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Vegetative Propagation in *Dilophus okamurae* and *Zonaria flabellata* (Dictyotaceae, Phaeophyta)[1]

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Results of the present writer's observations on vegetative propagation in *Dilophus okamurae* Dawson and *Zonaria flabellata* (Okamura) Papenfuss (Dictyotaceae, Phaeophyta) are presented in this report.

Vegetative propagation in *Dilophus okamurae* occurred on the blade margins and surfaces as well as at damaged portions. Proliferous branch initials for vegetative propagation developed into sparsely dichotomously branched subcylindrical to compressed stoloniferous branches which later terminally produced a dichotomously branched erect blade. Vegetative propagation in this species was detected to occur also in the vicinity of the Oki Islands during autumnal season extending from September to November.

In *Zonaria flabellata* vegetative propagation occurred on the primary rhizoids. Uniserial proliferous branch initials for vegetative propagation developed into biserial cylindrical erect branches which underwent apical growth with a single apical cell. The biserial developed erect branch terminally produced a fan-shaped blade which underwent meristematic marginal growth.

Key Index Words: Dictyotaceae, Dilophus okamurae, *Phaeophyta, vegetative propagation,* Zonaria flabellata.

Introduction

Vegetative propagation has not been reported for *Dilophus okamurae* (Okamura 1913 as *Dictyota marginata*; Dawson 1950) and *Zonaria flabellata* (Okamura 1931 as *Homoeostrichus flabellatus*; Papenfuss 1944) since they were described. The present writer could frequently collect specimens of *Dilophus okamurae* from deep-water in the vicinity of the Oki Islands, Shimane Prefecture in the course of his study on deep-water flora which started in 1966 and could observe the vegetative propagation of it in both culture and nature. Vegetative propagation was also observed in another deep-water species, *Zonaria flabellata* in culture.

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Materials and Methods

Material specimens of *Dilophus okamurae* and *Zonaria flabellata* for culture were collected with a steel dredge (Kajimura 1987) at a depth of 35 m off Tsudo, the Oki Islands, Shimane Prefecture on September 20, 1991. Cultures of entire material plants of both species were carried out in 8 *l* plastic tank at 20°C (corresponding to the mean water temperature at 50 m in the vicinity of the Oki Islands in September according to the Japan Oceanographic Data Center 1973) and under 12 : $\overline{12}$ h photoregimes with 2000 lux cool white fluorescent illumination. The culture medium (Erdschreiber) was used. Sections were made by hand.

Observations

Dilophus okamurae Dawson

Wholly developed proliferous branch for vegetative propagation in this species consisted of a stoloniferous portion and a foliaceous erect distal portion (Fig. 16).

Vegetative propagation occurred on the blade margins (Figs. 1–6) and surfaces (Fig. 7) as well as at damaged portions made by possible grazing which were commonly seen in this species (Figs. 8, 9, 17). The proliferous branch initials developed from cortical cells of the parent blade after discharge of tetraspores. The proliferous branch underwent apical growth with a single apical cell (Figs. 1–8, 11). They were cylindrical at juvenile stage (Figs. 3–8), and became subcylindrical to compressed later except the basal portion (Figs. 9, 10, 12–14). The apical cell of proliferous branches (Figs. 1–3, 11) attained *ca.* 45 μm in width and *ca.* 23 μm in length. The proliferous branches attained *ca.* 1 mm in width, *ca.* 4 cm in length and *ca.* 70 μm in thickness. They branched sparsely dichotomously (Fig. 10) and often had minute marginal proliferous branchlets. Developed proliferous branches terminally produced a single erect dichotomous blade (Fig. 16). The proliferous branches were similar to the basal stoloniferous branches of the parent plants, namely, the cortex was single-cell-layered and medulla was one- to several-cell-layered, however, the marginal portion was neither evidently thicker in cell layer than the other portion nor so swollen as seen in both parent and the terminal new blades. The stoloniferous branches as well as the terminal erect blade frequently bore tufts of multicellular colorless simple hairs (Fig. 15) arising from cortical cells as seen in the parent plants.

The similar vegetative propagation in this species was also detected to occur at *ca.* 35 m depth in the vicinity of the Oki Islands during autumnal season exteding from September to November.

Zonaria flabellata (Okamura) Papenfuss

Wholly developed proliferous branch for vegetative propagation in this species also consisted of two different portions, namely, an erect cylindrical proximal portion and a

fan-shaped distal erect blade (Figs. 26–28).

Vegetative propagation occurred on the primary rhizoids (Fig. 18). Segments of the primary rhizoids produced the proliferous branch terminally (Fig. 19) or laterally (Figs. 20–22, 24–26, 28). The erect proliferous branch was usually simple (Figs. 21, 22, 26), rarely dichotomously branched once (Fig. 25), and uniserial in the young portion (Fig. 21), but the developed portion became biserial by longitudinal divisions of the segmental cells (Figs. 23–25), which attained *ca.* 660 μm in length and *ca.* 50 μm in diameter. Segmental cells in the middle to lower portions of the proliferous branches produced one or two descending uniserial simple colorless secondary rhizoids frequently each (Figs. 20, 21, 23–25). The cylindrical proliferous branches underwent apical growth with a single apical cell (Fig. 21). Developed cylindrical proliferous branches produced a single fan-shaped blade terminally by replacing a single apical cell to a marginal meristem occupying almost distal edge (Figs. 26–28). The proximal cells of the fan-shaped blade also produced one or two colorless simple descending secondary rhizoids each (Figs. 26, 28), which attained *ca.* 25 μm in diameter and 1 mm or more in length.

Discussion

Dilophus okamurae is related to *Pachydictyon coriaceum* (Holmes) Okamura (Kumagae 1977) and *Dictyota dichotoma* (Hudson) Lamouroux (Hoyt 1907) in the occurrence of vegetative propagation on blades, however, it is distinct from *Zonaria flabellata* (present study) and *Dictyopteris divaricata* (Okamura) Okamura (Tokida, Masaki and Yabu 1953) in which vegetative propagation occurred on rhizoids. *Dilophus okamurae* is also distinct from *Zonaria diesingiana* J. Agardh (Kumagae 1977; Allender and Kraft 1983) and *Distromium decumbens* (Okamura) Levring (Kajimura 1986) in which vegetative propagation occurred on both blades and rhizoids.

Zonaria flabellata is related to *Dictyopteris divaricata* in the occurrence of vegetative propagation on rhizoids, however, it is distinct from *Dilophus okamurae, Pachydictyon coriaceum* and *Dictyota dichotoma* in which vegetative propagation occurred on blades. *Zonaria flabellata* is also distinct from *Zonaria diesingiana* and *Distromium decumbens* in which vegetative propagation occurred on both blades and rhizoids.

Figs. 1–4. *Dilophus okamurae* Dawson.

Fig. 1. A proliferous stoloniferous branch initial (arrowhead) arising from blade margin.

Fig. 2. A dome-shaped, one-celled stoloniferous branch initial (arrowhead) arising from blade margin.

Fig. 3. A cylindrical juvenile stoloniferous branch (arrowhead) arising from blade margin.

Fig. 4. Three cylindrical juvenile stoloniferous branches (arrowheads) arising from blade margin.

Figs. 5–8. *Dilophus okamurae* Dawson.

Fig. 5. Three juvenile stoloniferous branches (arrowheads) arising from subterminal margin of blade bearing hairs.

Fig. 6. Two juvenile stoloniferous branches (arrowheads) arising from blade margin.

Fig. 7. Eight juvenile stoloniferous branches (arrowheads) arising from blade surface.

Fig. 8. Four juvenile stoloniferous branches (arrowheads) arising from a damaged portion in blade.

Figs. 9–12. *Dilophus okamurae* Dawson.

Fig. 9. Many developing subcylindrical to compressed stoloniferous branches arising from a damaged portion in blade.

Fig. 10. Two dichotomies (arrowheads) in two developing stoloniferous branches.

Fig. 11. Hemispherical apical cell (arrowhead) of a developing stoloniferous branch.

Fig. 12. Cross section of a developing stoloniferous branch in the upper portion, showing one-cell-layered cortex (cort) and medulla (m).

Figs. 13–16. *Dilophus okamurae* Dawson.

Fig. 13. Cross section of a developing stoloniferous branch in the middle portion, showing two-cell-layered medulla (m) and single-cell-layered cortex.

Fig. 14. Cross section of a developing stoloniferous branch in the subcylindrical basal portion, showing parenchymatous medulla (m) and single-cell-layered cortex.

Fig. 15. Hairs (arrowheads) formed in tuft on the surface of a developing stoloniferous branch.

Fig. 16. Dichotomously branched new erect blade (large arrowhead) produced terminally from a stoloniferous branch (small arrowhead).

Fig. 17. *Dilophus okamurae* Dawson.

Fresh specimen collected at 35 m depth off Tsudo, the Oki Islands on October 16, 1991, showing many stoloniferous branches (arrowheads).

Figs. 18–20. *Zonaria flabellata* (Okamura) Papenfuss.

Fig. 18. Irregularly branched primary rhizoid.

Fig. 19. Initial cell of an erect proliferous branch (arrowhead) arising terminally from the primary rhizoid (prh).

Fig. 20. Developing cylindrical proliferous branch (arrowhead) arising laterally from the primary rhizoid and producing secondary rhizoids (rh) from its segmental cells.

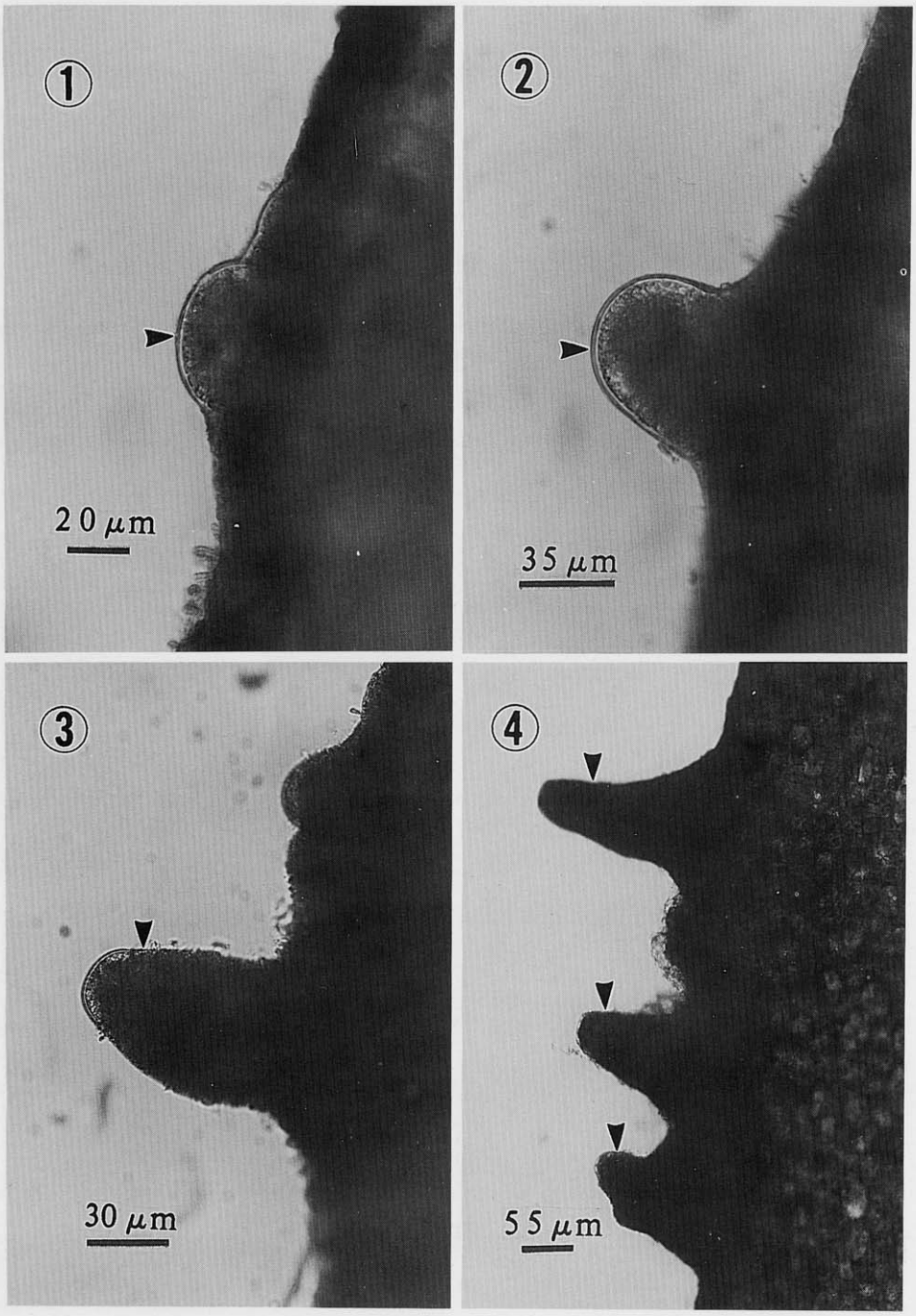
Figs. 21–24. *Zonaria flabellata* (Okamura) Papenfuss.

Fig. 21. Developing proliferous branch being uniserial distally, arising laterally from the primary rhizoid and with a dome-shaped large apical cell (a) and some secondary rhizoids descending from its middle to proximal segments.

Fig. 22. A pair of cylindrical proliferous branch (arrowhead) arising laterally from the primary rhizoid side by side.

Fig. 23. Three secondary rhizoids (arrowheads) arising from segmental cells of a biserial proliferous branch (cb).

Fig. 24. Biserial proximal portion of a proliferous branch (cb) arising laterally from the primary rhizoid, showing some secondary rhizoids (arrowheads) descending from its segmental cells.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20 μm
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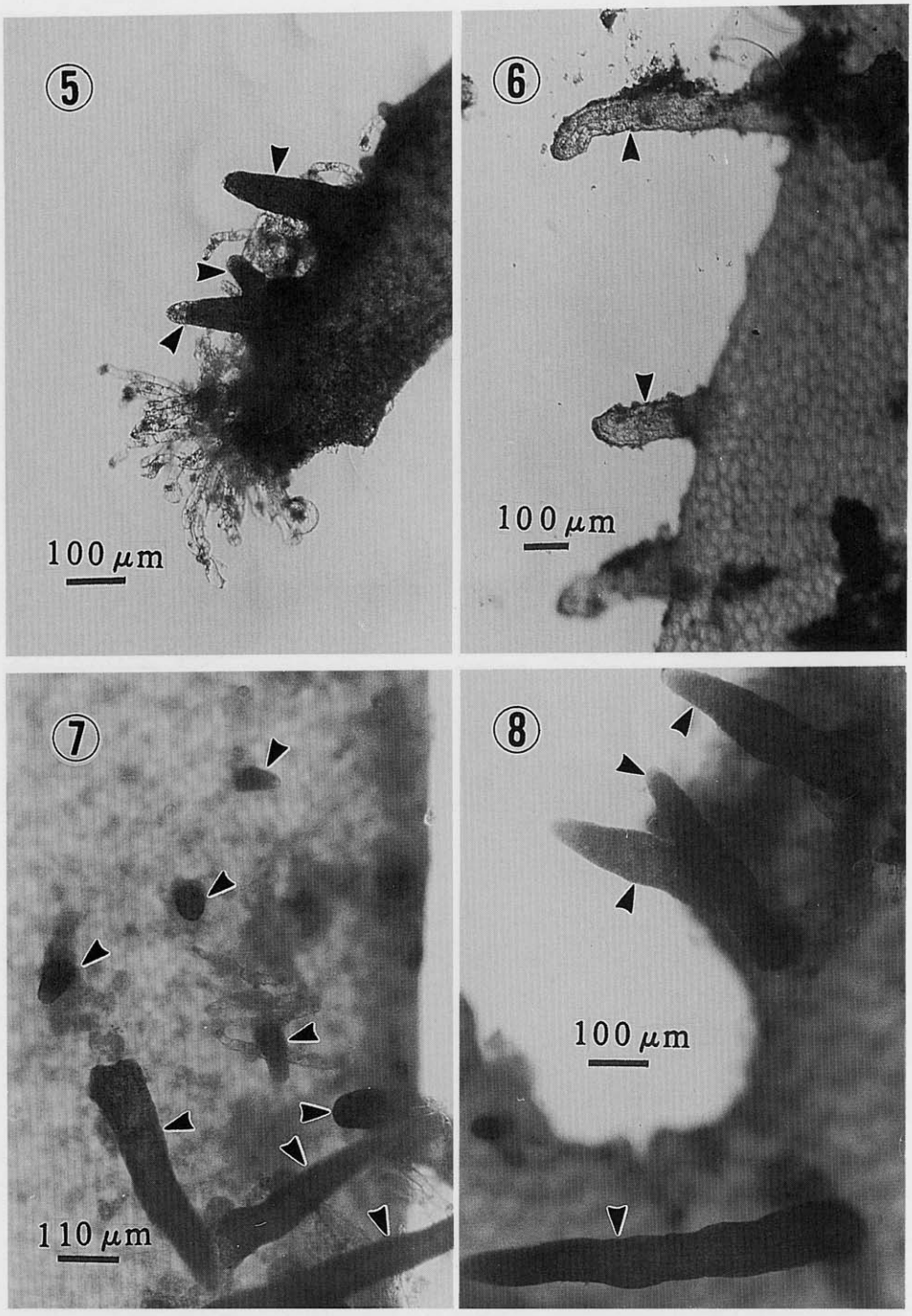
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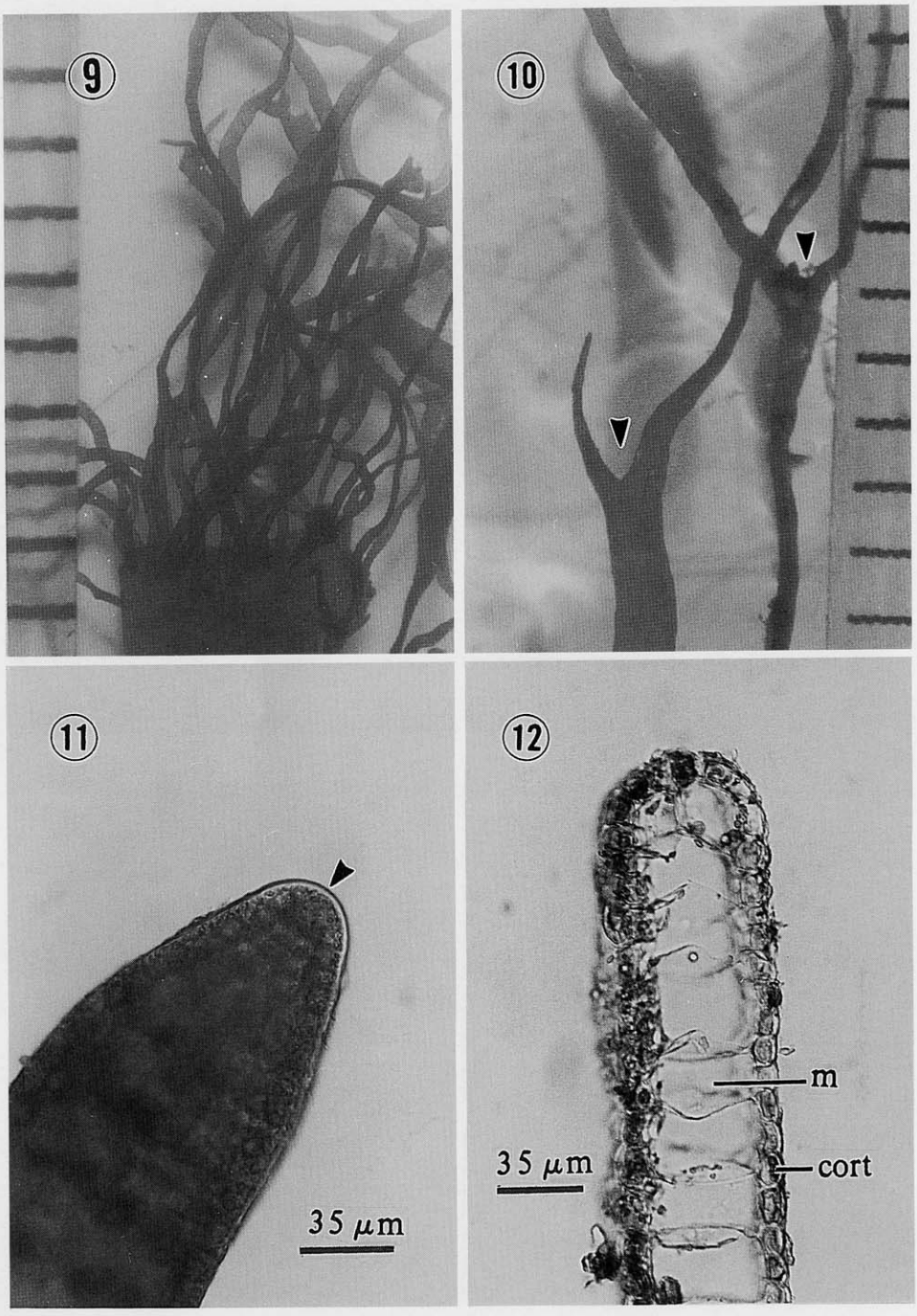
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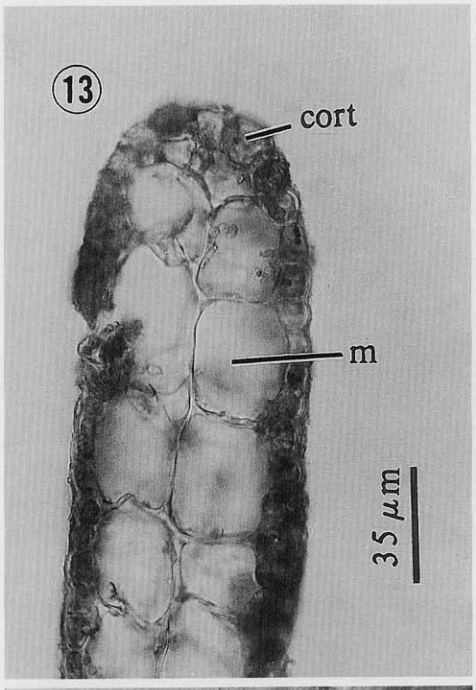
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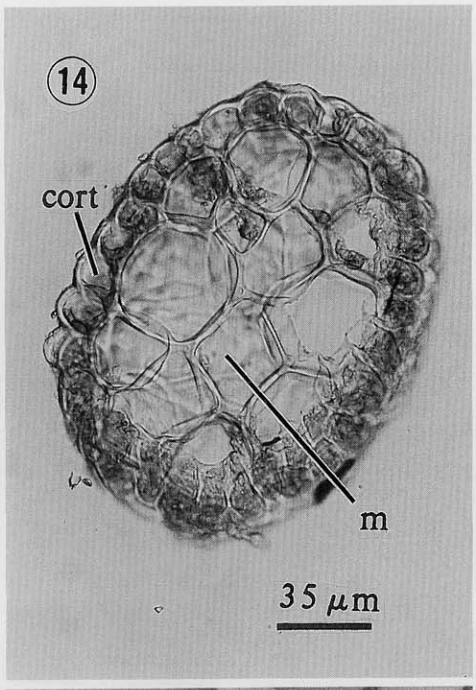
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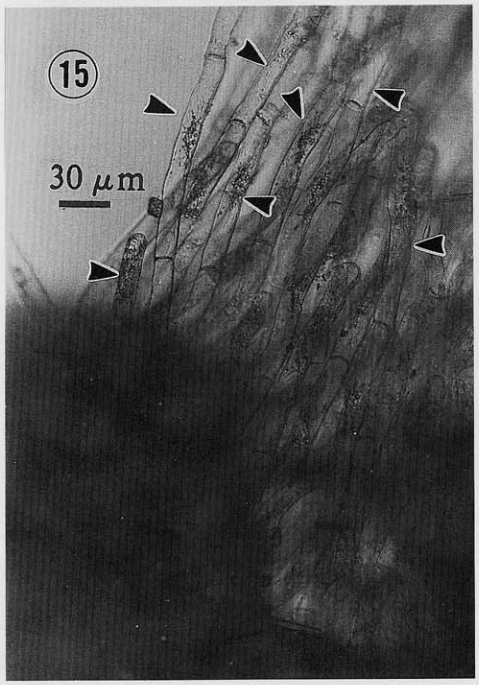
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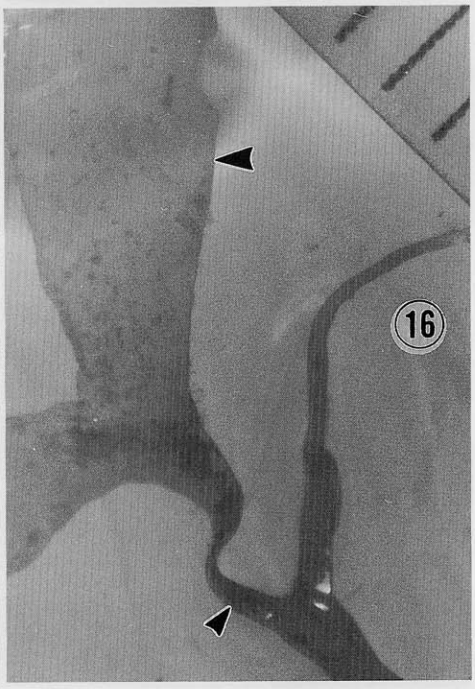
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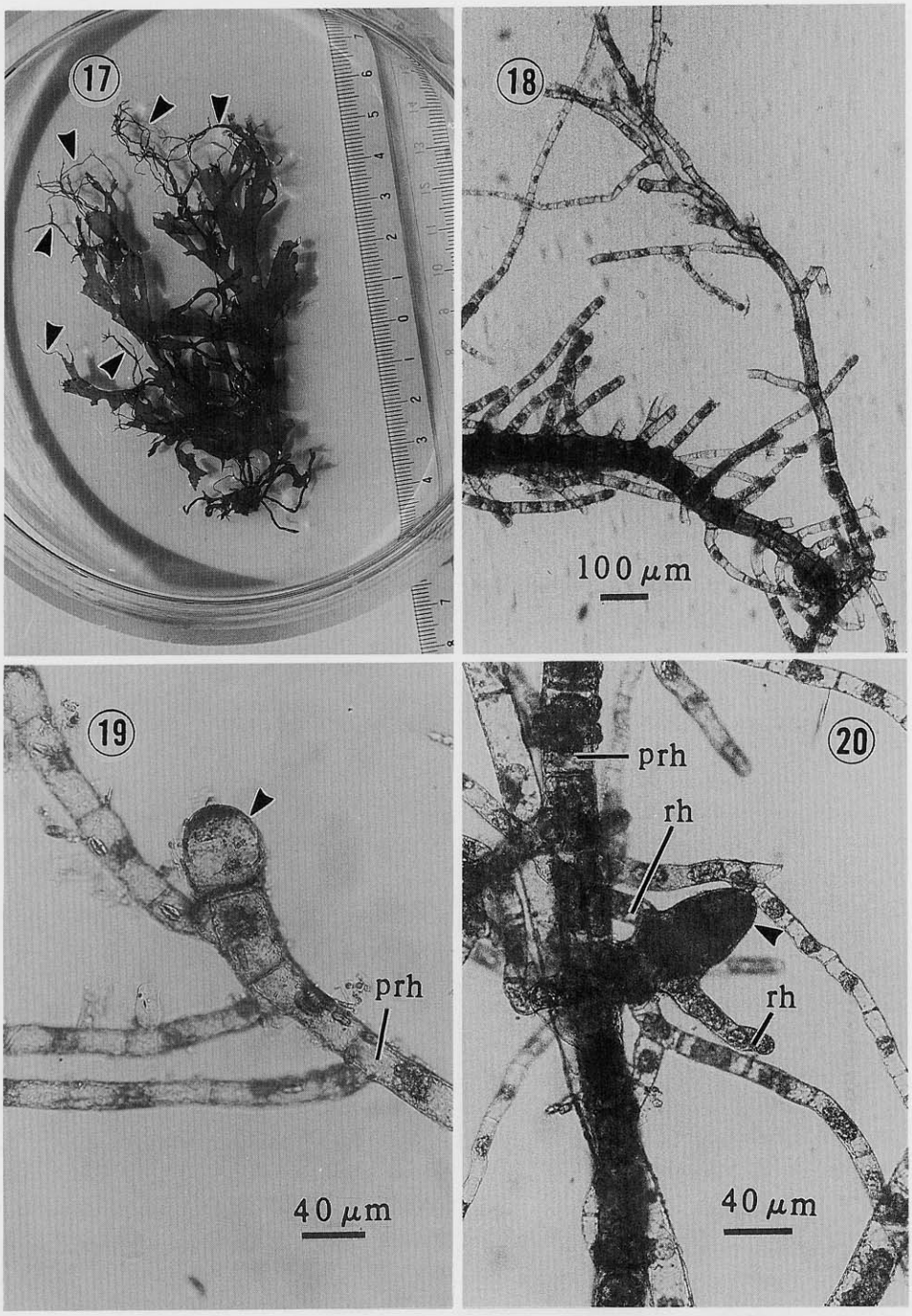
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18
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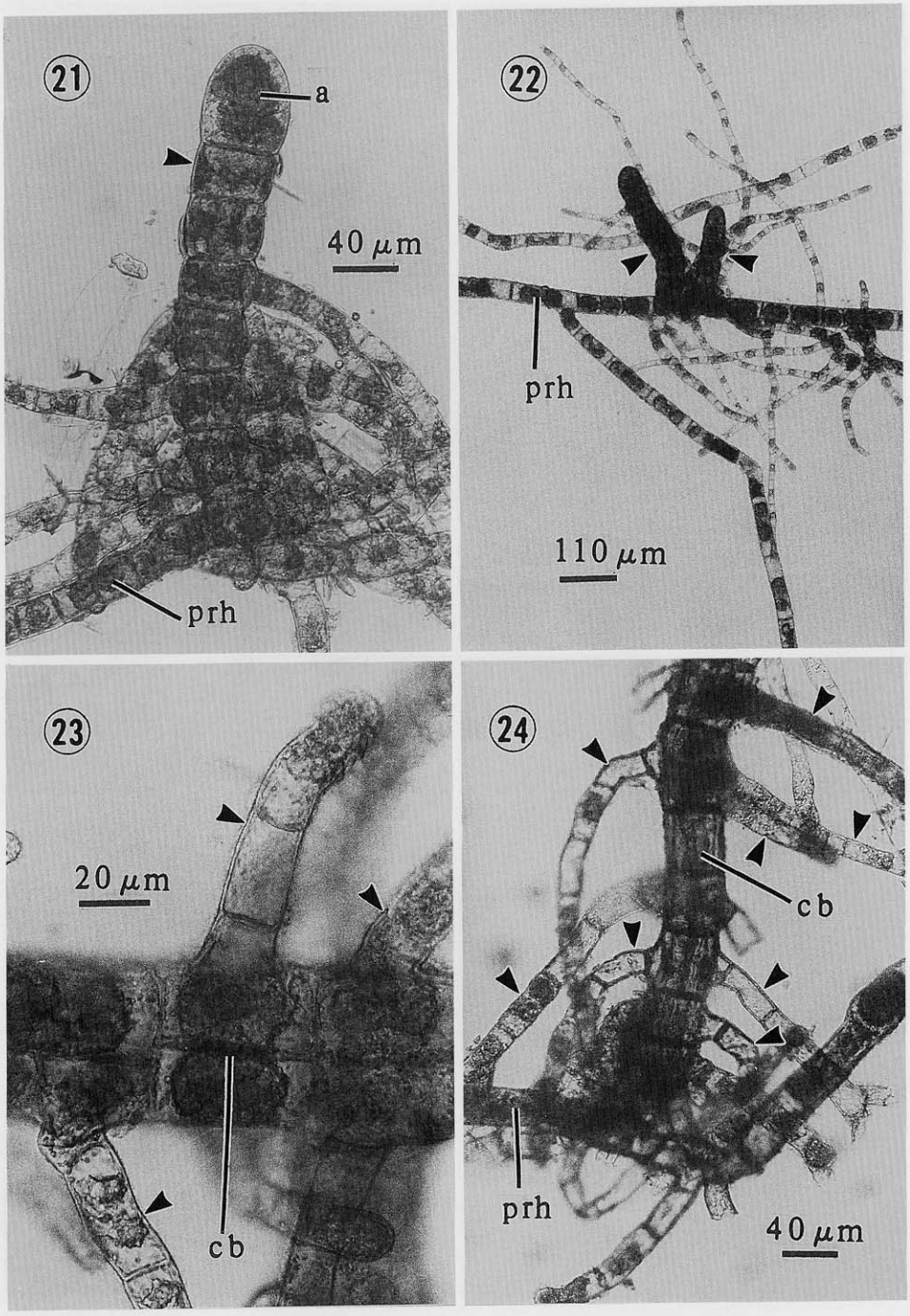
21
a
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22
prh
110 μm
23
20 μm
cb
24
cb
prh
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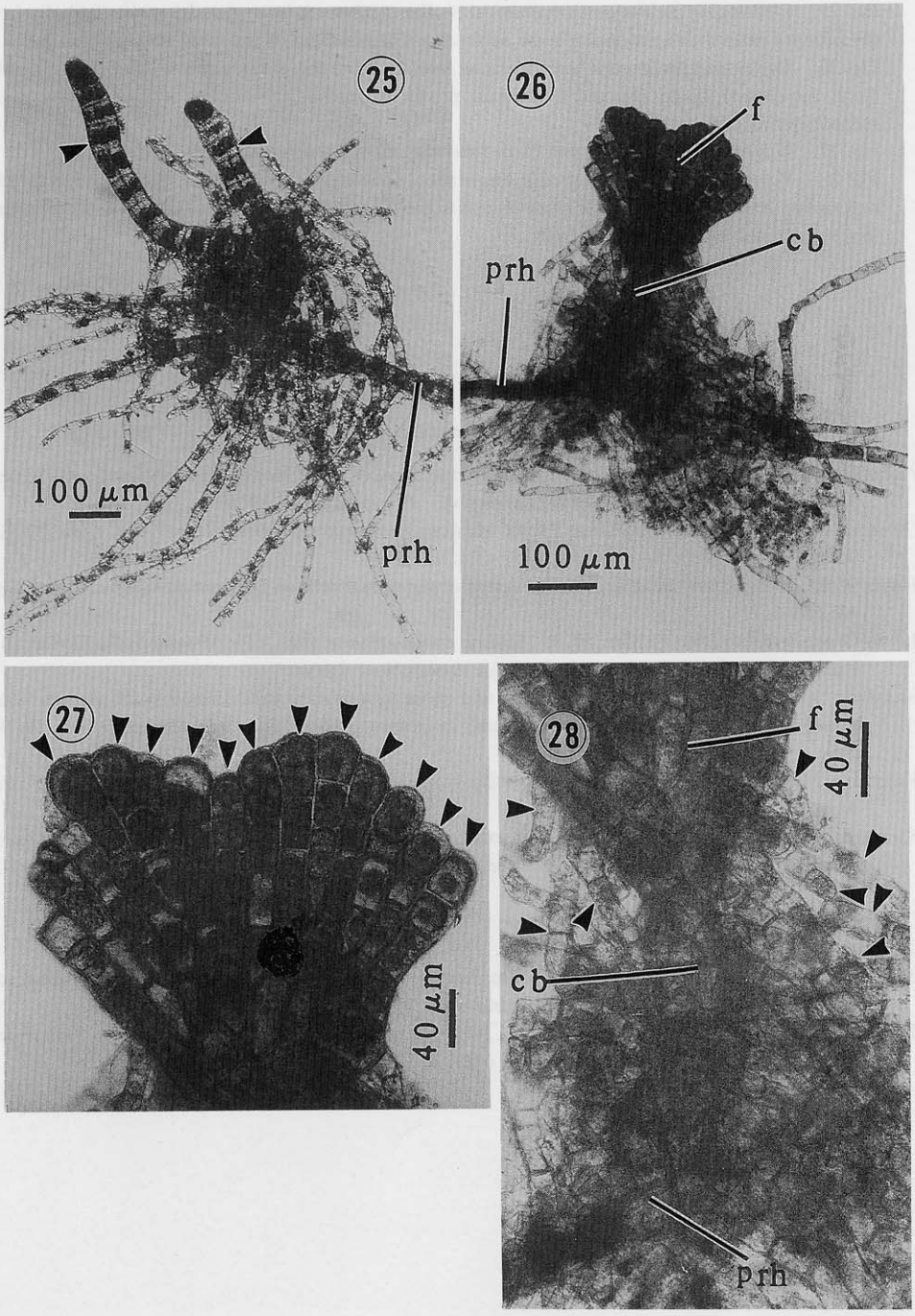
25
100 μm
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26
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prh
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27
40 μm
28
f
40 μm
cb
prh

Figs. 25–28. *Zonaria flabellata* (Okamura) Papenfuss.

Fig. 25. Developing dichotomous cylindrical proliferous branch (arrowheads) arising laterally from the primary rhizoid and producing some secondary rhizoids from its proximal segmental cells.

Fig. 26. Developed proliferous branch arising laterally from the primary rhizoid and consisting of a distal fan-shaped blade (f) and cylindrical proximal portion (cb) being surrounded by many secondary rhizoids.

Fig. 27. Upper half of a fan-shaped blade, showing many meristematic cells (arrowheads).

Fig. 28. Portion of a developed proliferous branch, showing some secondary rhizoids (arrowheads) descending from proximal cells of a fan-shaped blade (f) and the subsequent cylindrical erect portion (cb) surrounded by secondary rhizoids.

References

Allender, B. M. and G. T. Kraft. 1983. The marine algae of Lord Howe Islands (New South Wales): The Dictyotales and Cutleriales (Phaeophyta). *Brunonia* **6**: 73–130.

Dawson, E. Y. 1950. Notes on some Pacific Mexican Dictyotaceae. *Bull. Torrey Bot. Club.* **77**: 83–93.

Hoyt, W. D. 1907. Periodicity in the production of the sexual cells of *Dictyota dichotoma*. *Bot. Gaz.* **43**: 383–392.

Japan Oceanographic Data Center. 1973. Marine environmental atlas. Northwestern Pacific Ocean II (seasonal·monthly). Japan Hydrographic Association, Tokyo.

Kajimura, M. 1986. Vegetative propagation and spore germination in *Distromium decumbens* (Okamura) Levring (Phaeophyta, Dictyotaceae) in culture. *Mem. Fac. Sci., Shimane Univ.* **20**: 99–105.

Kajimura, M. 1987. Deep-water flora of benthic marine algae in the Oki Islands, Sea of Japan. *Bot. Mar.* **30**: 373–385.

Kumagae, N. 1977. Morphogenesis in Dictyotales XII. Vegetative reproduction in *Zonaria diesingiana* J. Agardh and *Pachydictyon coriaceum* (Holm.) Okamura. *Bull. Jap. Soc. Phycol.* **25**: 12–18.

Okamura, K. 1913. *Icones of Japanese Algae.* Vol. **III**. Kazamashobo, Tokyo.

Okamura, K. 1931. *Icones of Japanese Algae.* Vol. **VI**. Kazamashobo, Tokyo.

Papenfuss, G. F. 1944. Notes on algal nomenclature. III. Miscellaneous species of Chlorophyceae, Phaeophyceae and Rhodophyceae. *Farlowia* **1**: 337–346.

Tokida, J., T. Masaki and H. Yabu. 1953. On the rhizoids of *Dictyopteris divaricata* (Okamura) Okamura. *Bull. Fac. Fish., Hokkaido Univ.* **4**: 149–156.