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THE GEMMAE OF THE MOSSES COLLECTED FROM THE SYOWA STATION AREA, ANTARCTICA*

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Abstract: In three species of mosses collected from the Syowa Station area, Antarctica, three types of gemmae were found. One- to two-celled gemmae were found on protonemata of *Grimmia lawiana*. Filamentous gemmae were found on rhizoids of *Ceratodon purpureus*. The development of gemmae of these two mosses seems to be effected by the infection of algae or lichens. Multicellular, spherical to ellipsoidal gemmae (tubers) were observed on rhizoids of *Bryum* sp. submerged in some ponds.

1. Introduction

In the vicinity of the Syowa Station, Sôya Coast, Continental Antarctica, the following six moss species have been recorded (KANDA, 1981): *Ceratodon purpureus* (HEDW.) BRID., *Pottia heimii* (HEDW.) HAMPE, *P. austro-georgica* CARD., *Bryum argenteum* HEDW., *B. pseudotriquetrum* (HEDW.) GAERTN., MEYER et SCHERB., and *Grimmia lawiana* J. H. WILLIS. In addition to these, a bryaceous moss collected from the bottom of some ponds was reported by NAKANISHI (1977), and it was treated as *Bryum* sp. by OCHI (1979). Sporophytes of these mosses were extremely rare in this area.

HORIKAWA and ANDO (1967) mentioned that some vegetative reproduction from fragments of plants and bulbils, and the development of new plants from secondary protonemata, occurred to compensate for the scarcity of sexual reproduction.

In this study, we describe three types of gemmae in three Antarctic mosses, *G. lawiana*, *C. purpureus* and *Bryum* sp., with illustrations.

2. Materials and Methods

The materials used for this study were collected from the Syowa Station area by Dr. S. NAKANISHI in the 16th Japanese Antarctic Research Expedition (JARE-16, 1975) and one of the authors, KANDA in JARE-24 (1983–84). They were frozen at $-20°C$ and stored at National Institute of Polar Research. All herbarium specimens studied are housed at the Herbarium of National Institute of Polar Research (NIPR).

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3. Results and Discussion

3.1. Grimmia lawiana *J. H. WILLIS*

This species is endemic to Antarctica and relatively rare. No sexual organs and sporophytes have been reported (KANDA, 1982).

Apices of rhizoids were often chlorophyllous, and branched repeatedly, and became protonemata which are sometimes found in the dense turf of this moss. On these protonemata, numerous buds are observed and protonemal gemmae are occasionally found with them. The cells at apical part of protonemata become rounded, forming gemmae. They are produced as a branched chains of cells, and easily broken into fragments of 1–2 cells as gemmae. The cells of the gemmae have almost perpendicular or oblique septa, and are usually 15–40 μm long, 15–25 μm wide (Fig. 1: 1–4). Each cell is filled with chloroplasts, and the cell-wall is slightly thickened and hyaline.

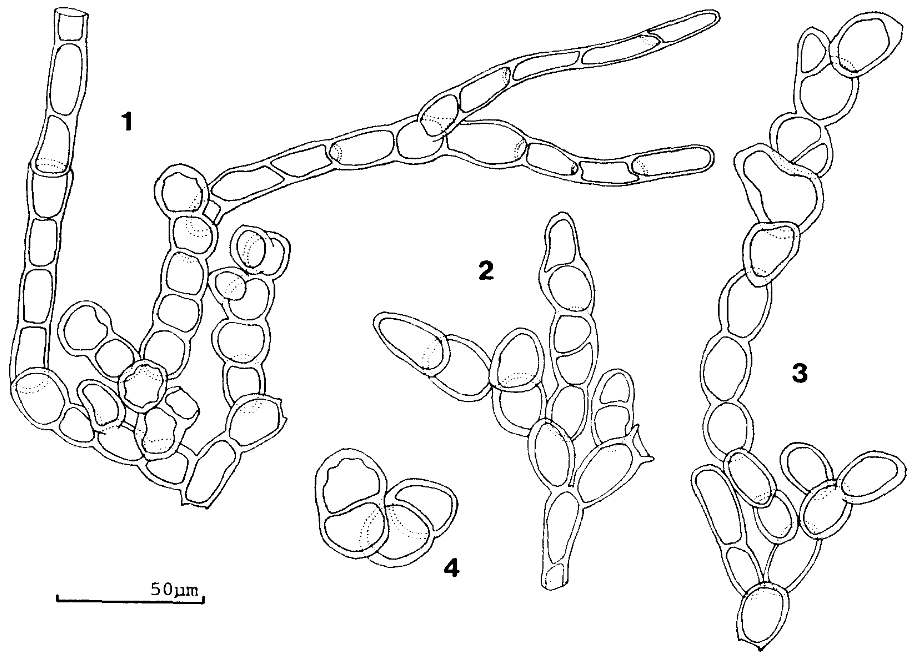

Fig. 1. Grimmia lawiana *J. H. WILLIS. 1: Normal protonemal cells and series of round cells. 2: Two-celled gemmae before detachment. 3: Series of one- to two-celled gemmae before detachment. 4: Detached gemmae. Drawn from KANDA 192 in NIPR.*

WOESLER (1933) has already reported such round cells (protonemal gemmae) in the protonemata of eight species examined in culture. VAN ANDEL (1952), in the experimental study of *Funaria hygrometrica*, suggested that round cells seemed to occur particularly under unfavorable conditions when cultures were strongly infected with moulds, bacteria or algae. Furthermore HANCOCK and BRASSARD (1974) mentioned that the protonemal gemmae found in *Buxbaumia aphylla* also developed in old and dry agar cultures.

The colonies of *G. lawiana* collected from the field are frequently covered with algae or lichens, and gemmae are observed near the surface of such colonies. It may be assumed that the development of gemmae is effected by the presence of algae or lichens covering these moss colonies.

Specimens examined: Langhovde, Lake Yukidori, KANDA 192.

3.2. Ceratodon purpureus (*HEDW.*) *BRID.*

This species is a cosmopolitan and weedy species, with dioicous inflorescenses. HORIKAWA and ANDO (1967) noted that male plants are more common than the female in Antarctica, and no sporophytes have been found in this area.

Many rhizoids are found frequently in axils of leaves. The apices of these rhizoids often become chlorophyllous, and branch repeatedly to make a cluster of gemmae (Fig.

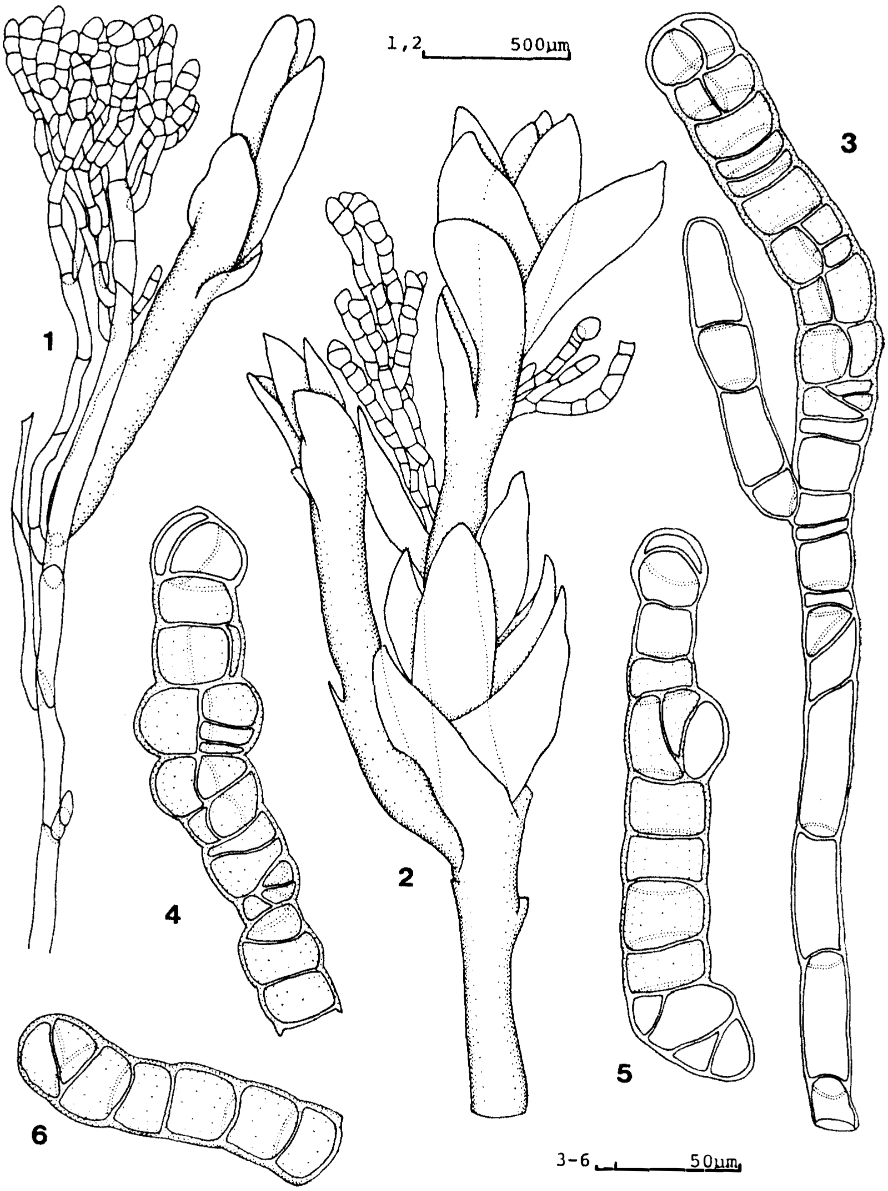

Fig. 2. Ceratodon purpureus (*HEDW.*) *BRID. 1, 2: Cluster of gemmae on rhizoidal filaments. 3: Gemma on rhizoidal filament. 4-6: Detached gemmae. Drawn from KANDA 228-G in NIPR.*

2: 1, 2). The gemmae are filamentous, composed of 1–2 rows of 3–20 cells, 100–200 μm long, 25–40 μm wide (Fig. 2: 3–6). The surface of the gemmae is smooth but sometimes bulging, and cell-walls are slightly thickened and pale brown when mature. The cells are filled with chloroplasts and oil drops. Tmema is not differentiated.

Vegetative diaspores of *C. purpureus* have been recorded outside of Antarctica. LOESKE (1931) and ZANDER and IRELAND (1979) described small clusters of filamentous gemmae borne directly on the stem and just above the leaf axils. The habitat of the gemmiferous plants of this species in North America is mostly river banks or lake shores (ZANDER and IRELAND, 1979). The morphological characters of gemmae described in North America are very similar to those of Antarctic plants.

Specimens examined: East Ongul Island, Naka-no-seto Strait, KANDA 222-A, 225-D, 227-F, 228-G, 229-H.

3.3. Bryum *sp.*

This species was growing submerged in some ponds in the Syowa Station area. Samples collected were sterile and no sporophytes or sexual organs have been observed (OCHI, 1979). The occurrence of spherical gemmae (tubers) on their rhizoids was reported by NAKANISHI (1977).

The tubers occur on short, lateral rhizoidal stalks, or on the tips of rhizoids (Fig. 3: 1, 2). They are spherical to ellipsoidal, composed of 10–15 cells, 150–200 × 125–150 μm, and brown to dark brown when mature (Fig. 3: 2, 3). The surface is smooth and not

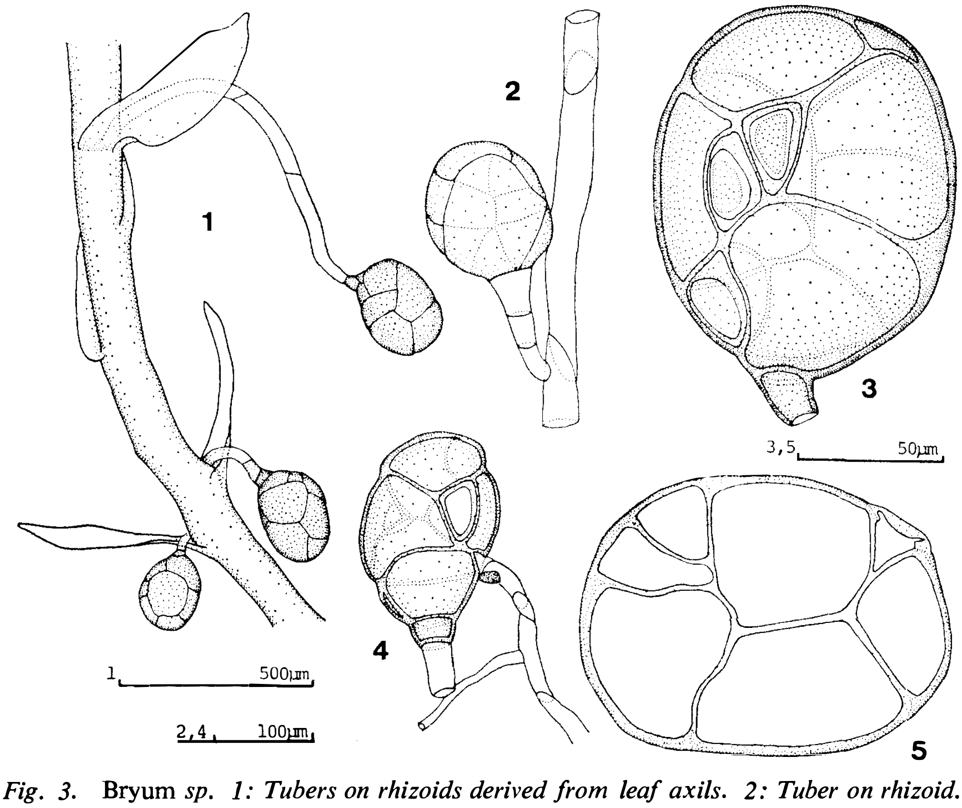

Fig. 3. Bryum *sp. 1: Tubers on rhizoids derived from leaf axils. 2: Tuber on rhizoid. 3: Matured tuber (enlarged). 4: Germinating tuber. 5: Cross-section of tuber. Drawn from NAKANISHI c-87 in NIPR.*

bulging. In cross-section, the cell-wall is slightly thickened (Fig. 3: 5). Each cell of a gemma is filled with yellowish oil drops and has no chloroplasts. No tmema is seen. Germination is observed in some gemmae (Fig. 3: 4). On germinating protonemata no bud is seen, but rarely, secondary tubers are observed.

The taxonomic position of this *Bryum* is not established yet. NAKANISHI (1977) suggested that this moss was externally similar to *Bryum korotkevicziae* SAV. et SMIRN. or its variety *hollerbachii* SAV. et SMIRN. OCHI (1979) treated it merely *Bryum* sp. since the plants were sterile. This moss is also similar to an aquatic form of *B. pseudotriquetrum* growing near the ponds. However, no tubers have been recorded in *B. pseudotriquetrum*, *B. korotkevicziae* and its variety. *B. pseudotriquetrum* has remarkable papillae on its rhizoids, while this *Bryum* sp. has smooth rhizoids. Cultural studies of these bryaceous mosses are necessary to understand their morphological variations in water.

Specimens examined: Skarvsnes, Lake Oyako, NAKANISHI c-7; a lake 1 km west of Mt. Suribati, NAKANISHI c-17, c-87.

4. Conclusion

In Antarctica, the severe environments (low temperature, dryness, shortage of growing period, etc.) result in bryophytes which appear unable to complete the normal alternation of generations and rarely produce sporophytes (STEERE, 1965). Another reason for this scarcity of sporophytes is assumed to be the irregular sex distribution in bryophytic population (LONGTON and GREENE, 1967). Many species of mosses in Continental Antarctica that do not reproduce sexually are thought to reproduce by vegetative means. Thus, vegetative propagation of mosses can be assumed to play an important role in Continental Antarctica (SELKIRK, 1984).

Two ways have been generally known for vegetative reproduction of mosses: one is reproduction from unspecialized organs (*e.g.* fragmentation of plants), and the other is from specialized ones (so called gemmae and propagules). Specialized vegetative diaspores reported from Continental Antarctica are classified as follows:

a) Slender, flagelliform branches (flagella) formed singly in leaf axils: *Schistidium antarctici* (SAVICZ-LYUBITSKAJA and SMIRNOVA, 1965).

b) Small, bulbiferous branches with rudimentary leaves (bulbils) formed in cluster in leaf axils or sometimes on protonemata: *B. argenteum* (SAVICZ-LYUBITSKAJA and SMIRNOVA, 1964; HORIKAWA and ANDO, 1967).

c) Swollen leaf apices, very fragile at the base: *Sarconeurum glaciale* (SAVICZ-LYUBITSKAJA and SMIRNOVA, 1961).

d) Leaf-like structures found among the young sexual organs: *Bryoerythrophyllum recurvirostre* (SAVICZ-LYUBITSKAJA and SMIRNOVA, 1963).

e) One- to two-celled round structures found on protonemata (Protonemal gemmae): *G. lawiana* (IMURA and KANDA, present study).

f) Filamentous, usually uniseriate structures formed on rhizoids: *Ceratodon purpureus* (IMURA and KANDA, present study).

g) Globose, multicellular cell masses with brownish thickened cell-walls, formed on rhizoids (rhizoidal gemmae, tubers): *Bryum* sp. (NAKANISHI, 1977; IMURA and KANDA, present study).

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