Taxonomical Studies on Asian Anthocerotae I

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The Anthocerotae constitute an isolated bryophytic class whose taxonomical position has been long discussed by various investigators. The class is different from other bryophytes in some important characters; they include the large chloroplast containing a pyrenoid, the endogenously formed antheridium, the archegonium almost completely embedded in the thallus, the cylindrical sporophyte with a central columella and an intercalary meristem, and the archesporium originated from the amphitheciun.

Formerly, the hornworts were generally regarded to be more or less related to the thalloid liverworts owing to the superficial similarity of the thalloid gametophytes and they were inevitably placed in the class Hepaticae. But the morphological studies of archegoniates carried out by such botanists as HOFMEISTER (1851), JANCZEWSKI (1872), LEITGEB (1879), HY (1884), etc. during the latter half of the 19th century revealed the above-mentioned peculiarities of the Anthocerotae and gave suggestions to separate them from the Hepaticae. Since HOWE (1899) regarded Anthocerotes as a class coordinate with the Hepaticae and with the Musci, this taxonomical treatment has been widely accepted. Recently, on the phylogenetic relationships between the Anthocerotae and other groups of land plants, some interesting ideas have been proposed in various occasions from various view-points; for example, it was regarded as a subclass within the class Hepaticae (PROSKAUER 1961), as a division Anthocerotophyta coordinate with Hepatophyta (STOTLER & CRANDALL-STOTLER 1977), and as a taxon (Anthocerophyta) coordinate with all other land plants (Schuster 1977), etc. I think, however, it is reasonable to follow HOWE (1899) at this stage of our knowledge.

In the class the gametophyte is a multilobed or radially dissected, dorsi-ventral thallus with scarcely differentiated internal tissues, except for some species which have large lacunae in the thallus. The ventral surface of the thallus has numerous smooth-walled rhizoids and scattered Nostoc colonies inside but lacks tuberculate rhizoids and scales. Each cell of the thallus usually has a single, large chloroplast with a conspicuous compound central pyrenoid, but in some species two or more chloroplasts are present in most cells. Both the antheridia and the archegonia lie sunken in the thallus. The antheridia occur

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singly or in groups in antheridal chambers beneath the upper surface of the thallus. Archegonia are nearly completely buried in the thallus tissue on the dorsal side, therefore they are hard to recognize without dissecting the thallus. The sporophyte consists of a bulbous foot, a meristematic zone and a cylindrical capsule. The foot is embedded in the gametophyte. The tissue just above the foot functions as a meristem, so that the sporophyte develops indefinitely by the intercalary growth. The elongation of the sporophyte by intercalary growth makes the capsule emerge through a gametophytic sheath, the involucre. The capsule is composed of an outer sterile wall with or without stomata, a central columella and a sporogenous layer between them, and usually dehisces into two valves which show hygroscopic twisting.

The class Anthocerota includes a single order the Anthocerotales which in turn consists of two families the Anthocerotaceae and Notothyladaceae. The genus Notothylas had been usually placed in the Anthocerotaceae, but for its morphological peculiarities chiefly of sporophyte, Müller (1940) assigned it to a separate family Notothyladaceae (as Notothylaceae)*. Recently Grolle (1972) described for Notothylas a new subfamily (Notothyladoideae) of the Anthocerotaceae, but I think it is better to place the genus in its own family. As the Müller’s family is unfortunately an invalid name accompanied by no latin diagnoses, I will validate it below**.

Formerly four genera, Anthoceros, Dendroceros, Notothylas and Megaceros were recognized in the order Anthocerotales. Among these the largest Anthoceros has been split into three genera, Aspiromitus Steph., Anthoceros L. emend Prosk. and Phaeoceros Prosk. Although latter two genera defined well by Proskauer in his excellent studies (1948, 1951) have been accepted in general, the validity of the genus Aspiromitus has been criticised by such bryologists as Campbell (1940), Proskauer (1951), Mehta and Handoo (1953), Meijer (1954), etc. In 1965 Bharadwaj revised the genus Aspiromitus Steph., putting a new definition on it, and in 1971 gave a new name, Folioceros for Aspiromitus Steph. emend. Bharadwaj***. The validity and systematic position of Folioceros are open to debatable question even at present. Although the Bharadwaj’s treatment is not supported by many bryologists, I am inclined to follow him (this problem will be discussed in detail in a succeeding paper of this series of studies). According to my treatment, therefore, the Antho-

* Milde (1859) separated for the first time the genus Notothylas from other members of the Anthocerotae (Anthoceros and Dendroceros of those days) and established two subtribes, Dendrocereae and Notothyladeae, within the tribe Anthocerotae.

** Notothyladaceae K. Müll., fam. nov. Involucrum horizontali deflexum, corniforme, plerumque locatum in frondis margine. Capsula brevis (minus quam 4 mm), cylindrica vel ovoidea, ex involucro carnoso aegre emergens, absque stomate; columella linearis, interdum perfecta cellularum ad basin usque solutione evanida. Elaters plerumque in cellulas singulas dissoluti, hyalini, saepe striis incrassatis parietalibus notati.

Type. Notothylas Sull.

*** The type of Stephani’s Aspiromitus, A. husnati Steph. does not belong Folioceros (= Aspiromitus Steph. emend. Bharadwaj) but the species is very similar to Anthoceros punctatus L., the type of Anthoceros L. emend. Prosk.
cerotae is to include two families and six genera.

In Stephani's "Species Hepaticarum" 319 species of the Anthocerotae were listed from the world, but they were briefly described without any comparison to allied species. And even now when it has passed away more than fifty years since its publications, many species described by Stephani still remain to be little-known. Such a chaotic situation in the specific classification of the Anthocerotae may be realised by the Proskauer's (1967) saying, "Phaeoceros laevis has probably some 200 synonyms." It is generally said that the actual number of species of the class may be less than one hundred, but these estimations are not always based on exact knowledges. Of six genera, Anthoceros, Phaeoceros and Notothylas are widely distributed in both tropical and temperate regions, but Dendroceros, Megaceros and Folioacers are mostly restricted to tropical regions. All the six genera occur in Southeast Asia including Japan, Formosa, Southern China, Philippines, Indochina, Borneo and Java—the areas treated in the present studies.

Phytogeographically, a few species such as Anthoceros punctatus and Phaeoceros laevis are cosmopolitan, and such Japanese species as Notothylas orbicularis and Anthoceros macounii are boreal, of which the former is distributed in the temperate region of the Northern Hemisphere, and the latter occurs in northern Japan and the eastern part of North America. Most other species of Southeast Asia have been known from rather restricted areas but they are supposed to be distributed much more widely, judged from the general pattern of distribution in bryophytes and the biological natures of these plants. For example, Megaceros tosanus, Dendroceros japonicus and Folioacers miyabenus are reported from southern Japan and Formosa, but it is reasonable to think that these species might be distributed in far southern areas, as Southeast Asia could be regarded as a phytogeographical unit for the taxonomical study of the Anthocerotae. Thus, in order to elucidate the taxonomy of Japanese species, we must have accurate informations about the species occurring in Southeast Asia.

I. On some Asian species of Notothylas

The genus Notothylas contains a small number of species, most of which have been little investigated from the taxonomical point of view. Because of the simple thallal structure and the small reduced sporogonium, it is very difficult to find distinguishing characters for the infrageneric taxa of Notothylas. Seven species of Notothylas have been recorded from various places in Asia, i.e. N. javanica (San Dee Lag.) Gott. from Java and Luzon, N. levieri Schiffn. ex Steph. from India, N. indica Kashyap from India, N. japonica Horik. from Japan and Formosa, N. veroorti Khanna from Burma, N. chaudhari Nirula from India, and N. orbicularis (Schwein.) Sull. from Japan. These species described briefly and fragmentally at various times were not well understood in regard to their systematic relationships. In 1976 Hassel de Menendez reviewed the species of this genus, regarding the spore ornamentation observed by the scanning electron microscope

* In addition to these six genera Nemejc & Paulcova (1972) reported an interesting fossil, Notothylacites filiformis resembling an extant Notothylas, from the Senonian beds in Czechoslovakia.
as an important character, and classified all the species described till then except for five Asian species (*N. javanica*, *N. indica*, *N. japonica*, *N. verdoorni*, and *N. chaudhuri*) into five groups. In spite of her noteworthy contributions to the classification of *Notothylas*, the taxonomical status of Asian species remains still uncertain.

I have studied Japanese material of the genus for years, and recently I had a chance to examine several specimens of *Notothylas* from Thailand kept in the Herbarium of the Kyoto University (KYO), in cooperations with The Royal Forest Department of Thailand (November 1965–February 1966, and August–October 1967). Moreover I could examine many specimen of *Notothylas* including types and exotic material kept in the Herbarium of the University of Hiroshima (HIRO), the Hattori Botanical Laboratory (NICH), the Osaka Museum of Natural History (OSAK), the National Science Museum, Tokyo (TNS), Conservatoire et Jardin botaniques, Geneva (G), and Rijksherbarium, Leiden (L). The present study is intended to be a short revision of the Japanese species and to describe a new species from Thailand.

I would like to express my sincere appreciation to Dr. M. Hamada, Kyoto, and Prof. A. Takimoto, Kyoto University, for their encouragement throughout the course of this study. I also express my cordial thanks to Professor N. Kitagawa, Nara University of Education, for his unending assistance and valuable suggestions. I am particularly thankful to Mr. T. Nosuchji, Department of Wood Science and Technology, Kyoto University, for his help in the scanning electron microscope work. My deep gratitude is also due to my colleagues of our laboratory for their help in various ways. Further, I am deeply grateful to the directors and curators of the herbaria mentioned above for their kindness in lending a number of specimens including types.

1) Japanese species of *Notothylas*

Since Horikawa (1929), for the first time, described a new species of *Notothylas*, *N. japonica* from Japan, there had been no intensive studies on Japanese plants of the genus, except several floristic studies which had shown the geographical distribution of this species ranging from Formosa to southern Hokkaido. Hatori (1952) suggested that *N. japonica* might be conspecific with *N. orbicularis*. Recently Inoue (1976) studied Japanese plants of the genus giving detailed descriptions and illustrations and treated *N. japonica* as a synonym of *N. orbicularis*. As the result *N. orbicularis* became to have a wide range through the boreal region of Northern Hemisphere including Europe, Asia and North America.

In the course of my studies on ample Japanese material from various localities and some exotic specimens from Southeast Asia, North America and Europe, it has become evident that (1) the northern Japanese plants including the type specimen of *N. japonica* are identical with *N. orbicularis*, (2) the central and southern Japanese ones are different from *N. orbicularis* and new species, *N. temperata* has to be proposed for them, and (3) the southernmost Japanese ones are neither *N. orbicularis* nor *N. temperata* but identical with *N. javanica*. Thus, three species of *Notothylas* occur in Japan and they are distinguished
from each other by the following key.

1. Capsule bivalved, with a special row of cells along the valve margin, epidermal cells narrowly rectangular (mostly 17.5–25 μ wide), rather regularly arranged, strongly thick-walled; spores yellow to dark brown; spiral thickenings of the elaters well-developed; distributed in northern Japan. \textit{N. orbicularis}

2. Capsule without such a special row of cells, thus without valves, epidermal cells broadly rectangular or quadrate (mostly 20–45 μ wide), irregularly arranged; spiral thickenings of the elaters poorly developed or elaters absent; distributed in central or southern Japan.

\textit{N. orbicularis} (Schwein.) Sull., Musci Alleghaniensis, Exsic. no. 290 (1845). Fig. 2.


\textbf{Habitat.} On moist soil in the garden and farm, and often on soil of the drained rice-field.


When Horikawa (1929) described \textit{Notothylas japonica} as new species, he compared it with \textit{N. orbicularis} by the following distinguishing characters; the size of capsules and spores, the degree of cell-wall thickenings of the capsule epidermis, and the absence or presence of columella. Among these the size of capsules has a considerable range of variation as 1.0–2.5 mm long or 1.5–3.5 mm long in capsules even on the same thallus,

* The following abbreviations are those of main collectors' names used in the "specimens examined". H. H. Hikaru Hasegawa (KYO), H. I. Hiroshi Inoue (TNS), J. H. Jiro Hasegawa (KYO), N. K. Naofumi Kitagawa (KYO), S. H. Sinske Hattori (NICH, TNS), T. K. Tsukumihiko Kodama (OSAK), Y. H. Yoshiwo Horikawa (HIRO).

** When Horikawa (1929) described \textit{Notothylas japonica}, he mentioned four specimens without designation of the holotype. I could examine one of them (above specimen) and designate it as lectotype.
while Horikawa (1929) wrote “Capsule 3-4 mm long.” The spore is 37.5-40 μ in diam. and yellow to yellowish brown in the type specimen of N. japonica, although it was described as black by Horikawa (1929). Plants from northern Japan agree well with N. orbicularis in the spore ornamentation—finely and faintly vermiculated (Fig. 5). Until now no one has reported the presence of columella in Japanese material of this genus, but I could recognize the well-developed columella in most capsules examined. Development of the columella seems not to be genetic but to be environmental in this species and we can not rely upon this character for the distinction of species or infraspecific taxa.

Japanese plants are different from European and North American ones in the relatively thin-walled epidermal cells of capsules, and the European have most strongly thickened walls. This suggests that N. orbicularis is differentiated into geographical races among these three regions—these races might be separated as infraspecific taxa.

Notothylas orbicularis is distinguished from other Asian species as follows: N. indica has larger spores (50-57.5 μ) with the baculate ornamentation on their distal surface, and more thick-walled epidermal cells of the capsule; N. levieri has the smaller spores (32.5-35 μ) with tuberculate ornamentation, and the special cells of more than one row (2-3) along the margin of the capsule-valves; N. temperata, N. javanica, and N. verdoorni have the non-valved capsule with irregularly arranged epidermal cells and the poorly developed elater. I could not examine the type specimen of N. chaudhuri nor get any idea on its distinguishing characters by the Nirula’s brief description.

In the distribution in Japan, the present species shows the range segregation with other two species, N. temperata and N. javanica, as shown in Fig. 1. The fact that this species was once found at Nichinan, Miyazaki Pref., southern Japan, is difficult to explain, but I think that it might have been unexpectedly brought there by human agency.

Notothylas temperata J. Hasegawa sp. nov. Fig. 2, 3.

N. javanicae (Sandé Lac.) Gott. valde affinis, sed differt sporis nigris, parietibus cellularum exteriorum capsulae non incrassatis, involucris paene laevibus. N. orbiculari (Schwein.) Sull. etiam affinis, sed differt capsulis non valvatis, cellulis exterioribus capsulae magnis non incrassatisque, sporis nigris, elateribus vix effectis. Habitat in Japonia centrali.

Fig. 1. Distribution map of Notothylas species in Japan and adjacent regions. ●, Notothylas javanica; +, N. temperata; ○, N. orbicularis.
Plants monoicous (protandrous), in scattered small patches on the ground, pale to dull green in fresh material, dark green to somewhat brownish in herbarium material. Thalli forming confluent rosettes 8–15 mm in diam., deeply divided into subboreal to broadly obcuneate lobes with rather narrow bases, nearly smooth but sometimes warty behind involucres, 6–8 cells thick, without lacunae; margins irregularly dissected into oblong and truncate lobules or bluntly crenate, 2–3 cells thick; on the ventral surface near the apex stoma-like slits scattered, backwards instead of them Nostoc colonies present; cells of the dorsal surface quadrate to five- or six-sided, (35 × 32.5 μ-)47.5 × 35 μ–55 × 40 μ (−75 × 35 μ), with a single large chloroplast; chloroplast in the young active cells round, fresh-green, with a single small pyrenoid near its centre; involucres cylindrical or often corniform, (1.0–)1.8–2.4 mm long, (0.5–)1.0–1.5 mm wide, dorsal surfaces slightly plicate, somewhat warty at the base, locating usually at the bottom of the marginal sinus but sometimes on dorsal surfaces of thallus, lying horizontally, solitary but often geminate or in groups. Capsules cylindrical or banana-shaped, or sometimes ovoid, (0.8–)2.0–3.5 mm long, (0.4–)0.7–0.8 mm thick, rarely projecting from the involucr, without any special row of thick-walled cells for the opening, thus usually longitudinally ruptured but not valvate; outer sterile tissue two- to four-layered, exterior cells mostly rectangular, 40–50 (−80) μ long, 20–30 (−45) μ wide, somewhat elongate, rather irregularly arranged, walls uniformly thickened but not strongly so, often rather thin, brown to dark brown; columella usually distinct, attaining to more than half the length of the capsule, sometimes indistinct. Spores rounded-tetrahedral, (35–)37.5–42.5 μ in maximum diam., blackish brown to black at maturity, faintly vermiculated. Elaters rounded-rectangular to quadrate, 30 × 25–42.5 × 35 μ, hyaline, bands of spiral thickenings poorly developed, mostly not completely separated into individual cell even in the mature capsule. Androecia sparse near the growing points on young thalli, antheridia usually four in each antheridial chamber, oval and shortly pedicellated, 100 × 70–125 × 100 (−165 × 150) μ, jacket layers with irregularly arranged small cells, ruptured irregularly.

Habitat. Most common on moist soil in rice-fields. Also common in the farms and gardens.


Fig. 2. Notothyla orbicularis (Schwein.) Sull. (a-g). a. Small plants with young sporophytes wholly enclosed by involucre, ×12. b. A portion of capsule wall showing thick-walled epidermal cells, ×325. c. Transverse section of thallus showing six mucilage cells, ×120. d. A portion of transverse section of capsule, ×325. e. A portion of one valve showing a special row of cells along the margin, ×70. f-g. Elaters, ×490. (Fig. a drawn from J. H. 6554, Fig. g from J. H. 6557, others from J. H. 6514). Notothyla temperata J. Hasegawa (h-k). h. A portion of ruptured capsule wall, ×70. i. Elater, ×490. j. A portion of transverse section of capsule, ×325. k. Stoma-like slit, ×280. (Fig. j drawn from J. H. 6574, others from type).


Range. Endemic to Japan (Honshu, Shikoku, Kyushu).
The present new species resembles *N. orbicularis*, but is clearly distinguished in the non-valved capsule (without any special row of cells on the capsule wall), the rather thin-walled and irregularly arranged epidermal cells of the capsule, the poorly developed elaters, and the black spores, etc. It is also closely related to *N. javanica* but is different from the latter in the rounded rectangular and thin-walled epidermal cells of capsules, the longitudinally ruptured capsule, the black spores, the nearly smooth involucres, etc. The relationships between this new and other two Japanese species will be discussed in detail under *N. javanica*.

The present species has an interesting pattern of distribution which ranges from Kyushu to the almost northern end of Honshu, but in the northern part it occurs only in the Japan Sea side, while another northern species *N. orbicularis* occurs only in the Pacific Ocean side (Fig. 1).

Around Kyoto the present species is found from late June to December and during winter the thallus disappears in the field. I have confirmed, however, that the plants cultured in greenhouse could grow even in winter. In this case fertile thalli collected in the field in autumn did not continue to grow but new shoots sprouted from the margins of parent thalli. These young thalli were totally sterile during winter.

Anatomically, the thallus of *Notothylas* has been said to be cavernous (with large lacunae within it) in some species as *N. orbicularis* in Howe (1898) and Müller (1940), *N. japonica* in Horikawa (1929) and *N. breutelii* in Frye & Clark (1947). On the contrary Pandé (1932, 1934) noted the presence of mucilage cells in *N. indica* and *N. levieri*. Moreover, Campbell (1908) wrote “Sections of the thallus of *N. javanicus* (*N. javanica*) shows it to be quite solid, and no trace of the mucilage-cavities which are conspicuous in *N. orbicularis* can be found.” I could not find such mucilage cavities in Japanese *N. orbicularis* and *N. temperata*, but find such mucilage cells as described by Pandé, which were distinctively tinged with purple or blue by the toluidine blue or the methylene blue (Fig. 2–b).

*Notothylas javanica* (Sandé LAC.) Gott., Beilage Bot. Zeit. 16: 20 (1858). Fig. 3.


Thalli forming rosettes 1.0–1.5(–2.0) mm in diam., in well-developed conditions densely overlapped, deeply divided into orbicular lobes, lobes slightly imbricate and sometimes somewhat erect along the margin due to mutual lateral compression of lobes, free margins irregularly crenate or densely laciniate, dorsal surface nearly smooth and flat, epidermal cells rounded-quadrate to irregularly hexagonal, 35×30–55×40(–60×25) μ in dorsal view; involucres small (about 1.0 mm long), conical, usually marginal but sometimes dorsal, scattered and solitary but often in groups, dorsal surface longitudinally plicate, plicae somewhat high, usually with irregular laciniae towards the tip. Capsules small, ovate- to oblong-cylindrical, 0.9–1.3(–1.6) mm long, epidermal cells irregularly arranged, broadly rectangular to quadrate, 55×25–40×25(47.5×45–30×30) μ, moderately thick-walled, without any special row of cells, thus irregularly ruptured and

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Fig. 3. *Notothyas temperata* J. HASEGAWA (a–c). a. Plants with both matured and immatures sporophytes, ×10. b. Ruptured antheridium, ×280. c. A portion of capsule wall showing rather thin cell-walls, ×325. (Fig. a, c drawn from type, Fig. b from J. H. 3910). *Notothyas javanica* (SANDE LAC.) GOTT. (d–g). d. A portion of capsule wall showing moderately thickened cell-walls, ×325. e. Plants with numerous young sporophytes wholly enclosed by involucre, ×7. f. Spore, ×490. g. Three involucres showing roughly lamellate and lobulate dorsal surface, ×6.3. (Fig. d–f drawn from S. H. 9667, Fig. g from J. H. 6344).
not valved; columella usually present in disintegrating condition but sometimes quite indistinct. Spores rounded-tetrahedral, 40-45 μ in diam., finely vermiculated, yellow (hardly brownish and never blackish). Elaters absent* (disintegrated in the early stage of development). Plants monoicous, androecia scattered, antheridia not seen.


Range. Southern Japan, Formosa, Luzon, and Java.

The present species is best characterized by that (1) the irregularly ruptured capsule without special rows of cells, thus without any definite mechanism for opening; (2) the moderately thick-walled and irregularly arranged epidermal cells of the capsule; (3) the yellowish spore (never blackish); (4) the almost total absence of elaters; and (5) the distinctly lamellate and laciniate involucre. Although the type specimen is somewhat different from Japanese plants in the dorsally located, larger capsules and somewhat larger spores, no discrepancy is found in other important characters.

Until now *Notothylas* of Japan has regarded to be represented by a single species, *N. japonica* or *N. orbicularis*. As mentioned above, we have now three species in Japan. These species have the same type of the spore ornamentation and the nearly orbicular thallus in common, but they are different from each other in some details. This fact suggests they are closely allied to each other, and it might be possible to consider that they represent merely geographical races. However I have found that the major character of the presence or absence of the special dehiscence line in the capsule-wall is correlated with such minor ones as the degree of the thickening, the shape and size of epidermal cells of the capsule, the nature of the disintegration and the spiral thickenings

Table 1. Comparison of Japanese species of *Notothylas*, concerning the capsule, the elater and the spore.

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<thead>
<tr>
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<th><em>N. orbicularis</em></th>
<th><em>N. temperata</em></th>
<th><em>N. javanica</em></th>
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<td>size</td>
<td>35-40 μ</td>
<td>37.5-42.5 μ</td>
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* The ruptured capsule-walls are sometimes fragmented into a single cell, which is easy to confuse with the elater.
of elaters, and the spore colour. I think these characters together with other gametophytic characters of minor importance give enough evidence to recognize three species rather than three races of a single species*. The distinctions among three species are summarized in the Table 1.

(2) A new species of Notothylas from Thailand

Tropical Asia may be one of the most interesting region from the view-point of the hornwort flora. As to the genus Notothylas, however, only two species (N. javanica and N. verdoorni) were reported from a few localities in this region. But it is natural to consider that these species might be more widely distributed and more species might occur there. Although there have been no records of the genus Notothylas from Thailand, I have found several species in the specimens collected in Thailand deposited in the herbarium of Kyoto University. Of these one is described as new species here, but I refrain from reporting other species, because their identifications are still uncertain.

Notothylas depressisspora J. HASEGAWA sp. nov. Fig. 4.

A omnibus speciebus hujus generis praefer N. dissectam STEPH. differt sporis cum depressione in quaque superficie proximali et projectura in superficie distali. Species valde similis N. dissectae guatemalensi, sed differt thallis parvis, sporis magnis flavidisque, elateribus sine incrassatis spiris, et columella diminuta.

Plants dark green in herbarium material, medium-sized, prostrate in patches, closely adhering to the substratum. Thalli densely overlapped, thin and somewhat membranous in texture, smooth and flat, deeply furcate, much lobulate towards the apex, lobules narrow and linear, truncate or shortly lacerate, margins nearly entire. Involucres usually solitary, at the bases of sinus, lying horizontally or somewhat ascending, small, cylindrical to conical, rather thick, longitudinally deep-plicate or lamellate, but not lobulate. Capsules short-cylindrical, 1.2—1.5 × 0.23—0.3 mm, completely enclosed by the involucre, bivalved into the middle of the capsule along suture lines, a single row

* On these characters in N. orbicularis, Howe (1898) discussed as follows; "Capsules that project well beyond the involucre seem invariably to exhibit well defined sutures and to have very thick-walled, usually oblong cells on the surfaces, while those that riped wholly enclosed in the involucre, on the same plant, sometimes, have only rudimentary sutures or none at all and show comparatively thin-walled, often irregularly quadr rate, surface-cells." Regarding the characters of the capsule wall, he recognized two types, but he regarded them within the range of variation of the same species due to the developmental condition. Through examination of ample Japanese material, however, I have come to the following conclusion; in N. orbicularis distinct dehiscence lines on the capsule wall are always present even in an immature capsule completely enclosed in the involucre, while in N. temperata and N. javanica such lines are never present even in a well-developed capsule. Two types of capsules do not seem to be differentiated by the developmental condition.

Through the examination of several specimens of Notothylas orbicularis from North America I have noticed there were certainly two types of capsules mentioned above and this seemed to correlate with other characters (the size of spores and the developmental degree of elaters). Now, it is suspected that in North America there might exist other species than N. orbicularis. I consider that for the more satisfactory elucidation of the mutual relationships among the taxa within the N. orbicularis group including Japanese three species, it is necessary to reexamine North American species including N. valvata and N. melanospora both of which have been considered to be synonymous with N. orbicularis.
(partly two rows) of thick-walled and reddish brown cells present along the valve margins, the exterior cells much elongated, narrowly rectangular, 75–115 × 12.5–17.5 μ, so strongly thick-walled that cell lumens only visible as a narrow line in the centre of the cells, columella very short or absent. Spores pale yellow, 30–32.5 μ in diam., faintly vermiculate, each face of proximal side with a small hollow at their centre, distal face with a large, dome-like projection. Elaters rounded rectangular to quadrate, 50 × 30–35 μ, dull yellow, bands of spiral thickenings poorly developed or indistinct. Androecia not seen.

Holotype: Thailand. PAYAP. Chiangrai; Mt. Doi Thung, north of Chiangrai, ca. 1000 m alt., middle elevation of the mountain, on soil, Sept. 24, 1967, Coll. N. K. No. T-12394, in herb. KYO. (duplicates in NICH, L, G).

Distr.: Endemic.

The present new species is easily distinguished from any other member of this genus except N. dissecta STEPH. by the peculiar type of spores. A little-known South American species N. dissecta seems to be closely related to this new species. They have some characteristic features in common; they include the small spore with a hollow on each face of proximal side and a large projection on the distal one, the strongly elongated and

Fig. 4. Notothylias depressispora J. HASEGAWA. a. Thalli with five sporophytes, ×8. b. A portion of capsule wall showing strongly thickened cell-walls, ×325, c–d. Elaters, ×490. e. Spore (proximal side) showing a hollow at the centre of each face, ×490. f. Spore (distal side) showing a large projection, ×490. h. Capsule separated in two valves, ×32. (drawn from type). Notothylias dissecta STEPH. g. Elater drawn from type, ×490.
considerably thick-walled cells of the capsule epidermis, the deeply furcate and flat thallus with narrow and linear lobes, and the rather deeply plicate involucres. However, through close examination of the type specimen of *N. dissecta* (Guatemala, Bernoulli 433, in G) it was proved to be different from the present new species in the larger capsule (up to 2.5 mm long) with a well developed columella (nearly attaining to the capsule tip), the elaters with distinct bands of spiral thickenings, and the smaller (27.5–30 μ in diam.) and brown-

ish spores, etc. Moreover, these two species are separable in the scanning electron microscopic figure of spore surfaces i.e. in *N. depressispora* the spore has verrucose ornamentations (Fig. 5) while in *N. dissecta* it has tuberculare ones [cf. Fig. 1-1 in HÄssel de Menéndez (1976)].

**Literature Cited**


新種

ツノゴケの

ツノゴケ類は、いくつかの形態的特徴によって、他のコケ類（苔類、苔類）から顕然と区別される。現在では、ツノゴケ類をセンケ類、タイケ類と対等なツノゴケ類として分類するのが、一般に支持されている。ツノゴケ類の生殖器官や胞子体の形態的、器官発生的特徴、あるいは葉緑体の特徴など、古くより系統的見地から注目され、多くの研究がなされてきたが、ツノゴケ類の種レベルでの分類は、センケ類、タイケ類に較べ、かなりちがっている。

Stephani (1917, 1923) は、300数種のツノゴケ類の種を世界から記載したが（その他ほとんどが、Stephani 自身が記載した新種である）、それらの種については、ごく一部をのぞいて、その後ほとんど研究がなされておらず、今なお、それらの種の分類上の位置は不明確なままである。日本産の種についても、近縁種との比較検討が世界的視野に立って、行なわれることの必要性が提かれているが、未だ実現していない。

本報では、ツノゴケモドキ属の邦産種の再検討の結果とタイ国産の標本を調べた結果を報告する。従来、日本には、ただ一種類のツノゴケモドキ属の植物が分布していると考えられてきた。堀川 (1929) は、それを日本固有種ツノゴケモドキ (Notothylas japonica) とし、井上 (1976) は、それをヨーロッパや北米に分布する N. orbicularis と同一種と考えた。著者は、日本各地のこの属の植物を調べた結果、日本には3種類があることを確認した。これら3種類のうち、関東から北東、北海道に分布するものがツノゴケモドキ (N. orbicularis) で、四国の太平洋沿岸、南九州、台湾に分布するものは、ジャワから記載された N. javanica (ジャワツノゴケモドキ) と同一種であることが明らかになった。又日本の中央部に分布するものは、日本固有の新種として、N. temperata (ヤマツツノゴケモドキ) の名称を与え、記載した。これら3種は、胞子表面の模様、葉状体の形などで、おたがいよく似ているが、主に萌 (capsule) の裂開のしかた、胞壁の構造、胞子の発達の程度、胞子の色と大きさなどによって区別出来る。

ツノゴケモドキでは、萌壁に明瞭な裂開線があり、成熟すると二裂開するが、他の2種には、このような裂開線はなく、ヤマツツノゴケモドキでは、萌は一般に縦方向に裂ける傾向があるが、ジャワツノゴケモドキでは、萌はまったく不規則に裂開する。

東南アジア (インドを除く) からは、ツノゴケモドキ属の植物としては、ただ2種がジャワとビルマから知られているだけであるが、京都大学の植物標本館に保存されているタイ国産のコケ類標本の中に数種を確認した。そのうち今回、特徴的な胞子表面の模様を有する顕著な一新種 N. depressispora を記載した。