Chapter III

Modern pollen study from surface peat samples

3.1 Introduction

Studies on modern pollen vegetation patterns and relationships provide a factual basis for the reconstruction of past vegetation through the extrapolation of modern analogues backwards in time. The potential sensitivity and resolution of pollen analysis reflecting the vegetation used as a tool for palaeoecological reconstruction can be assessed by modern pollen study This also provides insight into the accuracy of the pollen data reflecting the vegetation at geographical and vegetational scales (Birks and Gordon, 1985) The importance of studying modern pollen assemblages and pollen representation factors in relation to contemporary vegetation can be seen from the fact that this approach has been successfully used in the reconstruction and sophisticated interpretations of the vegatation history (Birks and Birks, 1980).

The local pollen deposition is deposition on the site itself The vegetation type can be easily identified by its pollen assemblage, due to high representation of herbaceous pollen types from the local vegetation present in the samples. The regional pollen deposition is found at some distance from the source of pollen dispersal The deposition of these regional pollen within a particular formation of the vegetation by and large remains constant (Janssen, 1972).

3.2 Pollen and spore assemblages

Pollen and spore assemblages preserved in sediments, are either of terrestrial, freshwater, or marine origin. The pollen grains and spores categorized under microfossils, liberated from plant communities living in the geological past, are very good proxy indicators and hence are used for reconstructing the vegetation and climatic changes that occurred in the past These microfossils are very small, generally falling into the 5 - 500 micro-millimeters range, and are found in rocks of all geological ages. Most palynomorphs are produced by flowering plants, Gymnosperms and also ferns and mosses, and some algae The most widely-studied group of microfossils are pollen grains and spores produced by plants. Pollen grains and spores are about the same size, are dispersed and deposited in similar ways, and are often found together.

Pollen grains are dispersed widely over the landscape, mainly by wind Much of the pollen falls to the ground or is washed from the atmosphere by rain and ultimately becomes part of sediments, especially the mud accumulating on the floor of lakes. Most pollen grains are extremely resistant to decay and are preserved in large numbers in many types of sediments.

Pollen grains are made up of two layers. The outer exine is composed of *Sporpollenin* (Zetsche, 1932), together with smaller quantities of polysaccharides (Rowely *et al.*, 1981) sometimes also referred to as glycocalyx. The inner layer or intine is made up of cellulose which is a major constituent (Brooks and Shaw, 1968b), along with other chemical substances like callose, pectic substances, polysaccharides, proteins and enzymes (Knox and Heslop-Harrison, 1969) plant cell wall. During fossilization only the resistant exine sporopollenin remains, and it is this that carries the characteristic feature and sculpture of pollen grains that are found relatively intact and identifiable after thousands or millions of years in burial

3.3 Identification of pollen grains

The morphological characters of pollen grains are very important in identification. The exine ornamentation has to be intact for a pollen grain to be identified correctly. The other important feature is the aperture An *aperture* is a thin or missing part of the exine that is independent of its pattern. There are two types of apertures named *pori* (pores) , that is isodiametric in shape and *colpi* (furrows) which is long and boat shaped with pointed ends Grains with pores are called porate, with colpi, colpate and sometimes with both colpus and porus combined in the same aperture, colporate In the living grains apertures are not actually open A thin layer covers them and delicate layer of exine substance and intine found under these apertures are usually thicker than elsewhere on the grain Based on the numbers of these apertures the pollen grains are divided into different groups (Moore *et al*, 1991)

3.4 Earlier studies

Montane regions have been selected for most palynological investigation as they provide very crucial information in the study of vegetation history during the late

Quaternary period. Montane regions are preferred as their vegetation is particularly responsive to climate change and bogs occur frequently in some montane regions (Morrison, 1968). The modern/surface pollen studies helps in interpreting the late Quaternary pollen assemblages They provide a basis for reconstructing the vegetation history The surface peat and pollen assemblage can be used in understanding the pollen distribution of the surrounding vegetation.

The surface peat samples can be used to record the modern pollen rain of the various surrounding vegetation types that are essential for the interpretation of fossil pollen floras in the reconstruction of the past vegetation and climate changes. The lake or bog deposits are known to have an amalgamation of pollen from all the surrounding communities (Birks and Birks, 1980) The transect of surface samples was recommended by (Wright, 1967) The uppermost stratum of peat bogs and living moss cushions by means of surface sampling was analyzed for the pollen content (Hedberg, 1954) in the earliest study of modern pollen rain on the East African mountains. A study by modern pollen rain along the gradient on the Tropical East African mountains has been made by (Hamilton and Perrott, 1980) and in Ethiopia it was initiated by (Bonnefille and Buchet, 1986)

Investigations based on Modern pollen assemblage using surface samples are very few from India. The study of Bera and Gupta, (1992) from Anamalai hills, Tamil Nadu has revealed that the occurrence of forest by virtue of being rich in tree pollen within the thickets of shola wood and reduction of tree pollen is observed proportionately to the distance of the forest patch. Another surface pollen investigation from Tarai-Bhabar in Kumaon division of Uttar Pradesh (Gupta and Yadav, 1992) indicate that the relative percentage of pollen and spores preserved in the sediment does not necessarily correspond to factual floristic composition A few pollen types are either over represented or under represented. Similar behavior has been noticed from Garhwal, Himalayas Surface sample investigated from Sal forest region are almost devoid of Sal

However, despite the discrepancies in the representation of pollen with respect to their vegetation types, several other pollen markers that enable their distinction is shown from other pollen studies from South India and Sri Lanka (Bonnefille, et al , 1999, Anupama et al , 2000, and Barboni and Bonnefille, 2001)

3.5. Objectives

The variation and distribution in modern pollen rain from different vegetation types (shola-grassland-peat bog) in the Nilgiris hills of Western Ghats, southern India is carried out in this present study to understand their relationship with the present-day vegetation and the fossil pollen spectra.

3.5.1 Materials and methods

The vegetation sampling of these peat bogs, the surrounding shola forest and the grassland has been carried out The results of which are reported in the earlier chapter on vegetation The sites where surface samples were taken are indicated on the map (Fig. 1 4 and 1 5) in Chapter II

3.5.2 Collection of modern/surface peat samples

Surface peat samples were collected from basins in the higher altitude region. Top 5 cm of the surface samples were collected from peat bogs. The samples were collected at a regular distance of every 20 m distance from a transect laid for vegetation sampling on these peat bogs. Ten samples were collected from Sandynallah basin, fifteen from Varahapallam basin and ten from Bangitappal basin The modern pollen assemblage is studied by analysing the pollen content retrieved from the surface peat samples.

The surface samples are collected on a peat bog transect in all the sites The grasslands are closer to the transect than the forest patches. Shola patches close to the surface sampling sites were found only in Bangitappal and Varahapallam The vegetation around the sampling areas consists of a mosaic of plant communities (Shola-Grassland-Peat bog) that are largely due to the topography and soil differences

3.6 Technique for retrieving pollen grains from peat samples

The peat samples were treated chemically to retrieve pollen grains by using the technique described in Faegri and Iverson (1989) A sub sample of about 5 g from each of these surface samples were treated separately Initially the samples were dried and then treated with 10% Hydrochloric acid (HCl) to dissolve carbonates present in the sediment sample. To remove humic acids (i.e, unsaturated organic soil colloids) present in them the samples were heated with 10% Potassium hydroxide (KOH). After this the samples were treated with 48% Hydrofluoric acid (HF) for 24 hours to dissolve siliceous particles (sand, clay, etc.). Later the residue was washed with distilled water thoroughly, until it is free of acid. The residue is then filtered with 125μ sieve, which will retain the larger particles and allow pollen grains to pass through the sieve. The filtrate was then centrifuged and the residue was mixed well with glycerine. Then known quantity (22μl) of the residue was mounted on slides Then a over slip of 22 mm was placed on the residue and then sealed with DPX mountant. After the mounting the slide was used for scanning

The microscopic scanning was carried out for surface sample slides The identification and counting of pollen was carried out by (using obj X40; oc X10 of the microscope) running 44 lines per slide at regular traverses with an interval of 0.1mm to avoid recounting of the pollen grains from the previous line.

3.7 Results from pollen analysis of surface peat samples

The pollen counts were obtained from 35 surface samples from three different locations (Sandynallah, Bangitappal and Varahapallam) The counts were obtained with 10 samples each from Sandynallah and Bangitappal and 15 samples from Varahapallam site Sufficient number of pollen grains were counted for them to be statistically significant. A total of 21,570 pollen grains distributed between 114 different pollen taxa were counted and identified from their morphological characters. Appendix 2 indicates palynomorph types identified from surface pollen samples.

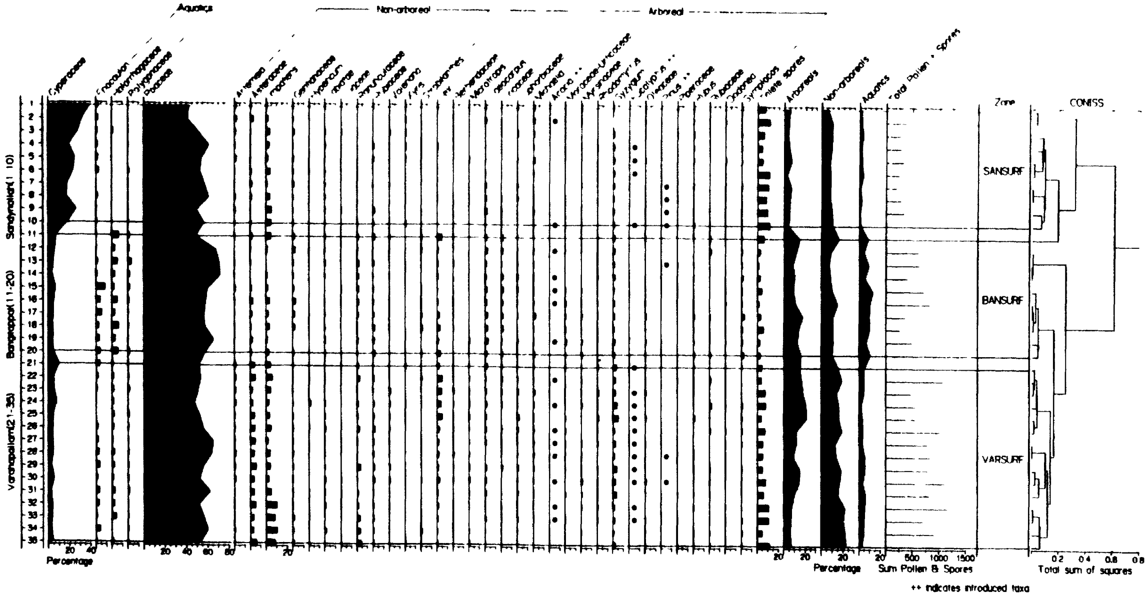
Pollen diagram is plotted with the help of TILIA Program (Grimm, 1991-92). Pollen diagram (Fig 3.1) indicates the percentage pollen of all 35 samples plotted independently Total pollen counts range from 248 to 1177 per sample. Both Pearson's and Spearman's correlation coefficients of the surface samples were calculated in order to see the level of correlation within samples and across samples from the sites. For the surface samples within Sandynallah , the Pearson's correlation co-efficient was found to be 0 93±0 03 (n=10) Sandynallah with Bangitappal samples averaged at 0.91 ± 0.06 (n=98). Sandynallah with Varahapallam showed a mean value of 0.91 ± 0.06 (n=148).

Samples within Bangitappal averaged to 0.99±0.004 (n=10) and Bangitappal with Varahapallam 0 98±0.007 (n=148), and samples within Varahapallam have mean values of 0 98±0 006 (n=15) Similarly the Spearman's correlation value within Sandynallah 0 73±0 05 (n=10), Sandynallah with Bangitappal 0.60±0.56 (n=98), and Sandynallah with Varahapallam 0.58±0 05 (n=98). The Spearman correlation values of samples within Bangitappal were 0.69±0.09 and Varahapallam 0.66±0.06 (n=15)

Sandynallah surface samples has total of 3741 grains counted from transect of 10 samples collected from the surface peat bog. The pollen counts on this transect range from a maximum of 610 to a minimum of 248 In Sandynallah it is observed that the ~~Gramineae~~ Poaceae averages to 52.6(±7.1, n=10) and Cyperaceae 24.2(±7.1, n=10). Non-arboreal and arboreal elements average to 8.4 and 4.6(±1.3, n=10) respectively. Aquatics are very low averaging to 1.7(±0.8, n=10). In these surface samples the introduced species such as *Acacia* sp, *Eucalyptus* sp, and *Pinus* sp. are encountered. This shows the degree of disturbance in an area Fig (3.1) indicates that the Sandynallah surface pollen assemblage seems to be having very low pollen deposition when compared with the surface samples of other two sites, although ~~Gramineae~~ Poaceae and Cyperaceae dominate in Sandynallah surface samples Aquatics are very low represented by taxa such as *Eriocaulon*, scanty distribution of *Polygonum*, with sporadic occurrence of Halorrhagaceae Aquatic sum excludes Cyperaceae. Among non-arboreals *Impatiens* is the most dominant taxon. Asteraceae and *Artemisia* are also represented in good numbers. Other taxa such as Gentianaceae, ~~and~~ *Xyris* ~~with scanty distribution of~~ and Labiatae ~~are observed~~ occur in low abundance Amongst the arboreal taxa the prominent ones are *Elaeocarpus* and *Syzygium* *Michelia* shows very scanty distribution Other palynomorphs such ~~such~~ as Ericaceae, Oleaceae, *Rubus* are in very low numbers Other important shola elements such as *Ilex*, Moraceae-Urticaceae, Myrsinaceae do occur in one of the samples. Trilete spores are indicated in good numbers

The surface samples of Bangitappal site have total pollen count of 5503 grains from 10 samples The counts range from a maximum of 869 to a minimum of 260 grains. Bangitappal pollen assemblages show much better representation compared to Sandynallah Although they show low Cyperaceae percentage, other palynomorphs are indicated in good numbers Cypearceae and ~~Gramineae~~ Poaceae averages to 4.7 (±1.2, n=10) and 61 1(±7.3, n=10). Other categories such as aquatics averages to 8.4(±2.5, n=10) , herbs 10.4 (±2.9, n=10), trees 12.1(±3.0, n=10) and spores 3.1(±1 5, n=10)

Figure 3.1: Pollen diagram of surface peat samples from Nilgiris, Western Ghats, south India



In the pollen diagram (Fig 3.1) it is clearly indicated that Cyperaceae has very low distribution in all the samples. Cyperaceae is even lower in Bangitappal samples, compared to Sandynallah samples. The aquatics are well represented with high percentage of palynomorphs such as *Eriocaulon*, Halorrhagaceae and *Polygonum*. ~~Gramineae~~ Poaceae is quite high in both Sandynallah and Bangitappal. Amongst non-arboreals, *Artemisia* and *Impatiens* are high in Sandynallah sample. Gentianaceae, Ranunculaceae and Rubiaceae have higher values *Hypericum*, Labiatae and *Valeriana* are present but in very low numbers Here arboreal group is indicated high compared to Sandynallah . The shola elements that are indicated in high numbers are *Ilex*, *Elaeocarpus*, *Syzygium* Oleaceae, *Symplocos*, Myrsinaceae, Moraceae-Urticaceae, *Michelia*, Euphorbiaceae and Rubiaceae The ecotone elements such as Berberidaceae, Ericaceae, *Strobilanthes*, *Rhodomyrtus*, *Rubus* and *Dodonaea* are also indicated in considerably high values. The introduced species *Acacia* sp. is indicated frequently than *Pinus* sp Spores are considerably low when compared to other two sites.

The pollen counts from Varahapallam peat bog has good surface pollen assemblage. The lower part of the pollen diagram (Fig 3 1) indicates the pollen percentage obtained from these 15 samples The total number of grains counted from Varahapallam surface peat samples are 12327, with the counts ranging from 471 to 1117

The percentage pollen of Cyperaceae and ~~Gramineae~~ Poaceae averages to 4.4 (±2.0, n=15) and 55 3(±5.2, n=15). The average values of other categories are, aquatics 3.9(±1.3, n=15), herbs 17 1(±3.2, n=15), trees 12.2(±5.0, n=15) and spores 6.8(±2.7, n=15). Cyperaceae are very low when compared to Sandynallah and to a very small extent vary from Bangithappal. ~~Gramineae~~ Poaceae are high but lower than Bangitappal. Here again dominant are non-arboreal such as *Impatiens*, Asteraceae, Ranunculaceae, *Artemisia* Other herbs represented in fairly good numbers are Gentianaceae, *Hypericum*, Labiatae and *Valeriana* *Eriocaulon*, Halorrhagaceae and *Polygonum* are low when compared to Bangitappal samples, but are quite high compared to Sandynallah. Most dominant among arboreal taxa are *Ilex*, *Elaeocarpus* and *Syzygium* along with Oleaceae, *Michelia*, *Symplocos*, *Microtropis*, Myrsinaceae. Ecotone elements such as Berberidaceae, *Rhodomyrtus*, *Rubus* are also represented in fairly large numbers. Spores are high when compared to Bangitappal *Acacia* sp, *Eucalyptus* sp and *Pinus* sp., occur quite frequently in these samples

3.8 Correlations of surface pollen with modern vegetation

The grassland and the shola patches were situated at a distance of about 100m and about 150 to 200 m respectively from the surface sampling site of Bangitappal peat bog The shola patch was at a distance of about 150m and grassland was about 100 to 150m from Varahapallam sampling site. In Sandynallh the grassland was at a distance of about 50m from the peatbog sampled for surface and vegetation sampling. All the three sites altitudinally vary from 100-150m a.s.l (above mean sea level).

Quantitative estimation of the vegetation ~~was~~ were analysed and discussed in the earlier chapter on vegetation and in the earlier paragraphs in this chapter it is detailed that the surface samples obtained for modern pollen analyses were collected from the same areas as the vegetation sampling This is in order to establish the distribution and deposition of modern pollen assemblage in the peat bogs.

In order to estimate the amount of variation between the vegetation changes and surface pollen assemblage, the parametric approach of Pearson's product moment correlation coefficient and the non-parametric approach of Spearman's rank correlation method was employed As the pollen of grasses and sedges can not be identified to their generic or species level; the plant abundances of these from vegetation composition are also considered at family level to carry out correlations

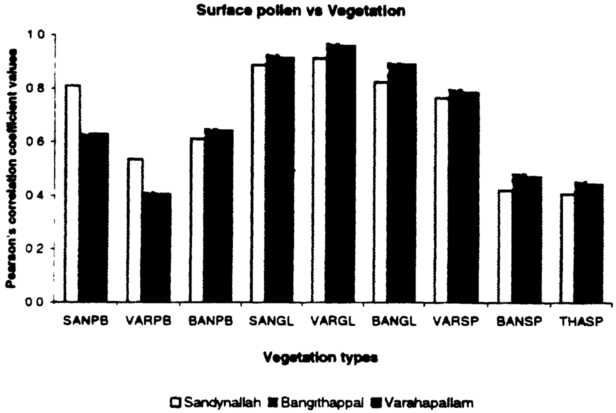
3.9 Results from correlations of surface pollen and modern vegetation

Table 3 1 depicts Pearson's and Spearman's correlation coefficient values between surface pollen assemblage and vegetation types from three sites In Fig.3.2 the vegetation types and sites are plotted against correlation values. The correlation coefficient values are estimated with n=198. Surface pollen samples having modern pollen rain from all three sites were correlated with different vegetation types In grassland vegetation type, Sandynallah surface pollen assemblage have highest value with Varahapallam grassland (0.91±0.06), while Sandynallah grassland has (0.89±

Table : 3.1

Correlation coefficient values between surface pollen and vegetation types

Veg type/Location		Sandynallah		Varahapallm		Bangitappal	
		Mean	Stdev	Mean	Stdev	Mean	Stdev
	Pearson	0 89	0 05	0.91	0.01	0.93	0 01
Sandynallah grassland	Spearman	0 70	0 06	0.57	0 07	0 58	0 06
	Pearson	0 91	0 06	0.96	0.01	0.97	0.004
Varahapallam grassland	Spearman	0 70	0 05	0 56	0 07	0.58	0 06
	Pearson	0 83	0 06	0 89	0 01	0 90	0 003
Bangitappal grassland	Spearman	0 68	0 04	0 54	0 05	0 54	0 07
	Pearson	0 81	0 06	0 63	0 02	0 63	0 02
Sandynallah peatbog	Spearman	0 73	0 05	0 59	0 06	0 60	0 05
	Pearson	0 54	0 04	0 41	0 02	0 41	0 01
Varahapallam peatbog	Spearman	0 73	0 03	0 58	0 06	0 60	0 07
	Pearson	0 61	0 04	0 64	0 01	0 65	0 004
Bangitappal peatbog	Spearman	0 70	0 05	0 55	0 07	0 57	0 06
	Pearson	0 77	0 04	0 79	0 01	0 80	0 01
Varahapallam shola	Spearman	0 67	0 05	0 52	0 08	0.54	0 06
	Pearson	0 42	0 04	0 47	0 01	0 48	0 01
Bangitappal shola	Spearman	0 65	0.06	0 50	0 07	0.53	0 07
	Pearson	0 41	0.03	0.44	0 01	0 45	0 01
Thaishola	Spearman	0.65	0.05	0 51	0 07	0.52	0 07



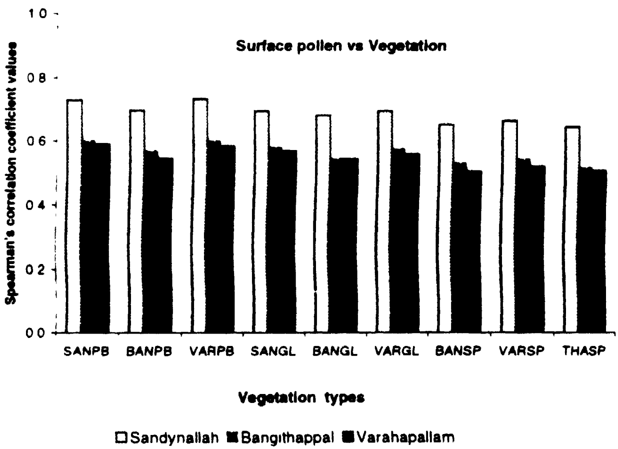


Figure 3 2 Plots of vegetation types and correlation coefficient values of surface pollen samples

0 05), and Bangitappal grassland being (0.83± 0 06). In peat bog vegetation type Sandynallah peat bog has (0.81±0 06), while Bangitappal and Varahapallam peat bogs shows low values of (0 61±0.04) and (0 54±0.04) respectively. Among sholas Bangitappal and Thaishola have the lowest value of (0.42±0.03) and (0 41±0.04), whereas Varahapallam shola has higher value (0 77±0.04). In terms of Spearman's correlation coefficients the highest values are seen in peat bogs of Sandynallah (0 73±0.05) and varahapallam (0 73±0.03). Grasslands of Sandynallah and Varahapallam have values (0 70±0.06) and (0.70±0.05) with Bangitappal peat bog having (0.70 ±0.05). Bangitappal grassland has value of (0 68±0.04) The sholas of Bangitappal has (0 65±0 06) and Thaishola has (0.65±0 05) with Varahapallam having higher value of (0 67±0 05)

Pearson's correlation coefficient values from Varhapallam surface samples shows highest values with Varahapallam grassland (0.96±0 01), while with Sandynallah grassland being (0.91±0.01) and with Bangitappal grassland having (089±0.01). In the peatbogs the highest values are from Bangitappal peat bog (0 64±0.01), with Sandynallah peat bog being (0 63±0 02). Varahapallam peat bog has lowest value (0 41±0.02) Among sholas Varahapallam shola has the highest value (0.79±0.01) and the lowest being Thaishola (0 44±0.01) with Bangitappal shola having (0.47±0.01) In term of Spearman's correlation coefficients peat bog from Sandynallah has value of (0 59±0.06) with lowest value being Bangitappal shola (0.50±0.07).

In terms of Pearson's correlation coefficient values from Bangitappal surface samples with grasslands show that Varahapallam grassland has highest value of (0 97±0.04) and with Sandynallah grassland (0.93±0.05) and while Bangitappal grassland has (0 90±0.03) In peat bogs. Bangitappal peat bog has the highest value (0.65±0.04) with its surface samples and the lowest value at Varahapallam peat bog (0 41±0 01) with Sandynallah peat bog having (0.64±0.02). Among sholas Varahapallam shola is the highest (0.80±0.05) and the lowest being Thaishola (0.45±0.01) while Bangitappal shola has (0 48±0.05) In terms of Spearman's correlation values from Bangitappal surface samples, the peat bogs of both Sandynallah and Varahapallam have (0.60±0.05) and (0 60±0.01) that are high when compared to spearman's values of Sandynallah and Varahapallam grassland with 0.58±0 06. Among sholas, Varahapallam sholas has a value of 0 54±0 06. Bangitappal shola 0 53±0.07 and Thaishola 0.52±0.07.

3.9 Numerical techniques

3.9.1 Ordination

The ordination methods arrange species and samples along gradients, such that samples (or species) arranged close together are similar in species composition, and samples (or species) arranged far apart which have dissimilar species composition.

Cluster analysis was carried out on the surface samples to show similarities between the samples. The dendrogram is represented in Fig 3.1 which clusters all the 35 samples based on the similarities in species composition. Among three sites, Sandynallah gets clustered separately Between Bangitappal and Varahapallam, the degree of similarity in species composition is higher than the Sandynallah.

3.9.2 Detrended Correspondence Analysis (DCA)

In this technique the basic assumption is that the most important environmental gradient causes largest variation in the species composition by means of a two way weighted algorithm The direction of this variation is calculated and represented as first DCA axis (Hill and Gauch, 1980, Jongman *et al.*, 1987). The second DCA axis represents the second important direction of variation which is interpreted in terms of environmental variation In the first and higher axes, the method of detrending (by segments) is applied (Hill and Gauch, 1980)

The variation represented by DCA axes can be interpreted based on one or more environmental variables The interpretation can also be facilitated by using environmental information derived from other studies The scores of the samples (or species) are plotted in ordination space using an X-Y plot. The arrangement of samples along the x-axis (axis 1) accounts for the greatest amount of variability in the data and the y-axis (axis 2) accounts for the second greatest source of variability. Samples located together in tight clusters in DCA ordination space are very similar in composition to each other, where as samples located farther apart are less similar in composition to each other. This technique therefore provides a quantitative means of identifying the variation between the communities

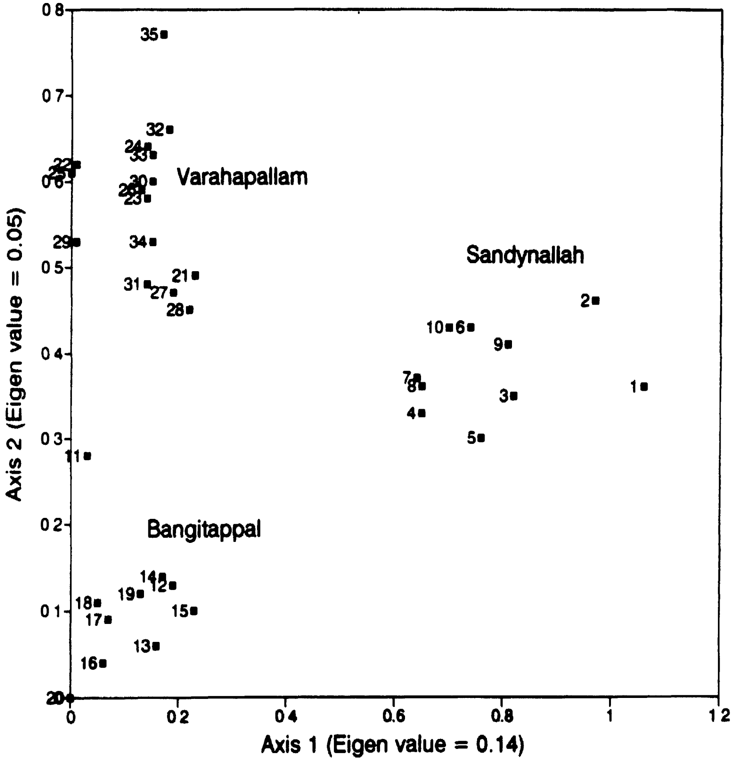
Detrended correspondence analysis was carried out on these surface samples. The sample scores of the ordination are plotted against axis 1 and axis 2 (Fig 3.3). The ordination clearly shows distinct clusters. Sandynallah cluster lie far apart from the other two clusters of Bangitappal and Varahapallam

3.10 Discussion

It is observed from the pollen results, that Sandynallah surface samples have shown that they are less diverse in pollen assemblages ~~Gramineae~~ Poaceae and Cyperaceae are dominant taxa Arboreal and aquatics show very low representation The arboreal taxa represented in considerably high numbers are *Elaeocarpus* and *Syzygium* The Sandynallah site is a much disturbed site with human settlements and the sheep breeding station, close by to the sampled sites Presence of *Pinus* sp., *Acacia* sp. *and Eucalyptus* sp represent plantation in the surrounding grassland areas. The grasslands are converted to plantations represented by *Pinus* sp , *Acacia* sp *and Eucalyptus* sp. The low arboreal pollen could be due to the absence of shola patch close to the basin and low aquatics may be due to the non-availability of soil moisture.

Bangitappal surface pollen, depicts high value of aquatics. Arboreal elements are found to be very high, representing the core shola elements indicating that there are still

Figure 3.3:Plot of DCA scores of Surface peat samples from 3 locations



shola patches left undestroyed in this region. There are a few introduced species such as *Pinus*, *Acacia*, that are from the recent plantations. Bangitappal being at much higher altitude from other two sites, receives high rainfall. It is seen that it harbors good number of taxa of shola, grassland and peat bogs that are distinctly shown in the pollen diagram.

Varahapallam site lying close to Bangitappal, slightly at a lower altitude also show good representation of shola elements Aquatics and Cyperaceae seem to be low which is observed in the pollen diagram (Fig 3 1) The arboreal pollen in both Bangitappal and Varahapallam samples seem to reduce towards the last samples that are collected on north-south transect in a sequence. The first samples in both the sites lie close to the shola patch and have more number of arboreals than the samples that are collected away from the patch Hence the surface sample reflects the surrounding vegetation from forests, uplands and locally from bog vegetation

Can the high correlation values of grassland types with the surface samples are due to wind pollination in grasses and its absence in shola patches ?

Yes ! The high correlation values of grassland types with the surface pollen samples from peat can be explained by the fact that grasses are wind pollinated and are not abundant in shola patches Another explanation would be that grasslands occupy much larger area than sholas that occur only in the valleys The grasses are also natural component of peat vegetation Hence, the grasses have a stronger potential of being highly represented in the pollen spectra from peat sampling sites

values indicates, the occurrence of common taxa in both surface pollen assemblages and the vegatation types. Low values indicate either their sporadic presence or there may be variation in the occurrence of the similar taxa in both vegetation and surface samples.

The pollen assemblage from these surface samples indicates that the representation of pollen grains reflects the local plant communities. These local communities are known to vary with other parameters such as climatic conditions, soil, availability of moisture etc. The three study locations vary to a small extent in their altitudinal gradients. The nature of disturbance in each of these sites strongly influences the pollen composition in the surface samples that has resulted from the changes in vegetation

As modern samples contains large proportion of locally produced pollen, with large number of pollen types, some of which may be the indicator species of a local community, that helps in distinguishing the local community (Janssen, 1966, 1973). This can be used to reconstruct the local community at the association level and in turn helps in the interpretation of fossil spectra

The surface sampling has to be done in a more systematic way at different altitudes necessary to establish curves for modern pollen rain (Bonnefille, 1993). Extensive information on modern pollen curves is very limited in the Nilgiris region Thus this exercise has to be carried out extensively in the Nilgiris region that help in interpreting and obtaining a better understanding of the fossil spectra.