

Pollen dispersal and sedimentation in tropical sal forest of Madhya Pradesh*

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The pollen dispersal and sedimentation study in tropical sal forest of Madhya Pradesh has enabled to understand modern pollen/vegetation relationship and to interpret the pollen diagrams from the area in term of origin and history of tropical forest and past climate. The pollen analysis of various surface samples and sediments reveals that about 42% of sal pollen is deposited at ground level, 35% at trunk space (4 m) and 12% at top canopy (10-12 m) of the sal forest. A small quantity of sal pollen is preserved in moss polsters and water. However, lower percentage of sal pollen (2-4%) is deposited in ground soil whether collected within or outside the forest. The reason for diverse deposition of sal pollen in surface samples and sediments has been discussed.

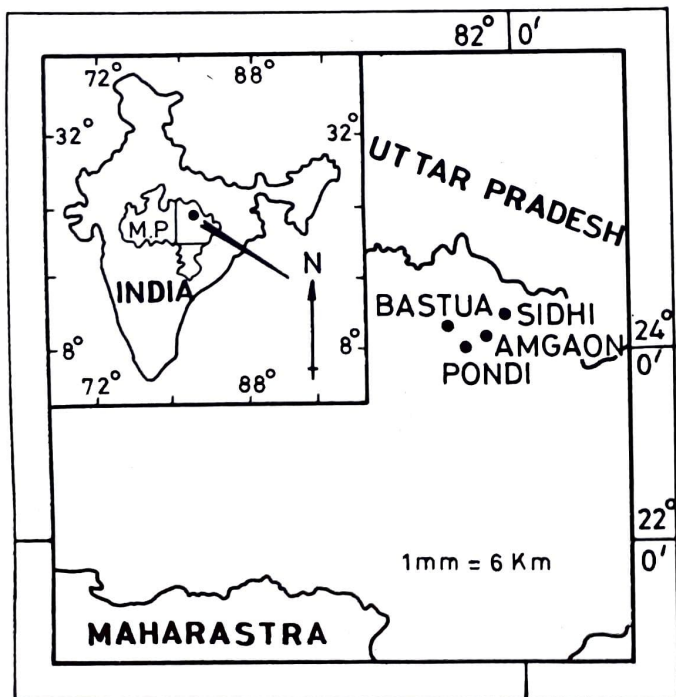
Key-words—Palynology, Pollen dispersal, Sal forest, Madhya Pradesh, India.

INTRODUCTION

HITHERTO work on production and dispersal of pollen has been carried out in India on *Holoptelea integrifolia* (Nair, 1965; Khandelwal & Vishnu-Mittre, 1973), *Mimosa rubicaulis* (Saxena & Vishnu-Mittre, 1977) and

Shorea robusta (Bera, 1990). The present study also conducted on four sites, viz., Pondi, Bastua, Amgaon and Tingi of Sidhi District in Madhya Pradesh (Text-fig. 1).

The forest is generally composed of *Shorea robusta* constituting 80-90% of the total forest vegetation. Other common arboreal taxa are *Madhuca indica*, *Buchanania lanzan*, *Diospyros melanoxylon*, *Emblica officinalis*, *Terminalia arjuna*, *Anogeissus latifolia*, *Sterculia urens*, etc. The shrubs and under-shrubs are represented by *Woodfordia fruticosa*, *Carissa opaca*, *Adhatoda vasica*, *Vitex negundo* and *Melastoma malabaricum*, etc. The herbaceous vegetation is comprised grasses and *Majus japonicus*, *Ajuga* sp., *Ageratum* sp. and *Argemone mexicana* etc. A pollination calender of few major taxa of sal forest is made which can be very useful for the present study (Text-fig. 2).

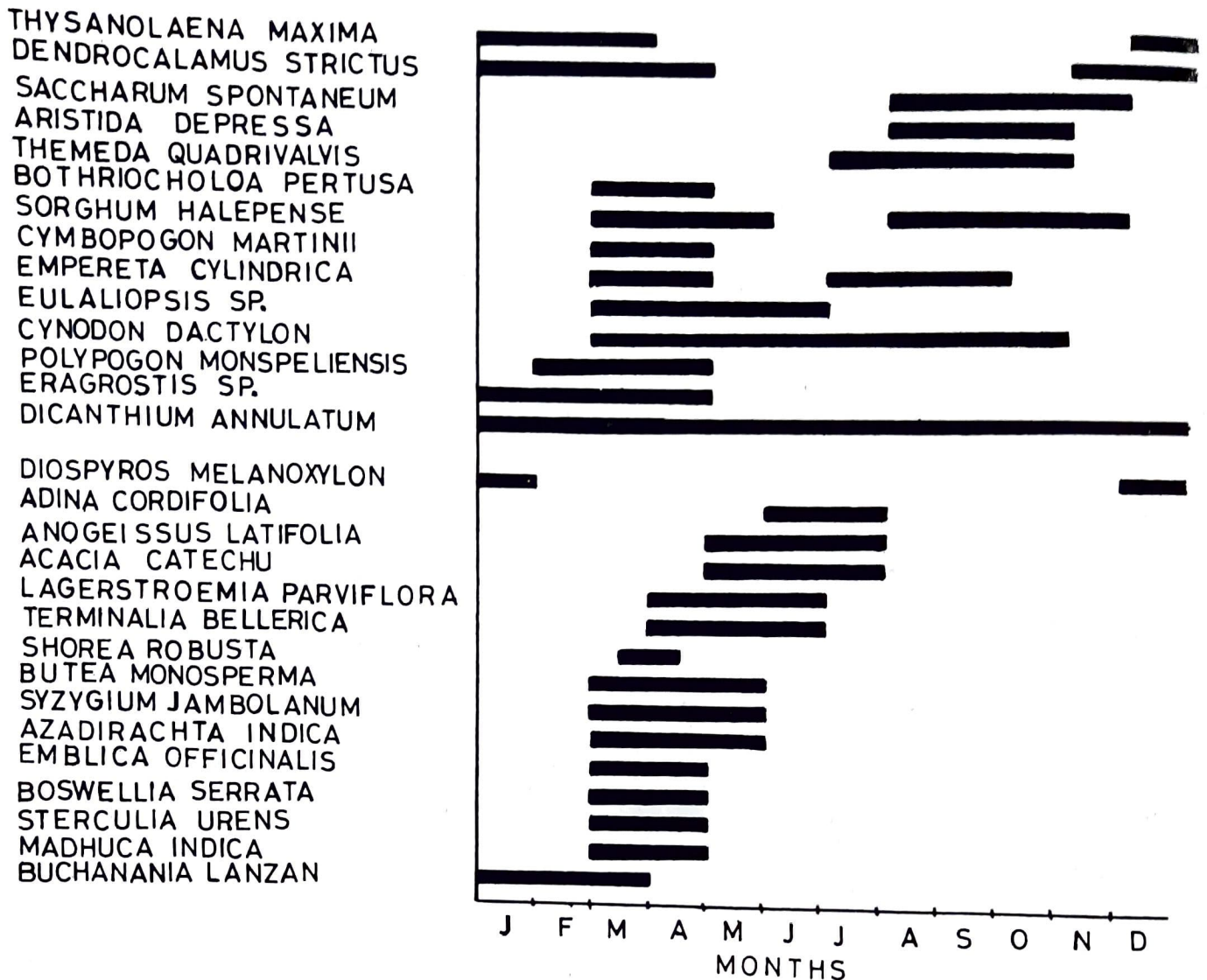


Text-figure 1. Map showing the Sampling sites

POLLEN ANALYSIS

Thirty six slide exposures, twenty seven petridish exposures, forty-two moss cushion samples, soil samples and seventeen water samples collected in a transect across Pondi, Bastua, Amgaon and Tingi of Sidhi District, Madhya Pradesh and were acetolysed following the conventional technique of acetolysis. All the pollen spectra have been constructed on the basis of total sum of land plants pollen.

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Text-figure 2. Pollination calendar of a few major taxa of sal forest, Sidhi, Madhya Pradesh

POLLEN DISPERSAL

The study of pollen dispersal was conducted through a series of different types of samples along the depth of the forest as well as the open area in order to know the vertical and horizontal dispersion of pollen in the forest. The pollen analytical data from within the forest and open land is separately presented in the following manner.

A. Pollen dispersal within the forest

The experiment conducted is confined to 36 slides exposed along the heights of sal forest in the sites namely Amgaon, Pondi and Bastua. The results obtained from different sites are given below.

Amgaon. - The area is confined with the indigenous sal forest and the open area is under intensive cultivation.

The pollen spectrum records average 46% sal pollen deposited on the ground floor, 37% at the trunk space (4-5 m) and 8% at the top canopy (10-12 m). The other tree taxa recorded are *Madhuca* (3-12%), *Buchanania*

(7-14%), *Emblica* (10%) and *Syzygium* (10-12%). Amongst non-arboreals the dominant taxa are Poaceae (5-21%) and other, like Scrophulariaceae, Acanthaceae, ranging from 5-12%.

Pondi - The forest is dominated by *Shorea robusta* and other components are represented by *Madhuca*, *Buchanania*, *Diospyros*, etc. *Butea monosperma* and *Sterculia urens* show their profuse growth in open areas. The shrubby vegetation is very rare within the forest but a few taxa like *Carissa opaca*, *Woodfordia fruticosa*, etc. are observed along the stream.

The pollen spectrum depicts average 43% sal pollen deposited on the ground floor, 32% at the trunk space and 10% at the top canopy. Other tree taxa present are *Madhuca* (1-7%), *Buchanania* (13-22%), *Butea* (5-7%) and *Syzygium* (5-12%). The non-arboreal taxa are represented by Poaceae (2-8%), Scrophulariaceae (5%), Acanthaceae (6%) and Asteraceae (4%).

Bastua - The Forest composition is more or less similar as in Amgaon and Pondi except for *Butea*

monosperma occupying open areas. *Adhatoda*, *Woodfordia*, *Strobilanthes*, *Ziziphus* and *Melastoma*, etc. grow along the water courses.

The pollen spectrum records average 37% sal pollen deposited on the ground floor, 36% at the trunk space and 18% at the top canopy. The other associated tree taxa are *Madhuca* (7-13%), *Anogeissus* (2-20%), *Buchanania* (3-16%), etc. Among non-arboreals the taxa represented are *Poaceae* (2-6%), *Scrophulariaceae* (9%), *Acanthaceae* (5%), *Rubiaceae* and *Asteraceae* (5%) each.

B. Pollen dispersal in the open area

The experiment is confined on thirty seven petridish exposures across forest edge to the open area at an interval of 10 meter distance of which 11 each in Amagaon and Pondi and 15 at Bastua were exposed. The results obtained from different sites are described separately.

Amgaon -The area is brought under cultivation and the vegetation is composed of grasses and a few stands of *Adhatoda*, *Woodfordia*, etc. could be seen scatteredly.

The pollen spectrum shows 70% sal pollen at the edge of the forest and declines upto 4.5% at the distance of 40 meter away from the forest. Along with sal pollen other arboreal taxa like *Buchanania* (3-27%), *Madhuca* (9-24%), *Embllica* (3-19%) and *Syzygium* (3-12%) are also recorded. Amongst non-arboreals, *Poaceae* is in highest frequency (34%) but *Lamiaceae*, *Acanthaceae*, *Asteraceae*, etc. are present in very low values.

Pondi -The whole flat open area is occupied with cultivation and the vegetation is comprised mostly grasses, *Butea monosperma* and *Diospyros melanoxylon* grow along the cultivated lands. The river 'Kormar' is flowing through the open area and *Syzygium* grows along its banks.

The pollen spectrum depicts 32% sal pollen at the edge of the forest and declines upto 9.5% at the distance of 20 meter away from the forest. The other arboreal taxa represented are *Madhuca* (1.5-17%), *Buchanania* (5-19%), *Embllica* (2-17%), *Lannea* (3-10%), etc. Among non-arboreals, *Poaceae* occupies the highest rank, i.e., 28%, whereas *Acanthaceae*, *Rubiaceae*, *Apiaceae*, *Asteraceae*, etc. are at very low values.

Bastua -The open area is covered partly by cultivation and plantation of *Acacia* and *Eucalyptus*.

The pollen spectrum records 70% sal pollen at the edge of the forest and declines upto 11% at the distance of 40 meter away from the forest. The other regular representatives of arboreals are *Madhuca* (2-34%), *Buchanania* (2-27%), *Embllica* (2-9%), *Lannea* (2-10%), etc. Among non-arboreals, *Poaceae* shows highest values (38%) whereas *Acanthaceae*, *Rubiaceae*, *Apiaceae* are low. Sal pollen dispersal through forest edge to open area

records an average of 38% ranging from 70-4.9%. This shows the gradual decline of sal pollen with the increase of distance.

POLLEN SEDIMENTATION

The study on deposition and sedimentation of sal pollen was carried out in four localities, viz., Pondi, Amgaon, Bastua and Tingi in the Sidhi District within and the vicinity of sal forest. A collection of samples along transects across the forests was made. The object of this study is to understand the settlement of pollen of both ground and water surface.

This study has been divided into the following phases.

A. Pollen sedimentation within the sal forest

- a. *On moss cushion from the edge to within the forest*—
 - i. The study shows irregular sal pollen frequency because at Amgaon, no pollen is recorded at the forest edge but inside the forest they are 25.5%. However, while reaching 450 m outside the forest the values have dramatically reduced to 3.5%. At Pondi, it is 19% at forest edge and 7% at 450 m. At Bastua, it is 10% at forest edge, and 20% at 100 m. At Tingi, it is only 2% at forest edge and 22% at 100 m.
 - ii. Along with *Shorea robusta*, other tree taxa represented at Amgaon are, *Madhuca* (3-13%), *Embllica* (1.5-17%) *Buchanania* (2%), *Anogeissus* (4-7%); at Pondi, *Madhuca* (5-19%), *Anogeissus* (2-8%), *Embllica* (2-7%); at Bastua, *Madhuca* (1-4%), *Anogeissus* (1-4%), *Syzygium* (1-3%); at Tingi, *Madhuca* (2-28%), *Embllica* (2-5%), *Anogeissus* (2-7%), *Terminalia* (3-5%) and *Lannea* (5%).
 - iii. Grass and *Cyperaceae* are recorded in highest frequency, i.e., 54% and 17% at Pondi, 47% and 13% at Amgaon, 15% and 2% at Bastua and 36% and 13% at Tingi, respectively.
- Trilete fern spores maintain 60% at Amgaon (Sample No. A9), 29% at Pondi and 9% at Bastua and 13% at Tingi. The overall representation of trilete spores is largely due to luxuriant growth of ferns in the area.
- b. *On water surface within the forest*—
 - i. Sal pollen records 26% (AW₂) at Amgaon, 15% (PW₇) at Pondi and 14% (BW₂) at Bastua.
 - ii. Other arboreal taxa represented are *Madhuca* (4-8%), *Syzygium* (2.5-3.5%), *Terminalia* (5%), *Buchanania* (3%) at Pondi and *Madhuca* (9%), *Terminalia* (2.5%), *Anogeissus* (3%), *Embllica* (4%) at Bastua.
 - iii. Grass pollen are recorded upto 30% at Amgaon, 35% at Pondi and 50% at Bastua.
 - iv. *Nymphoides*, a water plant, is represented by 2-4%

at all the three sites.

- v. Trilete fern spores are represented by 4-10% at all the sites.

B. Pollen sedimentation outside the sal forest

- a. On soil in open area outside the forest-
- i. Sal pollen is 2% at Pondi and 1% at Bastua.
 - ii. Other arboreals recorded are *Madhuca* (2-7%), *Emblica* (2-10%), *Syzygium* (1-10%), *Buchanania* (2-11%) at Pondi and *Madhuca* (3%), *Anogeissus* (4-7%), *Terminalia* (1.5-15%) at Bastua.
 - iii. Grass pollen are 55% each at Pondi and Bastua, whereas sedges are 22% at Pondi and 37% at Bastua. The value of grass pollen and sedges are higher than other surface samples owing to the fact that they grow luxuriantly throughout.
 - iv. Triletes are 10% at Pondi and monolete 3% at Bastua.
- b. On water surface
- i. Sal pollen records 11% and 14% at Bastua and Pondi respectively.
 - ii. Other tree taxa represented are *Madhuca* (3%), *Buchanania* (7%), *Syzygium* (6%), *Emblica* (2.5%) and *Acacia* (8%) at Pondi, whereas *Madhuca* (9%), *Terminalia* and *Anogeissus* (3% each), *Emblica* (4%), and *Buchanania* (3%) at Bastua.
 - iii. Grass pollen are recorded by 10% each at Pondi and Bastua, but the sedges are absent. *Nymphoides* is represented by 2% only at Pondi.
 - iv. Trilete fern spores are represented by 2% at Pondi, whereas, they are 10% at Bastua.
 - v. Non-arboreals predominate the arboreals in all the samples.

MODERN POLLEN/VEGETATION RELATIONSHIP

Shorea robusta is present to the tune of 90% in the sal forest and considered to be a high pollen producer. But the present study has highlighted the facts that its pollen are not truly represented in the sediments. The main features of the study within as well as outside the sal forest are given below separately.

Modern pollen/vegetation relationship within the sal forest

- i. The study of slides exposed along the heights of sal forest has shown gradual decline of sal pollen starting from ground floor to the top of the forest, i.e., 40-50% at the ground level, 35% at 4m and 9-14%

at 10-12 m height.

- ii. The pollen analytical study of moss cushions has revealed that sal pollen are represented by 10% at the forest out side and 15% within the forest.
- iii. The study on water surface depicts sal pollen deposited with the value of 15% within the forest and 9% outside the forest.
- iv. *Madhuca indica* and *Syzygium* have comparatively much higher value than those of other trees, and their representation is almost same at the edge and within the forest.
- v. The grasses predominate over the sedges, both within the forest and at the edge of the forest.
- vi. The trilete fern spores show their consistent occurrence and comparatively much higher values than the monolete fern-spores both at the edge and within the forest. The much higher value of trilete fern-spores are observed in pollen spectrum (A9) which may be due to the local factor.
- vii. The other herbaceous and shrubby taxa show their low value and similar representation both at edge and within the forest.
- viii. The dominance of AP over NAP is observed on slides exposed within the forest, whereas the reverse case has been observed on moss cushions and water surface within the forest.

Modern pollen/vegetation relationship outside the sal forest

- i. Sal pollen dispersed and deposited through open areas on petridishes with the value of average 38% ranging from 4.5-70%. The study also reveals the decline of sal pollen frequency with the increase of distance from the forest.
- ii. Sal pollen deposited in soil has revealed a considerable reduction of pollen with the increase of distance.
- iii. Sal pollen, deposited on water surface are 9% outside the forest.
- iv. *Madhuca indica*, in sample no. PT-25, is the second highest arboreal from Bastua. Others have no remarkable occurrence except for *Buchanania* and *Emblica* at Amgaon.
- v. The grasses are higher than sedges in the open area.
- vi. The non-arboreal pollen, in general, dominates the open land which also cohere the present day vegetation.
- vii. Trilete continues to be higher throughout.

DISCUSSION AND CONCLUSION

The results of pollen production in *Shorea robusta* is correlated with the study of its pollen dispersion and

sedimentation to understand modern pollen/vegetation relationship.

Pollen production—The trees of *Shorea robusta* produces short stalked yellowish flower, unilaterally on the racemose branches of axillary panicle. The number of stamens varies from 29-46 per flower. The total production of pollen grain is 61,020 per flower in a tree growing along the periphery of the forest at Pondi and up to 94,600 pollen grains per flower in a tree growing at Amgaon. A twig bearing about 40 million flowers will produce pollen ranging between 3.3×10^{14} to 6.2×10^{14} . Thus 80 trees of *Shorea robusta* growing per hectare will produce 3.5×10^{16} pollen grains in brief period of flowering in summer every year from middle of March to 1st week of April.

Pollen deposition and sedimentation - Three strategies for collection of samples adopted are mentioned below.

Strategy-A

The deposition of pollen grains on slides and petridishes coated with glycerine falls within the perview of Strategy A. The following two experiments were conducted.

- Ai. Slides were exposed at different heights of the forest to get information of vertical pollen deposition within the forest.
- Aii. Petridishes were exposed starting from the forest edge to open areas which provides information on horizontal deposition and dispersal of pollen.

Strategy-B

The deposition of pollen on moss polsters and on water surface falls within its perview. The following two

experiments were conducted.

- Bi. Moss polsters were collected at suitable intervals from within the forest to open land which provided information on horizontal deposition of pollen.
- Bii. The water samples collected from within and outside the forest were analysed for pollen content.

Strategy-C

The deposition of pollen on soil surface of the forest falls within this perview. The following experiment was conducted.

- Ci. Samples of surface soil collected from within and outside the forest were analysed for pollen contents. The results obtained are put in the tables and discussed below.

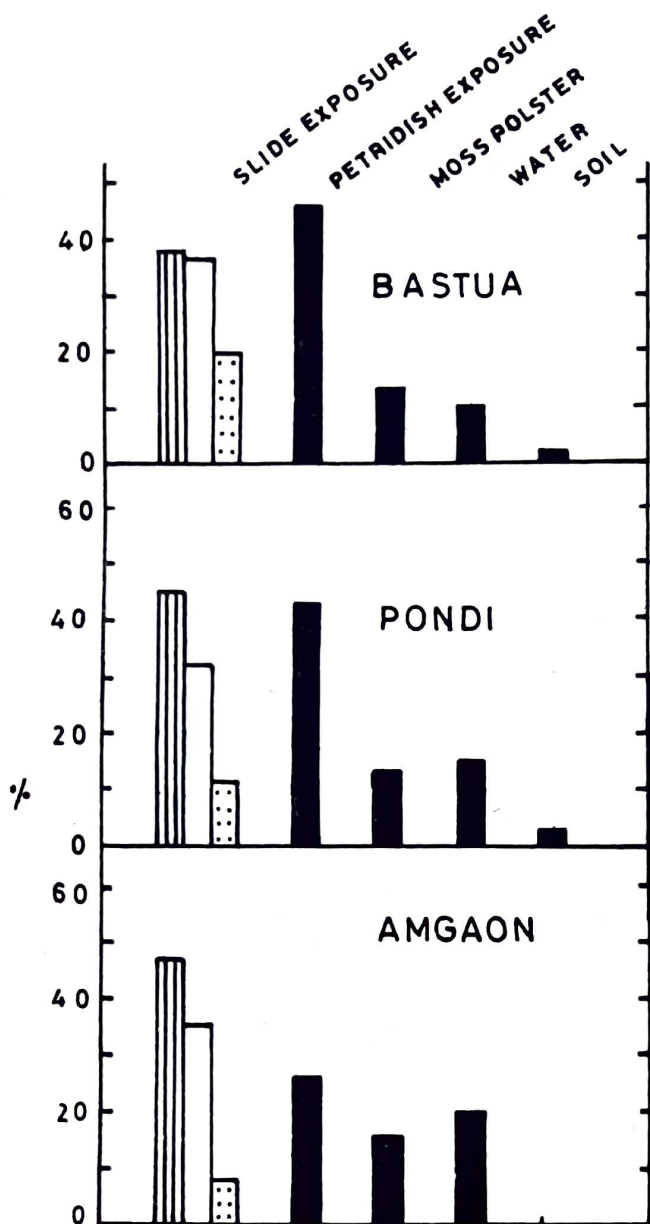
The experiment Ai (Table 1) under Strategy A shows that sal pollen deposited at canopy is 12% (8-18%), at 4-8 m height from the ground is 35% (32-37%) and at ground level it is 42% (37-46%). The experiment Aii (Table 2) under Strategy A shows that at the forest edge 38% sal pollen is deposited and beyond it within an area of 30 m from the forest edge the sal pollen records gradual reduction.

Table 1. Percentage frequency of sal pollen observed at different heights of sal forests in Pondi, Bastua and Amgaon area

Locality	At ground level	AT 4-8 m height	At 10-12 m height
Bastua	37	36	18
Amgaon	46	37	8
Average	42	35	12

Table 2. Percentage frequency of sal pollen recorded in different localities

Locality	Site of exposures (I, II & III denotes southern, eastern and western periphery of the forest respectively)	Edge of the forest	No. of samples	Open areas (at 10 m interval away from periphery)				No. of samples
				10m	20m	30m	40m	
Pondi	I	32	1	27	22	17	9.5	4
	II	27	1	16	13			2
	III	26	1		22			2
	Average	28						
Bastua	I	70	1	35	13	10	7	4
	II	37	1	33	26	19	16	4
	III	32	1	26	18	14	11	4
	Average	46						
Amgaon	I	70	1	34	13	9	4.5	4
	II	22	1	16	12			2
	III	31	1	20	13.5			2
	Average	41						



Text-figure 3. Average sal pollen frequency in various surface samples at ground level and at different heights of Sal forest, Sidhi, Madhya Pradesh Ground level, 4m above ground level, 10 m above ground level, other surface samples.

Emblica officinalis 5%, *Anogeissus* 4%, *Terminalia* 3%, *Syzygium* 3% and *Poaceae* 27%.

The experiment Bii based on water samples has recorded *Madhuca indica* 6%, *Emblica officinalis* 3%, *Buchanania lanzan* 4% and species of *Terminalia* 3%, *Syzygium* 5%, *Nymphoides* under 4.5% and *Poaceae* 24%.

The experiment Ci carried on soil samples has recorded *Madhuca indica* 3.5%, *Emblica officinalis* 5%, *Anogeissus* and *Terminalia* 5% each and *Poaceae* 34%.

The grass pollen are highest (34%) in the soil samples both from forest and openland. The high frequency of grasses and other wind dispersed pollen is largely due to the fact that they have splendid growth all around the cultivation zone.

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