



MID-HOLOCENE VEGETATION AND CLIMATE OF SOUTH INDIAN MONTANE

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ABSTRACT

The paper records a middle Holocene vegetational and climatic sequence from Konalar basin and Kuntan shola of Palni Hills in South India through pollen analysis. The lithology of sediment profiles consisted of either organic mud or silty clay with higher pH. The pollen spore content of sediments with abundant Poaceae (57-85%), Cyperaceae, shola forest associated ephemerals like *Senecio*, *Ranunculus*, *Impatiens*, *Artemisia*, *Heraclium*, pteridophytic spores, together with the relative abundance of shola arboreals such as *Ilex*, *Symplocos*, *Celastrus*, Oleaceae, *Ligustrum* and *Rhododendron* are indicative of the persistence of upland shrub savanna as climax vegetation during middle Holocene.

Key words : Mid Holocene, vegetation and climate, South Indian montane.

INTRODUCTION

The reconstruction of Quaternary vegetational history has been made from various localities from time to time in South Indian montanes, namely Nilgiris, Palnis and Anamalai Hills (Meher-Homji, 1967, 1975; Menon, 1968; Legris and Blasco, 1969; Vishnu Mittre and Gupta, 1970; Gupta, 1973; Blasco and Thanikaimoni, 1974; Gupta and Prasad, 1985; Vasanthi, 1988; Sukumar, Ramesh, Pant and Rajgopalan, 1993; Bera, Gupta and Farooqui, 1996; 1997; Gupta and Bera, *in press* and Bera, *in press*). In the present paper, a comprehensive attempt has been made through the pollen analytical investigation of two sediment profiles, one each from Konalar and Kuntan shola of Palni Hills in South India with a view to unravelling the short-term vegetational and climatic fluctuation in the study area during the mid-Holocene (fig.1).

KONALAR BASIN

“Konalar” (10° 12' 48"N, 77°22'E) is the name given to the river flowing in the middle of the swampy region that finally meets the river “Amravati”. The swamp lies 6 km south west of Berijam lake. The swampy area measures about 1000 m in length and 600 m in width, having a depth of 2 meter.

Kuntan shola

The Kuntan shola (10° 12'- 10° 18' Lat.N and

77°26' - 77°34' Long.E) lies in a swampy area covering about 1 sq. km and is about 5 km south west of Kodaikanal city. The most of the hill tops are denuded, wherein *Pinus*, *Acacia*, etc. have been largely planted along the swampy depression.

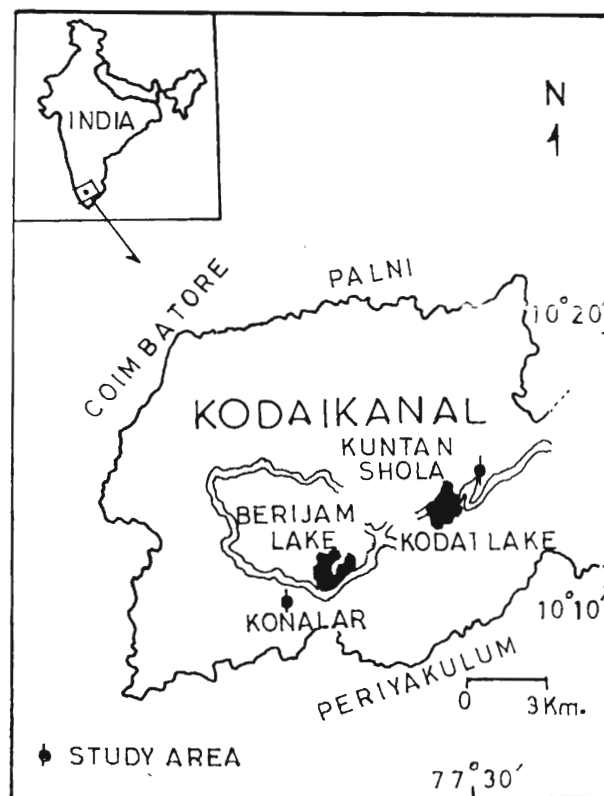


Fig.1. Showing the sampling sites.

However, a few protected pockets of the sholas are observed at the deep gorge in the southern part of the region.

VEGETATION

Shola forest is confined mainly to the higher hill slopes where favourable moisture and sunlight is available. The main shola tree components such as *Elaeocarpus ferrugineus*, *E. tuberculatus*, *Eurya japonica*, *Gordonia obtusa*, *Sideroxylon tomentosum*, *Euonymus crenulatus*, *Symplocos foliosa*, *Meliosma wightii*, *Cinnamomum wightii*, *Photinia notoniana* occur in the mid forest, while *Rhodomyrtus tomentosa*, *Ilex* spp., *Trema orientalis* and *Rhododendron nilagiricum* occupy the periphery of the forest.

Grasses largely comprise *Cymbopogon polyneuros*, *Fimbristylis* sp. and *Andropogon foulkrii* etc. The ephemerals comprising *Anaphalis lawii*, *Cyanotis* sp., *Leucas subfruticosa*, *Heracleum tingens*, *Cassia mimosoides*, *Cnicus wallichii*, *Viola patrinii*, *Impatiens floribunda*, etc. are seen colonising the areas. *Pteris anilina* that reaches the height of a man along with scattered *Rubus ellipticus* are regularly found in the grassy areas. In the vicinity of the swampy areas, the exotic spp. such as *Pinus*, *Betula*, *Acacia melanoxylon*, and *Eucalyptus globulus* have been planted in a large number along the road side. It is worth mentioning that most of the *Eucalyptus* trees planted around the Kuntan shola forest are dying due to heavy lopping.

MATERIAL AND METHODS

The localities from where the cores have been obtained are Konalar swamp in Berijam forest division and Kuntan shola from Kodaikanal forest division of Palni Hills. Radiocarbon date for Konalar sediment (2m deep) profile has revealed a span of 4000 years B.P for the total deposits, whereas only 990 years B.P is estimated for the Kuntan shola sediment profile (1.5m). The sediments are highly compressed organic muds or silty clay. Boring could be done up to the depth of 2 meter at the maximum by the Hillar type of peat borer due to the hard bottom sediment in the area of study. The sediments are mostly lacustrine and laid under reducing environment. For extraction of palynodebris, the

usual technique was followed, involving the use of KOH, HF and acetolysis (Erdtman, 1943). The frequency percentages of recovered plant taxa have been calculated in terms of total pollen counted. They have been categorized as trees, shrubs, herbs, marshy/aquatics and ferns in the pollen diagram. The comparative study of two investigated sediment profiles with Berijam lake is also provided with a view to understanding the vegetation and climate during Holocene in South Indian montane (table 1).

MODERN POLLEN/VEGETATION RELATIONSHIP

Five moss samples were pollen analysed to understand modern pollen/vegetation relationship and interplay of pollen in order to interpret precisely the palaeofloristic sequence from the sediment profile. Four samples around Konalar swamp were collected from a hill top covered with extensive plantations of pines and *Acacia* in a transect at an interval of 100m each, while a sample of Kuntan shola was collected from the forest floor.

The pollen spectra made from moss samples show predominance of nonarboreals over arboreals in all cases except in the sample no.4 where the arboreals attain up to 42 per cent and in others the value ranges from 24 to 33 per cent. Among the total arboreals, alien taxa like *Acacia* and *Pinus* effectively mask the other local taxa ranging from 16 to 35 per cent (in samples no.4) The major arboreal taxa namely, *Ilex*, *Osbeckia*, Sapotaceae, *Rhododendron*, Myrtaceae, Oleaceae, Malvaceae are the common elements recorded within 7-13 per cent. The ground vegetation is largely dominated by Poaceae (36-55 per cent) followed by *Senecio*, *Artemisia*, *Ranunculus*, *Chene/Ams.*, *Impatiens*, *Heracleum*, etc. in low to moderate value. The marshy plants like Cyperaceae, Gentianaceae and *Myriophyllum* are encountered in low to sporadic value in only sample no 4. Fern spores, both monolet and trilete, are recorded in low to sporadic values except slightly higher in the sample no. 3.

The pollen spectrum made from the moss sample collected from Kuntan shola reveals the over dominance of nonarboreals over arboreals. The value of arboreals account for 30 per cent, of which *Acacia* and *Pinus* comprise 10 per cent of the total. Other major shola taxa like *Ilex*, *Rhododendron*,

Table 1 : Comparative study of the investigated sediment profiles from Kuntan Shola , Konalar and Berijam Lake , Palni Hills, South India.

KUNTAN SHOLA			KONALAR			BERIJAM LAKE		
Time Frame	Vegetation	Climatic implication	Time Frame	Vegetation	Climatic implication	Time Frame	Vegetation	Climatic implication
Around 235 yrs. B.P	Decline in shrubby elements in grassland	Decreasing warm and humid climate						
235 - 780 yrs. B. P.	Substantial rise in shrubby elements (Shrub savanna)	Warm and Humid climate						
780 - 990 yrs. B.P.	Barren zone		Around 1150 yrs.	Persistence of shrub savanna	Amelioration of climate			
			1150 - 2300 yrs. B.P.	Expansion of grassland	Cold and Dry climate	Around 2000 yrs. B.P.	Shrub savanna	
			2300 - 3460 yrs. B.P.	Shrub savanna	Increasing warm and Humid climate	2000 - 4000 yrs. B.P.	Persistence of shrub savanna & decline in grasses	Amelioration of climate
			3460 - 4000 yrs. B.P	Gradual rise in shrubby elements in the grassland	Warm and Humid climate	4000 - 7000 yrs. B.P.	Substantial rise in arboreals & grasses	Warm and less Humid climate
						7000 - 14500 yrs. B.P.	Persistence of shrub savanna & rise in grasses	Increasing warm climate
						14500 - 17000 yrs. B.P	Barren zone	Warm and Humid climate
						17000 - 20000 yrs. B.P.	Expansion of grassland	Cold and Dry climate

Myrtaceae, Oleaceae, etc. are encountered in low value. Ground vegetation is dominated by poaceae which registers alone the value of 57% and other important ephemerals like *Senecio*, Urticaceae and *Impatiens* are recorded in low value. Fern spores are encountered in low profiles. Thus, almost all the samples exhibit the same palynological picture; excepting a slight reduction in overall value of arboreal taxa and a corresponding increase in the nonarboreals. The meagre or scanty representation of shola forest taxa in the spectra may be attributed to the absence of shola forest in the near vicinity of the study area. On the other hand, the occurrence of exotic taxa in good value is due to the surrounding plantations of *Pinus* and *Acacia*. However, there is no evidence of change in the ground vegetation except that Poaceae and Asteraceae improve in some instances. This aspects is to be judiciously considered during the interpretation of data in the pollen diagram. As is well known now, the concept

of face value evaluation of the pollen diagram does not mean much in building up the palaeofloristics unless viewed with the data from moss samples. Moreover, the study of moss samples has enabled us to work out all possible vagaries confronting the interpretation of pollen diagram.

POLLEN DIAGRAM AND ITS COMPOSITION

In order to have a better understanding of vegetation succession and accompanying climatic events during mid-Holocene, the pollen diagrams constructed from Konalar basin and Kuntan shola have been divided into pollen zones in a chronological order. The pollen zones are prefixed with the initials of the respective localities, i.e. KON for Konalar, KUN for Kuntan shola, whereas BZ denotes a nonfossiliferous zone at the depth of 90-50 cm. of Konalar and at 150-130 cm of Kuntan shola sediment profiles respectively (figs. 2 & 3).

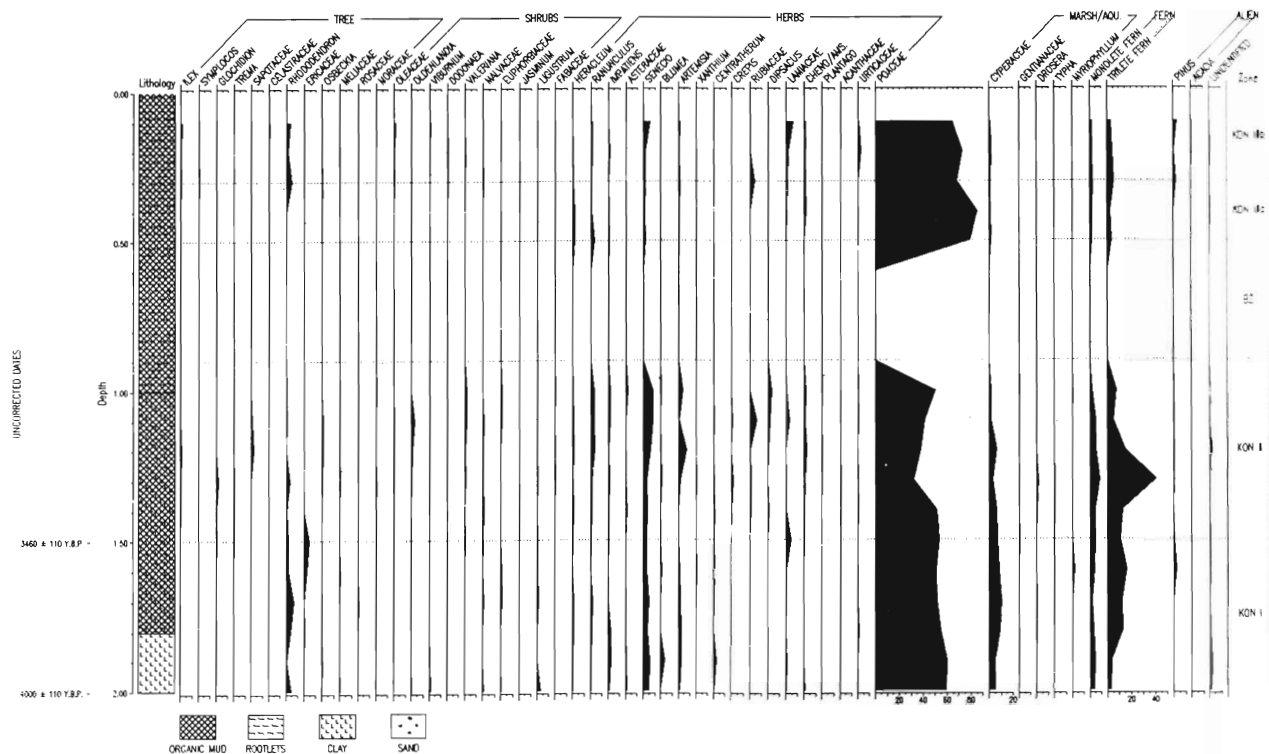


Fig.2. Pollen diagram from Konalar basin, Palni Hills, South India.

The palynomorphs recovered from sediment have been enumerated in an order to establish ecological conditions, differential pollen production, dispersal and preservation. The pollen grains and spores were identified in the usual way by comparing with reference slides available from sporothek of the division of Palynology, French Institute, Pondicherry and BSIP, Lucknow and largely by using a pollen/spore key prepared on the basis of local pollen flora. Some of the pollen types have been identified to species level but most were identified only to generic or family level.

GROUPING OF THE CHARACTERISTIC TAXA

Shola arboreal pollen (AP)

Closed evergreen woods occurring above 1500 m on Hills in the Nilgiris, Anamalai, Palni and Silent Valley in South India are known as sholas. This community is composed of both tropical and

temperate species which are generally restricted in the isolated patches in protected valleys often associated with streams.

a. Pollen grains of shola trees/shrubs : 1, *Ilex*; 2, *Symplocos*; 3, *Glochidion*; 4, *Trema*; 5, *Osbeckia*; 6, *Oldenlandia*; 7, *Viburnum*; 8, *Valeriana*; 9, Family Sapotaceae; 10, Family Celastraceae; 11, Family Ericaceae; 12, Family Meliaceae.

b. Pollen grains of trees/shrubs of the forest margins : 13, *Rhododendron arborium* var. *nilagiricum*; 14, Family Myrtaceae; 15, Family Rosaceae; 16, *Dodonaea*; 17, *Jasminum*; 18, *Ligustrum*.

Nonarboreal pollen/spores (NAP)

a. Pollen grains of shola herbs of the forest: 19, *Dipsacus*; 20, *Heracleum*; 21, *Impatiens*; 22, *Senecio*; 23, *Ranunculus*

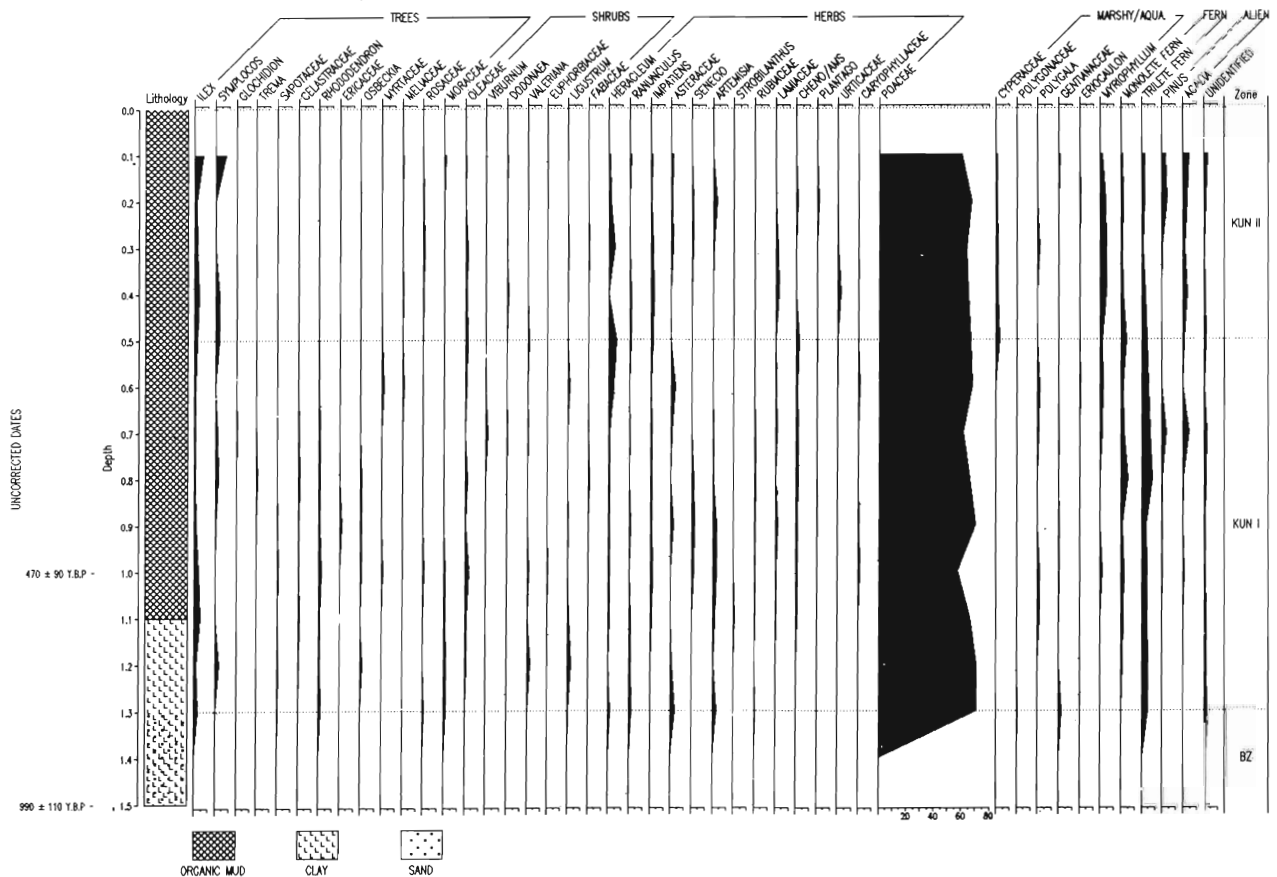


Fig.3 : Pollen diagram from Kuntan shola, Palni Hills, South India.

b. Pollen grains of shola herbs of the forest margin : 24, *Artemisia*; 25, *Xanthium*; 26, *Centratherium*; 27, *Crepis*; 28, *Strobilanthes*.

c. Cosmopolitan plants : 29, Family Rubiaceae; 30, Family Caryophyllaceae; 31, Family Lamiaceae; 32, Family Asteraceae; 33, *Blumea*; 34, *Plantago*; 35, Cheno/Ams; 36, Family Urticaceae; 37, Family Acanthaceae; 38, Family Euphorbiaceae; 39, Family Malvaceae; 40, Family Fabaceae.

d. Pollen grains of marshy/aquatic plants: 41, Family Cyperaceae; 42, Family Polygonaceae; 43, Family Gentianaceae; 44, *Polygala*; 45, *Drosera*; 46, *Eriocaulon*; 47, *Typha*, 48, *Myriophyllum*.

e. Pollen grains of *Poaceae* : (Grass pollen curve has been collectively represented).

f. Fern spores : (Sporomorphs are generally of spot origin, hence these are designated as monolete and trilete ferns)

KONALAR BASIN

Pollen zone KON I (200-150 cm): The time span of this zone is about 540 yrs ranging from 4000-3460 yrs B.P. The pollen zone depicts the overall dominance of nonarboreals over arboreals. The arboreals recorded at the tune of 2-12% of the total vegetation, comprising *Rhododendron*, *Meliaceae*, *Viburnum*, *Euphorbiaceae* and *Ligustrum* either in low values or sporadically. The ground vegetation comprises *Poaceae* (51-60%), *Cyperaceae* (5-10%) along with other ephemerals like *Senecio*, *Artemisia*, *Blumea*, and *Ranunculus* in low values. *Xanthium*, *Heracleum*, *Lamiaceae* and *Cheno/Ams* are present scantily. Monolete ferns recorded in low values (2-5%) as compared to the trilete ferns (4-16%).

Pollen zone KON II (150-100 cm) : The time span of this zone is about 1160 years ranging from 3460-2300 yrs B.P. On the basis of the pollen assemblage, the zone is characterised by the

predominance of nonarboreals over arboreals. The value of arboreals are slightly improved (4-14%). The taxa recorded are *Glochidion* and Ericaceae in low values, whereas *Ilex*, Sapotaceae, *Trema*, *Celastrus* and *Osbeckia* are present in trace value. The shrubby taxa such as *Valeriana*, *Jasminum*, Oleaceae, Moraceae and Fabaceae appeared for the first time in trace value. The value of Poaceae is reduced (32-53%), whereas other ephemerals like *Senecio*, *Artemisia*, *Ranunculus*, Rubiaceae and Lamiaceae improved as compared to the preceding zone. *Xanthium*, Acanthaceae and Urticaceae are present scantily. *Plantago*, *Dipsacus* and *Crepis* recorded for the first time sporadically. Gentianaceae, *Drosera*, *Typha* and *Myriophyllum* are recorded either in low values or sporadically. The value of monolete ferns improves slightly (2-8%) wherein trilete ferns reflect higher value (5-21%).

Pollen zone KON III (50-0 cm) : The time span of this zone covers 1150 years ranging from 2300-1150 years. On the basis of subtle changes in the value of some core shola taxa, the zone can be subdivided into two, i.e. KON IIIa & IIIb respectively.

Pollen subzone KON IIIa (50-30 cm) : This subzone is totally devoid of arboreal elements. The ground vegetation comprises Poaceae at the tune of 79-85%. Other ephemerals such as *Heracleum*, *Ranunculus*, *Impatiens*, *Senecio*, *Artemisia*, Rubiaceae, Chen/Ams, etc. are present either in low values or sporadically. The marshy as well as aquatic taxa totally disappeared except Cyperaceae in low value. Both monolete as well as trilete ferns are present in low values.

Pollen subzone KON IIIb (30-0 cm) : This zone covering 700 years B.P is characterised by the invasion of a few shola tree taxa and shrubs into the prevailing grassland. The major taxa recorded are *Ilex*, *Symplocos*, *Celastrus*, *Rhododendron*, *Osbeckia*, *Dodonaea* and Oleaceae either in low values or sporadically. Important ephemerals such as *Senecio*, *Artemisia*, *Ranunculus*, *Heracleum*, Rubiaceae and Urticaceae are recorded either in low values or sporadically. Among the nonarboreals, Poaceae shows a substantial reduction (65-73%). Cyperaceae and *Myriophyllum* are present

sporadically or in low values. Trilete fern spores register a slightly higher values (6%) than monolete ferns. The low value of *Pinus* and *Acacia* show the occurrence of exotic plantation during the recent past.

KUNTAN SHOLA

Pollen zone KUN I (130-50 cm) : This zone is marked by the intrusion of shola arboreals into the grassland as revealed by *Ilex*, *Symplocos*, *Celastrus*, *Rhododendron*, *Ligustrum*, Oleaceae and Moraceae in low values and of *Glochidion*, *Viburnum*, *Dodonaea*, Myrtaceae and Meliaceae in scant proportion. Simultaneously shola forest associated ephemerals like *Heracleum*, *Ranunculus*, *Impatiens*, *Senecio*, *Artemisia*, Rubiaceae, Lamiaceae and Chen/Ams are present in low values. Poaceae covers 71% of the total vegetation. *Polygala*, *Myriophyllum*, Gentianaceae and *Eriocaulon* are present in low profile. Monolete fern spores are present in relatively low values (5%) while triletes contribute 8%.

Pollen zone KUN II (50-0 cm) : This zone is marked by the reduction of major shola arboreals along with a substantial decrease in herbaceous taxa. Among arboreals, *Ilex* and *Symplocos* appear in low values at the beginning and gain thereafter at the top. The other tree taxa such as Rosaceae, Oleaceae, *Dodonaea*, *Valeriana*, *Ligustrum* & Meliaceae are recorded either in low values or sporadically. Among nonarboreals, Poaceae shows highest frequency (68% of the total vegetation). However, the other ephemerals such as *Ranunculus*, *Impatiens*, *Senecio*, etc., are present at the same value as before. *Heracleum* appear, in relatively higher value than before. Among marshy and aquatic plants, Cyperaceae, *Myriophyllum*, *Polygala* and Gentianaceae are present either in low value or sporadically. Both monolete as well as trilete fern spores continue in low profile throughout. The alien taxa such as *Acacia* and *Pinus* are also present in low profile as before.

DISCUSSION

Quaternary vegetational history has been reconstructed from various ecological zones in South Indian Montanes, namely Nilgiris, Palnis and

Anamalai Hills. The pollen assemblage from Pykara region, characterised by paucity of arboreal species is indicative of two phases of drier climate separated by a moist interval (Menon, 1968). Blasco and Thanikaimoni (1974) recorded dominance of pollen of Savanna species over that of shola trees in the Pykara and Parson's valley swamps. Vishnu Mittre and Gupta (1970) and Gupta (1973) proposed that at Kakathope grass cover was formed following the destruction of shola forest. Gupta and Prasad (1985) recorded three phases of vegetational development during 30,000 yrs. B.P. Vasanthy (1988) observed that montane grassland persisted in Sandynala of Nilgiri hills since 30,000 yrs. B.P. Gupta and Bera (*in press*) have recorded a pollen assemblage dating back to >40,000 yrs B.P. from Bombay shola in Palni hills indicating three phases of vegetational development, i.e. degeneration of shola forest, grassland, reestablishment of shola forest, reflecting on three-fold climate oscillations such as increasing cold and decreasing moist, cold and dry, warm and moist climate regime. The pollen assemblage from Anamalai hills indicate that the area during 1500 yrs. B.P. was without tree in the landscape except a few herbs associated with shola forest.

In the present investigation (table 1), the palynological data transmitted from Konalar and Kuntan shola have been used in order to compare with Berijam lake profile dated back to 20,000 yrs B.P. (Bera *et al.*, 1996). Three distinct phases of vegetational development were recorded from the sediment profile during the past 20,000 yrs B.P. During 20,000-17,000 yrs B.P. there was far and wide grassland under cold and dry climate, thereafter during 17,000-14,500 yrs B.P. was a barren zone signifying oxidizing environment precluding preservation of any biota and then during 14,500-7,000 yrs B.P. the phase witnessed a shift in vegetation, i.e. shrub savanna in warm and humid climate and then from 2,000 yrs B.P. the same vegetation pattern continued in pre-existing climate. Thus, the vegetational succession evidence from Konalar profile since 4000 years B.P. to 1150 yrs B.P. is well corroborated with Berijam profile, and Kuntan shola profile shows younger in age (990 yrs B.P.) than Konalar (4000 yrs B.P.). The evolution of swampy savanna with luxuriant herbaceous cover in

Kuntan shola of Palni hills from initial oxidizing environment through warm humid to semi-humid condition, is inferred from pollen analytical data.

CONCLUSION

In the present investigation a comprehensive picture of vegetational and climatic scenario has been built up since 4000 years B.P. through the pollen analysis of two lacustrine sediment profiles, one each from Konalar basin and Kuntan shola of Palni Hills in South India. The study has also enabled us in ascertaining the short term climatic alteration in the region during mid Holocene. The pollen data generated from the study of Konalar basin have unravelled three phases of palaeofloristic and palaeoclimatic oscillation, i.e. (a) the existence of shrub savanna during 4000-3460 yrs. B.P. under onset of warm and humid climatic regime, (b) persistence of shrub savanna during 3460-2300 yrs. B.P. under increasing warm and humid climatic conditions, (c) occurrence of vast stretches of grassland during 2300-1150 yrs B.P. indicating cold and dry climate and then climate amelioration leading to increasing warm and decreasing humid climate. The study from Kuntan shola reflected two phases of vegetation succession followed by a barren zone during 990 yrs. B.P. The first phase reflects the existence of shrub savanna during 780-235 yrs. B.P. under warm and humid climatic condition, whereas in the last phase the degeneration of savanna during the last 235 yrs. B.P. might be due to deterioration of climate.

Thus, the findings of the present study in and around Konalar and Kuntan shola forest areas have an important bearing upon the theories regarding the origin and ecological status of upland savanna of Nilgiris, Palnis and Anamalai. The existence of montane grasslands and evergreen shola forest have posed an enigmatic problem as to which plant community be considered as climatic climax plant community.

For the change in the vegetational scenario observed recently, the selective felling and lopping of major shola trees by the local folks to meet their domestic needs and also extensive plantation of *Pinus* and *Acacia* cannot be overruled. Although the high values of grasses, *Chenopodium*, *Amaranthus*, *Artemisia*, etc.

are suggestive of agricultural practice and intense anthropogenic pressure on the natural vegetation, they remain only a possibility without a definite proof. Whereas the shola forest has almost completely disappeared today remarkably from Konalar Basin, the formation of organic clay has revealed a rich and varied palynoflora reflecting the occurrence of least but true shola elements such as *Ilex*, *Symplocos*, *Celastrus*, *Rhododendron*, *Oleaceae*, etc. in the immediate vicinity during mid-Holocene.

The regular decrease of pteridophytes is also indicative of the reduction of the forest cover on which the majority of ferns are dependent. The meagre value in the pollen spectra of the two exotic genera such as *Pinus* and *Acacia* in the immediate vicinity of the swamp, is possibly due to the tendency of their pollen to travel long distances and not to get incorporated in the sediment.

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