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Evidence of deterioration in phytodiversity of Itanagar Wildlife Sanctuary, Arunachal Pradesh, India based on palynological evidence

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ABSTRACT

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The pollen–spore assemblage and their preservation status study based on 25 surface samples from different sites of Itanagar Wildlife Sanctuary, Arunachal Pradesh is documented. The survey was based on 25 surface samples from different sites of the sanctuary with a view to assess actual status of pollen preservation. The pollen assemblage depicts predominance of the nonarboreals over arboreals which do not fully match the present vegetation of the sanctuary. However, the occurrence and relative abundance of both deciduous and wet evergreen forest complex though in low frequency are of great significance towards its existence. Arecaceae pollen probably belongs to *Arenga* and *Livistona* despite their absence in surrounding vegetation. The presence of cerealia and other cultural pollen, viz. Chenopodiaceae and *Xanthium* are suggestive of the anthropogenic activity in and around the study area. The enhanced fern allies especially *Osmunda*, *Cheilanthes*, *Gleichenia*, *Dipteris* and *Pteris pentagyna* are supposed to be of subtropical–temperate in origin coupled with fungal complex (*Glomus*, *Xylaria* and Microthyriaceae) indicate humid depositional environment in the basin. Prevalence of rich organic matters festooned with fungal remains may be attributed due to relatively higher rates of weathering and erosion of the hinterland influenced by enhanced SW monsoon during the time of deposition. The incidence of degraded palynomorphs indicates aerobic microbial diagenesis of rich organic debris during sedimentation. The overall palynological result hints a deteriorating scenario of wildlife sanctuaries and associated region in recent times.

Key–words—Arunachal Pradesh, Biodiversity, Deterioration, Modern vegetation, Palynology, Palynoassemblage.

परागाणविक प्रमाण के आधार पर भारत में अरूणाचल प्रदेश के ईटानगर वन्यजीव अभयारण्य की पादप विविधता में ह्रास के प्रमाण

एस.के. बेरा, एस.के. बसुमतारी एवं आर. गोगोई

सारांश

अरूणाचल प्रदेश में ईटानगर वन्य अभयारण्य के विभिन्न स्थलों से प्राप्त 25 पृष्ठीय नमूनों के आधार पर पराग–बीजाणु समुच्चय एवं उनकी परिरक्षण दशा प्रलेखित की गई है। सर्वेक्षण पराग परिरक्षण की वास्तविक दशा को मूल्यांकित करने के मद्देनजर अभयारण्य के विविध स्थलों से प्राप्त 25 पृष्ठीय नमूनों पर आधारित था। पराग समुच्चय वृक्षीयों पर गैर–वृक्षीयों की पूर्व प्रभाविता चित्रित करता है जो कि अभयारण्य की मौजूदा वनस्पति से पूरी तरह से मेल नहीं खाती। फिर भी, पतझड़ी एवं आर्द्र सदाहरित वन जटिल दोनों की प्राप्ति व सापेक्षिक प्रचुरता यद्यपि निम्न आवृत्ति में हैं अपने अस्तित्व के लिए विशाल महत्ता की हैं। चहुंओर वनस्पति में अपनी अनुपस्थिति के बावजूद एरेकैसी पराग संभवतः *एरेंगा* एवं *लिविस्टोना* का है। अध्ययन क्षेत्र में एवं चहुंओर अनाज और अन्य संवर्धित पराग अर्थात चीनोपोडिएसी एवं *ज़ेन्थियम* मानव जनिक सक्रियता को सुझावित हैं। वृद्धित पर्णांग उपवर्ग विशेषतः *ऑस्मुंडा, कीलेन्थेस, ग्लीकेनिया, डिप्टेरिस* एवं *प्टेरिस पेंटागाय्ना* कवक सम्मिश्र (*ग्लोमस, जायलेरिया* और माइक्रोथाइरिएसी) सहित युग्मित उद्गम में उपउष्णकटिबंधीय–शीतोष्ण के होने चाहिए, द्रोणी में आर्द्र निक्षेपणीय पर्यावरण इंगित करते हैं। कवक अवशेषों सहित चुन्नटयुक्त प्रचुर कार्बनिक पदार्थ की व्यापकता निक्षेपण के दौरान वृद्धित दक्षिण–पश्चिम मानसून से प्रभावित अपक्षय

एवं पश्चभूमि के अपरदन के सापेक्षतः उच्चतर दर का कारण मानी जा सकती है। लघुकृत परागाणुसंरूपों की घटना अवसादन के दौरान प्रचुर कार्बनिक मलबा का वायुजीवी सूक्ष्मजीवी पीढ़ीएकांतरण इंगित करती है। समूचा परागाणविक निष्कर्ष हाल ही के समय में वन्यजीव अभयारण्यों एवं संबद्ध क्षेत्र के न्यून होते परिदृश्य का संकेत देता है।

सूचक शब्द–अरूणाचल प्रदेश, जैवविविधता, ह्रास, आधुनिक वनस्पति, परागाणुविज्ञान, परागाणुसमुच्चय।

INTRODUCTION

ARUNACHAL Pradesh is one of the global Mega–biodiversity hotspot lying in the eastern Himalaya which is considered as a botanical paradise (Srivastava, 2006; Srivastava & Choudhary, 2006, 2007). However, the Itanagar Wildlife Sanctuary is situated in Papumpare District which was created on 14.06.1978 having an area of 140.3 sq. km by superseding the earlier Itanagar Reserve Forest, Arunachal Pradesh (Fig. 1). The sanctuary is the home of a large numbers of mammals, birds and reptiles with high plant diversity. The sanctuary is close to Itanagar (the state capital) and surrounded by Poma River in the East, Pachin River in the South, Neorch River in the North West. However, the vegetation of any region is one of the most sensitive elements to show environmental condition and is usually used to get the environmental information (Davis, 1963). However, the modern vegetation is seriously destroying by the human activities such as over–logging and land coverage changes. Consequently, it is difficult to use the distorted modern vegetation in studying the actual environmental conditions. Among all the environmental proxies, the pollen analysis is one of the useful and a potential method to restore the vegetation and environmental condition due to small size, high production, stable chemical composition and preservation ability (Wang & Xu, 1988). In recent time the wildlife sanctuary, national parks and protected areas have been proved as important study areas to trace palaeovegetation and climatic history. Therefore, the first comprehensive attempt has been taken to establish a modern pollen deposition model from the present vegetation complex in the pristine sanctuary in Arunachal Pradesh of Northeast India through pollen analysis which is at the verge of extinction.

VEGETATION AND CLIMATE

The present study is performed in the tropical zone of the sanctuary where the forest belong to tropical mixed deciduous (Champion & Seth, 1968; Hajra *et al*., 1996; Singh *et al*., 2000) and the major tree taxa are represented by *Aphania rubra*, *Bauhinia purpurea*, *Schima wallichii*, *Syzygium cumuni*, *Terminalia bellerica*, *Salmalia malabaricum*, *Duabanga grandiflora, Alseodaphne obovata, Macaranga denticulata, Cinnamomum bejolghota*, *Dillenia pentagyna*, *Elaeocarpus sphaericus*, *Semecarpus anacardium*, *Michelia oblonga*, *Toona ciliata*, *Barringtonia acutangula*, *Hydnocarpus kurzii*, *Oroxylum indicum*, *Cordia dichotoma*, *Atlingera excels*, *Litsea monopetala*, *Pterospermum celenoides, Calicarpa macrophylla* and *Heteropanax fragren* (Fig. 2a, b). The major shrubs growing luxuriantly are *Desmodium caudatum*,

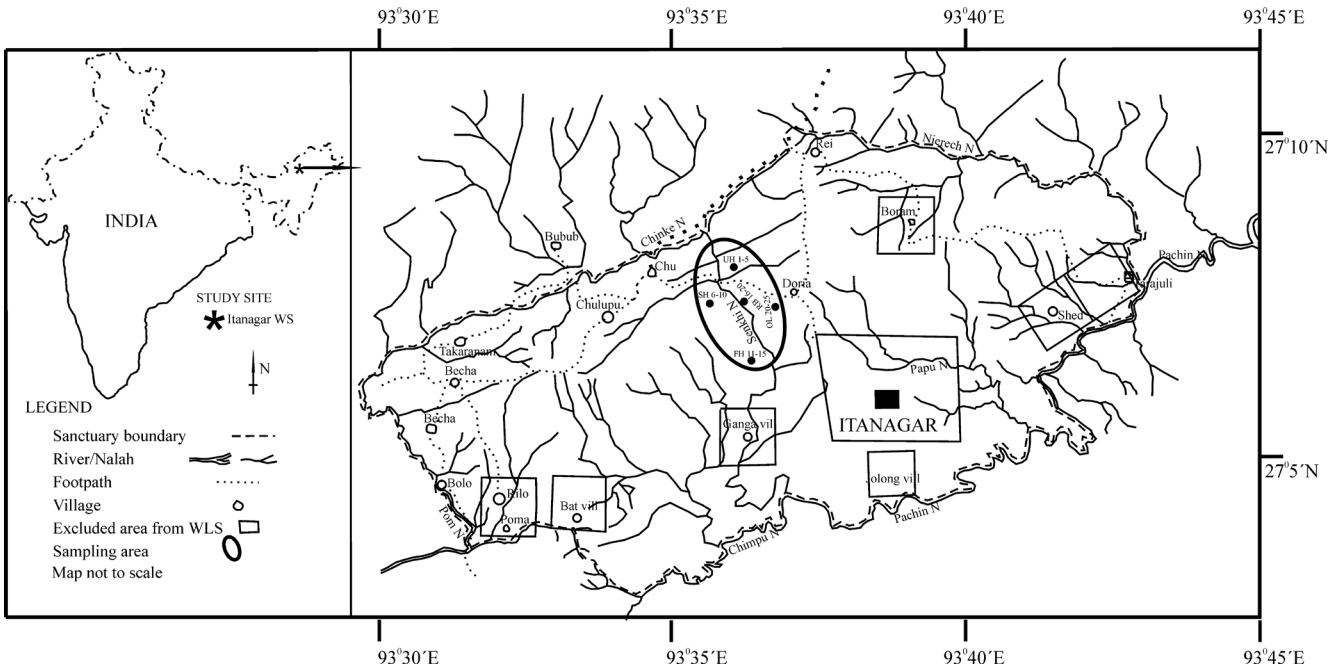

Fig. 1—Map of Itanagar Wildlife Sanctuary showing the sampling area and sites, Arunachal Pradesh, India.

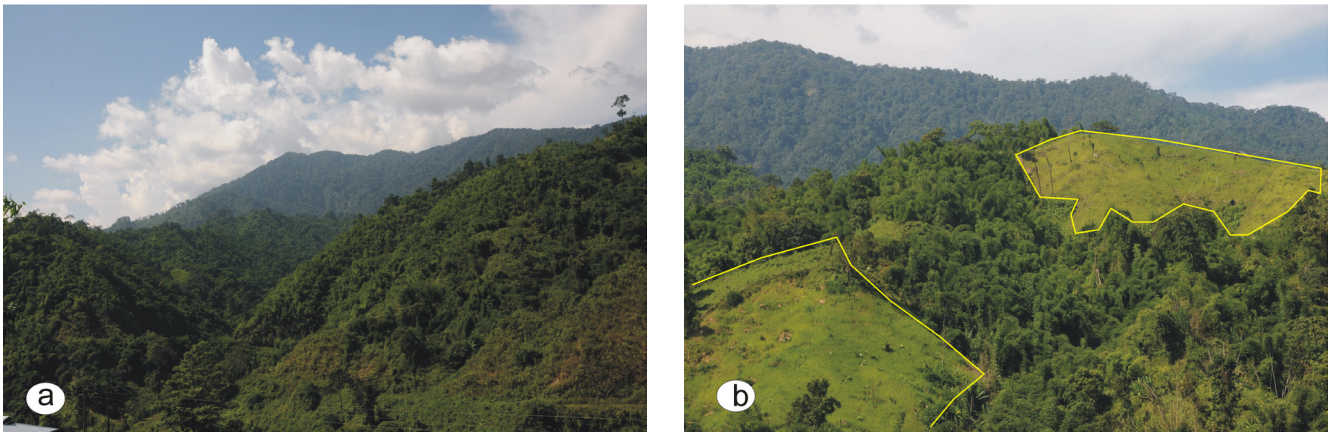

Fig. 2—(a) View of vegetation composition from Itanagar Wildlife Sanctuary, Arunachal Pradesh. (b) A view of hill top grassland with shrunken forest area (marked by outline), Itanagar Wildlife Sanctuary, Arunachal Pradesh.

Dalhousia bracteata, *Melastoma malabathricum*, *Holarrhena antidysenterica* and *Osbeckia rostrata*. The dominant bamboo species are *Bambusa polymorpha*, *Dendrocalamus hamiltonii*, *Melacanna bambusoides* and *Teinostachys dulloa* in and around the study area. Among the palm and canes *Wallichia densifolia* and *Zallaca scandens* are quite common in and around the study area. *Dendrobium moschatum, D. lituiflorum, Cymbidium aloifolium* and *Pholidota imbricata* are commonly found as epiphytes. The ground vegetation is meagrely represented with scattered ferns, namely *Lycopodium clavatum*, *Dryopteris filix–mas*, *Angiopteris evecta*, *Ophioglossum reticulatum*, *Cyathea brunoneana*, *Dipteris wallichii* and *Equisetum debile*. The climate is hot during summer and the maximum temperature reaches up to 30°C and minimum 3°C cold in winter. Rainfall ranges from 2,000 to 4,100 mm annually. The relative humidity ranges from 80 to 99% respectively.

MATERIALS AND METHODS

A sizeable number of surface samples (25) (both moss cushion and subsurface soil) were procured from Itanagar Wildlife Sanctuary randomly. Five samples from each location in an uneven distribution pattern, viz. upper hills (UH–1–5), slope hills (SH 6–10), foot hills (FH–11–15), river bank (RB–16–20) and open land (OL–21–25) (Fig. 1) were collected. The samples were processed employing standard acetolysis method (Erdtman, 1953) which include treatment with 10% aqueous KOH solution to deflocculate the pollen and spore from the sediments followed by 40% HF treatment to dissolve silica content. Thereafter, the conventional procedure of acetolysis was followed using acetolysis mixture (9:1 acetic anhydride and conc. H_2SO_4). Finally the material was kept in 50% glycerine solution for microscopic examination. A few drops of phenol were also added to the glycerine solution to protect the processed material from microbial decomposition. The total of 152 to 191 pollen and spore per sample were counted to make pollen spectra. The pollen study was carried out using Olympus BX–61 microscope and microphotograph has been taken with DP–25 digital camera under 40X magnification. The pollen spectra is made by computer program. The frequency of the recovered palynomorphs have been calculated in term of total sum including ferns and fungal remain. Finally the taxa were grouped as arboreal taxa (tree and shrub), nonarboreal taxa (terrestrial and marshy), highland taxa (conifers and other broad leaved taxa), ferns (monolete and trilete) and fungal remains respectively in the palynoassemblage (Pl. 1).

RESULTS

Pollen spectra

The pollen spectra of the sanctuary is described accordingly as below (Fig. 3).

UH 1–5—The study of moss cushion and subsurface soil shows an average value of nonarboreals (42.6%) is predominated over arboreals (11.1%) and highland taxa (28.9%) respectively. Besides, both monolete and trilete fern are occupied at the value of 4.3 and 5.2% respectively. However, fungal remain at the value of 7.7%. The rank wise frequencies of the nonarboreals are Poaceae (19.9%), Cyperaceae (5.0%), Tubuliflorae (3.2%), Liguliflorae (2.2%), *Impatiens* (1.6%), Rosacaeae (1.5%), *Artemisia*, *Mimosa* and *Oldenlandia* (1.3% each) and Lamiaceae (1.2%). However, Cerealia along with Caryophyllaceae, *Xanthium*, Chenopodiaceae and Onagraceae are represented sporadically.

Among the major tree taxa *Syzygium* (1.6%), *Schima* (1.3%) and *Bauhinia* (1.1%) are encountered in low to moderate values. However, Combretaceae, *Albizia*, *Salmalia malabarica Lagerstroemia*, *Duabanga*, *Cinnamomum*, *Elaeocarpus* and *Symplocos* are consistently represented

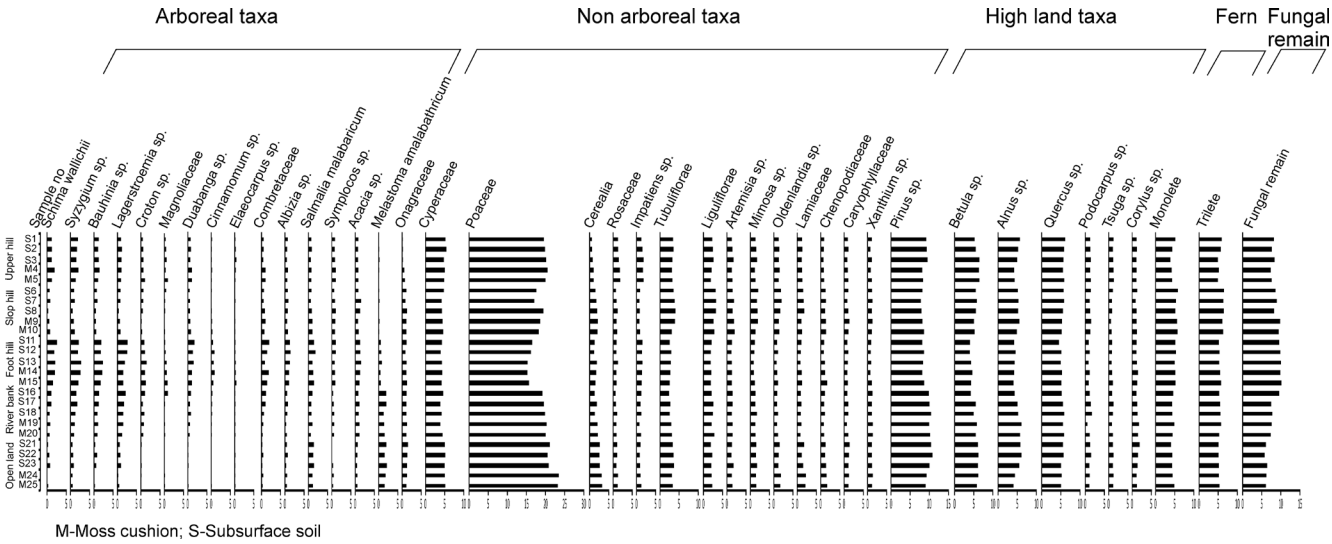

Fig. 3—Pollen spectra from Itanagar Wildlife Sanctuary, Arunachal Pradesh (percentage calculated in term of total pollen and spore sum).

in trace value. *Melastoma malabathricum* (2.1%) is a lone shrub encountered in moderate value and *Acacia* attains sporadically. Highland taxa like *Pinus* (8.8%), *Betula* (5.9%), *Quercus* (5.7%), *Alnus* (4.8%), *Podocarpus* (1.3%), *Tsuga* (1.1%) and *Corylus* (1.0%) are recovered in moderate to low value. The steady value of both monolete and trilete fern spores attain at the tune of 4.3 and 5.2% respectively. Fungal remains especially, *Xylaria* and Microthyriaceae show good value up to 7.7%.

SH 6–10—The study of moss cushion and subsurface soil shows an average value of nonarboreal taxa (43.6%) are dominated over arboreal taxa (8.2%), whereas, the highland taxa represented at the value of 27.3%. However, monolete and trilete are encountered at the value of 5.5 and 6.2% respectively. On the other hand, fungal remain represented at the tune of 8.9%. The nonarboreal taxa, like Poaceae (18.1%), Cyperaceae (4.4%), Tubuliflorae (3.6%), Liguliflorae (3%), Cerealia (1.8%), *Artemisia* and *Mimosa* (1.7% each), *Oldenlandia* (1.6%), Lamiaceae (1.4%), Chenopodiaceae (1.2%), *Xanthium* (1.1%), Caryophyllaceae and Onagraceae (1% each) are encountered good to moderate value. However, Rosaceae and *Impatiens* are in sporadic value. The tree taxa, like *Schima*, *Syzygium*, *Bauhinia*, *Lagerstroemia*, *Croton*, Magnoliaceae, *Duabanga*, *Cinnamomum*, *Elaeocarpus*, Combretaceae, *Albizia*, *Salmalia malabarica* and *Symplocos* are continuously represented in sporadic frequency. The major shrubby elements, namely *Acacia* and *Melastoma malabathricum* are also recovered in trace value. Highland taxa, like *Pinus* (8.1%), *Quercus* (5.5%), *Betula* (5.3%), *Alnus* (5.1%), *Podocarpus* (1.3%), *Corylus* (1.1%) and *Tsuga* (0.8%) are continuously encountered in good to low value. The good representation of fern spores both monolete and trilete at the value of 5.5 and 6.2% respectively. Fungal remains, especially *Alternaria* and *Helminthosporium* are recovered at the value of 8.9%.

PLATE 1

Palynoassemblage recovered from surface sample from Itanagar Wildlife Sanctuary, Arunachal Pradesh. →

1. *Schima wallichii*
2. *Symplocos* sp.
3. *Syzygium* sp.
4. *Lagerstroemia* sp.
5. Combretaceae
6. *Elaeocarpus* sp.
7. *Albizia lebbeck*
8. *Salmalia malabarica*
9. *Melastoma malabathricum*
10. *Quercus* sp.
11. *Pinus* sp.
12. *Betula* sp.
13. *Alnus* sp.
14. *Corylus* sp.
15. *Impatiens* sp.
16. Tubuliflorae
17. Liguliflorae
18. *Artemisia* sp.
19. Chenopodiaceae
20. Caryophyllaceae
21. *Mimosa pudica*
22. *Xanthium* sp.
23. Poaceae
24. Cyperaceae
25. Cerealia
26. *Dipteris wallichii*
27. Monolete
28. Trilete
29. Microthyriaceae
30. *Cookeina* sp.

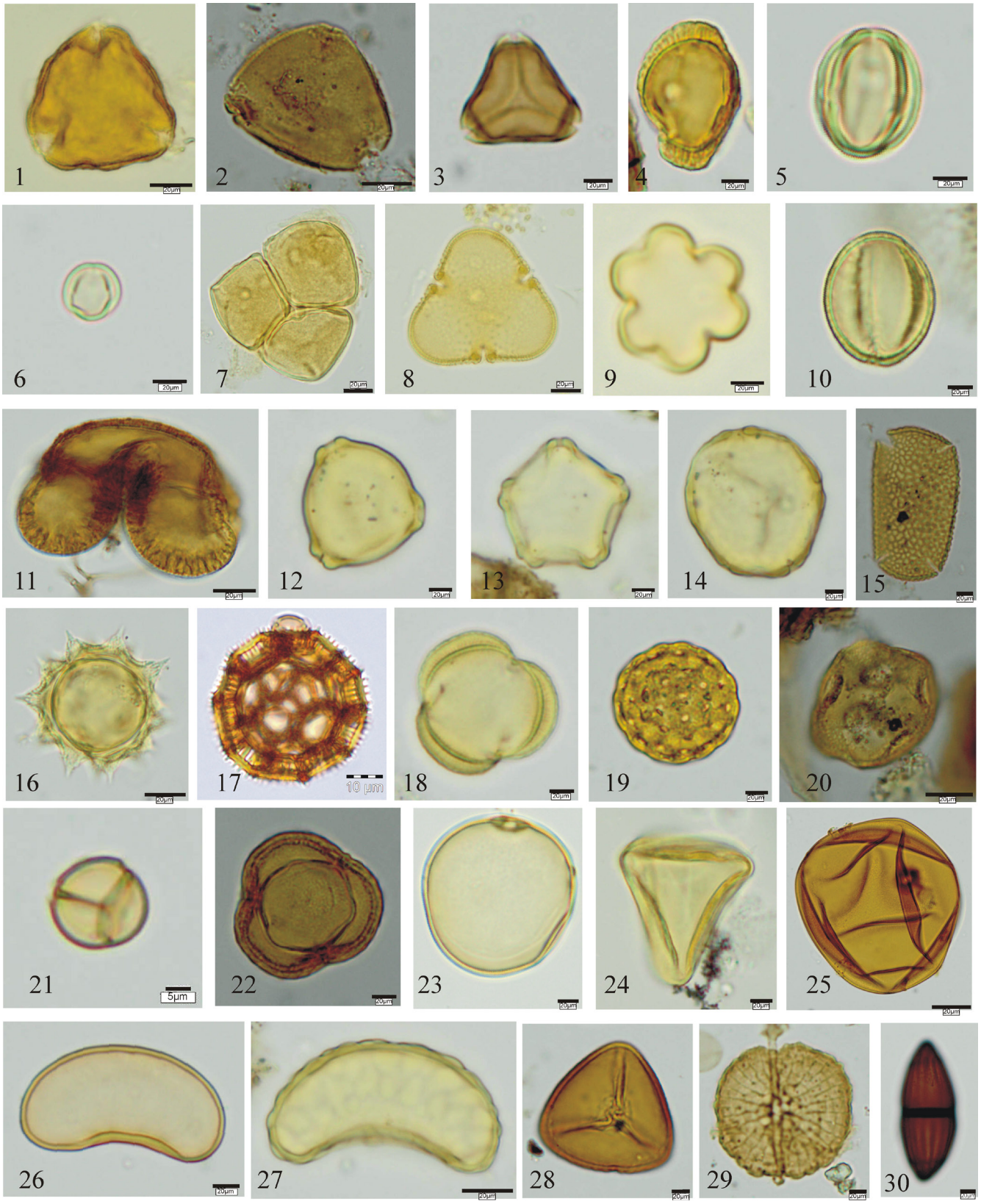
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PLATE 1

FH 11–15—The study of moss cushion and subsurface soil reveals the average values of nonarboreal taxa (36.2%) are dominated over arboreal taxa (18.7%). The highland taxa are represented at the value of 24.7%, whereas both monolete and trilete are recovered at the value of 5.1 and 5.3% respectively. However, the fungal remain is encountered at the value of 9.8%. The nonarboreal taxa, like Poaceae (15.7%), Cyperaceae (4.1%), Tubuliflorae (2.7%), Liguliflorae (2.0%), Cerealia and *Impatiens* (1.4% each), *Artemisia* (1.2%), *Mimosa*, *Oldenlandia*, Lamiaceae, Chenopodiaceae, Caryophyllaceae and Onagraceae (1.0% each) are continuously represented as high to low value. However, *Xanthium* and Rosaceae are recovered in sporadic frequency.

The major arboreals, like *Syzygium* (2.2%), *Lagerstroemia* (2.0%), *Schima* and *Bauhinia* (1.9% each), Combretaceae (1.5%), *Salmalia malabarica* (1.4%), *Duabanga* (1.3%), *Croton* and *Albizia* (1.1% each) are continuously represented in moderate to low value. Other associates taxa, like Magnoliaceae, *Symplocos*, *Cinnamomum* and *Elaeocarpus* (0.3% each) are also represented in low frequency. The major shrubby element, namely *Acacia* is recovered at the value of 1.3%, whereas, *Melastoma malabathricum* is sporadic. Highland taxa, such as *Pinus* (8.3%), *Quercus* (4.9%), *Betula* and *Alnus* (4.1% each) and *Corylus* (1.2%) are recorded at good to low values. However, *Podocarpus* (0.9%) and *Tsuga* (0.8%) are encountered in sporadic value. The good representations of fern spores both monolete and trilete at the value of 5.1 and 5.3% respectively. Fungal remains especially, *Diplodia* and *Glomus* are recovered at the value of 9.8%.

RB 16–20—The study of moss cushion and subsurface soil shows the average value of nonarboreal taxa (41.1%) is dominated over arboreal taxa (11.7%). The highland taxa are represented at the value of 29.5%. However, monolete and trilete are represented at the value of 4.5 and 5.4% respectively. Fungal remains are recovered at the value of 7.9%. The nonarboreal taxa, like Poaceae (19.7%), Cyperaceae (4.1%), Tubuliflorae (2.7%), Liguliflorae (2.4%), Cerealia (1.7%), *Artemisia* (1.4%), *Mimosa* (1.3%), *Xanthium* (1.1%), *Impatiens* and Onagraceae (1.0% each) are recorded high to low value. However, other associates, like *Oldenlandia*, Lamiaceae, Chenopodiaceae, Caryophyllaceae and Rosaceae are represented continuously in low frequency.

The major arboreal taxa, namely *Lagerstroemia* (1.5%) followed by *Syzygium* (1.2%) and *Bauhinia* (1%) are recovered in low frequency. However, Combretaceae (0.9%), *Schima* and *Salmalia malabarica* (0.8% each), *Croton* (0.7%), *Duabanga* (0.6%), *Albizia* and *Symplocos* (0.5% each), *Cinnamomum*, *Elaeocarpus* and Magnoliaceae (.2% each) are continuously represented in sporadic frequency. The shrubby elements, like *Melastoma malabathricum* (1.6%) and *Acacia* (1.5%) are encountered in moderate value. The highland taxa, namely *Pinus* is recorded at the value of 10%. However, *Quercus* (5.5%), *Alnus* (5.2%), *Betula* (5.1%), *Corylus* (1.3%) and *Podocarpus* (1.1%) are continuously represented in good to low value. *Tsuga* is recovered in sporadic. The fern spores both monolete and trilete are recorded at the value of 4.4 and 5.4% respectively. Fungal remains especially, *Cookeina* and Microthyriaceae are recovered at the value of 7.8%.

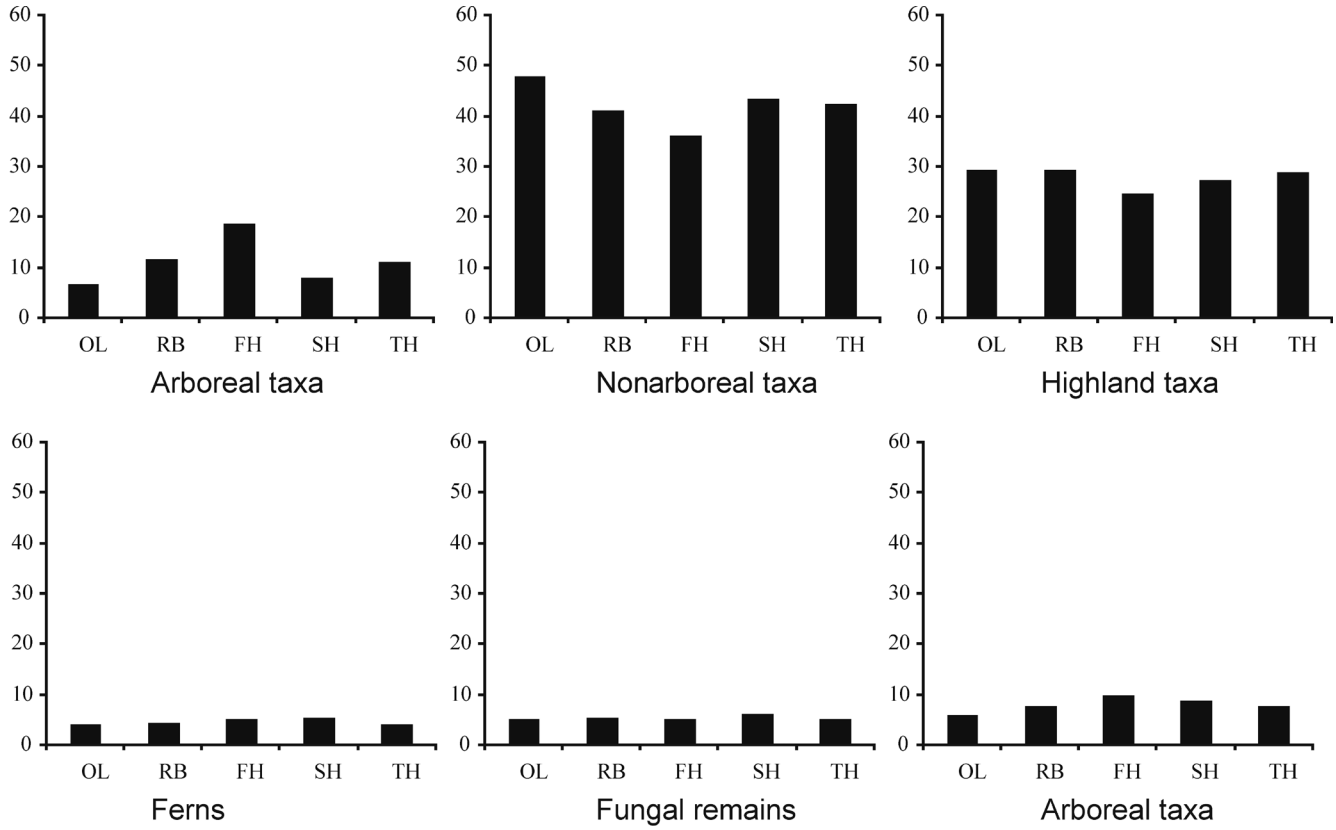
OL 20–25—The study of moss cushion and subsurface soil depicts predominance of nonarboreals (47.9%) over arboreals (6.7%). The highland taxa are recorded at the tune of 29.6%, whereas, monolete and trilete ferns are represented within the value of 4.3% and 5.1% respectively. Fungal remains are comprised at the value of 6%. Among nonarboreals Poaceae predominates at the value of 21.7% over other associates rank wise, namely Cyperaceae (5%), Tubuliflorae (3.3%), Cerealia (2.8%), Liguliflorae (2.0%), Lamiaceae (1.7%), *Mimosa* (1.5%), *Oldenlandia* (1.4%), Chenopodiaceae and *Artemisia* (1.3% each), Caryophyllaceae and Onagraceae (1.2% each), *Xanthium* (1.1%), Rosaceae and *Impatiens* (1.0% each) are continuously recorded in good to low values.

The tree taxa, like *Salmalia malabarica* attain the value of 1.2%. However, *Syzygium*, *Bauhinia*, *Lagerstroemia*, Combretaceae, *Duabanga*, *Schima, Cinnamomum*, *Elaeocarpus*, *Albizia* and *Symplocos* are represented sporadically. The *Melastoma malabathricum* is recorded as a lone shrub at the value of 1.8%, whereas, *Acacia* is sporadic. Highland taxa, like conifer and broad leaved taxa, like *Pinus* (9.8%), *Betula* (6%), *Quercus* (5.2%), *Alnus* (5.1%), *Corylus* (1.4%) and *Podocarpus* and *Tsuga* (1.1% each) are encountered in good to moderate value. Both monolete and trilete ferns are encountered within the value of 4.3% and 5.1% respectively. Among fungal remains Microthyriaceae is predominated with the value of 6.0%.

The overall palynoassemblage data recovered from the Itanagar Wildlife Sanctuary indicates that the arboreals are represented rank wise in the foothills (18.7%) followed by river bank (11.7%), upper hills (11.1%), slope hills (8.2%) and open land (6.7%). However, the nonarboreals are encountered by the highest frequency in open land (47.9%) followed by slop hills (43.6%), upper hills (42.6%), river bank (41.1%) and the foothills (36.6%) respectively. Highland taxa are also represented accordingly and complemented the data. However, the fern allies both monolete and trilete are occupied rank wise in the slop hills (11.7%) followed by foothills (10.4%), riverbank (9.9%), upper hills (9.5%) and lastly the open land (9.4%). Moreover, the fungal remains are recovered rank wise by foothills (9.8%) followed by slop hills (8.9%), river bank (7.9%), upper hills (7.7%) and open land (6.0%) respectively (Fig. 4).

DISCUSSIONS

The surface pollen study in any geographical area is prerequisite for interpretation of palaeovegetation and climate which reflect the present day pollen deposition scenario. The surface pollen data is most important through which one



LEGENDS

OL-Open land; RB-River bank; FH-Foothill; SH-Slopehill; TH-Tophill

Fig. 4—Comparison of different group of taxa in relation to the sampling sites.

can categorise the plant group preserved in the sediments in respective study area (regional/extra regional taxa) for fruitful utilisation (Wright, 1967; Janssen, 1967) in the precise interpretation of past vegetation and climate.

The palynodata obtained from the surface sediments of the coveted sanctuary have been found to be useful for illustration of various climatic variations and corresponding vegetation shifts in recent past. The occurrence and relative abundance of deciduous elements, namely *Croton*, *Terminalia* and *Salmalia* along with other wet evergreen forest complex, like *Duabanga*, *Cinnamomum* and *Elaeocarpus* are of great significance as they indicate the prevalence of heavy rainfall under warm and humid environment in which both the forest components grow together luxuriantly (Basumatary *et al*., 2013). The continuous occurrence of *Impatiens* in the assemblage is significant and suggestive of high rainfall in and around the region (Dixit & Bera, 2012). The presence of *Melastoma malabathricum* in the assemblage indicates deterioration of forest in the area. However, the presence of Cerealia along with other cultural pollen, like Chenopodiaceae and *Xanthium* signify the anthropogenic activity in the region. *Pinus* along with other broad leaved taxa, namely *Betula* and *Alnus* are suggestive of the high wind activity from higher Himalaya to the sanctuary. The presence of a large number of fern allies probably belong to subtropical–temperate zone is significant as the same are not found to grow in present scenario. Another significant aspect in the palynological record is the occurrence of Arecaceae, *Pterocarya* and *Tsuga* assemblage as these forms are not common presently around the sanctuary but reported to grow in Southwest of China. However, the abundance of fungal remains in the palynoassemblage especially Microthyriaceae and *Xylaria* along with degraded palynomorphs strongly suggest the humid climatic condition during sedimentation in the region. *Glomus* along with hyphae strongly indicates the soil erosion in and around the area. Prevalence of rich organic matters festooned with fungal complex as compared to pollen–spores in the assemblage may be attributed due to relatively higher rates of weathering and erosion of the hinterland influenced by SW monsoon during the time of deposition.

CONCLUSIONS

This study can help in the simulation of models for understanding the future course of vegetation and climate in a definite time frame. The palynodata base has been fruitfully utilised to explain the anthropogenic impact on natural vegetation in the coveted sanctuary. However, the reasons are for migration and extinction of many important plant elements as a consequence of increasing over exploitation, natural catastrophe, vegetation and climatic shifts. In turn, the information will enable us to suggest appropriate measures toward the conservation of natural sanctuaries. Therefore, to save the diversified life forms in this fragile ecosystem which has already been declared as a wildlife sanctuary within the mega–biodiversity region of eastern Himalaya, more multidisciplinary scientific approaches are needed.

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REFERENCES

Basumatary SK, Bera SK, Sangma SN & Marak G 2014. Modern pollen deposition in relation to vegetation and climate of Balpakram Valley, Meghalaya, Northeast India: Implications for Indo–Burma palaeoecological contexts. Quaternary International (in press).

Champion HG & Seth SK 1968. A revised Survey of the Forest Type of India, Manager of Publication, New Delhi.

Davis MB 1963. On the theory of pollen analysis. American Journal of Science 261: 897–912.

Dixit Swati & Bera SK 2012. Holocene climatic fluctuation from lower Brahmaputra floodplain of Assam, Northeast India. Journal of Earth System Science 121: 135–147.

Erdtman G 1953. An Introduction to Pollen Analysis, Waltham, Mass., USA.

Hajra PK, Verma DM & Giri GS 1996. Materials for the flora of Arunachal Pradesh, BSI, Kolkata.

Janssen CR 1967. A comparison between the recent regional pollen rain and the subrecent vegetation in four major vegetation types in Minnesota (U.S.A.). Review of Palaeobotany and Palynology 2: 331–342.

Singh NP, Singh DK, Hajra PK & Sharma BD 2000. Flora of India. Introductory Volume II, BSI, Kolkata.

Srivastava RC 2006. State tree of Arunachal Pradesh. Current Science 91: 857.

Srivastava RC & Choudhary RK 2006. Floristic Scenario of Itanagar Wildlife Sanctuary–a case study. Bulletin of Arunachal Forest Research 22: 17–21.

Srivastava RC & Choudhary RK 2007. Documentation of inherited traditional knowledge of 110 ethnic communities of Arunachal Pradesh. Current Science 92: 1198.

Wang KF & Xu X 1988. Quaternary palynology, The people's press of Guizhou; Guiyang.

Wright HE1967. The use of surface samples in quaternary pollen analysis. Review of Palaeobotany and Palynology 2: 321–330.