Satoshi IMURA* : Protonemal gemmae of *Garovaglia elegans*  
(Pterobryaceae, Musci)**

Garovaglia elegans (Dozy et Molk.) Hampe ex Bosch et Lac. is an epiphytic moss, whose distribution center is in tropical Asia. In Japan, it is found from Ryukyu Archipelago to southern Kyushu. Filamentous gemmae are frequently found in leaf axils of upper portion of shoots. The sexuality of this species is phyllodioicous with the dwarf male plants growing on leaves of the female plants. During (1977) reported the variation of spore-size of Garovaglioideae, and Une (1986) classified the spores of *G. elegans* as anisosporous. Une (1985) stated that large spores are female and small ones are male, and male dwarf-ness is genetically determined in anisosporous species of *Macromitrium* (Orthotrichaceae).

In the course of my study of vegetative reproduction of mosses, I found gemmae on protonemata of this species. In this paper, the development of the protonemal gemmae of *G. elegans* (Dozy et Molk.) Hampe ex Bosch et Lac. is reported, and the relationship between gemma formation and sexual differentiation of this species is discussed.

Materials and methods  The materials used for this study were collected in December 1985 on Iriomote Isl., Ryukyu Archipelago, Japan (coll. R. Suda, 2069, in HIRO), and sown on the medium on 25 April, 1986.

The size of spores were measured for 200 mature spores from a capsule from which the opeculum had just fallen. For each spore, the longest diameter was measured under the light microscope.

Unopened, mature capsules were sterilized for 2.5 minutes in 20 ml of 1% NaClO solution with one drop of the surface active agent and repeatedly washed with autoclaved water. Spores were squeezed out of capsules to a hanging-

---

* Botanical Institute, Faculty of Science, Hiroshima University, Higashi-senda-machi, Hiroshima 730, Japan. 広島大学 理学部植物学教室。
** Contribution from the Phytotaxonomical and Geobotanical Laboratory, Hiroshima University, N. Ser. No. 354.
drop slide containing autoclaved water and were sown in Knop III liquid medium (Nehira 1964), adjusted to pH 6. Forty small and forty large spores from one capsule were cultured separately. The experiment was carried out at a temperature of 20±2°C under a light intensity of 2000-2500 lux obtained from white fluorescent tubes with 12 hours diurnal light-dark cycle.

Observations
1) Spore-size. The spore-size varies from 18 to 48 μm in diameter. The differentiation of size of spores shows bimodal distribution curve (Fig. 1). Under the light microscope, the small spores (18-34 μm in diameter) are pale-green, while the large spores (36-48 μm in diameter) are fresh-green.

2) Culture of spores. Small spores (Figs. 2 & 3) germinated within 5 days after sowing on the medium (Fig. 4). After about 100 days, buds were formed on the protonemata (Fig. 5). After about 140 days, these buds produced 4-6 antheridia, and they had only 7-3 leaves (Figs. 6 & 17). These dwarf male plants were 300-500 μm long, and they did not continue growing.

Large spores (Figs. 7 & 8) also germinated within 5 days after sowing on the medium (Fig. 9). After about 80 days, buds were formed on the protonemata (Fig. 10). During the cultures (200 days), they grew continuously, but sexual organs were not found (Fig. 11). After about 90 days, unusual lateral branches were found on the protonemata from large spores. Clusters of filamentous gemmae were formed on these branches of protonemata.

The protonemal gemmae (Figs. 12, 15 & 16) are filamentous, composed of 2-20 cylindrical, uniseriate cells, 60-600 μm long, 12-25 μm wide. The transverse walls are perpendicular. The surface of the gemmae is smooth, and cell-walls are thin and hyaline. Each cell contains few chloroplasts. An abscission-cell (tmema of Correns 1899) is differentiated (Fig. 12: T). The gemma-stalk divided repeatedly to form clusters of gemmae. When gemmae are detached,

![](image.png)

Fig. 1. Variation of spore-size in *Garovaglia elegans*. 

-17-
any cell can germinate to form new protonemata (Fig. 18).

**Discussion** There are a large number of reports concerning the production of brood bodies on protonemata of mosses in cultural conditions. Among them, two types of brood bodies are recognized. The first is the fragmentation of protonemal filaments, reported by Woesler (1933), Andel (1952) and Hancock & Brassard (1974). It seems to occur particularly under unfavorable conditions, such as old and dry agar cultures, or those infected with molds, bacteria or algae. The second is the production of the so called protonemal gemma, similar to the gemmae on gametophores (Andrews & Redfearn 1965, Nishida & Iwatsuki 1982, et al.). According to Whitehouse (1980), mosses that produce gemmae on rhizoids, stems or leaves usually also produce gemmae on the protonema, at least in agar culture.

In the field, *G. elegans* bears clusters of gemmae on short gemma-stalks in leaf axils (Figs. 13 & 14). These gametophytic gemmae are filamentous, composed of 10-20 cylindrical, uniseriate cells, 300-600 µm long, 20-35 µm wide. The cell-walls are thick and hyaline. An abscission-cell is differentiated. They are somewhat larger in size and thicker in cell-walls, but quite similar to the protonemal gemmae. In this study, gametophores from large spores (female plants) did not produce axillary gemmae during the culture (200 days).

Noguchi & Muraoka (1959) observed clusters of unbranched worm-like branches containing numerous chloroplasts on regenerating protonemata from detached leaves of *G. elegans* (as *Endotrichella fauriei*). They thought of the structure as an assimilatory organ (chloronemal branch) furnishing nutrients or some other substances. The characters of these chloronemal branches are almost identical with the protonemal gemmae of this study. I think of these chloronemal branches as gemmae, on the basis of following two points: 1) they have a tmema (abscession-cell, Fig. 12-T) and germinate to form new protonema (Fig. 18); 2) they are quite similar to the gemmae on gametophore.

The differentiation of size of spores shows a obvious bimodal distribution curve (Fig. 1), and the spore type of *G. elegans* is classified as anisosporous in the sense of Vitt (1968). From cultural studies, it is inferred that small spores are male and large ones are female. The protonemal gemmae of *G. elegans* are found only on protonemata from large (female) spores and never found on those from small (male) spores. As stated by During (1977), gemmae on gametophores of this species were found only on female plants. Imura & Une
(1986) also reported gametophytic gemmae only on female plants of *Macro-mitrium gymnostomum* (Orthotrichaceae).

In *G. elegans*, female plants are large and bear vegetative diaspores on both protonemal filaments and gametophores. In contrast, male plants are small (dwarf males) and have no vegetative reproductive organs. During (1977) suggested that the gametophytic gemmae may serve to build up and maintain a population of female plants, until such time as male spores alight on them and produce dwarf males. The protonemal gemmae of *G. elegans* may play the same role in the reproduction of this species.

I wish to express my deep gratitude to Prof. Z. Iwatsuki of Hiroshima University for comments on the manuscript, and Dr. K. Une of Hiroshima University for giving me valuable suggestions. I am also grateful to Prof. A. J. Sharp of University of Tennessee, for suggestions concerning the English text.

**Literature cited**

の二型がほぼ同数ずつある。この二型の胞子を分離して培養すると、小形の胞子からできた原核体上には雌雄が形成された。大型の胞子からの原核体上の植物体は雌よりずっと大形で、これまでのところ生殖器官は形成されていないが、おそらく雌株であると想像される。無性芽は大形の胞子からの原核体上のみ形成された。以上のように、本種では胞子、植物体共に雌が雌より大きく、さらに雌株のみが植物体にも原核体上にも無性芽を持つことがわかった。

〇マンリョウ、カラタチバナおよびモクタチバナの果実色変り品種の学名（大橋広好）Hiroyoshi OASHI: New names for several forms of Japanese species of Ardisia (Myrsinaceae)

カラタチバナは花壇で錦抄巻(1965)，大和本草綱目(1708)，マンリョウはキンキンジュウの名で増補錦抄(1710)に既に庭木として栽培されていることが記述されている。

橘品(1797)，橘品類考(1797)，素封論(1797)にはカラタチナポの園芸品種が多数図説されている。植物学的には中井(1943)：大日本植物誌カラタチバナ科で初めてこれらの園芸品種の一部，マンリョウの35品種とカラタチバナの64品種，に対して学名が与えられている。しかし，原(1948)：日本種子植物集覧では僅かにマンリョウについてはシミノマンリョウとキミノマンリョウ，カラタチバナについてはキミノカラタチバナが認められているに過ぎない。その他に，カラタチバナには白実の野生品シミタチバナがある。また，モクタチバナにも赤果品アカノモクタチバナと黒果品クロミノモクタチバナが知られている。これらの色変りは，シミノマンリョウを除くといずれもArdisiaのシノニムであるBladhiaのもとで学名が作られている。杉本(1961)：新日本樹木総検索誌ではマンリョウとカラタチバナの前述の品種に対してArdisiaののもとで中井の品種名が使われているが，正式に発表されたものではない。したがって，マンリョウ，カラタチバナおよびモクタチバナの果実の色変り品種の学名は次のようにになる。


2) Ardisia crenata Sims f. xanthocarpa (Nakai) Ohashi, comb. nov. キミノマンリョウ.


Bladhia lentiginosa (Ker) Nakai f. xanthocarpa Nakai, l.c. 109 (1943).