delicate lappets. This indicates little post-mortem drift and almost no hydraulic movement after settling (Bardhan, pers. commun.). However, the possible cause of tibia breakage is hard to resolve. Without any appreciable weathering effect and bed-load transportation, bones may be cracked due to many factors like physical impact (the bed yielding the present bone is a product of high-energy storm event), sand blasting and bone crushing scavengers[28,36].

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Modern pollen–spore rain in Schirmacher oasis, East Antarctica

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Pollen analysis of five moss cushions and three dry algal mat samples collected from the vicinity of Lake Priyadarshini in Antarctica has been carried out to elucidate the interplay of pollen and spores deposited in the sediments. The encounter of different pollen and spore types reflects their long-distance transport ranging from tropical to temperate floristic regions around Antarctica mainland which is devoid of any higher plant taxa, except for members of Poaceae and Caryophyllaceae. Lower plants such as mosses, lichens and algae do inhabit the region, often forming gregarious patches or colonies.

POLLEN analytical studies of a region are based on the premise of subfossil pollen contained in the analysed sediments which reflect changes in the vegetation of the region through time. The studies thus involve on one hand, a detailed understanding of the ecology of the present vegetation in relation to climatic, microclimatic, edaphic and biotic factors, and on the other, the reconstruction of the existing pollen rain pattern in a region.

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The study area around the Lake Priyadarshini adjacent to Indian Research Station (70°45′ 39.4″S and 11°44′ 8.6′E) *Maitri*, falls under the Schirmacher oasis in Queen Maud Land of East Antarctica, having maximum length of about 20 km and width of 3.5 km. It is oriented approximately 35 sq km of solid bed rock; firn and ice field account for 27 sq km and 3 sq km, respectively. The lakes and ponds in the region cover a total area of about 2 sq km, representing the essential part of the surface water. The elevation of the oasis ranges between sea level and 228 m, with an average of 100 m. The surface of the oasis is undulating, the gentle slopes and plain areas are covered with mostly a thin blanket of moraine debris which allows moss turfs and lichens to grow luxuriantly on it.

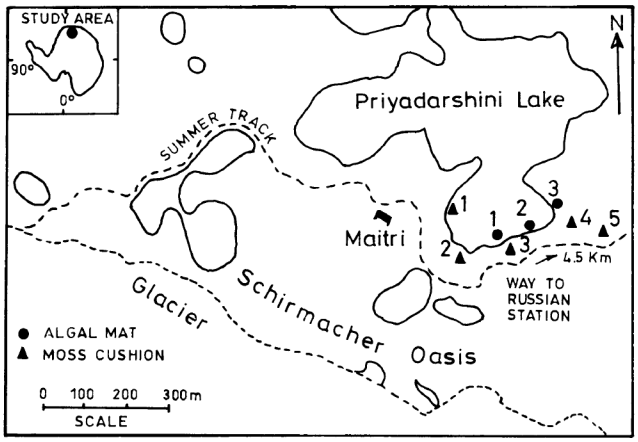

Figure 1. Map showing location of samples.

Floristically, Antarctica is almost barren and is restricted to only two existing known vascular plant species – *Deschampsia antarctica* (Fam. Poaceae–50%) and *Colobanthus quitensis* (Fam. Caryophyllaceae–10%), apart from mosses–*Polytrichum alpinum* (20%), *Depnocladus uncinatus* (10%), preponderance of aquatic algae and growth of various lichens on exposed rocky stratum.

The climatic conditions are similar to other East Antarctic ice-free regions with an annual mean temperature of – 8°C to – 10°C. January is the warmest (– 0.5° to – 0.8°C) and August is the coldest (– 18°C to – 22°C). Another characteristic weather feature around Antarctica is frequent depression which travels predominantly between latitude 50° and 70°S, producing Katabatic winds, accelerated to strong blizzards which can last several hours or even few days and which may locally sometimes exceed 300–350 km per hour in winter.

Little work done on long-distance transport of pollen–spore in the Antarctic region has indicated that there is a regular transport of pollen and spores to sub Antarctic Islands by the prevailing westerly wind across the circum Antarctic ocean[1]. Likewise, some other workers[2–4] have also supported pollen–spore transport and colonization in Antarctica through palynological studies.

Hitherto, no palynological data from surface samples are available from East Antarctica in context to the Indian Expedition since 1981. In the present study an attempt has been made to understand the distribution of pollen–spore

Table 1. Modern pollen-spore near Lake Priyadarshini, Antarctica

	Moss cushion 1	Moss cushion 2	Moss cushion 3	Moss cushion 4	Moss cushion 5	Algal sample 1	Algal sample 2	Algal sample 3
Larix	9	Barren		Barren	Barren	Algal filaments plus few pollen	Algal filaments plus few pollen	Rich in *Cosmarium* plus other algal remains
Pinus	2							
Podocarpus	2							
Betula	2							
Ulmus	4							
Myrtaceae	3							
Salmalia	2							
Solanaceae	6		2					
Rutaceae	2		2					
Oleaceae	3							
Poaceae	99		25					
Tubuliflorae	5							
Urticaceae	15							
Fabaceae	5							
Rubiaceae	4							
Cheno/Ams	7		2					
Euphorbiaceae	7		2					
Caryophyllaceae	5							
Fern monolete	3		3					
Bryophytic spores	7		2					
Cosmarium	4		3					
Other algal spores	7		33					
Fingal remains	7		12					
Acritarch	8		5					
Unidentified	15		12					
Total pollen	182	0	33	0	0	0	0	0

through the study of eight surface samples (moss cushions and algal mats) collected from near Lake Priyadarshini in East Antarctica in a transect, at the interval of 100 m distance starting from Maitri towards the Russian station, by one of the authors (D.K.U.) during the eleventh Indian Expedition to Antarctica, November 1991–March 1992 (Figure 1). Chemical processing of the samples is done by standard acetolysis technique[5]. Slides were prepared in 50% glycerine. Only two moss cushions (1 and 3) out of five were found palynologically productive, while algal mats were only rich in algal filaments along with few pollen of grasses (Table 1).

Moss cushion 1 (Figure 2 *a*) was collected from near-shore rock surface. The pollen spectrum brings out 42% Poaceae, and other herbaceous taxa comprising Asteraceae, Caryophyllaceae, Rubiaceae, Euphorbiaceae, Chenopodiaceae–Amaranthaceae, Urticaceae, etc. under 21%. Whereas, among arboreals some tree taxa such as *Larix*, *Pinus*, *Podocarpus*, *Betula*, *Ulmus*, etc. attained the value of 10% along with Myrtaceae, Solanaceae, Oleaceae, *Salmalia*, etc. under 7%. Monolete fern and bryophytic spores are recorded, at 4% each. Among algal remains *Cosmarium* attains 2% and the rest are under 3%, whereas fungal remains are encountered at 3%. Acritarchs are present at 4% and unidentified taxa are about 6%.

Moss cushion 3 (Figure 2 *b*) was procured from a moist sandy bed near the glacier nala on the way to the Russian station. The pollen spectrum brings out a comparatively low frequency of Poaceae under 24%, in contrast to sample 1. Among other herbaceous taxa, only Chenopodiaceae–Amaranthaceae and Euphorbiaceae attain the value of 4%. It reveals a poor assemblage of arboreal taxa belonging to Solanaceae and Rutaceae within the value of 4%. The fern and bryophytic spores are recovered in slightly higher frequency than the preceding one. The spectrum shows significantly higher percentage of algal remains up to 32%, out of which *Cosmarium* itself attains 4%. Fungal remains are encountered in high values (12%) compared to the preceding sample. Acritarchs attain the value of 5% and other unidentified taxa are within 12%.

The picture thus obtained from the pollen spectra reflects an overall dominance of nonarboreal taxa over arboreals. The arboreal taxa like *Larix*, *Pinus*, *Podocarpus*, *Betula* and *Ulmus* are of subtropical to temperate origin, whereas other elements like *Salmalia*, Myrtaceae, Oleaceae, Fabaceae, Rutaceae, etc. are from the tropical belt. All the recovered palynomorphs belong to the extra regional plant taxa growing far away from the site of deposition and which have travelled thousands of kilometres (Figure 3). Among the nonarboreal, Poaceae and Caryophyllaceae may be of local origin and are reported to grow in Antarctica; this still needs investigation. The rest are possibly derived from distant islands surrounding the icy continent. *Cosmarium* and other algal remains derived might be of local origin. The high frequency of nonarboreals, specially grasses encountered in moss sample-1 compared to sample 3 is indicative of deposition of microbiota through water, as the sample was procured from the rock surface near water. Fungal remains found in the sediment might have travelled along with long-distance transported pollen and spores which are incorporated in sediment, may be saprophytic in nature. Aeropalynological investigations carried out by exposing the slides by using Burkard Air Sampler during the XIX and XX Indian Antarctic Expediion (1999–2001) by one of the authors (S.K.B.) further support the long distance transfer of the palynomorphs.

The present finding was transmitted only from the study of two productive moss samples from East Antarctica. A large number of samples are still needed for investigation, in order to provide a pollen deposition model in the Antarctic region. From the present study it may be concluded that the calculation of deposition values for long-distance transported pollen and spores is a valuable tool which has helped in deciphering Early Holocene

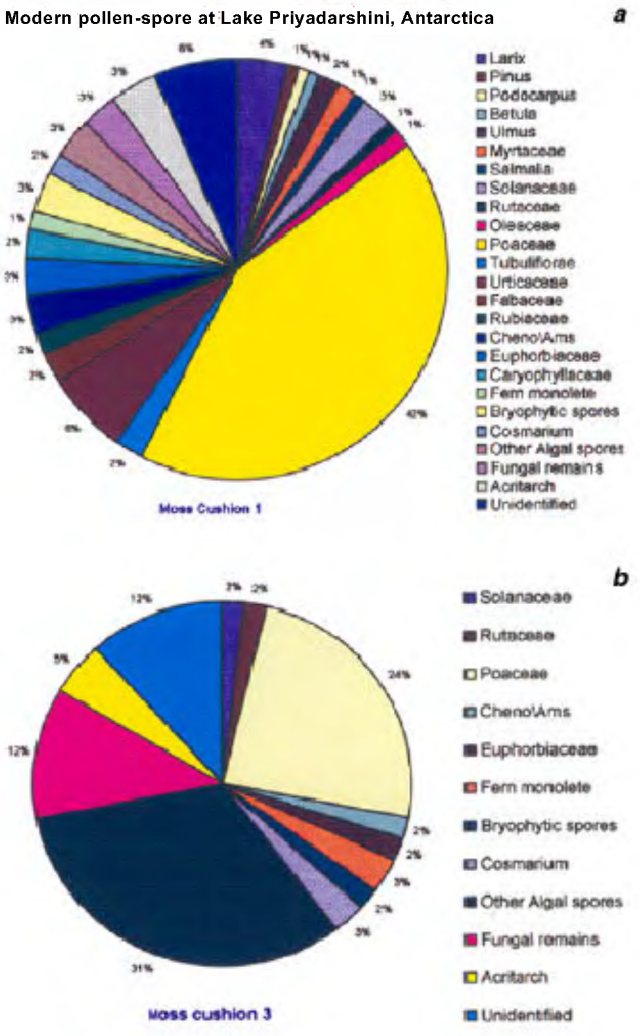

Figure 2. Pollen spectrum from (***a***) moss cushion 1 and (***b***) moss cushion 3, East Antarctica.

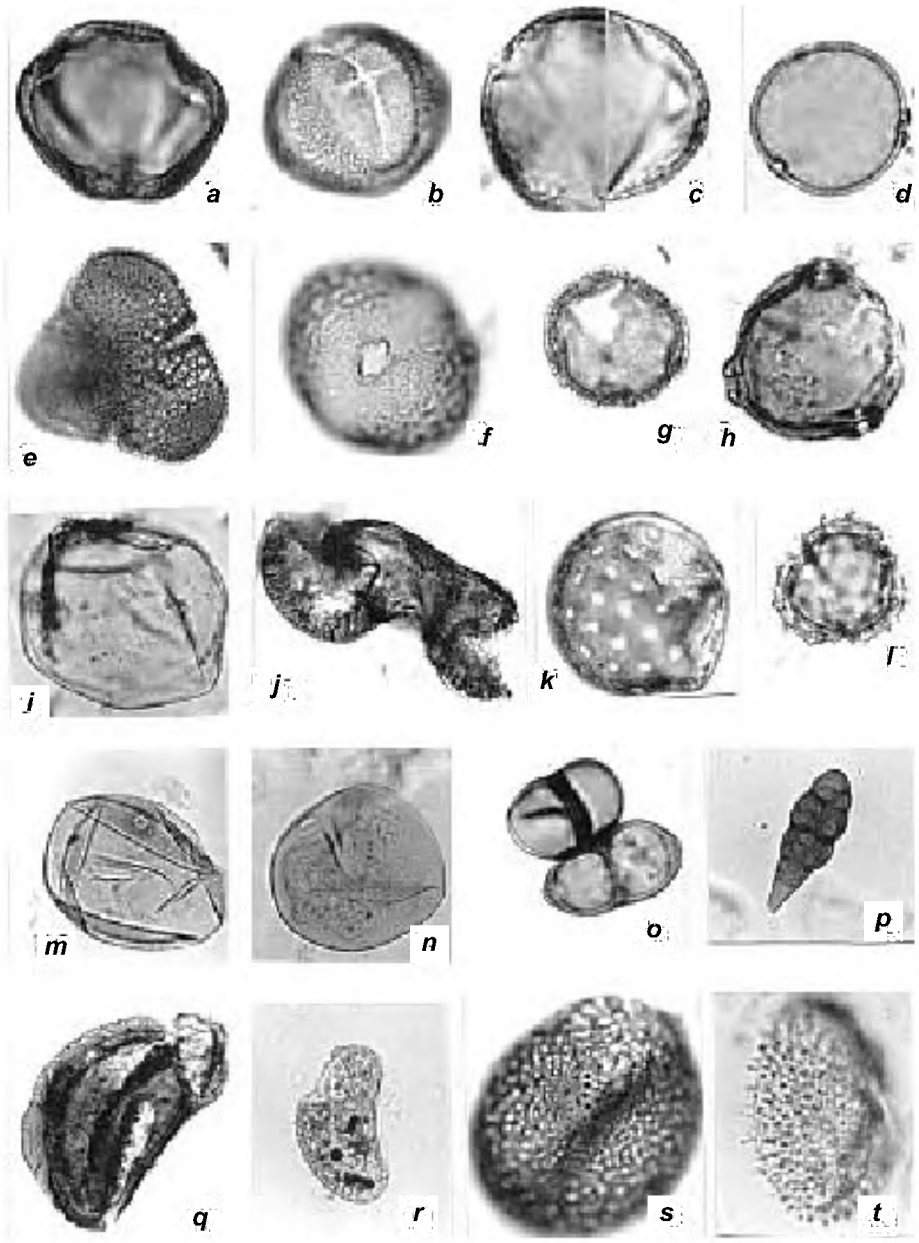

Figure 3. ***a***, ***b***, Euphorbiaceae; ***c***, Fabaceae; ***d***, Urticaceae–Moraceae; ***e***, *Salmalia*; ***f***, Unidentified; ***g***, Rubiaceae; ***h***, *Betula*; ***i***, *Larix*; ***j***, *Podocarpus*; ***k***, Chenopodiaceae–Amaranthaceae; ***l***, Tubuliflorae (Asteraceae); ***m***, ***n***, Poaceae; ***o***, Fungal spore; ***p***, *Alternaria*; ***q***, Reworked pollen; ***r***, Monolete fern spore; ***s***, Unidentified; and ***t***, Acritarch; × 1200.

climatic changes through worked out pollen sequence from Priyadarshini Lake[6–7]. Detailed study is required to understand local peat development for the reconstruction of past climate as well as to understand the palaeowind current around the Antarctic region, for which a beginning has already been made.

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