The Palaeobotanist, **31**(3), 201-207, 1984.

A FOSSIL FAN PALM FROM THE LIYAN FORMATION OF LADAKH (JAMMU AND KASHMIR)

*R. N. LAKHANPAL, **GYAN PRAKASH, **J. L. THUSSU & *J. S. GULERIA

*Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India

**Geothermal Division, Geological Survey of India, Nagpur, India

ABSTRACT

A fossil palm based on truly palmate leaves is described from the Liyan Formation (Miocene) of Ladakh in Jammu and Kashmir. It has been identified with the genus *Trachycarpus* H. Wendl. and assigned to a new species, *T. ladakhensis*. It is the first megafossil record of a member of the temperate element which seems to have entered the Himalaya during the Miocene from the mainland of Asia on the north.

Key-words — Megafossil, *Trachycarpus*, Liyan Formation, Miocene (India).

सारांश

लद्दाख (जम्मू-काश्मीर) के लियान शैल-समूह से एक पंखाकार ताड़-पर्णाश्म – राजेन्द्र नाथ लखनपाल, ज्ञान प्रकाश, जे० एल० थुसु एवं जसवंत सिंह गुलेरिया

जम्मू-काश्मीर में लद्दाख के लियान शैल-समूह (मध्यनूतन) से वस्तुत : हस्ताकार पत्तियों पर आधारित एक ताड़-पर्णाश्म वर्णित किया गया है। यह ऍच्० वैन्डलैन्ड के ट्रेकिकार्पस वंश से अभिनिर्धारित तथा एक नवीन जाति, ट्रे० लद्दाखेन्सिस, से नामांकित किया गया है। शीतोष्ण तत्व के एक सदस्य का यह पहला गुरुपादपाश्मीय अभिलेख है जो कि उत्तर में एशिया की मुख्य भूमि से मध्यनूतन काल में हिमालय में प्रविष्ट हुआ प्रतीत होता है।

INTRODUCTION

IN 1974 a party of the Geological Survey of India, engaged in geothermal exploration in the Puga-Chumathang hot spring region of Ladakh, came across a few leaf-impressions of a palm near Liyan at an altitude of 5,400 m above mean sea level, across the Great Himalayan Range in Upper Indus Valley, Ladakh (Jammu & Kashmir). The rocks bearing the impressions were purplish sandy shale or greenish gray sandstone exposed in the Changlung Nala section at a locality about 20 km east-southeast of Puga hot springs and 15 km west-southwest of Nyoma (Text-fig. 1). This locality is approachable from these places by foot-track. Because of high altitude and severe cold and dry climatic conditions prevailing in this area, field work here can only be undertaken in the form of a well organized expedition for which July-August is most suitable.

The occurrence of these palm fossils was already reported in a preliminary note by Gyan Prakash and Thussu (1975). Their detailed study is being presented in this paper.

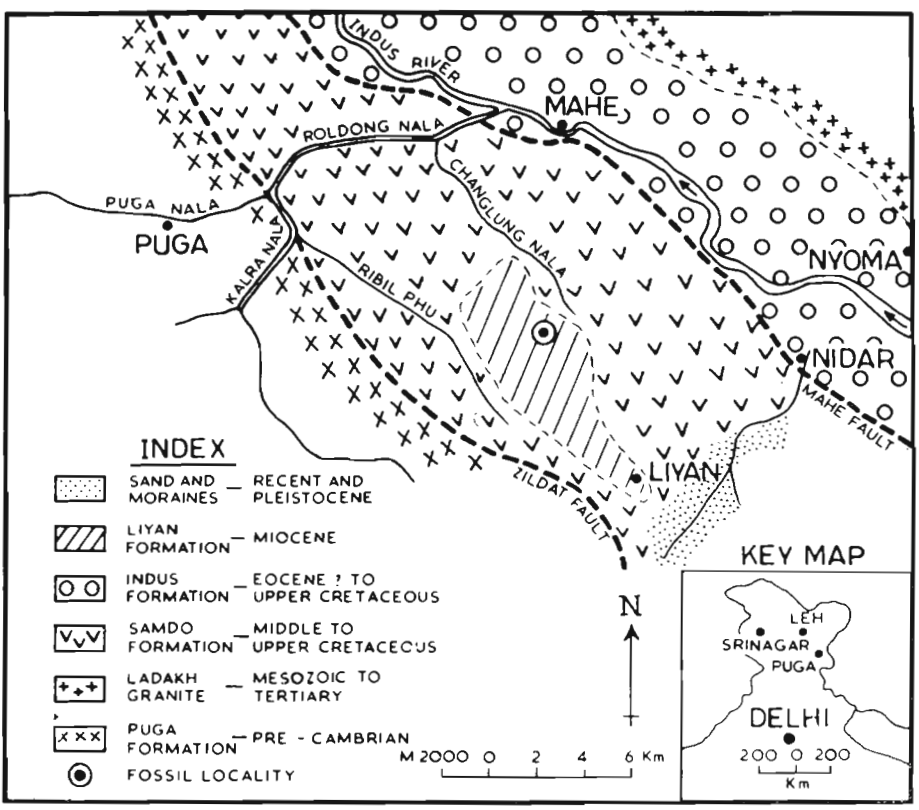
BRIEF GEOLOGICAL BACKGROUND

The area around Puga and Liyan is located in a region of the collided junction of two crustal plates which were involved in the Himalayan orogeny and witnessed intense basic and ultrabasic plutonic and submarine volcanism of Middle to Upper Cretaceous age (Ophiolites) and several phases of wide-spread acid igneous activity from Upper Cretaceous to Upper Tertiary times. In terms of the concept of plate tectonics, the region is divisible into three tectonic belts (Ravi Shanker *et al.*, 1975) — the Southern belt (the southern crustal plate), the Central belt (the oceanic crust with associated sedimentaries), and the Northern belt (the northern crustal plate).

The Southern belt exposes the Puga Formation comprising Precambrian paragneisses, schists and phyllites with occasional bands of limestone and is intruded by granite (Palaeozoic?), garnet amphibolite and tourmaline-quartz veins. The Central belt consists of the Samdo Formation and Liyan Formation, the latter unconformably resting over the former. The Samdo Formation comprises basalts, ultrabasic rocks, tuffs, agglomerates and associated sedimentary rocks (at times fossiliferous) of Cenomanian to Maestrichtian age and represents the remnant of the uplifted wedge of oceanic crust, now compressed between two continental masses. The Liyan Formation consists of a sequence of green and purple shale, sandstone, grit and conglomerate of Miocene age. It is the shale-sandstone assemblage of this formation that bears the palm-leaf fossils described in this paper. The Liyan Formation seems to be equivalent to the Kargil Mollasse (Ravi Shanker *et al.*, 1975, 1982) described by Tewari (1964).

The Northern belt exposes the Indus Formation consisting of a thick sequence of coarse clastic sediments of shallow marine to fluvial origin ranging in age from Cenomanian to Eocene and deposited unconformably over older granite basement (Mesozoic). The rocks are shale-sandstone-grit-conglomerate alternations, at places interlayered with fossiliferous limestone and intruded by granite of Tertiary age.

These three tectonic belts are separated from one another by high angle faults — the Zildat Fault along which the rocks of the Central belt (Samdo Formation) are juxtaposed against the Puga Formation (Southern belt) and the Mahe Fault along which the former is juxtaposed against the rocks of the Northern belt (Text-fig. 1).



TEXT-FIG. 1 — Geological map of Upper Indus Valley between Nyoma and Puga, district Ladakh (Jammu & Kashmir) showing the fossil locality (based on Ravi Shanker *et al.*, 1975).

The Mahe Fault is the same as the 'Counter Thrust' of Berthelson (1951).

SYSTEMATIC DESCRIPTION

FAMILY — PALMAE

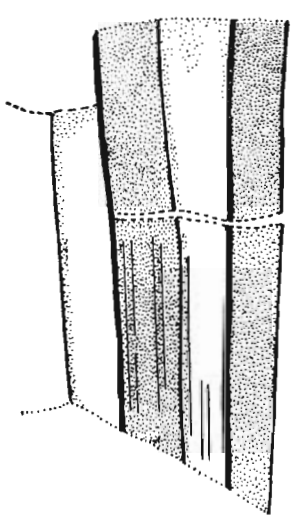
Genus — *Trachycarpus* H. Wendl.

Trachycarpus ladakhensis sp. nov.
Lakhanpal & Guleria

Pl. 1, fig. 1; Pl. 2, figs 2, 3; Text-fig. 2

The species is based on three incomplete but fairly well preserved specimens. They are all impressions of leaves. The best preserved specimen depicting the basal part of the lamina has been chosen as the holotype. The other two are fragmentary and represent different parts of the lamina somewhere between the base and margin.

Description — Leaf simple, palmate, preserved lamina length 10.5-19.0 cm, maximum preserved width 14.6 cm; petiole not preserved; hastula present as an irregular semi-lunar rim, about 2 mm wide in the middle; mid-costa seemingly absent; a large number of segments (about 34 discernible) radiating out from the base of the lamina, maximum width of segments about 1.8 cm, preserved segments fused, each with a mid-vein; in very few segments some fine veins visible running parallel to the midrib (Text-fig. 2).



TEXT-FIG. 2 — Part of Pl. 1, fig. 1 enlarged to show the finer venation, × 2·5.

Affinities — The main characters of the fossil leaf seem to be its truly palmate nature, rather medium size, a narrow hastula along the more or less rounded base of the lamina and approximately about 40 plicate segments whose maximum individual width might have been about 2 cm.

The true palmate leaves are found only in two sub-families of Palmae, i.e. Corypheideae and Lepidocaryoideae (Corner, 1966, pp. 347, 349, 351). In Lepidocaryoideae there are only three palmate genera, viz., *Mauritia* L. f., *Mauritiella* Burret and *Lepidocaryum* Mart., the rest being pinnate. However, all these three genera are confined to America. Hence, Lepidocaryoideae can be safely ruled out.

Of the five palmate Coryphoid genera found in India (Brandis, 1906, p. 644) only two, *Licuala* Thunb. and *Trachycarpus* H. Wendl. have true palmate leaves, the remaining three have costa-palmate leaves. There are two species of *Licuala* known from India. In having circular or nearly orbicular, peltate laminae with deeply partite cuneate segments, they are quite different from our fossil. On the other hand leaves of *Trachycarpus* exhibit a very close resemblance with the Ladakh impressions.

At present two species of *Trachycarpus*, viz., **T. martiana* H. Wendl. and *T. takil* Becc. are known from India. Based on the description of these species given by Blatter (1926) the leaves of *T. martiana* have "Blade orbicular, consisting of 30-40 linear segments, 15-20 inches** (about 38-50 cm) long, connate to one-third or one-half their length" while *T. takil* has "Blade ¾ orbicular, 3⅛-4 feet (about 114-122 cm) in diameter, with 45-50 divisions measuring 2⅛-2⅝ feet (about 71-86 cm) from the top of the petiole to the apex of the median segment". Considering the size, the lamina (blade) of *T. martiana* is closer to the fossil leaf although the latter is not orbicular. Blatter has also described a third species, *T. excelsa* (called *T. fortunei* by McCurrach, 1960, p. 250) growing from Upper Burma (which previously was a part of British India) to China and Japan. Its lamina is more like that of *Chamaerops* with numerous deeply cut segments and therefore can be

*McCurrach (1960, p. 251) has given this species as *T. martianus*.

**The figures in brackets are ours to represent the metric equivalents of inches and feet.

easily differentiated from that of the fossil. Thus it seems quite clear that our fossil belongs to *Trachycarpus* though not identical with any of its three species growing in the Indian region of Himalaya and Burma.

Comparison with Fossil Palmate Leaves — As far as we are aware, there are six records of fossil fan palm leaves from India. These are (i) a fan palm reported by Sahni and Bhatnagar (1962) from the Eocene (?) of Kargil, (ii) *Sabalites microphylla* and (iii) *Sabalites* sp. described by Sahni (1964) from the Miocene beds of Kasauli, Himachal Pradesh and Chakoti, Kashmir, respectively, (iv) *Palmophyllum* sp. Chaudhri (1969) from the Lower Miocene of Kasauli, (v) a palmate leaf described by Trivedi and Chandra (1971) from the Deccan Intertrappean beds of Mohgaon Kalan, Madhya Pradesh, and (vi) *Palmacites khariensis* Lakhanpal & Guleria (1982) from the Miocene of Kachchh, Gujarat. Besides, Bose and Sah (1964, p. 220; pl. 1, fig. 1) have reported as *Sabalites*?, a palm leaf most probably from the Lower Tertiary of Assam. However, from its photograph it is clearly a pinnate palm and hence is not being considered for comparison here.

The photographs of the two fan palm specimens described by Sahni and Bhatnagar (1962) from Kargil show the apical portions of hardly 3-4 segments which might have been united below in the form of a palmate leaf. However, as such they can not be identified with our fossil. *Sabalites microphylla* of Sahni (1964) can easily be ruled out as it is a costapalmate leaf in contrast to the present fossil which is true palmate. *Sabalites* sp. Sahni (1964) does not possess either the base or the apical part of the lamina and thus besides being a palmate leaf cannot be compared any further. *Palmophyllum* sp. of Chaudhri (1969) is too small to be comparable with our specimen. From the characters described for this species, it is not even certain if it is at all a palm. The leaf reported by Trivedi and Chandra (1971), though plicate and palmate, is much larger in size. Its segments are 3-4 times wider than those of the present fossil. Moreover, they seem to be wedge-shaped in contrast to the linear segments of the Ladakh palm. *Palmacites khariensis* Lakhanpal & Guleria (1982) also differs in having relatively narrow lamina (maximum width 9.0 cm) with greater number of segments (about 45). Further, the segments in *P. khariensis* are also narrower (0.1 to 0.5 cm) than in our fossil.

As the present fossil differs from all the known Indian species of palm leaf, a new specific name, *Trachycarpus ladakhensis*, is assigned to it. The specific epithet indicates the area from where the fossil was collected.

Holotype — B.S.I.P. Specimen no. 36030.

Paratypes — B.S.I.P. Specimen nos. 36031 and 36032.

Locality — 20 km ESE of Puga, Ladakh (Jammu & Kashmir).

Horizon — Liyan Formation.

Age — Miocene.

DISCUSSION

Usually the occurrence of palms is associated with hot and humid climate. However, Corner (1966, p. 352) has mentioned *Trachycarpus* and *Chamaerops* as temperate fan palms. Considering the occurrence of *Trachycarpus martiana* and *T. excelsa* even at altitudes around 1,250 m in the hills of Khasia and Manipur in eastern India, this genus may be regarded as temperate to warm temperate. It is distributed in the Himalaya, Upper Burma, China and Japan. Of the two Indian species, *T. martiana* grows in Central Himalaya, Nepal at altitudes about 1,550-2,450 m; Khasia Hills, 1,250-1,550 m; Manipur, about 1,875 m and Upper Burma, Kachin Hills, 1,250-2,200 m. The other species, *T. takil*, is found growing on Mount Takil in Kumaon at a height of about 2,200-2,450 m where it is annually covered with snow (Blatter, 1926, pp. 51, 54, 55). As mentioned by Takhtajan (1958, p. 1674) "The genus *Trachycarpus* belongs to the most frost-resistant palms extending farthest to the north and enduring frost up to −14°C".

Although traces of northern temperate flora in the form of Abietinean pollen grains, which might have flown in from the northern hills, are known from the Middle Miocene deposits of the Siwalik beds (Lakhanpal, 1970) there are so far no records of temperate plant megafossils from the Miocene beds of India. In this regard the present record of *Trachycarpus* would be the first temperate plant megafossil to be described from our country. According to Takhtajan (1958) *Trachycarpus rhapifolia*

was the most widely distributed fan palm in the Tertiary of U.S.S.R. This species is known from many localities of the Eocene of Ukraine as well as from the Eocene of the north-eastern part of Kazakhstan. It has further been reported from the Eocene of Geiseltal in East Germany (Rüffle, 1976). Being regarded as a Sino-Japanese genus, it was obviously occupying a very wide area from East Asia to Ukraine and even further west into Europe during the early Tertiary period. At that time, there was still the barrier of Tethys between India and the mainland of Asia on the north side. But by Miocene, with considerable rise of the Himalaya, land connection had been established between these two regions. That was most probably the time when the northern temperate element had entered the Himalaya and *Trachycarpus* was one of its components. It is presumed that some other temperate plants must also have accompanied *Trachycarpus*. A thorough search for these associates in the Liyan Formation of Ladakh might reveal their identity as well as help in collecting better and more complete specimens of this interesting palm.

REFERENCES

BERTHELSON, A. (1951). A geological section through the Himalaya. *Medd. Fra. Danks. Geol. For.*, **12** (3): 102-104.

BLATTER, E. (1926). *The Palms of British India and Ceylon*. Humphery Milford, Oxford Univ. Press.

BOSE, M. N. & SAH, S. C. D. (1964). Fossil plant remains from Laitryngew, Assam. *Palaeobotanist*, **12** (3): 220-223.

BRANDIS, D. (1906). *Indian Trees*. Fifth impression, 1971, Dehradun.

CHAUDHRI, R. S. (1969). Some leaf-impressions from the Kasauli Series of Simla Hills. *Curr. Sci.*, **38** (4): 95-97.

CORNER, E. J. H. (1966). *The Natural History of Palms*. Weidenfeld and Nicolson, London.

GYAN PRAKASH & THUSSU, J. L. (1975). A note on the new finds of fossil in the Upper Indus Valley, Ladakh, Jammu and Kashmir State. *Indian Miner.*, **29** (1): 93-95.

LAKHANPAL, R. N. (1970). Tertiary floras of India and their bearing on historical geology of the region. *Taxon*, **19** (5): 675-694.

LAKHANPAL, R. N. & GULERIA, J. S. (1982). Plant remains from the Miocene of Kachchh, western India. *Palaeobotanist*, **30** (3): 279-296.

MCCURRACH, J. C. (1960). *Palms of the World*. Harper & Brothers, New York.

RAVI SHANKER, PADHI, R. N., ARORA, C. L., GYAN PRAKASH, THUSSU, J. L. & DUA, K. J. S. (1975). Geothermal exploration of the Puga and Chumathang geothermal fields, Ladakh, India. *Proc. II U.N. Symp. Develop. and Use of Geothermal Res. San Francisco Proc. Lawrence Berkeley Lab. California Univ.*: 245-258.

RAVI SHANKER, PADHI, R. N., GYAN PRAKASH, THUSSU, J. L. & DAS, R. M. (1982). The evolution of Indus Basin, Ladakh, India. *Misc. Publ. geol. Surv. India*, **41**, pt. III: 157-172.

RÜFFLE, L. (1976). Eozäne floren des Geiseltales. *Abh. Zentr. geol. hist. Palaont.*, **26**: 337-438.

SAHNI, B. (1964). *Revisions of Indian Fossil Plants. Part* III — *Monocotyledons. Monograph No.* 1. Birbal Sahni Institute of Palaeobotany, Lucknow, pp. 1-89.

SAHNI, M. R. & BHATNAGAR, N. C. (1962). Fresh water mollusca and plant remains from the Tertiaries of Kargil, Kashmir. *Rec. geol. Surv. India*, **87** (3): 467-476.

TAKHTAJAN, A. L. (1958). A taxonomic study of the Tertiary fan palms of the U.S.S.R. *Bot. Zh. SSSR*, **43** (12): 1661-1674.

TEWARI, A. P. (1964). On the Upper Tertiary deposits of Ladakh Himalayas and correlation of various geotectonic units of Ladakh with those of Kumaon-Tibet region. *Proc. 22nd int. geol. Cong, New Delhi*, **9**: 37-58.

TRIVEDI, B. S. & CHANDRA, R. (1971). A palm leaf from The Deccan Intertrappean Series of Mohgaonkalan (M.P.), India. *Curr. Sci.*, **40** (19): 526-527.

EXPLANATION OF PLATES

PLATE 1

Trachycarpus ladakhensis sp. nov.

1. Leaf showing the basal part of the lamina, natural size.

PLATE 2

2, 3. Leaves showing different parts of the lamina, natural size.

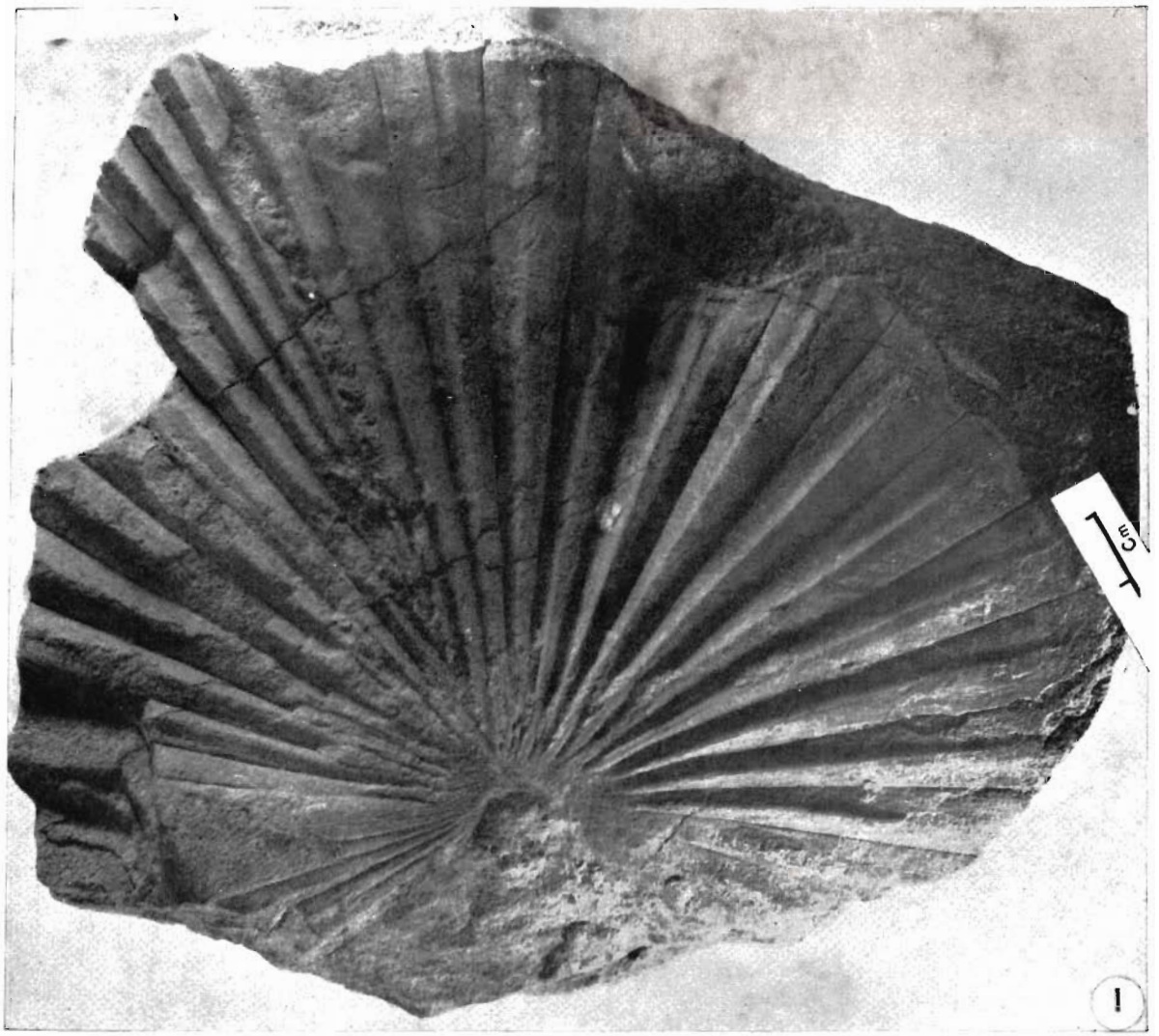


PLATE 1

PLATE 2