東ネパール，
バルン谷におけるシャクナゲ属の垂直分布と樹形

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Shuichi NOSHIRO* and Mitsuo SUZUKI**: Altitudinal Distribution and Tree Form of *Rhododendron* in the Barun Valley, East Nepal***

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シャクナゲ属の垂直分布と樹形***

Abstract

Diverse *Rhododendron* is distributed in East Nepal, but their state of diversification has not been studied. During the 1988 expedition we could observe and collect fourteen species above the montane zone in the Barun Valley of East Nepal. There we discovered one species new to Nepal, *R. hookeri*, with distinct fasciculate hairs scattered on the abaxial surface of leaves. Altitudinal distribution and tree form indicate existence of four groups among the studied species: trees, subtrees I, subtrees II, and shrubs. Trees grow as undergrowth of the montane and subalpine forests up to the forest limit at about 3750 m. Subtrees I and II both form continuous *Rhododendron* scrubs, about 3 m tall, in the lower part of the alpine zone. Subtrees I grow in open habitat within the subalpine zone, and form the lower part of the *Rhododendron* scrubs up to 3800 m. Subtrees II are the main components of these scrubs, and extend up to 4150 m. Subtrees I and II show existence of two upper limits in the lower half of the alpine zone. Shrubs grow as low mat-like scrubs in the alpine meadow above the continuous *Rhododendron* scrubs up to 5100 m, and also occupy neglected open habitat in the subalpine zone: they show wider ranges of distribution than trees or subtrees. Tree form of these species is closely correlated with tree height, and their altitudinal distribution defines the alpine vegetation in this valley.

Key Words: *Rhododendron*－*R. hookeri*－East Nepal－Altitudinal distribution－Tree form

Thirty species of *Rhododendron* have so far been reported in Nepal (HARA, 1982; POLUNIN and STAINTON, 1984; STAINTON, 1988), but most are distributed only in East Nepal. In the summer of 1988 we had a chance to study and collect various *Rhododendron* along the Arun River and in the Barun Valley of East Nepal, and could observe their diversification in the alpine and subalpine zones. *Rhododendron* in Nepal is diversified not only in general morphological characters but also in habit or tree form, but the state of diversification, not to say process, has never been studied.

Tree form or tree height strongly influences altitudinal distribution of woody plants. *Quercus mongolica* var. *grosseserrata*, one of the dominant trees of the Japanese montane zone, extends its altitudinal distribution into the scrub-dominated subalpine zone with its shrubby variety, var. *undulatifolia*, along the Japan Sea side of Honshu (YANAGIDA, 1933; NOSHIRO, 1984). Tree form also has great influence on wood structure. SUZUKI and OHBA (1988) studied wood structure of Himalayan *Rhododendron* of Central Nepal, and found that, compared with shrubs, trees have wider vessels, distinct spirals in both vessels and fiber tracheids, and numerous multiseriate rays. However the species studied were limited in number, and evaluation of tree form was not carried out.

In this paper we will first report the discovery of *R. hookeri* in Nepal, and describe altitudinal distribution of *Rhododendron* species in the Barun Valley. We will then evaluate tree form in relation to tree height, and discuss its role among *Rhododendron* species as components of the

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alpine vegetation.

Collection of Specimens and Vegetation of Study Site

The collection was made from middle July to early August in 1988, recording locality, altitude, tree height, tree form, and stem diameter. The Barun Valley is at the northern border of Sankhuwa Sabha District, Koshi Zone, Nepal, and the Barun Khola (khola: river in Nepali) runs down in the middle of it (Fig. 1). The collection route for this study is from Tashi Gaun (2160 m.a.s.l) to Makalu Base Camp (4680 m) via Shipton Pass (4120 m); the area ranges from 27°35'N to 27°55'N and from 87°05'E to 87°20'E. We attained the alpine zone twice along the route, and some *Rhododendron* species were collected on the southern slope of the Shipton Pass, that is, outside the Barun Valley. The voucher specimens for this study are all deposited in TI, and their specimen numbers are shown in the appendix.

The vegetation in this valley can be summarized as follows. On the southern side of the Shipton Pass, a montane *Acer* forest changes into a subalpine *Betula* forest at about 3100 m; to this altitude we could not go down in the Barun Valley. The subalpine zone consists of *Abies densa* or *Betula utilis* forests, and *R. hodgsonii* usually accompanies them as distinct undergrowth. These forests disrupt above ca. 3500 m with open scrubs or grassland along the Barun Khola or at cirque bottoms, and attain 3700-3800 m. They are then replaced with continuous *Rhododendron* scrubs, 2-3 m tall. The tree limit of *Abies densa* along the Barun Valley is at about 3950 m, and *Rhododendron* scrubs become scattered a little above this altitude, at about 4050 m. Above 4150 m they are then replaced with very low, mat-like scrubs of shrubby *Rhododendron*, less than 0.5 m tall, scattered in the alpine meadow.

Discovery of *R. hookeri* in Nepal

Near Khongma between Shipton Pass and Tashi Gaun, at about 3500 m, we collected three specimens of *R. hookeri* NUTTALL so far not recorded in Nepal.

Specimens: SUZUKI *et al.* 8840258, 8840368, 8840369.

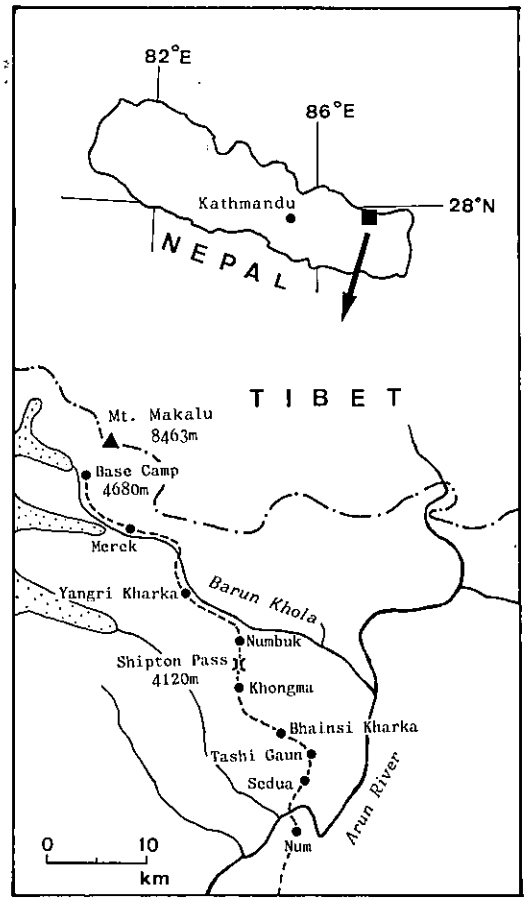

Fig. 1. Collecting route.

Description (Fig. 2): An evergreen tree, about 3 m tall and 20 cm in diameter. Branches glabrous. Leaves elliptic to slightly obovate, 95-150 mm long, 40-58 mm wide; apex rounded and apiculate, base rounded; adaxial surface glabrous, abaxial surface covered with long, sparse fasciculate hairs having strap-like broad arms (Fig. 2, b, c). Petiole glabrous, 15-24 mm long. Young infructescence short and slender conical, 11-20 mm long; pedicel short, 6-10 mm long. Calyx large, 2.5-5 mm long; usually 5-lobed, halfway or more than halfway lobed. Young fruits glabrous with persistent base of style; slender ovoid and obliquely curved, 10-14 mm long.

These specimens conform to *R. hookeri* in short infructescences, large calyces, and elliptic to obovate leaves with sparse, long fasciculate hairs. Indumentum of this species is very characteristic. COWAN (1950) described indumentum of *R. fulgens* and *R. hookeri* as "fasciculate", having

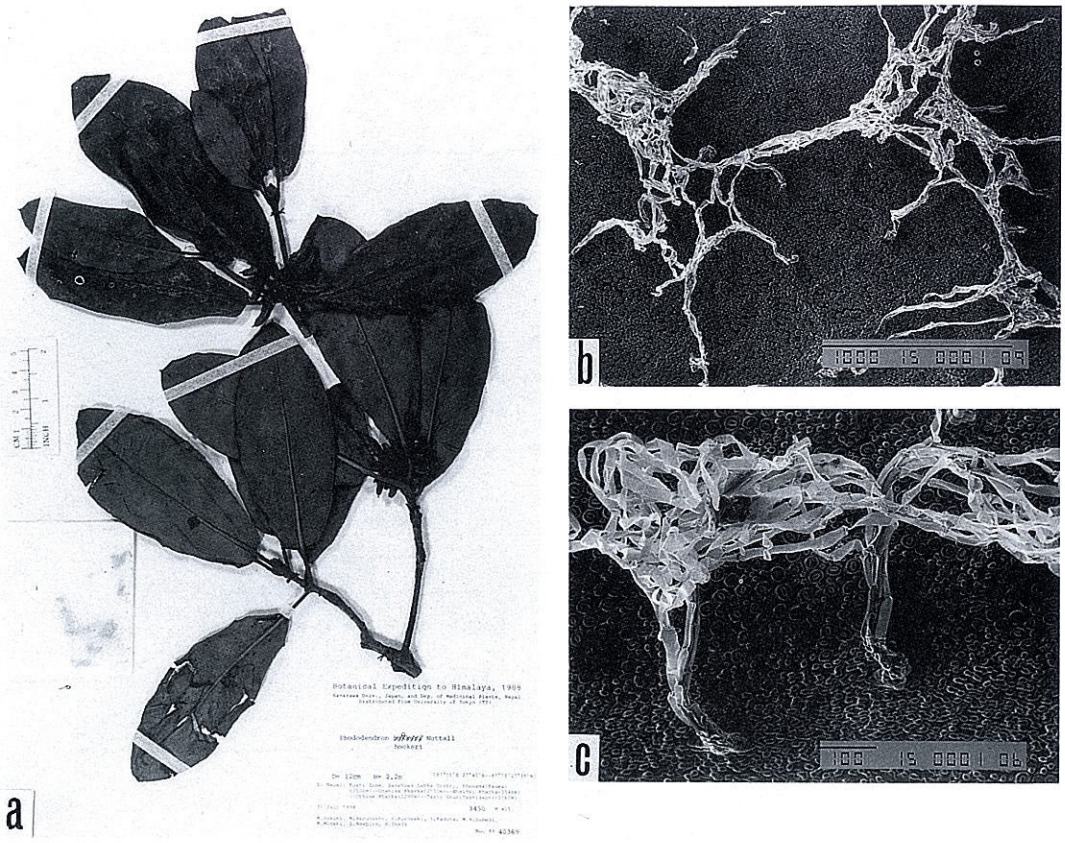

Fig. 2. *Rhododendron hookeri*. a : a herbarium specimen. b.c : fasciculate hairs on the abaxial surface of leaves. Bars indicate 1 mm in b, and 100μm in c. (a, b : SUZUKI *et al.* 8840369, c : do. 8840368)

stout stems and broad ribbon-like arms, and distinguished it from the typical "dendroid" hairs. Furthermore he described the fasciculate hairs of *R. hookeri* as particularly robust structure scattered on the under side of the leaf. Though stems are not thick in the specimens concerned, their broad arms and scattered occurrence conform to the description of *R. hookeri*. Thus these specimens should be identified with *R. hookeri*.

So far *R. hookeri* has been recorded in Bhutan (HARA *et al.* 9197 in TI ; HARA, 1971) and in Arunachal Pradesh, N. E. India (CHAMBERLAIN, 1982).

Altitudinal Distribution of *Rhododendron*

Fourteen species of *Rhododendron* have been recognized in the subalpine and alpine zones of this area. They extend from the montane deciduous forests to the uppermost part of the alpine zone. Based on their altitudinal distribution, these species can be divided into four groups of different tree forms : tree, subtree I, subtree II, and shrub. Trees usually have a distinct main stem, and grow up to 12 m tall and 25 cm thick. Most subtrees are of shrub form, up to 3 m tall and 22 cm in stem diameter ; but some have a distinct main stem, and grow up to 5.5 m tall and 25 cm in stem diameter. Shrubs are small, less than 0.8 m tall and less than 4 cm in stem diameter, and never have a distinct main stem.

The component species and distribution of these groups are as follows (Fig. 3) :

Tree. *R. barbatum* and *R. hodgsonii*. These species grow as undergrowth of the montane deciduous forests as well as that of the subalpine forests. In this area *R. hodgsonii* is far more conspicuous as forest undergrowth than *R. barbatum*.

Subtree I. *R. thomsonii, R. hookeri, R. campylocarpum,* and *R. cinnabarinum*. These

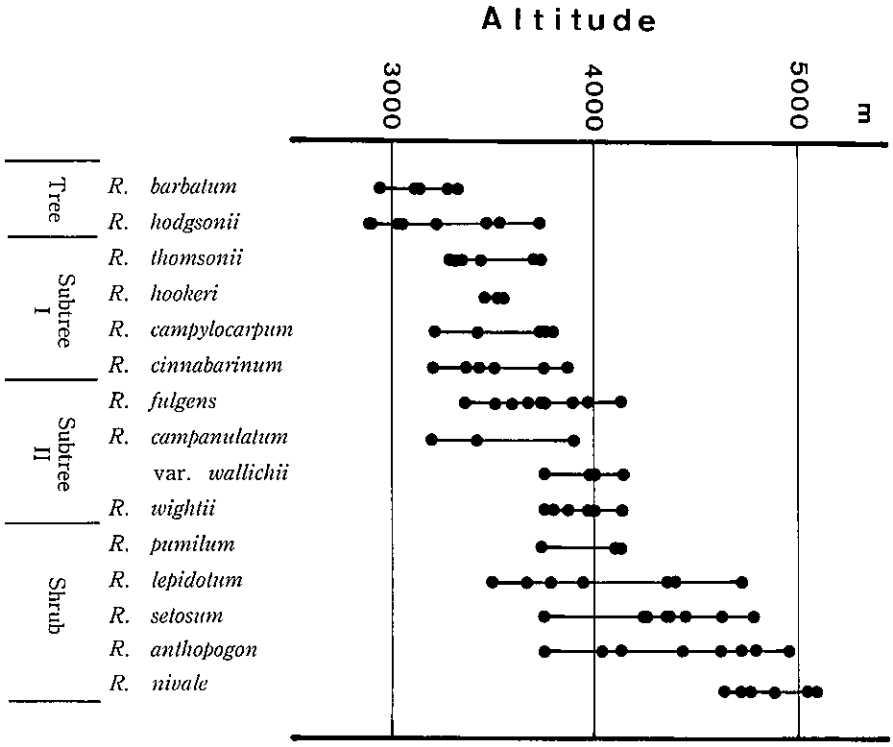

Fig. 3. Altitudinal distribution of *Rhododendron* in the Barun Valley.

species grow between 3200 m and 3800 m. They usually form open scattered scrubs within a subalpine forest, and the lower part of the continuous *Rhododendron* scrubs in the alpine zone.

Subtree II. *R. fulgens, R. campanulatum* including var. *wallichii,* and *R. wightii.* The lower limit of these species is variable, but all are above the montane zone. The upper limit is all at about 4150 m, and this is the uppermost limit of subtrees in this valley. These species are the main elements of the continuous *Rhododendron* scrubs in this area, but *R. fulgens* sometimes forms undergrowth of the subalpine forests. *R. campanulatum* var. *wallichii* is found only above Yangri Kharka, especially as scattered plants above the tree limit.

Shrub. *R. pumilum, R. lepidotum, R. setosum, R. anthopogon,* and *R. nivale.* These species are distributed among the continuous *Rhododendron* scrubs and above this zone. *R. nivale* is found only in the uppermost alpine zone far above the continuous *Rhododendron* scrubs, and goes up to 5100 m, near to the vegetation limit. *R. pumilum* is found only in the scattered *Rhododendron* scrubs between Khongma La and Shipton Pass. The other three species have wide ranges of distribution from the uppermost part of the subalpine zone to the upper part of the alpine zone; they form mat-like low scrubs in the alpine meadow, and also occupy open habitat within the subalpine forests or the continuous *Rhododendron* scrubs.

Thus *Rhododendron* species in East Nepal can be divided into four groups according to their tree form and altitudinal distribution. The alpine subtree species have two distinct upper limits, 3800 m in subtrees I and 4150 m in subtree II; both of them exist in the continuous *Rhododendron* scrubs, i. e., in the lower half of the alpine zone.

Discussion

Tree form can be quantitatively expressed as tree height in these *Rhododendron* species (Fig. 4). Tree height ranges from 2 to 12 m in trees, from 1.2 to 5 m in subtrees I, from 0.3 to 3.5 m in subtrees II, and from 0.05 to 0.8 m in shrubs. Tree

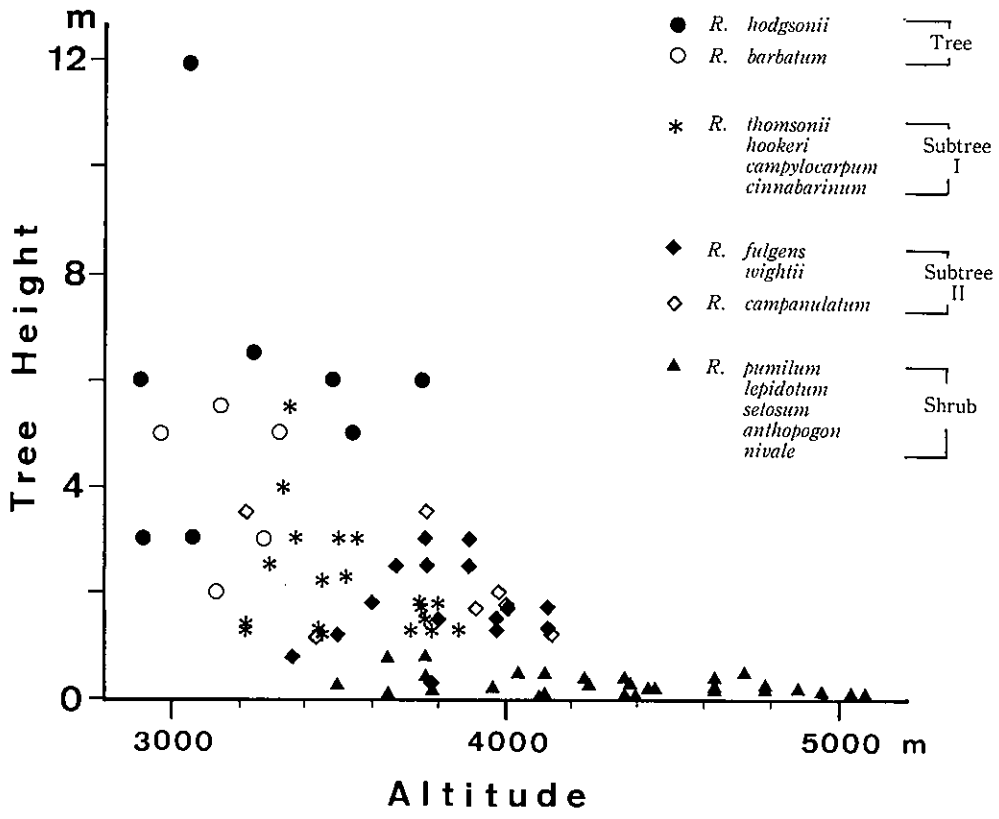

Fig. 4. Altitude and tree height of *Rhododendron* in the Barun Valley.

height does not decrease gradually according to altitude, but with two definite steps: from subalpine understory trees to subtrees forming continuous *Rhododendron* scrubs 2-3 m tall, and to shrubs forming low mat-like scrubs less than 0.5 m. Tree height of subtrees reduces to below 2 m above 3600 m in subtrees I and above the tree limit at 3950 m in subtrees II. Thus tree form defines altitudinal distribution of *Rhododendron*, and also defines the alpine vegetation itself.

Shrubs have wider ranges of distribution than trees or sub-trees (Figs. 3,4). This is due to the advantage of shrub from as a means of enduring limited environmental conditions in the alpine-zone or of occupying small neglected habitat in the lower zones as on or under rocks within a forest. *R. lepidotum* grows as low as 2500 m in open habitat of Kali Gandaki, Nepal (SUZUKI *et al*,. 8840548, 8860810 in TI). Adaptive significance of tree form should also be studied in relation to wood structure, and we should evaluate the primary results obtained by SUZUKI and OHBA (1988).

In the Barun Khola we collected fourteen species of *Rhododendron* above the montane zone, but its species number increases toward East, especially along the Tamur River. The two limits in the continuous *Rhododendron* scrubs may provide clues to the problems of speciation or adaptation in this genus, and may also lead to recognition of sub-zones in the alpine zone. To clarify them we should carry out field work in the eastern zone, and evaluate the distribution pattern presented here.

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APPENDIX. List of *Rhododendron* specimens used in this study. The collectors of all the specimens are M. SUZUKI, N. NARUHASHI, N. KUROSAKI, Y. KADOTA, M. N. SUBEDI, M. MINAKI, S. NOSHIRO, and H. IKEDA. The first set is deposited in TI.

R. barbatum WALL. ex G. DON: 8840234, 8840356, 8840370, 8840372, 8860207.

R. hodgsonii HOOK. f.: 8840221, 8840230, 8840289, 8840341, 8840344, 8840354, 8860197, 8860203.

R. thomsonii HOOK. f.: 8840244, 8840245, 8840263, 8840346, 8840336, 8860216.

R. hookeri NUTTALL: 8840258, 8840368, 8840369.

R. campylocarpum HOOK. f.: 8840265, 8840275, 8840336, 8840345, 8840351.

R. cinnabarinum HOOK. f.: 8840246, 8840247, 8840264, 8840347, 8840352, 8840365.

R. fulgens HOOK. f.: 8840262, 8840274, 8840337, 8840350, 8840357, 8840359, 8840362, 8840367, 8860222.

R. campanulatum D. DON: 8840348, 8840353, 8840358.

R. campanulatum var. *wallichii* (HOOK. f.) HOOK. f.: 8840308, 8840310, 8840313, 8840334.

R. wightii HOOK. f.: 8840272, 8840303, 8840309, 8840335, 8840360, 8840361, 8860244.

R. pumilum HOOK. f.: 8840270, 8840364, 8860228.

R. lepidotum WALL. ex G. DON: 8840248, 8840316, 8840331, 8840342, 8840343, 8840363, 8860225, 8860315.

R. setosum D. DON: 8840314, 8840315, 8840318, 8840321, 8840324, 8840339, 8860310, 8860313.

R. anthopogon D. DON: 8840311, 8840312, 8840317, 8840320, 8840323, 8840333, 8840338, 8860342.

R. nivale HOOK. f.: 8840322, 8840325, 8840327, 8840328, 8840329, 8840330.

摘　要

東ネパールには多様なシャクナゲ属の樹木が生育していることが知られているが，それらがどのように生育しているかについての報告は少ない。1988年夏にアルン川の支流であるバルン谷において現地調査をする機会が与えられ同属の樹木について標本を採集するほか，樹型や垂直分布について植生との関連で調べることができた。その結果，山地帯上部より上で14種のシャクナゲ属の樹木を採集し，これまでネパールからは報告のない *R. hookeri* をバルン谷の縁にあるシプトン峠の下で見いだした。それら樹木の垂直分布を調べた結果，これらの種はその垂直分布の幅によって，高木，亜高木Ⅰ，亜高木Ⅱ，灌木という四つのグループに分けられることが明らかとなった。高木は，山地帯や亜高山帯の森林の下層木をなしており，森林限界である標高3750 mまで生育していた。亜高木はいずれも，高山帯下部において樹高2〜3 mほどの連続した低木林をなしている。亜高木Ⅰは，この低木林の下部を構成するほか，亜高山帯林の疎開した部分にも分布しており，

その分布の上限はほぼ標高 3800 m であった。亜高木IIはこのシャクナゲ属の低木林の主体をなしており，標高 4050 m 付近からは疎開するものの，標高 4150 m まで生育していた。これより上部では，樹高 0.5 m 以下の灌木が高山草原のなかにマット状に広がって高山帯上部をなしており，なかには標高 5100 m に達するものもあった。またこうした灌木には，亜高山帯においても，岩のうえや岩陰のようなところに分布しているものがあり，高木や亜高木よりも垂直的に広い範囲に生育していることが明らかとなった。シャクナゲ属の樹形は樹高と密接に関連しており，樹高は標高が上がるにつれて，高木から亜高木，そして灌木と段階的に減少していくことが明らかとなった。これら樹形や樹高は，シャクナゲ属が重要な要素となる高山帯の植生とも密接に関っており，今後はさらに東部の地域において今回見いだされた現象の普遍性を検討する必要がある。

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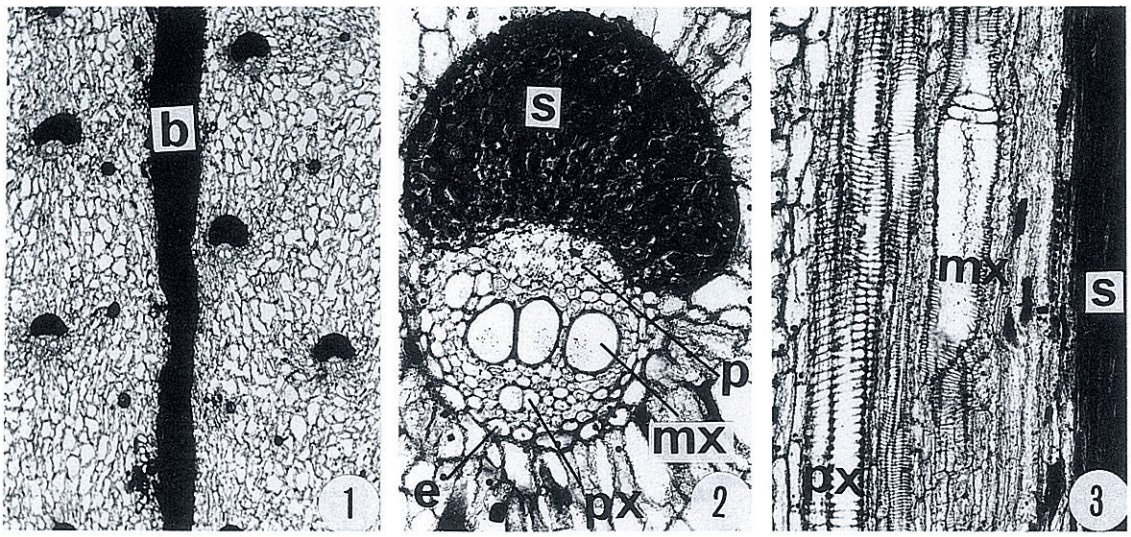
○ Mituso SUZUKI: **A New Record of *Palmoxylon* Fossil Wood from the Lower Miocene of Kanazawa.** 金沢郊外で新たに見つかった中新世前期のヤシ類の幹の化石（鈴木三男）

A *Palmoxylon* fossil wood was found in a small valley of the upper stream of Saigawa River, suburb of Kanazawa, Ishikawa Prefecture. Because the strata of Iozen Group (Lower Miocene) are exposed around the valley, it is sure that the fossil is originated from the group. The fossil shows following anatomical features: 1) vascular bundles are distributed evenly in the cross section, while some bundles run horizontally, 2) each circular or elliptical vascular bundle surrounded by a layer of endodermis is accompanied by large elliptical mass of fibers on its dorsal side are distributed evenly, 3) the bundle has protoxylem with 2 or 3 small vessels on its ventral side, 2-4 large metaxylem vessels at its central portion and phloem on its dorsal side. All of these anatomical features indicate the fossil is apparently the trunk wood of the Palmae. Basing on an anatomical comparison with holotype specimens of *Palmoxylon maedae* OGURA and *P. kagaense* OGURA which are known from the Miocene of Japan, the present fossil was identified to the former, *P. maedae.*

日本の第三紀からはヤシ類の葉の化石は比較的良く知られているが，材化石の報告はきわめて希で，これまでに石川県金沢市からの 3 例と福岡県の古第三紀層からの 1 例が知られているだけである。小倉は金沢市の名園，兼六園内の夕顔亭の手洗い鉢に用いられている「竹根石」がヤシ類の幹の化石であることを明らかにし，マエダヤシ *Palmoxylon maedae* (1952) の名をつけ，さらに同市内浅野川の河床から得た転石を *P. kagaense*



Figs. 1-3: Microphotographs of *Palmoxylon maedae,* No.53553. 1: cross section (×9.5) showing the even distribution of vertical vascular bundles and a horizontal bundle (b). 2: cross section (×40) of a vascular bundle. 3: radial section of a bundle (×40) showing spiral vessels in the protoxylem and a pitted vessel with a scalariform perforation plate in the metaxylem. e: endodermis; px: protoxylem; mx: metaxylem; p: phloem; s: fiber mass.