

Berijam Lake : 20,000 years sequence of palaeofloristics and palaeoenvironment in Palni Hills, South India*

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The paper embodies the pollen analytical results of 3 meter deep sediment profile from Berijam lake and modern surface samples around the lake. Study of surface samples has provided an insight knowledge as regard to the differential pollen dispersal and deposition in the sediments which has been taken up as a prerequisite for the face value interpretation of pollen diagram constructed out of the Berijam lake profile. The pollen evidence has enabled us to group the vegetation into three phases during the past 20,000 years B.P.

Key-words—Berijam lake, Palaeofloristics, Palaeoenvironment, Palni Hills, South India.

INTRODUCTION

THE Berijam Lake, about 24 Km southeast of Kodaikanal town, falls under Palni Hills range in Tamilnadu at an elevation of 2030m a.s.l. and lies between Lat. 10° 12'-10° 18' N and Long. 77° 26'-77° 34' E. The area under study is a temperate oasis within the tropics from the view point of palynological as well as phytosociological studies. The object of undertaking this area for the palynological study is to tune with the data obtained from Nilgiris, Silent Valley and Anamalai Hills concerning the status of grassland *vs* shola forest to ascertain climatic cycles involving various controlling factors (Meher-Homji, 1965; Menon 1968; Vishnu-Mittre & Gupta 1968, 1970; Blasco, 1970; Gupta 1973, 1990; Gupta & Prasad, 1985; Vasanthi 1988; Bera & Gupta 1992).

The indigenous flora of Berijam is typical of South Indian montane known as shola forest but due to considerable destruction of the shola plants, a large area has been transformed into savanna owing to extensive human pressure over the landscape and some of which are now brought under plantation of acacias, cinchona, eucalyptii, pines, tea and coffee. However, the pure shola formation could be seen only in patches in the protected areas.

On the basis of elevation as well as precipitation, the forest vegetation can be grouped into, I. Lower evergreen (457.5-915 m : 130-330 mm) and, II. Upper evergreen (above 1500 m : 300-650 mm). Phytosociological studies have shown that differences in the rainfall regime in the west (635-762 cm) and in the east (180-230 cm) of the plateau are reflected in the constituents of the sholas. For instance, *Sideroxylon tomentosum*, *Cinnamomum macrocarpum*, *Syzygium montanum*, *Elaeocarpus ferrugineus*, *Eurya japonica* and *Meliosma wightii* along with shrubby taxa like *Lasianthus venulosus*, *Rhodomyrtus tomentosa*, *Dodonaea viscosa* are growing commonly in high rainfall area. On the ground, *Prunella vulgaris*, *Lysimachia deltoidea*, *Sanicula europaea*, *Impatiens phoenicea*, *Andrographis resiana*, *Viola serpens*, *Senecio* spp. and *Calamintha umbrosa* are growing luxuriantly. Scattered trees of *Rhododendron nilagiricum* can be seen in the grassland where *Anaphalis lawii*, *Cyanotis arachnoides*, and *Leucas subfruticosa* are the most conspicuous herbs. The fernlands are chiefly formed of impenetrable thickets of *Pteris aquilina* that reaches the height of a man. *Rubus ellipticus* is also seen present but scattered. However, the above mentioned vegetation composition does not colonise the areas under low rainfall regime particularly east of Palni Hills.

The composition of grasslands near the top of the Hills include *Andropogon fowlkrii*, *Arundinaria villosa*,

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Cymbopogon polyneuros, *Fimbristylis ulginosa*, *Pollinia phaeothrix*, etc., mixed with other herbaceous taxa such as *Heracleum tingens*, *Crotalaria notonii*, *Indigofera pediculata*, *Cassia mimisoides*, *Cnicus wallichii*, *Cyanotis fasciculata*, *Bupleurum distichophyllum* and *Viola patrinii*, etc. Nevertheless, some of the present day existing sholas near the road side which are being cleared for coffee plantation are not successful. The owners are now shifting cultivation from coffee to banana and pear.

The surface rocks are largely metamorphic being granitic gneiss. The soil cover vary from extremely poor to shallow where they have been subjected to erosion and outwash. There are also peat and clay in moist swampy depressions. The lithology of soil profile consists of either dark black fibrous organic mud or silty organic mud with alkaline pH.

MATERIAL AND METHOD

One 3 meter deep sediment profile in the centre of the lake's swamp, after making trial borings, was procured for final sampling. The samples were taken with the help of Hiller's peat-auger with 50 cm long chamber at an interval of 10 cm each. The surface samples were collected in a transect from within the forest to outskirts of the forest in order to understand the vertical and transverse pollen dispersion which could be helpful in interpreting the pollen diagram precisely. For extraction of palynodebris, the usual technique was followed involving the use of KOH, HF and acetolysis (Erdtman, 1943). The sediment profile largely comprises black humified and highly compressed organic mud except for the bottommost part which include clay and sand. The details of lithological succession from top to bottom are given below:

0.0-0.5m - Black organic mud with abundant rootlets

0.5-1.0m - Black organic mud with less rootlets

1.0-2.9m - Black humified organic mud without rootlets

2.9-3.0m - Blackish clay with coarse sand

POLLEN/VEGETATION RELATIONSHIP

Five surface samples, collected from forested as well as deforested zones covering an area of about 300 m from dense forest to outskirts of the forest, have been analysed palynologically. The object of the study of surface samples is to assess present day vegetational composition through pollen production, dispersion and preservation in the modern context. The pollen assemblage has been described separately and its relationship to the modern vegetation has been discussed (Fig.1).

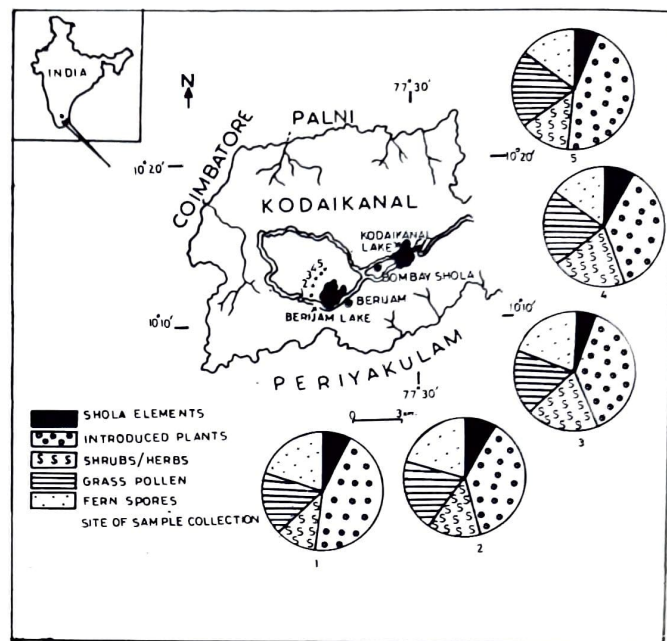


Figure 1. Recent pollen spectra from Berijam Lake, Palni Hills, South India.

Sample 1- This sample was procured within the forest floor. The pollen assemblage of this sample has revealed the dominance of alien taxa growing around the forest to the tune of 37.5% and core-shola taxa to the value of 15.4%. The alien taxa are represented rankwise as *Acacia* (18.4%), *Pinus* (10.7%), *Alnus* (6.8%) and *Betula* (1.6%). The important shola tree taxa recorded are Myrtaceae, *Elaeocarpus*, *Euonymus*, *Eurya*, Oleaceae, *Ilex*, *Glochidion* and *Osbeckia* which are either sporadic or low in values. Among shrubby elements *Dodonaea*, *Strobilanthes*, *Urticaceae* and *Euphorbiaceae* are encountered in meagre values whereas, *Berberis* and *Viburnum* are sporadic.

Among nonarboreals, Poaceae recorded highest value (12.6%) and other important ephemerals are recorded as *Impatiens*, *Senecio*, Rubiaceae, and Chenopods in low values but *Ranunculus*, *Artemisia*, and Lamiaceae are present sporadically.

Among ferns, trilete spores (10.4%) show good frequency as compared to monoletes (5.6%). The representation of arboreal taxa of inner shola is very low as compared to their factual occurrence in the forest. In other words, the above shola elements are under represented owing to several technical vagaries such as low pollen production, entomophily, differential pollen production, dispersion and preservation. *Acacia*, *Pinus*, *Betula* and *Alnus* out of the recent plantation show high values in the spectrum.

Sample 2- This sample was procured from the margin of the forest. The pollen spectrum obtained from this

sample reflects an overall dominance of arboreal pollen among which alien taxa itself reach upto 39% whereas, the core-shola tree taxa attain upto 10.8% which indicated a sharp reduction in shola components than the preceding one. The predominant tree taxa are *Elaeocarpus*, *Euonymus*, *Glochidion*, etc., whereas, Myrtaceae, *Osbeckia* and *Eurya* are recorded in low values. The shrubby elements show a sharp decline in their values (4.9%).

The ground vegetation displays an overall higher value as compared to the preceding sample. The predominating taxa are represented by Poaceae (15.5%), *Senecio*, *Heracleum*, Rubiaceae, *Ranunculus*, *Impatiens*, etc. Fern trilete spores attain upto 14.4% and monoletes remain under 3.3%.

Sample 3- This sample was procured from the outskirts of the shola forest. The pollen spectrum displays further reduction in true shola trees and uprise in non-arboreals. The tree taxa are reduced to 5.4% of the total vegetation. The alien taxa maintain the stable value i.e. upto 38%. The shrubby components are further reduced to 3.2% than in the preceding samples. Myrtaceae, *Elaeocarpus*, *Eurya* and *Euonymus* are some of the tree taxa encountered in low values.

The ground vegetation is frequent and represented by Poaceae (16.5%) followed by other taxa such as *Heracleum*, Lamiaceae, *Senecio*, Rubiaceae, etc. Among fern spores, triletes improved and maintain 16.5% whereas, monoletes attain 5.5%.

Sample 4- This sample was procured from 100 m away from the forest cover. The pollen spectrum depicts relatively higher values of nonarboreals over arboreals. The arboreals are present to the tune of 12%. Some of the prominent taxa such as *Elaeocarpus*, *Euonymus* and *Eurya* are recorded in low values, except Myrtaceae which is present in slightly higher values. *Glochidion* and *Osbeckia* are sporadic. The alien taxa maintain continuously stable values (35%). The shrubby vegetation remains poor.

Among ground vegetation, Poaceae (24%) is proportionately higher than in the preceding sample. Other herbaceous taxa represented are *Heracleum*, *Senecio* and Rubiaceae in low values but *Ranunculus*, *Impatiens* and *Artemisia* are sporadic. Fern trilete spores attain upto 12% and monoletes upto 4%.

Sample 5- This sample was procured from outskirts of shola forest, 200 m away from the preceding sample. The pollen spectrum constructed out of this sample has brought out almost same picture as observed in the preceding sample except for a slight fall in tree taxa and simultaneous increase in the values of shrubs. The pollen of *Euonymus*, *Ilex* and Oleaceae, the main con-

stituents of shola forest are totally absent in the scenario. The alien taxa remained same as before.

Amongst nonarboreals, Poaceae (26.5%) maintain highest value followed by other herbaceous taxa like *Senecio*, *Impatiens*, Lamiaceae, Urticaceae, etc. The value of ferns remain more or less same as before.

The face value interpretation of modern surface samples does not portray true picture of actual composition of modern vegetation. Keeping in view all these aspects, pollen diagram constructed from the sediment profile of South Indian Montanes be translated with great caution. In such cases, when arboreal taxa of shola forest are under represented or unrepresented inspite of their actual frequencies in modern vegetation, the sporadic and scanty occurrence of arboreal taxa carries great significance in the interpretation of palaeovegetation denoting the existence of shola forest.

POLLEN DIAGRAM AND PALAEOFLORESTICS

Based on pollen data of 3m deep vertical sediment profile from Berijam lake, covering time span of 20,000 years B.P. one pollen diagram (Fig.2) has been prepared. Relative values of each pollen/spore, calculated in terms of total plants pollen counted, are plotted in the pollen diagram in order to highlight the palaeofloristic development in and around Berijam lake. To achieve precision in evaluating the vegetation shifts and climate, three major pollen assemblage zones have been proposed in ascending chronological order and they are prefixed with the site initials viz., BJ-I to BJ-III. BJ-III has been further segregated into three sub-zones i.e. BJ-IIIa,b,c in order to record and interpret subtle changes in the vegetation within the zone. Besides, a barren zone (BZ) has also been recognised between 2.70-2.30m. This has been chiefly done to express biostratigraphic units in terms of palaeovegetation and to translate them in relation to the significant events and episodes which have occurred within the framework of this study. Each zone has been separately discussed and evaluated.

POLLEN ZONE BJ-1: (20,000-17,000 Years B.P.)- Poaceae-Senecio - Heracleum-Ranunculus Pollen Assemblage : This zone is devoid of typical constituents of shola forest but predominated by high values of graminoid pollen attaining upto the extent of 80 per cent of the total vegetation. Within the zone the occurrence of shola associated herbs such as *Senecio*, *Heracleum*, *Ranunculus*, Chen/Ams and Lamiaceae has been recorded in moderate to low values. Likewise, some of the shola associated shrubs viz., Malvaceae and Euphorbiaceae have also been encountered in low values.

Osbeckia, *Trema* and Fabaceae are present in improved values in the upper half of this zonule but Oleaceae relatively reduced. However, the shola herbs such as *Impatiens*, *Heracleum*, *Senecio*, *Artemisia*, and Caryophyllaceae have registered an overall increase in their values as compared to the preceding zonule. Poaceae has substantially reduced whereas Cyperaceae and fern spores have maintained the rising trend.

ZONULE BJ-IIIc (2,000 Years B.P. to Present)-*Elaeocarpus* - *Euonymus*-*Ilex* - *Glochidion* - *Impatiens* Pollen Assemblage : This zonule is marked by evident presence of shola trees such as *Elaeocarpus*, *Euonymus*, *Ilex*, *Glochidion*, *Trema*, Oleaceae, *Eurya*, *Osbeckia*, etc. Likewise there is general improvement in the shola shrubs which are represented by *Pavetta*, *Ephedra*, *Berberis*, Fabaceae, etc. The shola herbs like *Impatiens*, *Senecio*, *Heracleum*, *Ranunculus*, *Artemisia*, Urticaceae, Chenopodiaceae, Caryophyllaceae, Brassicaceae, Acanthaceae, etc. continued in high values as in the preceding zonule. Exotic tree pollen of *Acacia* and *Pinus* have also appeared although in low values.

DISCUSSION

Five surface samples, across the forested zone to deforested zone in Berijam lake area covering a distance of around 300 m, have been pollen analysed. The study has revealed that the typical shola trees and shrubs are feebly represented in the samples. However, exotic trees which have been recently planted and naturalised, dominate the pollen assemblage. Nevertheless, the shola associated herbs are frequented in the pollen spectra and therefore, in the absence of shola trees and shrubs, these herbaceous taxa have been considered as indicators of the existence of shola forest while interpreting the pollen diagram. Furthermore, the values of shola components have greatly reduced in the samples collected from the deforested zone as compared to the forested zone.

Three successional phases of vegetation development have been recognised out of the palynological study of the 3 meter deep profile from Berijam lake. The first phase covering a time span between 20,000-17,000 years B.P. is marked by very high values of Poaceae reaching upto the maximum of 84 per cent and the total absence of shola trees and shrubs. Thus, the pollen evidence of this phase envisages the existence of far and wide grasslands denoting the cold and dry climatic conditions. Thereafter, the period of 2500 years between the depth of 2.70 m to 2.30 is a barren zone signifying the total absence of palynomorphs. This feature reveals that the oxidising environment prevailed during this

period precluding the preservation of any biota in the sediment.

The second phase covering time span between 14,500-7000 years B.P. has witnessed a shift in vegetation therein some of the shola constituents such as *Ilex*, Moraceae, Rosaceae, *Eurya*, *Ligustrum*, Fabaceae, Malvaceae, etc. began to invade into the grassland and made their stable presence. Concurrently, the shola associated herbs like *Impatiens*, *Senecio*, *Artemisia*, Urticaceae, Lamiaceae, Chenopodiaceae etc. improved significantly. This change in the vegetation is indicative of climatic amelioration leading to warm and humid climate.

The third phase of vegetation development, ranging from 7,000 years B.P. to the Present, has registered overall improved values of shola forest constituents. In the beginning of this phase the shola components made their way into grassland - a step ahead in the establishment of shola forest. The aquatic plant taxa are also recorded in meagre values. This change in vegetation scenario could be accounted under the prevailing increased warm and humid climate. Thereafter, in the middle of this zone almost all the shola associated herbs, Cyperaceae and fern spores registered an evident increase in their values but aquatic plant taxa disappeared. This feature does not record any major climatic change except that precipitation and humidity considerably reduced.

The upper half of this zone records the establishment of shola forest. *Elaeocarpus*, *Euonymus*, *Ilex*, *Glochidion*, *Trema*, *Eurya*, *Osbeckia*, *Pavetta*, *Ephedra*, *Berberis*, Fabaceae, etc. colonized indicating the formation of shola forest. With the establishment of shola tree and shrubs, the shola herbs also improved reasonably. Cyperaceae and ferns remained static as before. Thus, Phase III reflects mixed reactions indicating peak development of both shola woods and grasslands from about 7,000 years B.P. and spread into vast areas. The climate might have been cool and humid.

The overall palynological studies in South Indian Montanes signify the degeneration of shola forest as evidenced by the striking scarcity of tree pollen in sediments. Moreover, palynology has been instrumental in unfolding the facts that shola species are not regenerating under adverse condition and, therefore, a phenomenal reduction in their areal extent is recorded. Keeping in view of wide spread herb land, the future of shola ecology as to how shola woods spread into herbland and overcome Acacias, Eucalyptii and Pines could be determined.

The continued exotic plantation and fast expanding grasslands will allow further shola destruction around

Berijam lake. Therefore, for the restoration of shola ecology and proper management of montane environment, various ways and means have to be found in order to regenerate shola species today.

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