

Hideaki OHBA*: A systematic revision of the genus
Cardiandra (Saxifragaceae-Hydrangeoideae) (1)**

大場秀章*: クサアジサイ属の分類 (1)

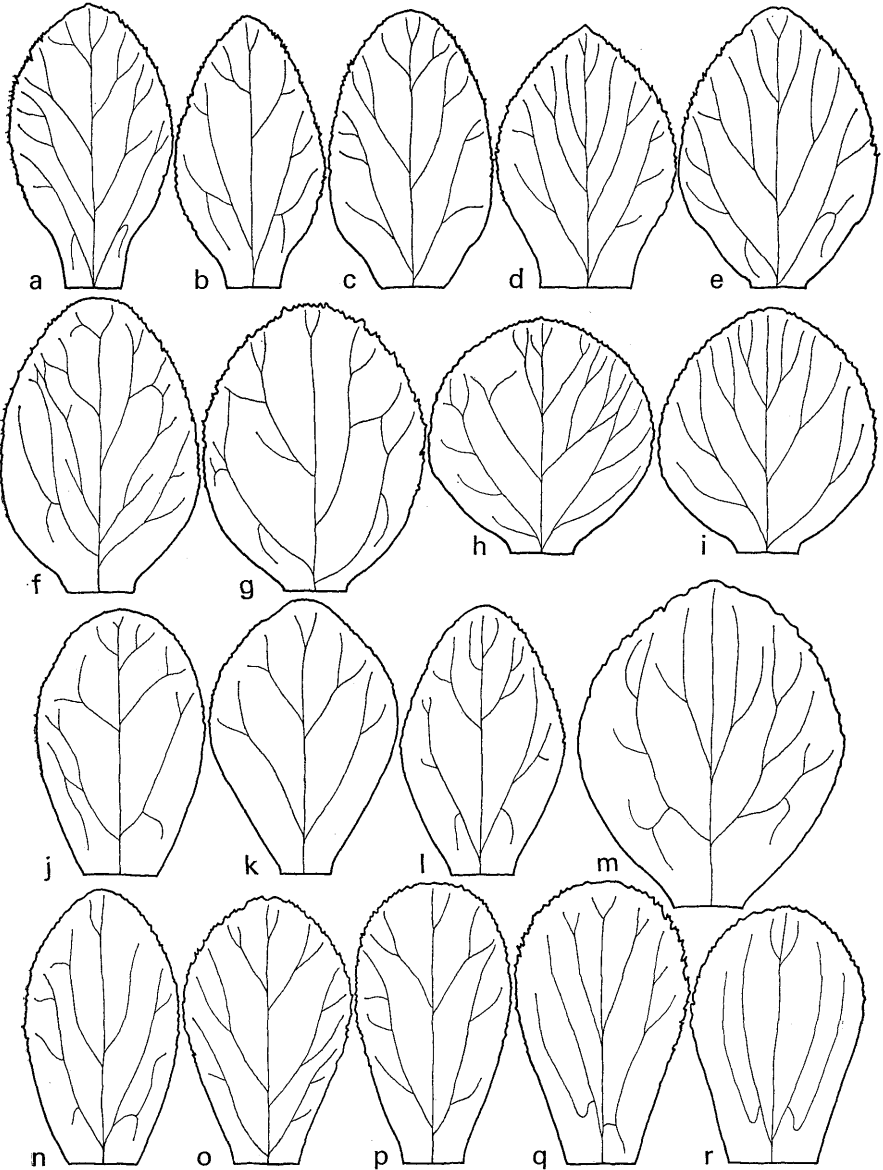
(Pls. II-III)

Cardiandra was described by Siebold & Zuccarini (1839) based on a single species from Japan, *C. alternifolia*. They found it to have numerous stamens with obcordate-truncate anthers and classified it in the tribe Hydrangeae DC. Four further species have been described from various localities in E Asia by several botanists: these are *C. sinensis* Hemsley (1903) from Ningpo, *C. formosana* Hayata (1906) from Taiwan, *C. amamioksimensis* Koidzumi (1928) from S Japan and *C. laxiflora* Li (1945) from Kwangsi. In 1942 Migo transferred *Hydrangea Moellendorffii* Hance (1874) to *Cardiandra* and regarded *C. sinensis* as a synonym of this species. But, there still remain some problems on delimitation of species and infraspecific taxa.

As regards the generic status of *Cardiandra*, the previous workers have attached importance to a single or a few diagnostic characters, e.g. the obcordate-truncate anthers and the alternate arrangement of leaves. At a glance *Cardiandra* resembles some species of *Hydrangea* and might be possible to be classified in that genus as done by Siebold (1829). Hutchinson (1927) considered that *Cardiandra* was one of the progenitors of *Hydrangea*, showing the path of development from a herbaceous to a woody habit. Then, he treated *Cardiandra* as a member of the tribe Kirengeshomeae (not Hydrangeeae) in the subfamily Hydrangeoideae, together with *Kirengeshoma* and *Deinanthe*. Engler (1930) treated *Cardiandra* in the tribe Hydrangeeae in the subfam. Hydrangeoideae and put it between *Deinanthe* and *Platycrater*. The generic segregation of *Cardiandra* and the status of this genus in the subfam. Hydrangeoideae now need further studies as the case of specific and infraspecific classification. This paper aims chiefly to provide a systematic revision of *Cardiandra* based on various

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morphological characters.

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Notes on the taxonomic characters In compiling features for examining in this work, a number of previous treatments of *Cardiandra* and its related genera were consulted, particularly useful in this respect were Siebold & Zuccarini (1839-40) and Engler (1930). In addition a thorough search was made for new features that might be of use.

Flower. *Cardiandra*, as well as *Hydrangea*, shows a strong tendency towards the abortion and enlargement of the outermost flowers with petaloid calyx-lobes. The number of the petaloid calyx-lobes is usually 3 (rarely 4 or 5) in *C. alternifolia* and 2 (very rarely 3) in *C. Moellendorffii*, but *C. amamiohsimensis* has no petaloid calyx-lobes. The aestivation of the petals should be described as 'imbricate' (not valvate) as pointed out by Hutchinson. The variation ranges of the petal shapes by each species are shown in Fig. 1 and also in the descriptions. The shape of petals is, however, diversified even in a single flower (Fig. 1). Generally the outermost of the five imbricate petal is the largest.

Pistils. In *Hydrangea* the degree of fusion between pistils and calyx-tube is greatly differentiated among species, while in the species of *Cardiandra* it is almost the same. The ovary itself is completely fused with the calyx-tube: That is, the flower of *Cardiandra* is semi-inferior having a flower-tube derived from the fusion between the ovary and the calyx-tube. The styles, usually 3 (rarely 2), are basally connate and extrude from the flower-tube. The length of the styles is apparently different among the species. *C. amamiohsimensis* has the longest styles, and the shortest styles are those of *C. alternifolia* (Fig. 2). The stigmas, densely papillate, are described as oblique occupying the dorsal upper part of the styles (Pl. II C).

Fig. 1. Petals of *Cardiandra*. a-i: *C. amamiohsimensis*. j-r: *C. alternifolia*, j-l: subsp. *Moellendorffii* var. *binata*, m: var. *Moellendorffii*, n-r: subsp. *alternifolia*. All $\times 10$. [a-e. Hatusima 20013, from a single flower; f. Hosoyamada s. n.; g. Hosoyamada 20827; h & i. Hosoyamada MAK 125440; j-l. Kawakami & Mori 1735, from a single flower; m. Furuse 4433; n-q. Saito s. n., from a single flower; r. Ohba 3524].

Anthers. *Cardiandra* is characterized by the anthers with expanded connectives by Siebold & Zuccarini. In *C. alternifolia*, the anther in younger stage before dehiscence is broadly elliptic or broadly ovate with a swelling in the centre (Pl. II A). Although the swelling looks from the outside very like a massive expansion of the anther itself, it faithfully reflects the peculiar development of the connective. The expansion at the connective apex continues till its time of dehiscence, and then the expanded connective penetrates between the thecae, so that the shape of the anther gradually changes from broadly elliptic or ovate to broadly obovate. Such conspicuous expansion of the connectives can be observed in the other species of *Cardiandra*, but not in *Hydrangea*, *Deinathe* or *Kirengeshoma*.

Pollen grains. Based on photomicroscope observation the pollen grains of *Cardiandra* were described in as tri-colporoidate (6B^b) with fine reticulation and 11-12×12-13.5 μm in size (Ikuse 1956) or Type VII with (i) j(k) forms of colpi and orae, psilate or fine reticulate sexine and 16-18 μm in maximum size (Wakabayashi 1970). As far as investigated in SEM (Pl. IIB & D), the ornamentation of the pollen grains of *Cardiandra* is different from the species of *Hydrangea*. The pollen grains of *Cardiandra* are microreticulate and its tectum seems to be consisting of sparse capitate columellae (Pl. IIB), while the pollen grains of *Hydrangea* have fine reticulate ornamentation without capitate columellae.

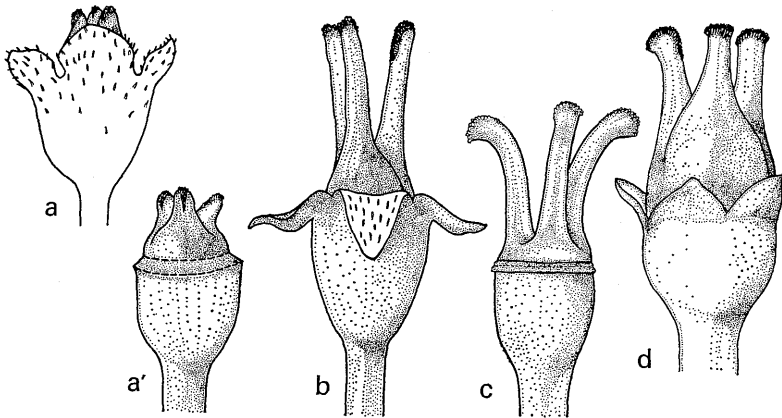


Fig. 2. Calyces and pistils of *Cardiandra*. a & a': *C. alternifolia* subsp. *alternifolia*, d: *C. alternifolia* subsp. *Moellendorffii*. b & c: *C. amamioshimensis*. All ×10.

Testa. The seeds are about 1 mm long, narrowly ovoidal or elliptic-cylindrical with thin testa (Pl. III B). The testa is regularly reticulate and granulate: It has a raised network of narrow and sharply angled lines presenting a geometric (rectangular) appearance and conspicuous or inconspicuous rounded projections (Pl. III C & D). As far as investigated in *Hydrangea*, the testa is fine lineate marked with fine continuous lines and lacks any projections (Pl. III A).

Seedling. As soon as the cotyledons developed, the initial stem appears (Fig. 3a & b). The initial stem is different from the hypocotyle by having sparse hairs. The seedlings produce 8 to 10 leaves within the first year. The leaves are always opposite (Fig. 3b & c). The hypocotyle together with the basal part of the initial stem becomes subterranean and being thickened gradually. The aerial part of the initial stem dies in late autumn. In the second year a single (or rarely two or more) aerial stem solitarily comes out from the axil of the former year's leaves. Therefore, the aerial stems are described as lateral. The aerial stems rapidly elongate in later spring or summer and the first one or two pairs of leaves are scaly or rudimental not foliaceous (Fig. 3d & e). From the second year the arrangement of leaves changes to alternate except the first or two (rarely three) lower opposite pairs (Fig. 3f-h).

Inflorescences. Some specimens of *C. alternifolia* have lateral inflorescences coming out from the axils of upper leaves. Others have 3 to 5 small bracteate leaves subtending the branches of the inflorescences, so that they seem to have only terminal inflorescences. There are, however, many specimens showing various intermediate appearances. In *C. amamiohsimensis* the inflorescence is apparently terminal with several small bracteate leaves, while in *C. Moellendorffii* the inflorescences are terminal or terminal and lateral.

Chromosome numbers. On *Cardiandra* no cytological data have been reported. Wakabayashi counted $2n=30$ in *C. alternifolia* from the material collected in Jakkonotaki, the foot of Mt. Nyohou, Nikko, Tochigi Pref. and cultivated at Botanical Gardens, Nikko, University of Tokyo (Fig. 4). The chromosome number, which was obtained from the usual squash method, is very interesting. Because the chromosome numbers known from *Hydrangea* are mostly $2n=36, 72$ and *Deinanth* $2n=34$ (Hamel 1951, Fedorov 1969).

Phylogenetic relationships The characters which apply to detect the phylogenetic relationship among three species of *Cardiandra* are now only the presence/absence of ornamental flowers, the length of styles and the num-

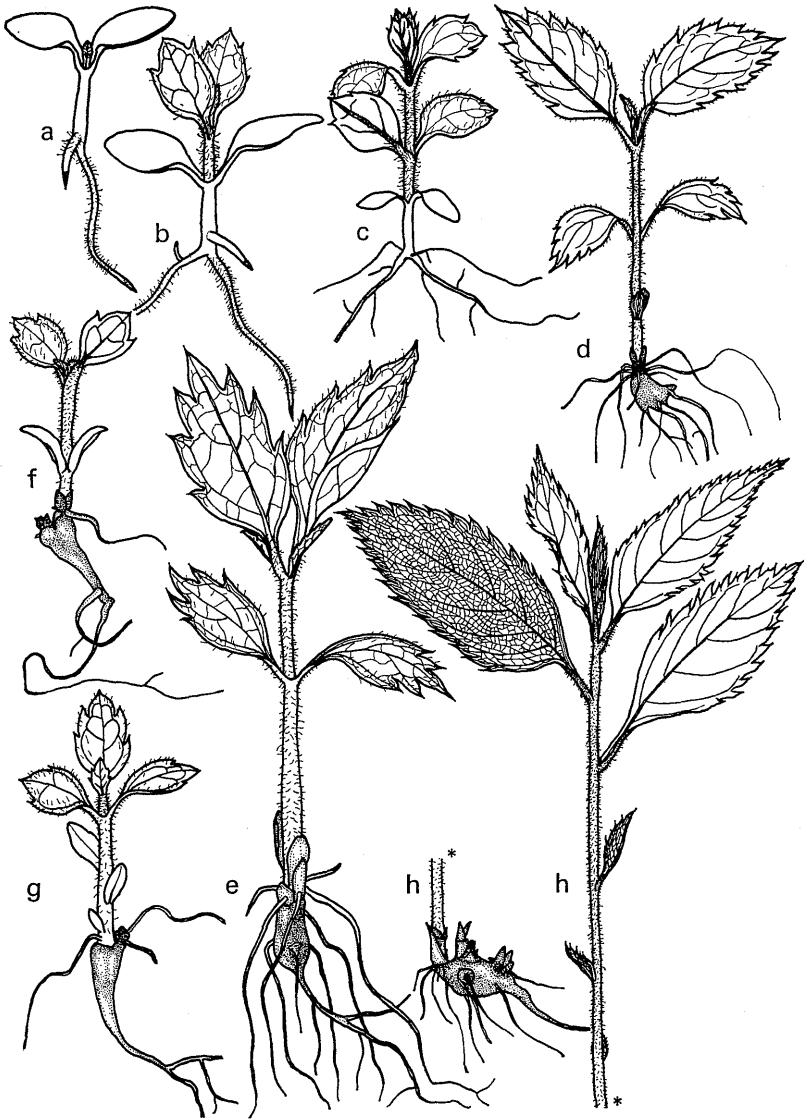


Fig. 3. Seedlings and juvenile plants of *Cardiantra alternifolia*.

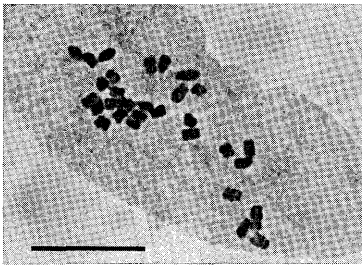


Fig. 4. Somatic chromosomes of *C. alternifolia*. Bar indicates 10 μ m.

ber of the petaloid calyx-lobes. The appearances of the two of these three characters are common in *C. Moellendorffii* and *C. alternifolia*, and different in *C. amamiohsimensis*. [In *Cardiandra* it is reasonable to postulate that the length of styles reduces size in the course of speciation. If the appearances of styles in *C. alternifolia* and *C. Moellendorffii* are synapomorphous

at the level of universality represented by these three species of *Cardiandra*, both species share an immediate common ancestral species not shared by *C. amamiohsimensis*. On the contrary, supposing the longest appearance of styles found in *C. amamiohsimensis* is autapomorphy and the shorter appearances in the other two species are plesiomorphy, I must think that the style length becomes longer throughout speciation in *Cardiandra*. It is difficult for me to accept this supposition. It would be reasonable to postulate that the styles are decreasing the size in the course of speciation. I then go to discuss another character, i. e. the ornamental flower. The presence of the ornamental flower is also found only *C. alternifolia* and *C. Moellendorffii* and not in *C. amamiohsimensis*. I consider that the presence of the ornamental flower is homologous not homoplasious. Then, this character is another synapomorphy and additional corroboration for the monophyletic status of *C. alternifolia* and *C. Moellendorffii*. If it is an acceptable postulation, on the number of petaloid calyx-lobes, 2 is plesiomorphic and 3 or more are apomorphic. In conclusion it is considered that *C. Moellendorffii* and *C. alternifolia* are monophyletic and *C. amamiohsimensis* occupies a more remote position as shown in Fig. 5. Although geographically *C. alternifolia* and *C. Moellendorffii* occupy different regions, no essential differences in other characters are found between them except for the number of the petaloid calyx-lobes and the length of styles. So it would be better to treat them as two geographical subspecies of a single species.

Cardiandra is considered to be closely related to *Deinanthe* and *Hydrangea*. *Deinanthe* is rhizomatous perennial herb, but has opposite leaves, 5-loculate ovaries, 5 highly connate styles and a different number of chromosomes as $2n=34$. *Hydrangea* is more or less woody shrub with opposite leaves and floral

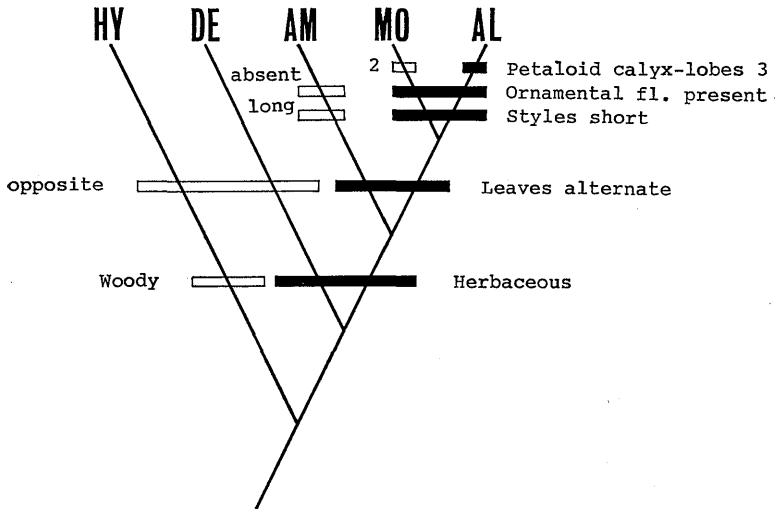


Fig. 5. Phylogenetic argumentation. Black bars connecting taxa with hypothesized apomorphies whereas open bars plesiomorphies. HY, *Hydrangea*. DE, *Deinathe*. AM, *Cardiandra amamiohsimensis*. MO, *C. alternifolia* subsp. *Moellendorffii* and AL, subsp. *alternifolia*.

features differentiated among the species. *Cardiandra* differs from *Hydrangea* in several features such as microstructure of testa, expansion of connectives, basic chromosome number, etc. *Kirengeshoma* is far removed from *Cardiandra* as well as *Deinathe* and *Hydrangea* in several morphological, cytological and also palynological characters (e. g. Hamel 1951, Wakabayashi 1970). *Platycrater* is also thought to occupy a remote position from *Cardiandra* in having obconical flower-tube and a peculiar form of the ornamental flower. Fig. 5 is an assumed phylogenetic argumentation based on information available.

Explanation of Plates II-III

Plate II. *Cardiandra alternifolia*. A: Anther (\times ca 70). B: Pollen (\times ca 5300).
C: Styles (\times ca 70). D: Germinated pollen grains on stigma (\times ca 900).
Plate III. Seed and testa. A: *Hydrangea chinensis* (\times ca 450). B-D: *Cardiandra alternifolia* (B \times ca 100, C \times ca 70, D \times ca 900).

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東アジアに特産するクサアジサイ属について行った観察をまとめ、さらにこれまでの知見をも加えて系統を考察した。その結果をもとに分類体系の校訂を行った。

クサアジサイでは幼茎は伸長し葉は対生する。幼茎基部と胚軸は肥厚し地中に残る。2年目は通常前年の葉腋のひとつだけから花茎をだす。葉の配列は最初の数対を除いて互生に変わる。蒴の特異的なかたちは蒴隔の頂端が肥大するためにできることが判った。花粉は蓋膜に頭状の Columella を散生する。これはいまのところアジサイ属にはみられない。種皮には明瞭な隆条があり、規則的に結合して長方形の網目をつくるが、アジサイ属では隆条は結合しない。染色体数は $2n=30$ (若林三千男博士による) で、アジサイ属やギンバイソウ属にこの数は見い出されていない。

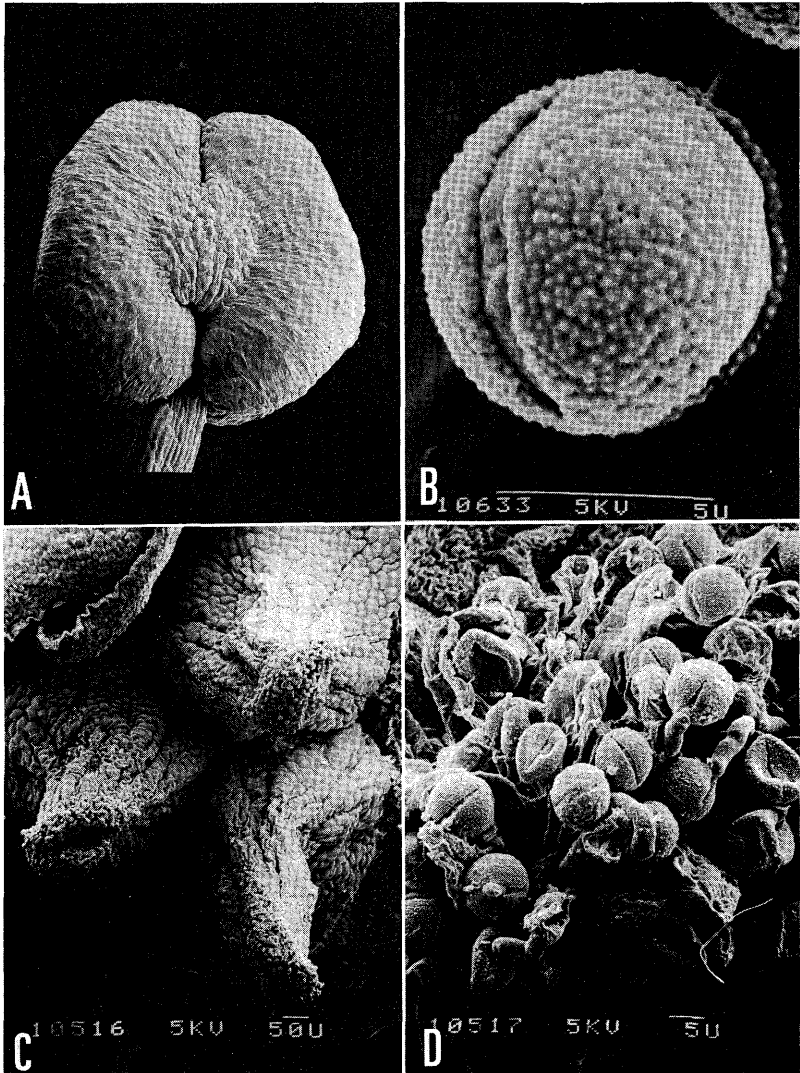
系統解析に有効な形質は雌蕊の長さや装飾花の有無とその萼片数と考えられ、これらの形質状態の分布を調べ、系統について考察を試みた。

□Dyer, A. F. & J. G. Duckett (ed.): **The experimental biology of bryophytes**

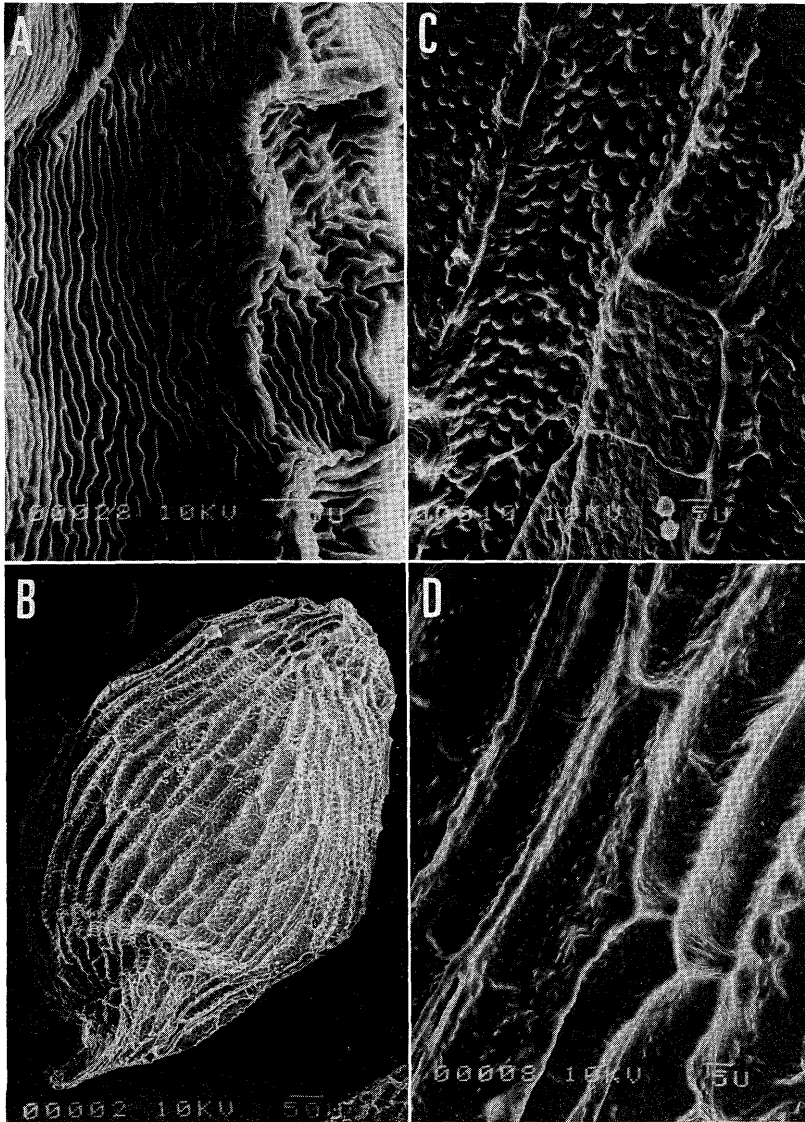
i-xvi+281 pp. 1984. Academic Press, London. \$68.50. 近年、蘚苔類について種々な分野で実験的な研究が行われており、特に組織培養やこれにともなう生理学的な現象面での研究成果には目覚ましいものがある。本書はこうした蘚苔類に対する実験的アプローチを集大成したもので、P. W. Richards が蘚苔類の形態、生活史、生態等に関する特性を述べた "Introduction" に続き、10篇の論文が集められている。ここに取りまとめられた興味深い成果は、日本ではまだほとんど研究されていない分野だけに、今後の研究の指針ともなろう。例えば、M. Lal: The culture of bryophytes including apogamy, apospory, parthenogenesis and protoplasts (蘚苔類の培養と無配生殖、無孢子生殖、単為生殖) とか、D. J. Cove & N. W. Ashton: The hormonal regulation of gametophytic development in bryophytes (蘚苔類の生長とホルモン)、N. Valanne: Photosynthesis and photosynthetic products in mosses (蘚類の光合成と光合成産物) などがある。本書を通読すると、蘚苔類という植物がこのような実験的研究の素材としていかに重要なものであるかが、改めてよくわかるのである。(井上 浩)

□Schultze-Motel, X. (ed.): **Advances in bryology, vol. 2** 229 pp. 1984. J. Cramer. DM 200.

本書は国際蘚苔類学会 (IAB) が企画し、いろいろな分野での蘚苔類研究を review するものである。今回は Mitosis in bryophytes (M. W. Steer), Moose als Bioindikatoren (H. Muhle), Desiccation and ultrastructure in bryophytes (M. J. Oliver & J. D. Bewley), Applied bryology (安藤久次・松尾昭彦) の4篇が収められている。蘚苔類学の現状を把握するために好都合な出版物である。(井上 浩)



H. OHBA: The genus *Cardiantora*.



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