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Modern pollen assemblage from surface samples and its relationship to vegetation in Sehore District, south-western Madhya Pradesh, India

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ABSTRACT

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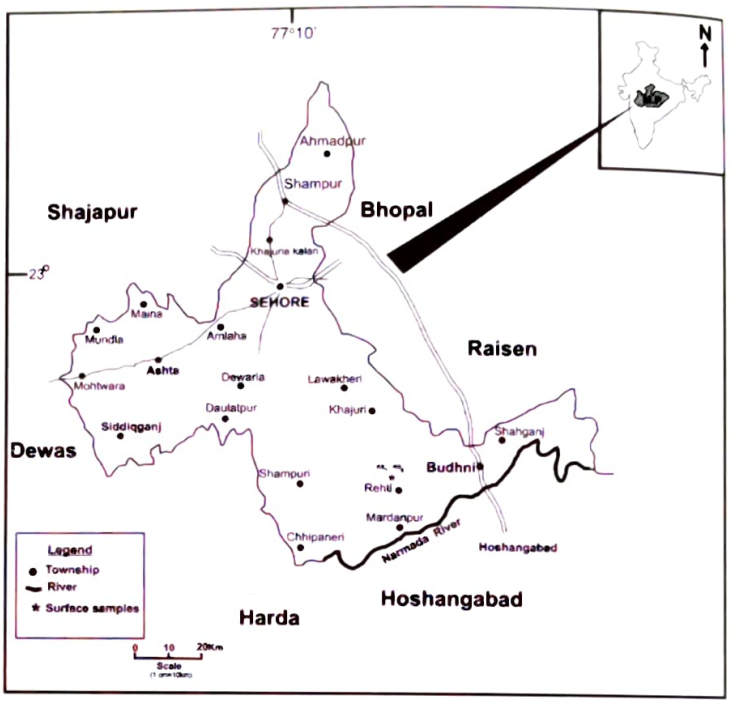
Pollen analysis of six surface samples from the open area at Raheti-Sehore route in Sehore District, where tropical deciduous teak-dominating forests are abundant, has been carried out to understand the relationship between modern pollen rain and contemporary vegetation patterns in the region. The study reveals better representation of non-arboreal pollen (NAPs) in comparison to the arboreals (APs). Among the tree taxa, *Tectona grandis* (teak) is encountered with an average value of 1.08% only in the sediments, despite being an enormous pollen producer and also a dominant forest constituent. This under-representation of *Tectona grandis* pollen could be attributed to its poor preservation in the sediments as well as low dispersal efficiency. On the other hand, the constant presence of *Madhuca indica* and Sapotaceae with maximum values of 37% and 8%, respectively corresponds more or less with their frequent presence in the forest coupled with good preservation of their pollen in the sediments. However, the other associates of teak, viz. *Grewia*, *Terminalia*, *Syzygium*, *Schleichera*, *Mitragyna*, *Lagerstroemia*, *Aegle marmelos*, *Ailanthus excelsa*, *Emblica officinalis*, *Acacia*, *Holoptelea*, *Schrebera*, *Flacourtia*, *Diospyros*, etc., occurring in excellent fraction in the forest, are marked by their sporadic presence owing to their low pollen productivity, since majority of them demonstrate a strong tendency of entomogamy. The microbial degradation of their pollen in the sediments cannot also be ruled out. Grasses, Tubuliflorae, sedges, Cheno/Am, etc. are the major herbaceous elements and their presence in good numbers point to more or less the actual composition of ground flora in the forest floor. The record of Cerealia and other culture pollen taxa such as Cheno/Am, Caryophyllaceae, Brassicaceae, *Cannabis sativa*, *Artemisia*, *Alternanthera*, etc. signifies close proximity of cultivated land and human habitation. This comparative data base on the modern pollen rain/vegetation relationships will serve as modern analogue for the proper portrayal of vegetation dynamics of the study area and contemporary climate change during the Late Quaternary Period.

Key-words: Pollen analysis, pollen rain, vegetation, tropical deciduous forests, Sehore, Southwestern Madhya Pradesh, India.

INTRODUCTION

Several modern pollen assemblages and their relationship with the tropical evergreen and deciduous floras have been published from South India and Sri Lanka (Bonnefille et al. 1999, Anupama et al. 2000, Barboni & Bonnefille 2001), Himalayan foothills (Sharma 1985, Gupta & Yadav 1992), Rajasthan desert (Singh et al. 1973) and North-East India (Basumatary & Bera 2007). These have facilitated the appropriate evaluation of palaeovegetation and existing climatic scenarios from their respective regions during the Late Quaternary Period. Nevertheless, very little information is available from Madhya Pradesh,

especially from north-eastern Madhya Pradesh (Chauhan 1994, 2008, Quamar & Chauhan 2007) and south-western Madhya Pradesh (Quamar & Chauhan 2010, 2011a). The available information on pollen rain/vegetation relationship from these areas has provided a valuable analogue for the precise appraisal of the past vegetation scenarios, which also symbolize the climatic changes during the Late Quaternary Period (Chauhan 1995, 2000, 2002, 2004, 2005, Chauhan et al. 2001, Yadav et al. 2004, Shaw et al. 2007, Patnaik et al. 2009, Chauhan & Quamar 2010, 2012a, b, Quamar & Chauhan 2011b, 2012, 2013). Hence in the present communication, an endeavour has been made to generate more data on the interplay of teak and its associates in the modern pollen rain, their pollen dispersal efficiency and factors affecting the preservation of pollen/spores in the sediments through the pollen analysis of six surface samples gathered from the open area enroute Raheti-Sehore in Sehore District, southwestern Madhya Pradesh, wherein tropical deciduous forests, dominated by teak, profusely grow. The principal aim of the present work, however, is to improve our understanding of the relationship between modern pollen-rain, vegetation and climate that provide a link to interpret the fossil pollen record.



Text-figure 1. Map showing the site of investigation in Sehore District, Madhya Pradesh.

PHYSIOGRAPHY

The investigation site is situated about 32 km west of Budhani of Sehore district, in the close vicinity of Rehti Township (Text-figure 1). Physiographically, the adjoining area of the investigation site is marked by the presence of flat to uneven land surface and deep gorges. The average altitude of the flat area is 250 m a.m.s.l., however, the hillocks in southeast are moderate with varying altitudes of 590-650 m and support dense and diversified tropical deciduous teak-dominating forests.

CLIMATE

The study area enjoys a warm and humid climate, which is largely affected by the southwest monsoon. The mean average minimum and maximum winter temperatures are 7°C and 17°C, respectively, however, the lowest temperature of 1°C is recorded during the severe cold month of January. The mean average minimum and maximum summer temperatures are 27°C and 32°C, respectively. The temperature seldom rises up to 45°C during the extreme hot summer month of June. The rainfall by and large occurs from southwest monsoon from mid June to September, however, major fraction of it takes place in July and August. The average annual precipitation recorded for the area is 1340 mm. Approximately 92% of the total precipitation occurs during the rainy season.

VEGETATION

The vegetation of the region is characterized by the presence of dense and diversified teak forests dominated by *Tectona grandis*, which are mainly confined in the rocky/bouldery hill tracks, however, they turned less varied and dense in the plains and gorges. The common associates of these forests include *Madhuca indica*, *Terminalia arjuna*, *T. tomentosa*, *Anogeissus latifolia*, *Diospyros melanoxylon*, *Lagerstroemia parviflora*, *Mitragyna parvifolia*, *Adina cordifolia*,

Schleichera oleosa, *Syzygium cumini*, *Lannea coromandelica*, *Buchanania lanzan*, *Emblica officinalis*, *Chloroxylon sweitenia*, etc. *Butea monosperma* occurs very frequently along the edge of forest as well as in the adjoining cultivated fields and in the waste land. However, *Mangifera indica*, *Melia azadirach*, *Ficus religiosa*, *F. benghalensis*, *Butea monosperma*, *Madhuca indica*, *Annona squamosa*, *Ailanthus excelsa*, *Aegle marmelos*, *Anthocephalus* spp., are the common village side/ avenue trees. In addition, *Acacia nilotica* has recently been planted as an avenue tree as well as on barren hill slopes owing to its rapid propagation. Bamboo clumps (*Bamboosa arundinacea* and *Dendrocalamus strictus*) occur profusely in groves in moist or damp situation and valleys. Similarly, *Phoenix acaulis*, a common palm in the region, can be seen in pockets in the outskirts of the forest. *Ficus tinctoria*, *Syzygium heyneanum*, *Mellastoma* spp., and *Aegle marmelos* occur along the bank of stream and river course. The shrubby vegetation in the forest is sparse and is chiefly constituted of *Ziziphus mauritiana*, *Strobilanthes* sp., *Woodfordia fruticosa*, *Acacia* spp., *Carissa opaca*, *C. spinarum*, *Nyctanthes arbor-tristis*, *Holarrhena antidysenterica*, etc. Thickets of *Ricinus communis* can be seen frequently around the habitations and villages. *Dendrophthoe falcata*, is a common epiphyte on *Madhuca indica* and *Diospyros melanoxylon* tree. *Cuscuta reflexa*, a parasite plant, is met with very commonly on moderate-sized trees along roadside. *Bauhinia vahlii* is a common liana in the forests, whereas *Dioscorea* sp., *Cissempelos* sp., *Butea superba* and *Zizyphus oenophila* are the usual climbers.

The herbaceous elements on the forest floor chiefly comprise grasses followed by *Ageratum conyzoides*, *Blumea spp.*, *Leucas aspera*, *Micromeria biflora*, *Mazus japonicus*, *Sida rhombifolia*, *Sonchus* spp., *Oxalis acetocella*, *Achyranthes aspera*, *Justicia simplex*, *Chenopodium album*, *Amaranthus spinosa*, *Euphorbia hirta*, *E. thymifolia*, *Ajuga* sp., *Commelina benghalensis*, *Hyptis suaveolens*, *Crotalaria juncea*, *Desmodium gangetica*, *D. triflorum*, *Cynotis* sp., etc. in the terrestrial habitats. In the open wasteland, exotic weeds, viz. *Hyptis suaveolens*, *Parthenium argentatum*, *Lantana camara*, *Argemone mexicana*, and *Xanthium strumarium* grow gregariously. Around marshy places and along the water course *Scirpus* sp., *Cyperus rotundifolia*, *Carex* sp., *Ammania baccifera*, *Centenella* sp., *Rumex* sp., *Polygonum plebieum*, *P. serrulatum*, *Mentha arvensis*, *Rotala rotundifolia*, *Eriocaulon quinquangulare*, *Jussieua repens*, *Hygrophila auriculata*, *Pimpinella tomentosa*, *Solanum xanthocarpum*, *Ocimum americanum* and *O. sanctum* occur abundantly. *Typha latifolia*, *Nymphoides indica*, *Potamogeton purpurascens*, *Lemna paucicostata*, are the aquatic plants of lakes, ponds and waterlogged areas. Ferns such as *Dryopteris prolifera*, *Adiantum philippensis*, *Diplazium esculentum*, etc. and lycopods, viz. *Selaginella semicordata*, *Lycopodium cernuum*, etc. are seen luxuriantly in damp and shady depressions.

MATERIAL AND METHOD

Altogether, six surface samples (surface soils) were collected in linear transect at 100m interval, each along the open area on the way to Sehore (adjoining to Budhani Township, where tropical deciduous teak dominating forests are luxuriant) in Sehore District to study the interplay of pollen assemblages and existing vegetation in the region.

Ten grams of surface soils were boiled in 10% aqueous KOH solution for 5 minutes to deflocculate the pollen/spores from the sediments and to dissolve the humus, followed by treatment of the samples with 40% HF solution in order to remove silica. Subsequently, the samples were acetolysed (Erdtman 1943), using acetolysis mixture of acetic anhydride and concentrated sulphuric acid, respectively in the ratio of 9:1. Lastly, the samples were prepared in 50% glycerin solution for microscopic examination.

The pollen sums range from 465 to 976 in the pollen analysed samples, depending upon

their potential. The percentage frequencies of the recovered taxa have been calculated in terms of total terrestrial plant pollen. The pollen of aquatic plants and fern spores have been excluded from the pollen sums because of their origin from the local sources. For the proper identification of fossil palynomorphs (Pollen plate 1) in the sediments the reference pollen slides available at the sporothek of BSIP Herbarium as well as the pollen photographs in the published literature (Chauhan & Bera 1990, Nayar 1990) were consulted. The plant taxa categorized as trees, shrubs, herbs, ferns, drifted, algal remains and fungal spores and have been arranged in the same manner in the pollen spectra. The pollen frequencies of < 0.5% are indicated by '+' sign in the pollen spectra.

MODERN POLLEN RAIN COMPOSITION

Six surface soils, which are commonly used as a collecting and preserving medium for modern pollen deposition from surrounding vegetation, were pollen analyzed from the open area on the road to Sehore District (Text-figure 2) to explore the relationship between pollen, vegetation and climate. The pollen assemblages have unravelled the dominance of NAPs over the APs. Among the tree taxa, *Madhuca indica* (2.94-37%) followed by Sapotaceae (2.14-8.24%) are recorded consistently with high frequencies. *Tectona grandis*, a dominant forest constituent, is recovered with av. 1.087% pollen only in the sediments. However, the rest of the tree taxa contribute with average frequency of 3.81% pollen only. The shrubby elements are a few and are represented by an average pollen value of 2.12% only. The drifted taxa such as *Pinus*, *Cedrus* and *Alnus* are meagerly present.

The non-arboreals are characterized by the steady presence of Poaceae (14.4-60.64%) in much increased frequencies. Cerealia has been frequently recorded with an av. frequency of 5.42% pollen. The culture pollen taxa such as Cheno/Am, Caryophyllaceae, Brassicaceae, *Cannabis sativa*, *Artemisia*, *Alternanthera*, and *Ricinus* contributed with an average value of 5.77% pollen, however, the heathland taxa have an average pollen frequency of 13.69% in the pollen rain. Among the marshy elements, Cyperaceae (2.2-12.2%) is marked by its consistent representation with moderate to high frequencies, whereas *Solanum*, *Hygrophila*, and *P. plebeium* (<0.5% each) are recorded in extremely low frequencies. *Typha* (<0.5-11.36%) and *Lemna* (< 0.5-7.09%) represent the aquatic vegetation. Trilete fern spore and lycopods (<0.5-1% each) are encountered in low frequencies. The fungal spores such as *Glomus*, *Diplodia*, *Tetraploa*, *Nigrospora*, *Cookeina*, *Alternaria*, *Helminthosporium*, Microthyriaceae, etc. have been encountered in variable frequencies while analyzing the samples.

DISCUSSION

The overall pollen rain composition of the pollen analysed surface samples revealed relatively lower frequencies of arboreals (trees & shrubs) over the non-arboreal taxa. *Tectona grandis* (Teak), a dominant forest constituent, is recovered with av. 1.087% pollen only in the sediments, despite being an enormous pollen producer. The under-representation of *Tectona grandis* pollen could be attributed to its poor preservation in the sediments as well as low dispersal efficiency. Similar observations have also been made regarding the ambiguous behaviour of teak pollen from other regions of central India (Quamar & Chauhan 2010, 2011a). The high pH value of soil and microbial degradation of its pollen in the sediments might have been detrimental factors for the scarcity

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Plate 1

1. *Tectona grandis*. 2. *Syzygium*. 3. *Schleichera*. 4. *Mitragyna*. 5. *Ailanthus excelsa*. 6. *Aegle marmelos*. 7. *Emblica officinalis*. 8. *Holoptelea*. 9. *Madhuca indica*. 10. *Grewia*. 11. *Lagerstroemia*. 12. *Lannea coromandelica*. 13. *Acacia*. 14. *Alternaria*. 15. Poaceae. 16. Cerealia. 17. Cheno/Am. 18. Caryophyllaceae. 19. Brassicaceae. 20. *Artemisia*. 21. *Alternanthera*. 22. *Cannabis sativa*. 23. Tubuliflorae. 24. Cyperaceae. 25. *Polygonum plebieum*. 26. *Typha*. 27. Monolete fern spore 28. Trilete fern spore. 29. *Glomus*. 30. *Tetraploa*. 31. Microthyriaceae.

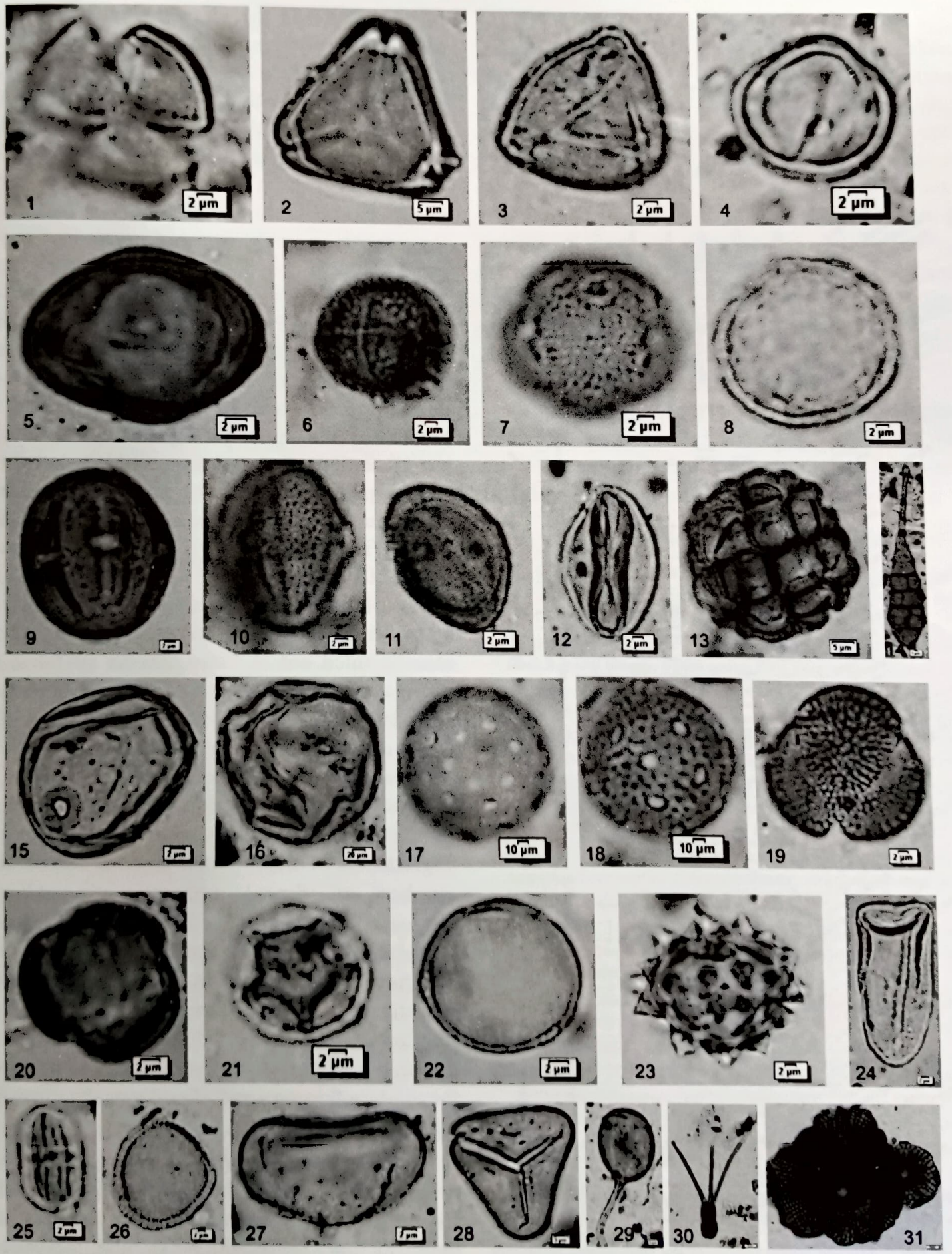
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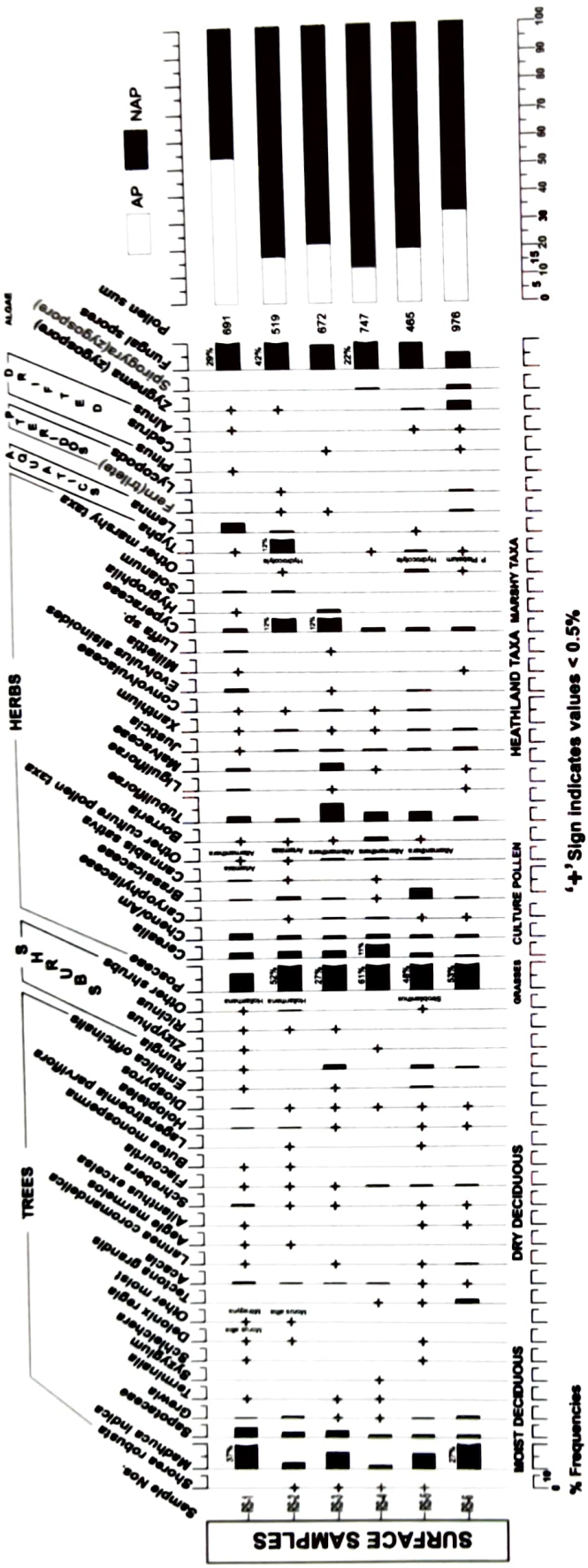
Plate 1



Text-figure 2. Modern pollen spectra of the studied area in Sehore District, Madhya Pradesh.

of teak pollen in the sediments (Gupta & Yadav 1992). On the other hand, the consistent presence of *Madhuca indica*, a common associate of teak, and Sapotaceae with highest frequencies of 37% and 8% respectively, suggests the local abundance of these taxa around the site of investigation coupled with good preservation of their pollen in the sediments. In addition, *Grewia* and *Acacia* (av. approx 1% each), and *Flacourtia* (0.67%) are encountered almost in the order of teak. However, a number of trees such as *Terminalia*, *Syzygium*, *Lagerstroemia*, *Emblica officinalis*, *Holoptelea*, *Diospyros*, *Butea*, *Mitragyna*, *Lannea*, *Aegle marmelos*, *Ailanthus excelsa*, *Schrebera*, etc. occurring in a good proportion in the forest are marked by their infrequent presence. The under-representation of these taxa could be attributed to low pollen productivity, since they exhibit a strong tendency of entomogamy (Chauhan 1994, 2008, Vincens et al. 1997, Quamar & Chauhan 2007, 2010, 2011a). The partial preservation of their pollen in the sediments as well as differential recognition of poorly preserved grains cannot also be ruled out. A large number of trees, viz. *Adina cordifolia*, *Buchanania lanzan Chloroxylon sweitenia, Boswellia serrata*, *Mangifera indica*, *Melia azadirach*, *Ficus religiosa*, *F. benghalensis*, *Annona squamosa*, *Anthocephalus* spp., etc. also occurring in the forest remain untraceable in the samples possibly due to the microbial degradation of their pollen since a considerable number of fungal remains, viz. *Glomus*, *Diplodia*, *Nigrospora*, *Tetraploa*, *Alternaria*, *Helminthosporium*, *Cookeina*, *Microthyriaceae*, etc. have come across in the sediments during investigation. Furthermore, it is surmised that a fraction of average 24.42% tree pollen, including the preponderant *Madhuca indica* pollen, reflects the modern floristics and also attests the prevailing climate in the region.

Among the non-arboreals, the high frequencies of grasses followed by Tubuliflorae, Cyperaceae, Cheno/Am, etc. correspond more or less with their factual composition in the herbaceous vegetation in the region. The record of Cerealia

and other culture pollen taxa, viz. Cheno/Am, Caryophyllaceae, Brassicaceae, *Cannabis sativa*, *Artemisia*, *Alternanthera* and *Ricinus* in the samples reflects the agriculture practice and other human engagements in the area of investigation. Further, presence of sedges (Cyperaceae) together with other scanty marshy taxa, viz. *Hygrophila*, *Solanum*, *Polygonum plebeium* and *Hydrocotyle* along with aquatic elements, *Typha* and *Lemna* points to the intermittent water-logging and wetlands near the provenance of the samples. The occurrence of drifted pollen of *Pinus*, *Cedrus* and *Alnus* (in low frequencies) from sub-tropical and temperate regions suggest the Himalayan connection of wind circulation pattern. The record of trilete fern spores and lycopods indicate humid climatic condition as fern and its allies grow best in moist and shady locations.

CONCLUSIONS

From the perusal of the aforementioned discussion, it has, thus, become clear that trees and shrubs (APs) are recovered in lower frequencies as compared to the herbs (NAPs). The average representation of trees in the pollen rain is 24.42%, whilst shrubs scarcely contributed with an average value of 2.12% pollen, representing the modern tropical deciduous forests in the area under investigation. On the other hand, the non-arboreals (NAPs) mainly comprising grasses (av. 39.01%), cerealia (av. 5.42%) and other culture pollen taxa (av. 5.77%), heathland taxa (av. 13.69%) manifest the bigger fraction with average pollen of 63.89% in the total pollen rain. However, approximately 10% pollen is shared by the sedges (Cyperaceae) and other marshy elements in the total pollen rain. The pollen rain composition, thus, is comparable to the actual vegetation of the area in question, so far as NAPs are concerned, however, the APs are partly in unity with the modern vegetation. In a nutshell, it is concluded that the present day set up of vegetation can be well differentiated by their modern pollen assemblages. This information on the relationship between modern pollen rain and present-day set up of vegetation has been taken as a modern analogue for the precise demarcation of the pollen sequences generated from the sedimentary bed in terms of palaeovegetation and palaeoclimate in chronological order in the region as well as other alike floristic regions of the tropics. From the available information, the physiognomic aspects of trees, i.e. whether they are dry, moist or evergreen/semi-evergreen, can be determined. The present study also symbolizes the prevailing climatic condition of the study area.

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