

Sholas in south Indian montane: Past, present and future

H. P. Gupta

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The forest, short to medium-boled attaining a height between 15 to 20 m, constitutes the only tropical montane forest in pockets in the montane region of Nilgiris, Anamalai, Palni and Silent Valley, southern India. Palynological studies have revealed that these shola forest communities had been wide spread in the past. They originated through gradual invasion of shrubs and under trees into the grassland, about 35,000 years BP, corresponding in time to the last glaciation in the north and were established about 24,000 years BP. The progressive recession of sholas had started around 7,000 years BP. Both biotic and climatic factors have not only reduced the sholas to its present day minimal size but have also created conditions under which the community has almost completely stopped regeneration outside the sholas.

Degeneration and fast receding trend in the shola communities and expanding grasslands and massive plantation of exotic trees reduced the soil as well as above surface moisture which is not conducive for the sholas. If preventive measures are not taken the sholas in near future would ultimately perish.

Key-words—Palynology, Shola forest, south Indian Montane.

H. P. Gupta, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow-226 007, India.

सारांश

दक्षिण भारतीय पर्वतीय शोला वन : अतीत, वर्तमान एवं भविष्य

हरीपाल गुप्ता

दक्षिण भारत में नीलगिरी, अनामलाई, पलनी एवं शान्त घाटी के पर्वतीय क्षेत्र के कुछ सीमित उपक्षेत्रों में 15 से 20 मीटर की औसत ऊंचाई वाले उष्णकटिबंधीय पर्वतीय वन विद्यमान हैं। परागानविक अध्ययन से व्यक्त होता है कि ये शोला वन अतीत में दूर-दूर तक विस्तृत थे। ये वन उत्तर में अन्तिम हिमनदन के समय लगभग 35,000 वर्ष पूर्व घासभूमि में झाड़ियों एवं अधोवृक्षों के शनैः शनैः अतिक्रमण से विकसित हुए तथा लगभग 24,000 वर्ष पूर्व स्थापित हो पाये। लगभग 7,000 वर्ष पूर्व शोला वनों का ह्रास हुआ। केवल जलवायवी एवं जैविक कारक इनके ह्रास का कारण ही नहीं हैं अपितु इनके और प्रसार एवं विकास के लिए इन कारकों ने प्रतिकूल परिस्थितियाँ उत्पन्न कर दी।

शोला वनों के तेजी से होते ह्रास तथा बढ़ते घास के मैदानों एवं विदेशी वृक्षों के लगाने के कारण मिट्टी एवं उपसतह की नमी काफी कम हो गई है जो कि शोला वनों की अच्छी वृद्धि के लिए सर्वथा अनुपयुक्त है। अगर उचित उपाय न किये गये तो निकट भविष्य में शोला वन समाप्त हो जायेंगे।

PRESENT

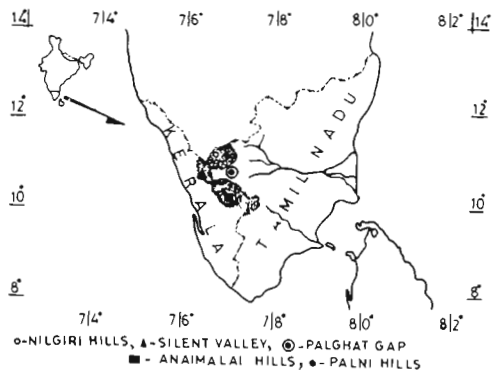
CLOSED evergreen woods occurring above 1,500 m on high hills in the Nilgiris, Anamalai, Palni and Silent Valley in southern India are known as sholas (Text-fig. 1). This community is composed of both tropical and temperate species which are generally found in the isolated patches in protected valleys, often associated with streams. Trees are characteristically short-boled, rarely exceeding 15 m in height, well branched, attaining considerable girth and supporting numerous epiphytes. The crowns are dense and leaves coriaceous. These

patches of shola grow under the equable climate with varying annual rainfall from 130 to 650 mm. The vegetation of south Indian montane region is ecologically important because two distinct plant communities, viz., evergreen shola and grassland, co-exist in juxtaposition and apparent equilibrium (Ranganathan, 1938).

Considering the status of shola and grassland, the following main points have been discussed:

1. Role played by man in grassland formation
2. Recent afforestation in the grassland
3. Future grassland—shola ecology

Besides the effect of high-speed winds, the



Text-figure 1—Showing shola localities in south Indian montanes.

effect of fire and grazing is very pronounced. A record, dated 1117 AD, refers to Todas—a pastoralist tribe who fired grasses annually in order to promote the growth of young tender grass more edible for livestock (Noble, 1967). If the practice of fire continues, the ever expanding grassland shall develop and the shola will be diminished in areal extent. During fire, flames reach shola edges and damage the trees too. The damaged trees are prone to diseases and insects. Slowly, shola trees perish and grasses spread.

Interestingly, phytogeographical affinities provide a link with western and eastern Himalaya. The wet forests of south Indian hills could be compared with the northern temperate oak-conifer forest of western Himalaya. The oaks and conifers, except for *Podocarpus* sp., are absent from south Indian hill forests, the members of Ternstroemiaceae and Lauraceae are common to both.

Rhododendron arboreum—a conspicuously common plant in north-west Himalaya is represented by its variety *nilgircum* in south Indian hill tops. Likewise *Gaultheria fragrantissima* is found on south Indian montanes while at the same elevation *Lyonia ovalifolia* occurs as a chief associate of oak-woods in north-west Himalaya.

The common plants that occur in eastern and western Himalaya and in south Indian hills are: *Indigofera pulchella*, *Hamiltonia suaveolens*, *Viola patrinii*, *Peperomia reflexa* and *Reinwardia trigyna* (Mukherjee, 1935).

Hills of Bihar and Orissa served as a route of migration and played a vital role in the migration from southwest to northeast, or *vice versa* according to Hooker and Thompson (1855). Razi (1954) suggested that there is a trend prevailing in the plant migration from south to northeast.

The statement of Fyson (1915-21) that 17 per cent of the species of south Indian hill tops occur on Khasi hills, 12 per cent in the temperate parts of

Himalaya and none in the intervening regions even along the Western Ghats, does not hold good since the species common to the Western Ghats, Bihar and Orissa have been recorded.

Regarding the occurrence of south Indian plants on the Bailadilla range in Baster, Madhya Pradesh, Mooney (1942) states "It does not call for great powers of imagination to visualize how species having their origin in Nilgiris, Palni and other hills of Mysore and Travancore, etc. may have travelled along the line of Eastern Ghats until they reached their extremity in Kshipur plateau of Kalahandi state and the agency tracts of Ganjam and Vishakhapatnam districts with their humid climate". He further presented evidence of the south-north migration of plants in the light of the occurrence of thirty-two species of southern India in Bailadilla range. However, at the same time, he found it difficult to explain the occurrence of 36 north eastern species in the latter.

Hora (1949) took recourse of his "Satpura hypothesis" and explained that although the present day topography and climatic set up do not permit the plants to migrate, the conditions that prevailed during the Plio-Pleistocene times were favourable for such migrations. It was once thought that freezing of climate was responsible for migration of plants and animals (Medicott & Blandford, 1870).

Meher-Homji (1975) opined that migration of species was possible, firstly climate was cooler in the past with lower rate of evapo-transpiration enabling species of tropical deciduous forest to thrive in the plains and the montane forest to descend below 1,500 m. The montane species, being finicky, disappeared quickly from altitude below 1,500 m when warmer climate set in during the post-glacial period, and secondly climate remained unchanged but diaspores of deciduous forest species reached the altitude of 800-1,300 m, and montane species above 1,500 m. Recently, Meher-Homji (1984, 1987-88) has provided further details of biogeographic and ecological diversity in Nilgiri District.

The commonly held view about the distribution of Himalayan species on south Indian hills is that the Pleistocene refrigeration was responsible for pushing some Himalayan plants southward (Burkill, 1924). Blasco (1970, 1971 a, b) emphasized that long distance dispersal through birds or winds is the main possibility for migration of plants, but Meher-Homji (1975) pointed out certain problems with the long distance dispersal and proposed three hypotheses, viz., (i) parallel evolution, (ii) long distance dispersal, and (iii) direct land-connection in the distant past.

It has been the subject of ecological discussions since long as to which of the two plant communities be designated as climatic climax. Champion (1936) did not consider grasslands as climax anywhere since he accounted for their origin from the destruction of sholas. Bor (1938) realised that sholas alone are the true climax whereas grassland is only a biotic climax. Ranganathan (1938) opined that both sholas and grasslands formed co-climaxes. Shankaranarayanan (1958) accepted the views of Champion and Bor that grasslands are, in real sense, not the true climax. He further suggested that grassland is a subclimax governed by a set of biotic factors which did not admit easy passage towards the final climax.

The precise information of vegetation of shola forest could be obtained by grouping taxa in an order, to meet the ecological requirements, differential pollen production, dispersal, and preservation. Such groupings of the characteristic taxa are as follows (Meher-Homji, 1965):

A. Core shola trees

- Aquifoliaceae
Ilex denticulata, *I. wightiana*
- Araliaceae
Schefflera racemosa
- Celastraceae
Euonymus crenulatus, *Microtropis ramiflora*,
Celastrum paniculata
- Elaeocarpaceae
Elaeocarpus ferrugineus
- Ericaceae
Rhododendron nilagiricum
- Euphorbiaceae
Glochidion neilgherense, *G. jagifolium*,
Macranga indica
- Flacourtiaceae
Hydnocarpus alpina
- Icacinaceae
Mappia tomentosa, *M. foetida*, *M. ovata*
- Lauraceae
Cinnamomum wightii, *C. perrottettii*,
Actinodaphne bourneae, *Litsea wightiana*,
Phoebe wightii.
- Magnoliaceae
Michelia nilagirica
- Myrtaceae
Syzygium arnottianum
- Oleaceae
Olea glandulifera
- Rosaceae
Pygeum gardneri, *Photinia lindleyana*
- Rubiaceae

- Ixora notoniana*
- Sabiaceae
Meliosma wightii, *M. arnottina*
- Sapotaceae
Sideroxylon tomentosum
- Staphyleaceae
Turipina nepalensis
- Symplocaceae
Symplocos foliosa, *S. obtusa*, *S. pendula*
- Ternstroemiaceae
Ternstroemia japonica
- Theaceae
Gordonia obtusa

B. Marginal shola trees

- Icacinaceae
Gomphandra coriacea
- Euphorbiaceae
Daphniphyllum glaucescens
- Rosaceae
Photonia notoniana
- Melastomataceae
Osbeckia reticulata
- Caprifoliaceae
Viburnum coraceum, *V. hebanthum*

C. Core shola shrubs

- Berberidaceae
Berberis tinctoria
- Theaceae
Eurya japonica
- Rutaceae
Melicope indica
- Rhamnaceae
Rhamnus wightii
- Rubiaceae
Oldenlandia stylosa, *Chomelia asiatica*, *Pavetta breviflora*, *Stylocoryne lucens*, *Psychotria elongata*, *Lasianthus coffeoides*
- Myrsinaceae
Maesa perrottetiana
- Acanthaceae
Strobilanthes foliosus, *S. pulneyensis*, *S. papillosus*, *S. urceolaris*, *S. micranthus*,
Barleria involucrata
- Thymelaceae
Lasisiphon eriocephalus
- Elaeagnaceae
Elaeagnus kologa
- Santalaceae
Osyris arborea
- Loranthaceae
Elytranthe loniceroides
- Urticaceae
Pouzolzia bennethina

D. Marginal shola shrubs

Berberidaceae

Mabonia leschenaultii

Sapindaceae

Dodonaea viscosa

Caprifoliaceae

Lonicera leschenaultii

Ericaceae

Gaultheria fragrantissima

Oleaceae

Jasminum brevifolium, *J. bignoniaceum*,
*Ligustrum perrottetii***E. Core shola herbs**

Ranunculaceae

Ranunculus muricatus

Brassicaceae

Cardamine africana

Violaceae

Viola serpens

Caryophyllaceae

Cerastium indicum, *Stellaria paniculata*, *S.*
media

Balsaminaceae

Impatiens orchitoides, *I. neo-barnesii*, *I.*
rufescens

Apiaceae

Sanicula europaea, *Heracleum sprengeianum*

Rubiaceae

Anotis longiflora, *A. monosperma*, *Ophiorrhiza*
brunonis, *O. roxburghiana*

Asteraceae

Senecio walkeri

Lamiaceae

Leucas lamifolia

Amaranthaceae

Achyranthes bidentata

Dipsacaceae

Dipsacus leschenaultii

Piperaceae

Peperomia reflexa

Moraceae

Dorstenia indica

Urticaceae

Laportea terminalis

Liliaceae

Disporum leschenaultianum

Poaceae

*Ischnone punitiana***F. Marginal shola herbs**

Ranunculaceae

Clematis wightiana

Pittosporaceae

Pittosporum tetraspermum

Malvaceae

Hibiscus angulosus

Geraniaceae

Geranium nepalense

Balsaminaceae

Impatiens floribunda

Melastomataceae

Osbeckia cupularis, *O. leschenaultiana*

Gentianaceae

Halenia perrottetii

Lamiaceae

Pogostemon speciosus, *Scutellaria violacea*, *S.*
rivularis, *Leucas lancaefolia*

Euphorbiaceae

*Euphorbia rotbiana***G. Shola climbers**

Menispermaceae

Diploclisia glaucescens

Rutaceae

Xanthoxylum tetraspermum, *Toddalia asiatica*

Vitaceae

Parthenocissus neilgherriensis

Papilionatae

Perochetus communis, *Dumasia villosa*

Rosaceae

Rosa leschenaultiana

Passifloraceae

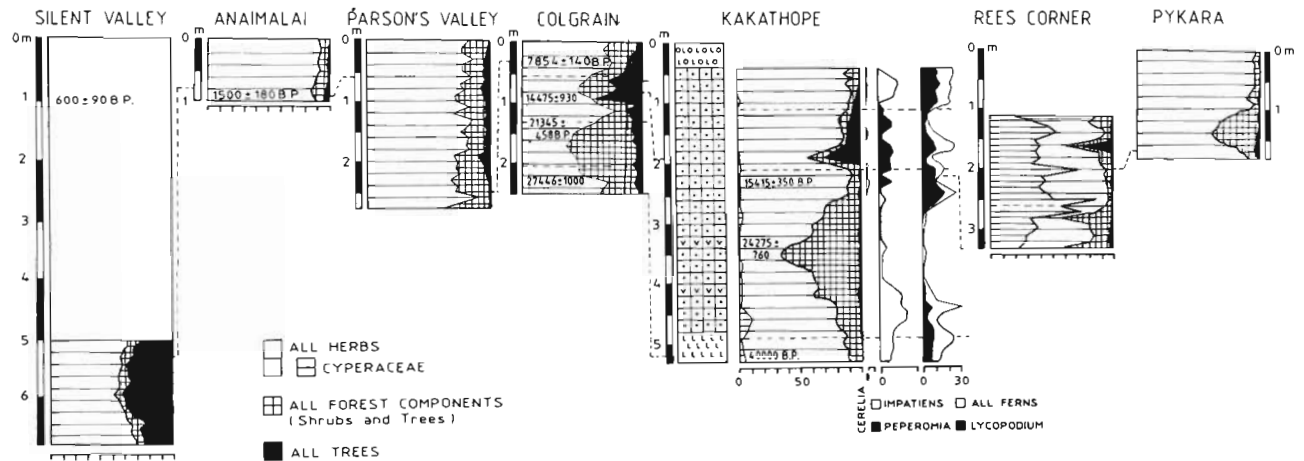
Passiflora leschenaultii

Loganiaceae

*Gardneria ovata***PAST**

An effort has been made to work out the history of shola, step by step, since the time of last glaciation. Fine resolution palynostratigraphy, correlation of Quaternary sedimentary sequences from Nilgiris, Palni, Anamalai in Tamil Nadu and Silent Valley in Kerala, have been used to reconstruct vegetation characteristics and land-use by man for pastoral and arable systems, which made it possible to translate all finer details of vegetation dynamics for the past 35,000-40,000 years BP.

For tracing the history and development of vegetation in time and lateral extent, the general practice is to work out changes in the relative abundance of pollen assemblages. These changes in the relative values of arboreal and nonarboreal vegetation pattern are considered to be brought about by climatic, biotic and edaphic factors or cumulative effect of all the three factors. However, in southern India, it is not possible to follow the conventional method to evaluate and reconstruct palaeofloristic models. Because of stenopalyny,



Text-figure 2—Palaeofloristic reconstruction in south Indian montanes.

differential production, dispersion and preservation of pollen and entomophily, generally tree taxa of shola are either unrepresented or are under represented in pollen assemblage. Hence, the face value evaluation of pollen diagram does not exhibit arborescent vegetation. To overcome this problem, modern surface samples have been investigated to correlate the distribution pattern of arborescent and non-arborescent taxa. Through these studies it has been proved that tree taxa are not represented in the pollen rain to the extent they are actually present in the forest composition. In view of these technical vagaries, certain herbaceous taxa which are associated with shola forest and are abundantly present in the pollen rain have been taken into consideration for highlighting the existence of forest (Gupta & Prasad, 1985). Thus, a forest type may be represented even when herbaceous taxa are found in abundance (Guinet, 1966).

In order to have precise information of palaeovegetation, different areas investigated so far are discussed separately and, thereafter, a synthesis has been made to present the regional picture of south Indian hills (Text-fig. 2).

PALAEOFLORESTICS OF NILGIRIS

Four soil profiles, one each from Kakathope, Rees-Croner, Colgrain, Pykara and Sandynallah have been palynologically investigated. In addition, a number of surface samples from Colgrain have been analysed. Kakathope, the reclaimed swamp area now transformed into the State Potato Seed Farm, situated about 6 km northwest of Udhagamandalam (Ootacamund) city, at an altitude of 2,500 m a.s.l. (lat. $11^{\circ}36' N$, long. $76^{\circ}52' E$). Kakathope swamp comprises an area of about 25 acres in a flat,

undulating valley following the contours of the valley between round-topped hills which are totally bare except for recent plantations of eucalyptii and acacias. The indigenous vegetation is lacking and the area is under extensive biotic pressure.

A 5.30 m deep soil-profile has been investigated palynologically (Gupta, 1971). Lithostratigraphy of the area has revealed that the deposits, largely composed of humified and compressed organic mud with abundant plant debris, were laid under lacustrine conditions. However, 30 cm top and bottom sediments with clay and pebbles indicate fluvial environment. The rate of deposition of organic mud was slow and estimated to be 1 cm per 83 years. The biomass potential since 35,000 years BP till 3,000-4,000 years BP was very high as compared to the present day biomass accumulation.

While analysing the signatures of past vegetation from 40,000 years old deposits, it was observed that vegetation was not static, instead, several vegetation shifts, small and big, had occurred. Following the concept that these shifts in vegetation was brought about by climate followed by biotic and edaphic factors, the pollen diagram plotted from Kakathope has been phased under four heads, as given below:

Phase I (between 40,000-35,000 years BP)

During this phase, the vegetation chiefly consisted of herbaceous elements with shrubs as co-dominant and a few scattered trees indicating an open shrub savanna. The taxa characteristic of this phase are as follows:

Dominant (Herbs) — Poaceae, Cyperaceae, Chenopodiaceae, Caryophyllaceae, Urticaceae, Liliaceae,

	<i>Justicia, Campanula, Geranium</i> etc.
Co-dominant (Shrubs)	— Malvaceae, Rutaceae, Fabaceae, Oleaceae, <i>Berberis, Strobilanthes</i> , etc.
Sporadic (Trees)	— <i>Rhododendron</i> and <i>Ilex</i>
High	— Ferns
Low	— Aquatics

Phase II (between 35,000-15,000 years BP)

This phase is characterized by a shift in vegetation through gradual invasion of shrubs into the open land, marking an initiation of a thicket with dominance of shrubs alongwith sporadic herbs. Nevertheless, tree taxa continued to be isolated. The species composition of this phase is as follows:

Dominant (Shrubs)	— Oleaceae, Rutaceae, Fabaceae, Rosaceae, <i>Lonicera, Berberis, Strobilanthes, Dipsacus, Sarcococca</i> etc.
Isolated (Trees)	— <i>Rhododendron</i> and <i>Ilex</i>
Sporadic (Herbs)	— Poaceae, Apiaceae, Urticaceae, Liliaceae, Chenopodiaceae, Caryophyllaceae, Asteraceae, <i>Artemisia, Justicia, Portulaca, Impatiens</i> , etc.
High	— Aquatics
Low	— Ferns

Phase III (between 15,000-7,000 years BP)

In this phase, arboreal vegetation was established indicating the formation of closed evergreen forest. Most of the shrubby taxa which were prevalent in the preceding phase declined significantly. Some shrubs of savanna, such as *Berberis* and *Sarcococca*, became rare with the onset of forest formation. Amongst herbs, the forest associates, like *Peperomia, Impatiens, Senecio*, etc. improved proportionately. A few herbaceous elements of open land have also been recorded. The floristic composition of this phase is as follows:

Dominant (Trees)	— <i>Gordonia, Elaeocarpus, Euonymus, Ilex, Rhododendron</i> , etc.
(Forest Associated herbs)	— <i>Peperomia, Impatiens, Senecio</i> etc.
Co-dominant (Shrubs)	— Rosaceae, Rutaceae, Fabaceae, <i>Lonicera, Strobilanthes, Dipsacus, Sarcococca, Berberis</i> , etc.
Sporadic	— Asteraceae, Liliaceae,

(Herbs)	Urticaceae, Caryophyllaceae, Apiaceae, Chenopodiaceae, Poaceae, <i>Gentiana, Portulaca, Justicia, Campanula, Plantago, Artemisia</i> , etc.
High	— Ferns
Low	— Aquatics

Phase IV (between 7,000 years BP-till date)

This phase has witnessed a decline in tree taxa. All those tree taxa alongwith shrubs constituting the closed evergreen forest in the preceding phase have slowly and gradually declined ceding place to the heathland condition. This shift in vegetation is not wholly and directly brought about by climate. During this phase, man had entered the landscape at Kakathope and exploited the forest wealth. In recent past, man has so ruthlessly damaged the forest elements that a major part of the hill tops has become bare and many of the forest associated herbaceous taxa, left after forest clearance, have also been damaged by frost and speedy chilly winds which otherwise would not have affected these ground cover herbs under the forest canopy.

Rees-corner, located about five km south-west of Udhagamandalam, is smaller as compared to Kakathope swamp. It is almost dry and inhabited by sedges, grasses, *Drosera* and *Equisetum*; along its margins, thick patches of shola could be seen. The swamp is regularly fed by sub-soil water from a nearby water-course flowing along its slope. It is also being regularly cleaned by the Soil Conservation Department and dykes have been constructed through the swamp for the purpose of drainage system.

One 3.30 m deep profile has been collected for investigation (Gupta, 1971). The top 0.30 m sediment is lateritic soil mixed with sand and pebbles and, thereafter, up to 0.90 m laminated gritty clay is present with no biomass accumulation. Between 0.90 to 2.80 m, sediments comprise clayey organic mud. The bottom sediments between 2.80 to 3.00 m are composed of clay, mixed with sand and pebbles with no biomass.

The palynological sequence from Rees-corner is comparable with upper part of Kakathope profile where the establishment of closed forest came into being. Therefore, on the basis of comparison, the total palynological sequence could be dated to about 15,000 years BP. In view of the total similarities in two pollen sequences, almost the same picture of vegetation development has emerged from Rees-Corner.

Colgrain, located about 15 km south of Udhagamandalam and 5 km south of Nanjanad on

Avlanche Road, at an altitude of about 2,450 m a.s.l. lies within the Kundah range in Nilgiris. This area is quite protected and the swamp is surrounded by patches of shola forest. The biotic pressure is mild and not yet fatal to the shola plant community.

A 2.50 m deep profile has been collected dating back to a period of about 30,000 years BP (Gupta & Prasad, 1985). In addition, surface samples procured from within the shola and open land have been investigated in order to work out the modern pollen vegetation relationship. The field examination of sediments reveals that degree of decomposition varies greatly; a sharp demarcation in the lithostratigraphy is seen at 1.30 m depth. The top 1.30 m sediments comprise clayey, organic mud which is largely mouldered; it contains high biomass potential. The bottom 1.20 m sediments are pale-yellow-coloured clay with fine to coarse sand and the biomass potential is almost negligible. The rate of sedimentation for the top and bottom sediments is estimated 1 mm per 16 years and 1 mm per seven and-a-half years, respectively.

Within the framework of pollen analysis of modern sediments, a surface sample procured from beneath *Eurya* complex within the shola yielded pollen of *Eurya* to the extent of 72 per cent of the total assemblage. In the successive samples procured on way to open land, *Eurya* pollen frequency began to fall considerably and ultimately the pollen disappeared from sample collected in the open land, near shola. Thus, surface sample study has added to our knowledge that pollen of tree taxa generally do not uniformly disperse throughout, and hence information so perceived could be utilized *Sensu stricto* for the reconstruction of palaeofloristics and its interpretation.

The palaeovegetation reconstructed from Colgrain is broadly similar to Kakathope. However, some minor differences and shift in time boundaries observed could be assigned to the local factors operating independently. For instance, the shrub savanna phase has been recorded between 30,000-25,000 years BP at Colgrain which was between 40,000-35,000 years BP at Kakathope. Similarly, Phase II, between 35,000-15,000 years BP at Kakathope recording the establishment of shrubby vegetation could be equated to Colgrain Phase II, between 25,000-12,000 years BP. The Phase III at Kakathope, between 15,000-7,000 years BP, marking the establishment of closed evergreen forest, corresponds to the Phase III of Colgrain, between 12,000-2,000 years BP. The decline in shola at Colgrain has been recorded only 2,000 years BP unlike Kakathope where decline of forest took place much earlier around 7,000 years BP. These variations

observed in two different localities are largely due to local anthropic factor; the exploitation of forest at Kakathope had begun for the last 7,000 years BP whereas human activity started at Colgrain only recently and not very intensively. Another reason for this phenological variation is that Kakathope abounds with the hill tribes such as Badagas, Kotas, Kurambhas, Irulas, Todas, etc.

Pykara, located about 19 km north of Udthagamandalam city on Mysore road, lies near the Pykara hydro-electric station. A 1.75 m deep profile has been investigated palynologically (Menon, 1968). As neither lithostratigraphy nor chronostratigraphy have been provided, nothing could be inferred about the nature and antiquity of the deposits. The palynological study reflects predominance of grasses throughout the pollen diagram attaining 85 per cent of total vegetation in upper half of the pollen diagram whereas lower half of the diagram is dominated by Poaceae and pteridophytes. Other taxa encountered in the assemblage are herbaceous, such as Brassicaceae, Balsaminaceae, Apiaceae, Asteraceae, Scrophulariaceae, Chenopodiaceae, Xyridaceae and Cyperaceae. Anacardiaceae and Caprifoliaceae in this assemblage belong to trees and shrubs, respectively.

On comparison, Pykara pollen diagram could be correlated with the top most part of Kakathope pollen diagram which has an estimated date of about 5,000 years BP. This period of Kakathope has been identified as the phase of anthropogenic activities and rapid savannization, this is true of Pykara as well.

Sandynallah, another reclaimed swamp area of about 422 hectare land now transformed into the sheep-breeding station, is situated (11°26' 12" N, 76°38'2" E; 2,200 m a.s.l.) on right side of the Pykara road about 70 km NW from Udthagamandalam. The indigenous vegetation is almost lacking in and around the area, except for recently introduced frost tolerant trees, viz., *Pinus patula*, *Acacia melanoxylon*, *A. decurrens*, *Grevillea robusta*, etc.

One 2.30 m deep soil profile was pollen analysed and dated to 30,000 ± 1,500 years BP (Vasanthi, 1988); however, anomaly is observed in Text-figure 4 where only 2 m depth has been shown. The cause of paucity of palynomorphs between 80 to 90 cm could have easily been determined if lithostratigraphic column was provided along the pollen diagram. The written version under the material and methods does not provide clarity as there are two contradictory statements, "a section of black argillaceous to silty peat was sampled to a depth of 230 cm" and "from 205 to 230 cm somewhat more arenaceous core was collected"

(Vasanthi, 1988). The summary pollen diagram from Sandynallah reveals overall predominance of Poaceae, followed by Asteraceae and other herbs except they declined at 55 cm depth coinciding with the spurt in swamp flora. Arborescent taxa are absent till the depth of 50 cm and, thereafter, they are recorded in reduced values. The face value interpretation of pollen diagram (Vasanthi, 1988) could have been altered if attempted to understand differential pollen dispersal and preservation through the study of modern surface samples. It has been established that the arborescent in the sediments from south Indian montanes are not represented to the tune they are actually present in the forest (Guinet, 1966; Gupta & Prasad, 1985).

The palaeofloristic picture at Sandynallah is more or less similar to Kakathope and coincides with phase 'b' and 'c' where the shrubs colonized and shola established, respectively.

PALAEOFLORISTICS OF PALNI

A 2.80 m deep profile from Parson's Valley has been analysed (Blasco & Thanikaimoni, 1974). This profile, too, does not record litho-chronostratigraphical details, hence it is difficult to assess the nature and time span taken for the deposits to be laid in. However, palynological details obtained with very high values of herbaceous elements, Poaceae being the most dominant point to open conditions. The tree/shrub savanna and forest elements are present in highly reduced values and do not exceed more than 6 per cent and 4 per cent, respectively. On comparison, Parson's Valley pollen diagram corresponds to upper part of the Kakathope pollen diagram which goes back to about 5,000-7,000 years BP envisaging a savanna type of landscape.

PALAEOFLORISTICS OF ANAMALAI

A number of surface samples and three soil profiles, one each from Arumparai, Kalikamati and Schichali, have been investigated. Most of the surface samples have revealed predominance of herbaceous group of vegetation. The arboreal vegetation is meagerly represented by taxa, like *Elaeocarpus*, *Meliosma*, *Symplocos*, *Glochidion*, etc.

All the three profiles investigated are not more than one meter in depth and lithology is clay with pebbles in plenty. The substratum is very stiff and does not permit the boring. The radiometric dates obtained are 1,500 years BP at 1 m depth in Kalikamati profile; Arumparai profile is dated to 710 years BP at the depth of 0.8 m and Schichali to 220

years BP at 0.60 m indicating the Late Holocene Period. The investigations have revealed that most of the profiles are palynologically barren and only sporadic pollen of some of the herbaceous taxa have been observed which are insufficient for percentage calculation. The most prevalent factors which inhibit the pollen preservation are: (i) excessive occurrence of saprophytic fungi which might have led to the pollen destruction, and (ii) that they have alkaline pH which is not favourable for pollen preservation.

PALAEOFLORISTICS OF SILENT VALLEY

Silent Valley is a reserved forest area and the shola is well protected. Due to difficult and remote nature of the terrain, a profile could not be collected. Byson swamp, which is deep into the forest, may provide ideal soil profile for palynological purpose.

Palynological analysis of several surface samples has revealed quantitative and qualitative richness. The pollen assemblage thus obtained matches with the modern vegetation to a greater extent and records arborescent taxa in good frequency. The important taxa encountered are *Elaeocarpus*, *Euonymus*, *Melastoma*, *Palaquium*, *Ilex*, *Michelia*, *Meliaceae*, etc.

Along the road-cutting, about six meter scarpment profile was collected and has been dated to about 600 years BP at 0.6 m level. The sediments are reddish-brown clay with plenty of sand and pebbles. The palynological investigation of the samples has revealed a good pollen assemblage mainly consisting of nonarboreal taxa. The arboreal taxa are poorly represented. This anomaly between the surface and profile samples' pollen assemblage as to why the profile samples lack arboreal vegetation, is yet to be worked out.

DISCUSSION

The palynostratigraphic study has brought out that vegetation cover on south Indian hill tops had witnessed considerable changes during the past 40,000 years BP. These changes were largely controlled by climatic factor, except for the last phase encompassing a few thousand years when the biotic factor coupled with climatic and edaphic factors played a vital role in transforming the forest cover into open land and in bringing about savannization.

The total vegetation development for the past 40,000 years BP could be segregated into four phases. Phase I is the period when only herbaceous group of plants predominated with sprinkling of a

few shrubs and under trees with cold and dry climate. The lithology, being yellowish green clay with abundance of sand and pebbles, further supports the view that cold climate with higher aridity prevailed at that time. This phase spanned for five thousand years, between 40,000-35,000 years BP.

In the succeeding Phase II, a shift in the vegetation through gradual invasion of shrubs into the open land took place—a step towards initiation of forest. The lithology of this phase is largely composed of organic mud with high biomass accumulation and less clay and sand. This shift in the palaeofloristics is believed to have been brought about by amelioration in temperature, increase in precipitation and humidity, as compared to the preceding phase. This phase lasted between 35,000-15,000 years BP. Phase III is quite important as it was a period for the establishment of closed, evergreen forest. In addition, all the forest associated herbs were present in their maxima and this phase continued for about 8,000 years indicating the period of maximum warmth with much higher precipitation and humidity than the preceding phase.

Phase IV has different time spans at different places, ranging from 7,000 years BP at Kakathope, 5,700 years BP at Pykara and Parson's Valley, and 2,000 years BP at Colgrain. This phase marks the decline of closed evergreen shola, its confinement to the protected moist depressions, loss of power of colonising open areas and in ultimate case the total savannization of the land. This phase is largely governed by consistent efforts and magnitude of man's activities to meet the hunger of pasture-land and farm-land. The recurrence of fire to obtain new tender grass for livestock, has forced the shola plant community to restrict to its present position. The uninterrupted biotic pressure over the forest has changed the climatic conditions as well. As a result, the speedy chilling winds coupled with frost have become effective in not providing the conditions conducive to the spread of shola.

As to the current burning problem regarding the status of shola *vis-a-vis* grassland, we now have enough data base to say that shrub savanna was the pioneer plant community on south Indian hills under the cold and dry climatic regime. With the amelioration in temperature and increase in precipitation, shola constituents invaded the grassland and established around 15,000 years BP. In the last phase, with increasing human needs, the closed evergreen forest came under heavy pressure and most of the landscape was transformed into the shrub savanna again. Under this type of vegetation cycle, in which open conditions are the ultimate

result, it may be suggested that the shrub savanna be designated as climatic climax plant community and the shola as a sub-climax.

FUTURE

From the foregoing account, it has been observed that how the vegetational development during last 40,000 years BP took place under various controlling factors. It has also been worked out that at times shola was established and thereafter declined in the areal extent; the biotic factor has been identified as the main reason for destruction of shola forest ceding place to savannization in the near past.

There are two main factors operating concurrently in the south Indian hill tops: (i) destruction of shola, clearing the land by way of felling the trees and repeated fires, and (ii) afforestation of the bare land with exotic plants, such as eucalyptii, acacias, teak, cinchona, coffee, etc. These factors are effectively operating and are chiefly controlled by man.

The pernicious practice of felling trees and fire promote the formation of shrub savanna. It has also been revealed by palynological investigation that forest got transformed into the shrub savanna with the advent of man into the landscape around 7,000 years BP. If the process of felling of trees and fire are intensified then shrub savanna gets converted into the herbland. Coupled with plantation of exotic trees, they exhaust the surface soil-moisture because of excessive evapo-transpiration. It is believed that the *Eucalyptus* tree absorbs large amount of sub-soil water, several times higher than indigenous trees, though experiments on the water uptake of *Eucalyptus* spp. are still in progress. Reduction of soil moisture, making the soil dry and winds to blow at a fast rate, help the erosion of top soil. Thereafter, degradation of rocks takes place making them denuded preventing the vegetation to colonize. These conditions play a havoc in extermination of shola from their homeland, disbalancing the ecosystem.

Palynology has been instrumental in unfolding the facts that shola species are not regenerating under adverse conditions and therefore, a phenomenal reduction in their areal extent is recorded. In view of the past and present features of the evolution of vegetation it had been suggested that the shola be considered as a living fossil plant community which, in due course of time may vanish and become extinct (Vishnu-Mitre & Gupta, 1968, 1971).

Keeping in view of wide spread herbland, one

ought to think about future of the shola ecology as to how shola woods could spread into herb land and overcome acacias and eucalyptii. The continued exotic plantation and fast expanding grassland clubbed with the hunger for pastoral and arable lands will tend further shola destruction.

For the restoration of shola ecology and proper management of the montane environment, the first step to be taken is to reduce the biotic pressure and put a check over unplanned development. Ways and means have to be found to regenerate shola species in the areas now covered by herbs, grasses and plantation. The slow but continuous process of plant succession has to pave the way for a thorough restitution of shola community which under the existing conditions is on its way to extinction like the Dodo or the Dinosaur.

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