One could argue that at their preferred tree, the higher pressures the barbets face from the members of other congeneric species has led to the temporal partitioning of the resource. Therefore at *F. drupacea*, which is not their preferred tree and where competition from the other barbet species is likely to be lower, the closely related barbets have similar patterns of visitation. However, the bulbul spp.–Golden Orioles pair neither have similar habits nor are they closely related[14] to explain the similarity in their visitation pattern to their preferred tree.

The reasons given for temporal variations are many[7,8,15]. Predation pressures and aggression were certainly not the major reasons at Karian Shola National Park as very few instances of predatory attempts (seven in 123 hours of which none were successful) and interspecific aggression (seven in 56 hours of observation) were seen among the birds[10]. While figs are a super-abundant resource, they are almost completely utilized by the frugivores[10] and one would expect competition over the resource. Perhaps past competition has moulded present frugivore behaviour and resource partitioning, and manifested in differing patterns of temporal visitations among frugivores.

In conclusion, the fruiting *Ficus* trees were host to frugivores throughout the day, with a higher activity in the early morning and mid afternoon. The major peak in the early morning could be explained by the increased food requirements of the frugivores who have started their day after a long gap in feeding. I would expect another peak in activity prior to sundown when the birds have to stock up for the night. The common frugivores occurred in larger numbers at certain species of *Ficus* and this preference is likely to be based on the optimal exploitation of a fig given the gape size of the frugivore. Most of the avian frugivores, including the two most common at each fruiting tree had differing temporal patterns of visitation to these super-abundant resources. Predation was rare and aggressive interactions between species very few which makes active interspecific competition an unlikely explanation for the differing patterns. What is difficult to explain is the similar temporal pattern of visitation of the bulbul spp.–Golden Oriole pair, at their preferred fruiting tree. Perhaps the biology and activity patterns of different species condition them to particular temporal patterns of behaviour.


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# Vegetational and climatic changes during recent past around Tipra Bank Glacier, Garhwal Himalaya

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**Palynological studies from Tipra Bank Glacier, UP Himalaya indicate that the climate was warm moist, similar to today's, prior to 720 yr B.P. This then reverted to comparatively cold dry climate around 620 yr B.P. when the glacier might have descended down. The climate changed to warm moist regime again around 460 yr B.P.**

PALYNOLOGICAL studies from glacial sediments above tree limit or alpine region of the Himalaya are limited in number[1–3]. Most of the studies on this aspect are confined to temperate and subtropical sites[4,5].

We have attempted here to understand the changes of vegetation around Tipra Bank Glacier and their relationship to glacial fluctuations using pollen data of both surface and subsurface sediments of near present day snout.

Tipra Bank Glacier (Figure 1), one of the major glaciers in Bhyundar Ganga valley of Alaknanda catchment, joins another major glacier, Rataban and together they form a common snout. Bhyundar Ganga river originates from this snout and flows through the famous Valley of Flowers and ultimately joins Alaknanda river at Govindghat near Pandukeshwar. There are fourteen other glaciers which are of small niche types. The detailed climatic data around the site is not available. A general observation in this regard indicates that the

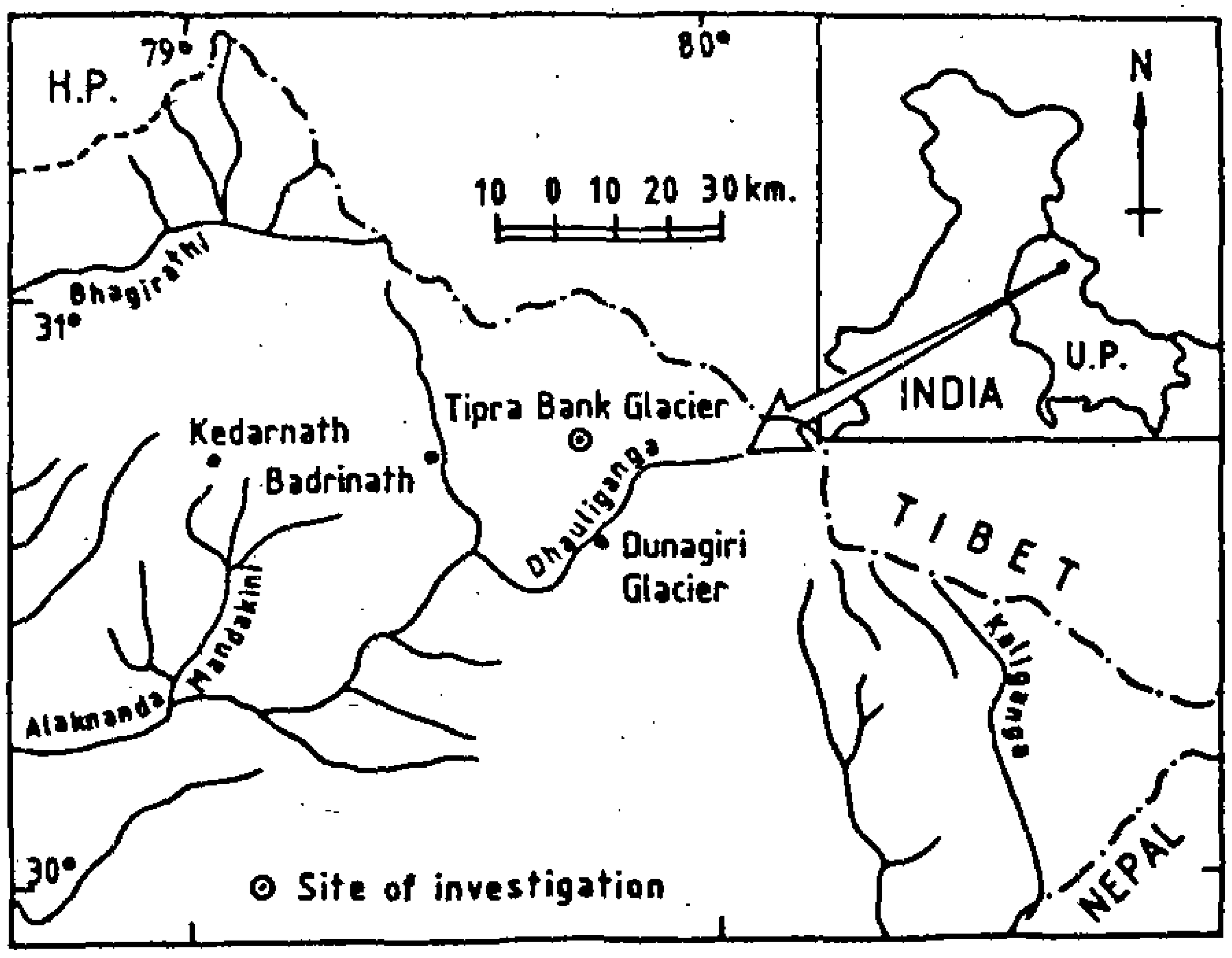


Figure 1. Sketch map showing the site of study.

precipitation is in the form of snow during the major part of the year except for frequent rains during May to September.

The area covers a large number of alpine taxa and these are mostly represented by *Aconitum* sp., *Anaphalis triplinervis*, *Androsace lanuginosa*, *Anemone* sp., *Angelica glauca*, *Artemisia* sp., *Bupleurum himalayense*, *Delphinium brunonianum*, *Geranium wallichianum*, *Geum alatum*, *Gypsophilla cerastoides*, *Heracleum brunonis*, *Meconopsis aculeata*, *Potentilla* sp., *Primula* sp., *Rubus natans*, *Saussurea gossypiphora*, *Saxifraga diversifolia*, other members of Caryophyllaceae, Chenopodiaceae, etc.

The trees in the subalpine zone today extend up to about 2 km south-west of glacier terminus, while scattered scrubs or small trees of *Betula utilis*, *Rhododendron campanulatum*, *Salix flabellaris*, *S. lindienana*, etc. are found even upstream of the glacier snout. Along the timber line, *Abies pindrow* and *Betula utilis* are the dominant species. Besides, the randomly distributed alpine bushes comprise *Acer cappadocium*, *Cotoneaster acuminata*, *Juniperus communis*, *J. squamata*, *Rhododendron lepidotum*, etc.

The samples were collected from the valley floor which consists mainly of glaciogenic deposits overlain at places by talus material. The present-day glacier terminus lies about 3 km NE of the Valley of Flowers. The present-day geomorphological features indicate that this area was occupied by the then Tipra Bank Glacier as evidenced by the existence of lateral, terminal and ground moraines. Towards downstream in Valley of Flowers, these evidences are not visible. Instead, the features indicate a fluvial environment. Quite a few talus cones and fans exist between the Valley of Flowers and the glacier terminus.

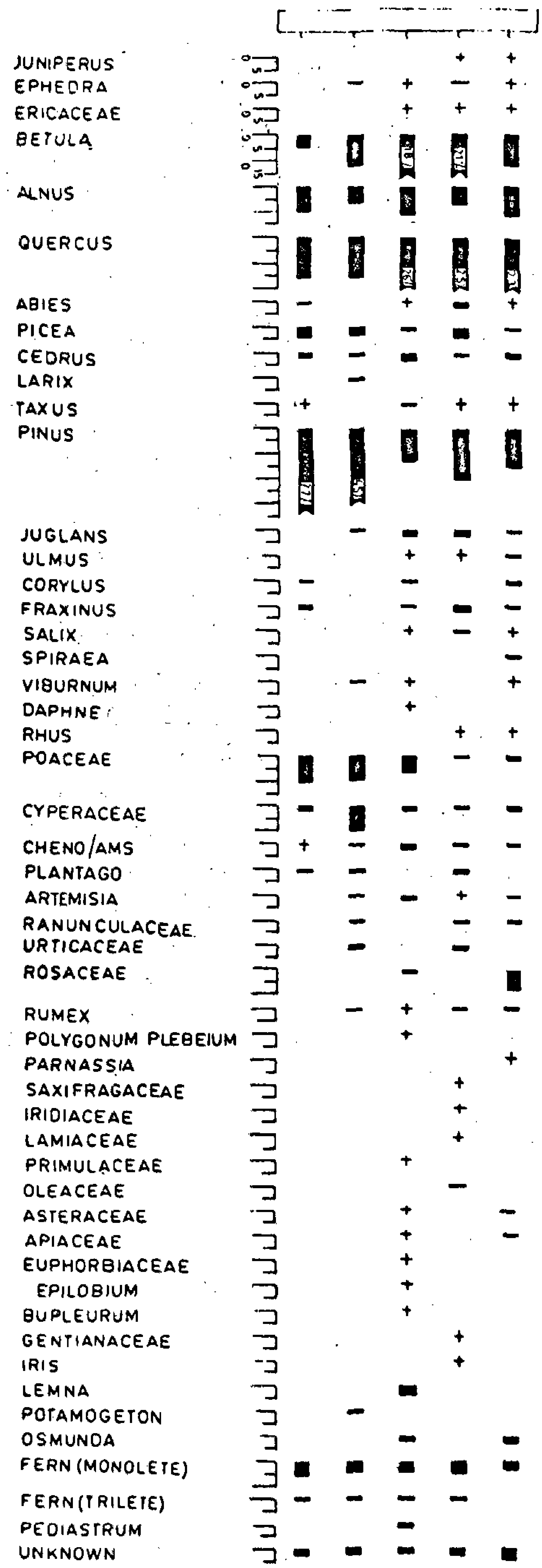


Figure 2. Recent pollen spectra from Tipra Bank Glacier, Garhwal Himalaya.

Table 1. $^{14}C$ dates and calendar years

| Depth | Nature of samples | Dates | (yr B.P.) ($^{14}C$) | Calendar years (yr AD) |
|---|---|---|---|---|
| 50–60 cm | Black soil | BS-437 | 460 ± 100 | 1401–1487 (ca.) |
| 60–70 cm | Black Soil | BS-438 | 620 ± 90 | 1275–1408 (ca.) |
| 70–80 cm | Black soil | BS-436 | 720 ± 90 | 1235–1300 (ca.) |

Materials for the present study have been taken both from surface and a small profile. For surface samples, moss cushions from five places were collected in a transect at different intervals to understand modern pollen vegetation relationship of this site. For the subsurface samples, an 80 cm deep trench was dug along the bank of Tipra stream and 5 samples consisting of black soil at an interval of 5 cm (except a 10 cm interval between 60 and 70 cm depth) were collected for pollen analytical investigation.

Besides, materials were also collected at three different intervals from this trench for radiocarbon dating. These materials have been dated at the Radiometric Laboratory of BSIP. The $^{14}C$ dates and calendar years are given in Table 1.

The $^{14}C$ dates are converted to calendar years so that the events of the present study could be related to other evidences under the same time scale. In calibration, 'O' yr BP of $^{14}C$ date is taken equal to AD 1950. Since the change of atomospheric radioactivity, $^{14}C$ data need to be recalibrated against tree ring dating. Details of the calibration of $^{14}C$ date to calendar years have been given elsewhere[6]. Both surface and subsurface samples were analysed using usual pollen analysis technique[7].

Five surface samples (moss cushions) analysed from the vicinity of the snout provide database regarding representation of modern pollen in relation to the extant vegetation (Figure 2). This study shows *Pinus* 15–77% followed by *Quercus* 15–26%, *Alnus* and *Betula* 2–5% each, *Picea* 1–5%, *Juglans* and *Cedrus* 1–4% each and 1% each of *Abies* and *Fraxinus*. The shrubby elements, viz. *Juniperus*, *Rhus*, *Daphne*, and *Spiraea* are extremely low and sporadic. Among the non-arboreals, Poaceae (1–12%), Cyperaceae, Cheno/Ams, *Artemisia*, Ranunculaceae (under 2% each) and *Plantago* and Rosaceae (1–8% each) are comparatively better represented than *Polygonum plebeium*, *Parnasia*, *Iris*, *Epilobium*, Saxifragaceae, Iridaceae, Primulaceae, Oleaceae, Asteraceae, etc. which are represented by under 1% each. Fern spores (monolete 4–6%, trilete 2–3% and *Osmunda* 2%) are also recorded frequently in the samples.

A pollen diagram (Figure 3) has been made only from five pollen spectra which are dealt with below along with their equivalent $^{14}C$ dates.

Around 720 ± 90 yr B.P. the pollen spectra are characterized by high frequencies of *Pinus* (10–24%)

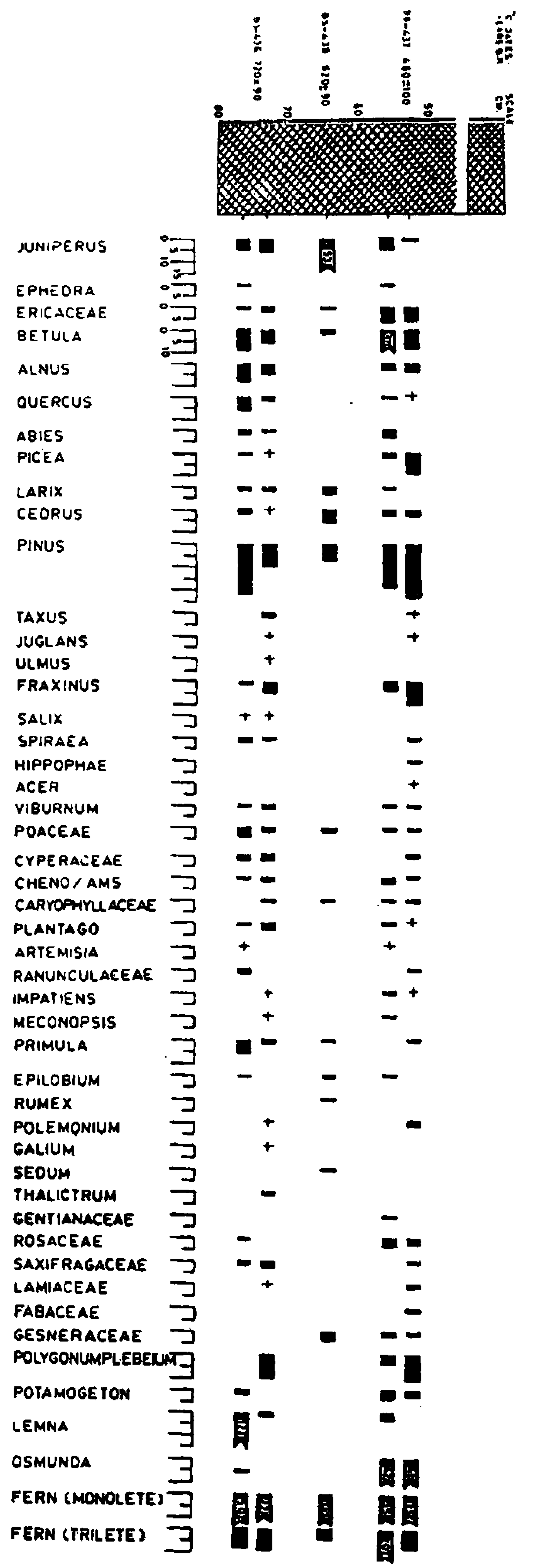


**Figure 3.** Pollen diagram from Tipra Bank Glacier, Garhwal Himalaya.

followed by *Betula* (5–10%), *Alnus* (4–10%), *Quercus* (2–6%), *Juniperus* (5–7%) and *Fraxinus* (1–5%). The other tree taxa such as *Abies*, *Cedrus*, *Larix*, *Taxus* and Ericaceae (under 2% each) are consistently represented in low frequencies. *Juglans*, *Ulmus* and *Salix* (under 1% each) are met with scantily. The shrubby vegetation is poorly represented (under 2% each) by *Spiraea* and *Viburnum*.

The non-arboreals are mainly represented by *Primula* (2–7%), Poaceae (2–5%), Cyperaceae, Cheno/Ams, *Plantago* and *Saxifraga* (2–3% each). *Artemisia*, *Impatiens*, *Meconopsis*, *Epilobium*, *Rumex*, *Polemonium*, *Galium*, *Sedum*, *Thalictrum*, Rosaceae and Lamiaceae (under 1% each) are extremely low and sporadic. Aquatic vegetation is represented by *Lemna* (2–12%) and *Potamogeton*.

Fern spores (monolete 22–50% and trilete 9–10%) are recorded in preponderance.

During 620 ± 90 yr B.P. in general, a comparatively poor assemblage as well as low frequencies of most of these taxa have been noticed, except *Juniperus* which shows a drastic enhancement (53%). *Cedrus* (6%) and *Larix* (3%) are also slightly better represented, whereas *Pinus* (11%) declines considerably. The ground vegetation is scantily represented by Poaceae (2%) and under 1% each of Caryophyllaceae, *Primula*, *Epilobium*, *Rumex* and *Sedum*. Fern spores (monolete 13% and trilete 5%) decline sharply.

During 460 ± 100 yr B.P. *Betula* (10–31%), *Pinus* (20–25%), *Picea* (2–9%) and *Abies* (3%) indicate the increased frequencies, but *Juniperus* (6–1%) declines abruptly. The other taxa such as *Fraxinus* (3–9%), *Alnus* (3–4%) and *Quercus* (1–2%) reappear after a lapse during the preceding phase, whereas *Ephedra*, *Taxus*, *Juglans*, *Spiraea*, *Viburnum*, *Acer* are sporadic and low (under 1% each).

The non-arboreal taxa are chiefly represented by *Polygonum* (3–10%), Rosaceae (2–4%), Cyperaceae and Cheno/Ams (1–3% each) and Caryophyllaceae (2%), whereas Poaceae, *Polemonium* and *Plantago* (under 2% each) are recorded in low values. Aquatic elements, viz. *Potamogeton* (3–4%) and *Lemna* (3%) are better represented than before. Fern spores (monolete 25–55%, trilete 10–20% and *Osmunda* 41–42%) have been recorded abundantly.

In spite of limited sample size, the study provides a synoptic view of the vegetation changes in relation to glacial fluctuations from a glaciated site where very little work has been done because of nonavailability of suitable sediments for both $^{14}C$ dating and pollen analysis. In this site an alpine-scrub vegetation had occurred prior to 720 ± 90 yr B.P., i.e. around 1200 A.D. in which thermophilous broad-leaved taxa, *Betula*, *Rhododendron* (Ericaceae) along with herbs like grasses, sedges, Cheno/Ams, *Primula* were the major elements. The thickets of *Juniperus* and *Ephedra* were most probably confined to the rocky habitats. The vegetational composition signifies that the region was under the impact of warm and moist climate during this period. This is also well corroborated by the abundance of fern spores during this phase. The fair amount of pollen of temperate broad-leaved taxa such as *Alnus*, *Quercus* together with conifers, *Pinus*, *Abies* and *Picea* during this period could be indicative of the extension of the temperate belt in response to favourable climatic conditions.

Around 620 ± 90 yr B.P., i.e. 1275–1408 A.D., the broad-leaved alpine-scrub vegetation was succeeded by the Juniper-scrubs as evidenced by high values of *Juniperus* and corresponding decline of broad-leaved elements from this site. The non-arboreals comprising grasses, sedges, Cheno/Ams together with ferns also grew meagrely. In general, the poor vegetation cover during this period implies deterioration of climate which was probably colder and drier than today's. Besides, the poor representation of conifers and other tree taxa also suggests that the tree line might have distantly located under the effect of this cold climate.

Thereafter, around 460 ± 100 yr B.P., i.e. around 1401–1487 A.D. and onwards, the summer temperature might have increased again to an extent to support small trees or scrub of *Betula*, *Alnus*, *Quercus* and *Rhododendron*. A good amount of pollen of other trees such as *Pinus*, *Picea*, *Abies*, *Cedrus* also indicates that some of these taxa especially *Abies* and *Picea* which grow near tree line had occurred around this site. Decline of *Juniperus* and increase of ferns also indicate less aridity during this period.

The present study based on an analysis of a small number of samples collected from near the snout of Tipra Bank Glacier has provided a broad understanding of vegetational changes *vis-à-vis* glacial fluctuation since around 1200 A.D. In general, two climatic phases, viz. warm moist to cold dry to warm moist again could be recognized in the region. In the beginning, around 1200 A.D. the climate was warm moist and the glacier reached almost to its present position. Around 1275–1408 A.D., however, the climate deteriorated and the glacier might have advanced towards lower elevation. Subsequently, with the amelioration of climate during 1401–1487 A.D. the glacier had started retreating. Presence of several recessive moraines also indicates that the glacier had retreated earlier. In comparison to the global scenario, the climatic amelioration recorded around 1200 A.D. falls within the duration of medieval warm period which is believed to have occurred around 1200 A.D. to 1400 A.D. in the northern hemisphere. Subsequent deteriorations around 1275–1408 A.D. lie within bracket years of climatic changes during Little Ice period. Corresponding to this climatic trend, a climatic amelioration was recorded during 1150 A.D. to 1450 A.D. which reverted to cold and dry again after 1450 A.D.; at Batal, Rohtang Pass, Himachal Pradesh[2].

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