples collected from different blocks will be compared to investigate spatial variations across the three agroecological regions. The comparative assessment will consider the number of identified pollen taxa, their relative frequencies, seasonal occurrence and distribution among the sampled locations.

The resulting information will be used to understand the relationship between regional ecological characteristics, floral resource distribution and the botanical composition of honey.

3.10 Data Presentation and Statistical Analysis

The recorded data will be organized in tabular and graphical formats for systematic interpretation. Pollen frequency distributions, regional variations and seasonal flowering patterns will be presented using appropriate tables, charts and pollen calendar diagrams. Where sufficient quantitative data are available, suitable statistical methods will be applied to evaluate variations in pollen composition among different sampling locations, blocks and agroecological regions.

IV. RESULTS

4.1 Regional Floral Resource Distribution

The floral resource distribution in Malda district varies across the three agroecological regions: Diara, Barind and Tal. Differences in soil, topography, vegetation and agricultural practices influence the availability and

distribution of potential bee-forage plants in these regions.

4.2 Seasonal Distribution of Potential Pollen Resources

The availability of floral resources varies seasonally across the district. Diara supports floral resources associated with horticulture and spring flowering, Barind is influenced by agricultural and terrestrial vegetation, while Tal provides resources associated with seasonal cultivation and wetland ecosystems.

4.3 Preparation of Seasonal Pollen Calendar

A preliminary seasonal pollen calendar has been prepared to illustrate the monthly distribution and flowering periods of selected plant families across the three regions. Different colours represent Diara, Barind and Tal, allowing comparison of regional and seasonal floral resource availability. The calendar will be further refined using pollen analysis of honey samples and field-based flowering observations.

4.4 Regional Significance of Seasonal Floral Resources

The regional assessment indicates that the three agroecological regions possess distinct potential floral resource characteristics. The variation in flowering periods may influence the seasonal availability of nectar and pollen resources for honeybees.

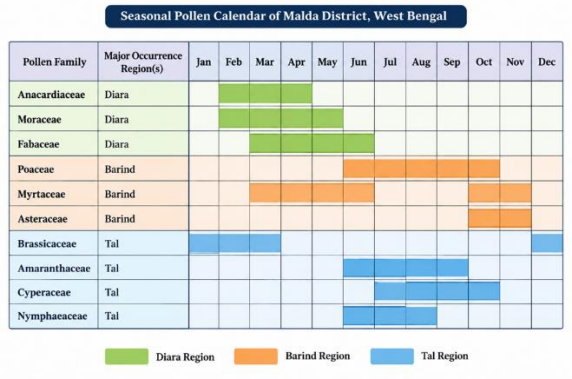

Figure 1. Preliminary seasonal pollen calendar showing the monthly distribution of selected pollen families across the three agroecological regions (Diara, Barind and Tal) of Malda district, West Bengal, India.

The integration of melissopalynological findings with flowering phenological observations will help establish the actual contribution of different floral resources to honey production and provide a scientific basis for understanding seasonal bee-forage availability in Malda district.

V. DISCUSSION

The present study provides an ecological framework for understanding the regional distribution and seasonal availability of potential floral resources across the three agroecological regions of Malda district, namely Diara, Barind and Tal. Differences in geographical features, soil conditions, vegetation and agricultural practices may influence the availability of bee-forage resources. The Diara region, with its fertile alluvial soil and extensive horticultural activities, may support diverse floral resources. The Barind region, characterized by elevated terrain and terrestrial vegetation, offers a different pattern of seasonal floral availability. In contrast, the Tal region, with its wetlands and low-lying agricultural landscapes, may support flowering plants associated with both terrestrial and wetland ecosystems.

Seasonal variations in flowering phenology influence honeybee foraging activities and the availability of nectar and pollen throughout the year. The proposed seasonal pollen calendar provides a comparative overview of potential floral resources and their flowering periods across the three regions. It may help identify periods of floral abundance and forage scarcity, supporting apiary planning and colony management. Integration of melissopalynological analysis with field-based flowering observations is essential for validating the seasonal pollen calendar and identifying the actual botanical contributions to honey. Overall, the study provides a preliminary framework for understanding floral diversity and the apicultural potential of Malda district.

VI. CONCLUSION

The present investigation highlights the importance of melissopalynological studies in understanding the botanical origin of honey and the seasonal distribution of floral resources in Malda district, West Bengal. The consideration of three distinct agroecological regions, namely Diara, Barind and Tal, provides an ecological framework for evaluating regional variations in vegetation characteristics and potential bee-forage availability. The preparation of a seasonal pollen

calendar offers a systematic approach to documenting the monthly distribution of important pollen-producing plant families and their potential flowering periods. Such information can contribute to understanding seasonal variations in floral resource availability and the foraging ecology of honeybees.

The integration of pollen analysis with flowering phenological observations is expected to provide valuable information regarding the botanical characteristics of honey and the regional diversity of floral resources. The study may also support sustainable apiculture through improved apiary management, identification of potential bee-forage periods and conservation of important melliferous vegetation. Overall, the investigation provides a foundation for developing a district-level seasonal pollen calendar for Malda and highlights the significance of regional ecological assessment in apicultural research. Further seasonal sampling, microscopic pollen identification and field-based validation will be essential for establishing a comprehensive and scientifically verified pollen calendar for the district.

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