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The life history of *Dudresnaya japonica* Okamura (Cryptonemiales, Rhodophyta) in culture

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The life history of a red alga *Dudresnaya japonica* Okamura collected at Bishamon, Miura Peninsula, Kanagawa Prefecture, was studied in laboratory culture. The carpospores released from a natural mature erect female gametophyte gave rise to compact crustose tetrasporophytes. The tetraspores were produced from surface cell layer of the crustose frond by cruciate division. They germinated and grew up to crustose fronds, which issued erect male and female gametophytes. Both of the two species, *D. minima* and *D. japonica*, occurring in Japan have crustose tetrasporophytes in the life history.

Key Index Word: Cryptonemiales—culture—Dudresnaya japonica—*life history—Rhodophyta.*

Two species of *Dudresnaya* (Cryptonemiales, Rhodophyta) are known in Japan. *Dudresnaya japonica* Okamura is distributed along the Pacific coast of southern Honshu (Okamura 1936) and *D. minima* along the coasts from Kyushu to Okushiri Island, Hokkaido (Okamura 1936, Hasegawa 1949). Both of the two species were endemic.

Among thirteen species hitherto known in the genus *Dudresnaya* (Robins and Kraft 1985, Seales and Ballantine 1986), four species were reported to have isomorphic tetrasporophyte and gametophyte, and one species (*D. minima*) was recently repoted to have heteromorphic gametophyte and tetrasporophyte in the life history in laboratory culture; the crustose tetrasporophyte and the erect gametophyte (Notoya 1989). Umezaki (1968) carried out laboratory culture of *D. japonica* and showed only the early development of carpospores without success in completing its life history.

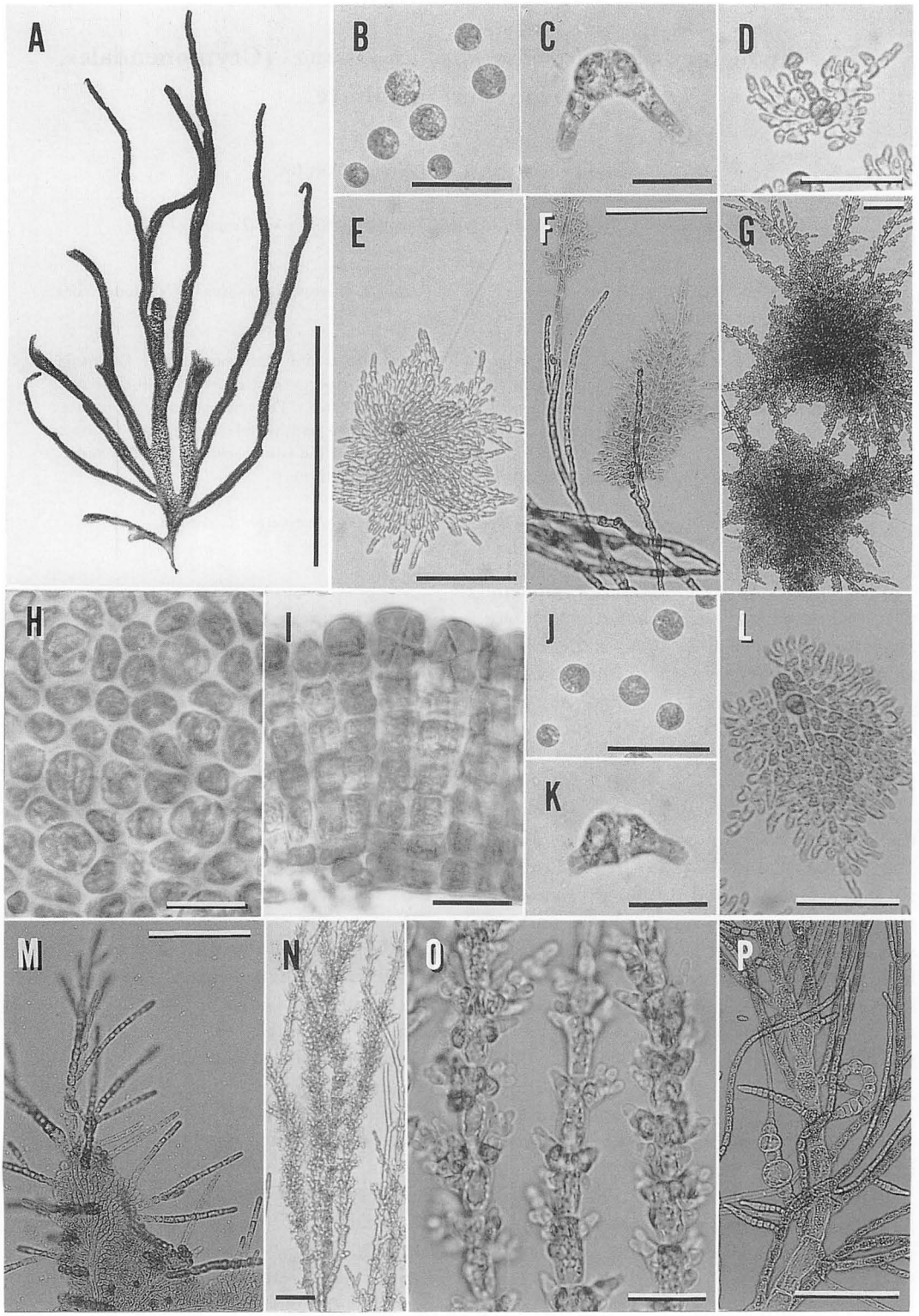
In this paper we report the life history of *D. japonica* having heteromorphic tetrasporophyte and gametophyte in a similar way to that of *D. minima*.

Material and Methods

Mature female gametophytes of *D. japonica* (Fig. 1, A) were collected on April 14, 1986, from a depth of 8 m, where *Ecklonia cava* and *Undaria pinnatifida* were mainly observed, at Bishamon, Miura Peninsula, Kanagawa Prefecture. They were put in a bottle of 3 *l* with natural seawater, and immediatly transported to the Aquaculture Center, Aomori Prefecture, for culture.

Well-mature cystocarpic branches 3–5 cm long were cut off, washed five or six times with brush in the sterilized seawater to take off contaminants attached to the surface of branches and finally set in Petri dishes with strilized seawater added with 5 ppm GeO_2 overnight. Next morning, released carpospores were collected by drawing with a glass capillary micropipet and were transferred into a new vessel containing sterilized seawater. Washing carpospores with sterilized seawater was repeated three or four times, and the spores were set on slide glasses for some hours in Petri dishes. Unialgal cultures were thus established.

The cultures were maintained at 25°C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under a photoperiod of 14L : 10D. During the light period, light of 2000–4000 lux was supplied from white fluorescent lamps. Modified Grund medium (McLachlan 1973) was used for the cultures and renewed once a week.

Results

The size of the liberated carpospores ranged from 11 to 18 μm (mean 14 μm) in diameter (Fig. 1, B) about one half that of *D. minima*.

In the early developmental stage from carpospore the germling of diprotocellular type was observed one day after germination (Fig. 1, C). Three-day-old germlings were monostromatic and prostrate with cells spread around the original spore (Fig. 1, D). Ten-day-old germlings spread more and became compact disks with fine hair cells appeared, but having one cell layer yet (Fig. 1, E). Sometimes, the filamentous cells were issued from surface or margin cells of the compact disk, and these filaments grew unattached. When attached to the substrate like a slide glass, the filaments often became re-prostrate monostromatic disks and grew to compact disks (Fig. 1, F). However, the filaments were not observed to be upright fronds.

About fourty five days after carpospore germination, compact disks were formed. They were composed of seven or nine cell layers, but their margins were thin, composed of one layer, and more spread (Fig. 1, G). The discoidal fronds were 1–2 mm in diameter, and they were not circular but like *Himenoclonium*.

In about two months of culture, the tetrasporangia were observed to lie scattered in the surface layer of the compact disks. In surface view, the tetrasporangia were 12–15 μm in diameter and bigger than other surface cells (Fig. 1, H).

Vertical section of the compact disk showed that the tetrasporangia were situated at the top of cell rows each of which were composed of seven or eight sterile cells. The mature tetrasporangia were globular in shape, 15–19 μm in height and 14–17 μm in diameter, showing cruciate division (Fig. 1, I).

Liberated tetraspores from the crustose fronds were spherical, red in color, and 8–9 μm in diameter (Fig. 1, J). The process of tetraspore germination was basically the same in their appearance as that of carpospore germination. One-day-old germlings of tetraspores were diprotocellular type (Fig. 1, K). Ten-day-old tetraspore germlings were quite similar to carpospore germlings in that they were monostromatic and prostrate in all directions around the original spore and became to form compact disks (Fig. 1, L).

After one and half a month in culture, branched upright fronds developed from the surface or marginal cells of the crustose compact disks (Fig. 1, M). The upright fronds grew up with alternate branches from the axis. After four weeks from the development of upright fronds, they reached about 1 cm in height and the spermatangia were observed at upper part of branches (Fig. 1, N & O).

In further three weeks, the fronds without

Fig. 1. *Dudresnaya japonica* Okamura in culture. (A) A female gametophyte collected at Bishamon, Miura Peninsula, Kanagawa Prefecture, Japan, on April 14, 1986. (B) Carpospores released from a natural gametophyte. (C) A carpospore germling of diprotocellular type after one day in culture. (D) A three-day-old germling, monostoromatic with prostrate cells around the original spore. (E) A ten-day-old germling, discoidal with fine hair cells. (F) Re-prostrate filamentous cells forming compact disk. (G) Fourty-five-day old germlings with several layers of cells in the centeral part. (H) Surface view of a mature tetrasporophyte, showing the tetrasporangia. (I) Vertical section of a mature tetrasporophyte, showing the tetrasporangia at the top of sterile cell row. (J) Tetraspores liberated from the crustose disk (tetrasporophyte). (K) A one-day-old tetraspore germling. (L) A ten-day-old tetraspore germling. (M) Initial upright growths from a tetraspore germling. (N) Branches of a mature male gametophyte with developed spermatangia. (O) Close up of parts of branches of a mature male gametophyte. (P) Parts of branches of a female gametophyte with young procarp-like cells.
Scale bar; 10 cm in (A); 20 μm in (C), (H), (I), (K), (O); 50 μm in (B), (D), (J), (L); 100 μm in (E)–(G), (M), (N), (P).

spermatangia reached about 1.5 mm long, and young procarp-like cell rows were observed on axial filaments of the upright fronds (Fig. 1, P). Even after three months more in culture, upright fronds with fruiting organs were not obtained.

Discussion

The early development of sporelings has been reported in *Dudresnaya* sp. by TOBLER (1903) and KILLIAN (1914). OKAMURA (1908) reported the germlings of carpospore within cystocarp in *D. japonica*, and UMEZAKI (1968) reported the development of carpospore germlings from early to later stages for one year until the prostrate crustose disk phase was reached in *D. japonica*. NOTOYA (1989) reported the early stage of sporeling development in *D. minima*. In the present paper the early stages of tetraspore and carpospore germlings of *D. japonica* were described. From these reports, it may be said that in the genus *Dudresnaya* the early stage of sporelings is diprotocellular type and the sporelings became prostrate crustose disks in more developed stage. The tetrasporophyte of *D. japonica* is a branched *Himenoclonium*-like crustose disk and its shape is quite similar to that of *D. minima* (NOTOYA 1989), *Schimmelmania* (CHIHARA 1972), *Acrosymphyton* (CORTEL-BREEMAN 1975), *Farlowia molis* (DECEW and WEST 1981) and *Gloeophycus* (NOTOYA 1983, 1984).

The branched filaments issued from a tetrasporophytic crustose disk were often observed in the present culture. They are similar to the frond reported by UMEZAKI (1986), but did not develop to upright gametophytic fronds.

The tetrasporangial division pattern of *Dudresnaya japonica* was completely cruciate type and differed from irregularly cruciate type of *D. minima* (NOTOYA 1989).

In the genus *Dudresnaya*, four species were hitherto known to have isomorphic gametophyte and tetrasporophyte; *D. australis, D. capricornica, D. crassa* and *D. verticillata*. Two species, *D. japonica* and *D. minima* which were endemic in Japan, possess the life history in which upright gametophytes alternate with crustose heteromorphic tetrasporophytes. The present results suggest the possibility that the remaining seven species, in which only the gametophyte is known up to the present, may have the heteromorphic tetrasporophyte.

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能登谷正浩・有賀祐勝：紅藻ヒビロウドの生活史

神奈川県三浦半島の毘沙門で採集した成熟したヒビロウド (*Dudresnaya japonica* OKAMURA) の雌性体（配偶体）から放出された果胞子を培養したところ，小さな殻状の藻体（胞子体）に発達し，それに四分胞子が形成された。放出された四分胞子は発芽して直立する配偶体に生長し，精子嚢をもつ体とプロカルプ様細胞をもつ体にまで発達した。従って，既に報告したヒメヒビロウド (*D. minima* OKAMURA) と同様に形態の異なる四分胞子体と配偶体からなる生活史を持つことが明らかになった。従って，本邦産のヒビロウド属2種は共に異形世代交代の生活史を持つことになる。（108 東京都港区港南4–5–7　東京水産大学藻類学研究室）