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STRUCTURE AND REPRODUCTION OF *SCINAIA MONILIFORMIS PAKISTANENSIS* VAR. NOV. (NEMALIALES, RHODOPHYTA)

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Abstract

A new taxon *Scinaia moniliformis* J. Agardh var. *pakistanensis* Afaq-Husain *et* Shameel is described. The vegetative, anatomical and reproductive structures of the Pakistani populations of this red alga have been investigated in detail. The new variety showed distinctive characters as thalli up to 22.5 cm long; deeply constricted into 4-26 mm long × 2.0-5.5 mm broad segments; branching di- to subdi-chotomous, from every segment in proximal and at 2-5 segment distances in the distal part of plants; utricles 30-38 μm long × 16-21 μm broad; hypodermal cells 5-15 μm broad; carpogonia conical distally, up to 10×4.5 μm; cystocarps up to 320 μm broad. These specimens were found to differ from *S. moniliformis* growing in Australia and India and, therefore, given the status of a new variety.

Introduction

The genus *Scinaia* Bivona-Bernardi (Galaxauraceae, Nemaliales) has been reported from Karachi (Anand, 1943), Lasbela (Shameel, 1987; Shameel *et al.*, 1989), Makran (Shameel *et al.*, 2000) and other coastal areas of Pakistan (Shameel & Tanaka, 1992). Two new species viz., *S. saifullahii* and *S. shameelii* have also been described from this region (Afaq-Husain, 1996; Afaq-Husain & Shameel, 1997, 1998). During a survey of various coastal areas of Karachi, specimens of *S. moniliformis* J. Agardh were collected and studied critically. They were found to differ in several respects with *S. moniliformis* growing in other countries (Bφrgesen, 1931; Huisman, 1986) and, therefore, these populations have been described as a new variety.

Materials and Methods

The fresh drift specimens were collected from Manora, Sandspit, Hawkes Bay, Buleji, Naugaza Mazar and Cape Monze, near Karachi (Pakistan) during the months of November-April 1985-1995. Some specimens were fixed in 4% formalin-seawater solution, others were mounted on herbarium sheets and stored in the herbarium of PCSIR Laboratories Complex, Karachi (CLH) and Seaweed Herbarium, MAH Qadri Biological Research Centre, University of Karachi (KUH-SW). The whole pieces of fronds (apical, middle and basal) were stained either in 1% aniline blue (for section cutting) or a mixture of 1% aniline blue + 10% HCl (for squashing) for 24-48h. For quick study the staining was carried out with a mixture of glycerine + acetic acid + distilled water (1:1:1, v/v) to which a few drops of 1% aniline blue were added which provided good staining within 1-6h. The techniques employed for section cutting and mounting were the same as described previously (Afaq-Husain, 1996).

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Results

The details of the external charaters, vegetative, anatomical and reproductive structures of the new variety growing at the coastal areas near Karachi, Pakistan are described.

SCINAIA MONILIFORMIS J. AGARDH 1885 VAR. *PAKISTANENSIS* AFAQ-HUSAIN *ET* SHAMEEL *VAR. NOV.*
Synonymy: *Scinaia indica* Bφrgesen 1931

References: Agardh, 1885: 72-73; Bφrgesen, 1931: 4-5, fig. 2, pl. I: fig. , 1934: 32; Anand, 1943: 14-16, figs. 7A, B; Farghaly 1980: 154, pl. XIX, fig. 2; Desikachary *et al.*, 1990: 164-165, figs. 34 G-J, pl. XVII.B.

Diagnostic charaters: Plants up to 22.5 cm long, 8-16 times bifurcated, deeply constricted into 4-26 mm long segments with random arrangement; segments conico-cylindrical, narrow below, 2.05-5 mm broad at distal end; branching di- to subdi-chotomous, from every segment in proximal part and at 2-5 segment distances in the distal part of plants. Utricles 30-38 μm long × 16-21 μm broad, interspersed at distances by narrow coloured branchlets, bearing monosporangia-like bodies; hypodermal cells 5-15 μm broad. Plants monoecious; spermatangia borne in cluster on up to 10 μm long, stalk-like structures each bearing a single spermatium; carpogonia conical distally up to 10×4.5 μm; hypogynous cell produces 3 daughter cells 1-celled and 2-celled filamentous branches of charateristic appearance; cystocarps up to 320 μm broad, carposporangia in distal chains of 3-4 (-5) cells, oblong, up to 16×10 μm, secondary sporangia develop within the discharged ones; carpospores of irregular shape, usually longer than broad.

Diagnosis: *Scinaia moniliformis pakistanensis: Plantulae usque ad 22.5 cm longae, thalli profunde constricti in segmenta 4-26 mm longi × 2.0-5.5 mm lati, disposita sine ordine. Ramificantes ex unoquoque segmento in parte proximali et ad distantias 2-5 segmentorum in partibus distalibus plantularum. Utricles 30-38 μm longae × 16-21 μm latae, cellulae hypodermales 5-15 μm latae. Rami carpogoniales in sexta-septima cellulis ex thalli superficie. Filiae-cellulae hypogynae apparent filamentosae.*

Holotype: H.Sc. 14 PCSIR (*Leg.* S. Afaq-Husain 30-4-1990) Buleji, Karachi (Fig. 30).

Isotypes: H.Sc. 15, 16 PCSIR (*Leg.* S. Afaq-Husain 30-4-1990) Buleji, Karachi.

Other specimens examined: Majora (*Leg.* S. Afaq-Husain 17-11-1985, 11-3-1989, M. Shameel 10-12-1994); Sandspit (*Leg.* S. Afaq-Husain, 11-11-1985, M. Shameel 21-4-1995); Hawkes Bay (*Leg.* S. Afaq-Husain 30-4-1990, M. Shameel 9-2-1995); Naugaza Mazar (*Leg.* S. Afaq-Husain 13-11-1985, M. Shameel 19-1-1993); Cape Monze (*Leg.* S. Afaq-Husain 5-2-1985, 9-4-1985, 13-11-1985, 11-3-1986, 27-4-1986, M. Shameel 15-3-1992).

Habitat: Subtidal, some plants seen growing in pools near low water mark at Naugaza Mazar, East to Cape Monze, Karachi, Pakistan.

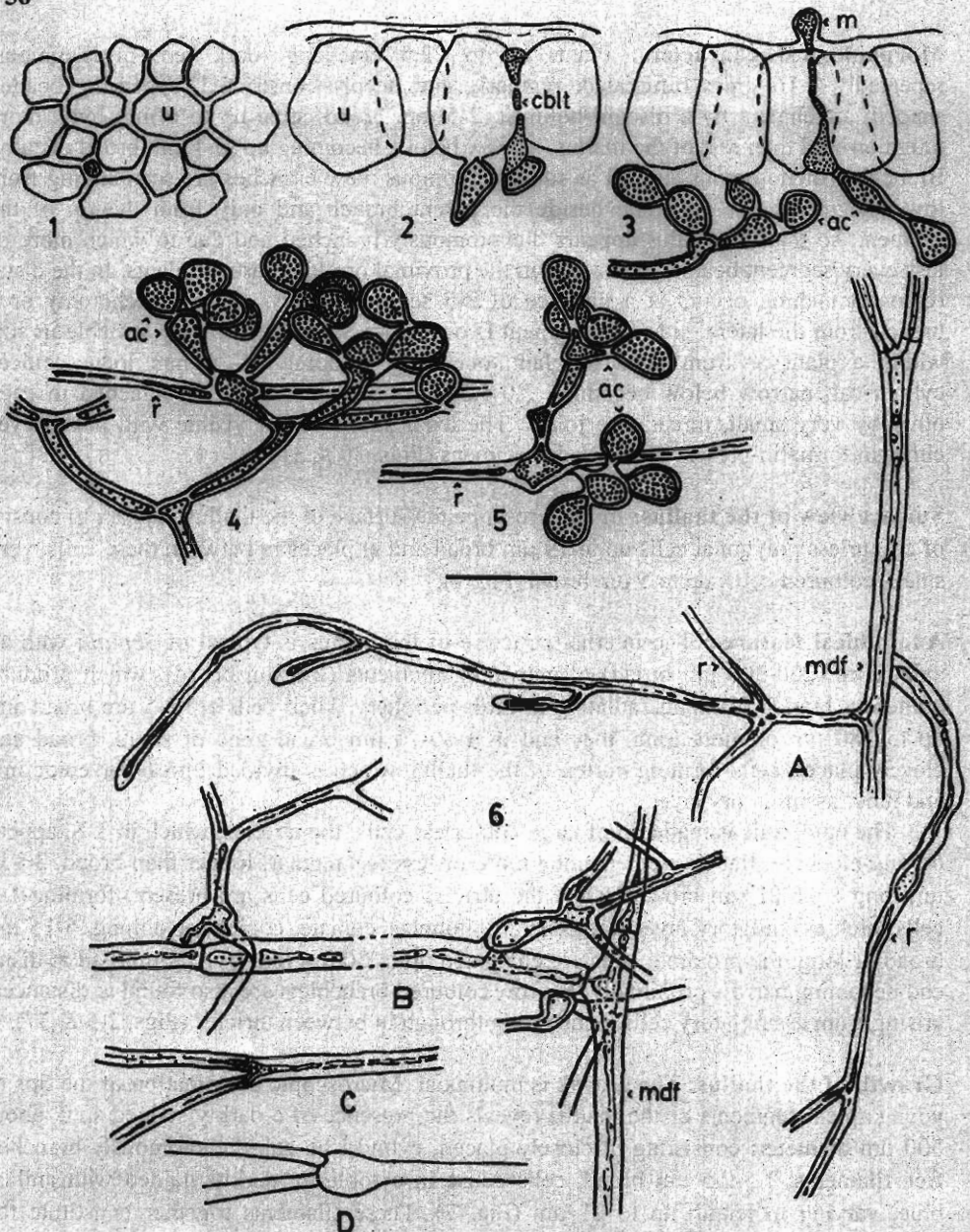
Morphological characters: Plants up to 22.5 cm long, dark red, mucilaginous, repeatedly 8-16 times bifurcated, regularly and deeply constricted, appearing beaded shaped; attachment by a discoid holdfast, 2-5 mm broad; stipe up to 6 mm long, more tough or hard than rest of the thallus, narrow below, becoming up to 4 mm broad distally. Branching dichotomous as well as sub-dichotomous, new branches are seen arising from lower segments but only one beside the parent branch and only from the tip of the segment, so that the thallus appears dichotomously branched and due to which more or less every segment bears a dichotomy in the proximal or older parts of plants. In the distal region branching occurs at a distance of 2-5 segments, very rarely a trichotomy or a branch from the lateral side of a segment is observed. Segments are very variable in size within a plant or from plant to plant, occurring randomly, 4-26 mm long, conico-cylindrical, narrow below becoming 2.0-5.5 mm broad at distal end, attached to each other by very small, thread-like joints. The axial strand is not visible with naked eyes either in formalin-preserved or dried specimens (Figs. 30 & 31).

Surface view of the thallus: In a microscope the surface of the thallus appears to consist of colourless polygonal cells up to 19 μm broad and at places in between these cells, very small, coloured cells, up to 5 μm broad (Fig. 1).

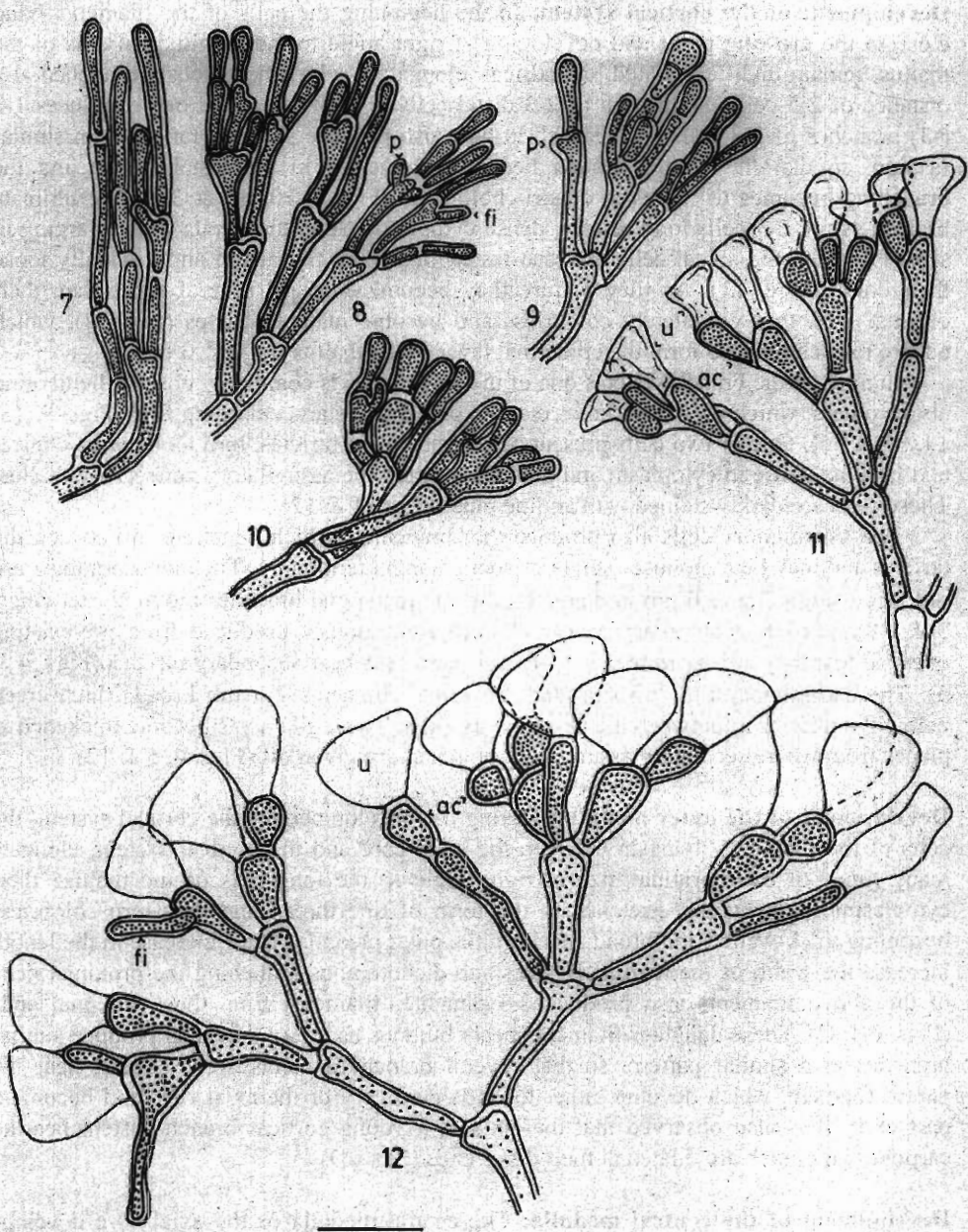
Anatomical features: The internal structure of the thallus is typical of *Scinaia* with an axial core (200-300 μm broad) of entwining filaments (2-9 μm broad), which produce numerous branch filaments radiating towards periphery. Their cells are 2-5 μm broad and up to 180 μm or more long, they end in a 60-70 μm broad zone of small, broad and closely placed cells forming cortex of the thallus which is divided into outer epidermis and inner assimilatory layer.

The epidermis is made up of large colourless cells, the utricles, which in T.S. appear oblong-elongate, flat above becoming more or less rectangular, longer than broad, 30-38 μm long × 16-21 μm broad. Below the utricles coloured cells are present, forming 1-2 cells thick assimilatory layer; the cells are globular, cuniate, conical or oblong, 5-15 μm broad or long; the proximal cells are elongated up to 30 μm long × 10 μm broad at distal end becoming narrow proximally. Narrow coloured branchlets are also found at distances, arising from assimilatory cells, penetrating through in between utricles (Figs. 2-5 & 37).

Growth of the thallus: The growth is multiaxial. Microscopic examination of the tips of young apical segments of the thallus reveals the presence of a darkly stained spot, about 500 μm diameter; consisting of closely placed, cylindrical, sub-dichotomously branched free filaments, 1.5-2.5 μm broad, cells dense in cytoplasm, darkly stained with aniline blue, varying in length up to 21 μm (Fig. 7). These filaments together constitute the growing point and are responsible for the multiaxial growth of the thallus, they are continued backward as axial filaments. Their apical cells continuously elongate and divide by cross walls, producing new cells proximally, increasing the length of the thallus. The daughter cells elongate and may produce one new branch from distal end so that the branching in the filaments appears dichotomous. The branch filaments either develop along the parent filaments becoming a part of the growing point or deflected outwards and develop at right angle to the long axis of the thallus increasing its breadth.



Figs. 1-6. *Scinaia moniliformis* var. *pakistanensis* Afaq-Husain *et* Shameel: **1.** Surface view of thallus showing large, colourless utricles and small coloured cell 9 stippled). **2 & 3.** T.S. of cortex from different plants. **4 & 5.** Teased out assimilatory branches showing branching of roundish hypodermal cells in bunches on elongate, oblong/conical cells and rhizoidal filaments. **5.** A thickening in the rhizoidal filament from which secondary assimilatory branches arise. 6. Medullary filaments showing different types of branching: A. rhizoidal branches arising laterally from proximal part of cell, B. several branch filaments arise close to the parent filament from the proximal part of basal cells of mother branches repeatedly, C. normal sub-dichotomous branching from distal end of cells, D. the cell of the filament become dilated at the distal end. (**ac** = assimilatory cell, **cblt** = coloured branchlet, **m** = monosporangium, **mdf** = medullary filament, **r** = rhizoidal filament, **th** = thickening in the filametn, **u** = utricle. **Scale:** 30 μm).



Figs. 7-12. *Scinaia moniliformis* var. *pakistanensis*: **7-12.** Cortical filament systems showing different stages of development of the cortex. **7.** Filametn system from growing point with cylindrical, elongated cells. **8.** Slightly older branch system with sub-trichotomous branching in the distal region. **9 & 10.** Showing enlargement of apical and sub-apical cells respectively. **11.** Slightly older filament system showing differentiation of utricles. **12.** Slightly older branch system showing nearly mature utricles and differentiation of hypodermal cells, the branches arising from young hypodermal cells may become coloured branchlets or rhizoidal branch. (**ac** = assimilatory cell, **fi** = filament initial, **p** = protubrance, **u** = utricles. **Scale:** 12 μm).

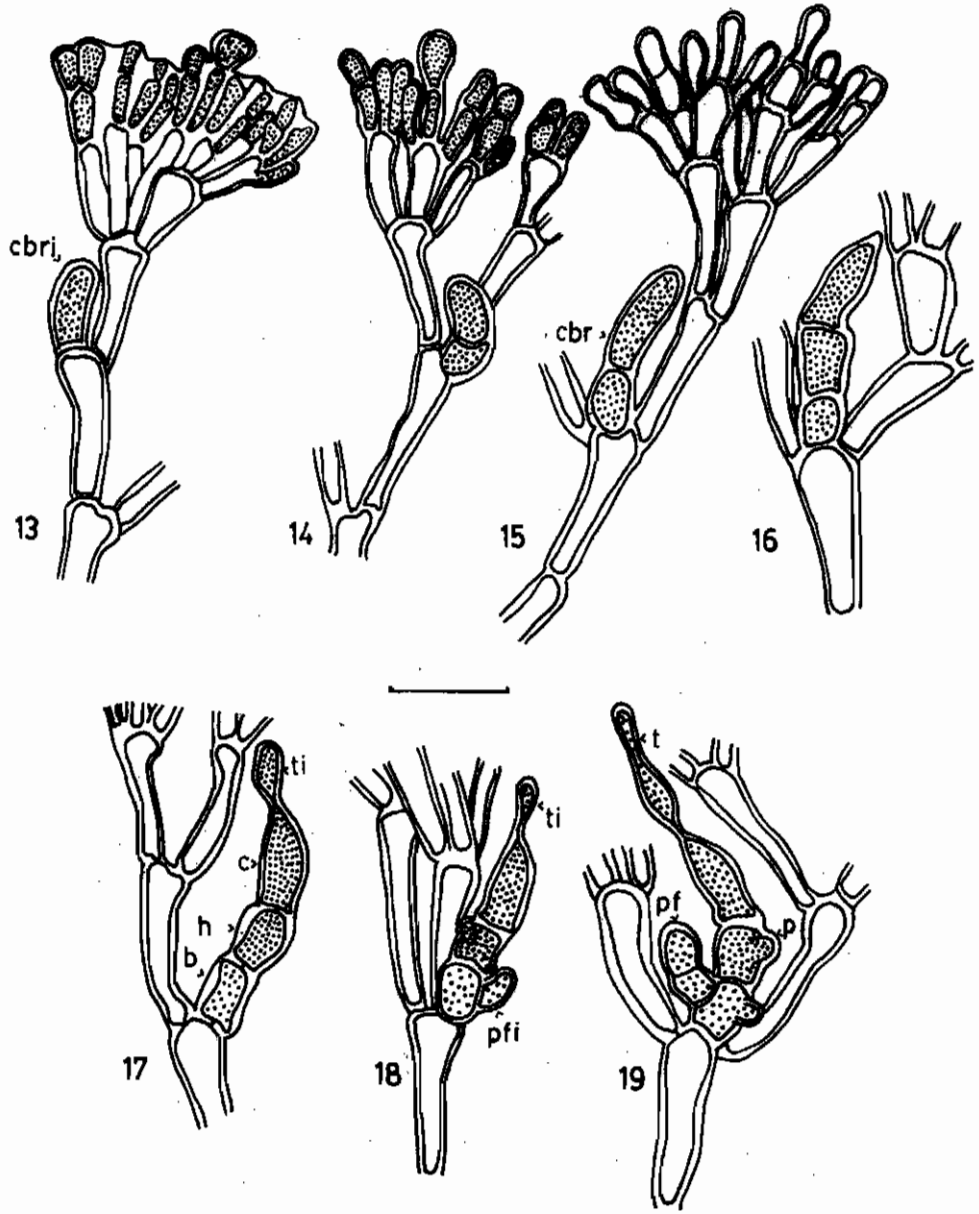
Development of the cortical system: In the beginning the cells of the filaments lying close to the growing point and developing at right angle to the longitudinal axis of the thallus, remain undifferentiated, cylindrical, elongated, sub-dichotomously branched at a distance of 2-5 cells. Soon each of 2-3 distal cells (except the apical one) produces 1-2 (-3) branches of 2-3 cells each, which in turn also prdouce similar branchlets in similar fashion, so that the branch system becomes congested in the distal region and the branching becomes tri- or even quadri-chotomous (Figs. 8-10, 35 & 36). The ultimate branchlets are 2-3 cells long bearing dense cytoplasm. Soon their cells start enlarging in size (Fig. 100, the apical cells increase faster, becoming flat at top and gradually loose their colour (Fig. 11). As they mature they become enlarged several times than their original size, turn completely colourless and become mature utricles (Fig. 12), which adhere to each other to form the epidermal layer of the thallus (Figs. 2, 3 & 37).

In most of the branch systems one of the apical cells is commonly observed emerging above others, which probably shows that the oldest cell starts enlarging first (Figs. 9, 13, 14, 35 & 36). One or two cells present below the young utricles, turn globular or conical and become dense in cytoplasm and plastids forming the assimilatory zone of the thallus. These cells are darkly stained with aniline blue (Figs. 11 & 12).

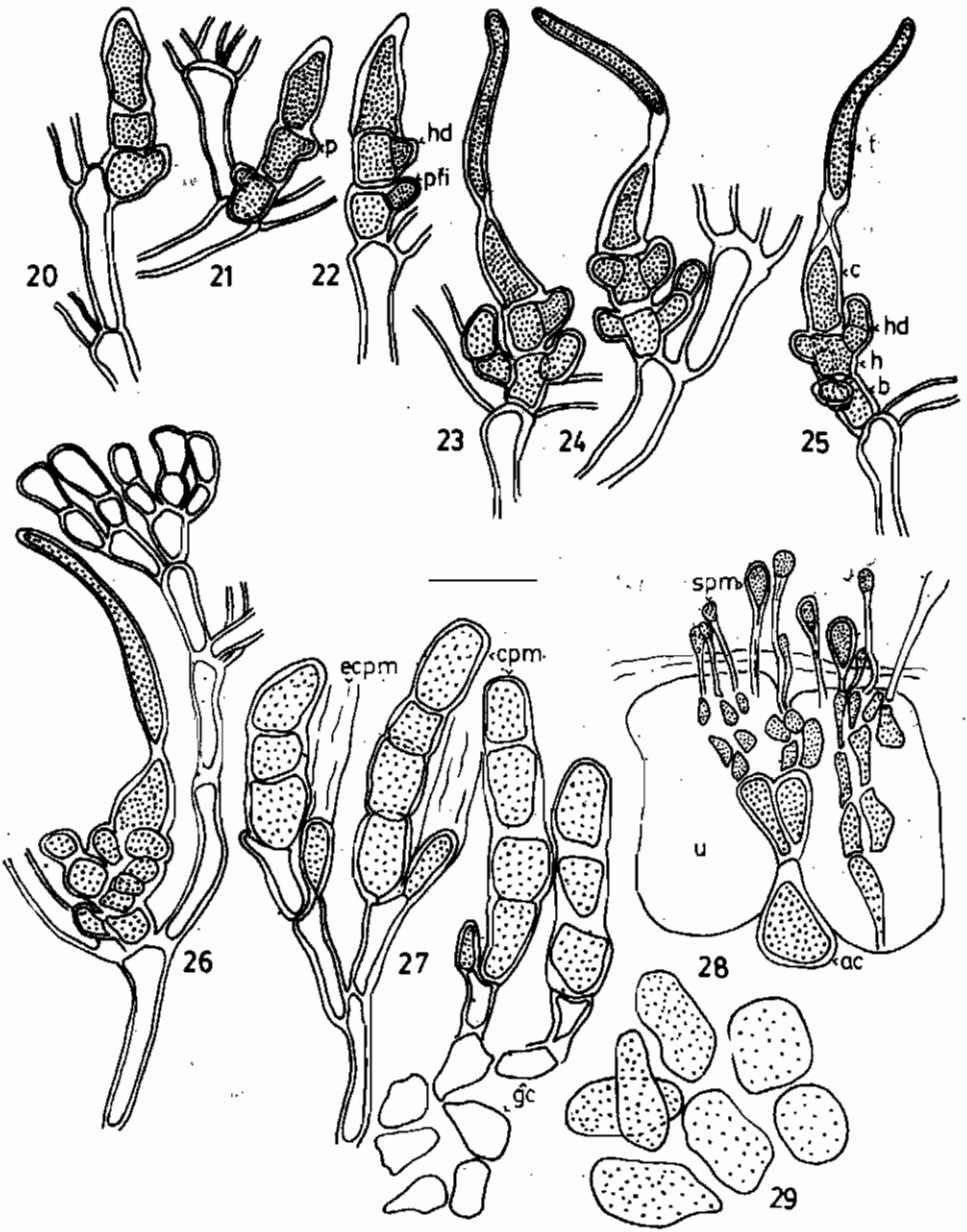
The assimilatory cells also produce thin branchlets which penetrate in between the utricles and may bear monosporangia or spermatangia terminally. The monosporangia are produced singly, up to 6 μm in diameter, the spermatangial branches are in cluster (Figs. 3 & 28). The daughter assimilatory cells are continuously produced from pre-existing ones, so that they appear in bunches, these in turn also bear secondary utricles (Figs. 4 & 5). The assimilatory cells also produce rhizoidal filaments 2-3 μm broad which creep below the utricles in between the assimilatory cells. These filaments become thickened at places from where secondary assimilatory branches are given off (Figs. 4, 5 & 12).

Development of the outer medulla: During the development of the cortical system, the cells of the filaments, lying in between the axial core and the cortical system, elongate many times of their original size at right angle to the long axis of the thallus, their cytoplasmic contents get stretched in the form of fine thread and they turn colourless becoming thick-walled and broad and form the outer medulla. Their increase in the length increase the width of the thallus. Besides sub-dichotomous branching the proximal cells of the above filaments also produce 2-3 daughter filaments from their proximal ends (Figs. 6B, C). These daughter filaments bears bulbous base and they also produce similar branches in a similar pattern, so that several branch filaments are produced near the parent filament, which develop either towards periphery or the axial core and become a part of it. It is also observed that the cells of a young cortical branch system bearing carpogonial branch are dilated at their distal ends (Fig. 6D).

Development of the central medulla: The central medulla or the axial core develops from the cells lying proximal to the growing point in line with the axial strand, in a similar way as mentioned above, here the cells elongate along the long axis of the thallus and increase in length. These filaments are also sub-dichotomously branched but they also produce rhizoidal branches irregularly, from any part of the cell. These branches are unevenly thickened and irregularly branched; they either travel in between the medullary filaments along the axial strand or in the lumen towards periphery (Fig. 6A).



Figs. 13-19. *Scinaia moniliformis* var. *pakistanensis*: **13-16.** Development of carpogonial branches from 1-celled to 3-celled stage. **17.** Carpogonial branch with trichogyne initial but no division in any cell. **18.** Carpogonial branch with trichogyne initial along with one initial each in basal cell and hypogynous cell. **19.** Carpogonial branch with young trichogyne, one protubrance from the hypogynous cell, and a 2-celled filament and a protubrance from basal cell. (**b** = basal cell, **c** = carpogonium, **cbr** = carpogonial branch, **cbri** = carpogonial branch initial, **h** = hypogynous cell, **p** = protubrance, **pf** = pericarp filament, **pfi** = pericarp filament initial, **t** = trichogyne, **ti** = trichogyne initial. **Scale:** 12 μm).



Figs. 20-29. *Scinaia moniliformis* var. *pakistanensis*: **20-22.** Carpogonial branches without initiation of trichogyne but with one protubrance initial each from basal and hypogynous cell. **23-25.** Carpogonial branches with young trichogynes, and bearing 1, 2 and 3 hypogynous daughter cells respectively. **26.** Slightly advance stage of carpogonial branch, the pericarp filament covering the hypogynous daughter cells. **27.** Gonimoblast filaments bearing 3-4 carposporangia distally. **28.** Coloured branchlets bearing spermatangia terminally on stalk-like filaments. **29.** Carpospores. (**ac** = assimilatory cell, **b** = basal cell, **c** = carpogonium, **cpm** = carposporangium, **ecpm** = empty carposporangium, **gc** = basal cells of gonimoblast, **h** = hypogynous cell, **hd** = hypogynous daughter cell, **p** = protubrance, **pfi** = pericarp filament initial, **spm** = spermatangium, **t** = trichogyne, u = **utricle**. **Scale:** 12 μm).

Branching in the filament at the growing point: Any cell of a filament except the apical one, broadens at distal end and puts forth a protuberance rich in cytoplasm, which elongates in the direction of growth and soon cuts off from the mother cell by a cross wall forming the filament initial, which then acts as the apical cell of the branch filament (Figs. 8-10).

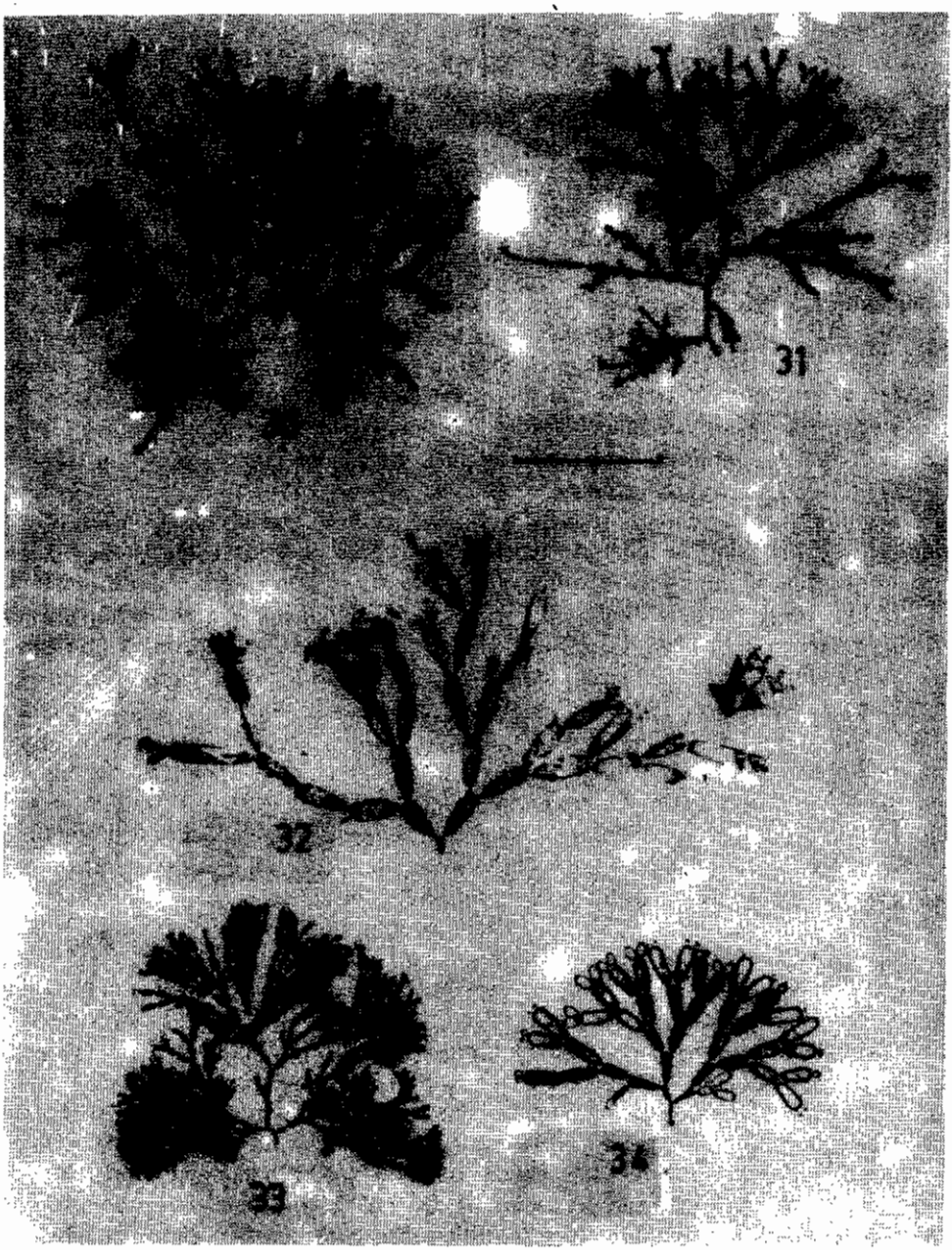
Reproductive structures: The plants are monoecious, both male and female reproductive bodies are found on the same plant.

Spermatangia: Spermatangia are borne in cluster on the surface of the thallus close to the tip. The coloured, narrow branchlets, which grow in between utricles, become branched several times and ultimately bear long stalk-like structures, which project beyond the utricles, each bearing a single spermatangium terminally (Fig. 28). The stalk-like structure up to 10 μm long and one μm or less broad; spermatangia oblong 3.5-4.5 μm long × 2.0-3.0 μm broad, each producing one spermatium.

Carpogonia: The carpogonial branches are borne on distal end of 6th or 7th cell (rarely on 5th cell) of a young assimilatory branch system. The supporting cell usually bears two vegetative branches besides the carpogonial branch showing a trichotomous condition (Fig. 26). The carpogonial branch is 3-celled, 18-22.5 μm long (without trichogyne); trichogyne measured up to 27 μm long × 1.5-2.0 μm broad, it bears a constriction above the carpogonium and slightly tapers to obtuse apex. The carpogonium is conical, broader at the base becoming narrow distally, 9-10 μm long × 3.0-4.5 μm broad; hypogynous cell 3.5-5.5 μm long × 3.5-4.5 μm broad (Figs. 23-26 & 40). The cells of carpogonial branch are formed successively from base upward. The 5th to 7th cell of a young cortical branch system puts forth a broad protubrance at its distal end, which is cut off from the mother cell (supporting cell) by a cross wall and behaves as the carpogonial branch initial. It becomes 8-10 μm long × 3.0-3.5 μm broad with obtuse end and cuts off basal cell first and then again elongates and cuts off the middle cell, hence becomes 3-celled (Figs. 13-16 & 39). The apical cell acquires the shape of carpogonium and then the trichogyne starts developing in the last (Figs. 16-19).

After the formation of 3 cells of the carpogonial branch, the basal cell is the first one to put forth a protuberance on one side, which is cut off from the mother cell by a cross wall and becomes the first initial of the pericarp filament (Figs. 20-22 & 38). It elongates in the direction of carpogonium and cuts off a cell proximally by cross wall, becoming 2-celled. During this period second initial develops in a similar way on the other side of the basal cell (Figs. 23, 24 & 40). These initials give rise to many sterile filaments by repeated branching, which develop around the middle cell product and ultimately form the sterile covering the pericarp of the cystocarp. Further initials may also be given off from the basal cell but could not be identified due to branch filaments from previous initials.

After the formation of first initial in the basal cell the middle cell also puts forth a protuberance either in the same direction or in opposite direction to the protuberance in the basal cell (Figs. 18, 19, 21-23 & 40). Then it gives second protuberance on the other side (Fig. 24). They are separated from the mother cell by cross walls. Formation of the first initials by the basal and hypogynous cells occurs either before or after the initiation



Figs. 30-34. *Scinaia moniliformis* var. *pakistanensis*: **30.** The type specimen, a preparation on herbarium sheet. **31**. Isotype of above showing range of habit, a preparation on herbarium sheet. **32**. Holotype of *S. moniliformis* J. Agardh (LD32207). **33**. Holotype of *s. indica* Børgesen (C5479). **34.** A specimen of *S. moniliformis* from Australia. (Figs. 32-34 have been reproduced from Huisman (1986). **Scle:** Fig. 30 = 95 mm, 31 = 75 mm, 32 = 28 mm, 33 = 94 mm, 34 = 48 mm).

Figs. 35-42. *Scinaia moniliformis* var. *pakistanensis*: **35 & 36.** Young cortical branch systems showing development of apical cells into utricles (*arrow*). **37.** T.S. of cortex showing epidermal utricle layer and hypodermal assimilatory layer and formation of secondary utricles (*arrow*) from hypodermal cells. **38.** Young carpogonial branch with a protubrance arising from basal cell but no initiation of trichogyne. **39.** Young cortical branch bearing developing carpogonial branch (2-called stage) on 6th cell from surface (*distal end*). **40.** Carpogonial branch bearing young trichogyne, 1 protubrance from hypogynous cell, 2 pericarp filaments (one 1-celled and one 2-celled) from basal cell. **41.** Distal part of a gonimoblast filament. **42.** Cystocarp. (**ac** = assimilatory cell, **b**= basal cell, **c** = carpogonium, **h** = hypogynous cell, **p** = protubrance, **pf** = pericarp filament, **t** = trichogyne, **u** = utricle. **Scale:** Figs. 35, 36 & 38-=40 = 12 μm, 37 = 54 μm, 41 = 18 μm, 42 = 200 μm).

of the tirchogyne. The development of initials after and before the initiation of trichogyne is clearly represented in Figs. 17 to 19 and 20 to 22, respectively. Several carpogonial branches have been observed with 2 daughter cells arising from the hypogynous cell in the form of filament initials (Figs. 23, 24 & 40). One carpogonial branch is found where the older protuberance becomes elongated and gets divided into 2 cells by a cross wall, whereas the younger protuberance remained 1-celled (Fig. 25), the trichogyne is young and the filamentous development of the hypogynous daughter cell is prior to fertilization; this type of cell formation is similar to 1-celled and 2-celled filament stage by basal cell in Figs. 19 and 23. This 4-celled stage of the hypogynous cell is different in shape and size from those found in other species of *Scinaia*. Further development is not clear due to the formation of pericarp filaments around the middle cell produced from the basal cell (Fig. 26). The development of gonimoblast initial either from carpogonium or middle cell product could not be observed clearly.

Cystocarp: Cystocarps are present below the cortex, they are orbicular-cuniate, 250-320 μm broad, neck up to 48 μm long × 60 μm broad, opens to the exterior through ostiole (Fig. 42). The cystocarp encloses the carposporophyte or gonimoblast which produces carpospores.

Gonimoblast: The gonimoblast consists of sub-dichotomously branched, closely placed, up to 90 μm long × 2-4 μm broad filaments (Fig. 41), arising from a mass of irregular cells, up to 10 μm long × 5 μm broad. On maturation 3-4 (-5) distal cells increase in size and turn into carposporangia, which are oblong, up to 16 μm long × 10 μm broad, each producing a single carpospore. Secondary carposporangia are seen arising within discharged or empty carposporangia (Fig. 27).

Carpospores: Carpospores are found to be of irregular shape, usually longer than broad, up to 15 μm long × 8.5 μm broad (Fig. 29).

Discussion

Huisman (1986) re-examined the types of *S. indica* Bφrgesen and *S.moniliformis* J. Agardh and concluded that both the species are conspecific and therefore, he made the former species a synonym of the later. The characters of the Australian population of *S. moniliformis* which he reinvestigated, are presented in Table I. The Pakistani and Australian populations differ in several respects. They are similar in height but differ significantly in the quantum of branching and the length of segments (Table I). Moreover, a critical examination of the figures of the type specimen of *S. moniliformis* and one of its representatives from the Australian population (Figs. 32 & 34) reveals two interesting differences in habit with the present as well as Indian populations, provided that the above specimens are considered to be the true representative of the Australian population: (a) more or less every segment of the Australian plants bear a dichotomy, (b) their segments may be of uniform size (Fig. 32) or they become uniformly larger distally (Fig. 34). The plants of Pakistani population and the figures of the Indian holotype (Figs. 30, 31 & 33) clearly show that in the distal region the branching occurs at a distance of 2 to 5 segments and the segments of different sizes are distributed randomly in the plants. Thus the Indian plants also become dissimilar with the Australian and closer to the Pakistani population in habit.

Table I. Comparative features of *Scinaia moniliformis* from Australia, India and Pakistan

Characters	Pakistani population (Present studies)	Indian population (Bǿrgesen, 1931)	Australian population (Huisman, 1986)
Plant height	22.5 cm	17.0 cm	22.0 cm
Branching	8-16 times di- to sub-dichotomous	11 times dichotomous	11 times dichotomous
Segments between successive constrictions	4-26×2.0-5.5mm, sub-cylindrical to oblong	15×4-5mm sub-cylindrical	10-15 (-17) × 4-5mm, oblong
Utricles	30-38×16-21μm	40-45×17-19 (-21) μm	25-30×17-23 μm near apex 35-50×20-30μm near base
Hypodermal cells	5-15μm diam.	16μm diam.	10-15μm diam. near apex 30μm diam. near base
Spermatangia	3.5-4.5×2-3μm borne singly on stalk-like filament	—	Unknown
Carpogonial branch	3-celled, 18-22.5 μm long on (5-) 6-7th cell	—	3-celled on 4-5th cell
Carpogonium	9-10×3-4.5 μm, conical	—	6-7×3.5μm, conical in figure
Hypogynous daughter cells	3 narrow cells in the form of one 1-celled + one 2-celled narrow filaments	—	3 broad cells in the form of one 1-celled + one 2-celled broad branches
Cystocarps	250-320μm broad orbicular-cuniate	250 μm broad roundish pyriform	250μm diam.. (urn-shaped in figure)
Carposporangia	16×10μm, oblong, in distal chains of 3-4 (-5)	—	—
Carpospores	15×8.5μm, shape indefinite	—	—

Huisman (1986) found out that in the basal part of Australian plants the sizes of utricles and hypodermal cells are much larger than those of the apical part, whereas in the present plants the size is uniform throughout, and as such the utricles and hypodermal cells are much smaller in the Pakistani plants (utricles 30-38 × 16021 μm, hypodermal cells 5-15 μm in diam.,) than those of the Australians (utricles 25-50 × 17-30 μm, hypodermal cells 10-30 μm in diam.,). In the size of the above cells the Indian plants also agree with those of Pakistan, with the exception that the utricles are to some extent longer

in the former (Table I). Moreover, the utricles of the Indian plants, as indicated by Bφrgesen (1931, Fig. 2, p. 4), appear quite identical in shape to those of the present plants (Fig. 37) when seen in low power, in high power they appear as shown in Figs. 2 and 3.

Differences are also noted in the reproductive features of the present and Australian plants. Both bear 3-celled carpogonial branches, which are borne on medullary filaments "some 3-4 cells from the surface of the thallus" (Huisman, 1986) in the australian plants but on 6th or 7th cell in the present plants (Figs. 26 & 39); the carpogonia also appear smaller (6-7 μm long) (Huisman, 1986, Figs. 9-11, p. 276) but in the present case 9-10 μm long (Figs. 17-25). The hypogynous cell produces 3 daughter cells in the form of one 1-celled and one 2-celled branches in both the populations, but in the Australian plants they are much larger and more globular (Huisman, 1986, Figs. 11 & 12, p. 276) and in the present plants they bear a characteristic appearance being narrow and filamentous (Figs. 23-25 & 40). In the Australian plants the carposporangia are produced in chains (number of cells not given), which are on maturation ovoid and measure 5-8 × 10-15 μm (Huisman, 1986) and probably show that they are broader than long, but in the present case the carposporangia are oblong up to 16 μm long × 10 μm broad, produced in chains of 3-4 (-5) cells. The cystocarps are usually of the order of 250 μm, but some range to 320 μm in breadth and appear orbicular-cuniate in the present plants (Fig. 42), thus slightly differing from those of Australian and Indian plants (Table I).

Although the plants of Pakistani coast are longer than the Indians and correspondingly the quantum of branching and range of length of segments are also greater in them, nevertheless the mode of branching and the random arrangement of segments are identical in both the populations due to which the holotype of *S. indica* Bφrgesen (1931) appears similar in habit with the Pakistani plants (Figs. 30 & 33). From the above study it may be concluded that the plants of Pakistan closely resemble in habit with Indian and distantly with Australian. Same is true as far as their intercellular structure of vegetative thalli is concerned. The details of reproductive structures in *S. indica* (Bφrgesen, 1931) are lacking and in the existing knowledge it is difficult to say whether the plants of Pakistan and India are similar or different at specific level.

The present plants appear distinctive from Australians in reproductive structures too. The points of difference lie in the position of carpogonial branch, size of carpogonium, appearance of hypogynous daughter cells and the size and shape of carposporangia; spermatangia are unknown in the Australian plants but are found in the plants of Pakistan.

The Indian coast adjoins the coast of Pakistan and the type locality of *S. indica* is not very far from Karachi. It is, therefore, highly probable that the above species may occur on the coast of study and it may be the reason that the present plants appear to be closer to the Indian plants than to those of Australian. But Huisman (1986) put *S. indica* in synonymy with *S. moniliformis*. Since he has not provided any data of the Indian plants in comparison with the Australians, it is difficult to understand that the two species are conspecific. From his work it is not clear that he has also studied the vegetative and reproductive structures of *S. indica* in detail. Huisman (1986) simply writes "the Australian material was found to be identical in all respects, including utricle size and shape, which appears to be more variable than that originally described by Bφrgesen". It does not show that he had studied the size and shape of utricles from apical and basal parts of Indian plants and the size of utricles and hypodermal cells is as large as in Australian plants. It rather shows that the size of utricles, as described by Bφrgesen in *S.*

indica, comes in the range of Australian plants. Similarly he did not mention about the reproductive structures of Indian plants. It is not understandable that the data provided for the Australian plants is exactly similar to the Indian plants.

In the present state of knowledge it is difficult to decide the specific status of the plants of Pakistan and India. There is a need for more details of vegetative and reproductive structures of the Indian plants and confirmation of the branching habit and segment arrangement in the Australian plants. Presently it seems reasonable to put the Pakistani plants in a new variety of *S. moniliformis* on the grounds of differences mentioned above.

Scinaia moniliformis is related to 15 other species of the genus in having one 1-celled and one 2-celled lateral sterile branches on the hypogynous cell i.e., *S. breggrenii* (Levring) Huisman, *S. caribaea* (Taylor) Huisman, *S. cottonii* Setchell, *S. flabellata* Kajimura, *S. forcellata* Bivona-Bernardi, *S. furcata* Zablackis, *S. howensis* Huisman, *S. japonica* Setchell, *S. okiensis* Kajimura, *S. pseudojaponica* Yamada *et* Tanaka, *S. saifullahii* Afaq-Husain *et* Shameel, *S. shameelii* Afaq-Husain, *S. snyderae* (Setchell) Huisman, *S. tokidae* Kajimura and *S. tsinglanensis* Tseng (Afaq-Husain & Shameel, 1998). This group of 16 species is considered to be more highly evolved than those species in which the hypogynous cell produces several lateral sterile branches (Kajimura, 1995) e.g., *S. aborealis* Huisman, *S. australis* (Setchell) Huisman, *S. prolifera* Huisman and *S. pseudomoniliformis* Kajimura.

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