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Development of *Streptophyllopsis kuroshioensis* (SEGAWA) KAJIMURA (Phaeophyta, Laminariaceae) in culture

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Results of the writer's observations on the development of a deep-sea Laminariaceous alga *Streptophyllopsis kuroshioensis* in culture are described herein. They fundamentally agree with those of other investigators on species in this order except *Chorda filum* in which the sporophyte has sterile hairs. The evidences that the development of gametophytes and young sporophytes of the alga observed is considered to occure in nature during winter to early spring are described herein.

Key Index Words: *cultural study*; *Laminariaceous alga*; Streptophyllopsis kuroshioensis.

Introduction

Streptophyllopsis kuroshioensis was reported as a new genus and a new combination by the present writer from the Oki Islands in 1981 (KAJIMURA 1981). This alga has been reported from deep-waters off Izu, Shizuoka Prefecture on the Pacific coast

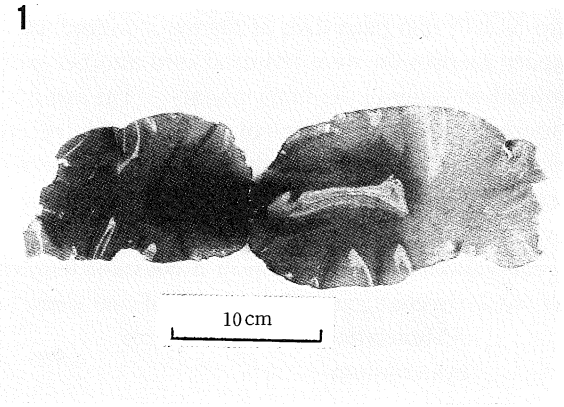

Fig. 1. *Streptophyllopsis kuroshioensis.*
Habit of a sterile specimen of the sporophyte (OS9884) collected from the depth of 40 m off Tsuma on June 2, 1983 and preserved in formalin seawater for 80 days.

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(SEGAWA 1948) where Kuroshio Warm Current is washing along and the Oki Islands in the Japan Sea where Tsushima Warm Current which is a branch of Kuroshio Current is washing along and has a significant effect upon the algal vegetations (KAJIMURA 1981).

This alga is externally differentiated into perennial holdfast, perennial prostrate branch, annual blade and stipe (Fig. 1). Sporophyte fruits in late autumn, the sporangial sori are formed on both surfaces of the blade and stipe, and rejuvenation of the sporophyte occurs in winter to early spring (KAJIMURA 1981). No report has been made on the development of the gametophytes and young sporophyte of this alga up to date. The present writer is fortunate enough to report the results of his observations on it herein this time.

Materials and methods

The materials used for this study were collected from the depth of 35 m off Tsudo, the Oki Islands on December 18, 1981.

Surfaces of the fertile pieces of the plant were cleaned with gauze to remove potential contaminants. The cleaned fertile pieces of the plant were kept out of water on a glass plate in the dark room at about 15°C for three hours to dry the surface of the sporangial sori. Then the fertile pieces of the plant were immersed in 160×40 mm dish of filtered sterilized seawater at about 16°C which corresponds to the mean water temperature at the depth of 50 m in the Oki Islands in December (NAGANUMA 1973) in 600 lux illumination under a cool-white-fluorescent lamp to release the zoospores. The cell suspension was allowed to stand in the same condition half an hour after observation of the release of the zoospores under microscope. About 2 ml of the zoospore suspension were removed by a Pasteur-type capillary pipette from just below the surface of water into 88×15 mm petri dish of filtered sterilized seawater. About 2 ml of the diluted zoospore suspension were removed into another petri dish of the same size and filtered sterilized seawater in the same manner. The same process was repeated successively twice more. Then about 3 ml of the most diluted zoospore suspension were removed from the petri dish into each of the four $15.8 \times 11.8 \times 4.5$ cm cubic plastic vessels where five clean sterile microscope slides were spaced on the bottom. Each vessel was covered with a glass lid and kept at 15–18°C in 600 lux constant illumination under a cool-white-fluorescent lamp in a constant temperature room. The culture medium was regularly changed with intervals of one week.

Abbreviations Used in Figures

a	antheridium
e	egg
e. a	empty antheridium
i. o	intercalary oogonium
o	oogonium
r	rhizoid

sp	spermatozoid
t. o	terminal oogonium
y. spo	young sporophyte
z	zygote

Results and discussion

Discharged zoospores are pyriform about 5 μm, 3 μm in average length and diameter respectively and have a single chromatophore and two lateral flagella of unequal length but lack stigma (Fig. 2, A). Discharged zoospores show considerable variations in morphology but they can not be divided into two different groups in size. After a period of mortility ranging from a few minutes to a few hours, the zoospores come to lose the flagella and rest, assume a rounded form, and secrete a wall about themselves. Germination begins shortly afterward and in culture which is one day old many germlings have evident germ tubes, and the single chromatophore divides once (Fig. 1, B–E). The gametophyte is dioecious, microscopic and multicellular filament which ramifies irregularly. The germination of zoospore is belonging to so called "mediate filamentous type" (INOH 1947), namely a germ tube develops on each germling of unicellular stage and the most of the cytoplasm and chromatophores migrate into the terminal portion of the germ tube and then the germ tube comes to be delimited by a cross wall from the embryospore case in two days old culture (Fig. 2, F). At this time the chromatophores undergo further division. During the following about 10 days, growth is more or less limited to enlargement though a few to some additional cells may be formed, and then it is possible to distinguish between the female and the male gametophytes, the female gametophytes being of a greater diameter than the male (Fig. 3). The female gametophytes ramify more infrequently than the male and the female plant cells have more chromatophores than the male. Most gametophytes of both sexes fruit in 30 days and young sporophytes may already be present at this stage (Fig. 5–7). The oogonia develop mostly from the terminal cells but infrequently from the intercalary. When an intercalary cell is transformed into an oogonium it forms a lateral extension which serves as the apical portion of the oogonium (Fig. 13, 17). When mature the egg is extruded through a rupture that arises at the apex of the oogonium (Fig. 7, 16–17). A small amount of cytoplasm sometimes remains in the oogonium. The extruded egg forms an ellipsoidal naked protoplast at the mouth of the oogonium, where it remains in position and will be fertilized (Fig. 7, 16–17). The male gametophytes are slenderer than the female. The antheridia are formed in clusters at the tips of the branches or as outgrowths from intercalary cells (Fig. 22). Mature antheridia usually contain a single chromatophore. Each antheridium forms only one spermatozoid. The spermatozoids are observed to have a single chromatophore but no stigma.

Fertilization of the egg was not observed but the first noticeable change which

presumably follows the process of fertilization is the formation of a wall about the zygote (Fig. 7, 16). The zygote then elongates and ultimately divides transversely (Fig. 8). The next few walls are also in a transverse plane (Fig. 9–10, 18). Longitudinal walls then set in, starting at the terminal end, and as a result growth takes place in two different planes, giving rise to a somewhat elongated monostromatic sporophyte

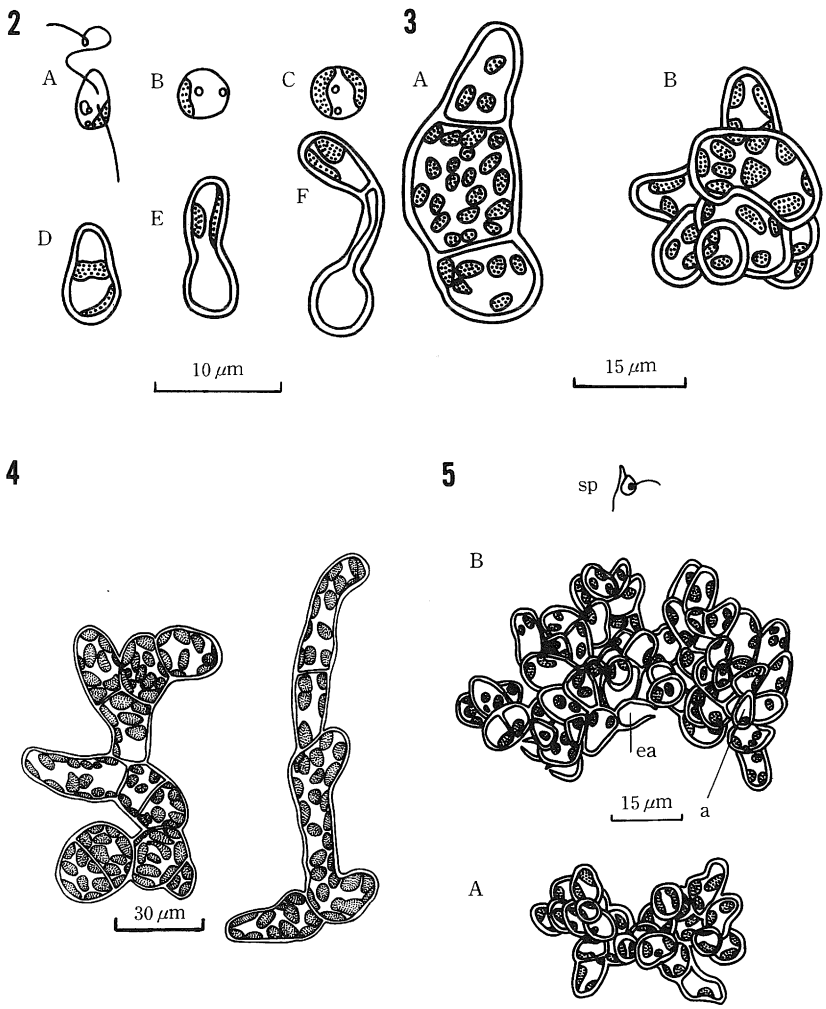

Fig. 2–5. *Streptophyllopsis kuroshioensis.*

2, Zoospore in motile condition (A), embryospores (B–C), gametophyte half a day old (D), same 1 day old (E) and same 2 days old (F); 3, A young female gametophyte 10 days old (A), a young male gametophyte 10 days old (B); 4, Two sterile female gametophytes 20 days old; 5, A sterile male gametophyte 20 days old (A), a mature male gametophyte 30 days old and a discharged spermatozoid (B).

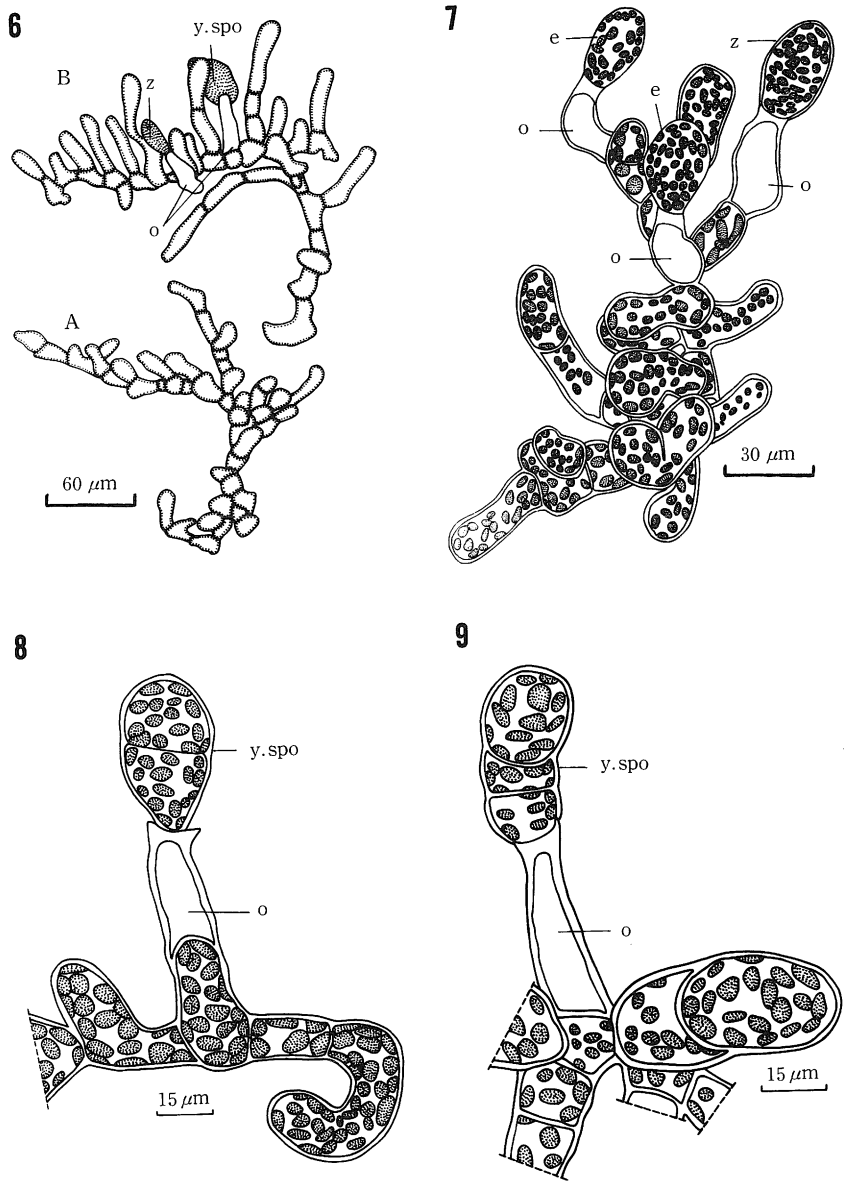

Fig. 6–9. *Streptophyllopsis kuroshioensis.*

6, Habit of a sterile female gametophyte 25 days old (A), and a mature female gametophyte 35 days old with a zygote and a young sporophyte, each attached to emptied oogonium (B); 7, Habit of a mature female gametophyte 30 days old, showing two eggs and a zygote, each attached to an emptied oogonium respectively; 8, Part of a mature female gametophyte 30 days old, showing a 2-celled young sporophyte attached to an emptied oogonium; 9, Same, showing a 3-celled young sporophyte.

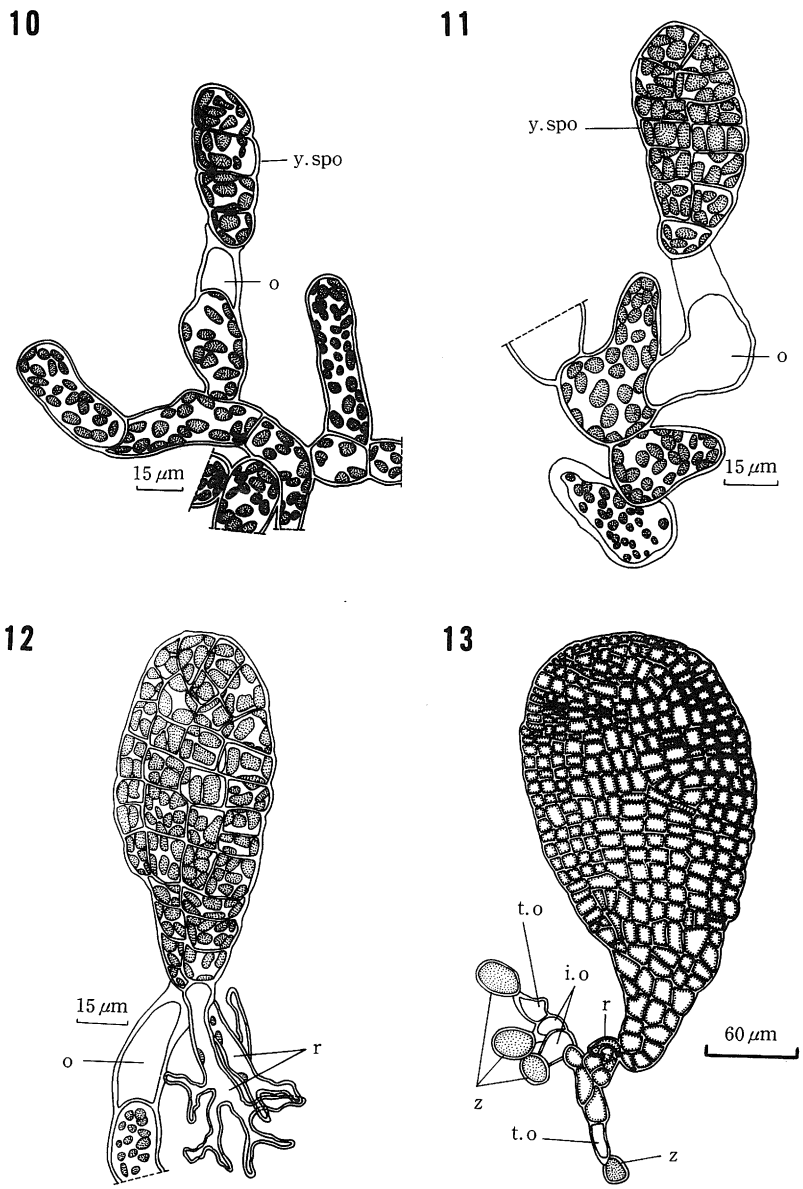

Fig. 10–13. *Streptophyllopsis kuroshioensis.*

10, Part of a mature female gametophyte 30 days old, showing a 4-celled young sporophyte; 11, Same 35 days old, showing 13-celled young sporophyte; 12, Same 40 days old, showing a 34-celled young sporophyte with two rhizoids arising from its basal portion; 13, A fully developed female gametophyte 45 days old, showing a further developed sporophyte, four zygotes, intercalary and terminal emptied oogonia.

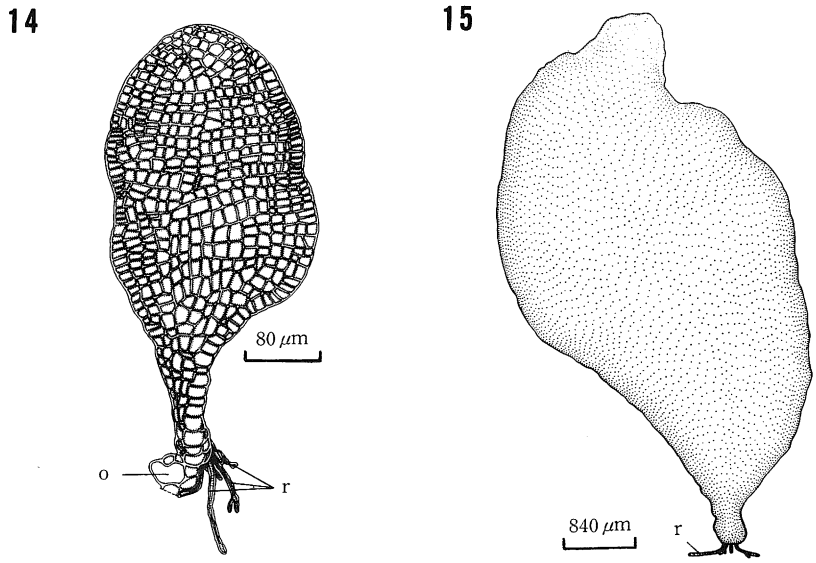

Fig. 14–15. *Streptophyllopsis kuroshioensis.*

14, Further developed young sporophyte attached to an emptied oogonium, distromatic below, with several rhizoids arising from basal portion; 15, Further developed young sporophyte 130 days old and polystromatic in the lower portion.

(Fig. 11–13, 19–21). One to several unicellular and simple rhizoids are formed from the basal part of the monostromatic young sporophyte. Development of rhizoid does not always accord with the one of the sporophyte. The rhizoids frequently contain several chromatophores but they seem to degenerate later, and the tip of the rhizoids irregularly ramifys taking frequently shape of pseudodisc (Fig. 12). The young sporophytes become distromatic at a comparatively early stage by periclinal division of the cells which starts in the basal region. The sporophytes shown in figures 13 and 14 are distromatic in the lower portion.

Streptophyllopsis kuroshioensis can be considered to agree fundamentally with the following 30 species of Laminariales investigated by other phycologists in the development of the gametophytes and young sporophytes but not with *Chorda filum* of which sporophyte has sterile hairs (KYLIN 1918, KANDA 1938): *Agarum cribrosum* (KANDA 1941b), *Alaria angusta* (KANDA 1944), *A. crassifolia* (KANDA 1936), *A. fistulosa* (KANDA 1944), *A. praelonga* (KANDA 1944), *Arthrothamnus bifidus* (KANDA 1936), *Costaria costata* (KANDA 1936), *Ecklonia cava* (KANDA 1941a), *E. maxima* (PAPENFUSS 1942), *E. stolonifera* (KANDA 1941a, NOTOYA and ASUKE 1983), *Ecklioniopsis radicosa* (KANDA 1941a), *Eisenia arborea* (CLARE and HERBST 1938, HOLLENBERG 1939), *E. bicyclis* (KANDA 1941a), *Kjellmaniella crassifolia* (KANDA 1938), *Laminaria angustata* (KANDA 1941b), *L. cichorioides* (KANDA 1938), *L. digitata* (KYLIN 1916), *L. pallida* (PAPENFUSS 1942), *L. sinclairii* (MYERS 1925), *L. subsimplex* (KANDA 1944),

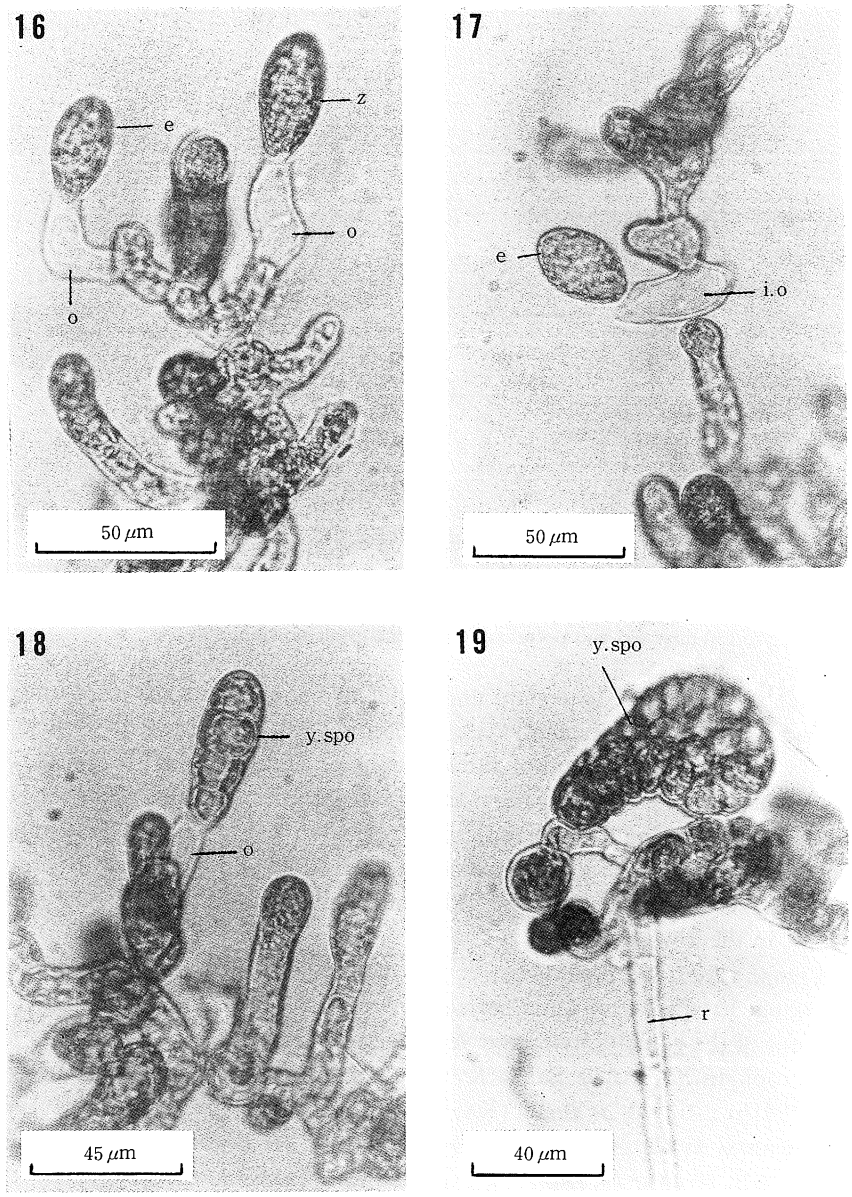

Fig. 16–19. *Streptophyllopsis kuroshioensis.*

—Photomicrographs.— 16, Part of a mature female gametophyte, showing an egg and a zygote; 17, Same, showing an egg attached to an emptied intercalary oogonium; 18, Same, showing a 4-celled young sporophyte; 19, Same, showing a young sporophyte with a long rhizoid.

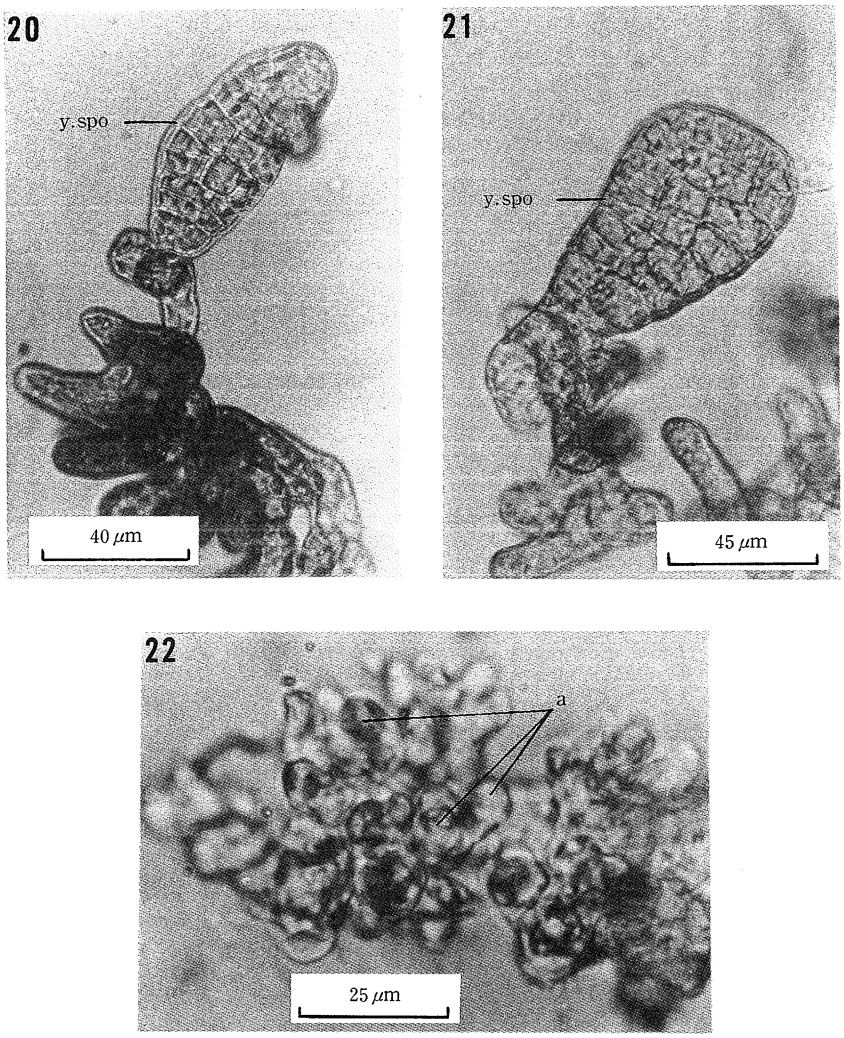

Fig. 20–22. *Streptophyllopsis kuroshioensis.*
—Photomicrographs.— 20, Part of a mature female gametophyte with an attached young sporophyte; 21, Same, showing a further developed monostromatic young sporophyte; 22, Part of a mature male gametophyte, showing several clusters of antheridia.

L. taeniata (KANDA 1944), *L. yendoana* (KANDA 1938), *L. yezoensis* (KANDA 1938), *Macrocystis integrifolia* (COLE 1968), *Nereocystis luetkeana* (KEMP and COLE 1961), *Pelagophycus porra* (HERBST and JOHNSTONE 1937), *Postelsia palmaeformis* (MYERS 1925), *Streptophyllum spirale* (KANDA 1944), *Undaria peterseniana* (KANDA 1941a), *U. pinnatifida* (KANDA 1936).

From the facts mentioned above it is considered that the development of the

gametophytes and young sporophytes occurs during winter to early spring in nature in the Oki Islands. This alga is considered to be different from *Ecklonia maxima* in the season of the development of the gametophytes and young sporophytes because of the fact that it occurs during spring and summer in the latter (PAPENFUSS 1942).

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