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First report of the plant fossils from the Manas National Park, Assam, India

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ABSTRACT

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Plant fossils, mainly leaf impressions, are described for the first time from the Tipam Group of rocks exposed at Subankhata Locality in Manas National Park in Baksa District of Assam. Two new fossil leaves showing affinities with *Parashorea stellata* Kurz and *Shorea ovalis* (Korth.) Bl. respectively of the family Dipterocarpaceae, along with a fern frond of *Cyclosorus* resembling *C. proliferus* (Retz.) Tard. and C. Chr. of the family Thelypteridaceae are described from the present assemblage. In addition, impressions of a monocot stem and a seed-like structure are also reported. These plant fossils indicate Middle-Late Miocene age and existence of rain forest in the region during the period of deposition of the rock successions.

Key-words—Leaf impressions, Dipterocarpaceae, Thelypteridaceae, Miocene, Palaeoclimate.

पादप जीवाश्मों की मानस राष्ट्रीय पार्क, असम, भारत से पहली रिपोर्ट

आर.सी. मेहरोत्रा, एस.के. बसुमतारी, एस.के. बेरा, गौरव श्रीवास्तव, जी.सी. शर्मा एवं सी.के. बरूआ

सारांश

असम में बक्सा जिले के मानस राष्ट्रीय पार्क में सुबंख्ता उपबस्ती में अनावरित चट्टानों के टीपम समूह से पहली बार पादप जीवाश्म मुख्यतः पत्ती मुद्राश्म वर्णित की गई हैं। थेलीटेरीडेसी कुटुंब के सी. *प्रचुरोद्भवी* (रेज़) टार्ड व सी. सीएचआर से मिलती-जुलती *साइक्लोसोरस* के पर्णांग प्रपर्ण सहित डिप्टेरोकार्पेसी कुटुंब के क्रमशः *पैराशोरिया स्टेलेटा* कुर्ज़ व *शोरिया ओवोलिस* (कोर्थ.) ब्लूम से बंधुता दर्शाती हुईं दो नवीन जीवाश्म पत्तियाँ मौजूदा समुच्चय से वर्णित की गई हैं। इसके अलावा, एक बीजपत्री तना की मुद्राश्में (छापें) तथा बीज की तरह संरचना भी मिली हैं। ये पादप जीवाश्म चट्टान अनुक्रमों की निक्षेपण की अवधि के दौरान प्रदेश में मध्य-अंतिम मध्यनूतन आयु एवं वर्षा प्रचुर वन का अस्तित्व इंगित करते हैं।

संकेत-शब्द—पत्ती मुद्राश्में, डिप्टेरोकार्पेसी, थेलीटेरीडेएसी, मध्यनूतन, पुराजलवायु ।

INTRODUCTION

The Manas National Park or Manas Wildlife Sanctuary (Fig. 1) is known for its rare and endangered endemic wildlife in Assam, India. Located in the Himalayan foothills, it is contiguous with the Royal Manas National Park in Bhutan. The name of the park is originated from the Manas River, which is named after the serpent goddess Manasa. The park area falls in six districts of Assam, namely Kokrajhar, Bongaigaon, Barpeta, Nalbari (including the newly constructed Baksa), Kamrup and Darrang. The Manas River is a major tributary of the Brahmaputra River which passes through the heart of the National Park. It also demarcates the International Border between India and Bhutan.

During the field work conducted in 2009 in the Subankhata Reserve Forest located in the fringe area of the Manas Tiger Reserve, we encountered a good exposure of Tipam rocks containing plant mega-fossils. This becomes the first report of the plant remains from the park stretched in the above six districts. Though some well preserved fossils were collected from there, there is a need to explore the whole region for further investigation.

MATERIAL AND METHODS

The material comprises of mostly leaf impressions collected from near Subankhata (26°48' N; 91°25' E) in the Baksa District of Assam (Fig. 1). The fossiliferous exposures belonging to the Tipam Group (Middle-Late Miocene) extend into Bhutan and are equivalent to the Siwalik of Bhutan (Karunakaran, 1974). The general stratigraphic succession of the region is presented in the form of a table (Fig. 2).

We followed the terminology put forth by Hickey (1973) and Dilcher (1974) in describing the leaves. The type material is housed in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATICS

Family—DIPTEROCARPACEAE

Genus—PARASHOREA Kurz

Parashorea palaeostellata comb. nov.

(Pl. 1.1)

2008 *Shorea palaeostellata* Prasad & Pandey, pp. 23-24, pl. 2, fig. 7, pl. 3, fig. 5.

Description—The study is based on a solitary specimen. Leaf symmetrical, elliptic; preserved lamina length about 12 cm and maximum width about 6 cm in the middle; apex slightly broken and base missing; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein stout and straight; secondary veins 12 pairs visible, alternate, 6-10 mm apart, uniformly curved, unbranched, moderately thick, angle of divergence narrowly acute (40°-45°); intersecondary veins not observed; tertiary veins fine, percurrent, unbranched, appearing RR, predominantly alternate and closely placed; further details not visible.

Holotype—Specimen No. BSIP 39822A.

Horizon—Tipam Group (= Siwalik).

Locality—Subankhata, Baksa District, Assam.

Age—Middle-Late Miocene.

Remarks—In order to identify the fossil we consulted the herbaria of the Forest Research Institute (FRI), Dehradun and Central National Herbarium (CNH), Howrah. The fossil shows maximum resemblance with *Parashorea* Kurz, especially with *P. stellata* Kurz (Pl. 1.2; Herbarium Sheet Nos. FRI 40709 and FRI 53614).

Wolfe (1977) for the first time recorded a fossil leaf of *Parashorea* as *P. pseudogoldiana* (Hollick) Wolfe from the Eocene of Gulf of Alaska region without giving its description or diagnosis. The same species has recently been recorded by Parrish *et al*. (2010) from the Palaeogene of southwestern

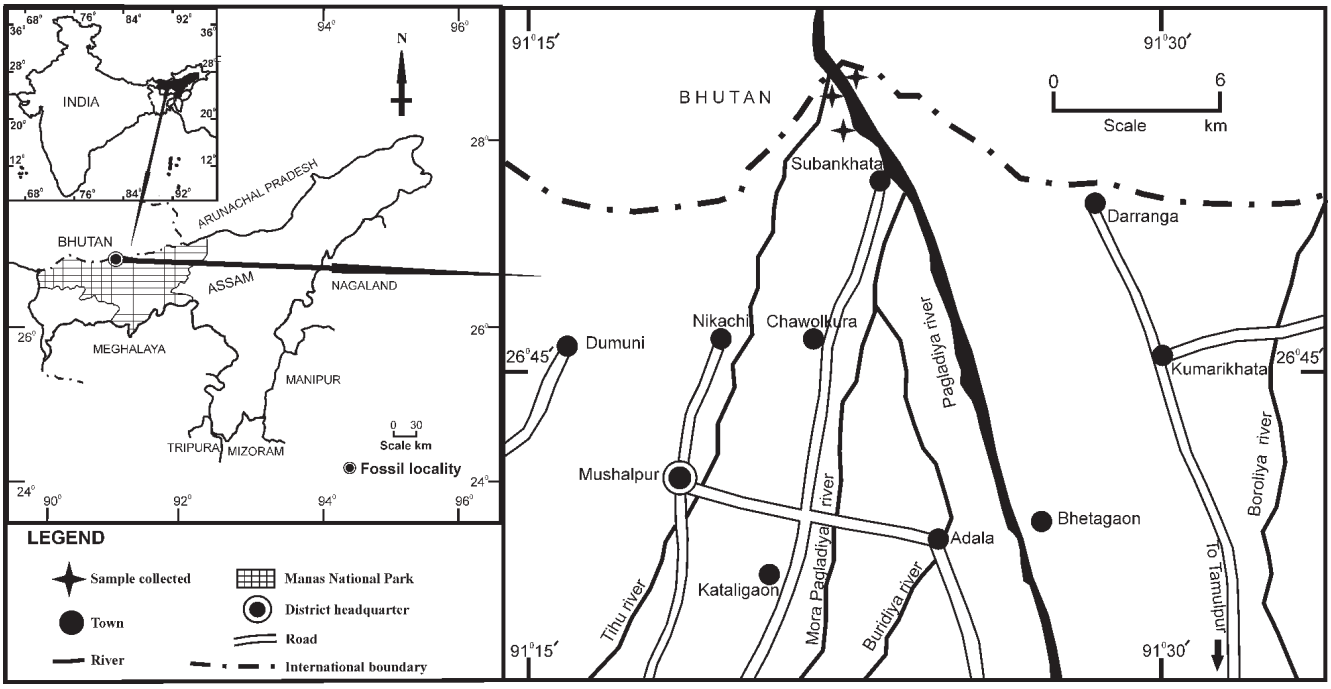

Fig. 1—A map showing the fossil locality.

Period	Epoch	Group	Formations	Lithology
Quaternary	Recent	Unclassified	Newer or low level alluvium	Clay, sand, silt and shingle
---------- Unconformity ----------				
Tertiary	Pleistocene	Unclassified	Older or high level alluvium	Clay, coarse sand, shingle, gravel and boulder deposit
---------- Unconformity ----------				
	Pliocene	Dihing	Dihing (900 m: not divided)	Pebble bed, soft sandy clay, clay, conglomerate, grit and sandstone
---------- Unconformity ----------				
	Miocene-Pliocene	Dupi Tila	Dupi Tila (Surma Valley: 3300 m) & Namsang (Upper Assam: 800 m)	Sandstone, mottled clay, grit and conglomerate; locally, with beds of coal conglomerate and poorly consolidated sand with layers and pockets of pebbles
---------- Unconformity ----------				
	Miocene	Tipam	Girujan (1800 m)	Mottled clay, sandy shales and subordinate, mottled, coarse to gritty sandstone
			Tipam Sandstone (2300 m)	Blush grey to greenish, coarse to gritty, false bedded, ferruginous sandstone, clay, shale and conglomerate
		Surma	Bokabil (900-1800 m)	Shale, sandy shale, siltstone, mudstone and lenticular, coarse; ferruginous sandstone
			Bhuban (1400-2400 m)	Alternations of sandstone, sandy shale and thin conglomerate and shaly in the middle part
---------- Unconformity ----------				
	Oligocene	Barail	Renji (600-1000 m)	Massive and bedded sandstones; its equivalent - the Tikak Parbat Formation, in Upper Assam is marked by thick coal seams at the basal part
			Jenum (1000-3300 m)	Shale, sandy shale and carbonaceous shale with interbedded hard sandstone; its equivalent – the Baragolai Formation, in Upper Assam is marked by numerous thin coal seams
			Laisong (2000-2500 m)	Well bedded, compact, flaggy sandstone and subordinate shale; its equivalent – the Naogaon Formation, in Upper Assam is marked by thin bedded, hard sandstone and interbedded shale
	Eocene	Geosynclinal	Shelf	
		Disang Group (not divided)	Splintery dark grey shales and thin sandstone interbeds — Jaintia Group	Kopili Formation: Shale, sandstones and marl Shella Formation: a) Sylhet Sandstone Member - Sandstone, clay and thin coal seam; b) Sylhet Limestone Member - Fossiliferous limestone
---------- Unconformity ----------				
Pre-Cambrian		Shillong	(not classified)	Quartzite, phyllite and schist
---------- Unconformity ----------				
Archaean		Archaean	(not classified)	Complex metamorphic Group of Ortho- and Para-gneisses and schists; meta-sediments, later intruded by acid (granitic) and basic (dolerite, epidiorite and amphibolite) intrusives

Fig. 2—Showing lithostratigraphy of Assam (after Karunakaran, 1974).

Alaska. A fossil leaf, *Shorea palaeostellata* Prasad and Pandey (2008), showing affinities with *Shorea stellata* (Kurz) Dyer has been described from the Himalayan foot hills of western Nepal. This leaf is very close to our fossil in most of the morphological features. Detailed investigation, however, shows that *Shorea stellata* is a synonym of *Parashorea stellata*. As *Shorea palaeostellata* Prasad & Pandey is a misnomer, a new species of *Parashorea, P. palaeostellata* sp. nov., has been created, the specific epithet is after the modern comparable species. Under the circumstances, *Shorea palaeostellata* Prasad & Pandey has been merged with the proposed new species.

Genus—SHOREA Roxb. ex C.F. Gaertn.

Shorea subankhatensis sp. nov.

(Pl. 1.7, 10)

Description— The study is based on a part and a counter part of the single specimen. Leaf symmetrical, wide elliptic; preserved lamina length and width about 8 cm and 5.2 cm respectively (estimated lamina width 6.6 cm); apex attenuate and base missing; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein moderately thick and straight; secondary veins 13 pairs visible, predominantly alternate but opposite to sub opposite in the upper part, 3-7 mm apart, decreasing upwards in distance, uniformly curved, unbranched, moderately thick, angle of divergence moderately acute (55°-63°); intersecondary veins absent; tertiary veins fine, percurrent, simple and recurved, rarely forked, oblique in relation to midvein, alternate to opposite and closely placed, angle of origin AA; quaternary veins rarely visible.

Holotype—Specimen No. BSIP 39822B.

Paratype—Specimen No. BSIP 39823.

Horizon—Tipam Group (= Siwalik).

Locality—Subankhata, Baksa District, Assam.

Age— Middle-Late Miocene.

Remarks—The diagnostic features of the fossil are symmetrical leaf having wide elliptic shape, attenuate apex, entire margin, eucamptodromous venation, moderately acute angle of divergence of secondary veins and percurrent tertiary veins. These features cumulatively indicate the affinities of the fossil with *Shorea* Roxb. ex C.F. Gaertn. of the family Dipterocarpaceae. A number of species of *Shorea* were examined in the herbaria of the FRI, Dehradun and CNH, Howrah. Though it is difficult to distinguish these species on the basis of their morphological characters, our fossil shows maximum resemblance with *S. ovalis* (Korth.) Bl. (syn. *S. sericea* Dyer) in almost all the features (Pl. 1.9, 11; Herbarium Sheet No. FRI 63288).

Fossil records of *Shorea* leaves are well known from the Siwalik sediments of India and Nepal. These are *Shorea siwalika* Antal and Awasthi (1993) and *S. bengalensis* Antal and Prasad (1997) from the Darjeeling District of West Bengal, *S. neoassamica* Prasad (1994) from Kathgodam area of Uttarakhand and the East Kameng District of Arunachal Pradesh (Joshi & Mehrotra, 2007), *S. palaeoridleyana* Joshi and Mehrotra (2007) from the West Kameng District of Arunachal Pradesh, *S. miocenica* Konamatsu and Awasthi (1999), *S. nepalensis* Konamatsu and Awasthi (1999) and *S. eutrapizifolia* Prasad *et al*. (1999) from Nepal. Besides, there is one more record, *S. robusta* Gaertn. f. (Bande & Srivastava, 1990) from the Late Plio-Pleistocene beds of Palamu District, Bihar. After detailed comparison with the above mentioned species, it has been found that the present fossil is distinct from all of them and therefore, is being described here as *Shorea subankhatensis* sp. nov., the specific epithet is after its occurrence in Subankhata.

Monocot stem

(Pl. 2.1, 4)

Description—The study is based on two specimens. Preserved length 15 cm, maximum width 0.9 cm; several

PLATE 1

(Scale 1 cm unless otherwise mentioned.)

1. *Parashorea miocenica* sp. nov. – A fossil leaf in natural size showing venation pattern; Specimen No. BSIP 39822A.
2. *Shorea stellata* Kurz – The modern leaf showing similar venation.
3. *Cyclosorus eoproliferus* (Prasad) Prasad, Ghosh & Tripathi - Fossil frond in natural size; Specimen No. BSIP 39825.
4. *Cyclosorus proliferous* (Retz.) Tard. & Chr.– The modern frond enlarged to show the margin and vennules arising from the mid-vein marked (scale 5 mm).
5. A seed like structure showing a small chamber in the centre (scale 2 mm); Specimen No. BSIP 39822C.
6. *Cyclosorus proliferous* Tard. & Chr. - The modern frond in natural size showing similar venation as found in the fossil.
7. *Shorea subankhatensis* sp. nov. – A fossil leaf showing venation pattern in natural size; Specimen No. BSIP 39822B.
8. *C. eoproliferus* (Prasad) Prasad, Ghosh & Tripathi - Enlarged view showing margin and vennules arising from the mid-vein (scale 3 mm); Specimen No. BSIP 39825.
9. *Shorea ovalis* (Korth.) Bl. – The modern leaf showing similar venation as found in S. *subankhatensis* sp. nov.
10. *S. subankhatensis* sp. nov. – Pl. 1.7 enlarged to show both alternate and opposite percurrent tertiary veins (scale 5 mm); Specimen No. BSIP 39822B.
11. *S. ovalis* – Pl. 1.9 enlarged view to show similar percurrent tertiary veins as found in the fossil.

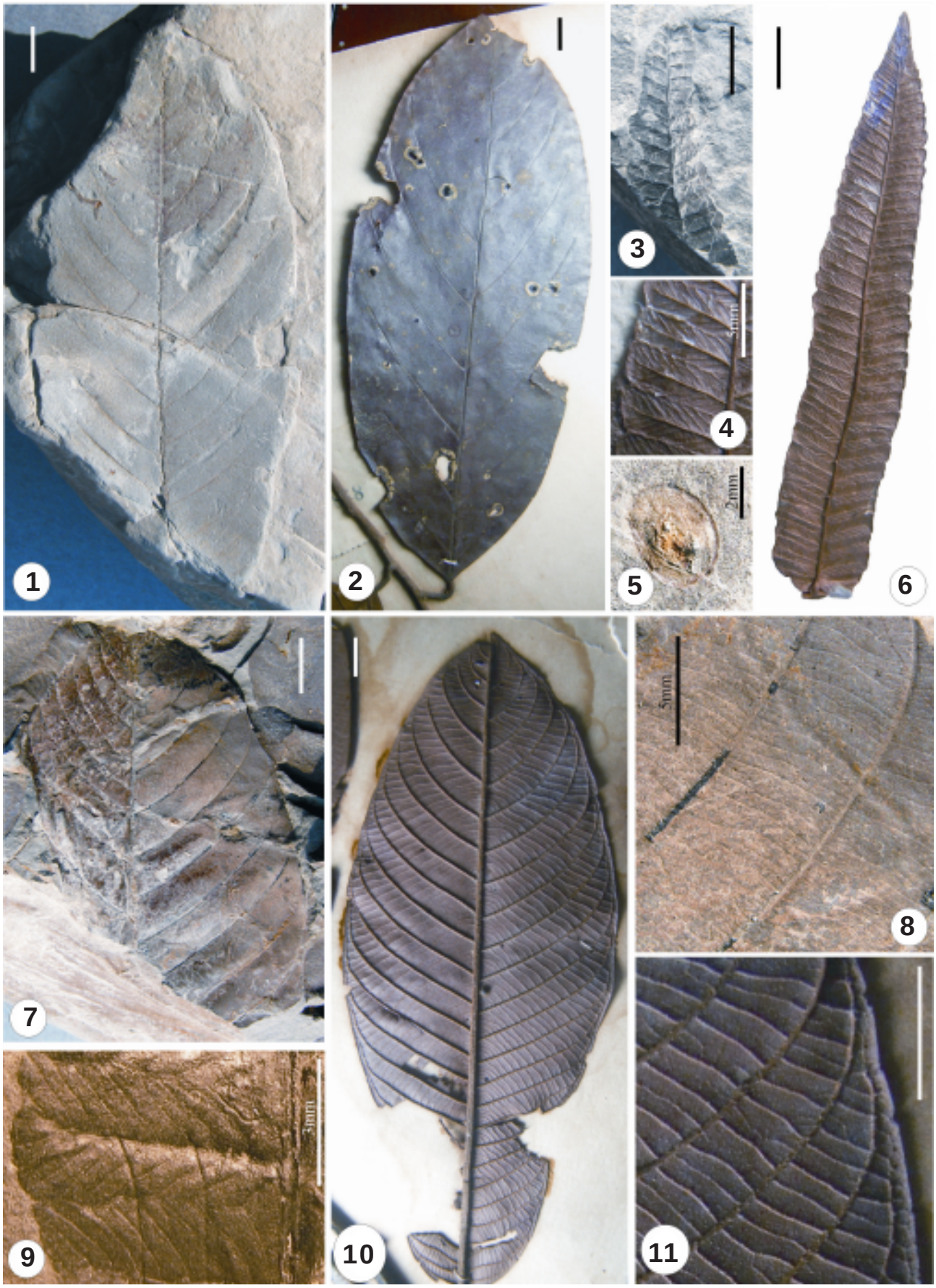

PLATE 1

striations in the form of parallel longitudinal ridges, often joining together with closely placed (less than 1 mm) transverse veins; one node present; a branch arising from the node, preserved length 6.5 cm and maximum width is 0.8 cm.

Figured specimens—Specimen Nos BSIP 39824A-B.

Horizon—Tipam Group (= Siwalik).

Locality—Subankhata, Baksa District, Assam.

Age— Middle-Late Miocene.

Remarks—It is a monocotyledonous stem due to the presence of nodes, internodes and parallel longitudinal ridges. Further affinities could not be traced due to homogeneity in the features of the stem.

Seed

(Pl. 1.5)

Description—The study is based on a solitary specimen. A small round to oval structure, measuring 4.2 mm in length and 3.1 mm in width, having a sac-like structure in the centre measuring 2.5 mm in length and 1.5 mm in width and showing basal attachment.

Figured specimen—Specimen No. BSIP 39822C.

Horizon—Tipam Group (= Siwalik).

Locality—Subankhata, Baksa District, Assam.

Age— Middle-Late Miocene.

Remarks—The above features indicate that it could be a seed like structure. However, its identification is not possible due to the absence of other preserved details.

Family—THELYPTERIDACEAE

Genus—CYCLOSORUS Link

Cyclosorus eoproliferus (Prasad) Prasad *et al.*, 2004

(Pl. 1.3, 8; Pl. 2.2, 3)

Description—The study is based on two specimens. Frond sterile, varying 2.4-3.7 cm in preserved length, ranging 1.2-1.5 cm in width, oblong in shape; apex and base broken; margin entire to slightly wavy; texture chartaceous; 8-17 pairs of pinnules visible, each about 6 mm in length and 2-5 mm in width, their size decreasing upwards, opposite to sub-opposite; midrib stout; vennules maximum 10 pairs observed in each pinna, arising at narrow acute angle, opposite to sub-opposite.

Figured specimens—Specimen Nos BSIP 39825-26.

Horizon—Tipam Group (= Siwalik).

Locality—Subankhata, Baksa District, Assam.

Age— Middle-Late Miocene.

Remarks—The diagnostic features of the fossil frond, such as oblong shape, entire to slightly wavy margin, about 17 pairs of opposite to sub-opposite pinnules with stout midrib and about 10 pairs of vennules arising at acute angle in each pinna indicate that it belongs to *Cyclosorus proliferus* (Retz.) Tard. & C. Chr. (Pl. 1.4, 6; Herbarium Sheet No. CNH 52291) of the family Thelypteridaceae.

Several such fronds have been described from the Siwalik sediments of India and Nepal. First of all Prasad (1991) described a fern frond resembling *Goniopteris prolifera* Presl from the Lower Siwalik sediments of Kathgodam-Nainital Road, Uttarakhand. Guleria and Srivastava (2000) assigned it to the genus *Ampelopteris* Kurz due to the fact that *Goniopteris prolifera* had been merged with the genus *Ampelopteris* as *A. prolifera* (Retz.) Copel. (Sledge, 1982). Later on Joshi and Mehrotra (2003) created a new organ genus *Thelypteridaceophyllum* to describe a similar frond from the Lower Siwalik of the East Kameng District, Arunachal Pradesh as *Thelypteridaceophyllum tertiarum* Joshi and Mehrotra (2003). As Mabberley (1997) had merged the genus *Goniopteris* into a broad genus *Cyclosorus* Link, Prasad *et al*. (2004) described a similar frond from near Kathgodam as *Cyclosorus eoprolifera* (Prasad) which is again recorded from the Middle Siwalik of Surai Khola, Nepal by Prasad and Pandey (2008). Our fossil being similar in nature has also been placed under the same, however, the name *Cyclosorus eoprolifera* being incorrect grammatically is changed to *Cyclosorus eoproliferus* as per article 23 of the International Code of Botanical Nomenclature (Mcneill, 2006).

DISCUSSION

Parashorea is a genus of hard wood and can reach up to 70 m. It consists of about 14 species distributed in South China, Southeast Asia and Malaysia (Mabberley, 1997). *P. stellata* with which our fossil shows maximum resemblance, is an evergreen shrub of more than 3 m height found in Myanmar (Hooker, 1872).

Shorea is a large genus of about 196 species of mainly rainforest trees of tropical Asia. It is found from Sri Lanka to China, Moluccas and Lesser Sunda Island. *S. ovalis*, the modern comparable form of our fossil, is found in peninsular Malaysia, Sumatra and Kalimantan (Hooker, 1872).

Cyclosorus is a large genus of about 600 species occurring in the tropical and subtropical southern hemisphere and found often in swamps or beside lakes (Mabberley, 1997). *C. proliferus*, the modern comparable species, occurs in fresh water swamps at low altitudes, mostly below 300 m altitude, but occurring as high as 1000 m, or beside rivers, at the water edge. It is widely scattered from West Africa, through tropical mainland Asia, the Philippines and Indonesia to Papuasia, north east Australia and New Caledonia.

The distribution of the modern comparable forms of the fossils indicates the existence of rain forests in the region during the deposition of the sediments. The fern fossil (*C. eoproliferus*) is known to occur only during the Middle-Late Miocene (Joshi & Mehrotra, 2003; Prasad & Pandey, 2008) and thus its presence confirms the age of the sediments as of

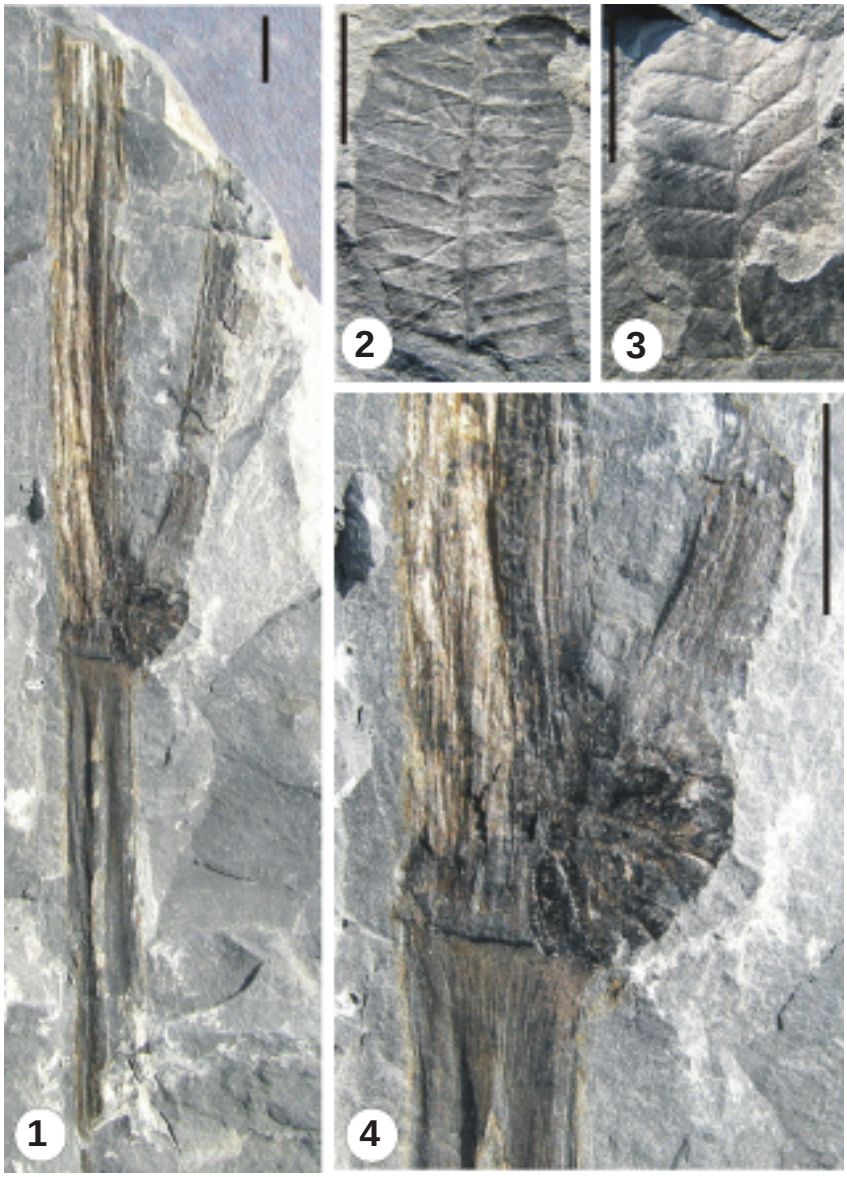

PLATE 2

(Scale 1 cm unless otherwise mentioned.)

1. A monocotyledonous stem in natural size; Specimen No. BSIP 39824A.
2., 3. *Cyclosorus eoproliferus* (Prasad) Prasad, Ghosh & Tripathi - Fossil fronds; Specimen Nos BSIP 39825-6.
4. Pl. 2.1 enlarged to show a branch arising from the node (); Specimen No. BSIP 39824A.

Middle–Late Miocene. Moreover, the family Dipterocarpaceae considered as Southeast Asian in origin is found in India after the Late Oligocene, i.e. after the complete suturing of the Indian and Asian plates (Srivastava & Mehrotra, 2010). Therefore, its presence indicated by *Parashorea* and *Shorea* fossils supports the age as mentioned above. Though it is difficult to traverse the Manas National Park infested with wild animals, an extensive collection from the park would enable us to understand the palaeofloristics of the region.

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