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Taxonomic study of *Bangia* and *Porphyra* (Bangiaceae, Rhodophyta) from Boso Peninsula, Japan*

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Abstract A total of 10 species of Bangiaceae (Rhodophyta) was recognized from Boso Peninsula at Chiba Prefecture in Japan with the distributional maps. 2 species of *Bangia* are *B. atropurpurea* (Roth) C. Agardh and *B. gloiopeltidicola* Tanaka, and 8 species of *Porphyra* are *P. suborbiculata* Kjellman, *P. dentata* Kjellman, *P. yezoensis* Ueda, *P. ishigecola* Miura, *P. lacerata* Miura, *P. tenuipedalis* Miura, *P. tenera* Kjellman, *P. pseudolinearis* Ueda. Especially *P. tenere* and *P. tenuipedalis*, as critically endangered species in Japan and its vicinity, were confirmed in Tokyo Bay.

Key words: taxonomy, *Bangia*, *Porphyra*, Bangiaceae, Rhodophyta, Tokyo Bay, Boso Peninsula, Chiba Prefecture, Japan.

More than a hundred species of *Porphyra* (Bangiaceae, Rhodophyta) have been described from the subtropical to arctic and antarctic waters after establishment of genus *Porphyra* by C. Agardh (1824), especially more than half from the North Pacific (Wynne, 1972; Conway *et al.*, 1975; Garbary *et al.*, 1980, Tseng, 1983; Lee and Kang, 1986; Silva *et al.*, 1987; Lindstrom and Cole, 1992).

In Japan, *Porphyra* is well represented with 28 species (Yoshida *et al.*, 1995) at present and the systematic study of *Porphyra* was done firstly by Kjellman (1897), who described 6 species as new to science. Thereafter Okamura (1909, 1916, 1936) and Yendo (1909, 1913, 1915, 1916, 1920) followed monographic study of it. Especially, Ueda (1932) described 18 species by Hus's formula (Hus, 1902) of divisional manner of spermatangia and carposporangia, and established the systematics of Japanese *Porphyra*. Then Tokida (1935) followed by the erection of subgenus *Diplastidia* in addition to the subgenera *Porphyra* (Rosenvinge, 1893) and *Diploderma* (Kjellman, 1883) Rosenvinge 1893. Other monographic studies were accomplished by Tanaka (1952) who worked on Protoflorideae in Japan. Furthermore Fukuhara (1968) carried out the taxonomic and ecological studies of *Porphyra* in Hokkaido and its vicinity, and described 22 species from there with definition of several types of the arrangement of rhizoidal filaments projected from basal cells in subgenera *Diploderma* and *Diplastidia*.

Besides in fisheries science fields, Kurogi (1961, 1963, 1972, 1977) and Miura (1961, 1967, 1968, 1984) studied additional new taxa or revisional knowledge.

As to systematics of *Bangia* (Lyngbye, 1819) in Japan, the work on Protoflorideae by Tanaka (1944, 1950, 1952) is prominent conspicuous with 2 species as new to science. Approximately 8 species of *Bangia* have been reported in the world (Sheath and Cole, 1984).

Under these circumstances, there is a few taxonomical studies on natural population of *Bangia* and *Porphyra* at the coast of Boso Peninsula (Okamura, 1892; Higashi, 1935; Chihara, 1958; Chihara and Numata, 1960; Arasaki, 1972; Tamura, 1975; Chihara, 1975;

* Dedicated to Professors Tadao Yoshida and Masakazu Tatewaki of Hokkaido University on the occassion of their academic retirement.

Oonisi, 1975; Miyata, 1995) located in central area of Honshu Island facing to Pacific Ocean in Japan. But many of those are list without description of species and biogeographical distribution. Especially in fisheries science, Tamura (1975) gave ecological information of 5 species; *P. suborbiculata* Kjellman, *P. dentata* Kjellman, *P. tenera* Kjellman, *P. angusta* Okam. et Ueda and *P. yezoensis* Ueda, and suggested living of 3 species; *P. umbilicalis* (L.) Kütz., *P. tenuipedalis* Miura and *P. pseudolinearis* Ueda.

The purpose of this study is to obtain a clearer understanding on taxonomy and biogeography of *Bangia* and *Porphyra* (Bangiaceae, Rhodophyta) from Boso Peninsula. This study is a part of research project on algal flora at the coast of Boso Peninsula and its vicinity, in Natural History Museum and Institute, Chiba.

Materials and Methods

Field collection of *Bangia* and *Porphyra* was carried out at the coast of Boso Peninsula from Choshi Prov. to the mouth of Edogawa River via Tateyama Prov. from September in 1994 to February in 1997. The research fields, Boso Peninsula, is situated on the coast of north eastern Honshu of Japan facing to Pacific Ocean at about N. Lat 34°50′ to 35°50′ and E. Long. 139°45′ to 140°50′, and look out into Tokyo Bay at west coast of the northern part.

The materials collected at 50 points were preserved in 5% formaldehyde-seawater at 4℃ under dark condition. For microscopical examination, sections with razor were sufficient. Cross-section and pieces of the thalli were kept as permanent slides. They were observed, measured and photographed either in fresh state or after addition of a small amount of staining reagents.

Taxonomic distinctions within this genus *Porphyra* are based upon the membranous thallus of the gametophyte (Hus, 1902; Kurogi, 1972; Conway *et al.*, 1975; Garbary *et al.*, 1980). The criteria used to separate infrageneric groups are as follows and type locality, (Tables 1,2 and 3); 1) monostromatic or distromatic thallus, 2) number of plastids per cell, 3) thallus shape, 3) marginal structure of thallus, 4) thickness, 5) colour, 6) habitat, 7) sex type, 8) division of carposporangium and spermatangium, 9) present or absent of monospore, 10) growing season, 11) vegetative cell size and shape, 12) presence of only one (dioecious) or both (monoecious) types of reproductive organs on a single individual, 13) location (marginal or submarginal) and arrangement (intermixed with vegetative cells or composed strictly of reproductive ones) of reproductive organs on thallus surfaces, 14) geographic distribution and so on.

Voucher specimens were deposited in the Algological herbarium in the Natural History Museum and Institute, Chiba (CBM-BA).

Descriptions of Species of *Bangia* and *Porphyra* in Boso Peninsula

Bangia Lyngbye 1819

Type species: Lectotype. *Bangia fuscopurpurea* (Dillwyn) Lyngbye. 1819 (Synonym: *Conferva fuscopurpurea* Dillwyn. 1807, vide Silva. Univ. Calif. Publ. Bot. 25: 261.1952)

Bangia atropurpurea (Roth) C. Agardh 1824

(Fig. 1; Plate I, Figs. 1 and 2)

Thallus: Simple, filamentous below, caespitose, 2–10 cm long, 20–70 μm diam. below, to 13 μm diam. above; usually purplish red in colour, chromatophore star-shaped with a central pyrenoid, thalli dioecious, male plant brownish to purple or light red, cylindrical about 95 μm width, female plant purplish red or yellowish red, cylindrical and to 100 μm in width.

Japanese name: Ushike-nori.

Etymology: "Ushike" from hair (*ke*) of cattle (*Ushi*).

Habitat: Epilithic, mainly intertidal, on rocks and woodwork, occasionally subtidal to 2 m deep, high littoral and spray zones of exposed sites, often upper intertidal boulder covering and dense patches on vertical faces, sometimes random covering on artificial bank in freshwater condition at mouth of river.

Seasonality: December to May, most luxuriantly March to April.

Geographical distribution: Inubosaki, Choshi-city to Urayasu, Urayasu-city at Boso Pen.; commonly distributed in the waters of both the Pacific Ocean and Sea of Japan in Japan, ranging from Formosa to Kurile

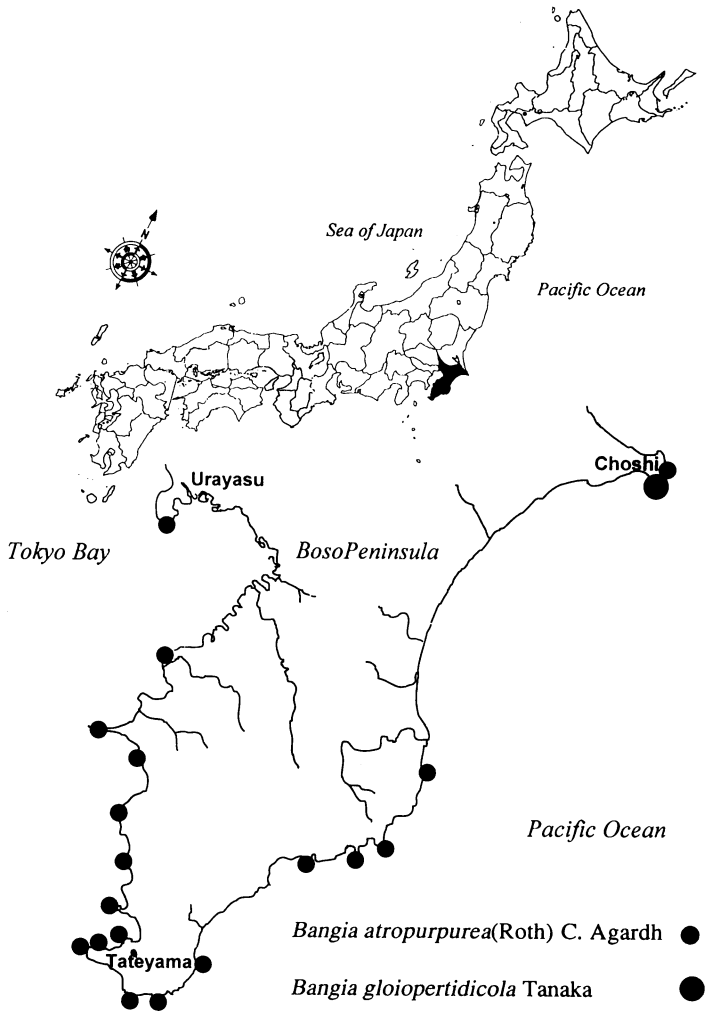

Fig. 1. Distribution map showing location of collection sites of *Bangia atropurpurea* (Roth) C. Agardh (small circles) and *Bangia gloiopeltidicola* Tanaka (large circle) at the coast of Boso Peninsula, Japan (1994–1996).

Islands, widely distributed in the world.

Type: Holotype. *Conferva atropurpurea* Roth, 1806: 208– 209, pl. VI.

Type locality: Weser River, Bremen, Germany.

Taxonomic synonyms: *Conferva fuscopurpurea* Dillwyn (1807), *Bangia fuscopurpurea* (Dillwyn) Lyngbye (1819), *Bangia versicor* Kützing (1843).

Representative specimen from Boso Pen.: CBM-BA 5001(Togawa, Choshi-city, Chiba Prefec., Boso Pen., M. Miyata, 16. i. 1996).

***Bangia gloiopeltidicola* Tanaka 1950**

(Fig. 1; Plate I, Fig. 3)

Thallus: Minute, simple, caespitose, flaccid, up to 2.0 cm long, yellowish red or light purple in colour, filaments at first composed of a single row of cells which are most quadrate with rounded angles, 10–20 μm thick, about 2 times as long as broad, later becoming polysiphonous by transverse divisions, ca. 50 μm thick, somewhat cuneate and usually arranged radial in transverse sections, chromatophore star-shaped and a central pyrenoid within it, asexual reproduction unknown, thalli dioecious.

Japanese name: Funorino-ushige.

Etymology: "Funorino-ushige" from some species of *Bangia* (*Ushike*) attached to *Gloiopeltis furcata* (*Funori*).

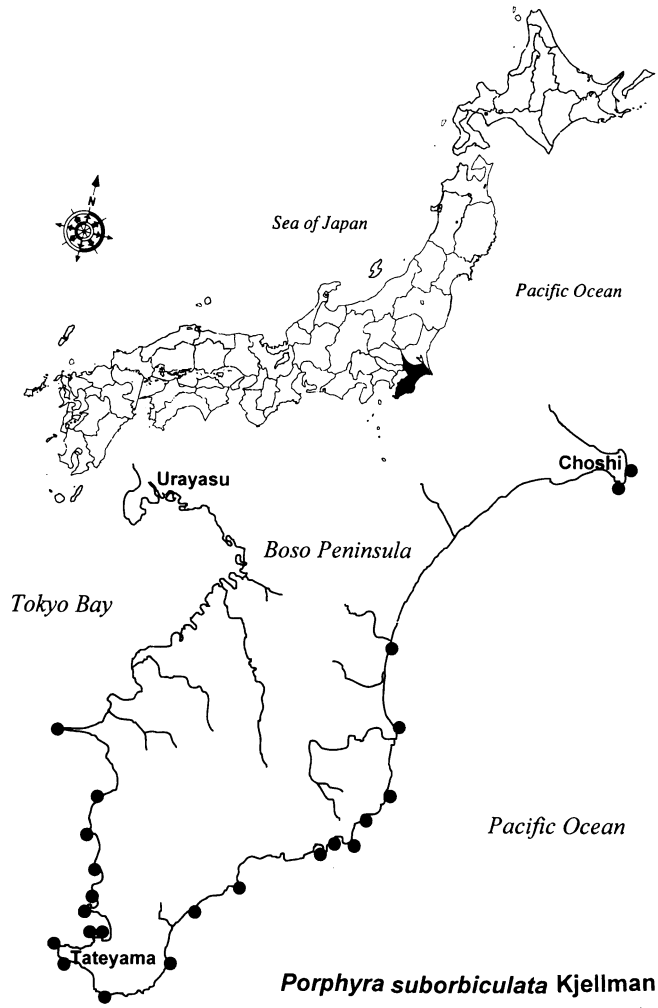

Fig. 2. Distribution map showing location of collection sites of *Porphyra suborbiculata* Kjellman (solid circles) at the coast of Boso Peninsula, Japan (1994-1996).

Habitat: Epiphytic growing on *Gloiopeltis furcata* (Post. et Ruprecht) J. Agardh.

Seasonality: December to March, most luxuriantly February to April.

Geographical distribution: Togawa, Choshi-city, Boso Pen. (Kominato, Amatsukominato-town in Tanaka (1950)); Endemic in Japan (Hokkaido Island to Kyushu Island).

Type: Holotype. *Bangia gloiopeltidicola* Tanaka, in Herbarium, Division of Biological Science, Graduate School of Science, Hokkaido Univ. (SAP); *In* Tanaka, T. 1950. On species of *Bangia* from Japan. Bot. Mag. Tokyo 63: 163–169.

Type locality: Awano, Nagato Prov. in Japan.

Representative specimen from Boso Pen.: CBM-BA 5002 (Togawa, Choshi-city, Chiba Prefec., Boso Pen., M. Miyata, 16. i. 1996).

Porphyra C. Agard 1824

Type species: Lectotype. *P. purpurea* (Roth) C. A. Agardh. 1824. (Synonym: *Ulva purpurea* Roth 1806, vide. Silva. Univ. Calif. Publ. Bot. 25: 261. 1952).

Porphyra suborbiculata Kjellman 1897

(Figs. 2 and 3; Plate I, Fig. 4)

Thallus: Membranaceous up to 4–6 cm height and width, generally orbiculate or round and sometimes reniform with dentate and inrolled margin, basal part cordate-reniform, glossy black or deep purple to brown in colour; monostromatic, 52–57 μm

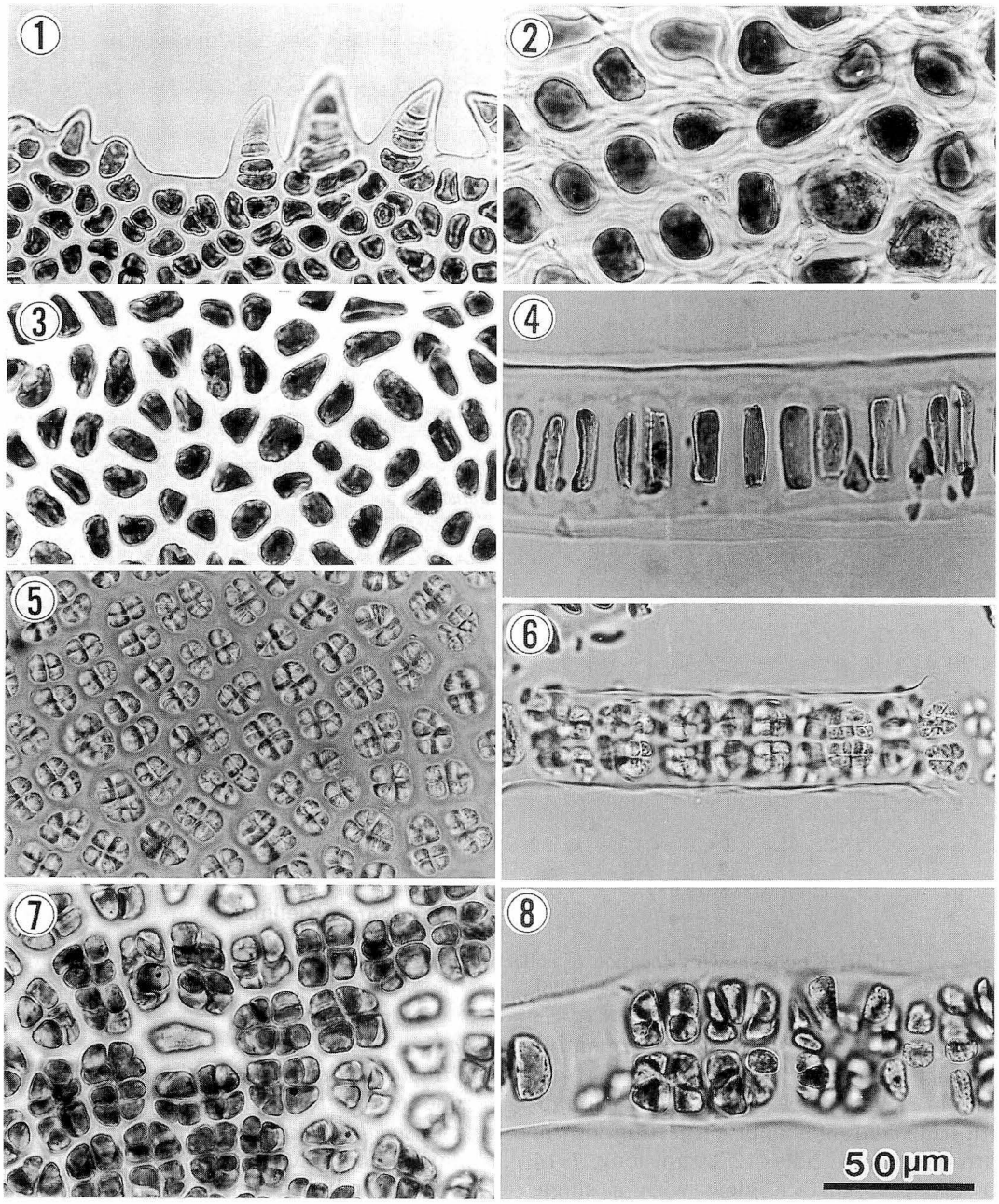

Fig. 3. *Porphyra suborbiculata* Kjellman CBM-BA 5003 (Takeoka, Futtsu-city, Boso Pen.,M.Miyata, 8.iv. 1996). **1.** Marginal portion of thallus, showing microscopic dentate margin (serration). **2.** Basal cells (19–31 μm long, 14–19 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (12–20 μm long, 7–14 μm wide). **4.** Transverse section of vegetative part (52–57 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 4 layers (c/4 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 8 cells (a/2, b/4). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 4 layers (c/4). Scale bar: 50 μm.

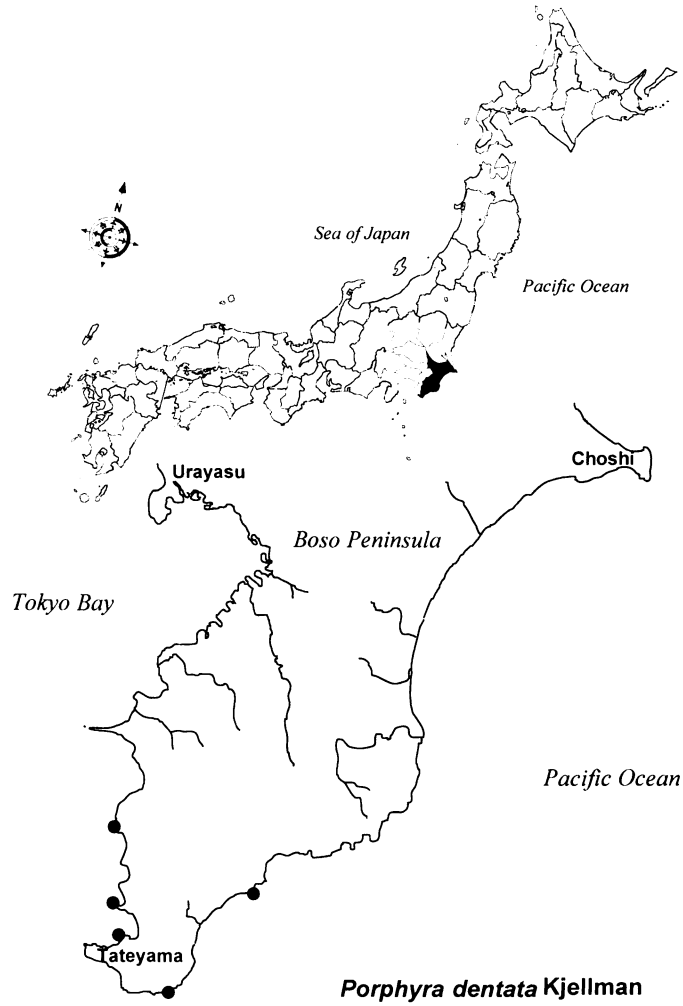

Fig. 4. Distribution map showing location of collection sites of *Porphyra dentata* Kjellman (solid circles) at the coast of Boso Peninsula, Japan (1994–1996).

thickness in surface view at the vegetative portion, basal cells (19–31 μm long, 14–19 μm wide) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (12–20 μm long, 7–14 μm wide) in surface view with a single stellate chromatophore; monoecious; spermatangial patches marginal stripe shaped; 64 spermatia by division of formula 64 [a/4, b/4, c/4]; 32 carpospores by division of formula 32 [a/2, b/4, c/4].

Japanese name: Maruba-amanori; Maruba; Goishi and Gaeloppa (Kisarazu-city area); Iwanori in generally speaking.

Etymology: "Maruba" from a appearance of thallus as circle, *Maru*, and "ba" from a leaf, *ha*.

Habitat: Usually epilithic in intertidal zone to sublittoral zone to 3 m deep.

Seasonality: Late September or October to May (autumn to spring), most luxuriantly from December to April.

Geographical distribution: Inubo-saki, Choshi-city to Futtsu-misaki, Futtsu-city, scacely in Tokyo Bay.

Type: Holotype: *Porphyra suborbiculata* Kjellman (Goto, Nagasaki Prefec. 25. v. 1881, J. Petersen collected), in Kjellman Herbarium, Univ. Uppsala; *In* Kjellman, F. R. 1897. Japanska Arter Af Slägtet *Porphyra*. Bihang Till Kongl. Svenska Vet.-Akad. Handl. 23(4): 1–34.

Type locality: Goto, Nagasaki Prefec., Kyushu Island in Japan.

Representative specimen from Boso Pen.: CBM-BA 5003 (Takeoka, Futtsu-city, Chiba Prefec., Boso Pen., M. Miyata, 8. iv. 1996).

***Porphyra dentata* Kjellman 1897**

(Figs. 4 and 5; Plate I, Fig. 5)

Thallus: Membranaceous up to 25 cm height and 2 cm width, lanceolate to linear lanceolate or sometimes ovate with dentate entire, purpule to brown in colour; monostromatic, 76–79 μm thickness in surface view at the vegetative portion, basal cells (21–31 μm long, 14–19 μm wide) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (11–20 μm long, 9–11 μm wide) in surface view with a single stellate chromatophore; dioecious; spermatangial area marginal stripe shaped; 128 spermatia by division of formula 128 [a/4, b/4, c/8]; 16 carpospores by division of formula 16 [a/2, b/2, c/4].

Japanese name: Oni-amanori; Iwanori in generally speaking.

Etymology: "Oni" from comparing microscopic marginal dentation of thallus to horn of Oni (devil with horns). Etymological origin is not clear.

Habitat: Usually epilithic in intertidal zone to sublittoral zone to 1 m deep.

Seasonality: November to March (autumn to spring), most luxuriantly from December to March.

Geographical distribution: Niemon-jima, Kamogawa-city to Takeoka, Futtsu-city, scacely in Tokyo Bay.

Type: *Porphyra dentata* Kjellman (Amakusa, Kumamoto Prefec. 9. vi. 1881, J. Petersen collected) in Kjellman Herbarium, Univ. Uppsala; *In* Kjellman, F.R. 1897. Japanska Arter Af Slägtet *Porphyra*. Bihang Till Kongl. Svenska Vet. -Akad. Handl. 23 (4): 1–34.

Type locality: Amakusa, Kumamoto Prefec., Kyushu Island in Japan.

Representative specimen from Boso Pen.: CBM-BA 5004 (Nojima-zaki, Tateyama-city, Chiba Prefec., Boso Pen., M. Miyata, 12. iii. 1996).

***Porphyra yezoensis* Ueda 1932**

(Figs. 6 and 7; Plate II, Fig. 1)

Thallus: Membranaceous up to 15 cm height and 6 cm width, elliptical, elongated elliptical, oval or sometimes round in shape, with entire, deep purpule to brown in colour; monostromatic, 36–39 μm thickness in surface view at the vegetative portion, basal cells (24–33 μm long, 17–19 μm wide) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (12–17 μm long, 7–10 μm wide) in surface view with a single stellate chromatophore; monoecious; spermatangial area patches intercalary, stripe shaped; 128 spermatia by division of formula 128 [a/4, b/4, c/8]; 16 carpospores by division of formula 16 [a/2, b/2, c/4].

Japanese name: Susabi-nori.

Etymology: "Susabi" from a beach name, Beach of Susabi of Ainu.

Habitat: Usually epilithic intertidal zone to sublittoral zone to 1 m deep and sometimes on other seaweeds.

Seasonality: October to April (autumn to spring), most luxuriantly from December to February.

Geographical distribution: Inubo-saki, Choshi-city to Urayasu at mouth of Edogawa River in Tokyo Bay.

Type: Holotype: *Porphyra yezoensis* Ueda (Hakodate, Hokkaido), in Herbarium, Lab. of Algal Cultivation, Tokyo Univ. Fisheries; *In* Ueda, S. 1932. "Nihonsan Amanori-zoku no Bunruigaku-teki-Kenkyu" (Systematic study of the genus *Porphyra* in Japan). Suiko-Kenkyu-Hokoku, 28 (1): 1–45, pls. I–XXIV.

Type locality: Hakodate, Hokkaido in Japan.

Representative specimen from Boso Pen.: CBM-BA 5005 (Kimigahama, Choshi-city, Chiba Prefec. Boso Pen., M. Miyata, 23. iii. 1996).

***Porphyra yezoensis* Ueda f. *narawaensis* Miura 1984**

(Fig. 8; Plate II, Fig. 2)

Thallus (*cultivated*): Membranaceous up to 45 cm height and 7 cm width, elliptical, elongated elliptical to linear in shape with entire margine, deep purpule to brown in colour; monostromatic, 26–30 μm thickness in surface view at the vegetative portion, basal cells (26–33 μm long, 14–17 μm wide) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (19–25 μm long, 10–19 μm wide)

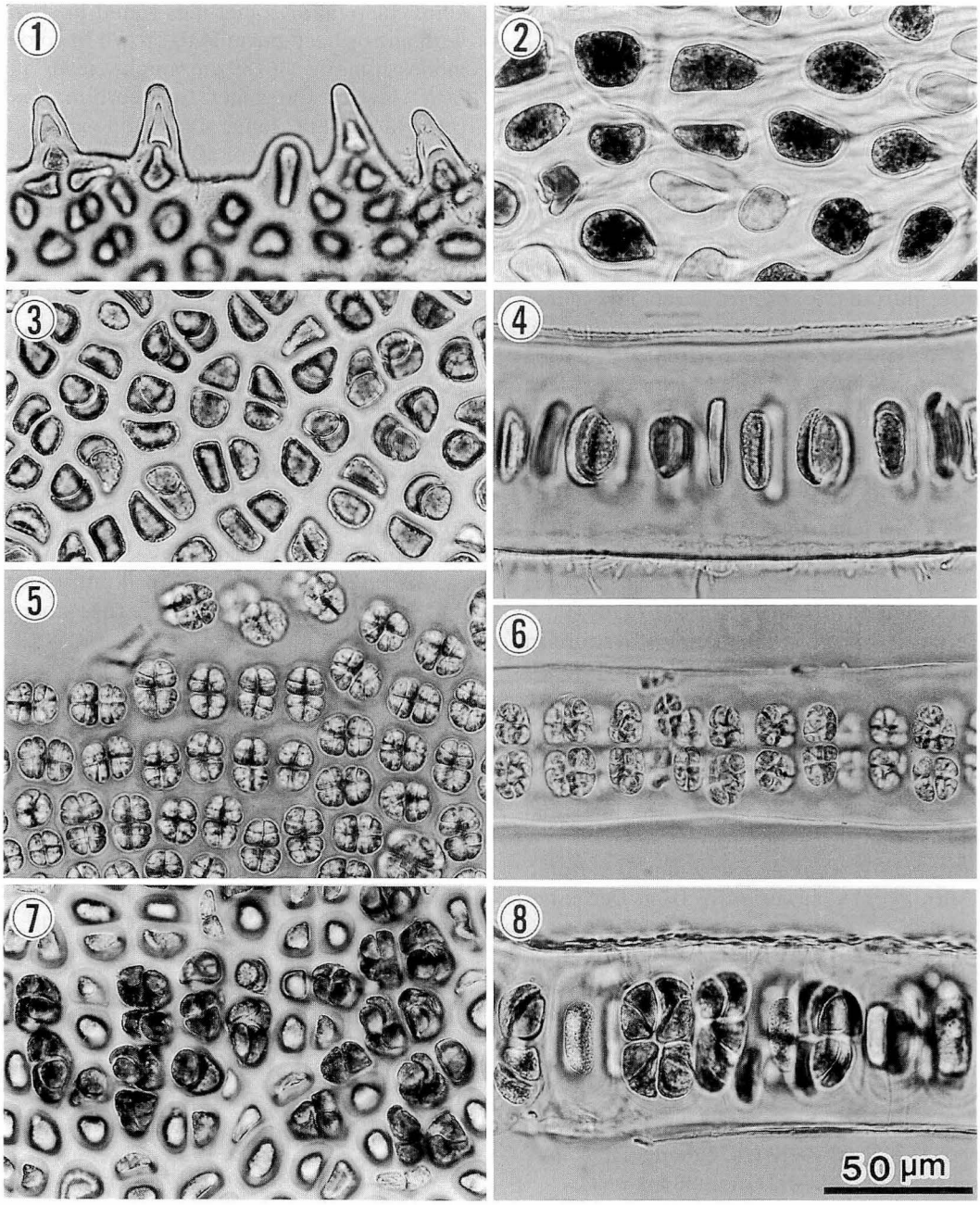

Fig. 5. *Porphyra dentata* Kjellman CBM-BA 5004 (Nojima-zaki, Shirahama-town, Boso Pen., M. Miyata, 12. iii. 1996). **1.** Marginal portion of thallus, showing microscopic dentate margin (serration). **2.** Basal cells (21–31 μm long, 14–19 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (11–20 μm long, 9–11 μm wide). **4.** Transverse section of vegetative part (76–79 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 8 layers (c/8 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 4 cells (a/2, b/2). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 4 layers (c/4). Scale bar: 50 μm.

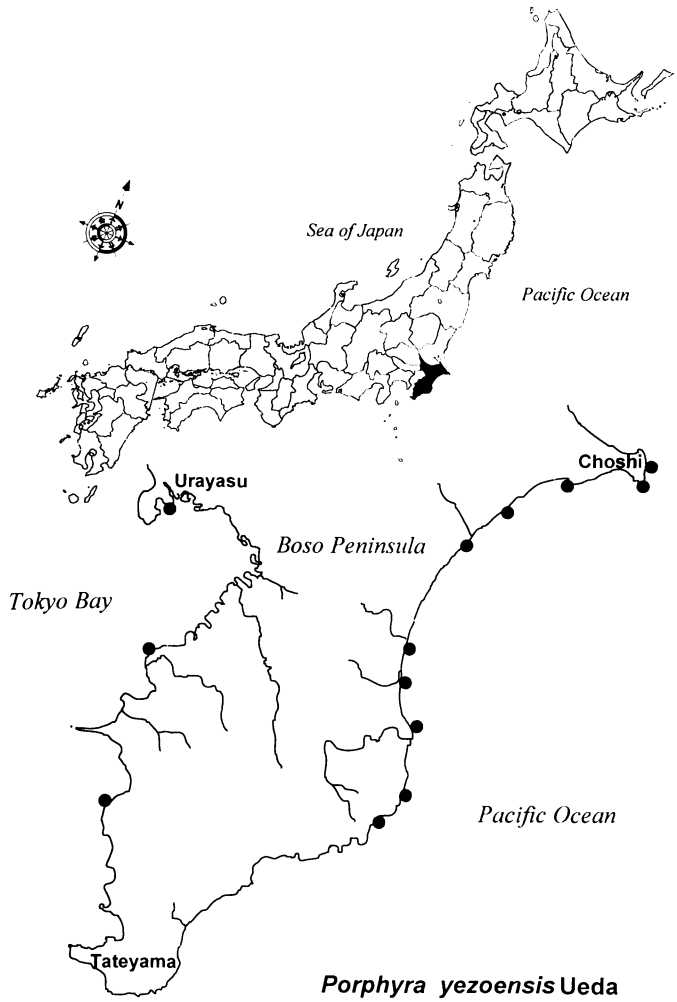

Fig. 6. Distribution map showing location of collection sites of *Porphyra yezoensis* Ueda (solid circles) at the coast of Boso Peninsula, Japan (1994-1996).

in surface view with a single stellate chromatophore; monoecious; spermatangial area patches intercalary, stripe shaped; 128 spermatia by division of formula 128 [a/4, b/4, c/8]; 16 carpospores by division of formula 16 [a/2, b/2, c/4].

Japanese name: Narawasusabi-nori.

Etymology: "Narawa" from a place name, Narawa, Sodegaura-city at present in Chiba Prefec., as a place of first detection of original specimens as *P. yezoensis* f. *narawaensis*.

Habitat: As it is only for cultivation, there is not reliable information on its living on natural substrata for its difficulty to descrete from *P. yezoensis* Ueda.

Seasonality: Cultivation in November to March (autumn to spring).

Geographical distribution: Cultivation at the coast of Kazusaminato, Futtsu-city to Urayasu, Urayasu-city in Tokyo Bay.

Type: Holotype: *Porphyra yezoensis* Ueda f. *narawaensis* Miura (Ushigome, Kisarazu-city, Chiba Prefec., 7. ii. 1973 and 23. iii. 1973), in Herbarium, Lab. of Algal Cultivation, Tokyo Univ. Fisheries; *In* Miura, A. 1984. A new variety and a new form of *Porphyra* (Bangiales, Rhodophyta) from Japan: *Porphyra tenera* Kjellman var. *tamatsuensis* Miura, var. nov. and *P. yezoensis* Ueda form. *narawaensis* Miura, form. nov. J. Tokyo Univ. Fish. 71: 1–37.

Type locality: Ushigome, Kiasarazu-city,

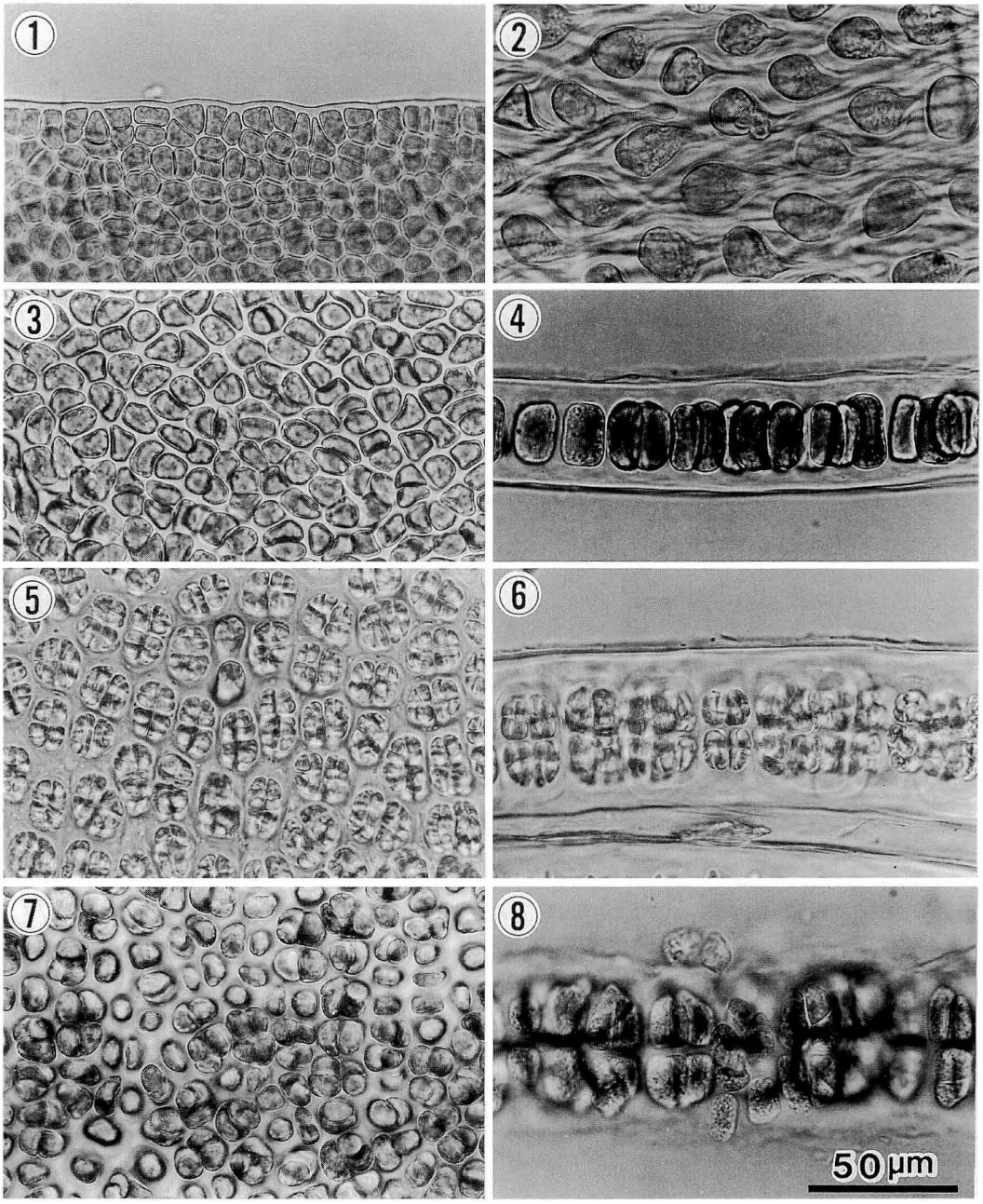

Fig. 7. *Porphyra yezoensis* Ueda CBM-BA 5005 (Kimigahama, Choshi-city, Boso Pen., M. Miyata, 23. iii. 1996). **1.** Marginal portion of thallus, showing microscopic entire margin. **2.** Basal cells (24–33 μm long, 17–19 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (12–17 μm long, 7–10 μm wide). **4.** Transverse section of vegetative part (36–40 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 8 layers (c/8 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 4 cells (a/2, b/2). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 4 layers (c/4). Scale bar: 50 μm.

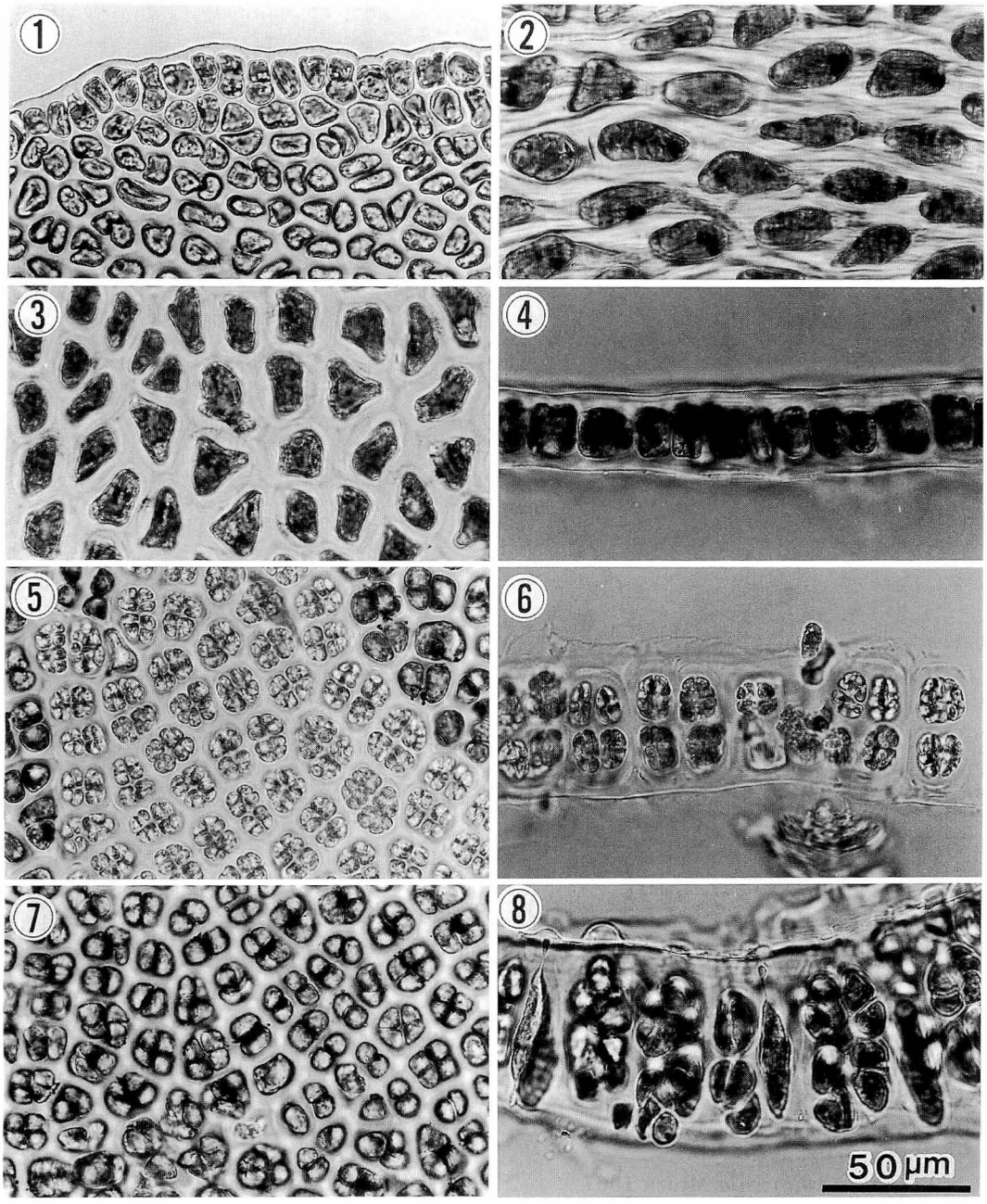

Fig. 8. *Porphyra yezoensis* Ueda f. *narawaensis* Miura CBM-BA 5006 (Amaha, Minato, Futtsu-city, Boso Pen., M. Miyata, 7. ii. 1995). **1.** Marginal portion of thallus, showing microscopic entire margin. **2.** Basal cells (26–33 μm long, 14–17 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (19–25 μm long, 12–14 μm wide). **4.** Transverse section of vegetative part (26–30 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 8 layers (c/8 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 4 cells (a/2, b/2). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 4 layers (c/4). Scale bar: 50 μm.

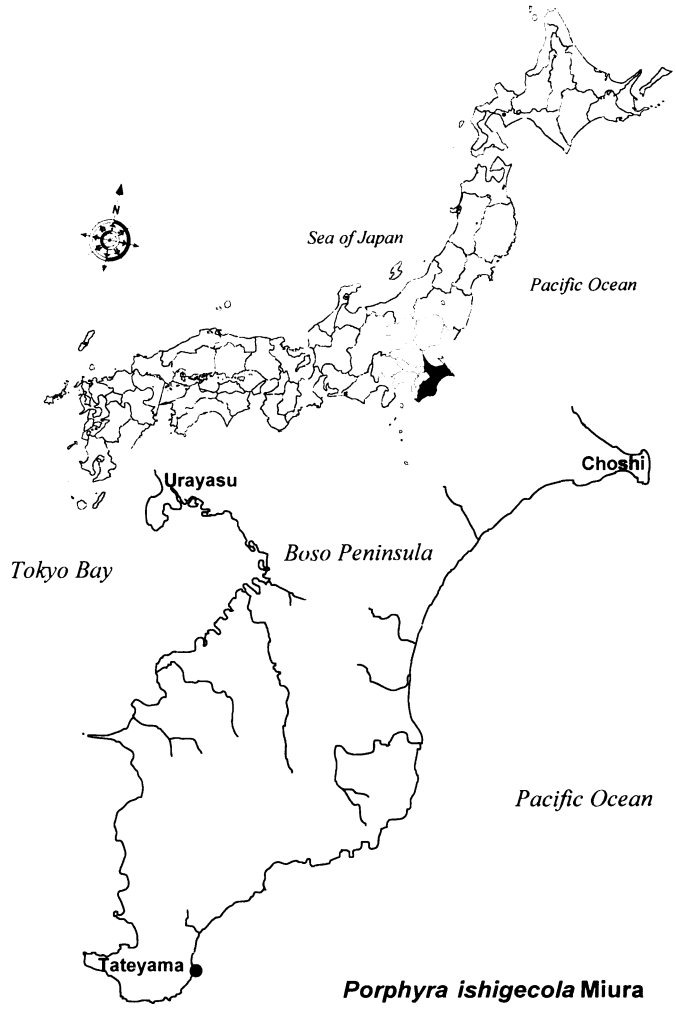

Fig. 9. Distribution map showing location of collection sites of *Porphyra ishigecola* Miura (solid circle) at the coast of Boso Peninsula, Japan (1994–1996).

Chiba Prefec. in Japan.

Representative specimen from Boso Pen.: CBM-BA 5006 (Amaha, Minato, Futtsu-city, Chiba Prefec.,Boso Pen., M.Miyata, 7. ii. 1995/ Cultivated specimens).

***Porphyra ishigecola* Miura 1967**

(Figs. 9 and 10; Plate II, Figs. 3 and 4)

Thallus: Membranaceous up to 2 cm height and width, generally orbiculate or round sometimes reniform with entire margine, deep purpule to brown in colour; monostoromatic, 48–52 μm thickness in surface view at the vegetative portion, basal cells (19–29 μm long, 14–17 μm width) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (14–25 μm long, 11–13 μm width) in surface view with a single stellate plastid; monoecious; spermatangial patches intercalary, stripe shaped, 128 spermatia by division of formula 128 [a/4, b/4, c/8]; 16 carpospore by division of formula 16 [a/2, b/2, c/4].

Japanese name: Benten-amanori; Matsuba-nori (Boso Pen.)

Etymology: "Benten" from *Benzaiten*, the Goddess of good fortune, at Enoshima as type locality; "Matsuba" from a manner that *P.ishigecola* adhesives at ramifying point as a folk branch, *Matsuba*, of seaweeds such as *Ishige okamurae*, and *Matsuba* from a leaf of pine trees.

Habitat: Epiphytic on principally *Ishige*

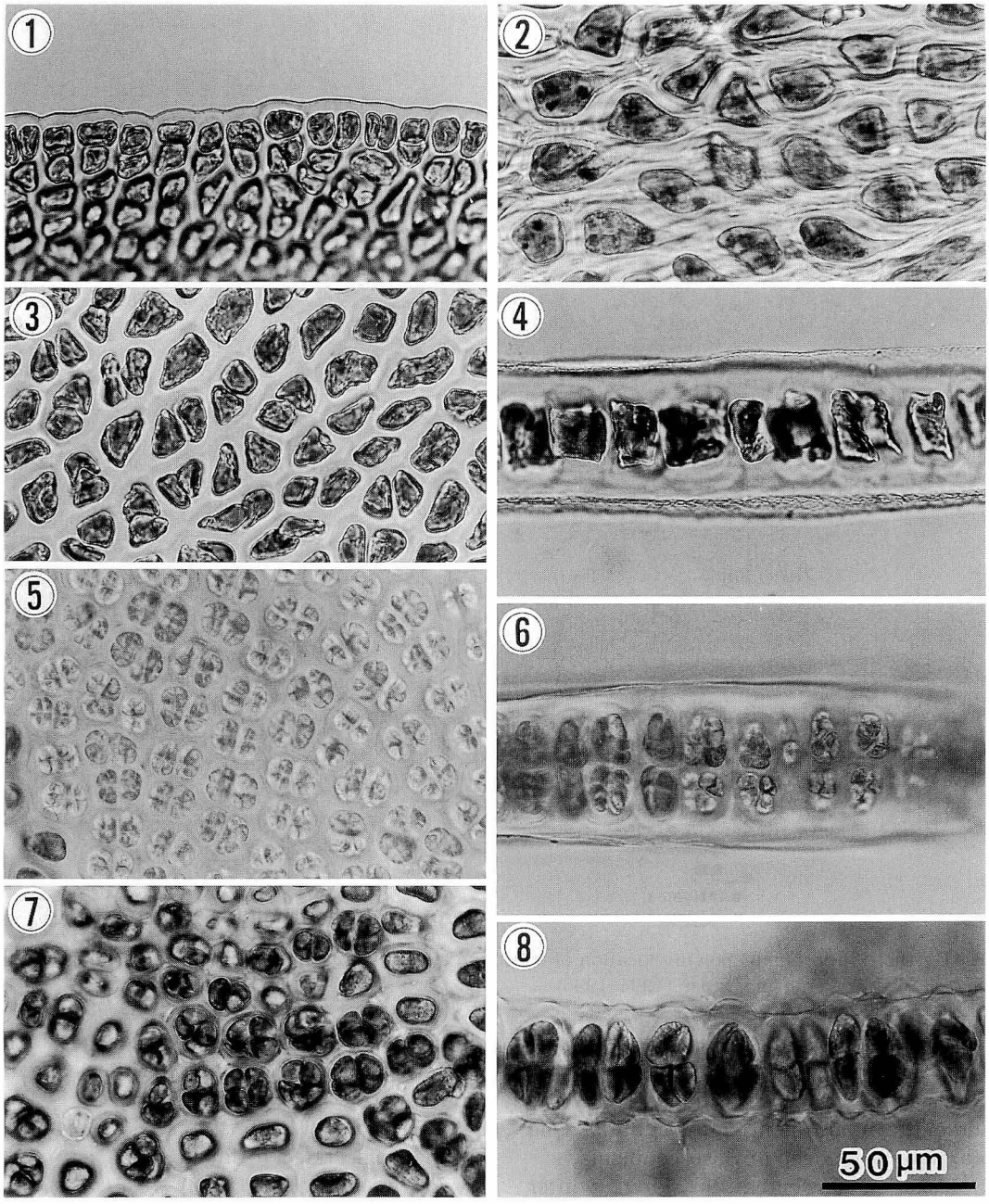

Fig. 10. *Porphyra ishigecola* Miura CBM-BA 5007 (Chikura, Chikura-town, Boso Pen., M. Miyata, 25. ii. 1996). **1.** Marginal portion of thallus, showing microscopic entire margin. **2.** Basal cells (19–29 μm long, 14–17 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (14–25 μm long, 11–13 μm wide). **4.** Transverse section of vegetative part (48–52 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 8 layers (c/8 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 4 cells (a/2, b/2). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 4 layers (c/4). Scale bar: 50 μm.

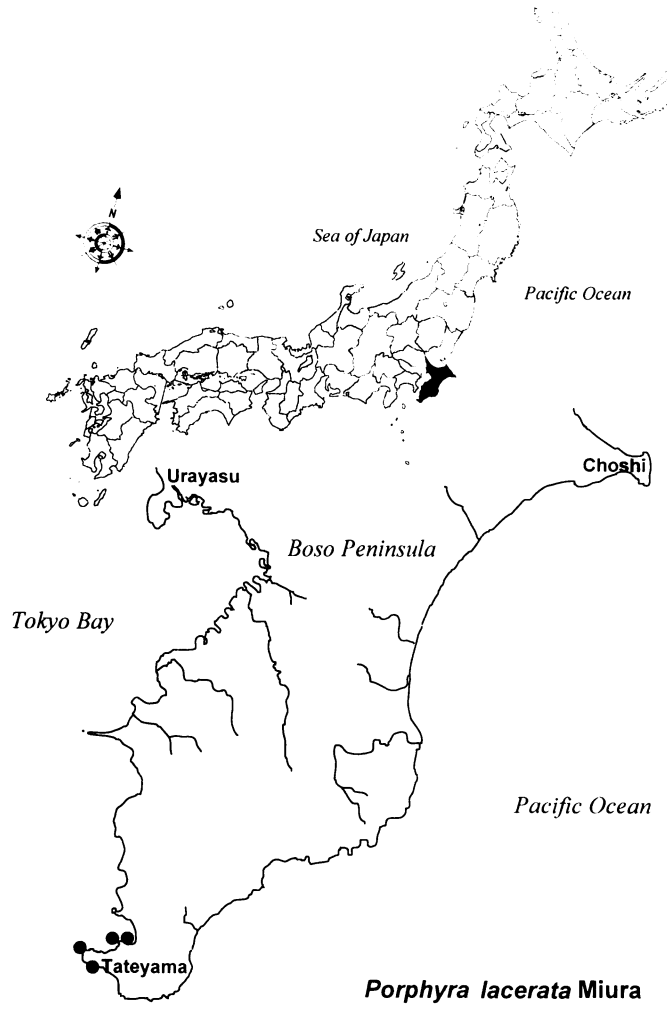

Fig. 11. Distribution map showing location of collection sites of *Porphyra lacerata* Miura (solid circles) at the coast of Boso Peninsula, Japan (1994–1996).

okamurae Yendo and sometimes other seaweeds, *Chondrus giganteus* Yendo, *C. ocellatus* Holmes and *C. verrucosus* Mikami, and in the middle intertidal zone to upper subtidal zone up to about 2 m deep at Boso Peninsula.

Seasonality: December to March (winter to spring), most luxuriantly December to February.

Geographical distribution: Chikura, Chikura-town, southern part of Boso peninsula facing to Pacific Ocean in this study; Endemic in Japan.

Type: Holotype: *Porphyra ishigecola* Miura (Enoshima, Fujisawa-city, Kanagawa Prefec., A. Miura, 19. iii. 1961), in Herbarium, Lab. of Algal Cultivation, Tokyo Univ. Fisheries; *In* Miura, A. 1967. Two new species and a new record of *Porphyra* from Enoshima, Sagami Bay. J. Tokyo Univ. Fish. 53: 65-71.

Type locality: Enoshima, Fujisawa-city, Kanagawa Prefec. in Japan.

Representative specimen from Boso Pen.: CBM-BA 5007 (Chikura, Chikura-town, Chiba Prefec., Boso Pen., M. Miyata, 25. ii. 1996).

***Porphyra lacerata* Miura 1967**

(Figs. 11 and 12; Plate II, Fig. 5)

Thallus: Membranaceous up to 1 cm height and width, ovate or round sometimes elliptical or reniform with entire margine and conspicuous stipe up to ca. 1 mm, purpule to brown in colour; monostoromatic, 24–29 μm thickness in surface view at the vegetative

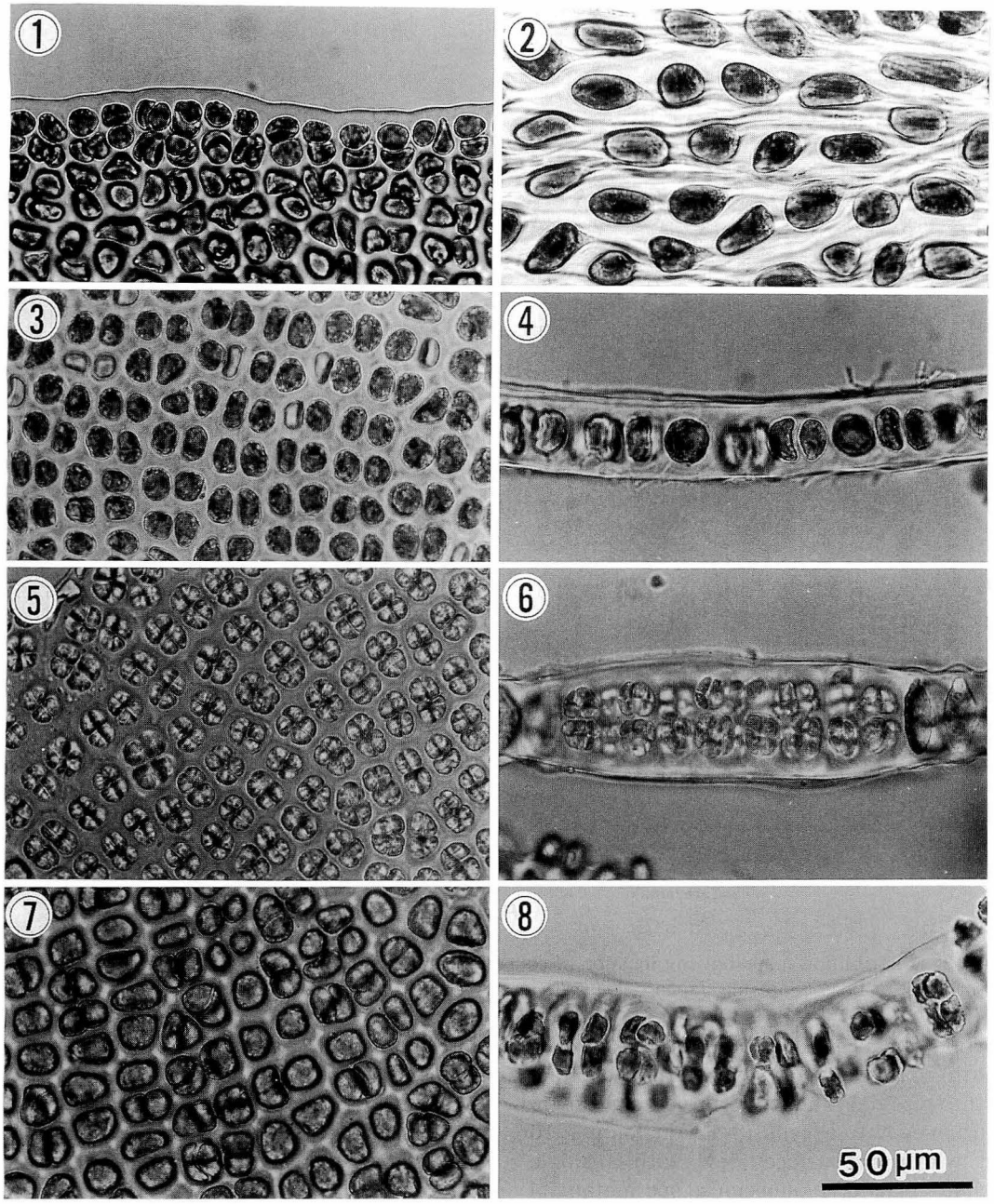

Fig. 12. *Porphyra lacerata* Miura CBM-BA 5008 (Suno-saki, Tateyama-city, Boso Pen., M.Miyata, 21.iii. 1996). **1.** Marginal portion of thallus, showing microscopic entire margin. **2.** Basal cells (21–38 μm long, 11–14 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (10–14 μm long, 7–10 μm wide). **4.** Transverse section of vegetative part (24–29 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 4 layers (c/4 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 2 cells (a/1, b/2). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 2 layers (c/2). Scale bar: 50 μm.

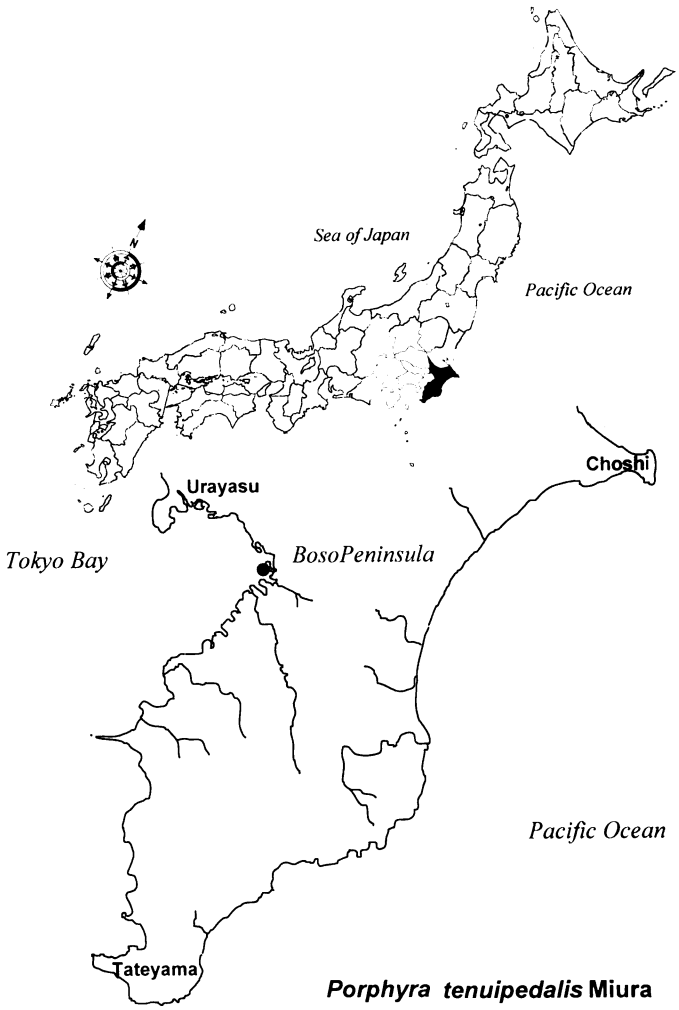

Fig. 13. Distribution map showing location of collection sites of *Porphyra tenuipedalis* Miura (solid circle) at the coast of Boso Peninsula, Japan (1994–1997).

portion, basal cells (17–38 μm long, 10–14 μm width) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (8–12 μm long, 7–10 μm width) in surface view with a single stellate plastid; monoecious; spermatangial patches intercalary, stripe shaped, 64 spermatia by division of formula 64 [a/4, b/4, c/4]; 4 carpospores by division of formula 4 [a/1, b/2, c/2].

Japanese name: Yabure-amanori

Etymology: "Yabure" from laceration along the spermatangial paches on mature foliose thallus.

Habitat: Principaly epiphytic on seaweeds as *Ishige okamurae* Yendo with *P. suborbiculata* and *Myelophycus simplex* (Harvey) Papenfuss, in the middle to upper intertidal zone at Boso Peninsula.

Seasonality: December to March (winter to spring), luxuriantly December to February.

Geographical distribution: Tateyama Bay and its adjacent waters at southern part of Boso Pen.; Endemic in Korea and Japan.

Type: Holotype: *Porphyra lacerata* Miura (Enoshima, Fujisawa-city, Kanagawa Prefec., A. Miura, 27. ii. 1962), in Herbarium, Lab. of Algal Cultivation, Tokyo Univ. Fisheries; *In* Miura, A. 1967. Two new species and a new record of *Porphyra* from Enoshima, Sagami Bay. J. Tokyo Univ. Fish. 53: 65–71.

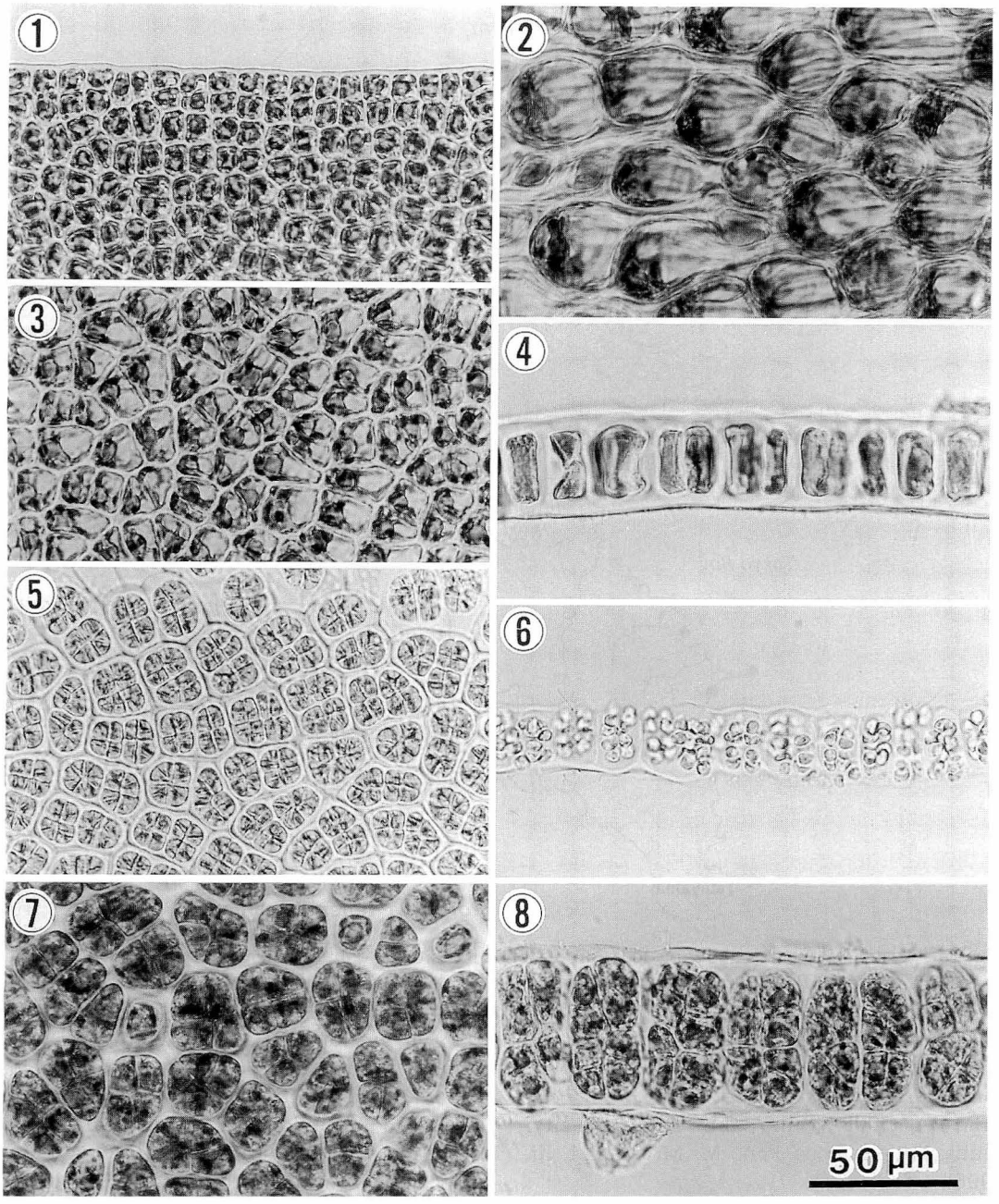

Fig. 14. *Porphyra tenuipedalis* Miura CBM-BA 5009 (Chiba Port Beach, Chiba-city, Boso Pen., N. Kikuchi, 8. ii. 1997). **1.** Marginal portion of thallus, showing microscopic entire margin. **2.** Basal cells (29–43 μm long, 21–29 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (13–26 μm long, 12–17 μm wide). **4.** Transverse section of vegetative part (33–36 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 8 layers (c/8 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 4 cells (a/2, b/2). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 4 layers (c/4). Scale bar: 50 μm.

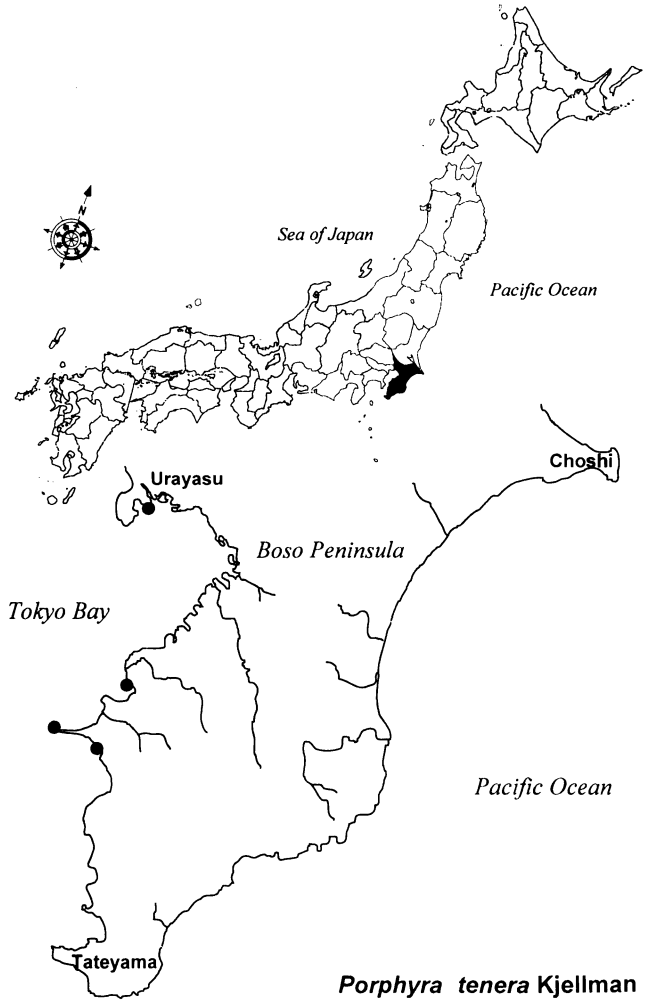

Fig. 15. Distribution map showing location of collection sites of *Porphyra tenera* Kjellman (solid circles) at the coast of Boso Peninsula, Japan (1994–1996).

Type locality: Enoshima, Fujisawa-city, Kanagawa Prefec. in Japan.

Representative specimen from Boso Pen.: CBM-BA 5008 (Suno-saki, Tateyama-city, Chiba Prefec., Boso Pen., M. Miyata, 21. iii. 1996).

***Porphyra tenuipedalis* Miura 1961**

(Figs. 13 and 14; Plate III, Fig. 1)

Thallus: Membranaceous up to 8–50 cm long and 2–9 cm width, oblanceolate or lanceolate with entire margine and foldings, wedge-shaped base with a distinct stalk (stipe), purple to deeply reddish-brown and sometimes crimson in colour; monostoromatic, 33–36 μm thickness in surface view at the vegetative portion, basal cells (29–43 μm long, 21–29 μm width) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (13–26 μm long, 12–17 μm width) in surface view with a single stellate plastid; monoecious; spermatangial patches marginally narrow stripe shaped, 128 spermatia by division of formula 128 [a/4, b/4, c/8]; 16 carpospores by division of formula 16 [a/2, b/2, c/4].

Japanese name: Kaigara-amanori.

Etymology: "Kaigara" from shell for *P. tenuipedalis* invariable growing.

Habitat: Growing only on dead bivalve shells deposited on sandy and/or muddy bottom in the subtidal zone in Tokyo Bay.

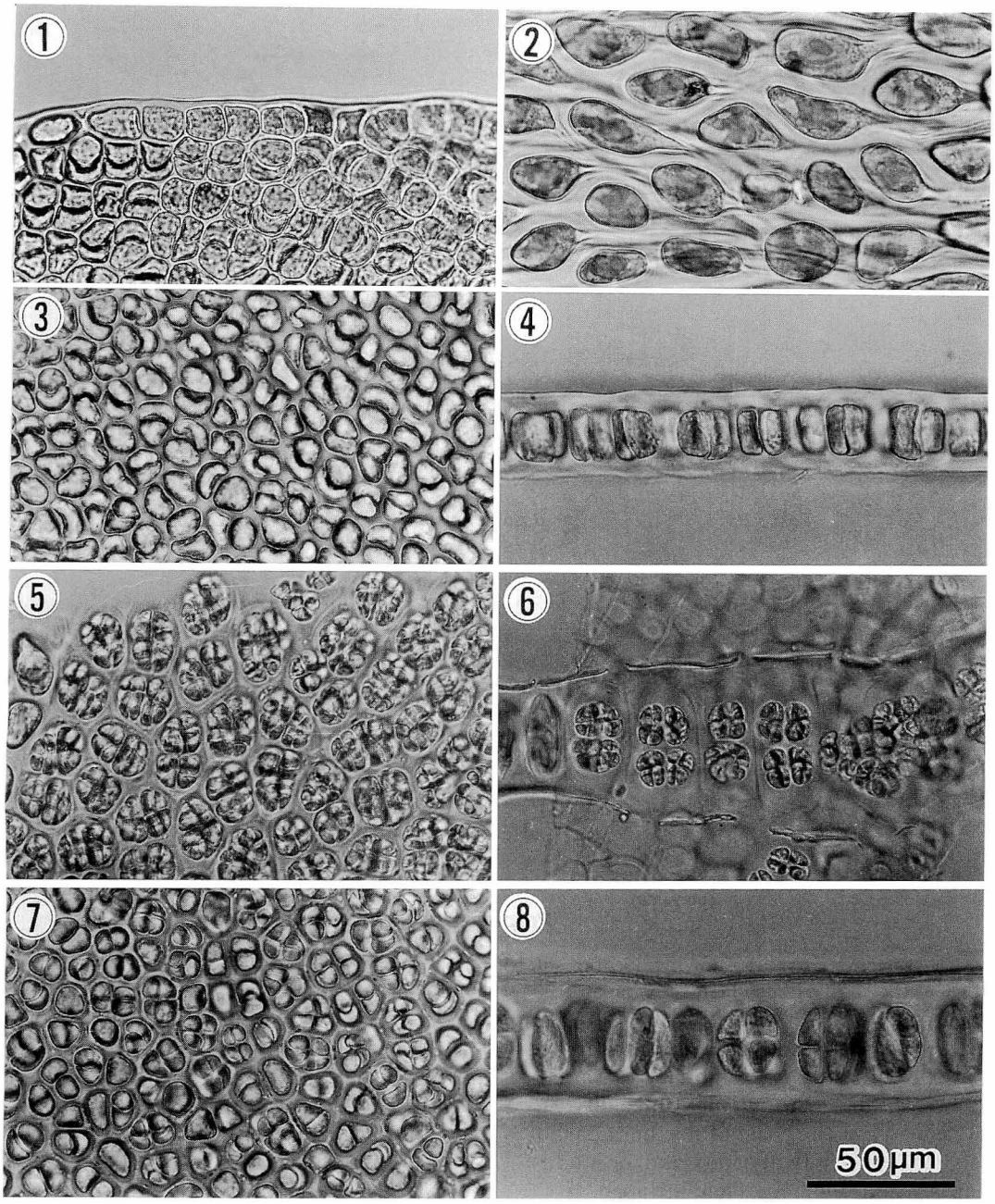

Fig. 16. *Porphyra tenera* Kjellman CBM-BA 5010 (Futtsu-misaki, Futtsu-city, Boso Pen., M. Miyata, 15. iii. 1996). **1.** Marginal portion of thallus, showing microscopic entire margin. **2.** Basal cells (23–38 μm long, 14–17 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (10–14 μm long, 8–12 μm wide). **4.** Transverse section of vegetative part (26–29 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 4 layers (c/4 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 4 cells (a/2, b/2). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 2 layers (c/2). Scale bar: 50 μm.

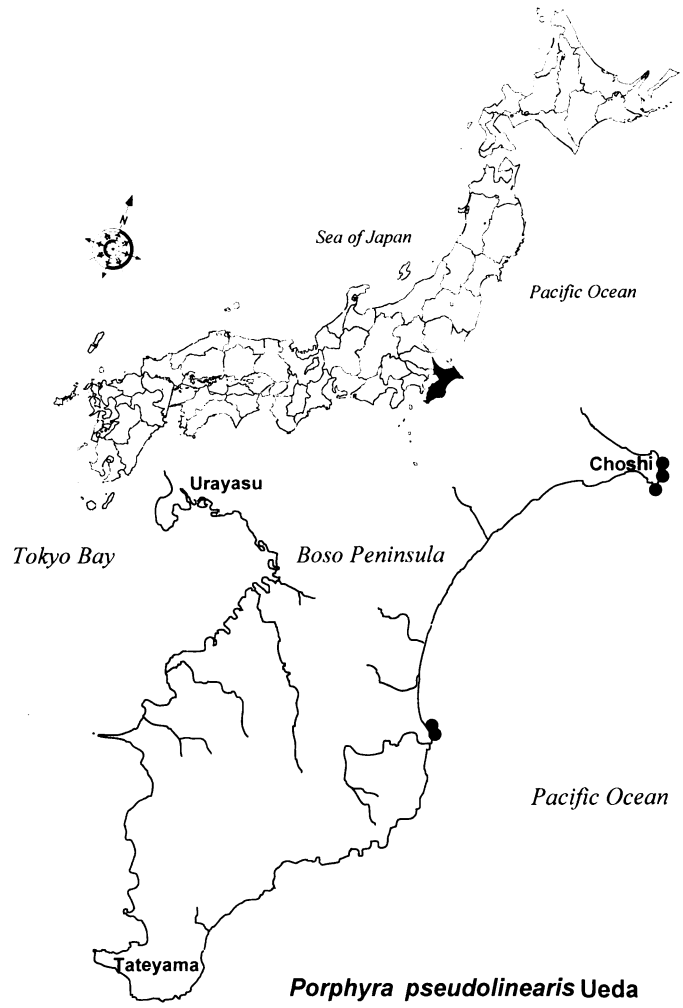

Fig. 17. Distribution map showing location of collection sites of *Porphyra pseudolinearis* Ueda (solid circles) at the coast of Boso Peninsula, Japan (1994–1996).

Seasonality: December to April (winter to spring), luxuriantly from January to March.

Geographical distribution: Chiba-city to Urayasu-city at the coast of northern part of Boso Pen., especially at sandy and/or muddy calm bay and inlet.; Endemic in Japan.

Type: Holotype: *Porphyra tenuipedalis* Miura (Haneda, Tokyo-to, A. Miura. 6. iii. 1958), in Herbarium, Lab. of Algal Cultivation, Tokyo Univ. Fisheries; *In* Miura, A. 1961. A new species of *Porphyra* and its *Conchocelis*-phase in nature. J. Tokyo Univ. Fish. 47: 305–311.

Type locality: Haneda, Ohta-ku, Tokyo-to in Japan (in Tokyo Bay).

Representative specimen from Boso Pen.: CBM-BA 5009 (Chiba Port Beach, Chiba-city, Chiba Prefec., Boso Pen., N. Kikuchi, 8. ii. 1997).

***Porphyra tenera* Kjellman 1897**

(Figs. 15 and 16; Plate III, Fig. 2.)

Thallus: Membranaceous up to 8–10 cm height and 3 cm width, mostly ovlanceolate or elliptical or linear lanceolate with entire margin and foldings, pale red to salmon pink in colour; monostromatic, 26–29 μm thickness in surface view at the vegetative portion, basal cells (23–38 μm long, 14–17 μm wide) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (10–14 μm long, 8–12 μm width) in surface view with a single stel-

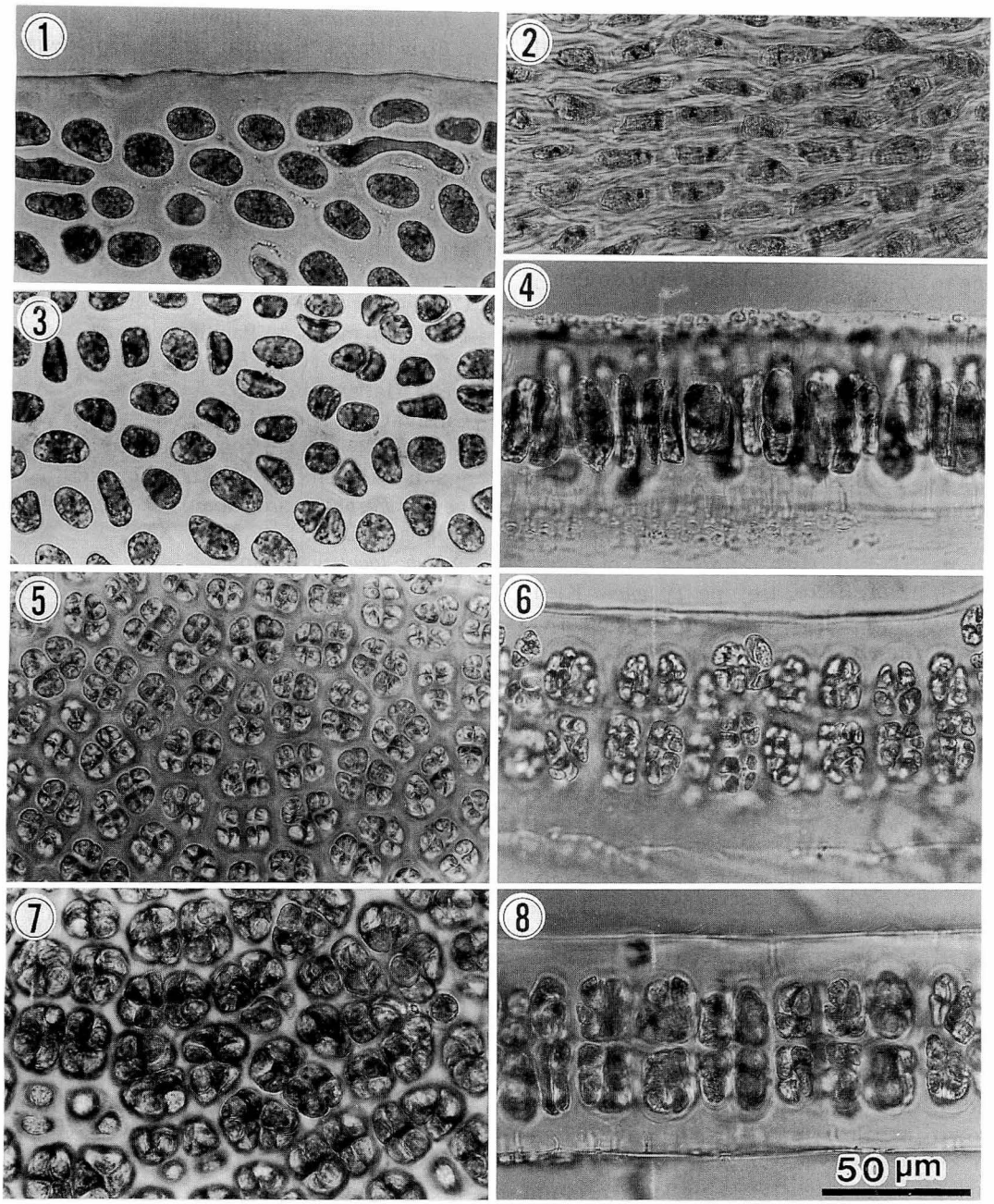

Fig. 18. *Porphyra pseudolinearis* Ueda CBM-BA 5011 (Inubo-saki, Choshi-city, Boso Pen., M. Miyata, 16. ii. 1995). **1.** Marginal portion of thallus, showing microscopic entire margin. **2.** Basal cells (18–24 μm long, 7–11 μm wide) projecting a rhizoidal filament in surface view. **3.** Vegetative cells in surface view, showing polygonal cell (13–20 μm long, 8–12 μm wide). **4.** Transverse section of vegetative part (62–67 μm thickness), showing quadrate cell with rounded angles. **5.** Spermatangial area of surface view, showing each spermatangium composed of 16 cells (a/4, b/4). **6.** Transverse section of a spermatangial area, showing spermatangia composed of 8 layers (c/8 stages). **7.** Carposporangial area of surface view, showing each carposporangium composed of 8 cells (a/2, b/4). **8.** Transverse area of a carposporangial area, showing carposporangia composed of 4 layers (c/4). Scale bar: 50 μm.

late chromatophore; monoecious; spermatangial patches marginally narrow stripe shaped or intercally splashed; 64 spermatia by division of formula 64 [a/4, b/4, c/4]; 8 carpospores by division of formula 8 [a/2, b/2, c/2].

Japanese name: Asakusa-nori.

Etymology: "Asakusa" from a place name, *Asakusa*, since *Edo Age*.

Habitat: Usually epilithic in intertidal zone to upper sublittoral zone at Boso Pen.

Seasonality: December to May (winter to spring), most luxuriantly from December to March.

Geographical distribution: Isonezaki, Futtsu-city to Urayasu, Urayasu-city in Tokyo Bay.

Type: Holotype: *Porphyra tenera* Kjellman (Japan, J. Petersen collected); *In* Kjellman, F. R. 1897. Japanska Arter Af Slägtet *Porphyra*. Bihang Till Kongl. Svenska Vet.-Akad. Handl. 23 (4): 1–34.; Isotype: *P. tenera* Kjellman (Omori, Tokyo Bay, Japan, 1880; Det. F. R. Kjellman, Misit. Farlow, 8. iii. 1901), Authentic specimens: Misit Farlow, Determ. F. R. Kjellman, 8. iii. 1901 with K. Yendo's sign "male/female examine 1912", in Kjellman Herbarium, Univ. Uppsala.

Type locality: Japan (Omori, Tokyo-to, Tokyo Bay?).

Representative specimen from Boso Pen.: CBM-BA 5010 (Futtsu-misaki, Futtsu-city, Chiba Prefec., Boso Pen., M. Miyata, 15. iii. 1996).

***Porphyra pseudolinearis* Ueda 1932**

(Figs. 17 and 18; Plate III, Fig. 3 and 4.)

Thallus: Membranaceous up to 15 cm height and about 2.5 cm width, usually lanceolate to linear lanceolate with entire margin and a little foldings, glossy deep purple to brown in colour; monostromatic, 62–67 μm thickness in surface view at the vegetative portion, basal cells (17–24 μm long, 7–11 μm width) in surface view polygonal or capitate with rhizoidal filaments projecting downward, vegetative cells (13–20 μm long, 8–12 μm width) in surface view with a single stellate chromatophore; dioecious; spermatangial patches marginally narrow stripe shaped or intercally splashed; 128 spermatia by division of formula 128 [a/4, b/4, c/8]; 32 carpospores by division of formula 32 [a/2, b/4, c/4].

Japanese name: Uppurui-nori.

Etymology: "Uppurui" from a movement of wave or flourish to take away sands from *P. pseudolinearis* just after collection, to eat.

Habitat: Epilithic in intertidal zone to upper sublittoral zone at Boso Pen.

Seasonality: October to April (autumn to spring), luxuriantly from December to February.

Geographical distribution: Inubo-saki, Choshi-city to Taito Misaki, Misaki-town at Boso Pen. facing to Pacific Ocean.

Type: Holotype: *Porphyra pseudolinearis* Ueda (Japan), in Herbarium, Lab. of Algal Cultivation, Tokyo Univ. Fisheries; *In* Ueda, S. 1932. "Nihonsan Amanori-zoku no Bunrui-gaku-teki-Kenkyu" (Systematic study of the genus *Porphyra* in Japan). Suiko-Kenkyu-Hokoku, 28 (1): 1–45, pls. I–XXIV.

Type locality: Japan.

Representative specimen from Boso Pen.: CBM-BA 5011 (Inubo-saki, Choshi-city, Chiba Prefec., Boso Pen., M. Miyata, 16. ii. 1995).

Discussion

Natural populatins of *Bangia* and *Porphyra*, Bangiaceae (Rhodophyta), were first reported with description in detail in Boso Peninsula.

Bangia

At least 8 species of *Bangia* have been argued on natural populations of the Pacific and Atlantic areas (Sheath and Cole, 1984) and 2 species of those have been reported in Japan and its vicinity (Tanaka, 1952). As a results of this taxonomical study, *Bangia atropurpurea* and *B. gloiopeltidicola* was demonstrated in Boso Peninsula and biogeographical distribution of it was cleared (Fig. 1). But the taxonomical criterion to distinguish 2 species may be only ecological one, which is epiphytic or not on *Gloiopeltis furcata* (Plate I. Figs. 1 and 3), because in morphological numerical criteria data of *B. atropurpurea* coinside with those of *B. gloiopeltidicola* in the extent, such as 2–10 cm in thallus length and 20–70 μm in thallus diameter, and thallus colour is same condition, such as purpulish red against yellowish red or light purple (Plate I. Figs. 1, 2 and 3). Furthermore, size, colour and chromosome numbers, which was as valuable criteria up to this time, have already been recognised as very variable crite-

ria depending on the surrounding conditions as temperature, photoperiod, salinity, age and seasonality (Smith, 1944; Somerfeld and Nicholes, 1973; Yabu, 1967; Sheath and Cole, 1984; Cole *et al.*, 1983). By the way, distribution in marine or freshwater environments have been employed as an additional taxonomic criterion. But Geesink (1973) and Sheath and Cole (1984) have demonstrated that populations of *Bangia* can adapt to broad range of salinities over a period of one or more generations as our observation, and concluded that the marine and freshwater taxa, *B. fuscopurpurea* (Dillw.) Lyngbye and *B. atropurpurea*, respectively, are conspecific and should be fused under the epithet *B. atropurpurea*. In this paper, *B. fuscopurpurea* is synonym of *B. atropurpurea*.

Under these circumstances, this study insist that type method depending on dried materials on herbarium sheets is small valuable for comparison with populations from different areas in the case of *Bangia*. So it will be necessary to detect the level of speciation of among populations of *Bangia* by combining morphological study with life-cycle and molecular analysis as DNA and Isozyme.

Porphyra

The morphological, reproductive and ecological features of natural populations of 8 species of *Porphyra* in Boso Peninsula are summarized in Tables 1, 2 and 3.

Firstly, although there were wide variation of shape of thallus in each depending on age and surrounding conditions and as Kurogi (1961) also reported, there are two morphological groups in shape of thallus as follows: 1) almost round shape group (orbiculate, ovate or reniform), *P. suborbiculata* (Plate I. Fig. 4), *P. yezoensis* (Plate II. Fig. 1), *P. ishigecola* (Plate II. Fig. 3) and *P. lacerata* (Plate II. Fig. 5); 2) alomost lanceolate shape group (lanceolate, oblanceolate or linear elliptical), *P. dentata* (Plate I. Fig. 5), *P. yezoensis* f. *narawaensis* (Plate II. Fig. 2), *P. tenuipedalis* (Plate III. Fig. 1), *P. tenera* (Plate III. Fig.2) and *P. pseudolinearis* (Plate III. Figs. 3 and 4). So we should study a shape of matured thallus just before releasing spores as taxonomical criteria.

In size of thallus, *P. lacerata* is extremely

Table 1. Comparison of morphological and ecological characters and habitat of *Porphyra* species from Boso Peninsula.

Species	Shape of thallus	Marginal structure	Thickness	Colour	Habitat
P. suborbiculata	round	dentate	>40	purpule to brown	epilithic
P. dentata	lanceolate	dentate	>40	purpule to brown	epilithic
P. yezoensis	reniform	entire	<40	purpule to brown	epilithic
P. ishigecola	orbiculate	entire	>40	purpule to brown	epiphytic
P. lacerata	ovate	entire	<40	purpule to brown	epiphytic
P. tenuipedalis	oblanceolate	entire	<40	red	shell
P. tenera	oblanceolate	entire	<40	pink	epilithic
P. pseudolinearis	lanceolate	entire	<40	purpule to brown	epilithic

Table 2. Comparison of reproductive characters of *Porphyra* species from Boso Peninsula.

Species	Sex type	Division of		Monospore
		carposporangium	spermatangium	
P. suborbiculata	monoecious	a/2, b/4, c/4	a/4, b/4, c/4	present (Matsuo *et al.*, 1994)
P. dentata	dioecious	a/2, b/2, c/4	a/4, b/4, c/8	absent (Notoya *et al.*, 1993b)
P. yezoensis	monoecious	a/2, b/2, c/4	a/4, b/4, c/8	present (Kito, 1978)
P. ishigecola	monoecious	a/2, b/2, c/4	a/4, b/4, c/8	?
P. lacerata	monoecious	a/1, b/2, c/2	a/4, b/4, c/4	present (Iima & Migita, 1990)
P. tenuipedalis	monoecious	a/2, b/2, c/4	a/4, b/4, c/8	absent (Notoya *et al.*, 1993a)
P. tenera	monoecious	a/2, b/2, c/2	a/4, b/4, c/4	present (Iwasaki, 1961)
P. pseudolinearis	dioecious	a/2, b/4, c/4	a/4, b/4, c/8	absent (Kito, 1978)

Table 3. Comparison of growing season and type locality of *Porphyra* species from Boso Peninsula.

Species	Growing season	Type locality
P. suborbiculata	autumn to spring	Goto, Nagasaki Prefec. (Kjellman, 1897)
P. dentata	winter to spring	Amakusa, Kumamoto Prefec. (Kjellman, 1897)
P. yezoensis	autumn to spring	Miyagi Prefec. to southwest Hokkaido. (Ueda,1932)
P. ishigecola	winter to spring	Enoshima, Kanagawa Prefec. (Miura, 1967)
P. lacerata	winter to spring	Enoshima, Kanagawa Prefec. (Miura, 1967)
P. tenuipedalis	winter to spring	Haneda, Tokyo (Miura, 1961)
P. tenera	winter to spring	Japan (Kjellman, 1897)
P. pseudolinearis	autumn to spring	Sea of Japan coast, east and west coast of Hokkaido. (Ueda, 1932)

small size species up to 1 cm height and width in comparing with other 7 species (Plate II. Fig. 5), as epiphytic species on *Ishige okamurae* with *P. suborbiculata* and on *Myelophycus simplex* in the middle to upper intertidal zone at Tateyama Bay and one close by in Boso Peninsula (Fig. 1). These coincide with the observation by Hwang and Lee (1994) on plants from Seongsanpo, Namchejugun in Korea, and uncommon endemic species at shore in Japan as Miura (1967) already stated, and *P. ishigecola* is close to *P. lacerata* in size (Plate II. Fig. 3). Then we can pointed out the presence of a macroscopic stalk (stipe) as criterion. *P. tenuipedalis* has distinct stalk up to 5 mm length (Plate III. Fig. 1). It is useful to discriminate from other species as same as marginal structure, entire or dentate. Only *P. suborbiculata* and *P. dentata* have microscopic dentate structures at marginal portion of thallus (Figs. 3-1 and 5-1).

Colouring of thallus in 2 species, *P. tenuipedalis* and *P. tenera*, is conspicuously different from other species as purple to brown (Table 1). *P. tenuipedalis* is purple to deeply reddish-brown, and *P. tenera* is pale red to salmon pink. These changing of colour of thallus may depend on growing conditions as *P. tenuipedalis* is certainly in subtidal zone.

In comparison of thickness in the middle or somewhat lower vegetative portion of thallus (Table 1), three groups of species are distinguishable in the thickness: 1) thin group (below 40 μm), *P. lacerata* (24–29 μm) (Figs. 12-3, 12-4), *P. tenera* (26–29 μm) (Figs. 16-3, 16-4), *P. yezoensis* f. *narawaensis* (26–30 μm) (Figs. 8-3, 8-4), *P. tenuipedalis* (33–36 μm) (Figs. 14-3, 14-4), *P. yezoensis*, (36–39 μm) (Figs. 7-3, 7-4); 2) medial group (above 40 μm), *P. ishigecola* (48–52 μm) (Figs. 10-3, 10-4), *P. suborbiculata* (52–57 μm) (Figs. 3-3, 3-4), *P. pseudolinearis* (62–67 μm) (Figs. 18-3, 18-4); 3) thick group (up to 80 μm), *P. dentata*, (76–79 μm) (Figs. 5-3, 5-4). *P. dentata* is 4 times as thickness in comparing with *P. lacerata*.

With regard to sexuality of thallus, there are two groups in 9 species of *Porphyra*: 1) monoecious group, *P. suborbiculata*, *P. yezoensis*, *P. yezoensis* f. *narawaensis*, *P. ishigecola*, *P. lacerata*, *P. tenuipedalis*, *P. tenera*; 2) dioecious group, *P. dentata* (Plate I, Fig. 5) and *P. pseudolinearis* (Plate III, Fig. 3). But in our examined specimens we can not find out androdioecious thallus and both monoecious and dioecious thallus that Kurogi (1972) and Miura (1988) have been reported.

The division of formula of both sexual reproductive organs, spermatangium and carposporangium, have been apointed as an imporatnt taxonomical criteria separating species. Table 2 shows varieties of divisional formula as results of this study. But there are classified two groups in divisional formulas of spermatangium separating the species: 1) 64 [a/4, b/4, c/4] group, *P. suborbiculata* (Figs. 3-5, 3-6), *P. lacerata* (Figs. 12-5, 12-6), *P. tenera* (Figs. 16-5, 16-6); 2) 128 [a/4, b/4, c/8] group, *P. dentata* (Figs. 5-5, 5-6), *P. yezoensis* (Figs. 7-5, 7-6), *P. yezoensis* f. *narawaensis* (Figs. 8-5, 8-6), *P. ishigecola* (Figs. 10-5, 10-6), *P. tenuipedalis* (Figs.14-5, 14-6), *P. pseudolinearis* (Figs. 18-5, 18-6). Furthermore, in divisional formula of carposporangium, four groups may be pointed out: 1) 4 [a/1, b/2, c/2] group, *P. lacerata* (Figs. 12-7, 12-8); 2) 8 [a/2, b/2, c/2] group, *P. tenera* (Figs. 16-7, 16-8); 3) 16 [a/2, b/2, c/4] group, *P. dentata* (Figs. 5-7, 5-8), *P. yezoensis* (Figs. 7-7, 7-8), *P. yezoensis* f. *narawaensis* (Figs. 8-7, 8-8), *P. ishigecola*

(Figs. 10-7, 10-8), *P. tenuipedalis* (Figs. 14-7, 14-8); 4) 64 [a/2, b/4, c/4] group, *P. suborbiculata* (Figs. 3-7, 3-8), *P. pseudolinearis* (Figs.18-7, 18-8). The divisional formula or numbers of spermatia and carpospores may be intimately related with the thickness of the thallus. In this study, carposporangium is employed as term to explain the zygote in *Porphyra*, though Guiry (1990) proposed a new term, zygotosporangium.

On periodical observation of *P. suborbiculata* and *P. yezoensis* in intertidal zone at Takeoka, Futtsu-city, thallus appears from late September or early October (autumn) in small size and well luxuriates from late November to May (winter to spring), and gradually declines in June and disappears in July (summer) (Table 3). Then it seems to be that on course of change from growing to maturing seasons, asexual organs, neutral sporangia (monosporangia), are formed in the young stage in autumn to winter and thallus are gradually sexualized as they grow older and at least become entirely sexual. Namely, spermatangia and carposporangia are found in winter to spring or early summer. There is a little information to discuss the taxonomical meaning of making monospore on *Porphyra* in Japan and adjacent waters (Iwasaki, 1961; Kito, 1978; Iima and Migita, 1990; Notoya *et al.*, 1993a, 1993b; Matsuo *et al.*, 1994) (Table 2).

On ecological peculiarity of habitats were shared in 3 groups: 1) usually epiphytic group, *P. ishigecola* (Plate II, Fig. 4), *P. lacerata*; 2) both epiphytic and epilithic group, *P. yezoensis*; 3) Usually epilithic group, *P. suborbiculata*, *P. dentata*, *P. tenuipedalis*, *P. tenera*, *P. pseudolinearis* (Plate III, Fig.4).

Finaly, with regard to biogeographical distribution on natural populations of *Porphyra* at Boso Peninsula, we can appoint out locally 4 groups of colonizing in 8 species as follows: 1) mixed-water group at locally Urayasu to Futtsu regions in Tokyo Bay, *P. tenuipedalis* (Fig. 13), *P. tenera* (Fig. 15); 2) warm-water group at Futtsu to Ohara regions affected by warm current (Kuroshio), *P. dentata* (Fig. 4), *P. ishigecola* (Fig. 9), *P. lacerata* (Fig. 11); 3) cold-water group at Ohara to Choshi regions affected by cold current (Oyashio), *P. pseudolinearis* (Fig. 17); 4) extensive group at Urayasu to Choshi regions, *P. suborbiculata* (Fig. 2), *P. yezoensis* (Fig. 6).

From outer appearances, reproductive characters and ecological features, 2 species of *Bangia* and 8 species of *Porphyra* in Boso Peninsula are separated from one another by following key.

At the point of "Present and future on biology of *Porphyra*", especially in taxonomical fields, we must endeavor to collect voucher specimens with exact information on sources at an official facility and we should open it to future scientific activities, *Porphyra* Science (Nori-gaku), under International Code of Botanical Nomenclature and International Code of Cultivated Plants.

Key to Species of *Bangia* and *Porphyra* from Boso Peninsula in Japan.

1. Erect thallus filamentous, becoming a solid cylinder ·····*Bangia* 2.
1. Erect thallus bladelike ····*Porphyra* 3.
2. Frond epilithic, reaches a height of 15 cm ·····*B. atropurpurea*
2. Frond epiphytic on *Gloiopeltis furcata* ·····*B. gloiopeltidicola*
3. Monostromatic thallus ····· 4.
3. Distromatic thallus ·····Subgenus *Diploderma* (Not found from Boso Peninsula)
4. One plastid in each cell ·····Subgenus *Porphyra* 5.
4. Two plastids in each cell ·· ·· ·· ·· ·· ·· ··Subgenus *Diplastidia* (Not found from Boso Peninsula)
5. Margin microscopically dentate ···· 6.
5. Margin microscopically entire ····· 7.
6. Rounded to funneled blade, monoecious ·····*P. suborbiculata*
6. Broad and/or linear lanceolate, dioecious ·····*P. dentata*
7. Monoecious ····· 8.
7. Dioecious ····· 9.
8. Spermatangial paches marginally, narrow stripe shaped or intercalary splashed and thallus colour red to pink ····· 10.
8. Spermatangial paches intercalary, striped shaped and thallus colour deep purple to brown ····· 11.
9. Formation of division of carposporangia

and spermatangia [a/2, b/4, c/4+a/4, b/4, c/8] ·····*P. pseudolinearis*

9. Formation of division of carposporangia and spermatangia [a/2, b/2, c/2+a/4, b/4, c/8] ·····*P. angusta**
(not be found in this study)
(not found from Tokyo Bay in this study)

10. Formation of division of carposporangia and spermatangia [a/2, b/2, c/2+a/4, b/4, c/4] ·····*P. tenera*

10. Formation of division of carposporangia and spermatangia [a/2, b/2, c/4+a/4, b/4, c/8] ·····*P. tenuipedalis*

11. Formation of division of spermatangia [a/4, b/4, c/4] ·····*P. lacelata*

11. Formation of division of spermatangia [a/4, b/4, c/8] ····· 12.

12. Usually epiphytic on *Ishige okamurae* ·····*P. ishigecola*

12. Usually epilithic·····*P. yezoensis*

* Tye locality of *P.angusta* is Tokyo Bay.

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房総半島に生育する紅藻ウシケノリ科，ウシケノリ属とアマノリ属の分類

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房総半島における紅藻ウシケノリ科，ウシケノリ属2種（ウシケノリ *B. atropurupurea* (Roth) C. Agardh, フノリノウシゲ *B. gloiopeltidicola* Tanaka），アマノリ属8種（マルバアマノリ *Porphyra suborbiculata* Kjellman, オニアマノリ *P. dentata* Kjellman, スサビノリ *P. yezoensis* Ueda, ベンテンアマノリ *P. ishigecola* Miura, ヤブレアマノリ *P. lacerata* Miura, カイガラアマノリ *P. tenuipedalis* Miura, アサクサノリ *P. tenera* Kjellman, ウップルイノリ *P. pseudolinearis* Ueda）の生育を確認し，その生育分布図と検索表を示した．また，絶滅危惧種とされた，アサクサノリとカイガラアマノリの自然集団を東京湾で確認した．

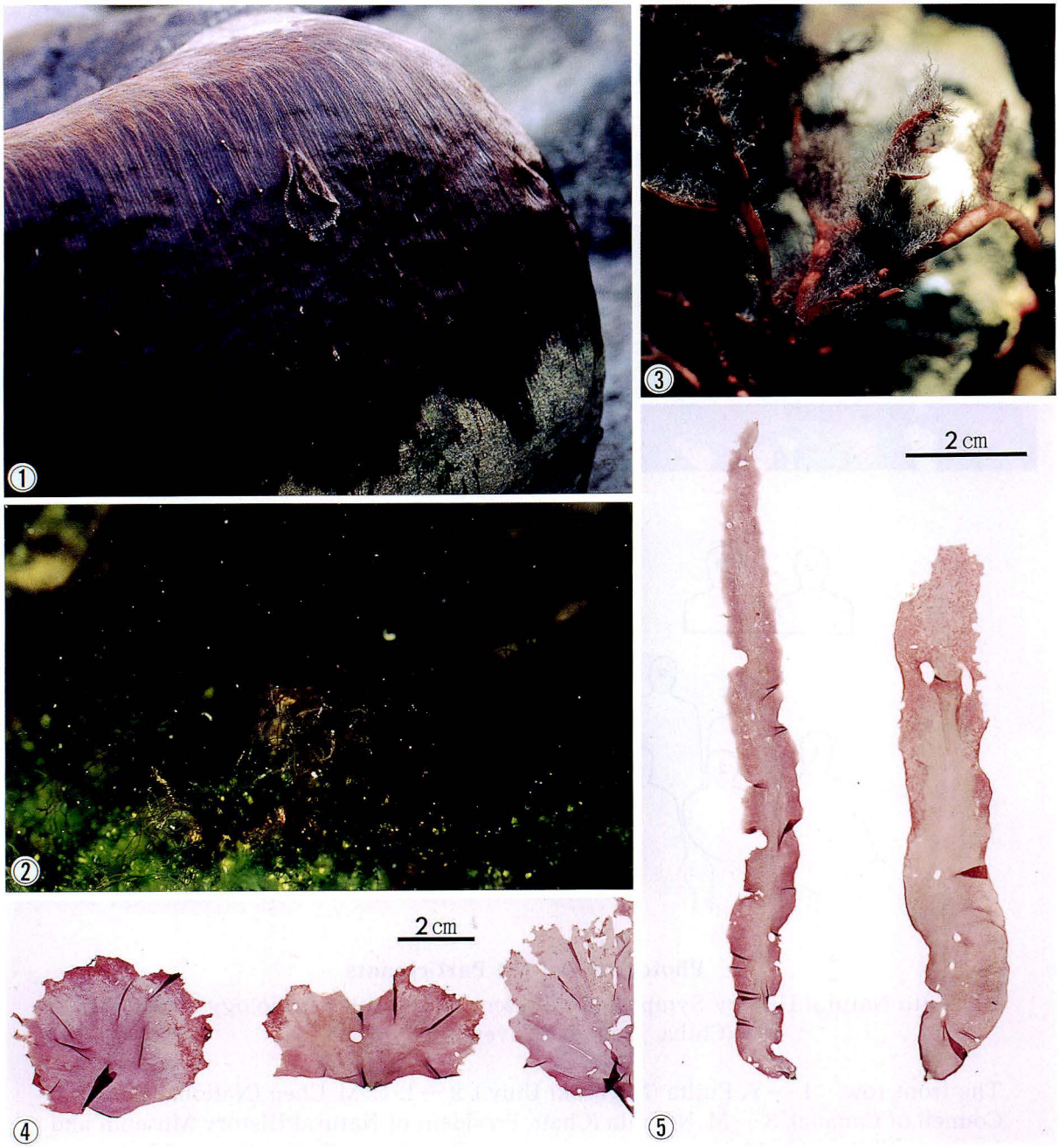

Fig. 1. Upper intertidal boulder covered with *Bangia atropurpurea* (Roth) C. Agardh, exposed at low water at Inubosaki, Choshi-city, Boso Peninsula on January 16, 1996. It looks like a part of cattle (Japanese: Ushi) with tufted hair (Japanese: Ke). Japanese name, Ushike-nori, is derived from "hair of cattle".
Fig. 2. *B. atropurpurea* (Roth) C. Agardh on the rock in the intertidal at high water.
Fig. 3. *Bangia gloiopeltidicola* Tanaka epiphytic on *Gloiopeltis fulcata* (Postels et Ruprecht) J. Agardh in the intertidal at high water, at Togawa, Choshi-city, Boso Peninsula on January 16, 1996.
Fig. 4. *Porphyra suborbiculata* Kjellman collected at Takeoka, Futtsu-city on April 8, 1996. Antheridia intermixed with cystocarps, ripe margin of blade is minutely dotted. Antheridal area partitioned to form a patch of stripe shape antheridial and cystocarpic areas halved longitudinally, male area ripens first.
Fig. 5. Dioecious *Porphyra dentata* Kjellman at Nojimazaki, Shirahama-town on March 12, 1996. Female on the right, male on the left.

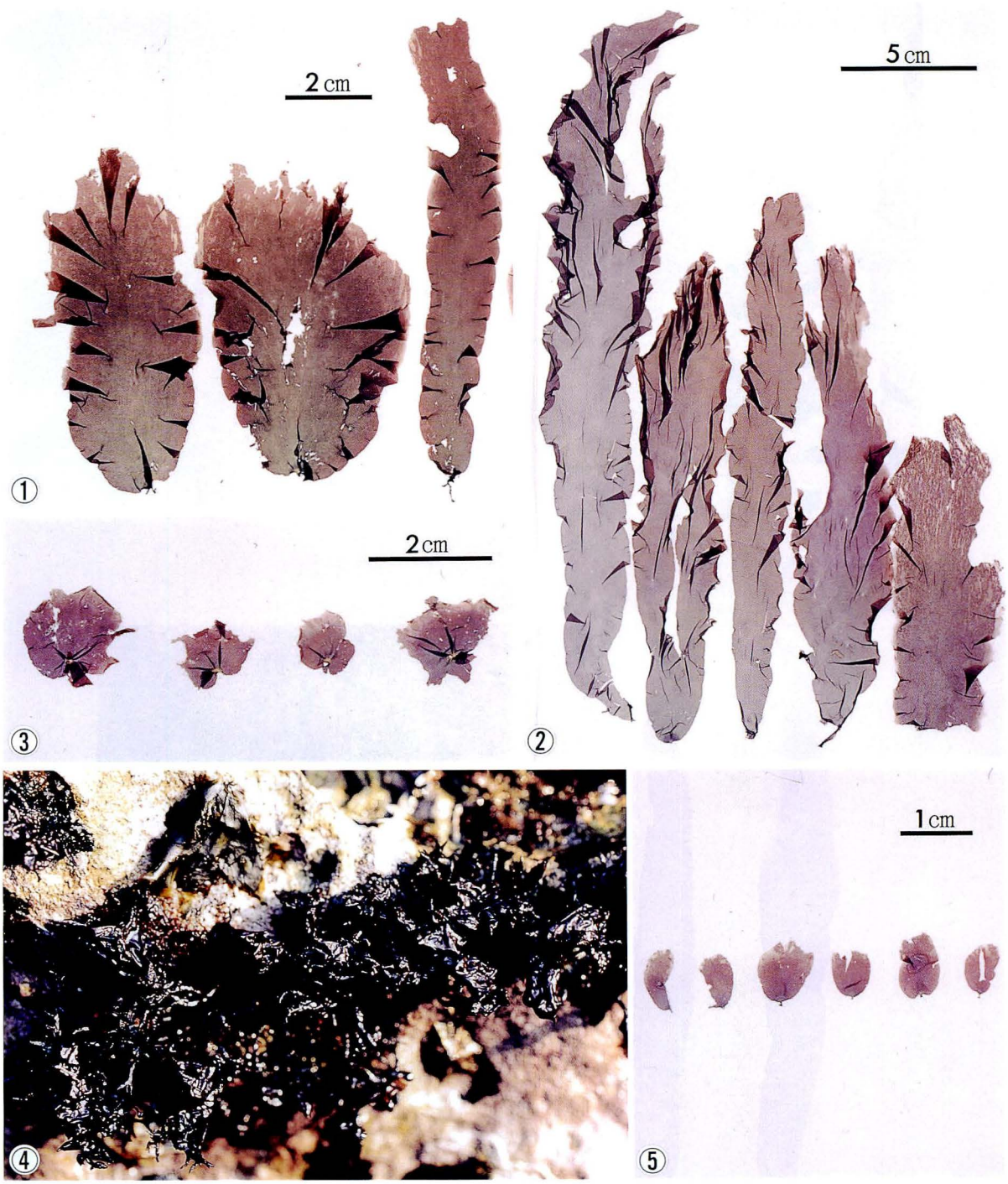

Fig. 1. Monoecious *Porphyra yezoensis* Ueda at Kimigahama, Choshi-city on March 23, 1996.
Fig. 2. Cultured *Porphyra yezoensis* Ueda f. *narawaensis* Miura at Amaha, Minato, Futtsu-city on February 7, 1995.
Fig. 3. *Porphyra ishigecola* Miura at Chikura, Chikura-town on February 25,1996.
Fig. 4. Habit of *Porphyra ishigecola* Miura epiphytic on *Ishige okamurae* Yendo in the intertidal zone.
Fig. 5. Tiny *Porphyra lacerata* Miura at Sunosaki, Tateyama-city on March 21, 1996.

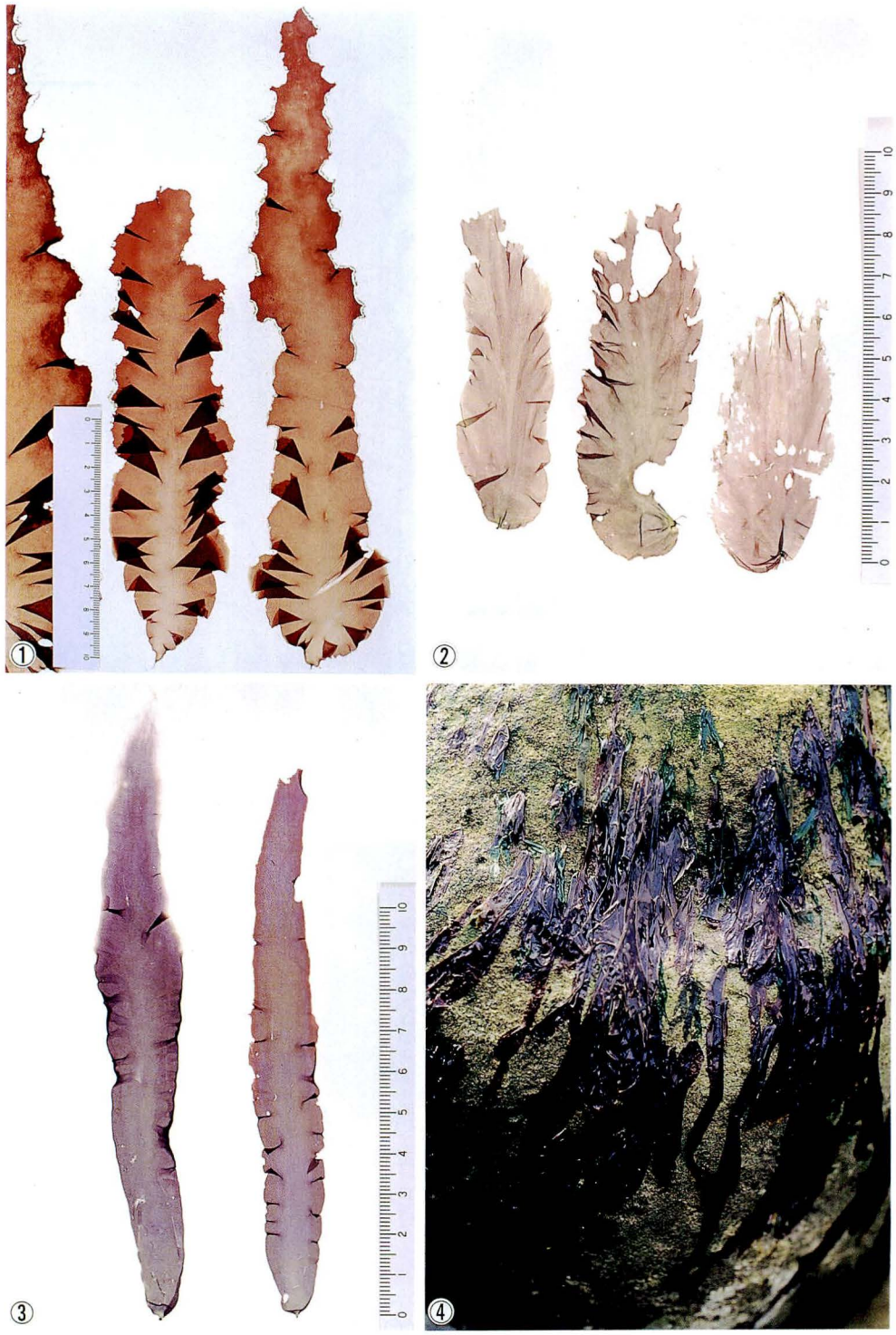

Fig. 1. *Porphyra tenuipedalis* Miura from sandy beach at Chiba Port, Chiba-city on February 8, 1997.
Fig. 2. *Porphyra tenera* Kjellman at Futtsu Misaki, Futtsu-city on March 15, 1996. This species is as "Critically Endangered Species" and was found out from Tokyo Bay in this reserch.
Fig. 3. *Porphyra pseudolinearis* Ueda collected at Inubosaki, Choshi-city on February 16, 1995.
Fig. 4. *Porphyra pseudolinearis* living on the boulder in the intertidal at low water.