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A new red alga Scinaia shameelii (Galaxauraceae, Bonnemaisoniales) from Pakistan

SYED AFAQ-HUSAIN

RÉSUMÉ

AFAQ-HUSAIN, S. (1996). Une nouvelle algue rouge du Pakistan, Scinaia shameelii (Galaxauracées, Bonnemaisoniales). *Candollea* 51: 445-459. En anglais, résumés français et anglais.

Description d'une nouvelle espèce de la côte de Karachi, Pakistan: *Scinaia shameelii* Afaq-Husain (Galaxauraceae, Rhodophycées). Etude détaillée des caractères externes, végétatifs, anatomiques, des structures reproductives et de leur développement. Les critères marquants de cette espèce sont: thalle fortement aplati; ses segments par dichotomies successives sont étroits à la base, le plus large aux dichotomies et atteignent 6 mm au milieu; les proximaux, petits et étroits, deviennent plus larges dans la partie distale de la plante; à la surface, les cellules colorées sont rondes, petites et présentes seulement par endroits dans les angles de grands utricules polygonaux sans couleur; les branches carpogoniales sont à 3-4 cellules; les spermatanges sont sur des sores en pustules et les cystocarpes sont disséminés sur les frondes. Les carposporanges forment des chaînes de 3-5 cellules.

ABSTRACT

AFAQ-HUSAIN, S. (1996). A new red alga Scinaia shameelii (Galaxauraceae, Bonnemaisonailes) from Pakistan. *Candollea* 51: 445-459. In English, French and English abstracts.

A new species, *Scinaia shameelii* Afaq-Husain belonging to the family Galaxauraceae (Rhodophyta), has been described from the coast of Karachi, Pakistan. The study circumscribes external characters, vegetative, anatomical and reproductive structures and their development in detail. The salient features of this species are: strongly flattened thallus; its segments between successive dichotomies, are narrow at base, broadest at dichotomies and up to 6 mm in the middle, the proximal ones being small and narrow, becoming longer and broader in the distal region of plant; in surface view the coloured cells are round and small and present only at places on the corners of large colourless utricles, which appear polygonal; carpogonial branches are 3-4 celled; spermatangia are born in pustular sori and cystocarps found scattered throughout the fronds; carposporangia are observed in chains of 3-5 cells.

KEY-WORDS: Marine Algae – *Scinaia* – *GALAXAURACEAE* – Rhodophyta – Karachi – Pakistan – Morphology – Anatomy – Reproduction.

Introduction

Scinaia Bivona-Bernardi is a cosmopolitan genus with 29 species distributed all over the world (HUISMAN, 1986; ZABLACKIS, 1987). Out of these, three species *viz. S. complanata* (Collins) Cotton, *S. hatei* Børgesen and *S. indica* Børgesen have been reported to occur at the coasts of Karachi (BØRGESEN, 1931; ANAND, 1943) and Lasbela (SHAMEEL, 1987; SHAMEEL & al., 1989). Afterwards no work appears in the literature on this genus from the coast of Pakistan.

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During the survey of Karachi and Lasbela coasts, which was primarily aimed at identification and assessment of biomass of economically important seaweeds (SHAMEEL & AFAQ-HUSAIN, 1987), specimens of *Scinaia* were also collected and studied critically. The flat specimens were found to differ in several respects with those of existing species of *Scinaia* and, therefore, given the status of a new specific taxon. The present work describes its external characters and vegetative, anatomical and reproductive structures in detail.

Material and methods

The fresh drift plants were collected from Manora, Paradise Point and Pacha (Nathiagali) during the months of November-January 1987-1991. 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 only with 1% aniline blue (for section cutting) or a mixture of 1% aniline blue + 10% HCl (for squashing) for 24-48 h. 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. This provides good staining within 1-6 h.

The sections were prepared either by free hand cutting or with the help of a rotary microtome. For this purpose a cheap and quick method was developed, the stained piece of frond was inserted in a cut or scar made in a trimed potato chip, already mounted on a steel or wooden block, and then the whole mount was kept in a freezer for 24 h. Then microtomy was done as usual but quickly, completing the process before melting of the mount. The sections were removed from the blade, washed thoroughly in distilled water and mounted on slides in glycerine + acetic acid + distilled water (1:1:1, v/v) or in Karo, a corn (pancake) syrup used as baby food.

Results

Following are the characters studied in detail of the new alga, *Scinaia shameelii* Afaq-Husain.

Morphological characters

Plants 6 to 11 cm high, brownish red, cartilaginous, flat, unconstricted; holdfast discoid, up to 2 mm broad; stipe tereto-compressed, 3-6 mm long and 1 mm broad at first dichotomy. Branching dichotomous up to 11 times, closely placed with acute angles; the segments between two successive dichotomies are very narrow and short in the basal region becoming longer and broader upwards, up to 20 mm long, narrow at base (2 mm broad) but not constricted, 4-5(-6) mm broad in the middle, becoming up to 10 mm broad at the upper dichotomy (Figs. 22 & 24). Branch apices tapering abruptly to a point and appearing broadly obtuse to truncate in microscope. New thalli (observed up to 5) arising from broken surface of the remnant thallus, appearing constricted at base (Fig. 22, arrow). The margins of the fronds are inflated due to which the T.S. appears dumb-bell shaped, 0.11 to 0.22 mm thick in the middle and 0.7 to 1.13 mm at margins; slightly inflated regions are also present in the middle, due to which the middle part of T.S. appears unevenly thickened (Fig. 1).

Surface view of the thallus

The microscopic examination of the surface of the fronds shows two types of cells:

(a) colourless, large, polygonal cells, usually penta- to heptagonal, up to 24 μm broad, but smaller quadrigonal cells also present singly surrounded by the above cells;

(b) small round, coloured cells (become darkly stained with aniline blue) usually present singly or occasionally in twos at distances, at the corners of the colourless cells, up to 7 μm broad (Fig. 2).

Anatomical features

The thallus construction is not exactly typical of *Scinaia* in the sense that it lacks an axial core of filaments, which form the central medulla in other species of *Scinaia*. In the present plants the axial filaments do not form a core, but are spread up in the middle, narrow part of the frond. In transverse section (T.S., Fig. 1) these filaments are seen as round, thick-walled cells which are scattered singly or in small groups. Such a group is usually found at the beginning of inflated margin. The filaments are also seen running across the lumen of the frond, forming a loose network connecting the cortex. The filaments are dichotomously branched, up to 6 μm broad, but their cells may become broader up to 13 μm at their distal ends. At places these filaments also bear noticeably small but broad cells, from which branch filaments are also seen arising (Fig. 3).

The epidermal layer is made up of large colourless cells, known as utricles, which are usually longer than broad, arranged anticlinally. In T.S. the utricles appear slightly flat and angular at distal end and round to broadly conical proximally, up to 44 μm long × 34 μm broad. At places coloured branchlets (darkly stained with aniline blue) are also observed in between the utricles given off from the hypodermal cells (assimilatory cells) (Figs. 5 & 6). These branchlets are 1-3 cells long, narrow below becoming broad distally.

The function of the coloured branchlets is probably to produce monosporangia, spermatangia or secondary utricles replacing the old ones. Some branchlets (narrow and dark in colour, up to 7 μm broad at distal end) cut off rounded bodies at the tip which may be the monosporangia (Figs. 6 & 7), or they further produce sub-branchlets bearing spermatangia (Fig. 10). Some single-celled branchlets having breadth up to 9 μm or more, light in colour, may gradually increase in size, loose their colour and become secondary utricles. Such cells of different sizes, which appear to be turning into utricles, have been observed clearly (Figs. 6 & 23). Below the utricles 1-2 layers of orbicular, oblong to conical cells are present, which are dense in cytoplasm and plastids and assimilatory in function (become darkly stained with aniline blue), up to 19 μm long or broad (Figs. 5 & 6). Some of the lower assimilatory cells give rise to 2-3 μm broad rhizoidal filaments, which run parallel to the surface in between or below the assimilatory cells.

Growth of the thallus

Microscopic examination of the tips of the young branches show that the growing point is present in slight depression and is slightly broad in the direction of the thallus-width. It consists of closely placed, sub-dichotomously branched, free filaments, which are made up of elongated, cylindrical, 1-2 μm broad cells (Fig. 4). Their apical cells, which are narrow and slightly swollen at the tips, continuously grow in length and divide by cross walls producing new cells proximally and increasing the length of the thallus. The daughter cells thus formed, may produce one young branch from their distal end so that the branch system appears dichotomous. These branch filaments either develop along the growing point in the direction of the long axis, or are deflected outward and grow at right angle to the above direction, increasing the thickness of the thallus.

Development of the cortical system

As the growth continues the cells of the deflected filaments become slender and elongated in the interior but at the periphery the cells remain shorter but become broader and 2-3 distal cells (except the apical) usually produce two branchlets consisting of 2-3 cells each. Their lower cells

in turn again produce similar branchlets 1-2 times more, so that the branch system gradually becomes trichotomous and conjusted distally (Figs. 7 & 8). Primarily all the cells of the branch system are alike and coloured (containing plastids) but soon they start differentiating into outer colourless cells and inner pigmented cells. Most of the apical cells of the branch system enlarge in size, become oblong or pyriform in shape and gradually loose their colour (Figs. 7-9 & 25). As the growth continues they become completely colourless and slightly flat above (Fig. 9). They press each other due to increase in breadth, and finally acquire the shape of mature utricles adhering to each other firmly and forming surface of the mature thallus (Figs. 5 & 6).

It is commonly observed that one of the apical cells (probably the oldest) in a branch system enlarges first and becomes emerged in the branch system. It is dense in cytoplasm and may bear a rounded body at the tip (probably a monosporangium) or it may turn into a utricle (Figs. 7 & 8). During the development of the branch system some narrow coloured branchlets are also produced, whose apical cells do not turn into utricles, but remain narrow and coloured in between the utricles (Fig. 25).

After the differentiation of utricles the lower 1-2 cells in the branch system also enlarge in size, become dense in cytoplasm and plastids and acquire the shape of assimilatory cells, forming the assimilatory layer of the thallus (Figs. 9 & 25). The cells proximal to assimilatory ones, become elongated, narrow, partially coloured to colourless. In some branch systems, during the development of the utricles, 3rd to 5th cell (usually 4th) produces a branch initial from below the distal end (Fig. 8). This initial develops into a long, slender, colourless, about 2 μm broad rhizoidal filament, which travels parallel to the thallus surface. In the mature thallus the assimilatory cells also produce secondary narrow coloured branchlets, which penetrate through in between the utricles.

Reproductive structures

The plants are monoecious, carpogonia and the spermatangia are observed on the same plants.

Spermatangia. – Spermatangia are produced on the surface of the thallus in small sori, which start appearing about 10 mm proximal to the tips of the fronds. The spermatangial branches are narrow, consisting of 2-4 cells, and arise in cluster from the assimilatory cells. These branches develop towards surface by forcing their way in between the utricles and finally bear up to 4 spermatangia distally, which emerge above the surface of the thallus (Fig. 10). Spermatangia are oblong, up to 5 μm long × 4 μm broad, each producing a single spermatium (liberated spermatium was not observed).

Carpogonia. – Carpogonial branches are produced on 5th or 6th cell of a young cortical branch system, consisting of 3-4 cells. The 3-celled carpogonial branches are common and up to 20 μm long, 4-celled ones are occasional and up to 25 μm long (excluding trichogyne) (Figs. 13, 14, 16 & 27). The carpogonium is broad at the base becoming conical distally, up to 10 μm long × 6 μm broad. The hypogynous cell is usually shorter in length than the other cells of the carpogonial branch, measured up to 4.5 μm long or broad. The basal cell is up to 5.4 μm long. One-celled, 2-celled and 3-celled stages of carpogonial branches have been observed, which show that these cells develop successively, the trichogyne develops in the last.

The 5th or 6th cell of a young cortical branch system puts forth a protuberance on its distal end. This protuberance is dense in cytoplasm and develops in the direction of growth. It soon cuts off from the mother cell by a cross wall and behaves as a carpogonial branch initial (Fig. 8). The later elongates and divides by cross walls first into 2 cells and then 3, successively, and sometimes into four cells as well (Figs. 11, 14 & 26). Its apical cell becomes conical at distal end and behaves as the carpogonium. The distal end of the latter produces a round to oblong protuberance, the trichogyne initial (Figs. 13, 14 & 26), which elongates up to 100 μm to form the mature trichogyne with obtuse tip. The trichogyne is about 1 μm broad, but becomes broader at both the

proximal and distal ends. A constriction is always seen at the joint of carpogonium and trichogyne (Figs. 16, 17 & 20).

After the inception of trichogyne the basal cell of the carpogonial branch divides first by longitudinal-slightly incurved wall to form the first initial of the pericarp filament, which elongates and divides by a cross wall forming 2-celled filament. During this period a second initial is cut off on the other side of the basal cell (Figs. 12, 13 & 15). During further development few more initials may develop in a similar way but only up to 3 initials are observed clearly (Fig. 17). These initials develop into repeatedly branched filaments by elongation and cross division of the apical cell. The filaments develop around the middle cell product forming a cup-like structure (Figs. 20 & 28), which is finally converted into 3-4 celled thick covering (the pericarp) of the mature cystocarp. After initiation of the pericarp filament the middle cell also divides into 4 cells successively, by longitudinal-slightly incurved walls (Figs. 13, 15 & 17).

Many carpogonial branches have been observed with divisions in the basal cell prior to the divisions in the middle cell but no branch is observed with a division in the middle cell prior to the division in the basal cell (Fig. 12). First one daughter cell is cut off on one side then the second on the other side of the middle cell forming 3 cells in the middle (Figs. 13 & 15). The 4th cell is cut off from one of the daughter cells so that 4 cells are formed connected in series through cytoplasmic connections. Thus the hypogynous cell produces a 1-celled and a 2-celled branch. Carpogonial branches, with trichogyne initials but no division in the basal cell, have been observed (Figs. 14 & 26) but those possessing divisions in the basal cells but no trichogyne, have not been seen. It shows that the trichogyne develops prior to any division in any cell of the carpogonial branch.

It was also observed that the carpogonium remains emerged through the young covering (young pericarp) for a long time but the formation of a gonimoblast initial from the carpogonium has never been observed, which shows that probably fertilization takes place after a long time and/or the formation of gonimoblast initials takes place after the carpogonium is completely covered by the developing pericarp (Fig. 20). In 4-celled carpogonial branch, the pericarp filaments develop from both the cells present proximal to hypogynous cell (Figs. 16 & 27).

Cystocarp. – Cystocarps are observed scattered in the entire fronds except the basal portion. They are urn-shaped, up to 250 μm broad, broader than long excluding the neck, which is up to 30 μm long (Fig. 30).

Gonimoblast. – The gonimoblast initials have not been observed arising either from carpogonium or middle cell product till later stage of the development of cystocarp (Figs. 17 & 20). It may be possible that the cells of the gonimoblast initials are not distinguishable from those of pericarp filaments. The mature gonimoblast consists of sub-dichotomously branched filaments arising from a group of roundish, oval cells, in the form of a broad cone or cup (Fig. 19). On maturation usually 3 but up to 5 distal cells increase in size and turn into carposporangia, each containing a single carpospore, which are discharged successively from apex downward (Figs. 18, 19 & 29). The mature carposporangia are oblong to roundish, up to 14 μm long × 8 μm broad.

Carpospores. – Carpospores vary in shape and size, roundish, oblong or slightly angular, up to 12 μm long × 7 μm broad (Fig. 21).

General characters

Plants up to 11 cm long, cartilaginous, dichotomously branched with acute angles, unconstricted, flat, the segments between successive dichotomies are up to 20 mm long, 2 mm broad at the base, 6 mm in the middle and up to 10 mm at the dichotomy; the proximal segments are much narrow and short, becoming longer and broader distally. The frond is 0.22 mm thick, margins inflated to 1.13 mm. Epidermis is made up of large, colourless utricles (which are up to 44 μm long × 34 μm broad), and narrow coloured branchlets at distances. In surface view the utricles appear polygonal up to 24 μm broad, and coloured branchlets as rounded cells placed distantly

at the corners of the utricles, up to 7 µm broad. Axial filaments found scattered singly or in small groups in the middle part of fronds. Plants monoecious; spermatangia borne in small sori, oblong, 5 µm long × 4 µm broad; carpogonial branches 3-4-celled, 3-celled up to 20 µm long, 4-celled up to 25 µm (without trichogyne); carpogonium conical distally, up to 10 µm long × 6 µm broad, hypogynous cell produces up to 3 daughter cells in the form of one 1-celled and one 2-celled branches. Cystocarps urnshaped, up to 250 µm broad. Up to 5 distal cells of the gonimoblast filaments are converted into carposporangia which are up to 14 µm long × 8 µm broad; carpospores roundish to elongate, up to 12 µm long × 7 µm broad.

Diagnosis

Scinaia shameelii Afaq-Husain, **spec. nova**

Plantulae usque ad 11 cm altae, frondes planae, 0.11-0.22 mm latae in medio et 0.7-1.13 mm ad margina, 4-5(-6) mm latae in segmentorum mediis. Rami carpogoniales 3-4 cellulati, cellula hypogyna producit usque ad 3 cellula-filia. Cystocarpi diffusi sunt per frondium latitudinem, usque ad 5 cellulas distales filamentorum gonimoblastorum et convertuntur in carposporangia.

Holotype: H.Sc. 1 PCSIR (Leg. *S. Afaq-Husain,* 28.1.1991) Manora, Karachi (Fig. 22).

Isotypes: H.Sc. 2, 3 PCSIR (Leg. *S. Afaq-Husain,* 28.1.1991) Manora, Karachi, Pakistan.

Other specimens examined: Paradise Point (Leg. *S. Afaq-Husain,* 20.12.1987, 23.12.1988); Pacha (Nathiagali, Leg. *S. Afaq-Husain,* 14.11.1989).

Habitat: Subtidal, only drifted plants were collected.

The new species, *Scinaia shameelii*, has been named after my teacher, Prof. Dr. Mustafa Shameel, who has developed a new concept of phycochemistry and made numerous contributions on the barobiology, bioactivity, ecophysiology, phycochemistry and taxonomy of marine benthic algae, especially the red algae of Pakistan.

Discussion

The flat species of *Scinaia* comparable to present one are *S. cottonii* Setchell described from Japan, *S. incrassata* Eiseman described from East Florida and *S. latifrons* Howe described from Pacific Mexico, but these are not reported from the shores of Indo-Pakistan subcontinent or its adjacent countries. However, *S. complanata* (Collins) Cotton has been reported from the area of study with a little description of uncertain value for identification (ANAND, 1943). According to EISEMAN (1979) *S. complanata* is not flat, he writes "*Scinaia complanata* is in the writer's experience only very slightly flattened if at all, contrasting with the very strongly flattened *S. incrassata*". Our species is also strongly flat and as such does not bear resemblance with *S. complanata*. OKAMURA (1921) includes Japanese plants of *S. complanata* Cotton in *S. cottonii* on the basis of flat thalli. He also reported that *S. complanata* was raised to specific rank from a form of *S. forcellata* Bivona, which is not flat.

Scinaia cottonii was described from two pressed specimens by SETCHELL (1914) and the description is not complete (EISEMAN, 1979). It is, therefore, difficult to compare it with the present species. Nevertheless the studies of OKAMURA (1921) show that *S. cottonii* is quite different in habit and appearance from *S. shameelii*. A critical examination of the figure of *S. cottonii* (OKAMURA, 1921, Fig. 1, Pl. CLXXIII) reveals that its fronds are broader throughout the plant, from base to apex except the stipe; the segments between successive dichotomies are not less than 5 mm broad at base, up to 10 mm in the middle and more than 10 mm at the dichotomies; but in the present species the fronds are relatively narrow, the segments are as narrow as 2 mm at the base, up to 6 mm in the middle and not more than 10 mm at the dichotomies. Moreover, in both the species the plants are equal in height but the quantum of branching is low

in *S. cottonii* than in *S. shameelii* and correspondingly the segments are also longer in the former species (Table 1).

The character, in which *S. shameelii* and *S. cottonii* widely differ, is the size of segments in the basal region of the plants. In former the proximal segments are very narrow and small (Figs. 22 & 24) as compared to the distal, whereas in latter the difference between proximal and distal segments is very little and its proximal segments appear much longer and broader (15-20 mm or more long × 6-8 mm or more broad in the middle of the segment) as compared to those of the new species. OKAMURA (1921) gave much importance to the transverse wrinkles or elevations present on the surface of the fronds of *S. cottonii* and which, according to him, are also present in *S. latifrons*, due to which he suggested that the two species might be conspecific. The same elevations are also found in the present species but only detected in T.S. as roundish or elongated pustules arranged randomly; their presence in *S. cottonii, S. latifrons* and the present species makes them to be of insignificant value.

Scinaia latifrons consists of larger plants than *S. cottonii* or *S. shameelii*, its fronds tend to be broader than in *S. cottonii*, and the margins are nearly twice as thick as in the new species but its utricles are smaller than in the later (Table 1). The other important difference is that *S. latifrons* is dioecious with continuous spermatangial sori, which are present from base to apex along the margins (EISEMAN, 1979), but the present species is monoecious with isolated pustular spermatangial sori. Moreover, the cystocarps of *S. latifrons* are up to 320 μm broad with tendency of marginal aggregations, but they are only up to 250 μm broad in *S. shameelii* and remain scattered at random.

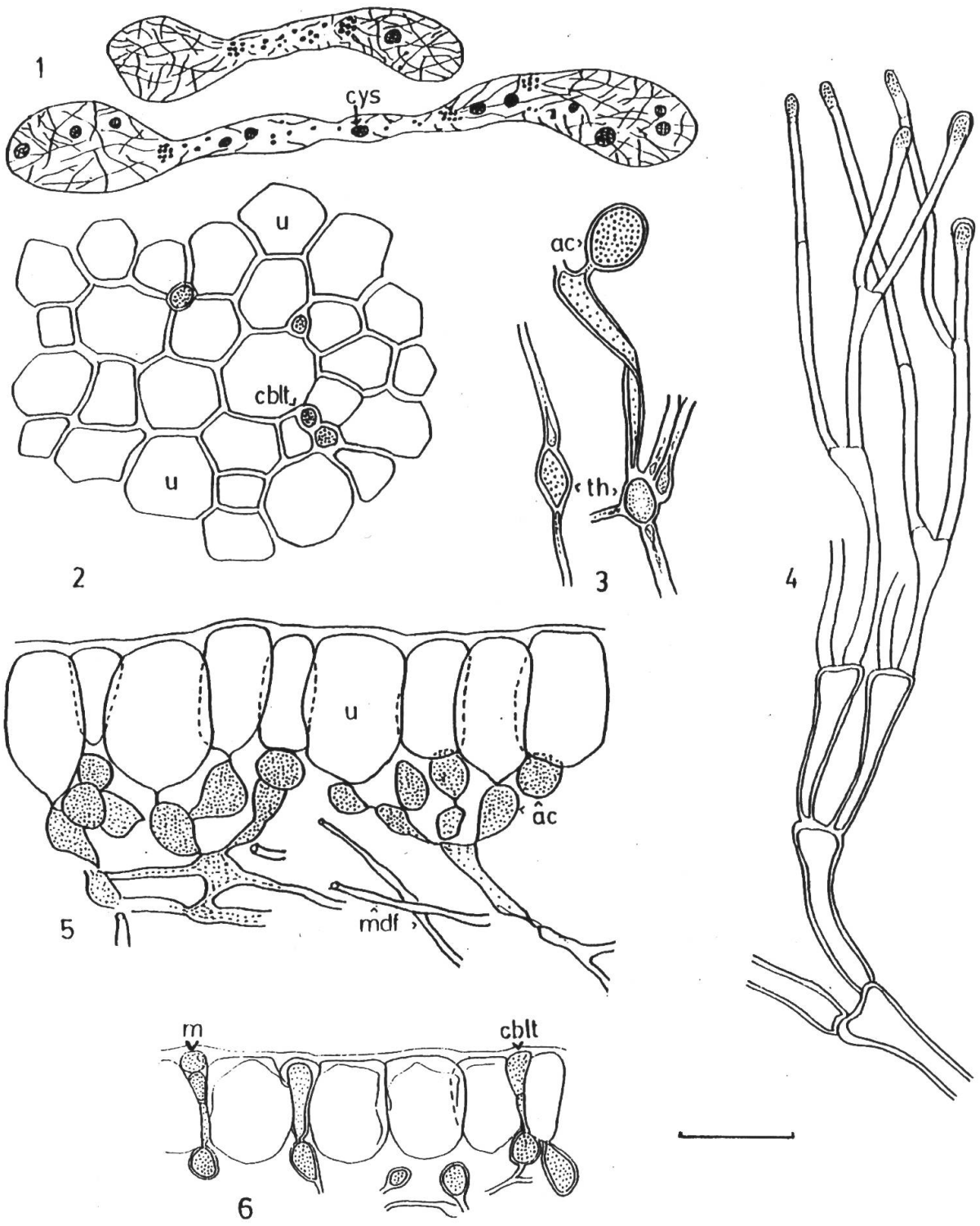
Scinaia shameelii widely differs from *S. incrassata* in plant height, margin thickness and location of the cystocarps; in the latter species the height is nearly three times and the margin thickness is only half of the former, and the cystocarps are restricted to the inflated margins in *S. incrassata* but found scattered throughout the thallus in *S. shameelii*. Moreover, these two species also differ in the number of cells of the carpogonial branch, hypogynous cell product and number of carposporangia produced in a gonimoblast filament. In the present species the carpogonial branch is 3- to 4-celled (Figs. 12, 16 & 26), the hypogynous cell divides into 4 cells (Fig. 17) and up to 5 distal cells of the gonimoblast filaments get converted into carposporangia (Fig. 18), whereas in *S. incrassata* the carpogonial branch is 3-celled, the hypogynous cell divides into 3-6 cells and 2-3 distal cells of gonimoblast filaments form carposporangia.

From the existing knowledge of the related species discussed above and the present work which circumscribes fully all the characters including the development of reproductive parts, except the gonimoblast initials, it becomes clear that the present plants differ in habit as well as in intercellular structures to an extent that they may be treated as a new specific taxon. It may be important to note that 4-celled carpogonial branches are only reported in *S. furcata* Zablackis (ZABLACKIS, 1987), which bears cylindrical thalli, besides the present species.

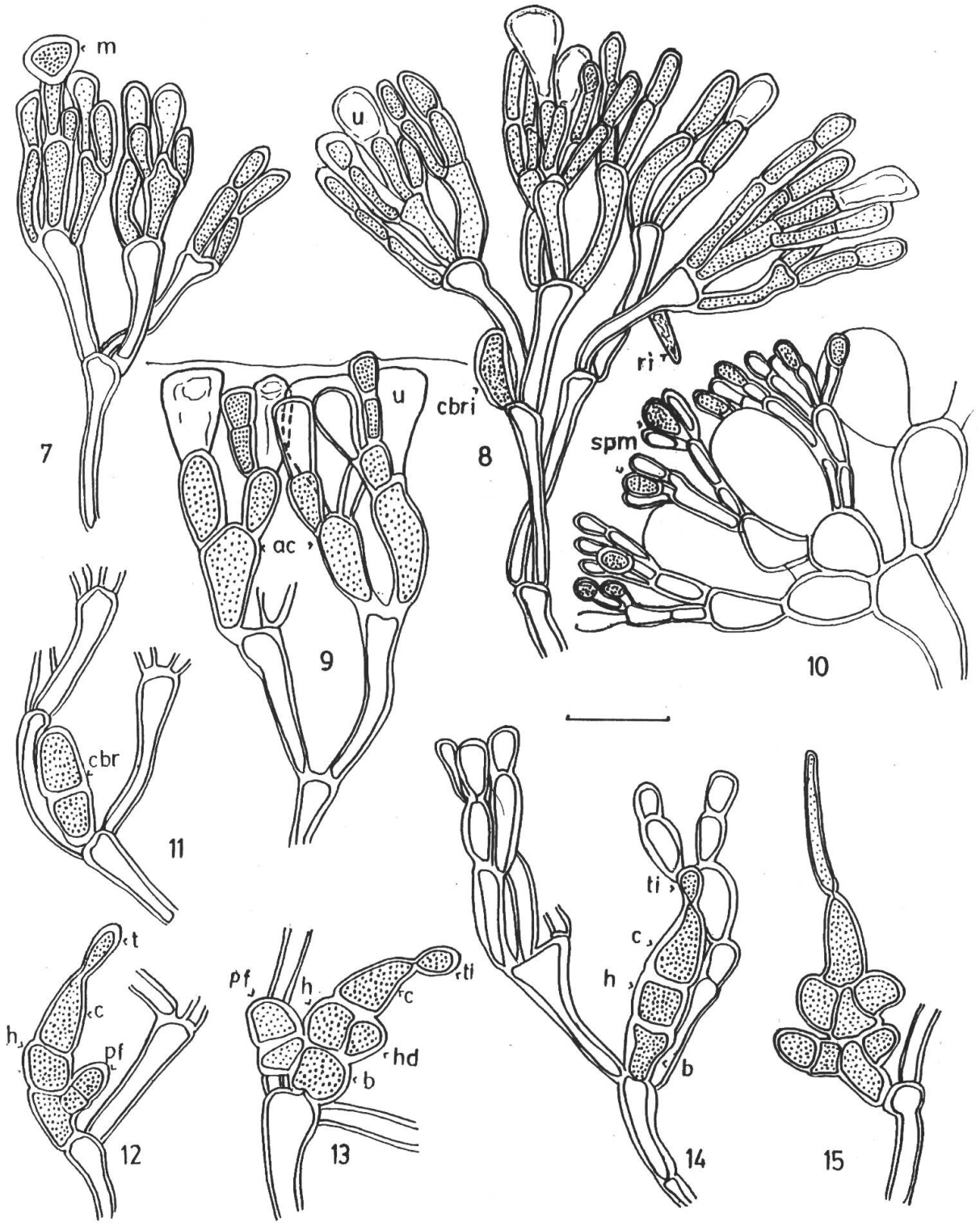
Table 1. – Comparative features of *Scinaia shameelii* and three related species.

Features	*S. shameelii* spec. nova	*S. cottonii*		*S. incrassata*	*S. latifrons*	
		SETCHELL (1914)	OKAMURA (1921)	EISEMAN (1979)	HOWE (1911)	ABBOTT & HOLLENBERG (1976)
Plantt height	11 cm	–	9-12 cm or more	30 cm	–	10-20 cm
Frond width	variable between successive dichotomies; 2 mm at base of segment, 4-5(-6) mm in the middle, 10 mm at the dichotomy	3-10 mm	3-10 mm, branches attenuate below middle of segment	4-10 mm	5-12 mm	5-10 mm or more, broader in the middle of segment
Surface of fronds	wrinkles or elevation of irregular shape and size present (not visible with nacked eyes)	–	transverse wrinkles, may become reticulate	–	–	(according to OKAMURA, 1921, wrinkles present)
Frond thickness (in the middle)	0.11-0.22 mm	–	–	0.1-0.2 mm	0.25 mm	–
Margin hickness	0.7-1.13 mm	–	–	0.4-0.6 mm	1-2 mm	–
Length of segments between successive dichotomies	very small at base to 20 mm in the distal region	–	up to 30 mm (in figure)	–	–	–
Branching	11 times dichotomous	–	dichotomous 5-7 times	–	–	dichotomous to subdichotomous
Branch apices	tapering abruptly to a pointor obtuse to truncate in microscope	–	–	linear in distal portion of branches	extensively expanded at branch apices	–

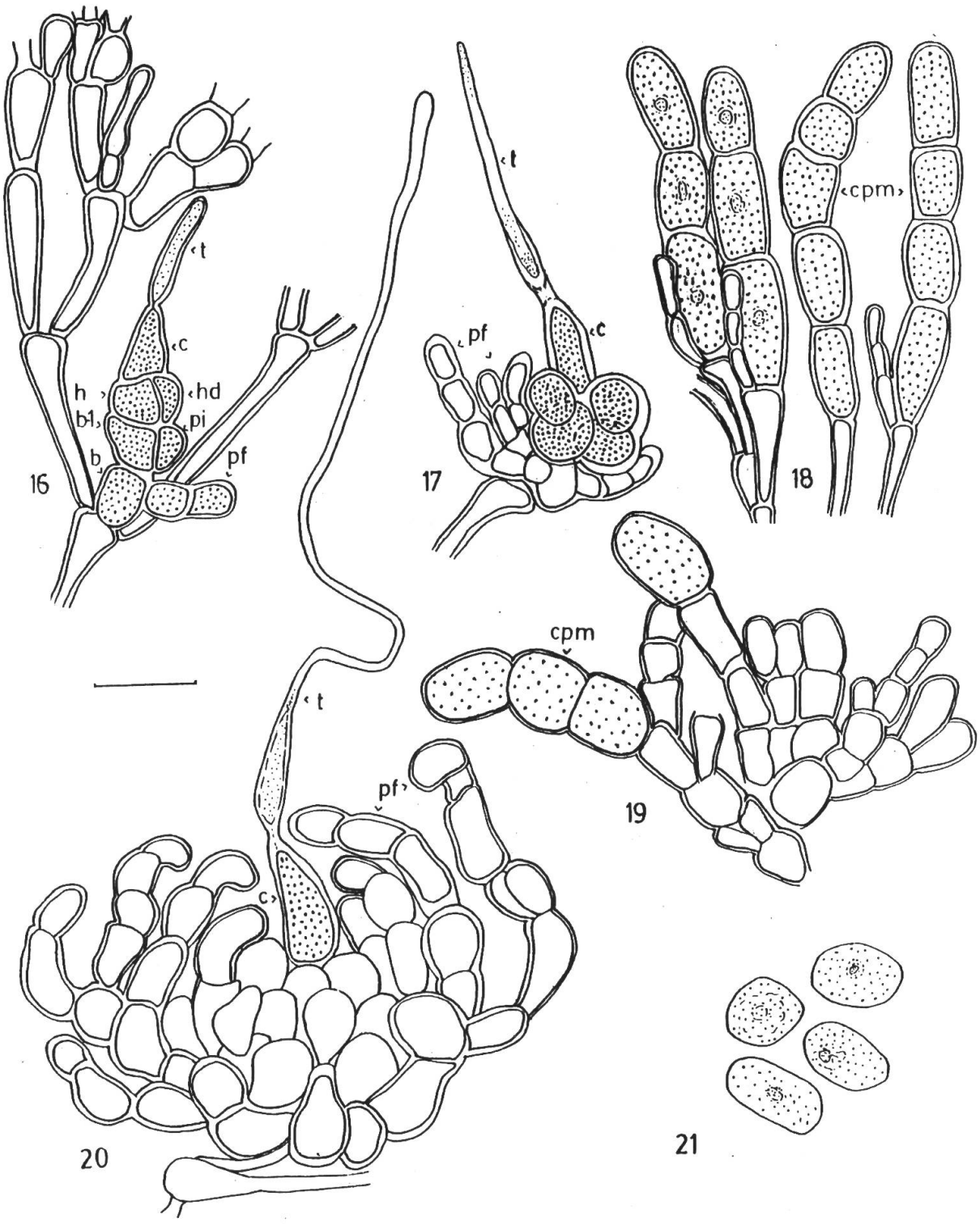
Utricles	rectangular to squarish, up to 44 × 34 µm	16-20 × 13-17 µm	rectangular oblong 40-46 × 27-30 µm	35-40 × 17-26 µm	30-35 × 20-30 µm	square to rectangular
Hypoderdermal cells	orbicular, oblong to conical, up to 19 µm long or broad	–	–	orbicular, 9-15 µm diam.	18-20 µm diam.	–
Sexuality of plants	monoecious	monoecious	–	monoecious	dioecious	–
Spermatangia	5 × 4 µm, borne up to 4 terminally on unbranched filaments in isolated sori	–	–	pyriform 4-8 × 2-4 µm (in pustular sori)	–	in dense sori, occupying margins from base to apex (in continuous sori)
Carpogonial branch	3 to 4-celled, up to 25 µm long	–	–	may be 3-celled (not observed by himself)		–
Carpogonium	conical, up to 10 × 6 µm	–	–	–	–	–
Hypogynous daughter cells	3 large roundish cells as a 1-celled and a 2-celled-branches	–	–	2-5 cells	–	–
Cystocarps	urn-shaped, up to 250 µm broad, scatted in the entire frond	scattered	scattered with some tendency towards interamarginal aggregation	broadly pyriform, 250 µm diam. restricted to inflated margins	200-320 µm diam.	aggregated along margins
Carposporangia	oblong to roundish, up to 14 × 8 µm, in linear groups of 3-5	–	–	oblong, oval or obovate, 6-24 × 6-8 µm, in linear groups of 2-3	–	–
Carpospores	irregular shape, up to 12 × 8 µm	–	–	–	–	–



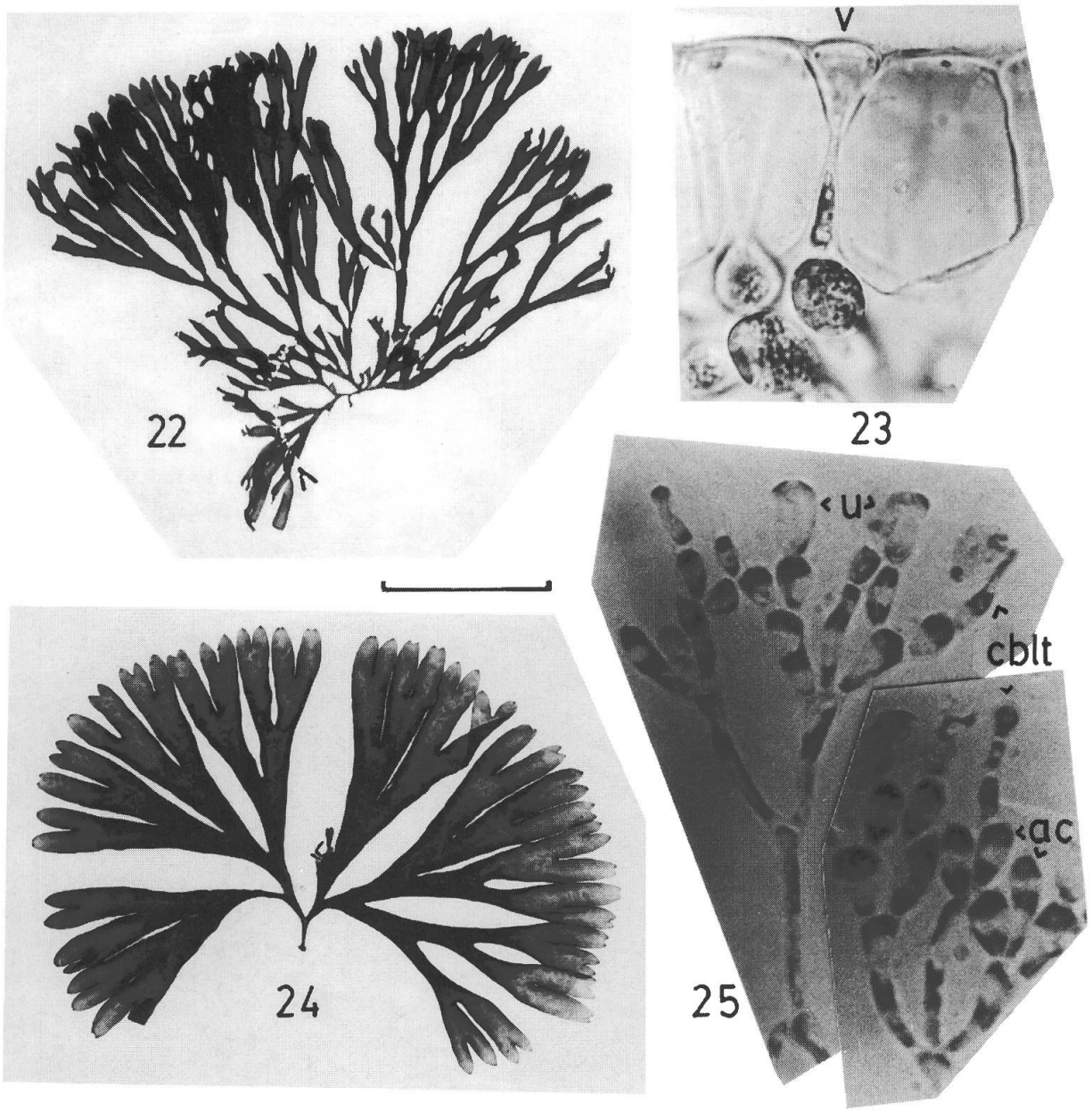
Figs. 1-6. – *Scinaia shameelii* Afaq-Husain
1, schematic diagrams of T.S. of the fronds from different plants; **2**, surface view of thallus; **3**, medullary filaments bearing small and broad cells from which branch filaments arise; **4**, A filament system from growing point; **5 & 6**, T.S. of cortex of fronds from different plants; (**ac** = assimilatory cells, **cblt** = coloured branchlet, **cys** = cystocarp, **m** = monosporangium, **mdf** = medullary filament, **th** = small and broad cells, **u** = utricle; scale for figs.: **1** = 1.07 mm, **2-6** = 30 μm).



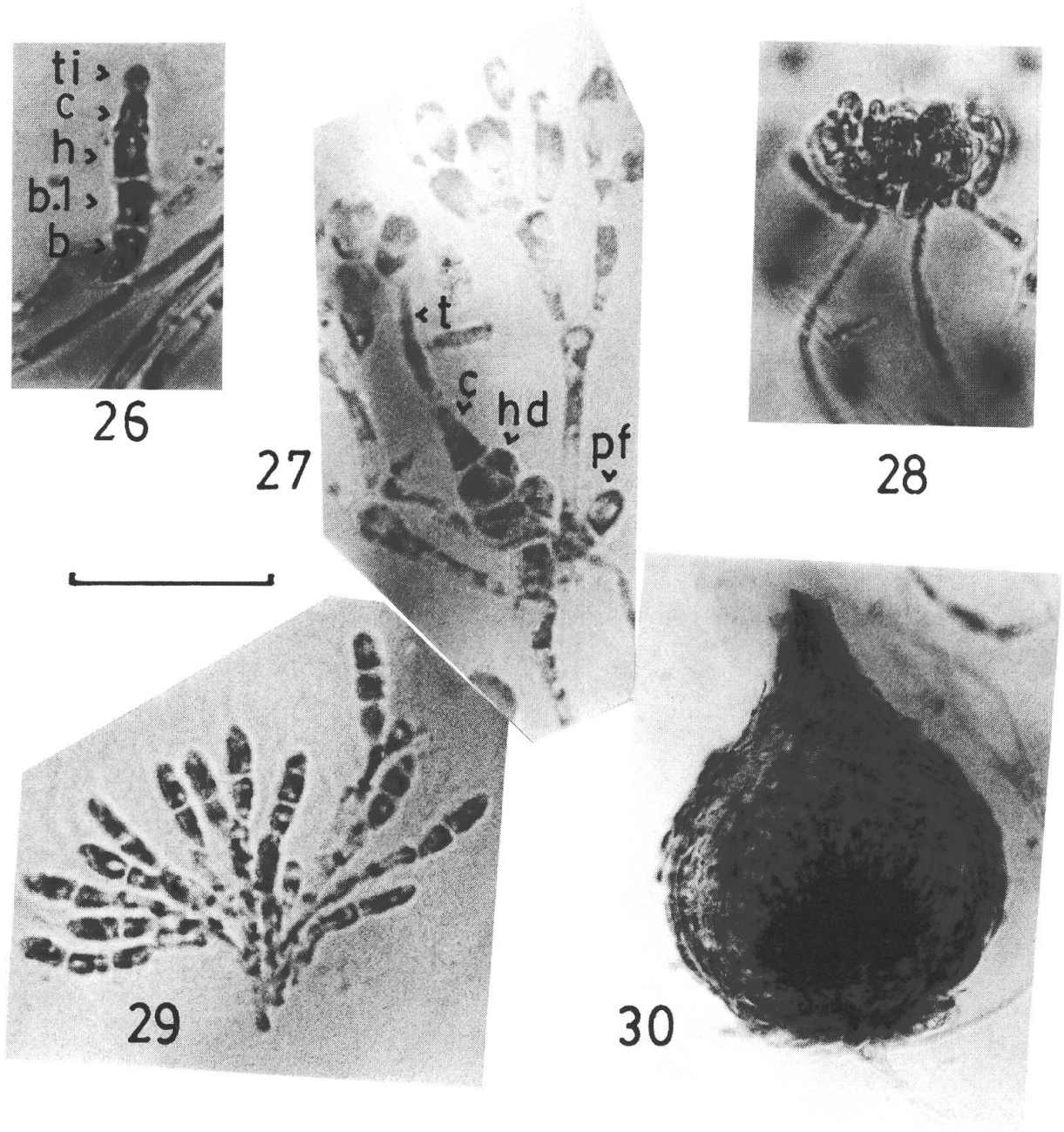
Figs. 7-15. – *Scinaia shameelii* Afaq-Husain
7-9, young branch systems showing development of utricles and assimilatory cells; **10**, cortical branch system with cluster of spermatangial branches; **11**, 2-celled stage of carpogonial branch; **12-15**, 3-celled carpogonial branches in different stages of development; (**ac** = assimilatory cells, **b** = basal cell, **c** = carpogonium, **cbr** = carpogonial branch, **cbri** = carpogonial branch initial, **h** = hypogynous cell, **hd** = hypogynous daughter cell, **m** = monosporangium, **pf** = pericarp filament, **ri** = rhizoidal initial, **spm** = spermatangium, **t** = trichogyne, **ti** = trichogyne initial, **u** = utricle; scale for figs.: **7-15** = 12 μm).



Figs. 16-21. – *Scinaia shameelii* Afaq-Husain
16, development of the 4-celled carpogonial branch; **17**, development of pericarp filaments and hypogynous daughter cells; **18-19**. gonimoblast filaments with chains of carposporangia; **20**, slightly older stage of pericarp filaments development covering the middle cell product completely; **21**, carpospores; (**b** = basal cell, **b-1** = epidermal cell, **c** = carpogonium, **cpm** = carpogonium, **h** = hypogynous cell, **hd** = hypogynous daughter cell, **pf** = pericarp filament, **pi** = pericarp filament initial, **t** = trichogyne; scale for figs.: **16-21** = 12 μm).



Figs. 22-25. – *Scinaia shameelii* Afaq-Husain
22, type specimen; **23**, T.S. of cortex showing a coloured branchlet (arrow); **24**, young plant; **25**, young cortical branch system of filaments from tip of frond; (**ac** = assimilatory cells, **cblt** = coloured branchlet, **u** = utricle; scale for figs.: **22** = 45 mm, **23** = 30 μm, **24** = 22 mm, **25** = 21 μm).



Figs. 26-30. – *Scinaia shameelii* Afaq-Husain
26, young 4-celled carpogonial branch; **27**, slightly older 4-celled carpogonial branch with divisions in basal, epibasal and hypogynous cell; **28**, very young cystocarp; **29**, gonimoblast filaments bearing 2-3 carposporangia distally; **30**, nearly mature cystocarp; (**b** = basal cell, **b-1** = epibasal cell, **c** = carpogonium, **h** = hypogynous cell, **hd** = hypogynous daughter cell, **pf** = pericarp filament, **t** = trichogyne, **ti** = trichogyne initial; scale for figs.: **26-29** = 30 μm, **30** = 100 μm).

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