

Taxonomy on the Elachistaceae (Chordariales, Phaeophyta) with Special Reference to Korean Plants

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Generic circumscription of the Elachistaceae is investigated with the plants from Korean coast. *Elachista*, *Halothrix* and *Leptonematella* are delineated by medullary construction, presence or absence of paraphyses, and the mode of plurilocular sporangial formation. *Portphillipia* is appraised for a distinct genus of the Elachistaceae in having a medulla composed of fine and linear filaments without agglutination as the medulla of *Elachista nipponica*. Interspecific relation among the members of *Elachista* is discussed on the basis of medullary construction.

Key Words: Taxonomy, Elachistaceae, *Elachista*, *Halothrix*, *Leptonematella*, *Portphillipia*

INTRODUCTION

Nine genera were referred in the Elachistaceae; *Elachista* Duby (1830), *Halothrix* Reinke (1888), *Leptonema* Reinke (1888), *Symphoricoccus* Reinke (1888), *Myriactis* Kuetzing (1843), *Philippia* Kuetzing (1843), *Areschougia* Meneghini (1844), *Giraudia* Derbes et Solier (1851), and *Philippia* Kuckuck (1929). The name *Leptonema* was changed to *Leptonematella* by Silva (1959) since *Leptonema* Jussieu was already used in the Euphorbiaceae, Spermatophyta. *Myriactis* was renamed to *Myriactula* by Kuntze (1898) and *Gonodia* by Nieuwland (1917), since the name *Myriactis* Lessing was previously accepted in the Compositae, Spermatophyta. Thus, *Gonodia* is superfluous in the Elachistaceae because it was predated by *Myriactula*. However, *Myriactula* has been embraced in the Corynophlaeaceae by several phycologists (e.g., Fletcher 1987, Womersley 1987). The name *Philippia* was also changed to

Portphillipia by Silva (1970). Silva (1959) previously suggested a name *Philippiella* against *Philippia* since *Philippia* Klotzsch was accepted in the Ericaceae, Spermatophyta. Later, Silva (1970) proposed a new generic name *Portphillipia* instead of *Philippia* since *Philippiella* Silva was predated by *Philippiella* Spegazzini of the Caryophyllaceae, Spermatophyta. The rest genera, *Symphoricoccus*, *Phycophila*, and *Areschougia*, has been known to be synonymous with *Elachista* because their type species were referred in *Elachista* (Table 1).

In Korea seven species of *Elachista*, one of *Halothrix* and one of *Leptonematella* are examined. The interrelationship between the species of three genera, *Elachista*, *Halothrix*, and *Leptonematella*, are to be discussed on the basis of medullary construction and reproductive structures with special reference to Korean plants. *Portphillipia* is also to be discussed adequately for a distinct genus of the Elachistaceae.

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Table 1. The genera related to the Elachistaceae

Genus	Type species	Notes
<i>Elachista</i>	<i>E. scutulata</i> (Smith) Duby 1830	basionym: <i>Conferva scutulata</i> Smith
<i>Halothrix</i>	<i>H. lumbricalis</i> (Kuetzing) Reinke 1888	basionym: <i>Ectocarpus lumbricalis</i> Kuetzing
<i>Leptonema</i>	<i>L. fasciculatum</i> Reinke 1888	non <i>Leptonema</i> Jussieu. renamed to <i>Leptonematella</i> Silva
<i>Symphoricoccus</i>	<i>S. radians</i> Reinke 1888	= <i>S. stellaris</i> (Aresch.) Kuckuck bas.: <i>Elachista stellaris</i> Areschoug
<i>Areschougia</i>	<i>A. stellaris</i> (Areschoug) Meneghini 1844	non <i>Areschougia</i> Harvey bas.: <i>Elachista stellaris</i> Areschoug
<i>Phycophila</i>	<i>P. fucorum</i> (Roth) Kuetzing 1843	bas.: <i>Conferva fucorum</i> Roth = <i>Elachista fucicola</i> (Velley) Areschoug (cf. Fletcher 1987)
<i>Myriactis</i>	<i>M. pulvinata</i> Kuetzing 1843	non <i>Myriactis</i> Lessing renamed to <i>Myriactula</i> Kuntze 1898 and <i>Gonodia</i> Nieuwland 1917
<i>Philippia</i>	<i>P. australis</i> (J. Agardh) Kuckuck 1929	non <i>Philippia</i> Klotzsch bas.: <i>Elachista australis</i> J. Ag. renamed to <i>Philippiella</i> Silva 1959 non <i>Philippiella</i> Spegazzini. renamed to <i>Portphillipia</i> Silva 1970
<i>Giraudia</i>	<i>G. sphacelariodes</i> Derbes et Solier 1851	Giraudiaceae

VEGETATIVE FEATURES

Plants of the Elachistaceae are generally epiphytic on other plants. The vegetative structure of the plants is rather primitive without true parenchymatous constructions. The plants of *Elachista* have a more elaborate structure than those of *Halothrix* and *Leptonematella*, which are composed of simple, free, long filaments (assimilatory filaments), a cortex made of short, free filaments and reproductive structures, and a medulla made of hyaline, branched filaments with or without lateral agglutination. The plants of *Halothrix* and *Leptonematella* are composed of only free and long filaments that are usually simple or with lateral branches at base.

The plurilocular sporangia of the two genera, *Halothrix* and *Leptonematella*, are formed on the upper part of assimilatory filaments. The plurilocular sporangia of *Leptonematella* are formed by the transformation of vegetative cells through several times of cell division. *Halothrix*

is distinguished by the respect that short spine-like plurilocular sporangial filaments are densely born as girdle-like sori around the assimilatory filaments.

Basal systems: The basal system of the Elachistaceae contributes for plants to fix themselves to host surface and are filamentous either prostrate in various directions forming a monostromatic plate or tufted with rhizodal filaments. Occasionally, the cells of the prostrate filaments issue spine-like projections below, which insert to host surface. Taylor (1957) considered that the basal system morphology was a very important character for species circumscription.

Medullae: The term "medulla" designates the colorless tissue occupying the part between basal system and cortical free filamentous zone. The medullary construction occurs in the plants of *Elachista*, while those of *Halothrix* and *Lep-*

tonematella have no or poor medullary tissue near base. There are two types of the medullary structure; filamentous and pseudoparenchymatous. The filamentous medulla is composed of slender and linear filaments which is branching dichotomously or subdichotomously without lateral agglutination. The pseudoparenchymatous medulla is built up of globose to longish clavate cells which are rather inflated and laterally agglutinated.

Assimilatory filaments: The assimilatory filaments are arising on the pseudoparenchymatous medullary filaments or directly on the prostrate filaments. In the latter case, the lower portion of the assimilatory filaments immersed in the medullary layer is colorless without chloroplasts but distinctive from the medullary filaments. The assimilatory filaments grow up indefinitely with intercalary meristem below. However, those of *Leptonematella* have no distinct meristematic zone. Occasionally, short laterals are issued at the hypomeristematic portion of assimilatory filaments. The morphology of assimilatory filaments has been regarded as one of main characters for specific classification. Assimilatory filaments was called as assimilatory hairs by certain phycologists because they showed phaeophycean hair-like appearance except including chloroplasts (Fritsch 1945). This means that the assimilatory filaments of *Elachista* may be homologous with the phaeophycean hairs of *Myriactula* and *Leathesia*.

Paraphyses: Fritsch (1945) called the paraphysis as assimilator. It seems to suggest that the paraphysis of *Elachista* may be homologous with the cortical assimilatory filaments of *Myriactula* and *Leathesia*. Paraphyses are free, simple, filamentous, and consisting of several cells. They grow definitely without meristem on the upper cells of medullary filaments. Occasionally, they seem to grow up with meristem.

Hairs: The phaeophycean hairs develop

solitarily on the superficial cells of medulla as do paraphyses. Pedersen (1979) and Skinner (1985) thought the Elachistaceae as a taxon of wanting in phaeophycean hairs. However, phaeophycean hairs are observed on the plants of *Elachista scutulata* (Smith) Duby and *Elachista flaccida* (Dillwyn) Areschoug among the collections from Korea (also cf. Kuckuck 1929).

Reproductive structures: Two kinds of reproductive structures have been known in the Elachistaceae; unilocular and plurilocular sporangia. The reproductive structures are generally homothallic or occasionally heterothallic in *Elachista nipponica* Umezaki. Generally, reproductive structures are born on the terminal cells of medullary filaments or on the hypomeristematic portion of assimilatory filaments as laterals, or occasionally on the upper portion of assimilatory filaments intercalarily or superficially. Plurilocular sporangia are filamentous including many loculi in single row or partially two rows.

Life histories: There are several attempts to investigate life histories of the Elachistaceae (Kylin, 1934, 1937; Kornmann, 1962; Blacker and Katpitia, 1963; Wanders *et al.*, 1972; van den Hoek, *et al.*, 1972; Koeman and Cortel-Breeman, 1976; Pedersen, 1978, 1979). The life histories of *Elachista fucicola* (Velley) Areschoug and *Elachista stellaris* Areschoug are made up of diploid macrothallus phase and haploid microthallus phase. The zoospores from plurilocular sporangia of a macrothallus develop into macrothalli while those from unilocular sporangia of a macrothallus develop into macrothalli. The zoospores from plurilocular sporangia of a microthallus develop into microthalli. No gametic fusion was observed. Thus, *E. fucicola* and *E. stellaris* have a heteromorphic developmental cycle without the intervention of sexuality (cf. van den Hoek *et al.*, 1972; Wanders *et al.*, 1972; Koeman and Cortel-Breeman, 1976; Wynne and Loiseaux, 1976;

Pedersen, 1978).

INTERRELATIONSHIP OF THE TAXA

Elachista is characterized by the presence of paraphyses and medullary structures. *Halothrix* is characteristic in the formation of girdles of plurilocular sporangial sori on the surface of the upper portion of assimilatory filaments. *Leptonematella* is distinct from *Halothrix* in the mode of plurilocular sporangial formation, the cells of assimilatory filaments of which develop into plurilocular sporangia. The criteria to distinguish species of *Elachista* from Korea are the thickness and development of assimilatory filaments, the morphology of medullary filaments, the shape and development of paraphyses, and the morphology of unilocular and plurilocular sporangia.

The basal system of *E. flaccida*, *E. fucicola*, and *E. stellaris* are composed of a tuft of rhizoidal filaments. The prostrate filaments of *E. nipponica* and *Elachista vellosa* Takamatsu form a monostromatic basal plate, cells of which issue spine-like projections below. Although the prostrate filaments of *E. scutulata* and *Elachista tenuis* Yamada form a monostromatic base, no spine-like projections from the cells are observed. The medullae of *E. flaccida*, *E. fucicola*, *E. stellaris*, and *E. tenuis* are composed of laterally agglutinated filaments with inflated cells. *E. vellosa* has medullary filaments with inflated cells which are less agglutinated (Fig. 5). The medulla of *E. nipponica* is of linear and dichotomously branching filaments without lateral agglutination (Figs. 2, 4).

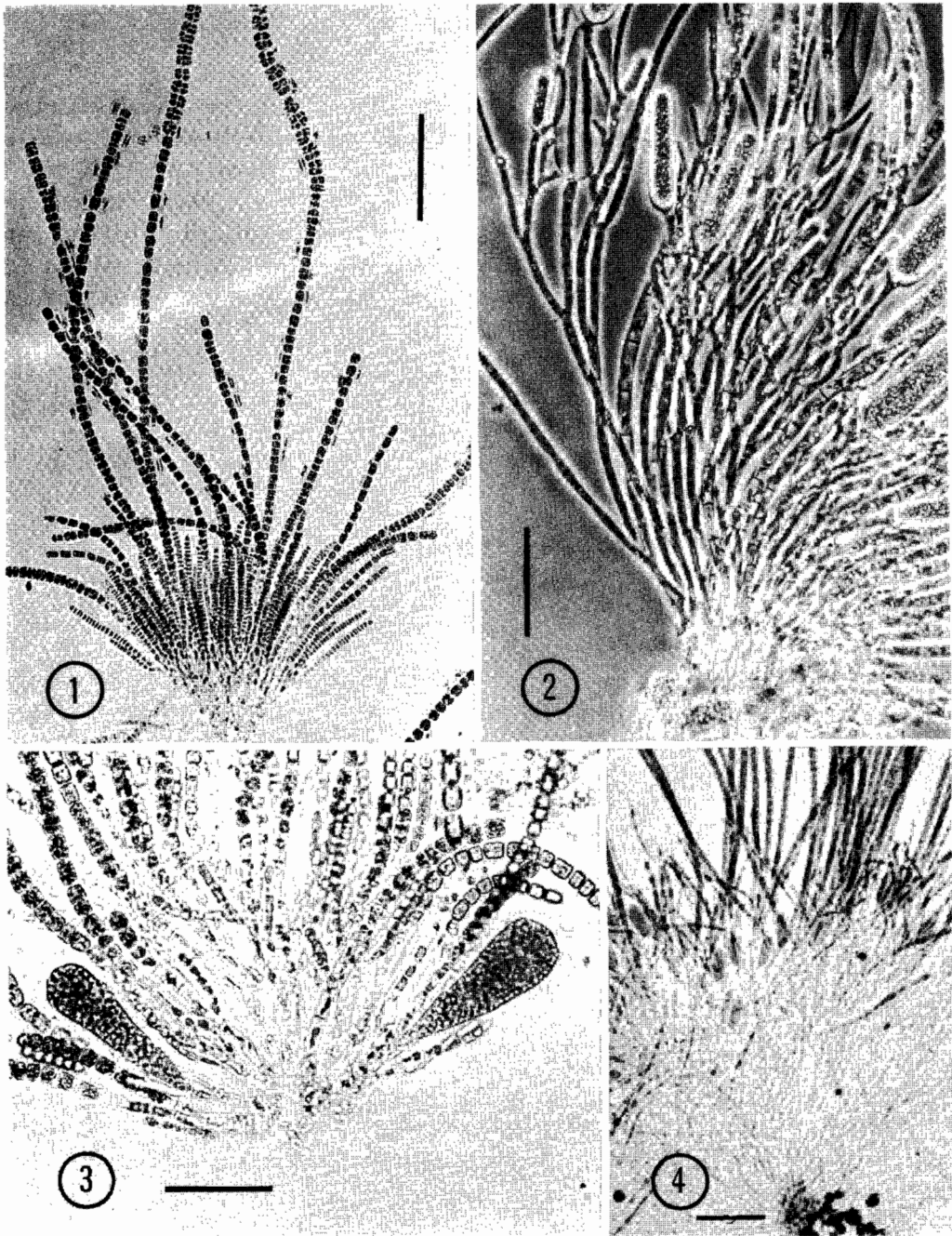
The assimilatory filaments of *E. nipponica* and *E. vellosa* arise from the cells of prostrate filaments directly (Figs. 2, 5). The assimilatory filaments of *E. flaccida*, *E. tenuis*, and *E. stellaris* are distinctive to the middle portion of medullary tissue, and occasionally give rise to many short laterals at the hypomeristematic portion (Fig. 6). The assimilatory filaments of *E.*

flaccida shows the polysiphonal construction at the hypomeristematic portion (Fig. 9). *E. fucicola* and *E. scutulata* have a medulla with homogeneously pseudoparenchymatous structure. Thus, the assimilatory filaments of *E. fucicola* and *E. scutulata* seem to arise on the outermost cells of medulla (Figs. 7, 8).

Umezaki (1965) and Lee (1974) observed the plurilocular sporangia of *E. nipponica*, which were formed by transformation of the cells of assimilatory filaments as those of *Leptonematella*. In Korea plurilocular sporangia of *E. flaccida* were born plentifully in early spring, while unilocular sporangia in late spring and early summer.

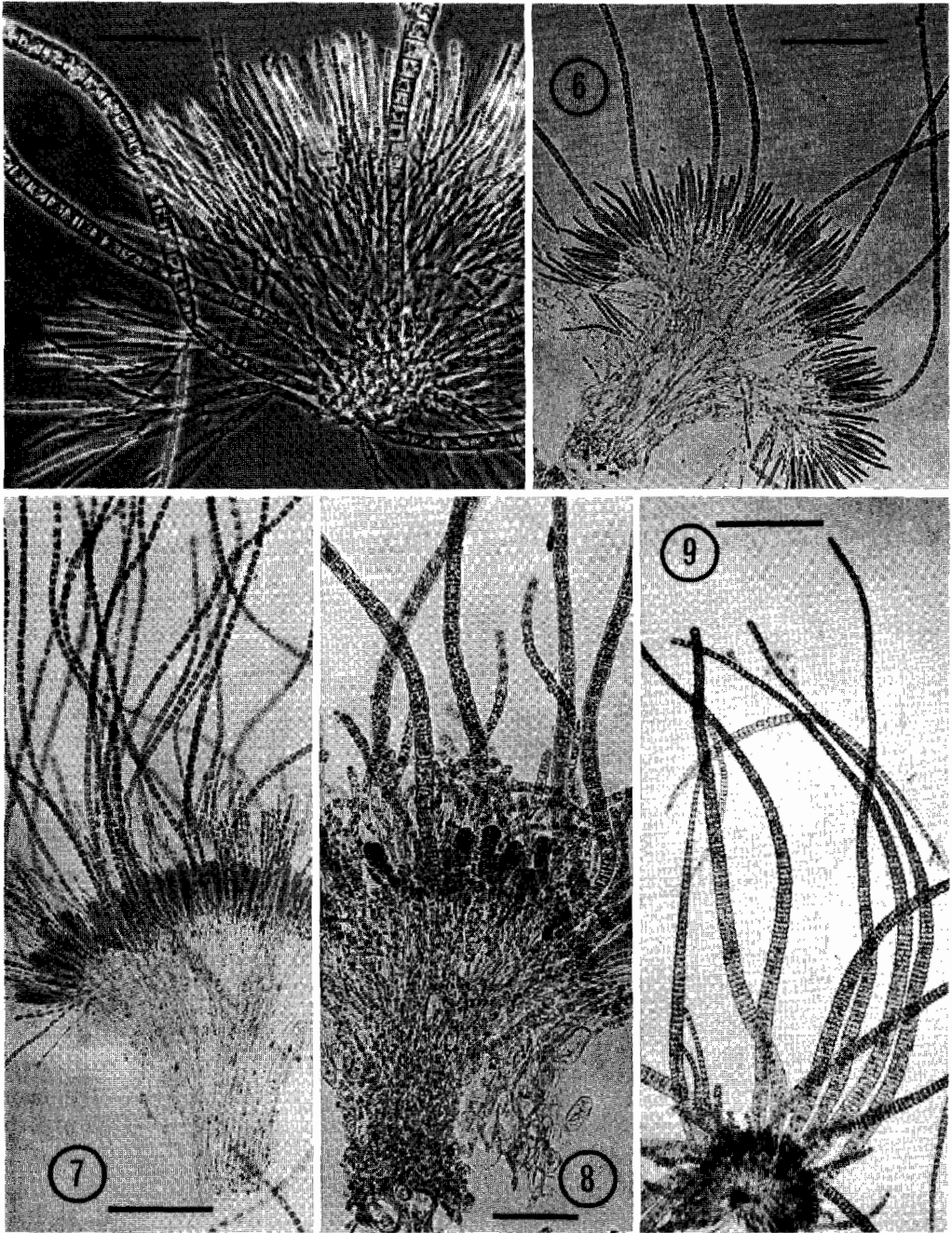
In *Leptonematella* the cells of the upper portion of assimilatory filaments divided in various directions, all daughter cells of which become plurilocular sporangia. The part of the sporangia formed leave only empty wall after spores being shed. The plants of *Leptonematella* sp. collected in Sinsan, Cheju (specimen no. LYP-333), have some interesting characters; 1) plurilocular sporangia formed by transformation of the cells of the upper portion of assimilatory filaments as those of *E. nipponica* and *Leptonematella fasciculata* (Reinke) Silva (cf. Umezaki, 1965; Reinke, 1889), 2) plurilocular sporangial filaments also formed on the outermost cells of medulla as those of *Elachista* species, 3) distinct meristematic zone on assimilatory filaments absent, 4) medulla poor in development, and 5) paraphysis-like short filaments present (Figs. 1, 3). Thus, the plants show an intermediate in the view point of having both kind of plurilocular sporangia.

Some cells of assimilatory filaments of *Halothrix lumbricalis* (Kuetzing) Reinke divide several times in various directions. Then, the assimilatory filaments appear in partially polysiphonal structure. The surface cells of the polysiphonal portion are getting small in size by repeated division. As a result, the outermost cells develop into short spine-like projections including two to four loculi. The short spine-like



Figs. 1-4.

Fig. 1. The thallus of *Leptonematella* sp., note the both type of plurilocular sporangia. scale bar: 500 μ m. Fig. 2. The medullary filaments of *Elachista nipponica*. scale bar: 100 μ m. Fig. 3. The unilocular sporangia of *Leptonematella* sp. scale bar: 50 μ m. Fig. 4. The medulla of *Elachista nipponica*. scale bar: 200 μ m.



Figs. 5-9.

Fig. 5. The medulla of *Elachista vellosa*. scale bar: $100\ \mu\text{m}$. Fig. 6. The medulla of *Elachista vellosa*. scale bar: $200\ \mu\text{m}$. Fig. 7. The medulla of *Elachista vellosa*. scale bar: $200\ \mu\text{m}$. Fig. 8. The medulla of *Elachista vellosa*. scale bar: $100\ \mu\text{m}$. Fig. 9. The medulla of *Elachista vellosa*. scale bar: $500\ \mu\text{m}$.



Fig. 10. The thallus of *Halothrix lumbricalis*. scale bar: 500 μ m.

sporangial filaments are born densely and forming a girdle around the polysiphonal portion. The internal cells with girdles of assimilatory filaments persist after spores being shed. The cells of basal portion of assimilatory filaments are hyaline and inflated such as a medullary tissue. Many laterals appear on the hypomeristematic portion of assimilatory filaments (Fig. 10).

Fritsch (1945) thought that three taxa, Myrionemataceae, Elachistaceae and Leathesiaceae, sharing a common character that numerous upgrowing filaments emerge from the basal system, constitute a progressive series on

the basis of medullary construction; i.e., the Myrionemataceae has no medullary tissue, the Elachistaceae shows the commencement and the Leathesiaceae the further elaboration of a proximal medulla. The medullary construction is also regarded as one of valuable characters for generic circumscription in the Elachistaceae.

I postulate affinities among the members of the Elachistaceae in Korea from the view point of medullary construction and development of assimilatory filaments. In *E. scutulata*, *E. tenuis*, *E. fucicola*, *E. flaccida*, and *E. stellaris* the cells of medullary filaments are inflated in globose to subglobose shape with agglutination. However,

the assimilatory filaments of *E. stellaris*, *E. tenuis*, and *E. flaccida* are distinctive to the fairly inner part of medullary layers. Thus, the medulla of these species shows a less homogeneous construction than those of *E. scutulata* and *E. fucicola*. The polysiphonal structure at the hypomeristematic portion of assimilatory filaments suggests that *E. flaccida* may evolve from *E. stellaris* on other line with *E. scutulata* and *E. fucicola* (Fig. 11). *Estellaris* seems to be related to *Gononema ramosum* (Skottsberg) Kuckuck *et* Skottsberg in the formation of plurilocular sporangial laterals on assimilatory filaments and the potentials of assimilatory filaments having a capacity as stolone (cf. Reinke, 1889; Wanders *et al.*, 1972; Skottsberg, 1921).

Pedersen (1978) elucidated the close relation of *L. fasciculata* with *Pogotrichum filiforme* Reinke in viewpoint of plurilocular sporangial formation, growth lacking of specialized structure and life history. *E. nipponica* seems to be closely related with *L. fasciculata* in respect of the mode of plurilocular sporangial formation on assimilatory filaments (cf. Newton 1931; Umezaki, 1965; Lee, 1974). *E. nipponica* also has a rather elaborate construction of medulla which is composed of linear and branching filaments without agglutination.

As a result, the members of *Elachista* are grouped into four types in viewpoint of medullary construction; 1) *Elachista scutulata* type ... medulla with homogeneous pseudoparenchymatous structure, e.g., *E. scutulata* and *E. fucicola*, 2) *Elachista stellaris* type ... assimilatory filaments distinctive in the middle part of medulla, e.g., *E. stellaris*, *E. tenuis* and *E. flaccida*, 3) *Elachista vellosa* type ... medullary filaments with less agglutination and assimilatory filaments distinctive in the whole medullary layer, e.g., *E. vellosa*, 4) *Elachista nipponica* type ... medulla consisting of fine and linear filaments without agglutination, e.g., *E. nipponica*. The medullary structure of the last type is quite different from those of other types. Therefore, it

may be proper to be considered *E. nipponica* as well as *Elachista australis* J. Agardh and *Elachista lindaueri* Chapman in a separate genus *Portphillipia*.

PANEL DISCUSSION

T. Yoshida: Dr. Lee made good observations and presentation of Korean species of the Elachistaceae. There are certain degree of host specificity in the species concerned. Interspecific and intergeneric relation will be investigated using culture technique as a next step. Through this type of study, generic status of *Leptonematella* will be made clear. This genus was also recently reported from Japan coast.

Lee: Thank you very much for valuable comments. I didn't get any result on the degree of host specificity in the species examined. But, *Elachista flaccida* occurs mainly on the blades of *Sargassum horneri* and seldom on those of *Sargassum fulvellum*. *Elachista nipponica* occurs on the blades of *Sargassum ringgoldianum* and *Ecklonia cava*. At first, I did do morphotaxonomic studies of the Elachistaceae. I do investigate the interspecific and intergeneric relation as well as life histories of the taxon with culture work as a next step.

N. Saga: Have you ever investigated the relationship between the formation of plurilocular sporangia of *Halothrix lumbricalis* and its host plant?

Lee: I didn't investigate it. But, I thought it very interesting that the plants of *Halothrix lumbricalis* grow only on the plants of *Zostera* or *Phyllospadix*. May I ask a question? Did you get any result on the relation between *Halothrix* and its host?

N. Saga: Yes, the plants of *Halothrix ambigua* produced plurilocular sporangia when they were cultured with a part of host plants.

REFERENCES

Blackler, H. and A. Katpitia. 1963. Observations on the life

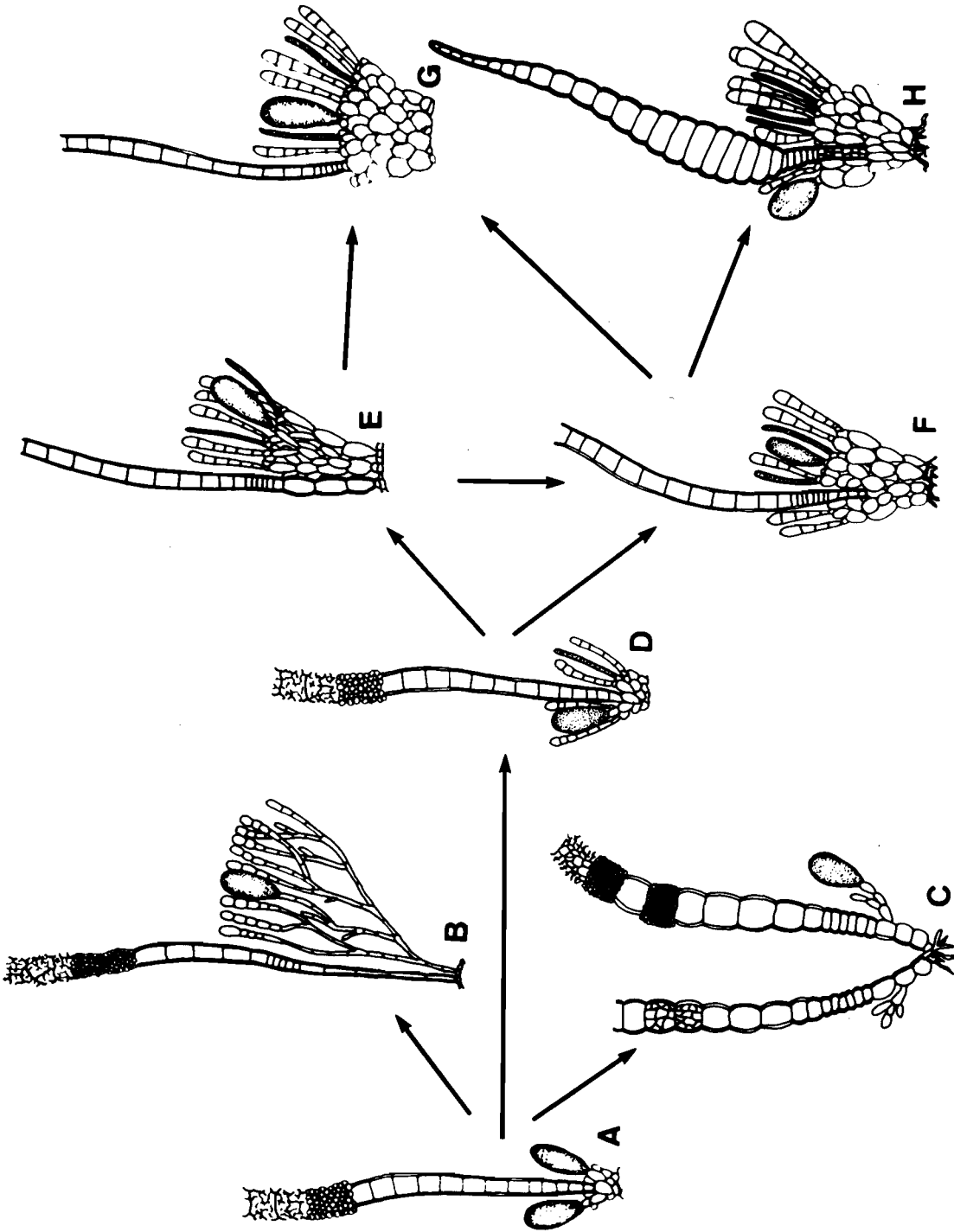


Fig. 11. A schematic representation of interspecific relationship of the Elachistaceae.
 A: *Leptonematella fasciculata* type. B: *Elachista nipponica* type. C: *Halothrix lumbricalis* type. D: *Leptonematella* sp. E: *Elachista vellosa* type. F: *Elachista stellaris* type. G: *Elachista scutulata* type. H: *Elachista flaccida*.

- history and cytology of *Elachista fucicola*. *Trans. Proc. Bot. Soc. Edin.* **39**: 392-395.
- Derbes, A. and A.J.J. Solier. "1851. Algues, In, Castagne, J.L.M., Supplement au Catalogue des plantes qui croissent naturellement aux environs de Marseille. pp. 93-121. Nicot & Pardigon."
- Duby, J.E. 1830. *Botanicon Galicum seu Synopsis Plantarum in Flora Galica Descriptarum. Part 2, Plantas Cellulares continens. Edn 2. Paris.*
- Fletcher, R.L. 1987. *Seaweeds of the British Isles. Vol. 3. Fucophyceae (Phaeophyceae) Part 1. pp. 1-359. British Museum (Natural History).*
- Fritsch, F.E. 1945. *The structure and reproduction of the algae. Vol. II. Cambridge University Press.*
- Hoek, C. van den, A.M. Cortel-Breeman, H. Rietema and J.B.W. Wanders. 1972. L'interpretation des donees obtenues, par des cultures unialgales, sur les cycles evolutifs des algues. Quelques exemples tires des recherches conduites au laboratoire de Gronique. *Soc. Bot. Fr.* **1972**: 45-65.
- Koeman, R.P.T. and A.M. Cortel-Breeman. 1976. Observations on the life history of *Elachista fucicola* (Vell.) Aresch. (Phaeophyceae) in culture. *Phycologia* **15**: 107-117.
- Kornmann, P. 1962. Pluriloculare Sporangien bei *Elachista fucicola*. *Helgol. Wiss. Meeresunters.* **8**: 293-297.
- Kuckuck, P. 1929. Fragmente einer Monographie der Phaeosporeen. *Wiss. Meeresunters. (Helgol.) N.F.* **17**: 1-93.
- Kuntze, O. 1891-1898. *Revisio generum plantarum. Parts I-III. Leipzig.*
- Kylin, H. 1934. Zur kenntnis der Entwicklungsgeschichte einiger Phaeophyceen. *Acta Univ. Lund.* **30**: 1-18.
- Kylin, H. 1937. Bemerkungen über die Entwicklungsgeschichte einiger Phaeophyceen. *Acta Univ. Lund.* **33**: 1-34.
- Lee, Y.P. 1974. *Studies on some members of Elachista in Korea. Thesis of M. Sci., Seoul National University.*
- Meneghini, G. "1844. Osservazioni su alcuni generi della famiglia delle Cordariee. *G. Bot. Ital.* **1**: 291-295."
- Newton, L. 1931. *A handbook of the British seaweeds. British Museum (Natural History). 478pp. London.*
- Nieuwland, J.A. "1917. Critical notes on new and old genera of plants-X. *Am. Midl. Nat.* **5**: 30"
- Pedersen, P.M. 1978. Culture studies on marine algae from West Greenland III. The life histories and systematic positions of *Pogotrichum filiforma* and *Leptonematella fasciculata* (Phaeophyceae). *Phycologia* **17**: 61-68.
- Pedersen, P.M. 1979. Culture studies on the brown algae *Halothrix lumbricalis* and *Elachista fucicola* (Elachistaceae). *Bot. Notiser.* **132**: 151-159.
- Pedersen, P.M. 1984. Studies on primitive brown algae (Fucophyceae). *Opera Bot.* **74**: 1-76.
- Reinke, J. 1888. Die braunen Algen (Fucaceen und Phaeosporeen) der Kieler Bucht. *Ber. Dt. Bot. Ges.* **6**: 14-20.
- Reinke, J. "1889. Algenflora der westlichen Oestsee, Deutschen Antheilis. *Ber. comm. Wiss. Untersuch. Dt Meere.* **6**: 1-101."
- Silva, P.C. 1959. Remarks on algal nomenclature. II. *Taxon* **8**: 60-64.
- Silva, P.C. 1970. Remarks on algal nomenclature. IV. *Taxon* **19**: 941-945.
- Skinner, S. 1985. Australian and New Zealand species of *Elachista* and *Halothrix* (Elachistaceae, Phaeophyta). *Trans. R. Soc. S. Aust.* **109**: 151-160.
- Skottsberg, C. 1921. *Botanische Ergebnisse der schwedischen Expedition nach Patagonien und dem Feuerlande 1907-1909. VIII. Marine algae. 1. Phaeophyceae. Kungl.* **56** pp.
- Taylor, W.R. 1957. *Marine algae of the northeastern coast of North America. Univ. of Michigan Press. 509 pp.*
- Umezaki, I. 1965. On *Elachista nipponica*, a new species from Japan. *J. Jap. Bot.* **40**: 182-185.
- Wanders, J.B.W., C. van den Hoek and E.N. Schillern-van nes. 1972. Observations on the life history of *Elachista stellaris* (Phaeophyceae) in culture. *Neth. J. Sea Res.* **5**: 458-491.
- Womersley, H.B.S. 1987. *The marine benthic flora of Southern Australia. Part II. pp.1-184. Adelaide, South Australia.*
- Wynne, M.J. and S. Loiseaux. 1976. Recent advances in life history studies of the Phaeophyta. *Phycologia* **15**: 435-442.

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