Sinske HATTORI*, Zennoske IWATSUKI*, Masami MIZUTANI* & Kosaku YAMADA**: **The genus *Takakia* in East Nepal*****

服部新佐*・岩月善之助*・水谷正美*・山田耕作**:
東ネパールのナンジャモンジャゴケ属***

One of the writers (Z. Iwatsuki) collected about 3000 packets of bryophytes in East Nepal from May to July of 1972 as a member of the Fifth Botanical Expedition to Eastern Himalaya organized by the University of Tokyo (Leader: Dr. Hiroo Kanai). He found *Takakia*-populations in many sites along the route from Ghopte (ca. 3500 m alt.) to Kipuphu (ca. 4550 m alt.), and brought to Nichinan 22 packets of *Takakia* among which 3 were in the living state.

The co-authors studied these materials and found *Takakia lepidozioides* in one packet (no. 1141) and *T. ceratophylla* in all of the other packets. Previously the two species of this genus have never been known in the same area. The 22 packets all contain female plants with archegonia. The following is a short report of the *Takakia* in Nepal.

In the field it was difficult to distinguish *Takakia ceratophylla* and *T. lepidozioides* from each other. However, under the microscope the two species are clearly distinguishable by the number of leaf-lobes and the thickening of the cell-walls in the leaves and in the stem-cortex, etc. These two taxa are clearly different species; we could find no apparently intermediate forms between them.

Cells of leaves and stem-cortex with strongly thickened walls, containing larger (5–6.5μ in diam.) and fewer (1–5) chloroplasts; in cross-section the leaf-lobe many-celled, the cells smaller; leaves quadrifid (=bisbifid), lobes never caducous; plant never fragrant when dry; gregarious mucilage hairs many-celled (to ca. 20 cells); 2–many-branched; axillary

* Hattori Botanical Laboratory, 3888 Honmachi, Nichinan, Miyazaki. 服部植物研究所.
** Ujiyamada High School, Ise, Mie. 三重県立宇治山田高等学校.
*** Acknowledgement is made of financial support of the field survey throuth grants from the Ministry of Education, Japan. We are indebted to Dr. W. B. Schofield who kindly read the manuscript.
東京大学インド植物調査研究報告 No. 28.

mucilage hair (=stylus) mostly 2-celled; known in Nepal, Sikkim, and Aleutian Is. (Amchitka I.) ..... *T. ceratophylla*

Cells of leaves and stem-cortex with thin walls, containing smaller (3.5–4μ in diam.) and more numerous (10–15) chloroplasts; in cross-section the leaf-lobe few-celled, the cells much larger; leaves bifid to the base, lobes caducous; plant with cinnamon-fragrance when dry; gregarious mucilage hairs 2–6-celled, not or 2(–3)-branched; axillary mucilage hair (=stylus) 2–4(–6)-celled; known in Nepal, N. Borneo (Mt. Kinabalu), Japan (Hokkaido and middle Honshu), Pacific N. America (S. E. Alaska southward to ca. 51°N. Lat. in coastal British Columbia) .... *T. lepidozioides*

Takakia ceratophylla (Mitt.) Gro.[1] (Figs. 1; 2, a–h & 3)

Specim. exam. East Nepal. Between Ghopte (Tal Pokhari) and Gosa (near Kobche), ca. 3970 m, on rocks, June 13, 1972, coll. Z. Iwatsuki 996, 996a, 997, 998, 999, 1000; —, 4020 m, on rock, ZI 1019; between Gosa and Banduke Pokhari (Duo Tulo Pokhari), ca. 4050 m, on soil, coll. ZI 1056; —, in crevices of cliff, June 14, 1972, ZI 1057; —, ca. 4210 m, in crevices of rocks, June 14, 1972, ZI 1085; around Banduke Pokhari (Duo Tulo Pokhari), ca. 4120 m, on rock, June 14, coll. ZI 1102; between Banduke Pokhari (Duo Tulo Pokhari) and Saju Pokhari, ca. 4150 m, in crevices of rocks, June 15, 1972, ZI 1132; —, ca. 4170 m, on rock, June 15, 1972, ZI 1141; —, ca. 4150 m, on rocky cliff, June 15, 1972, ZI 1144; between Saju Pokhari and the pass to Topke Gola, ca. 4100 m, on rock, June 16, 1972, ZI 1180; —, in crevices of rocks, June 16, 1972, ZI 1183; —, ca. 4350 m, on rock, June 16, 1972, ZI 1195; —, on rocky cliff, June 16, 1972, ZI 1196; —, on rock, June 16, 1972, ZI 1197; on a slope above Jalang Chhyongo, 4350 m, on soil, June 21, 1972, ZI 1392; around Kipuphu, 4550 m, on rock, June 26, 1972, ZI 1693; —, 4520 m, in crevices of cliff, June 26, 1972, ZI 1707.

This species usually forms a compact turf. In sheltered sites the turf is vivid green and not very compact and the plants are comparatively longer. In exposed sites, however, the turf is densely compact and more or less yellowish-brown and the plants are rather short. Compared with

1) For full synonymy and literature see Hattori et al. (1968, p. 148–149).

the plants from Lachen (Sikkim) and Amchitka Island (Aleutian Chains), the Nepal plants are well-developed; even under not very suitable conditions the turf is comparatively large (and loose), and the plants are slender with rather long shoots (never becoming so short as those of the Lachen and Amchitka plants). Such poorly developed plants are still easily distinguished from *T. lepidozioides* as emphasized by the above key.

Leafy shoots are usually 1 cm long, and many rhizomatic shoots (stolons) form a freely developed system below (in humus-substrata); each leafy shoot has 1–4 stolons at the basal portion, on which new leafy shoots innovate (Fig. 1, a; Fig. 3, a-b). The leafy shoot is usually simple, but rarely terminal branching occurs; these branches become similar to the main shoot and/or the branches of Crandall's *Philonotis*-type. Such branching occurs at the lower portion of the shoot or when the shoot is decapitated. This *Philonotis*-type branch develops from a primordium, and when it develops from the leafy portion, the branch originates in the axil of a leaf, in the same manner as the origin of the rhizomatic shoots. These leafy and rhizomatic shoots are considered to be essentially the same; under certain changes of environmental conditions, the rhizomatic shoot may bear normal leaves (thus become the leafy shoot).

Leafy shoots are thick and densely foliate toward the apex. The leaves are arranged in 3 rows. It is difficult to demonstrate whether the third leaf-row is dorsal or ventral, because no clear differentiation is found be-

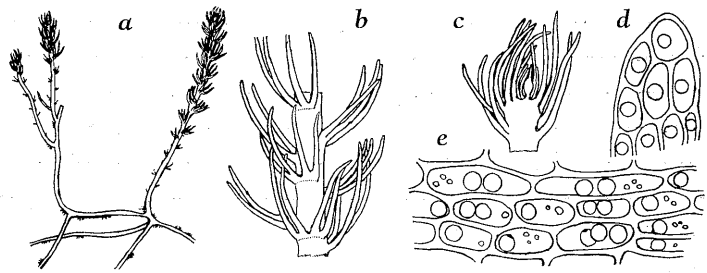

Fig. 1. *Takakia ceratophylla* (Mitt.) Gro. *a*. Plant, ×4.5. *b*. Portion of stem, ×17. *c*. Apical portion of stem, showing archegonium (several leaves are dissected away), ×17. *d*. Apical portion of leaf-lobe (circles showing chloroplasts), ×440. *e*. Epidermal cells of median portion of leaf-lobe (circles showing chloroplasts; much smaller irregular ones showing the bodies resembling oil-bodies), ×440. Drawn by S. Hattori from specim. from East Nepal, coll. Z. Iwatsuki no. 1707.

tween the leaves of any of the 3 rows. One of the writers (M. Mizutani) searched the plants with at least 2-3 leafy shoots connate in a single plane by rhizomatic shoots, and observed that the third leaf-row of each of the three shoots was parallel to the same leaf-row of the other erect shoots. Leafy shoots, when normally developed, have 5-10 sets of nomal leaves and several, much smaller, and almost scale-like leaves below. Mature leaves are bisbifid (leaf is bifid mostly up to the very base and each lobe is again bifid to near the base). The leaf is never caducous, so that it is not difficult to dissect away without tearing off or separating any of the four lobes. The growth-pattern of leaves is the same as in other bryophytes; that is, the distal cells earlier complete the growth. The lobes are cylindrical, tipped with a conic terminal cell neither acute nor elongate (Fig. 1, d).

The epidermal cells of the leaf-lobes are generally in about 20 rows at the middle and 25-30 rows at the basal portion, all equally thick-walled; the walls are almost hyaline or pale orange in color, and the cell cavity is narrow and long (20-30μ, rarely to 35μ long and about 8μ wide), containing 1-3-5 chloroplasts and, usually, several minute spherical bodies. The chloroplasts are discoid and large (5-6μ in diameter). The low number and large size of chloroplasts are characteristic of this species; in *Takakia lepidozioides* the chloroplasts are smaller and 10-15 in each epidermal cell of the leaf-lobes. The spherical bodies have formerly been considered comparable to the oil-bodies seen in the cells of *Haplomitrium* and other Hepaticae. However, these bodies can not be considered as 'true' oil-bodies, because they never retain a definite (or constant) structure and number (they are often absent or many may appear in an individual cell). These bodies are whitish, usually spherical, and mostly much smaller than the chloroplasts. They are mostly 1-3μ in diameter (rarely to 3.5μ), the larger ones (about 3μ or more in diameter) being more or less irregular-angulate, whereas the smaller ones are spherical and may be considered as decomposing.

The cortical cells of stems are in 40-50 cell-rows, narrow but long, with the cavity 25-40-55μ long and 7-10μ wide and the walls equally thickened and more or less brownish. The chloroplasts in the cell cavity are 2-6 per cell and as large as those in the cell-cavity of the leaf-lobes. The bodies similar to the oil-bodies are also present. The inner cells of stems are

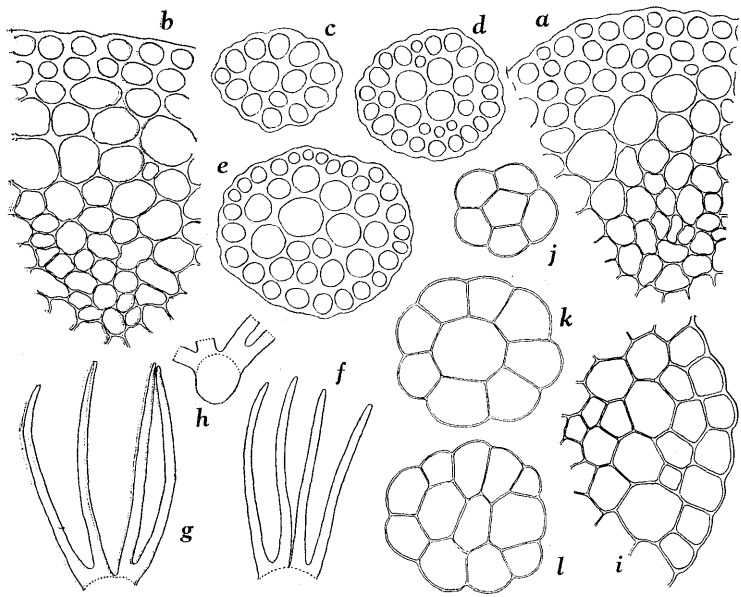

Fig. 2. *Takakia ceratophylla* (Mitt.) Gro. (*a–h*) and *T. lepidozioides* Hatt. & Inoue (*i–l*). *a–b*, *i*. Portions of cross-sections of stems, ×330. *c–e*, *j–l*. Cross-sections of leaf-lobes; *c*, *j* near apices; *d*, *k* at middle; *e*, *l* near base; all ×330. *f–g*. Stem leaves, ×33. *h*. Cross-section of stem showing the insertion of bisbifid leaf, ×33. Drawn by K. Yamada; *a–e* from specim. from East Nepal, coll. Z. Iwatsuki no. 998; *f–h*, coll. Z. I. no. 1056; *i–l*, coll. Z. I. no. 1141.

longer (ca. 100μ long and 12–15μ wide), thin-walled, and contain no chloroplasts. A few bodies like the oil-bodies are found.

The gregarious mucilage hairs (each hair is 3–20-celled and 2-many-branched) occur as irregularly scattered patches mostly on the rhizomatic shoots, or rarely also on the lower portion of leafy shoots, as also observed in the Amchitka plant.

The archegonia usually are solitary and 1–4 on each shoot, usually occurring at the apical portion where the leaves are so densely crowded that the archegonia are difficult to find without dissecting away many leaves which cover an archegonium; moreover, archegonia are similar to the leaf-lobe at younger developmental stage. The archegonia are large, pale green in color, and with a thick venter and more or less developed stalk. The neck-canal cells are in 6 rows.

Takakia ceratophylla is not rare at elevations from 3900 to 4550 m in East Nepal. At these elevations, some snow persists until the summer season on the shaded slopes. There is no forest vegetation, but small, shrubby *Rhododendron* often forms extensive scrubby mats. *Takakia ceratophylla* grows preferably on rocks or cliffs near perpetual snow. Occasionally it is found directly on soil. Among 21 collections collected in

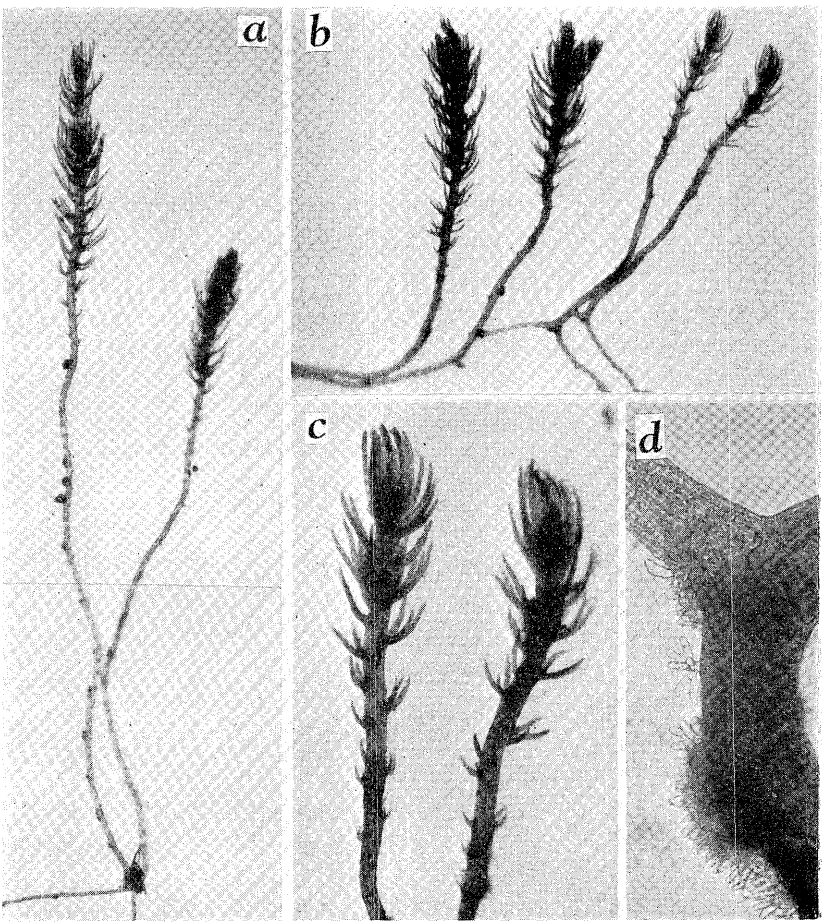

Fig. 3. *Takakia ceratophylla* (Mitt.) Gro. *a–b*. Plants, ×6. *c*. Upper portion of leafy shoots, ×16. *d*. Mucilage hairs on rhizomatic shoot, ×100. Photo by Z. Iwatsuki; *a–c* from specim. from East Nepal, coll. Z. Iwatsuki no. 996; *d*. coll. Z. I. no. 1693.

E. Nepal in June of 1972, 12 were found near the snow, and the remaining 9 specimens were also found within 100–200 m distant from perpetual snow, in other words, in the area where snow persists until late spring. It is found usually in partially shaded sites, but often grows in well shaded to exposed sites, although it is never found in sunny places. As mentioned previously in this paper, there is much variation in length of leafy shoots dependent on light conditions. In humid sites it often grows in crevices of rocky cliffs or vertical surfaces of rocks 1–2 m above ground level.

Takakia lepidozioides Hatt. & Inoue (Fig. 2, i–l)

Specim. exam. East Nepal. Between Banduke Pokhari (Duo Tulo Pokhari) and Saju Pokhari, 4170 m on rock, June 15, 1972, coll. ZI 1141.

The Nepal specimen of this species is rather poorly developed, compared with material from most of the Pacific areas of North America (Alexander Archipelago and Queen Charlotte Islands); it usually forms a turf, but the turf is not so dense and high. The leafy shoots are slender, often more or less flexuose, and, compared to those of *T. ceratophylla*, are more vivid green.

The leaf-lobes are strongly caducous; they are broken away just above the very base. New shoots may arise from these fallen leaf-lobe, as already observed in the plants from other regions. The epidermal cells of leaf-lobes are 25–30(–35) μ long and about 20μ wide at the middle portion, very thin-walled, and more or less mammillose, containing many chloroplasts (10–15 per cell). The chloroplasts are rotund, thinner and smaller than those of *T. ceratophylla*, measuring 3.5–4μ in diameter. The bodies resembling oil-bodies are similar to those seen in *T. ceratophylla* but much more numerous (mostly 3–15 per cell), most of which are smaller and spherical and are thought also to be decomposing ones. The largest is ca. 3μ in diameter.

The epidermal cells of stems are 35–40(–45) × 10–12μ, thin-walled (walls hyaline or almost so), each containing 10–20 chloroplasts and several bodies resembling the oil-bodies as in the leaf-cells.

The archegonia are solitary, and generally occur at or near the shoot-apex. We observed 1–3 archegonia each leafy shoot. The archegonia are similar to, but have a longer stalk than those of *T. ceratophylla*.

Dead and dried material has a peculiar fragrance which is similar to that of cinnamon. Whereas *T. ceratophylla* has no fragrance under the same conditions. When fresh or living, however, neither species has any apparent fragrance.

Only a single collection of *Takakia lepidozioides* was made on rock in a moist and shaded site near a pass, at 4170 m alt. in E. Nepal. The habitat seems similar to that of *T. ceratophylla*, but many specimens of the latter species were collected from more exposed and drier sites.

From the above observations, it is apparent that *T. lepidozioides* and *T. ceratophylla* cannot be considered to be clearly related to each other; each species may represent its own subgenus[1]. At present the Himalayas may be considered to be the center of distribution of *Takakia*, since both species occur in this area, although even there the male plant is not found. The fact that *Takakia* has no 'true' oil-bodies will be an important addition for the consideration of the relation of this genus to *Haplomitrium* and other bryophytes[2].

Additional remarks. Only recent literature is cited in this paper, since Hattori et al. (1968) gave a historical survey for *Takakia* study and cited all the literature published before 1968. Since then Winkler (1969) studied anatomy of the central strand of stems. Grubb (1970) published his observation on the structure and biology of *Takakia*, and Hébant (1972) studied, using electron microscope, the structure and effectiveness of the central strand of stems of *T. lepidozioides*. Schofield (1972) found *T. lepidozioides* on Mts. Daisetsu, Hokkaido, Japan, and reported ecology of this species there.

References

Grubb, P. J. 1970. Observations on the structure and biology of *Haplomitrium* and *Takakia*, hepatics with roots. New Phytol. **69**: 303–326, f. 1–8, t. 1–4, pl. 1. Hattori, S., A. J. Sharp, M. Mizutani, & Z. Iwatsuki. 1968. *Takakia ceratophylla* and *T. lepidozioides* of Pacific North America and a short history

1) *Takakia* Hatt. et Inoue subgen. **Prototakakia** Hatt. et al., subgen. nov. A subgen. *Takakia* differt foliis 4-fidis (=bisbifidis). Species typica: *Lepidozia ceratophylla* Mitt. [=*Takakia ceratophylla* (Mitt.) Gro.].

2) We think that the family Takakiaceae represents its own order Takakiales.

of the genus. Misc. Bryol. Lichenol. 4(9): 137-149, f. 1-7. Hébant, C. 1972. Précisions nouvelles sur la structure et la signification du faisceau conducteur irriguant le gamétophyte de *Takakia lepidozioides* Hattori et Inoue (bryophytes). C. R. Acad. Sci. Paris, t. 275, sér. d: 189-192, f. 1-10. Schofield, W. B. 1972. *Takakia lepidozioides* in Hokkaido, Japan. Misc. Bryol. Lichenol. 6(2): 17-18. Winkler, S. 1969. Anatomische Untersuchungen über Leitstränge der Gametophyten bei den Lebermoosen. Österr. Bot. Z. 117: 348-364

* * * *

筆者の1人岩月は東京大学第5次インド植物調査隊に参加し，1972年6月，東ネパールの山地（海抜3500-4150 m）から *Takakia lepidozioides* Hatt. & Inoue（ナンジャモンジャゴケ）1点及び *T. ceratophylla* (Mitt.) Gro.（ヒマラヤナンジャモンジャ，新称）21点を採集し，その一部を生品のまゝ持ち帰り，現在培養中である。*T. lepidozioides* はヒマラヤから初めて報告されるものであるが，これらの2種が同一地域に共に知られたのは今回が初めてであり，ヒマラヤ地方は本属の分布の中心と考えられる。他地域の標本と同様，今回も雌植物のみで，雄植物や胞子体は発見できなかった。

ヒマラヤの標本を充分に研究した結果，両種は明瞭に区別でき，夫々異った亜属を代表するものと考える。*T. ceratophylla* には英文中に述べたような多くの特徴があるが，特に 1) 葉が3列に並び，各々の葉は4個の裂片に bisbifid すること，2) 葉細胞や茎の表皮細胞が小形で膜が厚いこと，3) それらの細胞内の葉緑体が大きくて，数が少ないこと，4) 葉片が決して caducous にならぬこと，5) mucilage hair がしばしばたくさんに枝分れすることなどが重要である。*T. ceratophylla* に対して新亜属 Prototakakia Hatt. et al. を提案した。

今まで *T. lepidozioides* の油体と考えられてきたものは，他の苔類に含まれるような真の油体とは考えられない。*T. ceratophylla* では，この油体様のものは *T. lepidozioides* の場合よりも小さくて，数が多い。

両種の東ネパールでの産地や生態にも論及したが，*T. lepidozioides* の乾燥標本にシナモン様の特殊な香りがあり，*T. ceratophylla* にない点も両種の区別点となる。

（追記）本稿をまとめた後，服部植物研究所で培養中のネパールおよびアリウシャンの *Takakia ceratophylla* の染色体の研究を熊本大学の井上 覚教授にお願いした。その結果 n=5 であって，*T. lepidozioides* よりV染色体が1個多いことがわかった。同属下の2種でこのような結果が出たのは苔類ではじめてであり，本属の分類について重要な事実である。