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A FIRST RECORD OF THE GENUS *COTTONIELLA* BØRGESEN (CERAMIALES, RHODOPHYTA) FROM LIBYA

M. NIZAMUDDIN* AND M. GODEH

Department of Botany,
Garyounis University, Binghazi, Libya.

Abstract

This is a first report of the occurrence of the genus *Cottoniella* Børgesen from the coast of Libya. The number of pericentral cells in the specimens are 4-6 and not only 4 as in most species of the genus. The lateral pericentral cell is first formed and the development of monosiphonous filaments is endogenous as well as exogenous. The Libyan specimen is therefore designated as *Cottoniella libyensis* Nizam. & Godeh *sp. nova*.

Introduction

Marine algae of Libyan coasts are mostly known from the lists published by earlier phycologists. A few detailed morphological accounts of these have been published by Nizamuddin (1981). Besides, a large number of specimens were collected from different localities along the coast line among which a fine, delicate red algal genus *Cottoniella* Børg., was found as a new record from the country.

Børgesen (1919) established *Cottoniella* Børg., based on *C. arcuata* Børg. (from St. Thomas, West Indies) and later he added 2 more species – *C. filamentosa* (Howe) Børg. (from Cape Florida) and *C. fusiformis* Børg., (from Canary Is.) in 1920 and 1930 respectively. Howe (1928) also established a new species, *C. sanguinea* Howe, from the coast of Brazil. Schotter (1951) considered first three species of Børgesen as forms of one species and added a new variety from Algerian coast – *C. arcuata* var. *eu-arcuata* Schotter, *C. arcuata* var. *filamentosa* (Howe) Schotter, *C. arcuata* var. *fusiformis* (Børg.) Schotter and *C. arcuata* var. *algeriensis* Schotter. He did not consider absence or presence and distribution of flanking cells of any taxonomic importance but Womersley & Shepley (1959) gave more importance to these characters and recognized *C. arcuatta* as distinct species from *C. filamentosa* and *C. fusiformis* including *C. filamentosa* var. *algeriensis* (Schott.) Womersley & Shepley. According to Womersley & Shepley (1959) the flanking cells in *C. arcuata* are formed irregularly and discontinuously along the branches but Børgesen (1919) had already reported complete absence of flanking cells. Womersley & Shepley (1959) interpreted corticating cells in Figs. 335g & 336c (Børgesen, 1919) as flanking cells along the branches. Flanking cells are regularly formed in each segment of *C. filamentosa*, *C. fusiformis* and *C. filamentosa* var. *algeriensis*, but lacking in *C. triseriata* Hollenberg and *C. sanguinea* Howe. Monosiphonous filaments are endogenous in a single row up along the middle in *C. filamentosa* (Børgesen, 1930) and also in two rows

*Department of Botany, University of Karachi, Karachi-75270, Pakistan.

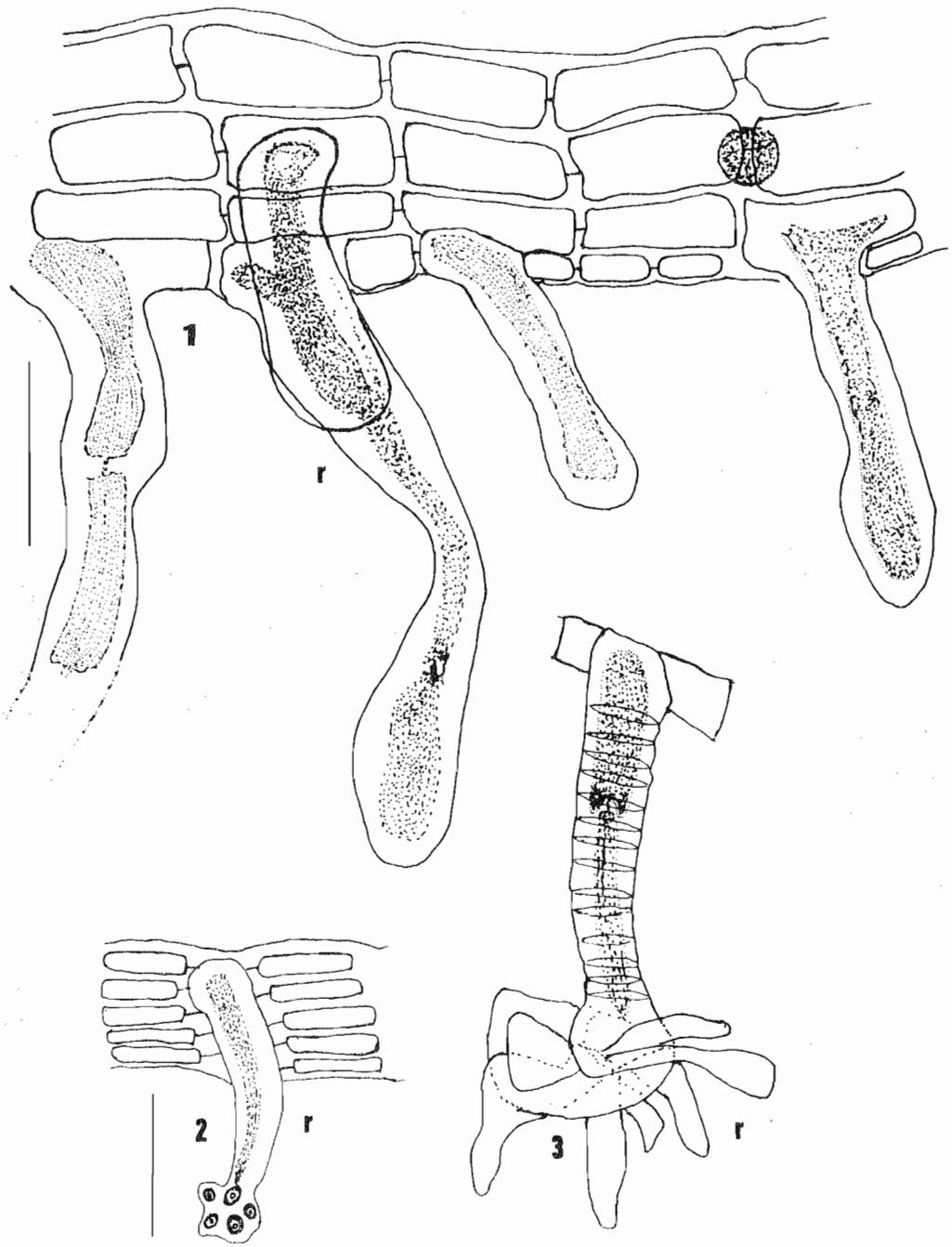

Fig. 1-3. 1. Prostrate axis showing development of rhizoids. 2. A rhizoid with discoid lobed attachment. 3. Rhizoid showing hapetroid attachment.

SCALE:

Figs. 1, 4-8, 15, 16	= 50µm.	Figs. 2, 3, 13, 17	= 150µm
Fiigs. 11, 12	= 300µm	Fig. 9	= 1cm
Fig. 18, 19	= x 500	Fig. 20	= x800
Fig. 21	= x 1280	Fig. 22	= x 320

Abbreviations:

AC = axial cell; CC = cortical cell; FC = flanking cell; MF = monosiphonous filament; PC = pericentral cell; r = rhizoid.

alternately to either side (Womersley & Shepley, 1959). In *C. fusiformis* these are endo- and exogenous in 2(-3) rows from each segment. In var. *algeriensis* these filaments are very irregular, in some parts in a single row, in other parts in two rows in a zig-zag manner but usually two filaments arise in pairs from the same segment. These are endogenous in origin but Fig. 4b (Schotter. 1951) shows one filament in lateral position. It seems likely that it is in fact cut off from the lateral pericentral cells. Schotter (1951) and Børgesen (1930) state that the lateral pericentral cells are first formed in var. *algeriensis* and *C. fusiformis* respectively but in *C. filamentosa, C. triseriata* and *C. arcuata* (Silva & Cleary, 1954) abaxial pericentral cells are first formed (Womersley & Shepley, 1959).

Hollenberg (1967) while describing *C. triseriata* Hollenb., expanded the generic characteristic to encompass species that also lack flanking cells (*C. arcuata*, at times, *C. triseriata* and *C. sanguinea* Howe) or which have monosiphonous filaments that arise exogenously as well as endogenously (*C. fusiformis* and *C. triseriata* and var. *algeriensis*). Tetrasporic and young procarpic phases were first reported by Hollenberg (1967) in *C. triseriata* and no flanking cells were involved in cystocarpic formation. No detailed study on the sexual and asexual plants were made because of lack of materials. Detailed study on the tetrasporophyte was made by Cormaci *et al.*, (1978) in *C. filamentosa* var. *algeriensis* where flanking cells were involved in the development of tetrasporangia. Sexual structures were reported by Gil Rodriguez *et al.*, (1985) in *C. filamentosa* var. *fusiformis* (Børg.) Cormaci *et al.*, but they did not study the development of cystocarp. They also studied the tetrasporic plants having flanking cells.

Materials and Methods

Materials were fixed and preserved in 4% formalin-seawater and some were mounted on herbarium sheets. For developmental studies the material was stained and squashed according to Womersley & Shepley (1959).

TAXONOMIC ENUMERATION

Cottoniella libyensis Nizamuddin & Godeh *sp. nova* (Fig. 18). Holdfast hapteroid or digitate or simple discoid (Figs. 1-3 & 22). Plants rosy- red or purple, filamentous, fine, delicate, prostrate with assurgent axes, giving rise to many erect axes (primary axes) up to 10 cm high, tereto-compressed, 300-700 µm broad, up to 300 µm thick, irregularly branched (Fig. 9) or di- or sub-dichotomously, alternately dorsiventrally organized; axes with 4-6 pericentral cells, corticated (Figs. 11-13); upper part ecorticated (Figs. 5-8), arcuate, pectinate (Fig. 19). Young axes fusiform tapering at both ends broader at the middle. Apical cell of the axis long, conical, 22-35 µm long, 17-23 µm across, with rounded ends. Segments of the prostrate axes 500-600 µm long, 250-300 µm across having 6 pericentral cells (Fig. 11). Branches are of two types (i) determinate, monosiphonous, multicellular, endogenous or exogenous on the concave side of the axes (Figs. 4, 19, 20) and (ii) undeterminate, polysiphonous, endogenous (Fig. 14, 19) with 4-5 per-

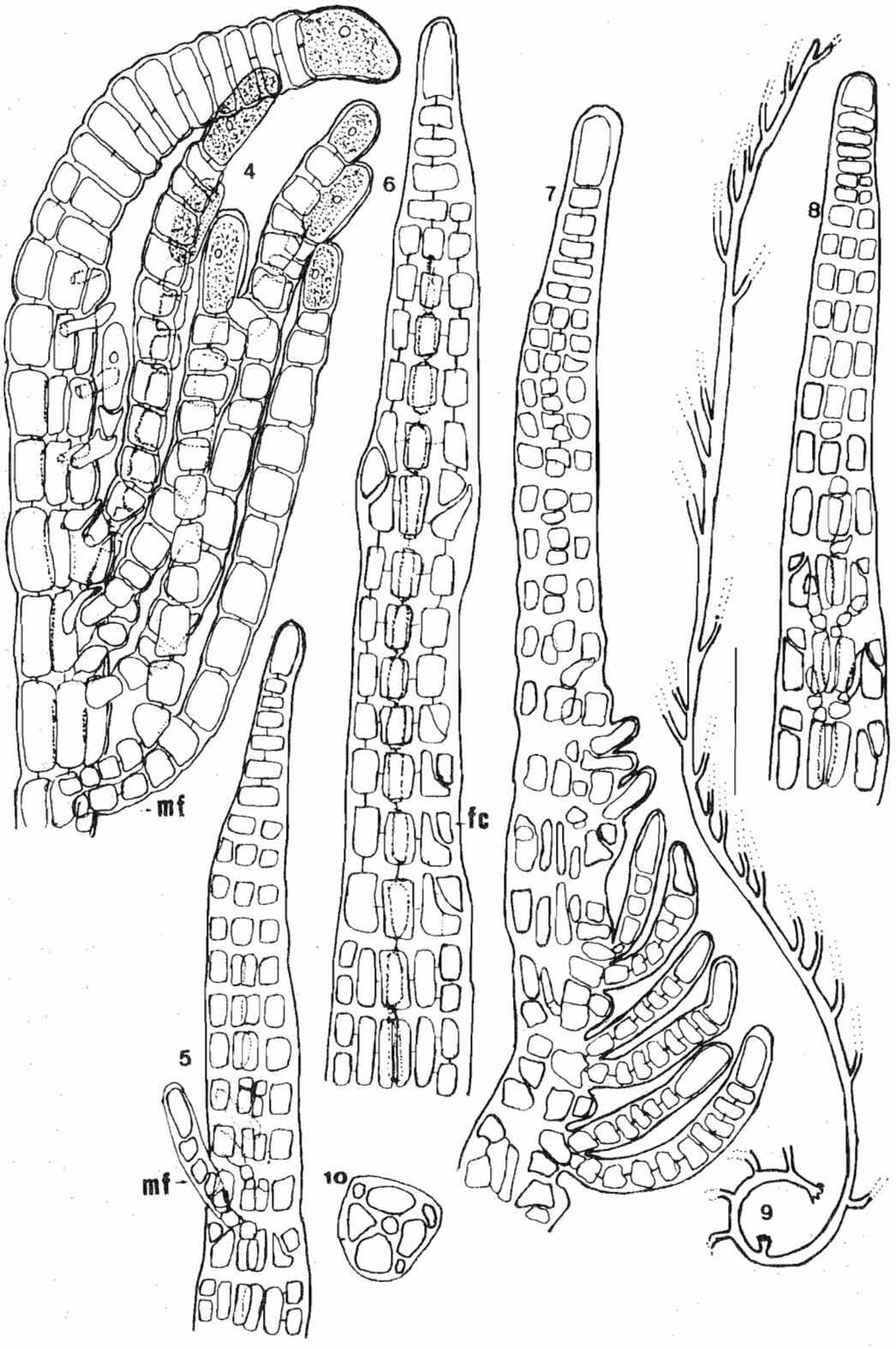

Fig. 4-10. 4. Summit of a primary axis showing development of monosiphonous filaments, apical cells. 5-8. Summit of the axes showing variation in the early development of pericentral cells, flanking cells, endogenous monosiphonous filaments (Figs. 5 & 7). 9. A part of the plant showing pattern of branching. 10. T.S. of a young axis.

icentral cells (Figs. 12, 13) except the young branches (tertiary or quartenary) having 3 pericentral cells at the base (as adaxial cell is not formed).

Determinate branches up to 1.2 mm long, monosiphonous in 2 (-3) rows on each segment of the young branches (Figs. 4, 17), persistent, with longer cells above, shorter ones at the base; elongated cells either rectangular or cylindrical 60-100 µm long and 10-20 µm across. Some segments bear only one row of monosiphonous filaments (Fig. 14) and a polysiphonous determinate branch (Fig. 17). In older parts determinate branches fall off leaving the basal cell only.

Primary axes pectinate or alternate, terete, 500-600 µm broad, 180-240 µm thick with 4-5 pericentral cells and corticated. Secondary axes cylindrico-terete up to 500 µm diam., 160-180µm thick, with 4 pericentral cells, slightly corticated (Figs. 10, 16). Tertiary axes cylindrical up to 400 µm diam., with 4 pericentral cells, slightly corticated. Quarternary axes also cylindrical, 200-250 µm diam., with 4 pericentral cells, ecorticated (3 pericentral cells at the base as adaxial cell is not formed). Rhizoids variable in shape, unicellular, developing from most segments, alternate or opposite, persistent, endo- or exogenous in origin (Fig. 1-3 & 22).

Holotype: GB 000400 in Binghazi. M.B.R.C., Tajura (Leg. A. Zubairi, 16-4-1983).

Specimens examined: M.B.R.C., Tajura (Leg. M. Nizamuddin, 10-4-1983, as epiphyte on *Chondria dasyphylla* (Woodw.) C.Ag. Leg. A. Zubairi, 2-4-1983; 7-4-1983; 16-4-1983). Zawia, near Scot's Club (Leg. Owaisha Mustafa, 1-4-1983 as epiphyte on *Dictyota linearis* (C.Ag.) Greville). El-Mina, Binghazi (Leg. M. Nizamuddin & M. Godeh 27-1-1990; GB 000651). Urdanu Beach, Tocra (Leg. M. Nizamuddin 4.6.90).

DEVELOPMENT OF THALLUS

The apical cell is large, conico- cylindrical with round apex, 17-23µm across, 22-25µm long, divides transversely at the base producing flat discoid cells (Figs. 4-8 & 21). These cells increase in size and divide first longitudinally on one side of the axis forming first lateral pericentral cell followed by another longitudinal division on the opposite side of the first division forming second lateral pericentral cell (Figs. 4-8). At this stage the axis is composed of three cells. One in the middle and one on either side of the axis. Later, the middle cell divides longitudinally by two walls (abaxially and adaxially) producing three cells. Thus the axis possesses 4 pericentral cells and one axial (central) cell. There may be further transverse division either of one or two pericentral cells producing 5 or 6 pericentral cells. Axis increases gradually in length. The upper outermost corners of the first two pericentral cells divide obliquely followed by longitudinal division. These two cells are the flanking cells which are smaller in size than the pericentral cells (Figs. 5-8, 14, 15) and do not divide further. Long before the flanking cells are formed, some outgrowths take place which protrude from the upper ends of the segments in the apical regions of the axes (Fig. 4). These are the initial stages of the monosiphonous filaments. The monosiphonous filament is formed due to cutting off a short cell at the anterior end

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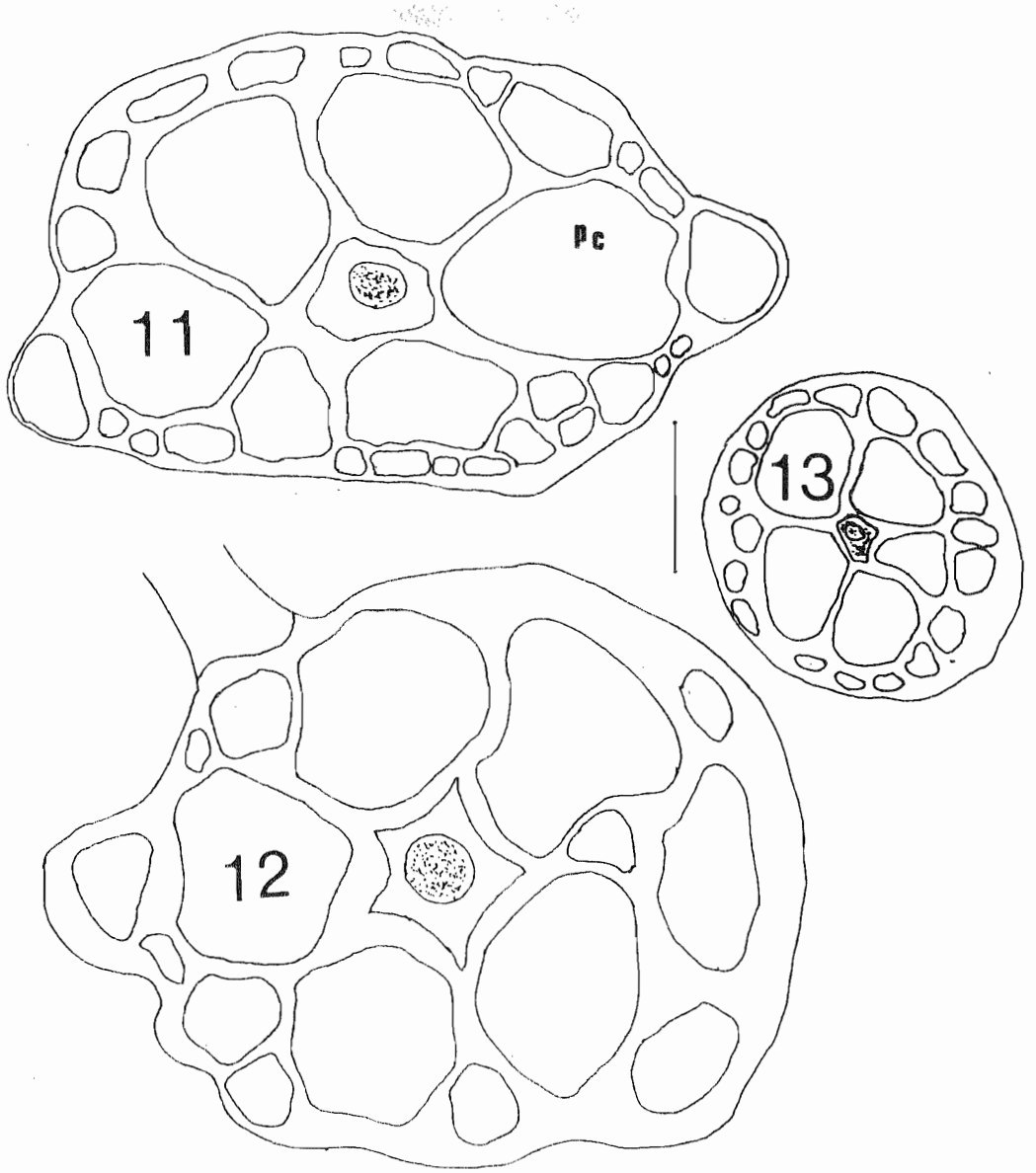


Fig. 11-13. 11. T.S. through compressed portion of an axis. 12. T.S. through terete portion of an axis. 13. T.S. through a cylindrical portion of an axis with regularly arranged cortical cells.

of the central cell (Fig. 4) or the pericentral cell. The central cell cuts off two short cells on either side at the anterior end, thus producing two monosiphonous filaments at the same time (Figs. 8, 20). The lateral branches are endogenous and develop from the anterior end of the central cell and lateral to the monosiphonous filaments (Figs. 14, 19). Mature and older parts of the plant contain a coherent cortical layer formed from the pericentral cells.

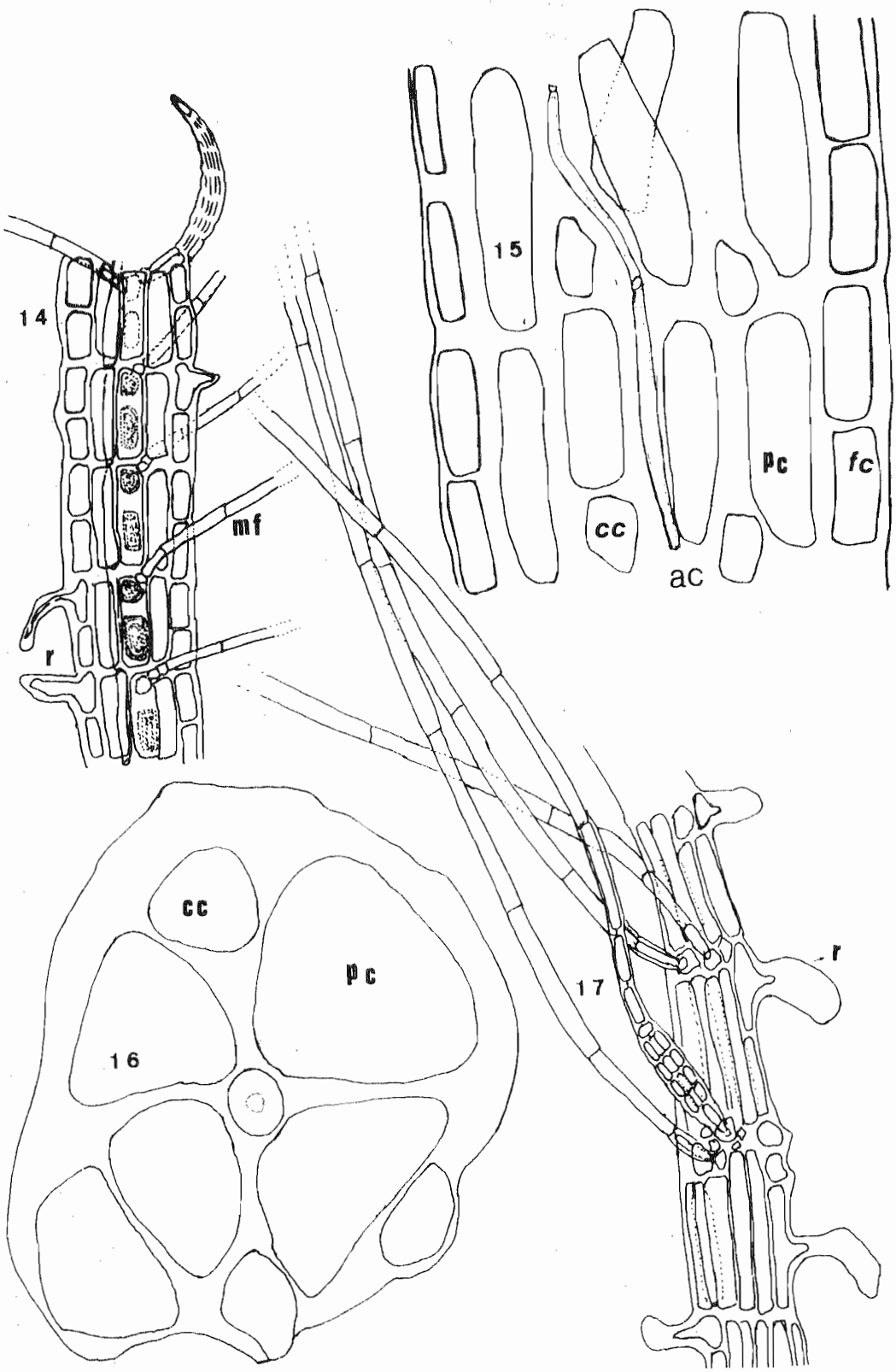


Fig. 14-17. 14. A portion of an axis showing rhizoids, a single row of monosiphonous endogenous filaments, endogenous secondary axis and pericentral cells (L.S. view). 15. Details of an axis showing pericentral cells, axial cells, cortical cells and flanking cells (Squashed in stain). 16. T.S. through the lower portion of a secondary axis. 17. Axis showing a filament with basal polysiphonous segment, monosiphonous filaments, pericentral cells and rhizoids.

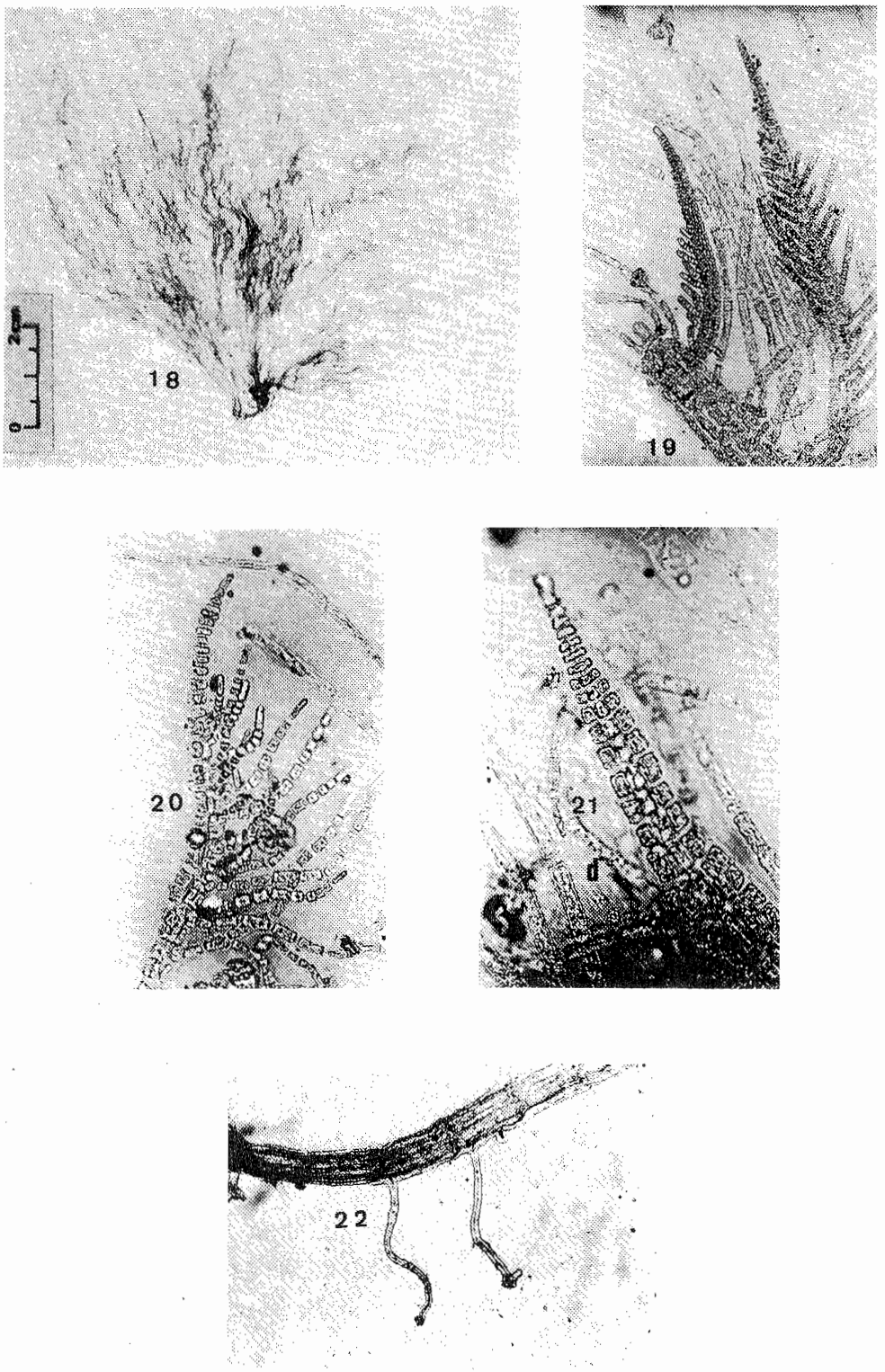


Fig. 18-22. 18. Habit of the Holotype, *Cottoniella libyensis* Nizam., & Godeh *sp. nova*. 19. A part of the prostrate (main) axis bearing primary axes and monosiphonous filaments. 20. Secondary axis bearing monosiphonous filaments. 21. Apical part of a primary axis showing origin and development of pericentral cells. 22. Axis showing rhizoids.

Discussion

In segregating species of the genus *Cottoniella* Børg., importance was given mostly to monosiphonous filaments and presence or absence of flanking cells. Consideration of pericentral cells is of little importance in distinguishing species as doubts were expressed in *C. sanguinea* Howe, which is known to possess five pericentral cells and poorly developed monosiphonous filaments (Cormaci *et al.*, 1978). Womersley & Shepley (1959) examined the type materials of this species and reported 4 pericentral cells near the tip but 5 in the older parts. In *C. libyensis* Nizam. and Godeh the number of pericentral cells from different parts of the thallus also showed variations, i.e., 3 near the base of tertiary or quarternary axes (as adaxial pericentral cell is not formed), 4 in upper or younger parts of the axes and 5 or 6 in prostrate or older parts of the axes. These variations in number of pericentral cells in this new species supports *C. sanguinea* belonging to the genus *Cottoniella* and not to any other genus. *C. libyensis* Nizam.& Godeh agrees well with the description and figures of *C. fusiformis* Børg., and *C. arcuata* var. *algeriensis* Schott., in origin and development of exo- and endogenous monosiphonous filaments on the concave side of the branch apices and in the regular formation of flanking cells on each segment but differs in the formation and number of pericentral cells and in cortication.

Cottoniella shows great similarity with the members of Delesseriaceae in (i) lateral pericentral cells being first formed, (ii) flanking cells in pairs from lateral pericentral cells, (iii) cells of monosiphonous filaments with dense rhodoplasts, (iv) sporangial mother cell is formed first then followed by cover cells and (v) second sterile cell being cut off after carpogonial initial. However it differs from the taxa of the Rhodomelaceae in (i) the abaxial pericentral cell first formed followed by two lateral pericentral cells and finally adaxial pericentral cell, the first formed pericentral cells are spirally arranged (ii) colourless exogenous trichoblasts (iii) one flanking cell is cut off from each pericentral cell and later divides into two cells lengthwise and (iv) cover cells first formed followed by sporangia. It is, therefore, suggested that the genus *Cottoniella* may be placed in a separate family intermediate between Delesseriaceae and Rhodomelaceae.

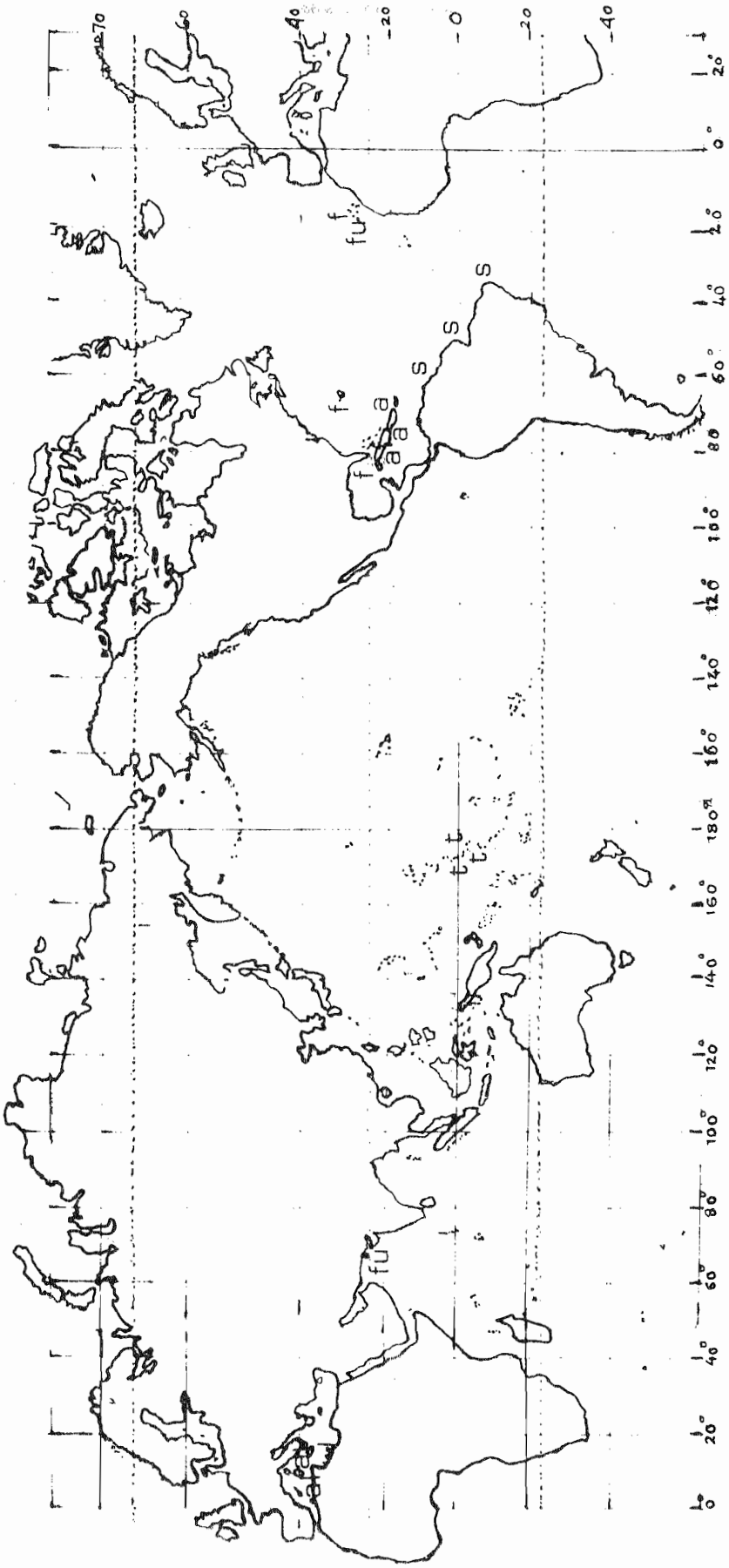
DIAGNOSES

Frons rosea, prostrata, erecta usque ad 10 cm alta ultra, corticata, irregulariter ramosa; ramis fusiformibus ex cellula centrali et quatuor ad sex cellulis pericentralibus. Filamentis monosiphoneis, endogeneis et exogeneis, saepe binis ex eodem segmento in latere ventrali concavo ramorum ortis.

Holotypus: GB 00400 in Binghazi, M.B.R.C., Tajura (Leg. A. Zubairi, 16-4-1983).

GEOGRAPHICAL DISTRIBUTION

Presently 6 species and a variety of the genus *Cottoniella* Børgesen are known in the World (Map) and their distribution is discontinuous. Plants were collected as drifts or



Distribution map of the species of *Cottoniella Børgesen*: a = *C. arcuata* Børgesen; al = var. algeriensis Schott; f = *C. filamentosa* (Howe) Børg; fu = *C. fusiformis* Børg; l = *C. libyensis* Nizam. & Godeh; s = *C. sanguinea* Howe; t = *C. triseriata* Hollenberg.

dredged from 10-30m depth growing as epiphyte on algae or Angiosperms. Howe (1928) reported *C. sanguinea* Howe along the coast of Brazil. *C. arcuata* Børgesen grows along the coast of Bermuda Is., and West Indies whereas *C. triseriata* Hollenb., grows in Central Tropical Pacific Ocean (Marshall Is., Phoenix Is., Bikini Atoll, Society Is.,) *C. filamentosa* (Howe) Børgesen grows along the coast of Cape Florida, U.S.A.; Bermuda Is., and Canary Islands, Atlantic Ocean. *C. libyensis* Nizam. & Godeh is endemic to Libyan coast and *C. arcuata* var. *algeriensis* Schott endemic to Oran, Algeria and along the Sicilian coast, Mediterranean Sea (Furnari *et al.*, 1970). *C. fusiformis* Børg., occurs along the coast of Karachi, Northern Arabian coast and Canary Islands, Atlantic Ocean.

COTTONIELLA BØRGESEN EMENDED

In the light of present investigations and findings of Gil-Rodriguez *et al.*, (1985) and Cormaci *et al.*, (1978) the genus *Cottoniella* is emended.

Plant slender, delicate, prostrate with erect assurgent axes, attached by holdfast having simple or digitate or hapteroid attaching organs, up to 12cm high, corticate; lateral branches endogenous, above more or less arcuate, pectinate; pericentral cells 4 or 4-6; each pericentral cell forming two flanking cells which do not divide further; monosiphonous filaments endo- and exogenous in origin, in one or two (-3) rows; stichidia on laterals of indefinite growth; sporangia first formed followed by 2 cover cells, tetrasporangia tetrahedrally divided lie in two parallel rows, having flanking cells; spermatangiophore elongate, lanceolate, fusiform, stalked, apically trichothallic; spermatia in between flanking cells and axial cells. procarps between 6 and 10 segments or polysiphonous branch. Cystocarp sub-spherical to globose, ostiolate, sub-sessile, having flanking cells; pericarp formation after fertilization; one cystocarp per axis; dioecious, trigenic isomorphic (Gil-Rodriguez *et al.*, 1985).

Key to the species

1.	Flanking cells lacking	2
	Flanking cells present	3
2.	Monosiphonous filaments poorly developed	*C. sanguinea*
	Monosiphonous filaments in 3-rows	*C. triseriata*
3.	Through out 4-6 pericentral cells	*C. libyensis*
	Through out 4 pericentral cells only	4
4.	Monosiphonous filaments endogenous	5
	Monosiphonous filaments endo-and exogenous	6
5.	Monosiphonous filaments in a single row	*C. arcuata*
	Monosiphonous filaments in 2 rows	*C. filamentosa*
6.	Two (-three) monosiphonous filaments on each segment	*C. fusiformis*
	In some parts one, in other parts two monosiphonous filaments on each segment	*C. arcuata* var. *algeriensis* Schott.

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