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Vegetative Propagation in *Padina japonica, Dictyopteris prolifera* and *Dictyota linearis* (Dictyotaceae, Phaeophyta)[1]

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Results of the present writer's observations on vegetative propagation in *Padina japonica* Yamada, *Dictyopteris prolifera* (Okamura) Okamura and *Dictyota linearis* (C. Agardh) Greville (Dictyotaceae, Phaeophyta) are presented in this report.

Vegetative propagation in *Padina japonica* occurred solely from rhizomes. Gemmae were conical to subcylindrical and underwent apical growth at early stage of the development. Thereafter they became broader and compressed to flattened by replacing an apical cell to the marginal meristem. The meristem circinately inrolled towards the reverse side, then gemmae became typical fan-shaped and slightly calcified on the reverse side.

In *Dictyopteris prolifera* vegetative propagation occurred solely from the primary rhizoids. Gemmae were cylindrical to subcylindrical and underwent apical growth at early stage of the development. Thereafter gemmae became broader and compressed to flattened by replacing an apical cell to the marginal meristem.

In *Dictyota linearis* vegetative propagation occurred solely from the primary blade. Gemmae were conical to subcylindrical at early stage of the development, thereafter they developed into the flattened and dichotomously branched new blades. The growth of gemmae was apical throughout the development.

Vegetative propagation in those three species mentioned above was commonly occurred in August in the studied area.

Key Index Words : Dictyopteris prolifera, Dictyota linearis, *Dictyotaceae*, Padina japonica, *Phaeophyta, vegetative propagation.*

Introduction

Vegetative propagation has not been reported for *Padina japonica, Dictyopteris prolifera* and *Dictyota linearis* since they were described. The present writer could frequently collect many specimens of those three species in the Oki Islands in the course of his study on marine algal flora which started in 1966, and this time he could fortunately observe the vegetative propagation occurred in those species in nature.

Materials and Methods

Many material specimens of *Padina japonica* were collected for this study at Minoura Bay on August 12, 13, 17, 1993, which were growing at low tide level on rocky bottom. Abundant material specimens of *Dictyopteris prolifera* were collected also for this study as follows :

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Takeishi, at low tide level on rocky bottom on August 12, 1993 ; Minoura Bay, at low tide level on rocky bottom on August 12, 1993 ; Sasuka, at 0.5 m depth on rocky bottom on August 12, 1993 ; Tsutsuka Bay, at low tide level on rocky bottom on August 12, 1993. Many material plants of *Dictyota linearis* were collected for this project at Minoura Bay on August 12, 1993, which were growing at 1.5 m depth on *Sargassum confusum* C. Agardh and *Sargassum piluliferum* (Turner) C. Agardh.

Observations

Padina japonica Yamada

Notes some Jap. alg. II, pp. 69-70, pl. 19, fig. 2, 1931.

Vegetative propagation occurred solely from rhizomes (Figs. 3-8, 11). Several to some rhizomes of 0.5-1 mm in diameter were formed in various directions from the short stipe of the thallus (Fig. 1). The rhizome was slightly compressed, had cortex with one cell layer and pseudoparenchymatous medulla (Fig. 2), and underwent apical growth (Fig. 7). Gemmae were formed from terminals (Figs. 7, 11) as well as margins (Figs. 3-6) and surfaces of the rhizome. The initial cell of gemmae was dome-shaped and *ca.* 50 μm in diameter. The gemma was conical to subcylindrical and underwent apical growth at early stage of the development (Figs. 4-7). The developing gemmae produced many trichoblasts in tufts on the surface (Fig. 6). Thereafter gemmae became broader, compressed to flattened by replacing an apical cell to the marginal meristem occupying almost semicircular distal edge (Fig. 9). The meristematic cells elongated perpendicularly to the distal margin of the gemma and divided repeatedly periclinally and anticlinally, consequently the gemma rapidly increased in total size as well as its cell number. The meristem then circinately inrolled towards the reverse side (Figs. 10, 11). The young monostromatic and spatulate gemmae became distromatic, typical fan-shaped, and slightly calcified on the reverse side (Fig. 11).

Dictyopteris prolifera (Okamura) Okamura

Rec. Oceanogr. Wk. Jap. 4(1), p. 76, 1932 ; as *Haliseris prolifera* Okamura, Icon. Jap. Alg. Vol. I, pp. 55-57, pl. 12, figs. 1-6, 1907.

Vegetative propagation occurred solely from the primary rhizoids (Figs. 13-16) which were mostly uniserial, irregularly branched and *ca.* 82 μm in diameter. Gemmae were usually initiated laterally from rhizoids (Figs. 13-16), cylindrical to subcylindrical and underwent apical growth at early stage of the development (Fig. 14). Thereafter the gemmae became broader and compressed to flattened by replacing an apical cell to the marginal meristem occupying almost semicirucular distal edge (Figs. 15-17). Gemmae of the spatulate stage were monostromatic (Figs. 15-19), then they became elongate with almost even width and several cell layers, which frequently produced many secondary rhizoids in tufts along the margin for the adventitious as well as at the base for the holdfast (Fig. 20).

Dictyota linearis (C. Agardh) Greville

Alg. brit., p. xliii, 1830 ; Okamura, K., Icon. Jap. Alg. Vol. Ⅲ, pp. 29-31, pl. 107, figs. 1-9, 1913.

Vegetative propagation occurred solely from the primary blade. The initial cell of gemmae was hemispherical (Fig. 21) and *ca*. 65 μm in diameter. Gemmae were initiated from margins and surfaces of the primary blade (Figs. 21-24, 26, 27, 32). They were conical to subcylindrical at early stage of the development (Figs. 22-24, 26). Thereafter the gemma became compressed to flattened and repeatedly branched dichotomously (Figs. 27, 28, 32). They underwent apical growth (Figs. 22-24) throughout the development. Apical cells were ready to divide into two (Fig. 19) prior to forking of branches. The developing gemmae produced many trichoblasts in tufts on the surface (Fig. 25). The developed gemmae had cortex and medulla with one cell layer respectively (Figs. 30, 31).

Vegetative propagation in those three species mentioned above commonly occurred in August in the studied area prior to decomposition of the old thallus.

Discussion

Padina japonica is related to *Padina pavonica* (Linnaeus) Thivy (Reinke 1878) in the occurrence of vegetative propagation solely from rhizomes, however, it is distinct from those ten species of Dictyotaceae in the position of vegetative propagation, such as *Dictyopteris prolifera* (present study), *Dictyota linearis* (present study), *Padina crassa* Yamada (Kajimura 1993), *Dilophus okamurae* Dawson (Kajimura 1992), *Zonaria flabellata* (Okamura) Papenfuss (Kajimura 1992), *Distromium decumbens* (Okamura) Levring (Kajimura 1986), *Pachydictyon coriaceum* (Holmes) Okamura (Kumagae 1977), *Dictyota dichotoma* (Hudson) Lamouroux (Hoyt 1907), *Dictyopteris divaricata* (Okamura) Okamura (Tokida, *et al.* 1953) and *Zonaria diesingiana* J. Agardh (Kumagae 1977) (Table 1).

Dictyopteris prolifera is related to those three species in the occurrence of vegetative propagation solely from rhizoids such as *Padina crassa, Zonaria flabellata, Dictyopteris divaricata*, however, it is distinct from those eight species in the position of vegetative propagation, such as *Padina japonica* (present study), *Dictyota linearis, Dilophus okamurae, Distromium decumbens, Pachydictyon coriaceum, Dictyota dichotoma, Zonaria diesingiana* and *Padina pavonica* (Table 1).

Dictyota linearis is related to those three species in the occurrence of vegetative propagation solely from the primary blades such as *Dilophus okamurae, Pachydictyon coriaceum* and *Dictyota dichotoma*, however, it is distinct from those eight species in the position of vegetative propagation, such as *Padina japonica, Dictyopteris prolifera, Padina crassa, Zonaria flabellata, Distromium decumbens, Dictyopteris divaricata, Zonaria diesingiana* and *Padina pavonica* (Table 1).

Abbreviations used in Figures

a	apical cell
cort	cortex
m	medulla
pb	primary blade
prh	primary rhizoid
r	rhizome
srh	secondary rhizoid
st	stipe

Figs. 1- 4. *Padina japonica* Yamada.

Fig. 1. Several rhizomes (r) arising from the stipe of thallus.

Fig. 2. A cross section of a developed rhizome, showing cortex (cort) with one cell layer and pseudoparenchymatous medulla (m).

Fig. 3. A dome-shaped initial cell of gemma (arrowhead) arising from a margin of rhizome (r).

Fig. 4. A conical juvenile gemma (arrowhead) with an apical cell (a) and arising from a margin of rhizome (r).

Figs. 5- 8. *Padina japonica* Yamada.

Fig. 5. Three young subcylindrical gemmae (arrowheads) with an apical cell (a) and arising from a margin of rhizome (r).

Fig. 6. A subcylindrical developing gemma (small arrowhead) with an apical cell (a) and a tuft of trichoblasts (large arrowhead), and arising from a margin of rhizome (r).

Fig. 7. Terminal part of a rhizome (r), showing its apical cell (arrow), three young gemmae (arrowheads) with an apical cell and arising terminally or subterminally from a rhizome (r).

Fig. 8. A developing compressed gemma (arrowhead) with the marginal meristem (arrow) and arising from a rhizome (r).

Figs. 9-11. *Padina japonica* Yamada.

Fig. 9. Distal part of a developing gemma, showing the marginal meristem (arrowhead) a little curving towards the reverse side.

Fig. 10. Upper part of a developing gemma, showing the distal free edge (arrowhead) circinately inrolled towards the reverse side.

Fig. 11. A developing typical fan-shaped gemma with the free edge circinately inrolled towards the reverse side (arrows), slightly calcified on the reverse side and arising terminally from the rhizome (r).

Fig. 12. *Dictyopteris prolifera* (Okamura) Okamura.

Some uniserial and irregularly branched primary rhizoids.

Figs. 13-16. *Dictyopteris prolifera* (Okamura) Okamura.

Fig. 13. An initial cell of gemma (arrowhead) arising laterally from the primary rhizoid (prh).

Fig. 14. A cylindrical juvenile gemma (arrowhead) with an apical cell (a) and arising laterally from the primary rhizoid (prh).

Fig. 15. A compressed young gemma (large arrowhead) with some marginal meristematic cells occupying almost semicircular distal edge (small arrowheads) and arising laterally from the primary rhizoid (prh).

Fig. 16. A spatulate developing gemma (arrowhead) with the marginal meristem and arising laterally from the primary rhizoid (prh).

Figs. 17-20. *Dictyopteris prolifera* (Okamura) Okamura.

Fig. 17. Part of a developing monostromatic gemma, showing longitudinal cell arrangement in surface view and a secondary rhizoid (srh).

Fig. 18. Terminal part of the gemma in Fig. 17, showing some marginal meristematic cells (arrowheads).

Fig. 19. Middle part of the gemma in Fig. 17, showing the enlarged cell arrangement in surface view.

Fig. 20. A developed gemma with several cell layers and many secondary rhizoids (srh) formed in tufts along margins as well as at the base.

Figs. 21-24. *Dictyota linearis* (C. Agardh) Greville.

Fig. 21. An initial cell of gemma (arrowhead) arising from a margin of the primary blade (pb).

Fig. 22. A conical juvenile gemma (arrowhead) with an apical cell (a) and arising from a margin of the primary blade (pb).

Fig. 23. Four young conical to subcylindrical gemmae (arrowheads) with an apical cell (a) and arising from margins of the primary blade (pb).

Fig. 24. Three subcylindrical developing gemmae (arrowheads) with an apical cell (a) and arising from a margin of the primary blade (pb).

Figs. 25-28. *Dictyota linearis* (C. Agardh) Greville.

Fig. 25. Part of a developing gemma (small arrowhead), showing trichoblasts arising in tufts (large arrowheads) from the surface.

Fig. 26. Seven developing gemmae (arrowheads) arising from a margin and surface of the primary blade (pb).

Fig. 27. Some developing gemmae (arrowheads) arising from surface of the primary blade (pb).

Fig. 28. Some developed and dichotomously branched gemmae.

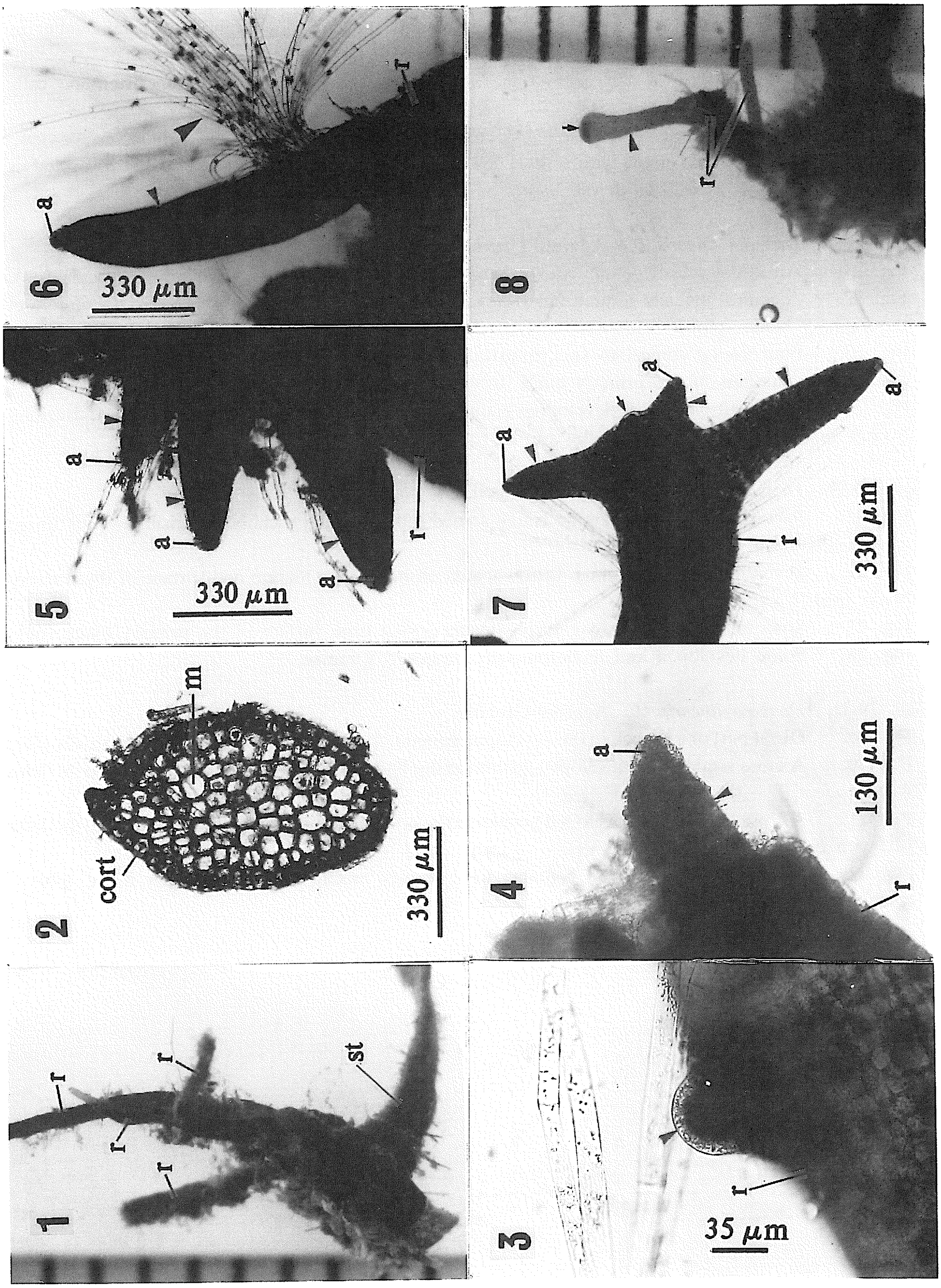
Figs. 29-32. *Dictyota linearis* (C. Agardh) Greville.

Fig. 29. Distal part of a branch in the developed gemma, showing a pair of apical cells (arrowheads).

Fig. 30. A cross section of a developed gemma in the basal part, showing cortex (cort) and medulla (m).

Fig. 31. A cross section of a developed gemma in the middle part, showing cortex (cort) and medulla (m) with one cell layer respectively.

Fig. 32. Habit of two developed gemmae (arrowheads) arising from the primary blade (pb).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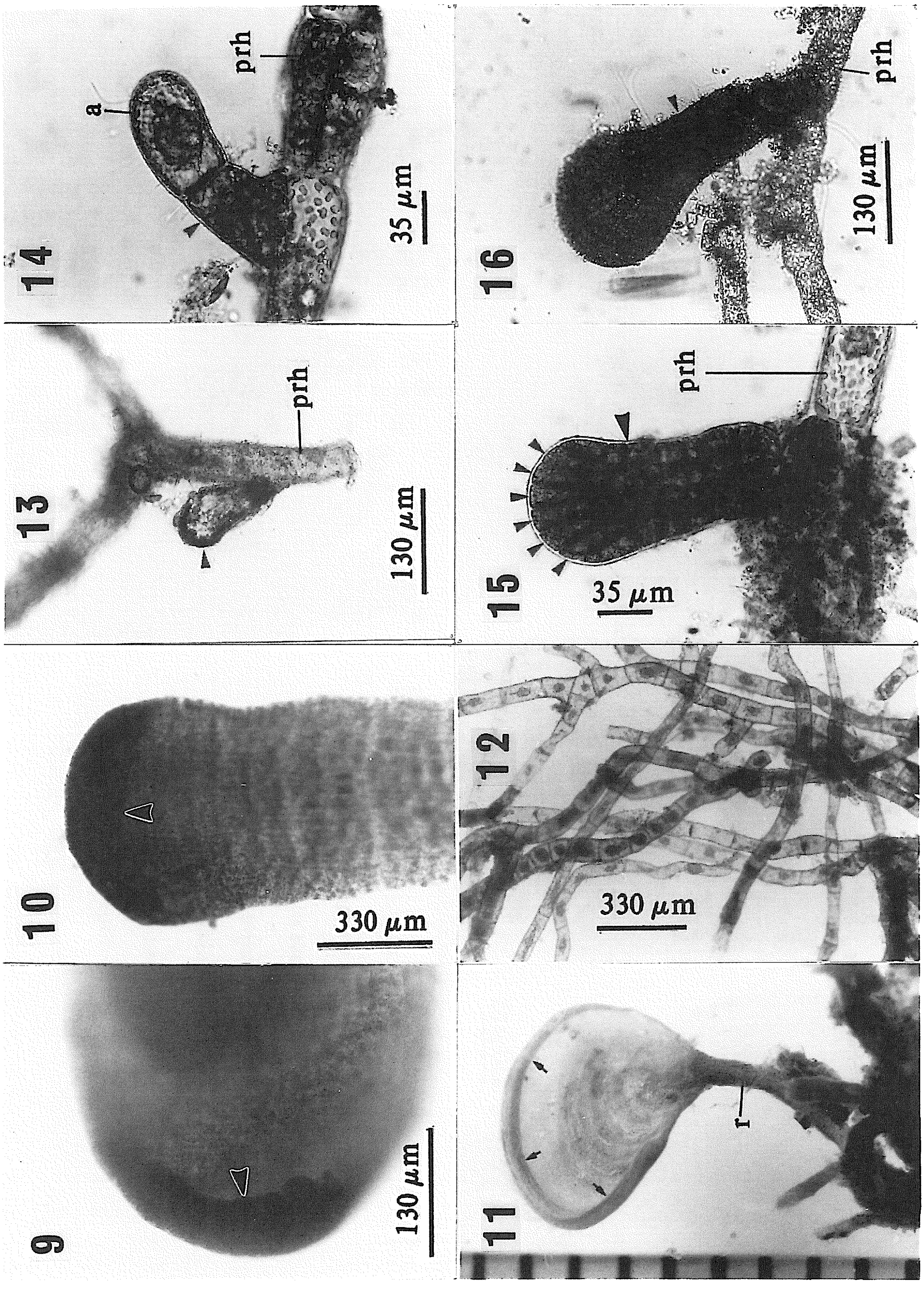
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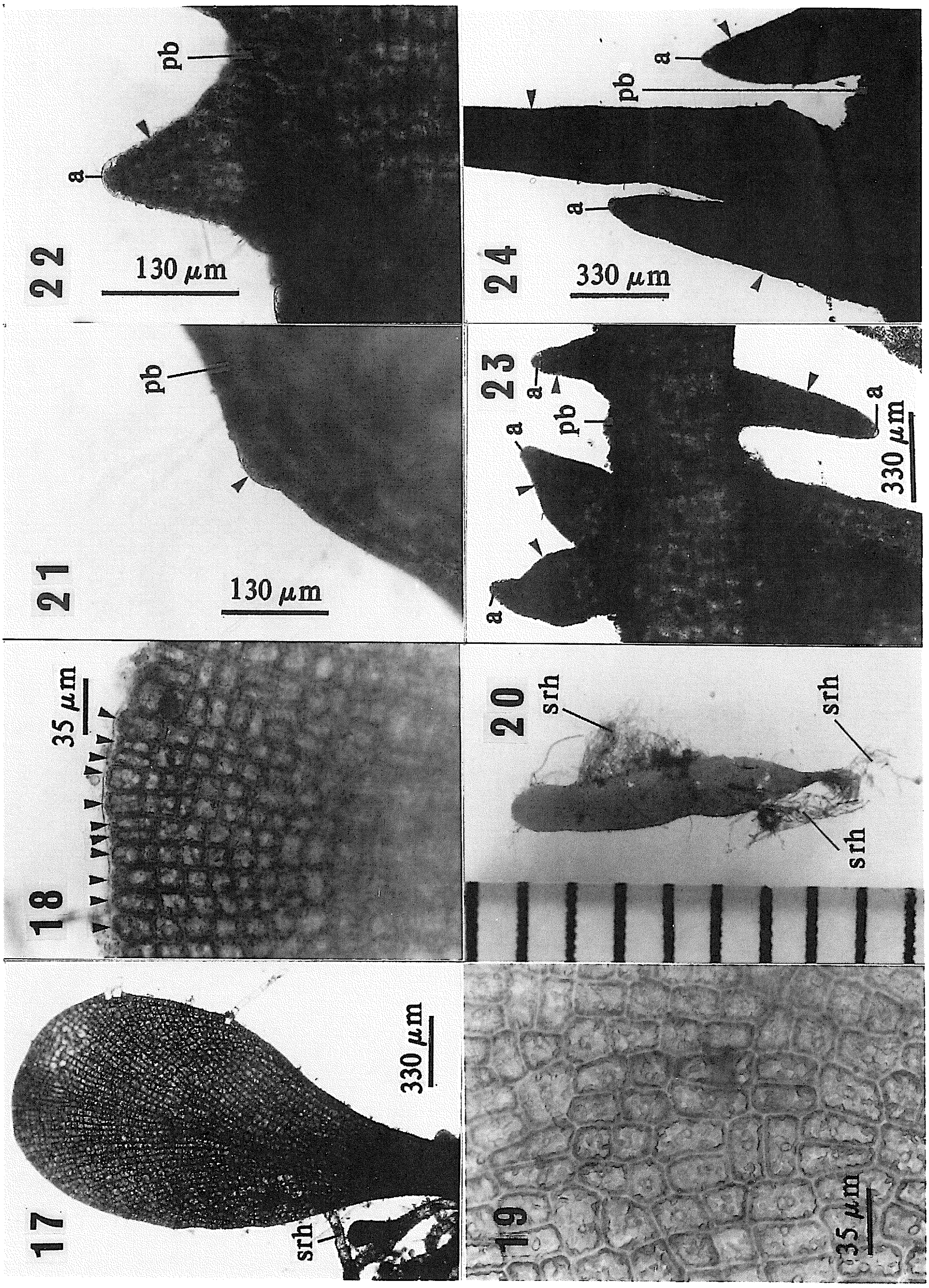
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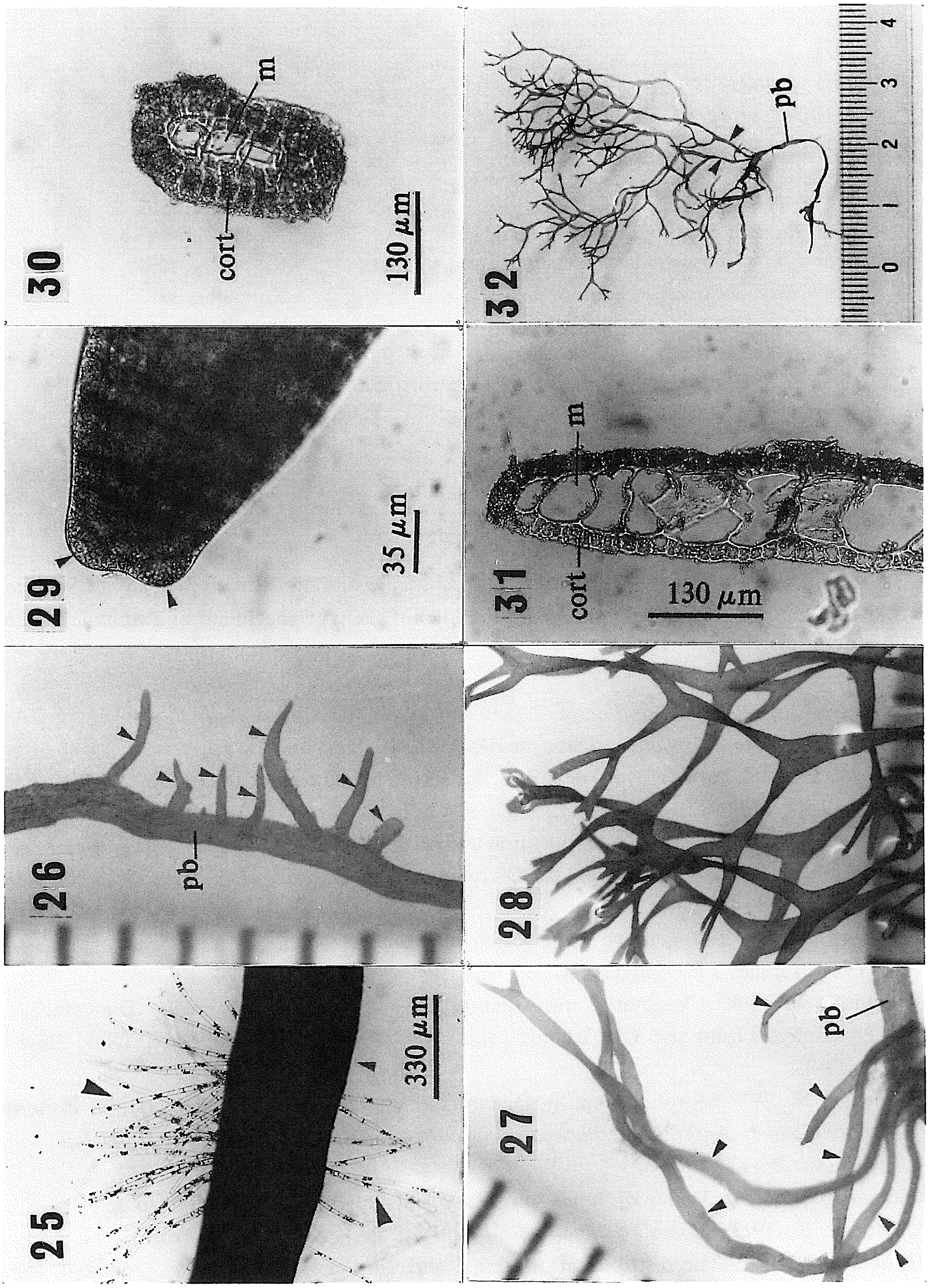
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Table 1. Comparison of dictyotaceous species on the position of vegetative propagation.

Species	Position	Reference
Padina japonica	On rhizomes	Present study
Dictyopteris prolifera	On rhizoids	Present study
Dictyota linearis	On blades	Present study
Padina crassa	On rhizoids	Kajimura, 1993
Dilophus okamurae	On blades	Kajimura, 1992
Zonaria flabellata	On rhizoids	Kajimura, 1992
Distromium decumbens	On blades and rhizoids	Kajimura, 1986
Pachydictyon coriaceum	On blades	Kumagae, 1977
Dictyota dichotoma	On blades	Hoyt, 1907
Dictyopteris divaricata	On rhizoids	Tokida, *et al.*, 1953
Zonaria diesingiana	On blades and rhizoids	Kumagae, 1977
Padina pavonica	On rhizomes	Reinke, 1878

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