STUDIES ON THE ANATOMY, MORPHOLOGY AND TAXONOMY OF SOUTHERN AUSTRALIAN FUCALES AND THE GENUS NOTHEIA Harvey and Bailey.

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FOREWARD

This is to certify that material contained in this thesis is the work of the author, except where acknowledged otherwise.

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A. THE SOUTHERN AUSTRALIAN FUCALES

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I. INTRODUCTION.

Southern Australia has long been recognised as a region characterized by numerous genera of Fucales, most of them endemic or largely so. These coasts are richer than any other comparable part of the world in number of genera and number of species of the Fucales. It is not surprising then that many of these genera have been studied from morphological and anatomical view points. But most previous studies have done little more than give some of the main characteristics of different genera, although recent studies (e.g. Naylor, 1949a; 1949b; 1953a; 1954a; Osborn, 1948) have been more comprehensive. There is thus a need for detailed and thorough studies of all the distinctive Southern Australian genera of Fucales, and of as many species as possible in the larger genera.

While the monotypic or smaller genera are fairly well known taxonomically, the species of larger genera such as *Cystophora*, *Myriodesma* and *Sargassum* are poorly known, and no adequate account of them is available.

This study was undertaken to obtain detailed morphological, anatomical (and where possible cytological) information on the Southern Australian Fucales, and to clarify and revise their taxonomy. The following table I sets out the accepted classification (e.g. Fritsch, 1945b;

1952) of the Southern Australian genera of Fucales, and references to previous anatomical work are given for each genus in order to indicate the previous state of knowledge. All the known southern Australian genera and species have been investigated — although some from only a taxonomic viewpoint due to lack of material — except *Sargassum*. This genus has been deliberately omitted since the southern Australian species are probably typical of the genus from an anatomical viewpoint yet are very much confused taxonomically. The recent paper of Womersley (1954) on the Subgenus *Phyllotrichia* shows the need for thorough developmental and seasonal studies in this genus. The following genera have not been investigated in view of recent thorough anatomical studies on them:- *Hormosira* (Osborn, 1948), *Durvillea* (Naylor, 1949b; 1953a).

TABLE I.

CLASSIFICATION OF THE SOUTHERN AUSTRALIAN GENERA OF FUCALES.

Family.	Genera	Previous anatomical studies.
1. Fucaceae:	*Myriodesma*	Gruber, 1896.
	Phyllospora	Gruber, 1896; Williams, 1923.
	Scaberia	Gruber, 1896.
	Scytothalia	Gruber, 1896; Naylor, 1949a)
	Seirococcus	Gruber, 1896; Smith, 1893.
	Xiphophora	Barton, 1893; Gruber, 1896; Heine 1932; Mitchell, 1941, Naylor 1954a.
2. Cystoseiraceae:	*Carpoglossum*	Gruber, 1896.
	Cystophora	Gruber, 1896; Reinke, 1876.
	Cystophyllum,	Gruber, 1896.
	Cystoseira,	Gruber, 1896.
	Platylobium	Gruber, 1896.
	Platythalia	Gruber, 1896.
3. Hormosiraceae:	*Hormosira*	Gruber, 1896; Mollet, 1880, Osborn, 1948; Roe, 1916.
	Notheia	Barton, 1899; Gruber, 1896, Mitchell 1893; Williams, 1923.
4. Durvilleaceae:	*Durvillea*	Gruber, 1896; Naylor, 1949b; 1953a; Whitting, 1893.

Material used in this study includes:

(1) Liquid preserved and fixed material, mainly from the coasts of South Australia (Kangaroo Island, Eyre Peninsula and near Robe), but also from other localities in Victoria and Tasmania.

(2) Herbarium material in the algal collection of the Department of Botany, University of Adelaide. This comprehensive herbarium contains a large range of specimens from all Australian States, and it was considered adequate to give a good concept of the variation within species and (together with the literature records) of their distribution. Other herbaria will, of course, have to be consulted before a taxonomic monograph of the Southern Australian Fucales is finalised.

The genus *Notheia* previously placed with *Hormosira* in a separate family of the Fucales, has proved not to belong to the Fucales but probably to the Heterogeneratae. *Notheia* is described and discussed at the end of this account.

II. REVIEW OF PREVIOUS STUDIES ON THE PHAEOPHYTA AND FUCALES IN PARTICULAR.

(a) Development of the classification of the Phaeophyta.

In the present century the knowledge of no other great plant group has broadened more rapidly and with more startling changes than has that of the algae. Algal nomenclature begins with the year 1753, when Linnaeus recognised 11 genera, but only four of his genera (*Chara*, *Fucus*, *Ulva*, and *Conferva*) are now accepted as genera of algae, and *Conferva* has been reduced to a synonym through the proposed conservation of *Tribonema* against *Conferva* L. (Briequet, 1935. Papenfuss, 1950. Silva, 1952). Botanists, in general, were content to arrange the species under the classical genera *Fucus*, *Ulva* and *Conferva* until Stackhouse (1795-1801) broke away from the classical system by introducing the use of colour. Esper (1800) published coloured plates of algae without any spacial arrangement and his works were largely based on fragmentary specimens. This gave impetus to Dawson Turner (1808-1819) whose "Historia Fucorum" marked the culmination of an epoch in which a great variety of forms were called *Fucus*, without any further classification. Turner's work is still a treasure of general

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N.B. Church (1919), Taylor (1922, 1936) and Papenfuss (1955) have traced the development of the Classification of the Phaeophyta.

information and is indispensible. Up to this period, all the changes that had been proposed were made either upon vague, uncertain or artificial principles or upon local and imperfect material.

New ideas and thoughts followed the increasing acceptance of the Natural System of Classification of flowering plants, which was to finally supersede the Linnaen System. Plants for the first time were grouped in subdivisions and orders which clarified their natural affinities. These concepts were applied to marine algae by Lamouroux (1813) who formulated a new scheme which not only segregated numerous genera, but arranged them in distinct Natural Orders. In fact he laid the foundation stone as well as making a considerable advance in the new classification of the algae. He also used a biochemical character (colour) in part in the classification of algae. He separated the order Floridées from the Fucacées and the Dictyotées. Some imperfections in his new system were the inclusion of *Furcellaria* under the Fucacees and *Amansia* with *Dic*tyotées, while *Asperococcus* was placed with the Ulvacées.

C. Agardh (1817) also did not reach perfection in classifying algae on a colour basis like Lamouroux, and the former changed the latter's designation of Fucacées to Fucoideae to include all the brown algae, but he still placed the Dictyotées of Lamouroux with the Ulvoideae. In 1821 C. Agardh included most of the brown algae under the Fucoideae, retaining Lichina, Lemanea and Furcellaria. C. Agardh differed from Lamouroux in the constitution of genera. Lyngbye (1819) following Stackhouse, Lamouroux and C. Agardh, drew up his own system of classification which was purely artificial and based only on local and scanty material. Brown and red algae still were confused, Delesseria placed next to Fucus and Ulva associated with Laminaria. Bory (1828) contributed much to the knowledge of the algae but restricted himself to the description of genera and species. Greville (1830) made a slight advance over his contemporaries and predecessors in algal classification but still retained Lichina and Polyphacum in the Fucoideae which he used for the first time as an order. Previous authors always used Fucoideae in a broad sense as Brown algae. Five out of his eight orders (Fucoideae, Laminarieae, Sporochnoideae, Chordarieae, and Dictyoteae) are retained still in the ~~Fucales~~ Phaeophyta of today.

Bartling (1830) in classifying the plant kingdom used Fucaceae as an order and placed most of the brown algae under it. Decaisne (1840, 1842) and Harvey (1836, 1841, 1849) stressed more the natural relationships and they rectified most of the obvious errors of the past. Harvey (1849) referred to the brown algae as the sub class Melanospermeae or Fucales and recognised six orders — Fucaceae, Sporochnaceae, Laminariaceae, Dictyotaceae Chordariaceae and Ectocarpaceae —. These were retained by

J. Agardh (1848) and by more recent algologists. Bromhead (1836) used Fucoideae as one of the races of Algae, which included the brown algae. Decaisne (1842) divided the brown algae into two families (i) Fucaceae and (ii) Sargasseae. Montagne (1842; 1845) like Bory restricted himself to the description of species and genera and placed them under the tribe Fucaceae. He transferred the genus Lichina to the lichens. Endlicher (1836; 1843) stressed more the natural relationships but still retained Lemaneae under the sub order Fucaceae before the families Fucoideae and Cystoseirae.

Kuetzing (1843; 1849; 1860) made a remarkable advance in systematic, anatomical and physiological work in algae, but he had peculiar ideas with regard to their classification and established many new genera out of the old ones. His works gave a considerable impetus to future algologists. In 1843 he established four families (i) Fuceae (ii) Cystoseireae, (iii) Sargasseae (iv) Halochloae, but in 1849 he absorbed Halochloae into Sargasseae. Though he made mistakes he corrected previous authors by excluding Lemaneae from the brown algae. Modern phycologists are highly indebted to his contribution to the classification of the algae as a whole.

Naegeli (1847) made a very remarkable contribution to the classification of algae by introducing biochemical and anatomical characters. His system was largely based on apical cells and apical growth, especially in the families Chantransieae, Padineae and Fuceae. In the Fuceae Naegeli established the presence of a single apical cell. His system was incomplete because he eliminated the important group Laminarieae from the brown algae, but on the other hand he introduced the conception of phylogeny in algae. J. Agardh (1848) drew up a complete system of all known algae. He extended the Phaeophyceae to include 7 orders (also referred to by him as families in certain places)and the genera were arranged in series from Ectocarpus to Sargassum. His orders of brown algae are still retained with altered circumscription. This arrangement of J.G. Agardh's constitutes the basis of modern classification.

The discoveries of sexuality and alternation of generations was the start of our understanding of life histories among algae. Fertilization in Fucus was first observed by Thuret (1854) though the significance of sexuality was first considered by Decaisne and Thuret (1845), Thuret (1851; 1855a; 1855b), and the theory of sexuality was clarified by Thuret and Bornet (1878) for the brown and red algae. Strasburger (1897) observed the fusion of egg and sperm nuclei of Fucus and established that Fucus was diploid; this was later confirmed by Farmer and Williams (1896; 1898), and by Yamanouchi (1909). Yamanouchi also established that meiosis occurs during the first two divisions of the nuclei in the oogonia and antheridia.

In 1891 and 1897 Kjellman reviewed in detail the Phaeophyceae, and De Toni (1895) published the most complete systematic account of the brown algae. The most complete work of the early 1900's is that of Oltmanns (1904; 1922). Oltmanns (1899) was very much influenced by Naegeli and did considerable research on the anatomy and development of several genera~~l~~ of "Fucaceen". He laid more emphasis on the number and the shape of the apical cells as well as the number of eggs produced in each oogonium. Oltmanns modified and enlarged on Naegeli's system of classification. Gruber (1896) was influenced by Oltmanns and placed *Xiphophora* in the Fucaceae, *Myriodesma* and *Scaberia* in the Cystoseiraceae and excluded *Ecklonia* from the Fucaceen. Le Touze (1912) suggested that a uninucleolate type of nucleus was characteristic of Fucaceae and a granular type of nucleus of the Cystoseiraceae.

Kylin (1917) revised the classification of Phaeophyceae, based largely on the development and the nuclear cycles. He established five orders, Phaeosporae (Thuret, 1850), Tilopteridales, Dictyotales, Laminariales and Fucales. Oltmanns (1922) placed the Durvilleae and Fucaceae under the Fucales, and further established 4 groups in the Fucaceae (Anomalae, Fuco-Ascophylleae, Loriformes and Cystoseiro-Sargasseae). In the Anomalae he included *Hormosira* and *Notheia*. Schaffner (1922) recognised 4 orders in the class Phaeosporeae, Ectocarpales (isogamous), Laminariales (Zoospores only), Cutleriales (angisogamous) and Tilopteridales (oogamous). In the class Cyclosporeae he included the Fucales and the Dictyotales. He based his system on the development of zoospores, sperms and the number of flagella. Taylor (1922) in reviewing the brown algae, stated that "in all classes parthenogenesis and other kinds of short cuts in the life cycle may be present, and may be so characteristic of the ordinary propagation of the plant that the fundamental type of alternation upon which the classification is based may be obscured". He recognized two orders:- Phaeosporales and Cyclosporales. The former included iso- and aniso-gamous forms. The Cyclosporales included all oogamous groups and showed a reduction from a morphological to a mere cytological alternation of generations. He recognized three families (the Dictyotaceae, Laminariaceae and Fucaceae) inthe Cyclosporales.

Kylin (1933) established a new system of classification of the brown algae dividing them into three classes — Isogeneratae, Heterogeneratae, and Cyclosporeae — and 12 orders. In the Class Heterogeneratae Kylin established two subclasses Haplostichineae and Polystichineae. Kylin's classification of the Phaeophyta is as follows:-

I. Class Isogeneratae. — Ectocarpales, Sphacelariales, Cutleriales, Tilopteridales, Dictyotales.

II. Class Heterogeneratae.—

(a) Sub Class: Haplostichineae. — Chordariales, Sporochnalis, and Desmarestiales.

(b) Sub Class: Polystichineae. — Punctariales, Dictyosiphonales, and Laminariales.

III. Class Cyclosporeae. — Fucales.

Kylin also considered three main types of development — *Dictyota* type, *Laminaria* type and *Fucus* type and placed the three classes under these types respectively. His system of classification has been accepted by most of the present day algologists except Fritsch (1943; 1944; 1945b; 1952). Papenfuss (1955) recognized all the orders of Kylin but without grouping them into the classes and subclasses.

Roy (1938) suggested separation of the Fucaceae and the Cystoseiraceae of the Fucales on the basis of reticulate nucleus and granular nucleus respectively. The classification of the Fucales adopted by Fritsch (1945b; 1952) is based on Oltmanns (1922) and Kjellman and Svedelius (1909). Fritsch established the family Hormosiraceae which included *Hormosira* and *Notheia*. Schmidt's (1938) classification of the Fucales is based on the position, number of oogonia and form and number of apical cells. It appears that Schmidt followed Oltmanns and

Gruber. Schmidt established the family Notheiaceae and absorbed the family Cystoseiraceae within the Sargassaceae. Papenfuss (1951a; 1953a) followed Kylin's (1933) system of classification of the Phaeophyta with the exception of the Punctariales which were merged with the Dictyosiphonales (Papenfuss, 1947). According to Fritsch (1945b, 1952) and Papenfuss (1951a; 1955), the Fucales is composed of 7 families; Papenfuss recognises Notheiaceae, instead of Hormosiraceae.

Recent authors have regarded the major groups of algae as being of divisional rank, and the brown algae are accordingly known as the Phaeophyta. Papenfuss (1946; 1951b; 1953b) has proposed the endings "Phycophyta" for the algal divisions, but in this account the name Phaeophyta will be used.

(b) The distribution and occurrence of the Fucales.

The Fucales are probably the most advanced group of the Phaeophyta and also the most widely distributed. The species of Fucales have reached the highest level of morphological and anatomical differentiation but the origin of the group is still very uncertain. This large order is particularly well represented in Pacific and Australian waters. Most genera are restricted to a particular climatic zone — i.e. tropical, warm temperate, cold temperate, and subantarctic (or subarctic) though Sargassum occurs from the tropics into cold temperate waters. *Fucus* and *Cystoseira* are common in northern latitudes while *Sargassum* is conspicuous in the tropics and the subtropical regions. *Cystophora* is the largest genus of the Australian Fucales while *Durvillea* is a characteristic ~~as a~~ of subantarctic and cold temperate genus. *Hormosira* is the chief emergent form in Australasian waters.

Cystoseira, a large genus of Fucales is largely restricted to the Northern Hemisphere; species of *Cystoseira* are also known from the Arabian sea, a few from Australia, and one species (*C. myrica*) from South Africa (Isaac, 1957).

Turbinaria is distributed through tropical and temperate seas, never reaching further south than the Cape of Good Hope and Fremantle, Western Australia (*T. gracilis*, Harvey, 1854), or further north than the China Sea; otherwise it is confined to the tropics (Barton, 1891). Two species occur in the West Indies. A few species occur in the Indian Ocean. *Coccophora* and *Hizikia*, monotypic genera, are so far known only from the Japan Sea (Okamura, 1927), where most species of *Cystophyllum* occur. In Australia this latter genus is represented by *C. muricatum* throughout the coast of Australia. *Himanthalia*, a distinctive genus of the northern hemisphere, is a widely distributed member of the Fucales on the Atlantic shores of America, Iceland, the Faroes and Europe from Norway to Spain (Harvey, 1851; De Toni, 1895; Naylor, 1951).

Pelvetia canaliculata is a common European form while *P. fastigiata* occurs along the North Pacific Coast of America from Coos Bay, Oregon, to Lower California (Tilden, 1937).

Pelvetiopsis and *Hesperophycus* are distributed on the North Pacific Coast of America.

Ascophyllum is commonly distributed along the North Atlantic coast of Europe and America (Tilden, 1937). *Bifurcaria* is frequent on the Atlantic shores of Europe and also on the wouth west corner of Cape Province (Stephenson, 1947; Isaac, 1951). This genus is one of the exceptions among the Fucales in possessing a perennial creeping rhizome which adheres to the rock by means of small disks (Isaac, 1956). The genus *Bifurcariopsis* is endemic in South Africa, on the coast of the South Western corner of the Cape Province (Isaac, 1942; Laing, 1941; Stephenson, 1947). *Hormophysa* occurs in the Meditteranean Sea, along the east coast of Africa, (Isaac, 1956; 1957) and also on the west coast of Western Australia.

Axillariella (= Axillaria Grub.) Silva (1959) is monotypical from the South West of Cape Province, South Africa, (Stephenson, 1947).

Acystis, a Red Sea genus, possesses a prostrate flattened rhizome, and lacks airbladders (Schiffner, 1934).

In the Southern Hemisphere the Fucales reach an extensive development and diverse distinctive genera occur especially in Australia and New Zealand. *Seirococcus*, *Scytothalia*, *Phyllospora*, *Scaberia*, *Carpoglossum* and *Myriodesma* are endemic to Australian waters while *Carpophyllum*, *Landsburgia* and *Marginariella* are endemic to New Zealand. *Hormosira*, *Cystophora*, and *Xiphophora* inhabit Australasian waters. *Durvillea potatorum* is endemic in Australian waters and is distributed from Robe South Australia to Pambula, New South Wales and in Tasmania. *D. willana* is endemic to New Zealand. *D. antarctica* is distributed from Chile to Cape Horn, Falkland Islands, Kerguelen Islands, Chatham Islands, Auckland and Campbell Islands and New Zealand, (Skottsberg, 1907; 1941). This marine species has also been recorded in drift in Tasmania and South West of Western Australia (Moore and Cribb, 1952), and fragments recorded from Kangaroo Island (Womersley, 1959).

The Australasian region is also the chief centre of certain groups of *Sargassum*. Subgenus *Phyllotrichia* is mostly confined to Australia and Tasmania although two species are known from outside Australia, one from the Canary Islands and one from Japan (Womersley, 1954). One species only, *S. verruculosum* is recorded from New Zealand (Lindauer, 1947). The subgenus *Arthrophycus* is largely confined to the southern part of Australia and Tasmania; two species (*S. heterophyllum* and

S. longifolium) are found in South Africa and *S. undulatum* and *S. lacerifolium* in New Zealand. The most typical subgenus, *Eusargassum* is of world wide distribution in warm waters. The floating *Sargassum* (*S. natans* and *S. hystrix*) of the Sargasso Seas of the Atlantic belongs to this subgenus. Some species are known from Southern Australia and one species, *S. spinuligeru* is recorded from New Zealand.

Ascoseira and *Cystosphaera* are characteristic of the Antarctic and the Subantarctic region (Skottsberg, 1907).

The Fucales mostly grow attached to rocks of the intertidal zone or just below, but some inhabit the deeper levels or in a very few cases are free floating (*Sargassum natans* L. and *S. hytrix* J. Ag. in the Sargasso Sea.). Intertidal species are rarely up to 1 metre in length but some species growing below low water level reach up to 5 metres or more in length (e.g. *Durvillea*).

Womersley and Edmonds (1958) and Womersley (1959) have used various species of *Cystophora* in Southern Australia and *Durvillea potatorum* in Tasmania in defining the upper limit of the sublittoral zone. The Fucales are a group which is variously adapted to air exposure. In the cold northern hemisphere they are largely an intertidal group, but in South Australia only one species is essentially intertidal — *Hormosira banksii* (Womersley, 1959). Several Fucales in New Zealand are lower littoral e.g. *Durvillea antarctica*, *D. willana*, *Xiphophora chondrophylla* var. *maxima*, *Cystophora torulosa*, *C. scalaris* and *Carpophyllum maschalocarpum* (Womersley, 1959). In the northern hemisphere *Fucus* and *Pelvetia* are important littoral species but these genera are unknown in the southern hemisphere.

Hesperophycus and *Pelvetiopsis* are littoral species of the North Pacific Coasts. In the tropical and subtropical regions of the world *Sargassum* is the most important alga in the upper sublittoral (Womersley, 1959) but it is also conspicuous at and below the top of the sublittoral region of the warm-temperate coasts of the southern hemisphere.

Phyllospora is an upper sublittoral alga and is dominant on rough coasts in New South Wales (Womersley, 1959). *Cystophora retroflexa*, *Marginariella* and *Landsburgia* are common in the upper sublittoral but generally not dominant in this zone in New Zealand. *Scytothalia* and *Seirococcus* are sublittoral, and may occur in rock pools; Fucales are not conspicuous in the South African lower littoral, except *Bifurcaria* and *Bifurcariopsis*.

Himanthalia grows on the rough shores near the lower limi of the littoral zone, often exposed only at the lowest spring tides (Gibb, 1937; Naylor, 1951).

Axillariella Silva 1959, inhabits the sublittoral zone of the south west of Africa. The Fucales are thus a widespread group, common to most shores of the world.

(c) The thallus structure of the Fucales.

The thalli of the Fucales are differentiated into holdfast, stipe, axis and branches or segments. The axes or branches grow by means of an apical cell, with the exception of *Durvillea*, where growth is diffuse. In *Fucus*, *Hesperophycus*, *Pelvetia*, *Pelvetiopsis*, *Xiphophora*, *Carpoglossum*, *Durvillea*, *Phyllospora* and *Myriodesma*, the receptacles are metamorphosed vegetative segments or laterals. In *Hormosira*, the vesicles bear the conceptacles in the surface. In the Sargassaceae the receptacles are specialized organs. In *Scaberia* the vegetative warty leaves become fertile and the conceptacles are borne on the under surface of the leaves.

(1) The apical growth:

Apical growth in the Fucales was first recognised by Naegeli (1847) who separated the Chantransiae (red algae) Padineae and Fuceae by the presence of an apical cell. Later Kny (1872) and Rostafinski (1876; 1878) investigated apical growth in *Fucus* and *Himanthalia* respectively. Oltmanns (1889) made use of their work in his classification of the Fucales (= Fucaceen) and also contributed to the histology and the cytology of the Fucales. Gruber (1896) and Schmidt (1938), influenced by the previous workers, classified the Fucales on the presence or absence of the apical cell.

The apical cells are situated at the base of the funnel-shaped or flask-shaped apical depression, protected by mucilage. The genera of the Fucaceae possess 4-sided apical cells in which segmentation occurs longitudinally at the lateral faces and transversely at the base. The lateral segments divide transversely to form rows of cells, the uppermost of which elongate and form the meristoderm. The lower cells contribute to the cortex. The basal segment, cut off from the apical cell, divides transversely and longitudinally to build up the medulla.

Early differentiation of the meristoderm, the cortex and the medulla occurs near the apical region. At the embryo stage, in the Fucaceae, the apical cell is 3-sided (Nienburg, 1931; Fritsch, 1945b; 1952; Woodworth, 1888; Oltmanns, 1889; Rostafinski, 1876; Subrahmanyan, 1956) and is replaced by a 4-sided apical cell at the adult stage. Baker (1950) and Moss (1956) describe a 3-sided apical cell at the adult stage of _Fucus vesiculosus_ L. var. _muscoides_ Cotton which grows in salt marshes. Baker and Bohling (1916) suggest the possibility that the fertilized eggs are cast up onto the shore into a zone unfavourable for normal growth and development. Under these conditions plants grow slowly, retaining juvenile structures (such as 3 sided apical cells) and never reach maturity nor do they form reproductive cells. The distinctive 4-sided apical cell has been investigated in *Pelvetia* (Kny, 1875; Oltmanns, 1889; Holtz, 1903; Moore, 1928; Subrahmanyan, 1956), *Ascophyllum* (Fritsch, 1945b; 1952), *Xiphophora*, (Gruber, 1896; Heine, 1932), *Seirococcus*, *Scytothalia* and *Phyllospora* (Gruber, 1896). This definite 4-sided apical cell arises from the 3-sided apical cell of the embryo by longitudinal division (Fritsch, 1945b; 1952; Nienburg, 1927; Oltmanns, 1889). The 4-sided apical cell may differ in shape or in segmentation in longitudinal sections but it is always rectangular in transverse sections. In *Pelvetia canaliculata* (Subrahmanyan, 1956) and in *Xiphophora* (Mitchell, 1941; Naylor, 1954a), the apical cells appear to be 3-sided in longitudinal sections. Fritsch (1945b; 1952) describes the segmentation in *Pelvetia* and in *Ascophyllum* as being less regular.

In *Hormosira*, the only genus of the Hormosiraceae, the apical growth is initiated by a group of 4 (rarely 3) apical cells (Gruber, 1896; Osborn, 1948; Schmidt, 1938).

In *Durvillea* growth is diffuse (Grabendoerfer, 1885; Gruber, 1896; Fritsch, 1945b; 1952; Naylor, 1949b; Schmidt, 1938).

The genera of the Himanthaliaceae, Cystoseiraceae and Sargassaceae possess 3-sided apical cells - biconvex in longitudinal sections and triangular in transverse sections. These apical cells remain 3-sided throughout the life of the plant. The segments of the apical cell are cut off from the three faces by anticlinal divisions, giving rise to curved rows of a few cells each. The uppermost cell of each segment lengthens rapidly and divides anticlinally to form the meristoderm. The lowermost cell of each segment broadens and divides periclinally and anticlinally to form the medullary tissues. The middle cells of the primary segments, cut off from the apical cell, divide anticlinally as well as periclinally, contributing to the cortex. The presence of a 3-sided apical cell, apical growth and the segmentation of the apical cell has been investigated in *Sargassum* (Hansteen, 1892, Kuntze, 1881; Oltmanns, 1889. Reinke 1876, Simons, 1906), *Halidrys* (Fritsch, 1945a; 1952. Gruber, 1896. Hansteen, 1892. Oltmanns, 1889. Reinke, 1876), *Himanthalia* (Naylor, 1951. Oltmanns, 1889. Rostafinski, 1876. Thuret and Bornet, 1878. Wille, 1910), *Cystoseira* (Dawson, 1941. Valiante, 1883), *Carpophyllum* (Oltmanns, 1889. Gruber, 1896. Delf, 1939a. Dawson, 1940), *Marginariella* (Naylor, 1953b), *Turbinaria* (Barton, 1891), *Bifurcaria tuberculata* (Rees, 1933), and *Bifurcaripsis capensis* (= *Bifurcaria laevigata* Laing, 1941).

(2) The mature structure of the thallus.

The mature structure of the thallus of the Fucales is derived from the apical cells. Three distinctive tissues — the meristoderm, the cortex and the medulla — occur in all parts of the thallus. These tissues have been studied in *Turbinaria* (Barton, 1891), *Xiphophora*, (Barton, 1893; Reinke, 1876; Heine, 1932; Mitchell, 1941; Naylor, 1954a), *Cystoseira* (Dodel-port, 1885; Reinke, 1875; 1876), *Fucus* (Hick, 1885; Woodworth; 1888; Oltmanns, 1889; Nienburg, 1885; 1923; Reinke, 1876; Hansteen, 1892; Thuret and Bornet, 1878; Le Touze, 1912; Moss, 1948; 1950), *Himanthalia* (Rostafinski, 1876; Oltmanns, 1889; Wille, 1910; Naylor, 1951), *Bifurcaria* (Le Touze, 1912; Reinke, 1876; Rees, 1933), *Bifurcariopsis* (Laing, 1941), *Pelvetia* (Thuret and Bornet, 1878; Hansteen, 1892; Henckel, 1912; Holtz, 1903; Le Touze, 1912; Moore, 1928; Oltmanns, 1889; Subrahmanyan, 1956), *Marginariella* (Naylor, 1953b), *Sargassum* Hansteen, 1892; Oltmanns, 1889; Reinke, 1876; Simons, 1906), *Halidrys* (Doubt, 1928; Fritsch, 1945a; Gibb, 1937; Le Touze, 1912; Reinke, 1876), *Hormosira* (Mollet, 1880; Osborn, 1948), *Durvillea* (Naylor, 1949b; 1953a; Whitting, 1893), *Phyllospora* (Williams, 1923), *Ascophyllum* (Le Touze, 1912; Oltmanns, 1889; Reinke, 1876), *Coccophora* (Smith, 1893), *Seirococcus* (Smith, 1893).

In descriptions of the structure of the thallus different terminology has been used by different authors.

Reinke (1876) states that the thallus of the Fucales is composed of epidermis, cortex and medulla and describes the occurrence of hyphae (sometimes mistaken for intercellular spaces) in the older parts of the thallus of Sargassum boryanum. A middle lamella is present in the cell wall of all the species studied by Reinke except Fucus vesiculosus which also lacks pores. Rostafinski (1876) uses the terms "ausserrinde" and "innerrinde" for the cortical tissue, instead of epidermis of previous authors. Bower (1880) uses "limiting tissue" (ausser rinde of Rostafinski) and cortical tissue (innerrinde of Rostafinski) in describing the development of the conceptacle of the Fucales. In describing Hormosira, Mollet (1880) and Osborn (1948) follow the terms used by Bower except that Osborn refers to the medulla instead of the "central part" of the thallus. Pit connections and lamellae are described in the cortical and the medullary cells of Hormosira (Osborn, 1948). She also describes the presence of hyphae among the inner cortical cells and the medullary cells. Lateral connections in the medullary cells have been observed (Mollet, 1880; Osborn, 1948). The tissues in Sargassum (Hansteen, 1892; Simons, 1906), Fucus (Hansteen, 1892), Himanthalia (Wille, 1910), Bifurcaria, (Rees, 1933), and Xiphophora (Mitchell, 1941) are termed the assimilatory system, the storage system and the conducting system according to their function. The outermost layer is the assimilatory system which possesses dense chromatophores and the cells are meristematic. In the peripheral cells radial division is followed by tangential division, towards their bases. The storage system comprises many cells between the assimilatory system and the conducting system. The conducting system consists of long cells of small diameter and with oblique end walls. Hansteen believes that these cells function as sieve tubes and the cells of the three systems communicate by pores, but he is not certain whether protoplasmic strands continue through the pores in _Fucus_, _Pelvetia_ and _Sargassum_. He observed fucosan for the first time in 1892 and considered it as a product of photosynthesis (1900). In _Sargassum_ scalariform thickenings occur on the walls of medullary cells (Hansteen, 1892)

Barton (1893) and Heine (1932) referred to the peripheral cells, the parenchyma and the central strand in the structure of _Xiphophora_, but Naylor (1954a) prefers to use the terms meristoder cortex and medulla respectively. Mitchell (1941) describes the hyphae which are abundant in the medulla (= the conducting system) of the lower thallus. They are branched or unbranched, ramifying amongst the primary cells of the medulla.

In Pelvetia fastigiata three tissues — the epidermis, cortex and pith or central cylinder — occur (Holtz, 1903. Moore, 1928). In this species the epidermis is considered as assimilative, protective and meristematic, containing dense chromatophores. Anastomoses and pit formations occur in the cortex and the pith (Holtz, 1903). Lamellae also occur in this species (Moore, 1928). Lateral connections, and the cytoplasmic connections pass through the pores. Hyphae are confined to the holdfast in P. fastigiata (Moore, 1928). Mucilage occurs throughout the thallus of Pelvetia fastigiata.

In Sargassum filipendula the three tissues are meristematic near the apical region and the epidermal cells retain their activity indefinitely (Simons, 1906). In the conducting system inner thin-walled and outer thick-walled cells occur where the latter are supporting as well as conducting in function and the middle lamella is present between the cells in the tissues of S. filipendula (Simons, 1906) Reinke (1876) describes rhizoids in the holdfast and intracellular filaments (= hyphae) in the older parts of S. boryanum.

In Himanthalia lorea the assimilating system is composed of an outer zone of assimilating cells and inner zone of mechanical cells occur; the latter also functioning as storage cells (Wille, 1910). Naylor (1951) describes 4 regions —— the meristoderm, the inner cortex of thin walled cells, the large thick walled cells and the medullary cells. Both Wille and Naylor describe the occurrence of pit formation, lamella and the presence of hyphae in the cortical and the medullary cells.

Rees (1933) describes radial communication by pores in the conducting system and suggests the occurrence of protoplasmic connections due to the lateral contractions of the protoplasm. She also describes septate,hyphae, which become more branched, with age, in the attaching disc.

(p.t.o.)

Church (1920) suggests as descriptive terms for the thallus structure, the peripheral layer, the cortex and the medulla. His terminolgy agrees with that of Hansteen andWille. Church states that (i) cells of the peripheral layer contain dense chloroplasts and are meristematic, (ii)the cortical cells contain fewre chloroplasts, the meristematic activities of the cortical cells are reduced and these cells expand more affording more room for the storage of photosynthetic products (iii) the medulla contains no chloroplasts and the medllary cells do not divide but increase to large dimensions.They function as conduction, or storage cells, or break down to be filled with mucilage fluid,or act as mechanical support for the plant. They elongate more in length.

Doubt (1928) describes the occurrence of protoplasmic connections, lamellae and sieve plates in Halidrys dioica.She also obsreved hyphae in the midrib and vesicles.

Fritsch (1945a) describes the meristderm, the cortex, the outer medulla and inner medulla in H. siliquosa, where cell walls are thick, lamellate and pitted. Hyphae occur in in the basal parts of the plant.

The firm adherence of the protoplast to the transverse walls in Bifurcaria (Rees,1933), Ascophyllum (Hick, 1885) and Fucus (Hick,1885),suggests an approach to the sieve tube.

(p.t.o)

Marginariella (Delf, 1939b) the sieve tube appearance is greatly strengthened by the presence of large callus pads on the transverse and lateral walls.

In *Bifurcariopsis capensis*, Laing (1941) describes the medullary tissues as compact without secondary filaments but having interweaving filaments which develop from the cortical as well as from the medullary cells. She also reports the presence of beaded structures across the transverse walls of the medullary filaments, resembling a young callus. Whitting (1893) describes a cortical and a medullary portion in *Durvillea* (= *Sarcophycus*) *potatorum* where the former is a compact mass of parallel rows of cells becoming broader and looser towards the medullary portion which is made up of filaments anastomosing and branching in every direction. Naylor (1949b; 1953a) describes the meristoderm the cortex and the medulla in *D. antarctica* and *D. Willana*. Numerous longitudinal and some horizontal hyphae are produced as outgrowths from the cortical and medullary cells in *Durvillea*. Cellulose is present throughout the walls of the hyphae and in the walls of some of the medullary and cortical cells (Naylor 1949b).

Three layers of tissues — the epidermis, the cortex and central portion — occur in *Seirococcus* (Smith, 1893).

(3) The receptacles.

Like vegetative apices the receptacles also grow by means of a single 4-sided or 3-sided apical cell. The development and segmentation of the apical cell of the receptacle has been studied in *Fucus vesiculosus* (Bower, 1880), *Carpophyllum flexuosum* (Dawson, 1940), *Turbinaria* (Barton, 1891. Blomquist, 1945), *Himanthalia lorea* (Naylor, 1951), *Carpophyllum maschalocarpum* (Delf, 1949a), *Scytothalia dorycarpa* (Naylor, 1949a). In *Fucus*, *Pelvetia*, *Xiphophora*, *Myriodesma* and *Hormosira* the fertile segments comprise the receptacles. The apical cells and segmentation of the fertile segments of these genera are similar to those of the vegetative segments of the genus concerned. The three tissues, the meristoderm, the cortex and the medulla — occur in the receptacles.

Conceptacles occur scattered or in rows on the receptacles. At an early stage the conceptacles bear sterile hairs. Later on antheridia and oogonia are borne on the wall of the conceptacles or on paraphyses. The receptacles may be unisexual or bisexual. The conceptacles also may be uni- or bi-sexual. In *Cystoseira foeniculacea* the oogonia are deeper in the conceptacle and the antheridia are in a ring below the ostiole (Dawson, 1941). There is a trend of segregation of sexes and ~~the~~ of reduction of antheridia in *C. foeniculacea*, *C. discors*, *C. ab-*

rotankfolia, *C. myriophylloides* and *C. canariensis* (Sauvageau, 1911). In *Scytothalia dorycarpa* near the base of the marginal groove there is a single large cell, probably the initial of a future receptacle (Naylor, 1949a). Naylor describes the receptacle as bisexual bearing male and female conceptacles but occasionally bisexual conceptacles may occur. There may be segregation of sexes in the bisexual conceptacles where antheridia are few.

The fertile segments of *Xiphophora* (Heine, 1932; Mitchell 1941) grow by means of a 4-sided apical cell. The segments are bisexual and the conceptacles are either uni- or bi-sexual.

The segment of *Hormosira* grows by means of a group of 4 (rarely 3) apical cells (Gruber, 1896; Osborn, 1948; Mollet, 1880). The plant is dioecious. Medullary cells are loosely arranged and the intercellular spaces are filled with mucilage. The medullary ~~cells-are~~ region is traversed by hyphae.

In the fertile segments of *Xiphophora* as well as those of *Hormosira* pit connections, lateral connections and hyphae are strongly developed.

Durvillea is a dioecious plant so the conceptacles are always unisexual, borne scattered over the thallus. The apices of the segments are dome-shaped and growth is diffuse (Naylor, 1949b).

In *Seirococcus*, Smith (1893) describes erect, torulose crowded receptacles in the axils of segments with the male conceptacles borne near the base and the female ones near the top but both occurring on the same branch.

The conceptacles are scattered or in vertical rows along the edge, but are spirally arranged in *Carpophyllum flexuosum* (Dawson, 1940) and *Turbinaria turbinata* (Blomquist, 1945).

(4) *Conceptacles*.

Initiation of the conceptacles occurs near the apical cell of a receptacle or a segment. Kuetzing (1843) describes the conceptacle as a roofed - in sorus ("eingestülpter" sorus) lined by a slightly modified continuation of the meristoderm (= cortical schicht). Further he speaks of cryptostomata (Fasergrübchen), which are related to conceptacles (Hüllenfrucht). J. Agardh (1848) suggests that the "Fasergrübchen" may become the conceptacles (= scaphidia) in the fertile part of the plant. Reinke (1875; 1876) contributes to an accurate description of the development of the conceptacle or Fasergrubchen. In *Fucus vesiculosus* the "Fasergrübchen" originates by separation of 4 or 5 neighbouring meristoderm cells as well as of the cortical cells and the intercellular space is filled with mucilage (Reinke, 1875; 1876). The cavity thus formed becomes flask-shaped, and the lining cells put out papillae which develop into hairs. Reinke concludes that the Fasergrubchen is homologous with the conceptacles but his investigation is not supported by any illustrations.

The development of the conceptacle is initiated by a single initial cell in *Fucus serratus*, *F. spiralis* (= *F. platycarpus*), *F. vesiculosus*, *Ascophyllum* (= *Ozothalia*) *nodosum*, *Halidrys siliquosa*, and *Himanthalia lorea* (Bower, 1880). Further details of the development of a conceptacle are given by Oltmanns (1889), Simons (1906) and Nienburg (1913). Simons describes the early development of the sterile and fertile conceptacles as similar in *Sargassum filipendula*. Fritsch (1945b; 1952), describes the development of the conceptacle in the members of the Fucales as commencing from a superficial cell. In *Cystoseira* (Valiante, 1883; Nienburg, 1913; Fensholt, 1955; Delf, 1939b), *Sargassum* (Simons, 1906; Tahara 1940a; 1940b; 1941; Fensholt, 1955), *Carpophyllum* (Delf, 1939a; Dawson, 1940; Naylor, 1953c), *Halidrys* (Doubt, 1928; Nienburg, 1913; Oltmanns, 1889), *Bifurcaria* (Rees, 1933), *Bifurcariopsis capensis* (Laing, 1941) and *Turbinaria* (Blomquist, 1945), the conceptacles initial is flask-shaped and divides by a curved transverse wall forming an upper tongue cell and ~~the~~ a lower basal cell. The latter has been variously called the "lower cell" (Simons, 1906), the basal cell (Nienburg, 1913), the lower segment (Delf, 1939a; 1939b) or the true conceptacle initial (Dawson, 1940). The basal cell divides longitudinally to form a series of cells which form the lining cells of the conceptacle. While these divisions are taking place the adjacent cells divide leading to the sinking of the derivatives of the basal cell and to the separation of the tongue cell from the adjacent cells. In *Sargassum*, *Carpophyllum*, female *Turbinaria* *Bifurcaria* and *Bifurcariopsis* the tongue cell elongates and sometimes divides to form a row of a few cells, but in *Cystoseira*, male *Turbinaria* and *Halidrys* the tongue cell develops into a many-celled hair with a basal meristem. Meanwhile the cells formed by the longitudinal division of the basal cell develop the gradual widening of the cavity. In *Hormosira* the initial is flask-shaped and divides by an oblique septum (Osborn, 1948). The basal cell divides radially forming a single layer of lining cells to the conceptacle; the fate of the tongue cell is not described by Osborn.

In *Himanthalia* (Bower, 1880; Nienburg, 1913; Oltmanns, 1889) the basal cells of the hairs within the depression at the summit of the receptacle persist and function as conceptacle initials. These initials divide vertically, then transversely. The central cells thus formed do not divide as actively as the marginal ones which form the cavity of the conceptacle. According to Nienburg (1913) the tongue cell forms a long multicellular hair with basal growth.

Naylor (1949a) describes the presence of a single hair with a basal meristem in a narrow slit in the young developing conceptacle of Scytothalia. In Marginariella (Naylor, 1953b) the conceptacle initial divides by a straight transverse septum forming a tongue cell and a basal cell. The basal cell divides repeatedly by anticlinal walls forming a single layer of small cells constituting the wall of the conceptacle. The tongue cell divides by a series of transverse walls forming a uniseriate filament.

In Seirococcus, the adjoining cells of the initial form the conceptacle (Gruber, 1896).

In Fucus (Bower, 1880; Nienburg, 1913; Fritsch, 1952) the initial is situated at the base of a deep and narrow cavity due to the outgrowth of adjacent cells. A straight transverse septum divides ~~vert~~ the initial into a tongue cell and a basal cell. The basal cell divides vertically then transversely to form 2 layers and by this time the tongue cell is deeply sunk. Further division of the derivatives of the basal cell forms the floor of the conceptacle. The tongue cell sooner or later disintegrates. Similar development occurs in Xiphophora (Heine, 1932).

In Pelvetia fastigiata (Moore, 1928; Nienburg, 1910) and in P. canaliculata (Subrahmanyan, 1957a) the conceptacle initial divides longitudinally into two. This is somewhat different from what has been observed in other genera. Each derivative so formed divides transversely a number of times to form basal cells which form the wall of the conceptacle. The wall of the conceptacle of P. canaliculata is 3 to 4 cells thick but in P. fastigiata it is only one cell thick. The development of the conceptacle in P. fastigiata (Holtz, 1903) is initiated by cutting off the basal cells from the meristoderm cells. These basal cells divide periclinally and radially to form a small pad of meristematic cells while the meristoderm cells immediately above them collapse and so form the cavity. In P. fastigiata (Moore, 1928; Nienburg, 1910) the upper cells form many celled hairs but no hairs develop in P. canaliculata. Further Nienburg (1913) states that the first division of the conceptacle initial in P. fastigiata is not always vertical. In Ascophyllum irregular segmentation occurs (Nienburg, 1913, Oltmanns, 1889; Bower, 1880) forming a mound of cells on the wall of the conceptacle.

(5) Structure of the fertile receptacle.

Reproductive bodies of the Fucales are borne in the conceptacles. Sterile conceptacles also occur in Fucus, Sargassum, Turbinaria, Xiphophora, Myriodesma, Cystophyllum and Cystoseira. In these conceptacles the hairs are sterile, simple and develop at the middle of the conceptacle floor by basal growth. These hairs project through the osteole. Shorter pigmented hairs with diffuse growth also occur. First they are one celled, then becom~~ing~~e multi-cellular producing unicellular branches (Fritsch, 1952). These hairs produce a mucilaginous fluid which fills the cryptostomata (Fritsch, 1952). According to Fritsch the cryptostomata are to some extent, influenced by habitat conditions. They are prominent in the saltmarsh forms of *Fucus vesiculosus* (Baker and Bohling, 1916). In some genera (*Sargassum*, *Cystoseira*, etc.) the leaves contain sterile cavities or cryptostomata within which sterile hairs are produced.

(i) Reproductive organs.

In the Fucales reproductive organs are borne in the conceptacles and the distribution of the reproductive organs varies in different genera and even in one and the same species (Kniep, 1925; Fritsch, 1945b; 1952). Several genera are dioecious but the monoecious condition is more usual in the Fucales (Fritsch, 1945b; 1952). In *Cystoseira* the conceptacles may be unisexual or bisexual (Dawson, 1941, Sauvageau, 1912). *Sargassum* also exhibits a condition similar to that of *Cystoseira* (Grunow, 1915; Setchell, 1931), but many species of *Sargassum* are dioecious. In dioecious species of *Sargassum* the male receptacles may be smooth and the female ones spinous (Fritsch, 1945b; 1952).

In S. horneri (Kunieda 1924; 1928), the male receptacles are longer and more slender. Doubt (1928) states that the receptacles are tufted in male plants of Halidrys dioica. The genus Turbinaria is generally considered to be strictly dioecious. This may be true of Hizikia fusiformis (= T. fusiformis Tahara 1929a), T. ornata, and T. filiformis (Inoh, 1937b), but T. turbinata (Blomquist, 1945) on rare occasions possesses bisexual conceptacles or occasionally antheridial and oogonial conceptacles occur in one receptacle. Barton (1891) observed bisexual conceptacles also in T. conoidea. The conceptacles in Bifurcaria brassicaeformis are unisexual and the plant is more or less dioecious; when monoecious, one branch may be male and another branch female (Delf, 1935; Isaac, 1951). Fucus ceranoides is mostly dioecious but occasionally monoecious (Naylor, 1936).

Generally oogonia and antheridia are intermingled in the bisexual conceptacles but in a few species of Cystoseira (Sauvageau, 1912), in Bifurcaria tuberculata (Rees, 1933) and Sargassum (Setchell, 1931), oogonia occur at the base and antheridia on the sides of the conceptacle. This condition in Sargassum has been termed "androgynous" (Setchell, 1931).

The oogonia are spirally arranged in the genus Carpophyllum (Dawson, 1940; Delf, 1939a). The oogonia mature successively or simultaneously in the Fucales.

(a) *Oogonia*.

The oogonia (Thuret and Bornet, 1878; Oltmanns, 1889; Nienburg, 1910; Delf, 1939a; Dawson, 1940; Blomquist, 1945; Mitchell, 1941; Moore, 1928; Naylor, 1949a; 1953b; Laing, 1941; Osborn, 1948; Rees, 1933; Simons, 1906) always develop directly on the wall of the conceptacle and possess a definite basal cell which is either embedded in the wall ~~of~~ in *Cystoseira* (Nienburg, 1910; Dawson, 1941), *Sargassum* (Kunieda, 1928; Nienburg, 1910, Simons, 1906), *Cystophyllum* (Fensholt, 1955), *Carpophyllum* (Dawson, 1940; Delf, 1939a; Naylor, 1953c), *Marginariella* (Naylor, 1953b), *Scytothalia*, (Naylor, 1949a), *Bifurcaria* (Rees, 1933), *Bifurcariopsis* (Laing, 1941), *Hormosira* (Osborn, 1948) and *Turbinaria* (Blomquist, 1945), or ~~on the basal cell which~~ develops as a stalk in *Fucus* (Oltmann, 1889), *Xiphophora* (Heine, 1932) and *Pelvetia fastigiata* (Holtz, 1903; Moore, 1928); the stalk cell is lacking in *Pelvetia canaliculata* (Fritsch, 1945b; 1952; Subrahmanyan, 1957a). In *Durvillea* the oogonia are borne mostly on branched hairs (Whitting, 1893; Naylor, 1949b; 1953a), but they are also borne directly on the wall of the conceptacle (Herriot, 1923, Naylor, 1949b, 1953a). The occurrence of oogonia on branched hairs is comparable to the usual occurrence of antheridia in the Fucales (Fritsch, 1945b; 1952).

The young oogonium is uninucleate containing dense chromatophores and food reserves. There are three nuclear divisions in the developing oogonia. On maturation 1,2,4 or 8 eggs may be produced.

A great contribution to the development and the subsequent fate of the nuclei in the developing oogonia of *Ascophyllum*, *Pelvetia*, *Himanthalia* and *Fucus* was made by Oltmanns (1889). Three nuclear divisions occur in an oogonium forming 8 nuclei. In the oogonia of *Ascophyllum*, *Pelvetia canaliculata* and *Himanthalia* 4 or 6 or 7 nuclei respectively disintegrate in situ or at the periphery to leave 4 or 2 or 1 eggs in each oogonium of the respective genera. There is no disintegration of nuclei in *Fucus*, which produces 8 eggs.

Since that time Oltmanns findings have been confirmed in *Ascophyllum* and *Fucus* (Farmer and Williams, 1896; Strasburger, 1897; Yamanouchi, 1909), *Pelvetia fastigiata* (Holtz, 1903; Moore, 1928), *Pelvetia wrightii*, *Fucus evanescens* (Inoh, 1935), *Sargassum horneri* (Kunieda, 1926; Okabe, 1929b), *Cystoseira* and *Sargassum* (Nienburg, 1910), *Coccophora* (Tahara, 1929b), *Sargassum* (Tahara and Shimotomai, 1926). *Cystoseira montagnei* and *C. opuntioides* (Sauvageau, 1911), *P. canaliculata* (Subrahmanyan, 1957a), *Fucus evanescens* f. *typicus*, *Hesperophycus harveyanus*, *Pelvetiopsis limitata*, and *Cystoseira osmundacea* (Gardner, 1910), *Bifurcaria*

(Rees, 1933), *Bifurcariopsis* (Laing, 1941), *Carpophyllum* (Delf, 1939a; Dawson, 1940; Naylor, 1953c), *Marginariella* (Naylor 1953b), *Xiphophora* (Naylor, 1954a) and *Turbinaria* (Blomquist, 1945).

Only in *Fucus* (Thuret and Bornet, 1878; Fritsch, 1945b; 1952) does the cytoplasm undergo cleavage forming 8 eggs. *Ascophyllum* (Oltmanns, 1889; Gruber, 1896; Fritsch, 1945b; 1952), *Xiphophora* (Gruber, 1896; Barton, 1893; Heine, 1932; Mitchell, 1941; Naylor, 1954a), *Bifurcariopsis* (Laing, 1941), *Hormosira*, (Gruber, 1896; Mollet, 1880; Osborn, 1948) and *Durvillea* (Whitting, 1893; Gruber, 1896; Naylor, 1949b; 1953a) produce 4 eggs. *Pelvetia* produces 2 eggs and the other genera of the Fucales produce one egg. There are delicate septa separating the eggs in the mature oogonia of *Fucus* (Farmer and Williams, 1898; Thuret and Bornet, 1878), *Hormosira* (Getman, 1914; Osborn, 1948) and *Durvillea* (Naylor, 1949b; 1953a). In *Pelvetia canaliculata* the eggs are separated by a mucilaginous septum (Fritsch, 1945b; 1952, Oltmanns, 1889) and in *P. fastigiata* (Gardner, 1910; Moore, 1928) the eggs show a collateral or oblique arrangement and this is also observed in *P. wrightii* (Inoh, 1935). According to Moore (1928) production of 4 eggs is common in *P. fastigiata* but this condition rarely occurs in *P. canaliculata* (Subrahmanyan, 1957a). In *Xiphophora* the 4 eggs are formed in a compartment~~s~~ and not attached to the inner wall of the oogonium

(Naylor, 1954a). According to Fritsch (1945b; 1952) and Papenfuss (1951a) the production of 4 or 8 eggs is the primitive condition.

The nuclei which are not used in the production of eggs take up diverse positions. In *Pelvetia canaliculata* they lie in the equatorial region between the two eggs (Thuret and Bornet, 1878; Fritsch, 1945b; 1952). Similar conditions occur in *P. fastigiata* (Moore, 1928). Subrahmanyan (1957a) describes the degeneration of scattered nuclei inside the protoplast of the oogonium of *P. canaliculata*. The four degenerating nuclei in *Ascophyllum* form a central group (Oltmanns, 1889; 1922) and much the same is true of *Bifurcaria tuberculata* (Rees, 1933). In *Xiphophora* (Mitchell, 1941), the degenerating nuclei are peripheral but Naylor (1954a) describes one degenerating nucleus in each compartment of the oogonium. In *Hesperophycus* and *Pelvetiopsis* the 7 degenerating nuclei are cut off from the base of the oogonium together with a small amount of cytoplasm; the fate of this cytoplasmic mass is not known (Gardner, 1910). In *Sargassum* (Abe, 1938; Hiroe and Inoh, 1955; Kunieda, 1928; Kunieda and Suto, 1940; Tahara, 1913; 1927; Tahara and Shimotomai, 1926), *Carpophyllum* (Dawson, 1940; Delf, 1939a; Naylor, 1953c), *Coccophora* (Tahara, 1929b) and Turbinaria (Blomquist, 1945; Inoh, 1937b) the eggs possess 8 nuclei at the time of discharge but seven nuclei undergo disintegration before or after fertilisation. In Marginariella (Naylor, 1953b) and in Cystoseira (Sauvageau, 1912), 7 nuclei lie between the egg and the mucilaginous layer of the wall. In Himanthalia, 7 nuclei disintegrate at the periphery (Oltmanns, 1889).

The wall of the oogonium is generally composed of 3 layers (Farmer and Williams, 1898) - exochite, mesochite and endochite; the mesochite is thick and separated from the exochite by a space (Fritsch, 1945b; 1952). Mitchell (1941) distinguishes 5 layers in Xiphophora. In Pelvetia fastigiata (Holtz, 1903) only two layers occur. Subrahmanyan (1957a) describes a thick mucilaginous wall but without differentiation of layers. The occurrence of three layers of the oogonial wall has been ascertained in almost all the genera so far investigated. The eggs are liberated in part of the oogonial wall. The exochite remains attached in the conceptacle or occasionally the entire oogonium is liberated. Gibb (1937) describes the liberation of eggs through a small lateral aperture in the exochite of the oogonium of Himanthalia but generally in other genera the eggs are liberated through an apical pore.

Fritsch (1945b; 1952) states that among the more specialised Fucales the liberated eggs are enclosed in mucilaginous membranes; which form a kind of stalk and which remain attached to the receptacle.

The first record of attachment of eggs of *Cystoseira barbata* was described by Dodel-Port (1885). Since that time incomplete descriptions of stalks or attachments in the species of *Sargassum* (Delf, 1935; Kunieda, 1928; Nienburg, 1910; Simons, 1906; Tahara, 1909) and *Cystophyllum* (Delf, 1935) have been given. The liberated eggs may remain attached on the receptacle by means of mucilaginous stalks (mesochiton stalks) in *Cystoseira* (Sauvageau, 1909; 1912; Dawson, 1941), *Carpophyllum* (Dawson, 1940; Naylor, 1953c) *Bifurcaria* (Delf, 1935), *Bifurcariopsis* (Laing, 1941), *Marginariella* (Delf and Hyde, 1936, Delf, 1937; Naylor, 1953b), *Cystophyllum* (Inoh, 1937c) and *Turbinaria* (Blomquist, 1945; Inoh, 1937b; Tahara, 1929a). Dawson (1941) states that a uniform type of specialisation of the mesochiton is widespread in the Sargassaceae. In *Marginariella* the mesochiton stalk is hollow and tubular whereas it is solid in the Cystoseiraceae and Sargassaceae. Dawson (1941) suggests that the mesochiton stalk is one of the characters of the Fucaceae and Cystoseiraceae - Sargassaceae.

(b) *Antheridia*.

The antheridia are borne in large numbers on the branched paraphyses of the male conceptacles or directly on the wall of the male conceptacle. The antheridium develops as an outgrowth from the lining cells of the conceptacle and is cut off by a transverse wall to form a stalk cell and antheridium proper (Simons, 1906; Bower, 1880, Blomquist, 1945; Moore, 1928; Moss and Elliot, 1957; Subrahmanyan, 1957a, Yamanouchi, 1909). The former produces a branch which pushes the antheridium to one side and itself gives rise to a second antheridium. These events are repeated indefinitely to form branched paraphyses.

Antheridia are borne directly on the wall of the conceptacle in *Pelvetia fastigiata* (Holtz, 1903; Moore, 1928) and this condition also occurs in *Cystoseira* (Dawson, 1941; Fensholt, 1955), *Phyllospora* (Williams, 1923), *Durvillea* (Herriot, 1923), *Pelvetia canaliculata* (Subrahmanyan, 1957a), *Turbinaria* (Blomquist, 1945) and *Sargassum* (Simons, 1906, Fensholt, 1955). The antheridial wall is composed of exochite and endochite.

In an antheridium six nuclear divisions occur forming a 64 - nucleate stage and producing 64 sperms. The sperms are pear-shaped and biflagellate. The flagella are laterally attached with the anterior one short and the posterior one long (Strasburger, 1897, Kylin, 1920, Retzius, 1906). A long posterior flagellum is the characteristic feature of the Fucales as distinct from other Phaeophyta (Fritsch, 1945b; 1952) in which the posterior flagellum is very short compared with the anterior one. The proportions of the flagella are 3:1 in *Fucus serratus* and 2:1 in *Ascophyllum nodosum* (Manton, Clark and Greenwood, 1953). Manton and Clark (1951) describe the proboscis of a sperm~~s~~ as a highly mobile, funnel shaped membrane partially surrounding the anterior flagellum and attached to the body at its base. The proboscis in *Ascophyllum nodosum* is composed of 14-15 concentric bands and in *F. serratus* of 13 bands. These bands are structureless in *F. serratus* (Manton and Clark, 1951) and fibrillar in *Ascophyllum nodosum*. *Pelvetia canaliculata* possesses a smaller proboscis than *Fucus* and contains 11 bands. In *Himanthalia* the sperm possesses a shorter posterior flagellum with a whiplash point as in the zoospores of other Phaeophyta (Fritsch, 1952). There is no proboscis but the anterior flagellum is "Flimmergeissel", (fimbriated flagella) with a large spine situated laterally on the flagellum near ~~the~~ its distal end, and there is no whiplash at the end of the anterior flagellum (Manton, Clark and Greenwood, 1953). These authors are of the opinion that the presence of a spine facilitates contact with the surface of the egg and suggest it is perhaps an organ of copulation rather than a swimming or a sense organ.

(6) Embryology.

Fertilisation in the Fucales occurs after the liberation of the eggs. A large number of sperms surround an egg to which they become attached ~~to~~ by the anterior flagellum while the posterior one continues to move vigorously causing the eggs to rotate (Fritsch, 1945b; 1952). As soon as the sperm penetrates the attraction ceases.

After fertilisation the zygotes attach themselves on the substratum by a mucilaginous secretion. Thuret and Bornet (1878) were the first to study the embryology of *Fucus vesiculosus*. The first transverse segmentation of the zygote is followed by longitudinal segmentation of the upper cell. The lower cell of the zygote produces a single rhizoid. In *Cystoseira* the first transverse division of the zygote is followed by 2 longitudinal divisions of the upper cell ~~and~~ while the lower cell divides by 2 successive longitudinal divisions forming 4 primary rhizoids. Two or four apical hairs are formed in the apical groove (Valiante, 1883). In *Sargassum filipendula* a many-celled ellipsoidal embryo develops several rhizoids at one end of the embryo (Simons, 1906). In *S. linifolium* the third transverse division of the zygote leads to the formation of a lenticular rhizoid cell (Nienburg, 1910). The second transverse segmentation of the zygote~~s~~ of *Hizikia fusiformis* and *Sargassum thumbergii* leads to the formation of a lens-shaped rhizoid initial; two divisions perpendicular to each other follow, thus forming a quadrant

(Tahara, 1929a). In H. fusiformis each cell of the quadrant divides by walls which are parallel, oblique or radial to the first two segmentation walls so that each cell produces 8 rhizoids; the division of each cell of the quadrant of the embryo of S. thunbergii is usually oblique and not radial (Tahara, 1929a). Abnormalities occur in the development of the embryos of S. enerve and S. horneri such as a half embryo which is partly segmented and partly unsegmented (Tahara, 1927). Inoh (1930) describes the first two divisions in the embryo of Sargassum as transverse forming a small lens-shaped rhizoid cell at one extremity of the embryo. This rhizoid cell divides twice perpendicular to each division and is followed by irregular segmentation forming 8 or 16 rhizoids. He concludes that the rhizoid number in Sargassum and Cystophyllum has a definite relation with the size of the primary rhizoid cell, and the species with larger eggs are in a higher systematic position.

Inoh (1937) states that in most of the Fucaceous plants of Japan the division of a lens shaped rhizoid initial leads to the formation of several rhizoids and the number of rhizoids is proportional to the size of the egg. The egg of Fucus evanescens measures 60 µ in diameter and produces a single rhizoid whereas in Cystophyllum sisymbrioides the egg averages 321 µ x 229 µ and produces 32 rhizoids. The number of rhizoidal cells varies in various species in geometrical progression 2:4 : 8:16 : 32. Inoh's conclusion is based on Fucus, Pelvetia, Cystoseira, Turbinaria, Hizikia, Coccophora, and Sargassum.

In T. ornata and H. fusiformis 8 rhizoids are formed due to the three successive divisions of the rhizoid initial (Inoh, 1937b). The lower cell of the zygote of Cystophyllum crassipes undergoes two successive divisions forming 4 cells, then each cell produces one rhizoid, but 8 rhizoids may develop due to the bifurcation of the rhizoid (Inoh, 1937c). In C. sisymbrioides the lower cell of the zygote, formed after two transverse divisions, is a lens-shaped rhizoid cell which undergoes longitudinal divisions forming 32 rhizoids (Okabe, 1929a).

The second division of the zygote of Xiphophora is vertical to the first transverse division in the upper cell and the third division is transverse in the lower cell of the zygote forming a primary rhizoid cell which divides longitudinally to form many branched or unbranched rhizoids. (Heine, 1932, Naylor, 1954a). On the embryos of Xiphophora 4 or 5 apical hairs occur (Heine, 1932). The multicellular embryo of Sargassum or Cystophyllum possesses a tuft of short rhizoids (Delf, 1935). A tuft of 4 or 16 rhizoids occurs at one end of the embryo of Carpophyllum flexuosum (Dawson, 1940), and Cystoseira foeniculacea

(Dawson, 1941) respectively.

The lenticular rhizoid cell of the embryo of Turbinaria turbinata divides by two perpendicular walls forming 4 equal cells each of which divides by an oblique wall to give 8 rhizoids, further forking and branching also occurs (Blomquist, 1945).

In Hormosira the second transverse division of the zygote forms the rhizoid cell and the third division is vertical in the upper cell of the embryo. The primary rhizoid of the embryo of Hormosira first elongates, becomes 2 or 3 celled, and then branches by means of protuberances. Thus 3-6 rhizoids are formed and up to 4 apical hairs occur in the apical groove (Osborn, 1948).

In Marginariella urvilliana, the first three divisions are transverse, and the second transverse wall forms a rhizoid initial. The fourth division is vertical to the uppermost cell of the embryo, and the rhizoid initial divides into a quadrant each cell of which develops a rhizoid which further bifurcates and branches to form a number of rhizoids (Naylor, 1953b).

The first transverse division of the zygote of Carpophyllum plumosum forms two multinucleate cells and the rhizoid initial of the zygote of C. plumosum, C. maschalocarpum and C. flexuosum is relatively large and multinucleate, and divides to form a tuft of 16 rhizoids (Naylor, 1953c).

In *Durvillea* a primary rhizoid is formed by the second transverse wall and the large upper cell divides by vertical walls into quadrants after which horizontal and vertical divisions occur in quick succession (Naylor, 1953a). No apical hair or apical groove was observed in *Durvillea*.

In *Pelvetia canaliculata* the first segmentation is perpendicular to the direction of light, and the rhizoids are first formed in fours at one end of the embryo. These rhizoids increase in number becoming septate and branched (Subrahmanyan, 1957b). Subrahmanyan also observes abnormalities in this species due to the development of rhizoids at both poles in which case there is no development of an apical groove or of apical hairs. There occurs a single 3-sided apical cell in the embryo of *P. canaliculata*.

In *Fucus spiralis* (Giraud, 1956), the first transverse division of the zygote occurs after the establishment of polarity and thus forms a rhizoid initial. The second segmentation occurs in the upper cell and this segmentation is followed by longitudinal division of the uppermost cell.

(7) Cytology.

The cytological studies in the Fucales were first made by Oltmanns (1889) to investigate the fate of the supernumery nuclei of an oogonium. Strasburger (1897) and Farmer and

Williams (1898) describe the reduction in chromosome number during the first nuclear division in the oogonium of *Fucus* and *Ascophyllum*. Strasburger gives 30 as the probable number of chromosomes in the oogonium of *F. spiralis*. In *Ascophyllum nodosum* counts of 26 - 30 chromosomes were made in the oogonium mother cell and 14 - 15 in the third division of the oogonium (Farmer and Williams, 1898).

According to Simons (1906) mitosis in the oogonium of *Sargassum filipendula* is suppressed and occurs only within the wall cell of a conceptacle the division of which produces the oogonium. She also described one nucleus of the oogonium as remaining in a resting stage throughout its development — and becoming the nucleus of the egg. According to Nienburg (1910), Simons statement for *S. filipendula* is erroneous.

Spindles and asters occur in *S. filipendula* but their origin and relationship to the process of mitosis were not traced by Simons (1906).

Yamanouchi (1909) made a great contribution to the cytology of *Fucus vesiculosus*. The nuclei of the thallus in this species are smaller than those of the apical region, and the cytoplasm is granular towards the nuclear membrane. A centrosome and spindles occur in *F. vesiculosus* and 64 chromosomes were counted in the vegetative cells and the zygote. The first two divisions in the antheridium and oogonium are meiotic. There are 32 chromosomes in the antheridium and oogonium. This shows that the thallus of *Fucus vesiculosus* is diploid and the reproductive bodies are haploid. Polyspermy occurs in *F. vesiculosus* and the constancy of the number of chromosomes is maintained by producing multipolar spindles (Yamanouchi, 1909).

Since then mitotic and meiotic divisions have been studied in *Pelvetia wrightii* (Inoh, 1935), *Sargassum enerve* (Tahara and Shimotomai, 1926), *Coccophora langsdorfii* (Tahara, 1929b), *Cystophyllum sisymbrioides* (Shimotomai, 1928), *Sargassum* and *Cystoseira barabata* (Nienburg, 1910) and *S. horneri* (Kunieda, 1926; Okabe, 1929b).

In *Fucus evanescens* (Inoh, 1935), *Pelvetia Wrightii* (Inoh, 1935), *Hizikia fusiformis* (Inoh and Hiroe, 1954b), *Coccophora langsdorfii* (Tahara, 1929b, Tomita, 1932), *Cystophyllum crassipes*, (Inoh, 1944), *C. sisymbrioides* (Shimotomai, 1928), *S. piluliferum* (Inoh and Hiroe, 1954a), *S. confusum* (Abe, 1933), *S. enerve* (Tahara and Shimotomai, 1926), *S. horneri* (Okabe, 1929b; 1930. Hiroe and Inoh, 1954a), *S. patens*, (Hiroe and Inoh, 1954b), and *S. tortile* (Hiroe and Inoh, 1956), there are 64 diploid and 32 haploid chromosomes. In English genera of the Fucales, *Pelvetia canaliculata* (Subrahmanyan, 1956; 1957a; 1957b), *Halidrys siliquosa* (Naylor, 1958a; 1958b) and *Himanthalia elongata* (Naylor, 1957) only approximate numbers of chromosomes have been reported (Table II). Lower chromosome numbers are given for Sargassum horneri (Kunieda, 1928), and Hormosira banksii (Osborn, 1948). The presence of centrosomes has been ascertained in S. patens, S. enerve, S. horneri, Cystophyllum crassipes, C. sisymbrioides, Hizikia fusiformis, Pelvetia Wrightii, P. canaliculata and Fucus evanescens.

In Halidrys dioica (Doubt, 1928) the nuclei of the vegetative cells are smaller than those of the apical cells. The nuclei occupy a central position in the older cells but they lie near the base in the meristoderm cells of the apical region.

The fine granular cytoplasm in the oogonium of Carpophyllum flexuosum possesses a large central granular nucleus with a faintly staining nucleolus and scattered granules in the nucleoplasm. According to Dawson (1940) the meiotic phase in the oogonium of C. flexuosum is indicated by the appearance of a darkly staining spherule in connection with the nucleolus.

The large central nucleus in the oogonium of Carpophyllum divides to give an 8-nucleate stage. These nuclei lie first in the centre, then migrate to the periphery and subsequently 7 nuclei disintegrate. Occasionally two nucleoli are reported in the oogonium of Carpophyllum (Naylor, 1953c).

The nucleus in the oogonium of *Marginariella* is characterised by a large nucleolus and uniform granular structure (Naylor, 1953b). Naylor observed a 4-nucleate stage after the uninucleate stage and suggests that this involves meiotic division. These 4 nuclei migrate to the periphery, enlarge and then divide again to form 4 pairs of small nuclei. These nuclei remain scattered throughout the periphery and enlarge further. One becomes the egg nucleus and occupies a central position. The seven nuclei disintegrate before or after the liberation of the egg or during this process.

In the oogonium of *Cystoseira barbata*, at the third nuclear division 18 to 20 chromosomes were counted by Nienburg (1910) who believed this to be half the number of those in the vegetative divisions. The spindle formation is intranuclear in *C. barbata*.

In *Hesperophycus* and *Pelvetiopsis* the nucleus of the oogonium undergoes 3 divisions forming 8 nuclei. One of the nuclei enlarges to several times the size of the other seven, and lies at the centre while the seven nuclei collect at the base but do not disintegrate (Gardner, 1910). The oogonium produces 2 eggs of unequal size; the larger is the functional egg with a centrally placed nucleus, and the smaller has seven small nuclei which disintegrate after extrusion (Gardner, 1910, Walker, 1931). In *Hesperophycus* asters have been described and the centrosomes from which aster rays extend are uniformly granular, but no definite centrosomes have been observed (Walker, 1931). The spindle is intranuclear in origin in *Hesperophycus* (Walker, 1931). Walker also describes the difficulty in counting the exact number of chromosomes but gave from 14 to 18 as the diploid number.

The nuclei of *Fucus serratus*, *F. vesiculosus*, *F. spiralis* *F. ceranoides*, *Pelvetia canaliculata*, *Ascophyllum nodosum*, *Bifurcaria tuberculata*, and *Halidrys siliquosa* are uninucleolate or granular and there are no centrosomes in the resting cells (Le Touze, 1912). In *Cystoseira foeniculacea*, *C. myriophyllоides*, *C. granulata*, *C. ericoides*, *Fucus lutarius*, *F. spiralis*, *F. vesiculosus*, *F. serratus*, *Pelvetia canaliculata*, *Ascophyllum nodosum*, *Bifurcaria tuberculata* and *Halidrys siliquosa* the apical nuclei are larger than those of the other tissues and these nuclei are granular or reticulate containing one or two nucleoli and have also a finer granular structure (Roy, 1938). Spindle formation, centrosomes and asters occur in the above species and Roy suggests the granules are prochromosomes.

The nucleus of the zygote of *Bifurcaria rotunda* measures 25 u x 15 u with one or two nucleoli (Giraud, 1956). Giraud also observed spindle formation and asters but only approximate chromosome counts (100 - 130) were made. In *Fucus spiralis* aster formation was observed and in certain cases multiple asters were present between which globular chromosomes were disposed. The existence of numerous asters is a consequence of frequent polyspermy in Fucus (Giraud, 1956).

In Halidrys siliquosa densely staining particles scattered over the surface of the nucleus were observed by Moss and Elliot (1957). Counts of 8 chromosomes were made in the vegetative apices, paraphyses, antheridia and oogonia by these authors. Presence of asters and centrioles were also reported in the zygotic nucleus where reduction division occurred. These authors suggested the thallus of H. siliquosa was haploid and the zygotes were diploid. These observations of Moss and Elliot have been refuted by Naylor (1958b).

Counts of 56 - 62 chromosomes were made by Naylor (1958a; 1958 b) in H. siliquosa. The nucleus contained 2-9 granules and these were termed chromocentres (Naylor, 1958a). There were 30, 28 and 55 chromosomes in the antheridium, oogonium and vegetative apices respectively (Naylor, 1958b). Commenting on the observations of Moss and Elliot (1957), Naylor (1958b) stated that counts of 8 chromosomes by these authors were in reality the chromocentres and that the thallus ~~is~~ was diploid and reduction division occurred in the developing antheridia and oogonia.

In the vegetative parts of *Himanthalia elongata*, counts of 56 - 62 chromosomes were made by Naylor (1957).

As a rule there are no centrosomes in the cells of higher plants in contrast to animal cells. Some of the primitive forms, such as mosses, ferns, cycads, and ginkgo reveal the presence of centrosomes during the differentiation of the motile cells (Swanson, 1958). The centrosome appears to be a determining factor in the formation of the flagellar structures, where the centriole is the basal granule.

Centrosomes have also been recorded in the cells of some Chlorophyta, Phaeophyta, and Rhodophyta (Fritsch, 1945b; 1952). In algae they are distinguishable only at times of nuclear division. Centrosomes are more readily demonstrated in the Phaeophyta than any other class of algae. According to Fritsch (1945b; 1952), they are very conspicuous in the apical cells of Sphacelariales, in Dictyotales and in Fucales. Asters have been described in many Phaeophyta. Centrosomes and asters are characteristic of animal cells but also occur in most of the species of Phaeophyta studied: The order Fucales in particular show a resemblance to animal cells in this respect.

TABLE II. Chromosome Counts in the species of the Fucales.

	Antheridium	Oogonium	Thallus or embryo.	Author.
Hormosiraceae -				
Hormosira banksii	12	0	24	Osborn (1948)
Fucaceae -				
Fucus spiralis	-	30 prob.	-	Strasburger (1897)
F. vesiculosus.	32	32	64	Yamanouchi (1909)
F. evanescens	-	32	-	Inoh (1935)
Ascophyllum nodosum	-	14 - 15	26 - 30 (oogonium mother cell)	Farmer & Williams (1898)
Pelvetia Wrightii	-	32	-	Inoh (1935)
P. canaliculata	22	22	40 - 44	Subrahmanyan (1956, 1957)
Hesperophycus harveyanus		-	14 - 18	Walker (1931)
Himanthaliaceae -				
Himanthalia elongata	-	-	56 - 62	Naylor (1957)

	Antheridium.	Oogonium.	Thallus or embryo.	Author.
Sargassaceae -				
Hizikia fusiformis	32	-	-	Inoh & Hiroe (1954b)
Sargassum confusum	32	-	-	Abe (1933)
S. enerve	-	30 a pprox	-	Tahara & Shimotomai (1926).
S. horneri	16	16	32	Kunieda (1928)
S. horneri	-	32	-	Okabe, (1929b)
S. horneri	-	-	64	Okabe (1930)
S. horneri	32	-	-	Hiroe & Inoh (1954a)
S. patens	-	-	64	Hiroe & Inoh (1954b)
S. piluliferum	32	-	-	Hiroe & Inoh (1954c)
S. piluliferum	-	-	64	Hiroe & Inoh (1954a)
S. tortile	32	-	-	Hiroe & Inoh (1956)
S. tortile	-	16 or 32	-	Abe (1938)
Cystoseiraceae -				
Cystophyllum crassipes		-	64	Inoh (1944)
C. sisymbrioides	-	32	-	Shimotomai (1928)
Halidrys siliquosa	30	28	55	Naylor (1958b)
Bifurcaria rotunda	-	-	64	Magne in Giraud (1956)
Bifurcaria rotunda	-	-	100-130	Giraud (1956)
Cystoseira barbata	-	18 - 20	-	Nienburg (1910)
Coccophora langsdorfii		-	64	Tomita (1932)
Coccophora langsdorfii		32	-	Tahara (1929b)

III. ANATOMICAL STUDIES

1. MATERIALS AND METHODS.

Material was fixed either in Karpechenko solution (Papenfuss modification) or in equal parts of 10% commercial formalin and 1% chromic acid. After 24 hours in fixative it was then washed in five or more changes of seawater to eliminate chromic acid. After gradual dehydration in sea water - distilled water - alcohol mixtures, the material was stored in 60% or 70% alcohol. Dehydration of material for embedding was carried out as recommended by Johansen (1951). Microtome sections were cut at various thickness between 4 and 12 µ and stained in 0.5% iron alum haematoxylin and 0.5% orange G, or 1% acid fuchsin and 0.5% Fast green, or Bismark brown and 0.5% Fast green. Haematoxylin gave better results as a nuclear stain than 2% orcein in 60% acetic acid. Acid fuchsin and fast green proved best for conceptacles and reproductive structures while the axis and other vegetative parts were usually stained in Bismark brown and Fast Green.

2. PHYLLOSPORA COMOSA C. Agardh 1839.

(Plates I - III)

Structure of the apical and subapical regions.

Phyllospora comosa C. Ag. is characterised by apical growth. In longitudinal sections, at right angles to the flat surface (Plate I, fig. B), and parallel to the flat surface (Plate II, fig. B) the apical cells are situated at the base of the apical depression which is filled with mucilage protecting the apical cells. In other members of the Fucales except Hormosira where a group of 4 apical cells occurs, a single apical cell is placed at the base of the apical depression; in Phyllospora several apical cells occur (Plate II, figs. A and B). In transverse section the apical cells are rectangular with more or less rounded corners and undulating sides (Plate II, fig. A). The apical cells occur in a row, separated from each other by a very few of their derivatives.

In median longitudinal sections parallel to the flat surface of the axis, the bases of the apical cells are broader than the apices. Apical cell measures 80 - 100 µ x 25 - 30 µ at its longest and broadest parts respectively and the nucleus 6 - 8µ. They segment longitudinally on the longer sides and transversely at the base.

Median longitudinal sections, at right angles to the flat surface of the axis, show one apical cell only, which is more or less biconvex (Plate I, fig. B). In this case the apex of the apical cell is broader or in some cases rounded and its psterior end is more or less narrow.

The basal segments divide anticlinally and then periclinally to form a small group of cells immediately below the apical cell (Plate II, fig. B). These cells gradually enlarge and contribute to the medulla. The segments of the apical cell divide transversely to form a curved row of 3 or 4 cells (Plate I, fig. B); the uppermost cell of which always remains elongate. It divides transversely near its base forming a basal cell which contributes to the cortex. The upper meristoderm cell divides longitudinally, increasing the surface of the thallus. The meristoderm cells contain dense chromatophores and cytoplasmic contents with a basally or centrally located granular nucleus. The meristematic activity of the meristoderm cells extend to a great distance from the apex of the axis and branches. The meristoderm, which is a single layer, has a fairly thick mucilaginous covering known as the cuticle.

The cells, which are cut off towards the base of the meristoderm cell and the innermost derivatives of the basal segments of the apical cells, broaden and then divide transversely and their lowermost derivatives lengthen to form medullary cells while the upper derivatives divide transversely and longitudinally to form the cortex. Near the apex the cortical cells function as assimilatory cells as they possess a considerable number of chromatophores. The walls of the cortical cells become thickened very early but divisions still continue. The cells of the medulla show progressive elongation from the apex downwards and occur in longitudinal files as a result of early thickening of their lateral walls and continued transverse divisions. The cross-walls always remain thin. Fucosan vesicles have been observed aggregated round the nucleus of the apical cell (Plate I, fig. A. and B).

Thus there is early differentiation of meristoderm, cortex and medulla near the apex. Mucilage formation occurs very early near the apex (Plate I, fig. B, Plate II, Fig. B), at the corners of the cell walls. Hyphal development was not observed near the apex.

Structure of the leafy laterals.

Minute ciliary processes occur along the margin of the branches and the axis. These are initiated by a single four sided apical cell (Plate I, figs. A, D and E), and they develop into the lateral blades which characteristically fringe the branches and the axis. The segmentation of the apical cell and the development of tissues in the leafy laterals are similar to that in the vegetative apices. Mature laterals, however, do not show apical cells and have ceased apical growth. Internal structures in the mature leafy laterals are similar to the structures of the axis (Plate I, fig. F. and Plate III, figs. A and B). Hyphae do not occur in the leafy laterals but the mucilage accumulation is more abundant in the medulla than in any other parts. Scalariform thickening of the cell walls has been observed only in the medulla of fertile leafy laterals possessing female conceptacles (Plate III, figs. B and C).

Structure of the vesicle.

The vesicles develop close to the apex of the branches and the axis. The minute ciliary processes which fringe the axis and the branches develop into the vesicles. Development of the tissues is similar to that in the axis and the branches. Surface growth and the increase in thickness of the cortex lead to rupture of the medulla, remnants of which are commonly found around the edge of the cavity. Internal structure of the stalk of the vesicles also shows similarity to that of the axis and branches. Hyphae develop in the medullary region of the vesicle stalk.

Protoplasm aggregates in the form of yellow-brown round masses between the cell-walls of adjacent cells and from these masses hyphae develop (Plate I, figs. K to N). Sooner or later these hyphae become septate but do not branch. In the vesicle stalk hyphae are always small in size.

Structure of the mature thallus.

Mature parts of the axis and the branches show that several changes take place in the tissues. The meristoderm in the mature thallus always remains a single layer of radially elongate cells containing dense chromatophores and cytoplasmic contents with centrally located granular nuclei. They divide more often anticlinally than periclinally (Plate I, fig. G). The former divisions increase the surface of the thallus while the latter divisions add to the cortex. Soon the lateral walls of the meristoderm cells become thick and lamellate and pit connections occur on the inner cross-walls. Hyphae do not occur in the meristoderm. The meristoderm is covered by a mucilaginous layer which is very thick and lamellate. The number of layers of meristoderm cells increases in the region of stipe and these cells also contain dense chromatophores.

The cortex comprises about six layers of isodiametric cells and is differentiated into inner cortex and outer cortex (Plate I, fig. C). The outer cortex is generally composed of 3 or 4 layers of small cells which contain dense chromatophores. No hyphae develop from the outer cortex but pit connections and mucilage formation occur. The cell walls are thick and lamellate. The inner cortex comprises 2-3 layers of large and elongate cells and these cells contain dense granular cytoplasm and chromatophores. Some inner cortical cells contain dense, compact, light brown contents (storage material) in rounded or elongate masses with extensions towards the pits (Plate I, fig H). These cells give rise to hyphae. The cell walls are strongly thickened and lamellate and pit-formation is very common. Mucilage occurs at the corners of the inner cortical cells. Divisions of the cortical cells have been observed in a few cases only.

The medulla is composed of many layers of elongate cells tapering at both ends (Plate I, fig. C). Medullary cells contain granular cytoplasmic contents and a few cells contain very sparse chromatophores. The lateral walls are thick, pitted and strongly lamellate. Mucilage is formed at the corners of the cells, possibly due to the separation of the corners of the cells. The cross walls always remain thin.

Hyphae develop between the walls of the medullary cells and they contain chromatophores and storage materials. The hyphae are septate and unbranched, descending longitudinally

(Plate I, figs. K to N). In the region of the stipe the inner cortex is mostly traversed by hyphae and the cell walls of hyphae are very much thickened and lamellate. The medulla occupies the largest area of the stipe and it is difficult to locate the original medullary cells because of the tortuous development of hyphae which resemble the parent cells. The lateral walls of the medullary cells are strongly thickened and pitted, but the cross walls remain thin.

Reproductive organs.

Phyllospora is dioecious. Fertile leafy laterals are smaller than the vegetative ones. The internal structure of the fertile laterals is similar to that of the vegetative branches except in the scalariform thickening of the cell walls in the medulla of the female fertile leafy laterals (Plate III, figs. B and C). The conceptacles are scattered over the fertile leafy laterals. The female conceptacles are larger and darker in colour than the male ones. Mucilage occurs in abundance in the female leafy laterals.

Development of antheridia.

The antheridium arises as a small papilla (Plate III, fig. Da) from a wall-cell of the conceptacle. The papilla divides transversely forming the antheridium proper and a stalk cell (Plate III, fig. Db). The latter divides further and may produce an antheridium directly (Plate III, fig. Dc) or a papilla which in turn produces an antheridium and its stalk. A complex branching system results bearing antheridia which are either lateral or terminal in position (Plate III, fig. E). The nucleus of the young antheridium undergoes six nuclear divisions (Plate III, figs. Dd to Dh) so that 64 nuclei are formed within it. The antheridium is stalked and mature one measures 26 - 47 µ x 8 - 13 µ. Antheridia mature successively.

Development of oogonia.

The conceptacles bearing oogonia possess unbranched paraphyses and only one egg is produced in each oogonium.

An oogonium develops directly from the wall-cells of the conceptacle (Plate III, figs. F and G). The oogonial initial divides transversely into two cells, the oogonium and its stalk cell. The stalk cell does not divide further. The young oogonium possesses one large granular nucleus and an extremely large nucleolus (occasionally 2 nucleoli). The nucleus undergoes three divisions (Plate III, figs. H to K). At 2 and 4-nucleate stages the oogonium increases in size very rapidly with differentiation of three oogonial walls — exochite, mesochite and endochite (Plate III, figs. H and J). Degeneration of seven nuclei occurs in situ and only one nucleus becomes functional.

The mature egg contains a large nucleus about 10 u across with a large nucleolus. The mature oogonium is ovoid and measures 132 - 275 μ x 78 -180 μ. Maturation of oogonia occurs successively.

In the apical region of the oogonium there occur thickened rings of mucilage laterally near the apex. These rings further increase in size and cause the constriction of the cytoplasmic contents in this region (Plate III, figs. J to L). As the ring becomes more and more differentiated the wall increases in thickness due to the development of a mucilaginous region which invests the cytoplasmic contents. At first this is a thin layer but increases progressively in thickness. The swelling of the mucilage forces the thickened apical collar away from the cytoplasmic contents. The swelling also causes the separation of cytoplasmic contents from the basal region of the oogonial wall, causing it to become drawn out into several projections (Plate III, fig. K). This thickening and swelling occur in the mesochite and is referred to as a "mesochiton collar" by Naylor (1949a) in her description and discussion of the oogonium of <u>Scytothalia dorycarpa</u>.

3. SEIROCOCCUS AXILLARIS Greville 1830

(Plate IV)

Structure of the apical and subapical regions.

Growth in Seirococcus axillaris occurs by means of two apical cells which are four-sided in transverse section (Plate IV, fig. D). These cells lie at the base of the two apical depressions one on either side of the apical round disc (Plate IV, fig. B). The apical round disc is a persistent prolongation of the main axis which separates the two apical cells. Gruber (1896) described a round apex and a single 4-sided apical cell in the axil of the curved leafy laterals near the apex. Gruber in his diagrammatic figure describes the other apical cell as the lateral initial. Each apical depression is filled with mucilage which protects the apical cells (Plate IV, fig. A). The apical cells occur at different levels so it is only possible to observe both apical cells together in a longitudinal section parallel to the flat surface of the thallus (Plate IV, fig. B). The apical cell possesses a conspicuous granular nucleus and less dense cytoplasmic contents than the adjacent cells. These apical cells are rectangular with rounded ends, in transverse sections (Plate IV, fig. D).

The apical cells segment longitudinally on the longer sides and transversely near the base. The basal segment divides anticlinally and then periclinally to form a group of cells which enlarge gradually to form the medulla (Plate IV, figs. A and B). The longer segments divide periclinally to form curved rows of 2 or more cells (Plate IV, fig. C). The uppermost cell on either side of the apical cell elongates. It divides periclinally near the base forming a basal cell and an upper meristoderm cell. The basal cell contributes to the cortex, and the cells formed by the longitudinal division of the meristoderm cells increase the surface of the thallus. The meristematic activity of the meristoderm extends well down from the apex of the axis. The lowermost derivatives of the longer segments divide and redivide to contribute to the medulla. The middle derivatives of the longer segments divide periclinally and anticlinally to form the cortex. Fucosan vesicles occur aggregated round the nucleus of the apical cell (Plate IV, fig. C).

In the apical and subapical region the meristoderm is a single layer of elongate cells containing dense chromatophores and a conspicuous granular nucleus. This layer is covered by a thick mucilaginous " cuticle". The cortex is composed of small isodiametric cells containing chromatophores, and thus it functions as assimilatory tissue. Cells of the medulla show gradual elongation from the apex downwards and because of the early thickening of their lateral walls and subsequent transverse divisions, they form longitudinal files (Plate IV, fig. B). The crosswalls remain thin. Mucilage formation occurs near the apical cells as well as in the subapical regions (Plate IV, figs. A to D). Hyphae do not occur in this region. Pit connections occur in the cortical and medullary cells.

Development of the leafy laterals.

Mature laterals do not show any apical cell. The growth of the laterals is initiated by the development of lateral initials from one of the segments cut off from the vegetative apical cells (Plate IV, figs. A and B). These initials are four-sided and are lighter in colour than the adjacent cells. Divisions of these initials are similar to those in the apical cells of the axis. These initials become inactive at an early stage, after which the lateral branch enlarges only by means of cell division within the tissues and by cell expansion. Lateral initials have also been reported by Gruber (1896). Fritsch (1945b, 1952) states that the leafy laterals do not grow by means of an apical cell but by the division of groups of surface cells. In laterals the cortex consists of up to four layers of elongate cells, loosely arranged and with more mucilage than in the axis, (Plate IV, figs. I and J). They also contain large and dense chromatophores than in the cortical cells of the axis. In leafy laterals, the medulla is composed of about 4 layers of cells in depth and these are narrowly elongate. The walls of the cortical cells and medullary cells are more strongly thickened than those of the axis. Other characters of the tissues of the leafy laterals are similar to those of the axis and the branches.

Structure of the mature thallus.

In the mature thallus particularly in the stipe the meristoderm becomes 2-4 layered. The cells are radially elongate with dense chromatophores and these cells function as assimilatory tissue. The lateral walls are thick and the inner cross walls are pitted. The meristoderm is covered by a thick mucilaginous cuticle. In the mature thallus meristematic activity of the meristoderm cells does not occur. No hyphae occur in the meristoderm.

The cortex is composed of 5 or more layers of cells which are isodiametric (Plate IV figs. E and F). The cortical cells ame densely cytoplasmic with few chromatophores. The cells also contain masses of light brown coloured material (storage material). This storage material increases in the cells at the base of the axis and in the stipe. These cortical cells may also function as assimilatory tissue. The cortical cells containing storage material develop hyphae (Plate IV, fig G). Hyphal development increases in the region of the stipe, where the hyphae are septate and unbranched, running transversely towards the medulla. The walls of the cortical cells are thick, lamellate and pitted. Mucilage accumulation is in abundance.

The medulla is made up of many layers of elongate cells in longitudinal section (Plate IV, fig. E) and these cells are so similar to the cortical cells in transverse section that it is difficult to distinguish between the two tissues in the upper part of the axis. They contain sparse cytoplasmic contents and occasionally a few chromatophores. The lateral walls are thick, lamellate and pitted and the crosswalls are thin. Mucilage occurs abundantly in this region. Hyphae develop profusely near the base of the axis and the stipe, originating from the lateral walls and the end walls. These hyphae are septate and unbranched, running longitudinally downwards (Plate IV, fig. G), following a tortuous course so that they appear as small cells in transverse section (Plate IV, fig. H). In the basal part of the axis and the stipe, few large medullary cells were observed as most of the medullary region is full of hyphae. Smith (1893) described briefly the occurrence of a central portion, the cortex, and an epidermis in *Seirococcus axillaris*.

Structure of the receptacles.

Receptacles are either bisexual or unisexual but generally they are bisexual. Smith (1893) and Gruber (1896) described the receptacles as bisexual with the male conceptacles at the base of the receptacle and the female ones near its top. In bisexual conceptacles the oogonia and antheridia are borne on opposite sides.

Internal structure of the receptacles is similar to the vegetative parts of the thallus but with greater mucilage formation and looser cell arrangement. The cortex and medulla are interrupted due to the development of the conceptacles. The walls of the cortical cells and medullary cells are considerably thicker than those of the vegetative parts (Plate IV, fig. R). Hyphae do not occur in any part of the receptacle.

Development of antheridia.

Antheridia develop from an outgrowth which arises directly from the wall-cells of the conceptacle (Plate IV, fig. Ka). The outgrowth contains dense cytoplasmic contents and a large nucleus. This papilla divides transversely to form the antheridium proper and the stalk cell (Plate IV, fig. Kb). The latter also produces papillae which form antheridia, thus developing a branched antheridial cluster (Plate IV, fig. Kg). Antheridia are also borne singly on the wall of the conceptacle. In some cases the stalk of the antheridium is poorly developed. Young antheridia have been observed developing from the base of an empty antheridium (Plate IV, fig. Kc). Antheridia are club-shaped and the antheridial wall is composed of exochite and endochite. Sperms are liberated through an apical pore (Plate IV, figs. Kc and Kg). Nuclear divisions have not been observed but it is certain that six nuclear divisions occur in an antheridium of Seirococcus as in the other members of the Fucales since 2 to 64 division stages have been observed (Plate IV, figs. Kc to Kg). Successive maturation of antheridia occurs. There is gradual development of antheridia up to the 2-nucleate stage but after this there is appreciable increase in size of antheridia. A mature antheridium measures 24 - 40 µ x 8 - 14µ.

Development of oogonia.

Conceptacles, bearing oogonia, generally possess unbranched paraphyses made up of irregular cells and containing dense cytoplasm. Smith (1893) reported the branching tendency of the paraphyses. The lower cells of paraphyses are oblong and the upper ones are more or less round. Bisexual conceptacles bear both branched and unbranched paraphyses.

An oogonium develops directly from the wall-cell of the conceptacle as an outgrowth (Plate IV, fig. L). The oogonial initial contains dense contents and a large granular nucleus and the initial divides transversely to form the oogonium proper and a stalk cell (Plate IV, fig. M). The latter never elongates. There is gradual increase in the size of the oogonium up to the 4-nucleate stage, and it becomes much larger by the 8-nucleate stage (Plate IV, fig. P). Three nuclear divisions occur in an oogonium (Plate IV, figs. N, R and P). Degeneration of 7 nuclei has not been observed, but one nucleus remains functional in the single egg. Oogonia are ovoid and measure 90-275 μ x 6--150 μ. The maturation of oogonia is successive. The nucleus of the oogonium is surrounded by Fucosan vesicles (Plate IV, fig. ~~S~~ a). The egg nucleus is large and measures up to 10 μ across with a large nucleolus up to 8 u across. The oogonial walls are composed of exochite, mesochite and endochite (Plate IV, fig. Q). The mesochite is strongly thickened to form a ring or mesochiton collar as in Scytothalia dorycarpa.

4. SCYTOTHALIA DORYCARPA Greville 1830

(Plate V)

Structure of the apical and subapical regions.

In Scytothalia dorycarpa growth is initiated by two apical cells. Two apical depressions occur one on either side of the round apical disc and one apical cell lies at the base of each depression (Plate V, fig. A). Apical cells are ~~leafy laterals,~~ four sided and occur in an elongated groove overgrown by leafy laterals. at the apex of the thallus (Plate V, fig. A).

The apical depressions are filled with mucilage which protects the apical cells. The two apical cells occur at slightly different levels so that both can be observed only in the longitudinal sections parallel to the flat surface of the axis (Plate V, fig. A). In transverse sections, these apical cells are more or less rectangular with rounded ends (Plate V, fig. D).

Longitudinal sections parallel to the flat surface exhibit 4-sided apical cells (Plate V, fig. B). In longitudinal sections perpendicular to the flat surface, the apical cell is biconvex with rounded ends (Plate V, fig. C). The apical cells segment longitudinally on the longer sides and transversely near the base (Plate V, figs. B and C). The basal segment divides anticlinally to form a group of cells which contribute to the medulla. The longer segments divide periclinally to form curved rows of cells, the uppermost derivatives of which always remain longer than broad and in turn divide periclinally forming basal cells and upper cells. The upper cells divide anticlinally to form radially elongate meristoderm cells with dense chromatophores and cytoplasmic contents. The meristoderm cells remain meristematic. The lowermost cells, cut off from the longer segments, divide periclinally and anticlinally to form the medulla, while the middle cells, cut off from the longer segments, divide irregularly to contribute to the cortex. These cells contain chromatophores and function as assimilatory tissue. Mucilage formation occurs near the apical cells. The basal cells cut off from the meristoderm cells also contribute to the formation of the cortex. The thickening of cell walls in the cortex occurs very early but divisions still continue. The medullary cells gradually elongate to form longitudinal files of cells. Hyphae do not occur in the apical and subapical regions. In the subapical region the cell walls of the cortex and the medulla are strongly thickened, lamellate and pitted. Mucilage formation increases in the subapical region. Fucosan vesicles occur round the nucleus of the apical cell and its segments (Plate V, figs. B and C).

Development of the leafy laterals.

Sections through the apices of the mature leafy laterals do not show the presence of apical cell but the longitudinal sections cut parallel to the flat surface of the axis and passing through the apex show large and radially elongate cells, differing from the meristoderm cells, on the side of the apical depression (Plate V, figs. A and E). These are lateral initials, which are longer than the meristoderm cells. The initial is formed from a meristoderm cell which does not divide transversely. The initial cell (Plate V, fig. E) is broad anteriorly and narrow posteriorly and it contains a large granular nucleus with light cytoplasmic contents. In transverse section the lateral initial cell is rectangular (Plate V, fig. F). The growth and division of the initial cell are similar to those of the vegetative apical cell.

Gruber (1896), Naylor, (1949a) and Fritsch (1945b; 1952) stated that the initial cell did not exist in the laterals.

Structure of the mature thallus.

Internally the axis, branches and the leafy laterals are composed of the meristoderm, the cortex and the medulla. Meristoderm in the upper part of the axis is a single layer of radially elongate cells containing dense chromatophores and cytoplasmic contents (Plate V, fig. G). In the basal part of the axis and the stipe, the meristoderm becomes about 4 layers of cells. The lateral walls are thick and lamellate and the inner crosswalls are pitted. Meristematic activity of the meristoderm cells extends some distance down the axis and the branches. Mucilage occurs at the inner corners of cell walls, and the meristoderm is covered by a thick mucilaginous "cuticle".

The cortex is composed of 4-10 layers of isodiametric large cells which are loosely arranged in old parts due to the abundance of mucilage. These cells contain dense chromatophores and storage material occupying the entire cell.

In the laterals and in the branches the contents of the cortical cells are lighter than those of the axis. The cell walls are strongly thickened, lamellate and pitted. In the stipe and the basal parts of the axis, the contents of the cortical cells are very dark brown and these cortical cells produce hyphae.

The medulla comprises 4-6 layers of cells in the leafy laterals and in the upper parts of the axis, but it becomes many layers thick of elongate cells near the base of the axis and the stipe. The cross walls of the medullary cells are thin and the cells contain sparse contents. The cell walls are strongly thickened, lamellate and pitted, sometimes with scalariform thickenings. The medullary cells are separated by the abundant mucilage accumulation.

Very few hyphae develop in the upper part of the axis but they increase greatly in the basal part of the axis and in the stipe. They develop from the ends and sides of the medullary cells and run longitudinally downwards following a tortuous course (Plate V, fig. G). In transverse section the hyphae are made up of small cells which contain chromatophores, and they are septate and branched. Naylor (1949) also described the increase of hyphal production in the basal part of the axis and the stipe. In the stipe and in the extreme basal part of the axis, the medullary cells and the hyphae may function as mechanical tissue due to strongly thickened walls and frequent transverse division of the cells.

Development of the receptacles.

The receptacles develop in the marginal groove of the axis. The receptacle protrudes beyond the groove and possesses a deeply indented apex covered by a large and a small incurved lobe. This assymetry is lost as the receptacle develops but the indented apex remains until the conceptacles are developed. The sterile tip develops after the disappearance of the indented apex as described by Naylor (1949a). The marginal groove is confined to one margin of the axis which is slightly more flattened than the sterile one. The marginal groove is filled with mucilage (Plate V, figs. J and K).

Longitudinal sections cut parallel to the flat surface of the thallus through the marginal grooves show flask shaped cells along the base of the groove (Plate V, fig. K). These are initial cells of the future receptacles. Sections cut through the apex of the young developing receptacles also show similar cells at the base of the apical depressions (Plate V, fig. J). Apical cells are always present in the receptacles as long as their apices are indented. No apical cell was observed in a mature receptacle.

The apex of the developing receptacle is extraordinary because it shows in transverse section, a regular 3-sided apical cell (Plate V, fig. L). Longitudinal segmentation of the apical cell occurs near the base. The basal segment divides periclinally to contribute to the medulla. The lateral segments also divide periclinally to form curved rows of cells. The lowermost cells cut off from the lateral segments continue periclinal divisions and add to the medulla. The middle cells of the lateral segments divide longitudinally and transversely to build up the cortex. The uppermost cell of the curved rows always remains longer than broad and forms the meristoderm where the cells are radially elongate with dense chromatophores and cytoplasmic contents. The basal cells, cut off from the meristoderm cells, also add to the cortex. The meristoderm remains meristematic for some time.

Early thickening of cell walls and mucilage formation occur in the cortex and the medulla (Plate V, fig. J). The cortical cells remain isodiametric and the medullary cells gradually elongate to form longitudinal files of oblong cells (Plate V, fig. J). Pit-connections occur near the apex of the receptacle but no hyphae occur near the apex.

Structure of the mature receptacles.

Receptacles may be either bisexual or unisexual. Internally the receptacle is composed of meristoderm, cortex and medulla; the meristoderm in the receptacle always remains as a sihgle layer of cells extending from the tip to the stalk (Blate V, figs. M to P). Meristematic activity of the meristoderm cells does not occur in the mature receptacles. The cortical cells in the receptacle become larger and more loosely arranged, with dense mucilage accumulation (Plate V, fig. Q). In the cortical region of the female receptacles the cells contain dense light brown contents (storage material). In receptacles the medulla is only a few layers of cells deep and the cells are very long so that ih transverse section (Plate V, fig. P) they are smaller than the cortical cells. In fertile parts of the receptacle the cortex and the medulla are frequently interrupted by the formation of conceptacles and the cells are very much stretched. The structure of the sterile tip and stalk of the receptacle are similar to that of the main axis. According to Naylor (1949a) hyphae occur in great numbers in the basal part of the receptacle but these were not observed.

The conceptacles.

The conceptacles are borne on both surfaces of the receptacles. They occur as light circular patches but sometimes they are elongated in the direction of the longitudinal axis. The ostiole is either circular or elongated as also described by Naylor (1949a). Male and female conceptacles occur on the same receptacle. Bisexual conceptacles also occur. In some conceptacles the oogonia are separated by tufts of antheridial hairs and in others one side of the conceptacle is entirely male and the other entirely female.

The conceptacles are lined with a layer of cells. Paraphyses do not occur near the ostiole either in male or female conceptacles, but in both cases the ostiole is lined with meristoderm cells.

The male conceptacle.

The male conceptacles bear antheridial hairs which are borne in tufts on the wall of the conceptacles. The hairs are many-celled and branched and bear numerous antheridia. There are no sterile hairs in the male conceptacles.

Antheridia develop as outgrowths from the wall-cells of the conceptacle. The papilla divides transversely to form the antheridium proper and a stalk cell (Plate,V fig. Ra). The stalk cell increases in size and develops more papillae which further form antheridia. So there is complex branching system bearing clusters of antheridia, which may be terminal or lateral in position. The antheridium initial differs from paraphyses in young stages by possessing dense cytoplasmic contents and a large nucleus. The antheridium develops gradually and six nuclear divisions occur thus forming 64 sperms. Two to sixty four division stages have been observed (Plate V, figs. Rb - Rg). Sperms are extruded through the apical pore (Plate V, fig. Rd) and they measure about 3 µ x 0.6 µ. The antheridial wall is composed of exochite and endochite. The antheridial maturation is successive. A mature antheridium measures 24 - 42 µ x 6 - 14 µ.

The female conceptacle.

The female conceptacles bear oogonia at all stages of development indicating the successive development of oogonia as described by Naylor (1949a); the oogonia arise from the wall cell of the conceptacle. The paraphyses are unbranched and composed of barrel shaped cells with dense contents (Plate V, fig. Sa); in rare cases only has branching been observed (Plate V, fig. Sb).

Development of oogonia.

An oogonium develops directly from the lining cells of the conceptacles. Some of the wall-cells enlarge containing dense cytoplasmic contents and a large granular nucleus (Plate V, fig. T). These cells function as oogonium initials (Plate V, fig. T). The oogonium divides transversely near the base forming the oogonium proper and the stalk cell (Plate V, figs. U and V). The latter never develops into a stalk but remains embedded in the tissue. The oogonium increases gradually in size (Plate V, Figs. V to Z). The oogonial wall thickens early and forms exochite, mesochite and endochite.

Three nuclear divisions occur and the oogonium is appreciably elongate at the 2-nucleate stage (Plate V, figs. W and X). The oogonium increases in diameter at the 4-nucleate stage (plate V, fig. Y) and the wall develops a ring-like thickening near the apex. The oogonium increases in diameter and size along with the development of the mesochite at the 8-nucleate stage (Plate V, fig. Z). At this stage the thickened mesochiton collar is prominent and increases greatly causing contraction of the oogonial contents near the apex.

Degeneration of seven nuclei has not been observed but only one nucleus remains functional in the single egg. A mature oogonium measures 162 - 276 µ x 60 - 150 µ.

5. XIPHOPHORA Montagne 1842.

(Plates VI and VII)

Structure of the apical and subapical regions.

The apices of X. chondrophylla and X. gladiata are blunt and the apical groove is a narrow slit in the plane perpendicular to the flat surface (Plate VI, fig. B and Plate VII, fig. B). The apical groove widens basally to form a flat-bottom flask-like structure with a narrow neck, filled with mucilage. At the base of the apical depression lies the apical cell/which initiates the growth of the plant in both species. The apical cell is four-sided in longitudinal sections cut parallel to the flat surface in both species as described by Gruber (1896), and Heine (1932) and is slightl broader at the base than at the apex (Plate VI, fig. A and Plate VII, fig. A). In longitudinal section perpendicular to the flat surface, the apical cell of X. chondrophylla is more or less triangular in form with a broad base at the anterior end (Plate VI, fig. B), but is more or less circular in X. gladiata (Plate VII, fig. B). Mitchell (1941) and Naylor (1954a) describe a triangular form of apical cell in X. chondrophylla in both longitudinal planes. In transverse section the apical cell in both species is rectangular (Plate VI, fig. C and Plate VII, fig C) , similar to that of X. chondrophylla described by Heine (1932), Mitchell (1941) and Naylor (1954a). The apical cell of *X. chondrophylla* figured by Heine is the basal dilation of the apical groove and does not show its segmentation. Mitchell (1941) and Naylor (1954a) described and figured the correct form of apical cell in the longitudinal section perpendicular to the flat surface only. M

Segmentation of the apical cell occurs first transversely towards the base and then longitudinally on each of the four sides. The basal segment, cut off from the apical cell, divides first parallel to the original division in *X. gladiata* and perpendicularly to the first division in *X. chondrophylla*. This division in *X. gladiata* is followed by a perpendicular division whereas in *X. chondrophylla* the second division is parallel to the first one (Plate VI, fig. A. and Plate VII, fig. A). Later these cells undergo anticlinal and periclinal divisions to form a small group of cells. The lowermost cells gradually broaden and lengthen to form medullary cells. The outermost cells of this group of cells add to the cortex.

The lateral segments of the apical cell divide transversely near the base. The uppermost cells are radially elongate and divide longitudinally, and always remain longer than broad. These cells form the meristoderm which lines the sides of the apical furrow and extends further outwards.

The surface layer is covered by a thick mucilaginous "cuticle". Each cell of the meristoderm possesses a granular nucleus at its base or centre and dense chromatophores. Meristoderm cells undergo longitudinal divisions increasing the surface of the thallus and also cut off basal cells which add to the cortex. The activity of the meristoderm cells continues indefinitely.

The cells, cut off towards the base of the lateral segments of the apical cell, undergo periclinal divisions and the lowermost cells gradually lengthen to form medullary cells. The middle cells of the lateral segments contribute to the cortex. Fucosan vesicles occur round the nucleus of the apical cells.

Early thickening of lateral walls and mucilage accumulation occur in the cortical as well as in the medullary cells (Plate VI, figs. A and B. and Plate VII, figs. A and B). Dense chromatophores occur in the cells of the three tissues.

One of the lateral segments cut off from the apical cell is more or less equal to the apical cell (Plate VI, fig. A, Plate VII, fig. A), and this segment may function as an apical cell. These 2 apical cells give rise to the more or less dichotomous branching, as occurs in *Fucus vesiculosus*

(Oltmanns, 1889, Fritsch, 1945b; 1952), Pelvetia canaliculata (Oltmanns, 1889, Fritsch, 1945b; 1952, Subrahmanyan, 1956), and in Ascophyllum nodosum (Fritsch, 1945b; 1952).

Structure of the mature thallus.

Mature thalli of X. chondrophylla and X. gladiata also possess the usual three tissues — the meristoderm, the cortex and the medulla (Plate VI, figs. D to G and Plate VII, figs. D to G).

The meristoderm is composed of a single layer of radially elongate cells containing dense chromatophores. In the stipe the meristoderm becomes many layered. The meristoderm cells divide more anticlinally than periclinally. The cells formed by the former divisions increase the surface of the thallus considerably while the latter add to the cortex. The meristoderm continues its activity indefinitely. The lateral walls become thickened as do also the outer transverse walls. Pit connections occur in the inner transverse walls.

The cortex is composed of many layers of oblong - polygonal cells in both species. The cortical cells are small towards the meristoderm but gradually broaden and enlarge towards the medulla. They are compact and contain dense chromatophores. The cell walls are thickened, lamellate and pitted. Compact dichotomous branching of cortical cells also occur (Plate VII, fig. H). Mucilage accumulation occurs. Few hyphae develop in the cortical region. In the basal parts of the plant the cortical cells increase in depth and also in the number of chromatophores. Hyphae develop in the cortical region especially in the basal parts of the thallus and in the fertile branches.

The medulla is also composed of many layers of elongate cells containing dense chromatophores. The cell walls are thickened, lamellate and pitted. In both species cytoplasmic connections occur through the pores (Plate VI, figs. I - L, Plate VII, figs. I and J). Lateral connections also occur in the medullary cells of X. chondrophylla and X. gladiata. (Plate VI, figs. H, M. Plate VII, fig. J). Medullary cells are more eaily distinguished in longitudinal sections than in transverse sections. Hyphae are very well developed in the medullary region of the basal part of the thallus in both species. Medullary cells are distinguished from hyphal cells in the basal part of the thallus, due to their large size. In transverse section, the medullary cells are surrounded by a number of small hyphal cells containing dense chromatophores.

Hyphae develop laterally or from the lower end of the medullary cells as protuberances. These septate hyphae are branched and abundant in the lower thallus, ramifying amongst

(p.t.o.)

the medullary cells, and grow longitudinally downwards. They contain dense chromatophores. Cytoplasmic and lateral connections are common in the hyphae (Plate VI, figs. I and J. and Plate VII, fig. I).

Reproductive organs.

Antheridial development in both species is successive and antheridia are borne on branched septate hairs. Antheridia are club-shaped and pedicellate (Plate VI, fig N. and Plate, VII fig. K). The wall is composed of exochite and endochite.

X. chondrophylla and *X. gladiata* are monoecious and produce 4 eggs in each oogonium. The development of oogonia is successive in both species. Paraphyses and reproductive organs develop in that order from the wall-cells of the conceptacle~~s~~. The paraphyses are slender and simple (rarely branched) in the female conceptacles. In male conceptacles paraphyses are simple and slender and branched hairs bearing antheridia also occur. Unisexual conceptacles occur in both species. In *X. gladiata* male conceptacles are near the edge of the segment, whereas male and female conceptacles are scattered in *X. chondrophylla*. Oogonial stalks occur in both species (Plate VI, fig. P, Plate VII, fig. Ld), as reported by Heine (1932). The contents of the oogonia divide tetrahedrally (Plate VI, fig. Pc Pd and Plate VII, figs. Lc to Lf), producing 4 eggs in each case. The oogonial wall is composed of exochite, mesochite and endochite.

The oogonia of *X. chondrophylla* and *X. gladiata* measure 228 - 270 µ x 108 - 228 µ and 200 - 276 µ x 108 - 162 µ respectively. The antheridia measure 26 - 34 µ x 13 - 16 µ and 20 - 31 µ x 10 - 14 µ respectively in each species.

6. CYSTOPHORA J. Agardh 1841

(Plates VIII - XVIII)

Structure of the apical and subapical regions.

Sections through the apices of *Cystophora uvifera*, *C. cephalornithos*, *C. paniculata*, *C. intermedia*, *C. platylobium* *C. moniliformis*, *C. xiphocarpa*, *C. racemosa*, *C. cuspidata*, *C. siliquosa*, *C. retorta*, *C. botryocystis*, *C. subfarcinata*, *C. polycystidea*, reveal the presence of a funnel-shaped apical depression filled with mucilage similar to the apical depression in other Cystoseiraceae and Sargassaceae (Fritsch, 1945a). The apical cell is lenticular in longitudinal section (Plate VIII, figs. A, C, F, G, J, K, Plate IX, figs. A, D, F, Plate X, figs. A, and C, Plate XII, fig. A, Plate

Plate XVIII, fig. A.

XVII, fig. A) and triangular in transverse section (Plate VIII, figs. B, D, E. H, J, L, Plate IX, Figs. B, C, E, Plate X, figs. B, D, E, Plate XII, fig. B, Plate XVII, fig B. and Plate XVIII, fig. B), each side being slightly convex and more or less equal in length. The apical cell is distinguished from adjacent cells by its large size, distinctive shape, denser cytoplasmic contents, few chromatophores, lighter colour and a large granular nucleus. The nuclei in <u>Cystophora</u> species range from 7 - 16 μ in diameter (Table III).

The apical cell segments longitudinally at the three faces and the resultant segments divide transversely. The lowermost cells of the segment again divide transversely forming a compact group of small cells. These cells gradually increase in size to form the medulla, where the cells become elongate and narrow. The longitudinal walls undergo thickening but the cross walls remain thin.

The uppermost cells of each segment divide lengthwise to form a single meristoderm layer of elongate cells with dense cytoplasmic contents and numerous chromatophores which obscure the nucleus. These cells remain meristematic for a considerable distance from the apex. The meristoderm is covered by a continuous thick mucilage layer. The meristoderm

TABLE III. — Measurement of apical cells at their longest and broadest parts and the diameter of nuclei of the apical cells in the species of Cystophora

Species	Apical cell		Diameter of nucleus.
	Length.	Breadth	
C. uvifera	about 120 µ	about 60 µ	9 - 11 µ
C. cephalornithos	" 107 µ	" 34 µ	7 - 11 µ
C. paniculata	" 47 µ	" 20 µ	8 - 11 µ
C. intermedia	" 119 µ	" 42 u	8 - 12 u
C. platylobium	" 119 µ	" 60 µ	9 - 16 µ
C. moniliformis	" 61 µ	" 20 µ	8 - 11 µ
C. xiphocarpa	" 108 µ	" 47 µ	7 - 11 µ
C. racemosa	" 68 µ	" 22 µ	14 - 15 µ
C. cuspidata	" 95 µ	" 41 µ	7 - 10 µ
C. siliquosa	" 81 µ	" 34 µ	10 - 11 µ
C. retorta	" 54 µ	" 21 µ	7 - 11 µ
C. botryocystis	" 108 µ	" 54 µ	11 - 14 µ
C. subfarcinata	" 90 µ	" 30 µ	7 - 9 µ
C. polycystidea	" 108 µ	" 54 µ	10 - 11 µ

cells divide transversely near the base producing cells which contribute to the cortex. The upper cells of the meristoderm divide lengthwise to increase the surface area.

The middle cells, produced by the transverse division of the first segment cut off from the apical cell, undergo slight enlargement but remain isodiametric. Their walls thicken early but divisions still continue. These cells form the cortical tissue. At the same time, however, the inner daughter cells of the meristoderm and outer derivatives of medullary cells also contribute to the cortical tissue. Meristoderm, cortex and medulla are clearly differentiated shortly below the apical cell. In the subapical region intercellular spaces containing mucilage do not occur, whereas in Fucaceae this is one of the chief characteristics (Fritsch, 1945b; 1952). The formation of pits and cytoplasmic connections does not occur either. In _Cystophora uvifera_ a few medullary cells cease active division and increase in size, these cells contain dense cytoplasm and numerous chromatophores (Plate X, fig. A). Such cells have not been observed in other species, of _Cystophora_. Fucosan vesicles have been observed round the nucleus of apical cells and oogonia in most of the species of _Cystophora_.

Structure of the mature thallus.

Like other Fucales there occur three tissues — meristoderm, cortex and medulla. The meristoderm is covered by a mucilaginous layer which has been referred to as a cuticle. In branches of the meristoderm is a single layer of radially elongate cells containing dense chromatophores which often obscure the nucleus. The nuclei in all the species of Cystophora investigated are located basally or centrally and are granular (Plate X, fig. G, Plate XII, fig. I). Each nucleus shows 4-8 chromocentres which stain deeply with iron-alum-haematoxylin. Meristoderm cells away from the apex are shorter than those of the apical and subapical regions. They are palisade-like cells which form the main assimilatory tissue (Plate X, fig. G). In young parts these cells remain compact, retaining their shape, whereas in old parts of the axis or near the stipe they become irregular, or may be lost. In the latter case the cortical cells functio as the outer assimilatory tissue of the axis. In the region of the stipe the meristoderm becomes 2-4 layers of cells. In young parts the single layer of meristoderm cells divides periclinally near the base, followed by an anticlinal division of the upper cell forming a characteristic arrangemen of paired palisade like cells over a basal cell (Plate XII, fig. E). The basal cell does not divide but subsequent periclinal and anticlinal divisions follow in the meristoderm cells to form regular columns of cells. This results in considerable increase in thickness of the thallus.

The radial walls of meristoderm cells are thickened and lamellate. A maximum thickening of 4 μ in lateral walls occurs in *C. subfarcinata*, *C. botryocystis*, *C. cuspidata*, *C. platylobium*, *C. retorta*, *C. racemosa*, and *C. paniculata*. The inner tangential wall remains thin. Pit formation has only been observed in *C. intermedia*.

The thickening of cuticle varies in different species (Table IV). A maximum thickening of 18 μ occurs in *C. xiphocarpa*. In most of the species of *Cystophora* investigated the cuticle is from 2-9 (-13) μ thick.

Beneath the meristoderm lie a few layers of cells which are polygonal in transverse section and elongate in longitudinal section (Plate XI, figs. S, T, Plate XII, figs. C, D, Plate XVII, Fig. C, H, Plate XVIII, figs. C and G). These cortical cells undergo anticlinal or periclinal divisions and are larger towards the medulla. The larger inner cells of the cortex contribute to the central strand of medullary tissue.

In young parts of the plant the cortex is differentiated into inner small cells and outer large cells but this distinctive feature disappears in older parts of the plant. The cortical cells contain very few chromatophores and little

TABLE IV. Thickening of Cell Walls.

Species of *Cystophora*.	Cuticle		Meristoderm		Cortex		Medulla	
	Thallus	Receptacle.	Thallus	Receptacle	Thallus	Receptacle	Thallus	Receptacle
C. uvifera	up to 2 µ	up to 2µ	up to 2µ	up to 2µ	7 - 8 µ	up to 3µ	2 - 5µ	up to 4µ
C. cephalornithos	" 4 µ	" 4µ	" 2µ	" 2µ	1 - 3 µ	" 4µ	3 - 4µ	5 - 8 µ
C. paniculata	" 2 µ	" 2µ	3 - 4µ	" 3µ	3 - 9 µ	" 2µ	4 - 8µ	up to 6µ
C. intermedia	7 - 9 µ	" 2µ	upto 2µ	" 3µ	5 -13 µ	" 6µ	6 - 7µ	" 5µ
C. platylobium	upto 12 µ	" 5µ	3 - 4µ	" 3µ	3 - 7 µ	6 - 8µ	upto 8µ	" 10µ
C. spartioides	" 5 µ	" 3µ	upto 2µ	" 4µ	6 -13 µ	upto 4µ	4 -12µ	7 - 9µ
C. xiphocarpa	" 18 µ	" 3µ	" 2µ	upto 5µ	2 - 3 µ	4 - 5µ	3 -13µ	12 -16µ
C. racemosa	" 5 µ	5 -12µ	3 - 4µ	" 7µ	6 - 8 µ	5 - 8µ	upto 13µ	upto 14µ
C. cuspidata	" 7 µ	upto 4µ	3 - 4µ	" 3µ	4 -18 µ	13 -26µ	5 -16µ	5 -14µ
C. siliquosa	" 5 µ	" 2µ	1 - 2µ	" 3µ	4 -14 µ	upto 8µ	2 - 8µ	7 -12µ
C. retorta	" 13 µ	" 3µ	3 - 4µ	" 3µ	4 -10 µ	2 - 4µ	2 - 3µ	upto 3µ
C. botryocystis	" 5 µ	" 7µ	upto 4µ	" 4µ	7 -24 µ	10 -15µ	6 - 9µ	" 10 µ
C. subfarcinata	" 2 µ	" 2µ	3 - 4µ	" 3µ	10 µ	upto 3µ	6 -13µ	" 10 µ
C. polycystidea	" 3 µ	" 2µ	2 - 3µ	" 2µ	3 - 7 µ	" 5µ	5 - 8µ	" 8 µ

cytoplasmic contents. The cell walls are thick and lamellate (Plate XI, fig. V. Plate XII, fig. E). Pit formation is common in all species investigated. Cytoplasmic connections have not been observed.

Old parts of axis and stipe possess dense chromatophores in cortical cells, thus obscuring the nucleus. In old cortical cells thin cross walls occur which show cell division is still continuing. Division of cortical cells is very pronounced in *Cystophora platylobium*. The cell walls of the cortical cells greatly increase in thickness reaching a maximum of 7 - 24 μ in *C. botryocystis* and minimum of 1 - 3 μ in *C. cephalornithos*.

The medulla forms an axial core of many layers of cells. The cells are compact and isodiametric in transverse section, but many times longer than broad in longitudinal section. The lateral cell-walls are thick and lamellate but the cross walls remain thin. The corners of the cells become separated and the intervening space is filled with mucilage. Pit formation is very common in the species of *Cystophora* investigated (Plate XI, fig. U, Plate XII, fig. F). Cytoplasmic and lateral connections have been observed in *C. uvifera* (Plate XI, fig. U, Plate X, fig J).

Medullary cells contain few chromatophores in young parts of the plant but are rich in chromatophores in mature parts. Meristematic activity has not been observed in the stipe. The nucleus is very distinctive in young parts of the plant, containing 4-8 chromocentres and a nucleolus. The nucleus is located near the septum (Plate XI, fig. U).

Secondary changes occur in the medulla with the production of hyphae in the stipe and the basal parts of the axis but this has not been observed in young parts of the plant.

Production of the hyphae.

Hyphae are common mainly near the base of the axis and the stipe in both the cortex and the medulla. They occur as small elongate cells with dense contents, intercalated between the individual cells of the cortex and the medulla. In transverse section hyphae appear as round or oval in outline and some appear embedded amongst the large medullary cells. Developing as outgrowths from the medullary cells and inner cortical cells, they grow downwards and become septate as they increase in length (Plate X, figs. I and J, Plate XVII, fig. I, Plate XVIII, Fig. F). In transverse sections of the axis most of them are seen cut transversely (Plate XVIII, fig. D and G). Hyphae follow a tortuous course and their cell-walls are more or less of the same thickness as those of the medullary cells, with the contents of the cells also appear~~ing~~ almost identical. The only difference noticeable is that the hyphae are narrower.

In the stipe the hyphae make up the bulk of the medulla; the medullary cells proper being scarcely recognisable (Plate XVIII, fig. D). Near the base of the stipe, the hyphae are cut obliquely and longitudinally in longitudinal and transverse sections respectively indicating their zigzag and transverse course. The ramification of hyphae and the thickened nature of their walls indicate a mechanical function for these elements. The dense contents of the hyphae and medullary cells suggest that they function as storage tissue as well.

Structure of the receptacle.

Growth of the receptacle, in the species of Cystophora investigated, is initiated by a single apical cell similar to that in the vegetative apex (Plate XI, figs. A and B, Plate XII, figs. G and H, Plate XVII, figs. D and E). Division of the apical cell of the receptacle occurs as in the vegetative apical cells. No apical cell has been observed in mature receptacles, indicating cessation of growth. In the receptacle there is very little difference internally from the rest of the thallus and it consists of the same three tissues, meristoderm, cortex and medulla (Plate X, figs. E, F and G, Plate XVII, fig. J and K, Plate XVIII, fig. G). The structure of the sterile tip (Plate XII, fig. I, Plate XVII, fig. H) and stalk (Plate XII, figs. J, and K, Plate XVII, figs. F and G), of the receptacle are similar to those of the main axis and the branches but the fertile regions differ from the thallus in the frequent interruption of the tissues by the development of the conceptacles (Plate XIII, fig. A). Cortex and medulla are considerably reduced by the development of the conceptacles. Hyphal growth has not been observed in the receptacle. Pit connections and lamellare are common in the cortical and medullary cells (Plate XIII, fig. B). The maximum thickening of cell wall of the cortex is reached in C. cuspidata (Table IV).

Origin and development of the conceptacles.

Differentiation of conceptacles begins close to the apical cell of the receptacle. The conceptacle initial develops from one of the successive segments cut off from the apical cell. The initial cell becomes flask shaped or tongue shaped (Plate XI, fig. C, Plate XIII, fig. Ca), and is distinguished from the adjacent cells by its large size and slightly depressed position due to a delay in the first transverse division. A transverse section passing through the base of the conceptacle initial shows a three sided cell. The adjacent cells continue to divide, overarching the initial cell to form a conceptacle cavity. The initial cell in

Cystophora does not break down, but initiates the development of the conceptacle whereas in Fucus (Bower, 1880) this cell does break down. In Cystophora it divides by a transverse wall into an upper narrow "tongue cell" and lower broader "basal cell" (Plate XI, fig. D, Plate XIII, fig. Cc). The basal cell divides longitudinally and its derivatives possess deeply staining contents and prominent nuclei. The tongue cell then divides transversely, forming a uniseriate hair (Plate XI, figs. G and H, Plate XIII, fig. Cf), the uppermost cell of which is covered with mucilage. As the tongue cell divides, the basal cell and its derivatives divide rapidly until the wall of the conceptacle is complete. In transverse sections the young developing conceptacles show lining cells with the tongue cell in the centre of the cavity (Plate XIII, figs. Cg - Ci). Lining cells are larger and thinner walled than the cortical cells. These lining cells produce papillae which develop into paraphyses, antheridia or oogonia. The conceptacles are flask-shaped only in young stages (Plate XIII, fig. Cj) and later become spherical or more irregular and often elongate. Conceptacles are either bisexual or unisexual, and if unisexual then male and female conceptacles occur in the same receptacle. Sterile conceptacles occur near the base of the receptacle.

Development of antheridia.

Antheridia occur in large numbers borne directly on the wall of the conceptacle or more often on branched hairs in the species of *Cystophora* investigated. The development of antheridia has been studied in *C. subfarcinata*, *C. retorta*, *C. cephalornithos*, *C. moniliformis*, *C. intermedia*, and *C. uvifera*. All these species of *Cystophora* show similar development of antheridia. Small papillae develop from the wall cells of the conceptacle into the cavity (Plate XI, fig. Ka, Plate XVI, fig. Ca). Each papillae is cut off by a cross wall (Plate XI, figs. Kb, Kc, Plate XVI, fig. Cb, Cc.). The lower cell forms the stalk cell and the upper one develops into an antheridium which when mature is club-shaped. Secondary antheridia also develop laterally on the stalk. Antheridia are stalked and also borne on branched hairs (Plate X, fig. H, Plate XI, fig. K, Plate XIII, fig. F, Plate XVI, fig. C. Plate XVII, figs. L, M, and N, Plate XVIII, fig. H). The size of antheridia differs from species to species (Table V). The antheridial wall in all the species is composed of exochite and endochite (Plate XI, fig. Ki, Plate XIII, fig. F, Plate XVI, figs. A, Ci, Db, Ed,). The exochite ruptures at the apical end and the antheridium

TABLE V. Measurement of reproductive organs of Cystophora species.

Species.	Antheridia	Oogonia.
C. uvifera	30 - 40 μ x 10 - 16 μ	90 - 156 μ x 36 - 66 μ
C. cephalornithos	24 - 40 μ x 10 - 20 μ	100 - 150 μ x 40 - 70 μ
C. paniculata	20 - 26 μ x 13 - 23 μ	126 - 240 μ x 90 - 192 μ
C. intermedia	30 - 54 μ x 13 - 19 μ	66 - 132 μ x 66 - 120 μ
C. platylobium	18 - 24 μ x 6 - 8 μ	66 - 156 μ x 54 - 90 μ
C. moniliformis	24 - 36 μ x 12 - 18 μ	72 - 210 μ x 36 - 72 μ
C. xiphocarpa	30 - 40 μ x 12 - 16 μ	126 - 204 μ x 60 - 102 μ
C. racemosa	30 - 38 μ x 13 - 20 μ	120 - 240 μ x 60 - 180 μ
C. cuspidata	23 - 40 μ x 9 - 13 μ	54 - 180 μ x 54 - 108 μ
C. siliquosa	24 - 42 μ x 12 - 18 μ	60 - 150 μ x 36 - 96 μ
C. retorta	24 - 42 μ x 12 - 20 μ	102 - 162 μ x 54 - 96 μ
C. botryocystis	33 - 44 μ x 10 - 18 μ	132 - 168 μ x 42 - 132 μ
C. subfarcinata	36 - 43 μ x 13 - 18 μ	120 - 162 μ x 90 - 114 μ

still within the endochite extrudes through the ostiole of the conceptacle. The sperms are liberated by the gelatinisation of the endochite. The sperms are pyriform, and biflagellate with a long posterior flagellum directed backward and short anterior one directed forward. Sperms have a short life in suspension — some have been observed to live for 30 minutes or slightly more. Development of antheridia in all the species of Cystophora investigated is successive, and 2 - 64 nucleate stages have been observed (Plate XI, fig. K, Plate XVI, fig. C). Each antheridium produces 64 sperms.

Papillar growth from the wall of the conceptacle also forms paraphyses which arise similar to antheridia. Young, antheridia are distinguished from the paraphyses by their dense contents and centrally located nucleus. The papilla elongates and forms a unicellular paraphysis with nucleus near the apex (Plate XIII, figs E and F, Plate XVI, figs. C and D).

Development of oogonia.

Oogonia develop from the lining cells of the conceptacle and are distinguished from the surrounding cells by their large size and large nuclei (Plate XI, fig. L, Plate XIII, figs. Da, Db). Different stages of oogonia have been observed in most of the species of *Cystophora* indicating that the development of oogonia in the same conceptacles is successive but in *C. intermedia*, *C. platylobium*, *C. xiphocarpa* and *C. racemosa* oogonial maturation is simultaneous.

The oogonial initial divides periclinally into two cells, the outer of which is the oogonium mother cell (Plate XI, fig. M, Plate XIII, fig. Dc), the inner or "stalk" cell does not function as a stalk but remains embedded in the wall of the conceptacle. The oogonium enlarges gradually and expands into the cavity of the conceptacle. The upper part of the oogonium increases in diameter whereas the basal part remains narrow.

The first differentiation in the oogonium is the appearance of numerous small chromatophores around the nucleus. As the oogonium enlarges, chromatophores, plastids and food reserves increase in size and number. Mature oogonia contain dense chromatophores and food reserves. No hairs develop from the outer wall of the oogonium as occurs in *Carpophyllum flexuosum* (Dawson, 1940), but as the oogonium matures the paraphyses near the oogonium come to lie on its outer surface. Mature oogonia vary from oval to spherical. In a few cases the basal part of the oogonium is so narrow that it resembles a stalk. The number of oogonia per conceptacle varies but generally lies between 4 and 16. The oogonial wall is composed of exochite, mesochite and endochite ~~(Fig.~~). In each mature oogonium there is a large granular nucleus with a big nucleolus (occasionally two), (Plate XI, fig. R, Plate XIII, figs. Dd, De, Plate XVI, figs. A, D, and E, Plate XVII, fig. V, Plate XVIII, fig. J). There is a great rage of variation in the size of oogonia in the species of Cystophora investigated (Table V). Nuclear stages have been observed in C. uvifera and C moniliformis, and C. intermedia (Plate XI, figs. P and Q, Plate XVI, figs. B, F, Plate XVII, figs. Q - U). The nuclei are arranged in a linear series in C. moniliformis (Plate XVI, fig. F).

Paraphyses in C. intermedia and C. platylobium contain dense chromatophores and are clavate in form (Plate XVII, fig. P). In other species they are slender and the end cell is club-shaped. Fucosan vesicles have been observed round the nucleus of the oogonium (Plate XI, figs, P to R, Plate XIII, figs. Dd and De, Plate XVI, fig. F).

Embryology.

Fertilisation in C. subfarcinata, C. retorta, C. cephalornithos, C. intermedia, C. uvifera, C. polycystidea, and C. platylobium has been observed by immersing fertile receptacles in sea-water or culture solution in dishes at room temperature (18 - 20°C). Mature and immature eggs are extruded successively within an hour. The mature eggs (Plate XIV, fig. A, Plate XVII, fig, W, Plate XVIII, fig. K), contain dense brown contents with thick walls whereas the immature ones are thin-walled and light in colour. Extrusion of eggs is followed by the liberation of antheridia and sperms. Within an hour the eggs have been fertilised and have attached themselves to the bottom of the dish by a secretion of mucilage which forms a layer round the fertilised egg. Zygotes become very dark brown with dense contents whereas unfertilized eggs remain light in colour. The pellicle first remains thin and then gradually thickens. Zygotes in the species investigated are spherical measuring 75 - 100 μ in diameter (Plate XIV, figs. B, H, Plate XV, figs. Aa, Ba, Ca, Da). The zygotes of *C. cephalornithos* become slightly flattened and the surface appears rough due to an aggregation of dead sperms. This is not noticeable in the other species of *Cystophora* investigated.

The segmentation of zygotes normally begins within 16 to 18 hours after fertilisation at room temperature (18 - 20°C). Polarity is revealed by the first transverse segmentation of the zygote into two unequal cells (Plate XIV, figs. C I, Plate XV, figs. Bb, C2, Db). The lower cell divides transversely forming a rhizoid initial (Plate XIV, figs. D, J, Plate XV, figs. Bc, C4, Dc), within two hours after the first segmentation. The third division in the embryo occurs vertically in the upper cell (Plate XIV, fig. E, Plate XV, figs Bd, Dd). The fourth division occurs vertically in the middle cell which is formed by the second division (Plate XIV, fig. F, Plate XV, figs. Bf, C5, De). The fourth division is followed by a longitudinal divksion of the rhizoid cell into halves, and this is complete within 24 hours after fertilisation. Further segmentations of the body of the embryo occur longitudinally and transversely with the elongation of the rhizoid cell into 2 rhizoids (Plate XIV, fig. G, Plate XV, figs. Bg, C6, Dg). The embryo elongates and within two days the embryos possess two more rhizoids which develop from the adjacent cells lyihg above the primary rhizoids. Within two more days the embryos become many celled and further segmentations are obscured by the heavy pigmentation of cells.

Abnormal development of zygotes has been observed in *C. subfarcinata* and *C. retorta* (Plate XIV, figs. H - J, Plate XV, figs. Dk,Dt). In this case occasional zygotes are ellipsoidal and divide along the short axis in two cells.

The second division occurs transversely in each cell near the narrow end, forming a single rhizoid cell at each end. Further divisions ofthis embryo have not been observed but rhizoids occur at both ends (Plate IX, figs. G and H). This type of embryo has been termed a double embryospore (Hiroe and Inoh, 1955).

Within a week the body of the embryo is raised from the surface, with the loss of the mucilage membrane which remains attached to the embryo on one side (Plate XIV, fig. N). In C. polycystidea the membrane is cast off after a week. Embryos of each species of Cystophora studied develop an apical groove or depression within a week (Plate XIV, fig. L, Plate XV, fig. C10, Dh). One or more papillar protrusions develop from the base of the depression and push the mucilage membrane to one side. These protrusions become apical hairs (Plate XIV, figs. M, N and P, Plate XV, figs. Bj ~~/~~, K, C11, Di, Dj). The rhizoids become septate within a week and the branching of rhizoids has been observed in a few cases. The embryos of Cystophora uvifera differ from the other species by producing a single rhizoid only, but after two weeks they develop many rhizoids (Plate X, fig. K). In C. intermedia and C. uvifera apical hairs have not been observed because of the death of the embryos in 18 days (Plate X, fig. K, Plate XV, fig. A). Most of the other species of Cystophora studied possess 4 to 8 apical hairs but in a few cases up to 16 hairs have been observed. The apical hairs grow by basipetal segmentation from a flask-shaped basal cell (Plate XIV, fig. R), they are small and rectangular at first but gradually increase in length. These delicate and unbranched hairs measure up to 3 mm. in length and up to 13 μ in breadth. In the embryos of C. subfarcinata and C. retorta there is a swelling of one cell of the apical hair (Plate XIV, fig. Q) which has not been reported in other Fucales. After a week or so the apical hairs begin in most cases to break off into pieces, but sometimes they may last for months. In some cases the hairs may develop from any part of the body of the embryo. In C. platylobium two tufts of apical hairs develop on the body of the embryo (Plate XVII, fig. L). In C. subfarcinata and C. retorta there is development of an apical cell which is triangular in transverse section. Sections (Plate XIV, figs. S and T) through the embryo show differentiation into three regions of cells. In the centre there are large cells which form the medulla and from which secondary rhizoids develop. The peripheral layer develops into meristoderm cells which are radially elongate containing chromatophores and a single nucleus. Chromatophores are aggregated towards the inner margin of the cells. Beneath the meristoderm lie small cortical cells. A large number of small cells occurs in the lower part of older embryos (4 months). These are rhizoidal cells which extend within the base of the embryo (Plate XIV, fig. S).

7. SCABERIA AGARDHII Greville 1830

(Plates XIX - XX)

Structure of the apical and subapical regions.

Sections through the growing points of Scaberia agardhii reveal the presence of a single apical cell at the base of an apical depression. It is covered by mucilage which protects the apical cell. The terminal end of the axis and the branches are covered by slender young laterals which make the apical depression obscure.

The apical cell is biconvex in longitudinal section (Plate XIX, fig. A) and triangular in transverse section (Plate XIX, fig. B). The apical cell segments on three faces. These segments divide anticlinally and periclinally forming a curved row of elongated cells which form the lining of the apical depression. Frequently one segment of the apical cell is more developed than the other two segments, indicating the successive segmentation of the apical cell.

The upper cells of the primary segments, cut off from the apical cell, elongate, and develop into the meristoderm. The meristoderm cells contain dense chromatophores and basally located nuclei. These cells are meristematic as well as assimilatory. Meristoderm cells first divide periclinally near the base, the lower cells contributing towards the cortex. Later the upper elongated cells divide anticlinally to increase the surface of the thallus.

The middle cells, produced by anticlinal division of the segments of the apical cell, undergo some enlargement and some further divisions, but remain oblong or polygonal. Their walls are thickened early but subsequent divisions are indicated by the occurrence of thin septa in some cells. These cells contribute to the cortical tissue. The lower cells of each segment cut off from the apical cell broaden somewhat and divide both periclinally and anticlinally thus forming oblong cells which give rise to the medulla. These medullary cells cut off cells towards the cortex, which further contribute to the cortex. The medullary cells are compactly arranged in longitudinal rows with centrally located nuclei. Away from the apex the individual cells of each row gradually lengthen, producing an axial core of elongate cells. Fucosan vesicles occur round the nuclei in the apical region (Plate XIX, figs. A and B).

Immediately below the apex, two distinct zones of medullary cells are present; a central zone of large cells and an outer zone of smaller cells. Divisions in the large cells situated at more than 30 µ from the apical cell obliterate the two zones, except for about four scattered large cells which tend to remain undivided. Pit formation and lateral communication between the cells has not been observed in the apical region but in the region lying beyond 100 µ from the apex cytoplasmic connections occur (Plate XIX, fig. E).

Structure of the mature thallus.

The anatomy of the stipe, main axis and the branches are similar. While 3 distinct layers are present in the apical region, cortex and medulla are not clearly differentiated in the older parts of the plant (Plate XIX, fig. C). The meristoderm is very distinct due to its meristematic character and is covered by a continuous mucilaginous cuticle. In the stipe the meristoderm is composed of up to three layers of compact cells containing dense chromatophores which are 8 - 16 µ in diameter, ovoid and either light brown and refractive or dark brown and less refractive. The chromatophores are elongated in cells near the apex of the axis and in youhg tissues and divide transversely. No division of chromatophores has been observed in older parts ofthe plant. The lateral walls of the cells are thick and the end-walls taper. The peripheral cells are more or less uniform in shape. Hyphae do not occur in the meristoderm except in the stipe where the inner cells of the meristoderm may develop hyphae as described for the medulla.

Just beneath the meristoderm lie 3-5 layers of cells which are more readily distinguishable in longitudinal section (Plate XIX, fig. D), than in transverse section (Plate XIX, fig. C). The cells in the outer part of the cortex are large and polygonal in transverse section and in the inner part they are small and more or less isodiametric. Chromatophores are few in number, scattered or aggregated in groups. The end walls of the cortical cells are rounded and cell-walls are thick and lamellate. Pit formation and cytoplasmic connections between them occur (Plate XIX, fig. E). Lateral connections between the cortical cells also occur (Plate XIX, figs. K, L). Hyphal production is not common in the cortical cells except in the basal part of the main branches and the stipe where the hyphae are well developed. They develop as in the medulla.

The medulla is composed of many layers of cells containing dense chromatophores which are either scattered or aggregated in groups. Some of the medullary cells are devoid of chromatophores. The inner medullary cells are large and contain denser chromatophores than the outer medullary cells. Cell walls are thick and lamellate. Pit formation and cytoplasmic connections occur in the medullary cells and lateral connections are also very common. Perforated septa have not been observed. Hyphae are very common in the medulla in the basal part of the axis (Plate XIX, fig. F) and stipe, growing downwards between the cells. Medullary cells become elongated and form a bulbous structure from which the hypha develops. Two types of hyphae occur and both of them are very common. Anastomosing hyphae (Plate XIX, fig. N) are very pale in colour and large in size and more common in the inner medulla, than in the outer medulla. Filiform hyphae are scattered abundantly and intermingle with the anastomosing hyphae. They are dark brown in colour and most common in the outer medulla, and have chromatophores.

Structure of the filiform leaves.

These develop at a young stage or near the base of new branches of the plant. The vegetative growth occurs from a single apical cell as described in the axis. Internally three zones, meristoderm, cortex and medulla are present (Plate XIX,fig. M). Meristoderm is a single layer of radially elongate cells containing dense contents with a distinct central nucleus. The lateral walls are thick and the outer wall is covered by a continuous mucilaginous layer. The cortex consists of 2 or 3 layers of polygonal cells with thick walls. These cells contain dense chromatophores. No pit formation nor cytoplasmic connections have been observed. The medulla is composed of about 4 layers of cells. The medullary cells are more or less isodiametric and are smaller in size than the cortical cells. The cell-walls are thickened and pit formation and cross connections do not occur. Cryptostomata occur but they are very few in number. The sterile hairs are unbranched and filiform and do not project out from the ostiole.

Structure of the verruciform leaves.

The verruciform leaf is also composed of three layers — the meristoderm, cortex and medulla. Meristoderm is a single layer of cells radially elongated on the dorsal side of the leaf but tangentially elongated on the ventral side. These meristoderm cells are twice as long as broad with central nuclei and dense contents. The cell-walls are thick and the cells are compact. The meristoderm cells of verruciform leaves are more active in growth. The cortex is composed of 2-3 layers of cells which are polygonal and compact, containing fewer chromatophores than the meristoderm. In transverse section (Plate XIX, figs. G, H), the cortex is indistinguishable from the medulla, but it is distinct in longitudinal sections (Plate XIX, figs. I and J). Pit formation and connections do not uccr. The cell-walls are thick and lamellate. The medulla is composed of up to 4 or more layers of cells in the old parts but is made up of a single layer in the younger parts (Plate XIX, Fig. G). In longitudinal sections (Plate XIX, figs. I, J), the cells are elongated, compact and placed end to end with sparse chromatophores. The cell walls are thick and lamellate and pit connections occur.

Structure of the scale leaves.

The internal structures of the scale leaves are similar to those of filiform leaves having the same pattern of cells in the three zones. Pit formation and cross connections occur in scale leaves but not in filiform ones. Sterile conceptacles occur and the lining of the sterile conceptacle is composed of a single layer of cells. The paraphyses are slender and unbranched.

Reproductive organs.

Bisexual conceptacles occur in the verruciform leaves. In a few conceptacles only antheridia have been observed. Antheridia are usually far more numerous than oogonia in contrast to *Scytothalia dorycarpa* where oogonia outnumber the antheridia. The conceptacles are lined with a layer of small cells. Tufts of antheridial hairs and paraphyses occur between the oogonia. The paraphyses are long, slender, septate and unbranched (Plate XX, fig. C), those near the ostiole being shorter, and broader.

Development of antheridia.

Antheridia originate in the same way as paraphyses. At first they are indistinguishable except that antheridial initials have denser cytoplasm and larger nuclei. Antheridia may be sessile and sometimes pedicellate (Plate XX, fig. E), or on branched hairs (Plate XX, fig. B). The stalks of the antheridia are simple but they give rise to further antheridia by continued branching. Young antheridia often develop below the old ones. Commonly a conceptacle contains antheridia at different stages. In antheridia up to 64-nucleate stages have been observed (Plate XX, fig. A). Proliferations through old empty antheridia also occur. The ripening of antheridia occurs successively. The mature antheridium wall is differentiated into exochite and endochite. Antheridia are extruded through the ostiole. Each antheridium produces 64 sperms. The mature antheridium measures 30 - 46 µ and x 9 - 16 µ. The exudation of sperms and their structure have not been studied.

Development of Oogonium.

Oogonia arise from the wall-cells of the conceptacle and are interspersed with antheridia and paraphyses. The oogonium possesses a large granular nucleus with a large nucleolus (occasionally two nucleoli). Oogonia occur in small numbers only. Oogonia observed have been at the same stages of development indicating that simultaneous ripening occurs. The mature oogonia generally measure 95 - 241 µ by 60 - 90 µ. Nuclear divisions result in the formation of eight nuclei, seven of which are expelled from the centre towards the periphery. One nucleus remains in the centre of the oogonium and functions as the egg nucleus. All stages from 2 to 8 nucleate (Plate XX, figs. Da to Dd) have been observed while the oogonia are still within the conceptacle. In the 8-nucleate stage all the nuclei are of the same size except the larger central one. No mucilaginous caps on the oogonia have been observed. The egg is disharged through a latero-apical aperture (Plate XX, fig. De). The eggs are spherical (Plate XX, fig. Df) and measure 65 - 138 µ across. The mature eggs are dark brown in colour whereas immature ones are pale in colour. The oogonial wall is composed of 3 layers — exochite, mesochite and endochite (Plate XX, fig. Dg).

Embryogeny.

Fertilisation in *Scaberia agardhii* has not been observed but it is presumed that this may take place inside the conceptacle or after the extrusion of eggs. After fertilisation the zygotes are attached to the substratum by a mmcilaginous secretion. After sixteen hours a cross wall is formed across the zygote with the differentiation of upper and lower cells (Plate XX, fig. G), which exhibit polarity. Within an hour after the first segmentation a second division occurs, perpendicular to the first division, in the upper cell (Plate XX, fig. H). A third division occurs transversely in the lower cell forming a lenticular cell which becomes the primary rhizoid cell (Plate XX, fig. I). ~~cell~~

The fourth division occurs perpendicular to the first and third division of the zygote (Plate XX, fig. J), and is followed by a longitudinal division of the primary rhizoid cell into two cells. Each of these two cells develops into a rhizoid. A multicellular body with two rhizoids is thus developed within forty eight hours (Plate XX, fig. K). After seventy two hours the embryo has developed four, eight or sixteen rhizoids (Plate XX, figs. L, M. and N). At this stage the embryos are attached by means of rhizoids and the body of the embryo is raised up. It has not been observed how the additional rhizoids are developed. After three days the embryos measured 400 - 500μx 300 - 400 μ. The rhizoids are septate and the embryo becomes 760 - 390 μ within a week. The apical hairs develop in about one month. Firstly one or two hairs develop from the apical groove, formed in the body of the embryo. These hairs grow in length and more hairs develop from the base of the apical groove (Plate XX, fig. N). Four to six hairs are common but up to 12 hairs have been seen and have a basal meristem. As the apical hairs develop the embryo elongates. Embryos have been grown for up to five months but their growth was inhibited due to bacterial growth in the dishes.

8. CYSTOPHYLLUM MURICATUM (Turner)

J. Agardh 1848.

(Plates XXI - XXII).

Structure of the apical and subapical regions.

Vegetative growth in C. muricatum is initiated by a single apical cell in the apical depression. The apical cell is triangular in transverse section (Plate XXI, fig. B) and biconvex in longitudinal section (Plate XXI, fig. A). Segmentation of the apical cell occurs longitudinally at an early stage and each segment undergoes transverse divisions to form a curved row of cells; sometimes part of the segment may divide longitudinally to produce a series of meristoderm cells lining the apical furrow.

The lowermost cell of each segment divide longitudinally and transversely to form longitudinal rows of meristematic cells. The individual cells of each row gradually lengthen and become rectangular as shown in longitudinal section (Plate XXI, figs. A and J). These axial cores of elongate cells are slightly thickened but the transverse ones always remain thin.

The middle cells, produced by division of the segment of the apical cell, enlarge and divide further but remain isodiametric. Their walls thicken early but divisions still occur in these cells. These cells develop into the cortical tissue. The outer products of the medullary cells and inner products of the meristoderm cells also contribute to the cortex.

Shortly below the apical cell there occur three different tissues — meristoderm, cortex and medulla. In the apical and subapical region the meristoderm is a single layer of radially elongate cells. They are meristematic and undergo transverse and longitudinal divisions. The cortex is composed of 2-3 layers of isodiametric cells with dense chromatophores. The medulla consists of up to 4-6 layers of oblong cells. In the subapical region the cortical and medullary cells are also meristematic like the meristoderm cells.

Fucosan vesicles occur round the nucleus of the apical cell (Plate XXI, figs. A and B).

Structure of mature thallus.

Three distinct tissues occur in the old parts of the plant as in the subapical region.

The meristoderm is a single layer of radially elongate cells which are compact, containing dense cytoplasmic contents, with a considerable number of chromatophores and basally located nuclei (Plate XXI, fig. E). The lateral walls are thick. The meristoderm is covered by a continuous mucilaginous cuticle. The meristematic activity of the meristoderm cells continues indefinitely.

Underlying the meristoderm are the larger cortical cells. The cortical cells are arranged in 3-5 layers and contain dense chromatophhres of varying size. The cells are isodiametric or polygonal in transverse section (Plate XXI, figs. C and E) but elongate in longitudinal section (plate XXI, fig. J). The innermost cortical cells become longer than the outermost ones and the lateral walls become slightly thicker with a distinct middle lamella.

Running centrally through the length of the plant are strands of elongate cells forming the medulla (Plate XXI, fig. D). This tissue is composed of many layers of cells. In young parts of the plant the medullary cells contain dense cytoplasmic contents and chromatophores. Cytoplasmic connections occur commonly in the young parts of the plant (Plate XXI, fig. J) but no such connections were observed in the old parts of the plant. Tapering end walls of cells are common in older parts of the axis but not in the young parts. The lateral walls are thick and strongly lamellate. The septa of the medullary cells are straight and thin. Pit formation generally occurs.

Hyphae usually occur in the cortex and the medulla of the stipe and of the axis.

Structure of the slender leaves.

Vegetative growth in the slender leaves is also initiated by a three sided apical cell (Plate XXI, figs. F and G) similar to that of the axis. The segmentation of the apical cell and division of the segments follows the same pattern, as described for the apex of the axis. In this case also the meristoderm is a single layer and the cells are radially elongate containing dense chromatophores with a basally located granular nucleus. The cortex is of 2 layers and the cells are polygonal and rather isodiametric. The medulla near the apex is 3-4 layered, compact and meristematic (Plate XXI, fig. H). The medullary cells are few in the older parts of the slender leaves and the cortical cells are large (Plate XXI, fig. I). Cryptostomata with projecting hairs occur in the slender leaves. Lateral walls are slightly thickened but no pit formation occurs.

Structure of the receptacle.

The receptacle also possesses a single apical cell similar to those of vegetative parts (Plate XXI, figs. K and L). The receptacle is composed of a single layer of meristoderm cells, 2-6 layers of cortex and 2-4 layers of medulla. The medullary cells are elongate and the lateral walls are thickened. Pit formation was not observed in cells of the receptacle. The structure of the receptacle differs from the vegetative parts of the plant due to the development of conceptacles which are scattered throughout the outer tissues of the receptacle. Empty conceptacles occur near the base of the receptacle. The conceptacles are arranged in acropetal succession.

Development of the conceptacles.

The development of a conceptacle is initiated by a segment cut off from the apical cell of the receptacle. This segment is termed the "initial cell" of the conceptacle (Plate XXI, fig. M) and is distinguishable from the surrounding meristoderm cells in its being slightly depressed in position because of a delayed transverse division; it is also flask shaped. The initial cell is evident in longitudinal section rather than in transverse section of the receptacle. A transverse section passing through the basal parts of the initial cell reveals a somewhat triangular cell. The initial cell is divided transversely into two unequal parts by a downwardly curved wall (Plate XXI, fig. N). This wall is concave towards the upper cell which is termed the "tongue cell", and the lower cell is called the "basal cell". The basal cell undergoes repeated longitudinal divisions forming a single layer of cells lining the cavity. The basal cells first divide longitudinally into two similar daughter cells, thus producing a three-celled stage of the conceptacle (Plate XXI, fig. P). A transverse section cut through the upper part at the 3-celled stage, shows a circular cell which is the tongue cell (Plate XXI, fig. S).

The two basal derivatives divide longitudinally in various planes. A condition thus results which exhibits eight cells in longitudinal section (Plate XXI, fig. R). Seven of these cells are the young cells of the recept divisions of the basal derivatives and one is the centrally placed tongue cell. The longitudinal divisions continue. The tongue cell is conspicuous and develops into a filament of 3 cells (Plate XXI, fig. U). Longitudinal divisions continue until the wall of the entire conceptacle is formed (Plate XXI, fig. V). The succeeding stages of the tongue cell have not been observed.

Development of oogonia.

The oogonial mother cell develops from the wall of the conceptacle. Some of the lining cells of the conceptacle enlarge and become densely filled with cytoplasm, and possess a large nucleus. The mother cell enlarges greatly and divides transversely (Plate XXI, fig. W). The outer cell facing the conceptacle cavity forms the oogonium, and the lower one the stalk cell. The stalk cell does not raise the oogonium above the lining of the conceptacle but becomes embedded due to the growth of the surrounding cells. The oogonia when mature enlarge greatly and become either partly embedded in the tissue or project into the cavity of the conceptacle (Plate XXI, figs. X and Y). They are ovoid, measuring 120 - 204 µ x 100 -150 µ. The oogonial wall is composed of exochite, mesochite and endochite, and measures 4 µ in thickness.

During the early stage of development of oogonia the cytoplasm is evenly distributed throughout the oogonium and has a large granular nucleus with one or two conspicuous nucleoli. The nucleus is surrounded by numerous plastids. As the oogonia mature they are discharged periodically in zones on the receptacle indicating that maturation is simultaneous within a conceptacle. Young oogonia do not occur in the conceptacles from which mature oogonia have been discharged. The longitudinal secretion of the receptacle often shows three distinct zones of oogonial development of the conceptacles, (1) a basal zone with empty conceptacles (2) middle zone with mature oogonia, (3) upper zone of young conceptacles near the apical region of the receptacle. Mucilage caps on the terminal end of the oogonia occur and extruded oogonia have been observed attached by a mucilage stalk to the surface of the receptacle as in *Cystophyllum trinodis* (Delf, 1935).

Nuclear division in the oogonium results in the formation of eight nuclei, seven of which gradually pass towards the periphery. Up to four nuclei have been observed while the oogonia are in situ (Plate XXI, figs. X and Y) and in the extruded oogonia 2-8 nucleate stages have been observed (Plate XXII, figs. D. and H). At first all the nuclei in the extruded oogonia are of the same size but sooner or later all nuclei except one become small and lie towards the periphery. In a few cases two big nuclei have been observed while the rest have been small.

Development of antheridia.

The lining cells of the conceptacles develop into papillae which divide transversely. The outer cells facing the cavity function as antheridial initials and are distinguished from the paraphyses by having darkly staining contents and large granular nuclei. These initials further divide transversely; the outer cell is the antheridium proper and the lower one is the stalk cell. The antheridium greatly increases in size and becomes club-shaped (Plate XXII, fig. A), while the nucleus divides ultimately to form sperms. Different stages of antheridia occur in one conceptacle. The mature antheridia generally measure 30 - 40 µ x 9 - 15 µ, and have a wall of exochite and endochite. Antheridia are pedicellate (Plate XXII, figs. B and C).

Embryology.

The eggs are ovoid and covered by a mucilage sheath on the outer surface of the receptacle. Fertilisation has not been observed but it is presumed that it takes place within the conceptacle or inside the mucilage sheath. Fertilised eggs attach themselves to the bottom of culture dishes. The segmentation of the zygotes occurs while attached on the surface of the receptacle, or on the bottom of the culture dishes. The zygotes divide transversely into two unequal parts —— the upper cell small and the lower cell large (Plate XXII, fig. K). The second divisions is perpendicular to the first in the upper cell (Plate XXII, fig. L). The third division is transverse on the lower cell forming a lenticular rhizoid initial (Plate XXII, fig. M). The fourth division is perpendicular in the middle cell (Plate XXII, fig. N) and is followed by three successive longitudinal divisions of the rhizoidal initial forming 4 rhizoidal cells in all (Plate XXII, figs. P - R); each rhizoid cell develops into a rhizoid within 48 hours (Plate XXII, fig. S). In the meantime the embryo becomes multicellular and increases in length and breadth. By this time the embryos have become attached to the substratum by means of rhizoids and the body of the embryo is raised up. The rhizoids grow rapidly. The mucilage layer is pushed off from the embryos within a week (Plate XXII, figs. S and U), and an apical groove develops. Embryos measure 300 - 400 µ x 100 - 150 µ by the the end of one week, and the number of rhizoids increases to 12 or more in two weeks. One or two apical hairs develop within two weeks from or mear the apical groove (Plate XXII, fig. U). The number of apical hairs may increase to as many as 16, but 4 or 6 apical hairs are more common (Plate XXII, fig. V). Septation of rhizoids occurs by the end of the second week and the transverse wall may be straight or oblique. In the third week the embryo measures 600 - 900 µ x 150 - 250 µ but there is no appreciable increase in the diameter of the rhizoids.

Inculture, floating embryos detached from the substratum, differ in shape than attached ones, measuring 1000 - 2000 µ x 120 - 150 µ in three weeks compared with a measurement of 650 - 1800 µ x 175 - 300 µ for attached embryos. As the embryo grows in length more hairs develop in tufts from different places on the body of the embryos. The apical hairs measure more than a millimeter in length and 10 - 15 µ in breadth and have a basal growth region. The maximum number of rhizoids is 16 to 18 in three months (Plate XXII, fig. W).

9. CARPOGLOSSUM CONFLUENS (R. Brown ex Turner) Kuetzing 1843

(Plate XXIII).

Structure of the apical and subapical regions.

The vegetative growth in *C. confluens* is initiated by a single three sided apical cell as described by Gruber (1896).

In longitudinal section the apical cell is biconvex with a conspicuous nucleus (Plate XXIII, figs. B and C); the two sides taper to the anterior end while the posterior end is rounded and rather broader. In transverse section the triangular shape of the apical cell is manifest, the sides being slightly convex (Plate XXIII, fig. A).

Segmentation of the apical cell occurs longitudinally at an early stage and each daughter cell undergoes transverse divisions to give a curved row of 3 or more cells; sometimes part of the daughter cell may divide longitudinally.

The uppermost cells of each segment divide rapidly to form a series of elongated cells which contain dense chromatophores. These cells are meristematic and divide first periclinally near the base and then anticlinally in the upper cells. The divisions of these cells continue indefinitely.

These elongated cells are the meristoderm, which commonly consists of a single layer of cells near the apex. The lowest cells formed from each segment of the apical cell broaden somewhat and divide both periclinally and anticlinally to form rows of longitudinal cells. These cells are meristematic near the apex, more or less oblong and compact. Behind the apex the individual units of each row gradually lengthen and form an axial core of elongated cells (Plate XXIII, fig. C) which continues downwards as the medulla.

The middle cells, produced by the transverse division of the segments of the apical cells, enlarge and divide further but remain isodiametric. The walls of these cells thicken but division still occurs. These cells help to build up the cortical tissues. The products of the outer cells of medulla and inner cells of the meristoderm further contribute to the cortex. Thus there are three distinct tissues near tha apex-meristoderm, cortex and medulla.

Structure of the mature thallus.

The anatomy of the mature thallus also reveals the presence of three distinct tissues as in the apical and subapical regions.

The meristoderm consists of a single layer of radially elongate cells (Plate XXIII, figs. D - F). The lateral and inner walls are thick and the outer convex walls are protected by a continuous layer of mucilage. The cells are meristematic and compact with dense chromatophores obscuring the nuclei (Plate XXIII, fig. F). In the stipe and the basal part of the axis the meristoderm is up to six layers of cells thick, all containing dense chromatophores.

Immediately below the meristoderm lies a zone about 5 layers of cells deep (Plate XXIII, figs. D and E), with sparse chromatophores. These cortical cells are isodiametric or elongate with thick lamellate walls and pit connections.

Running centrally through the length of the axis or branches are strands of elongate cells (Plate XXIII, fig. J) in the older parts these cells become broader (Plate XXIII, fig. H). The cell walls are thick and lamellate and show pit connections (Plate XXIII, fig. I). The medullary cells are small and isodiametric in transverse section (Plate XXIII, fig. D), with transverse septa simple and thin. Medullary cells contain sparse chromatophores. Lateral connections and perforated septa have not been observed, but hyphae occur in the basal parts of the plant (Plate XXIII, fig. K).

Structure of receptacles (fertile segments).

Each receptacle is notched at the tip. At the base of the apical depression lies a single three sided apical cell similar to that of vegetative parts. The growth of the receptacle is initiated by an apical cell as described for the apex of the axis. Sections through the apical region ofthe receptacle show the arrangement of the conceptacles in rows on each surface but this arrangement is obliterated due to the displacement of the conceptacles by mutual pressure during their enlargement. Sterile conceptacles occur near the base of the receptacle. They contain sterile slender paraphyses with club-shaped end cells. The internal structure of the receptacle is similar to that described for the axis except for the development of conceptacles.

Reproductive organs.

Mostly the conceptacles are bisexual, with the oogonia scattered between the antheridia and paraphyses (Plate XXIII, fig. L). But some conceptacles are entirely male and a few produce oogonia only.

Paraphyses.

The wall-cells of the conceptacle give rise to long, basally growing paraphyses which project out of the ostiole, while the sides produce short, unbranched paraphyses. In all conceptacles the central area of the floor is sterile, producing a group of paraphyses. This feature was first observed in Cystoseira (Sauvageau, 1911; 1912). Paraphyses also originate in the fertile region of the conceptacle, between antheridia and oogonia, but these are shorter than the central paraphyses and decrease in length towards the upper part of the conceptacle. The paraphyses arise from the wall of the conceptacle and develop club-shaped end cells.

Development of antheridia.

Antheridia may develop directly from the wall of the conceptacles or on short filaments. The initial papillae arise from the lining cell of the conceptacle (Plate XXIII, fig. Ya). The antheridia are distinguishable at an early stage from the paraphyses because they have darkly stained contents and larger nuclei. These papillae divide transversely and then the outer resulting cells function as antheridial initials. The antheridial initial divides transversley forming an antheridium proper and a stalk cell (Plate XXIII, fig. Yb). The antheridium proper grows towards the cavity of the conceptacle and becomes club-shaped. The stalk cell later may produce a branch which pushes the original antheridium to one side and itself gives rise to a second antheridium (Plate XXIII, fig. Z). In a few cases the stalk elongates, becomes septate and bears many antheridia. Antheridia may also occur in a cluster terminally or laterally on the paraphyses. Different stages of antheridial development occur in the one conceptacle. Division stages of 2-8 nuclei have been observed in the young antheridia (Plate XXIII, fig. X). Successive development of antheridia occurs in the same conceptacle. The antheridia measure 25 - 40 µ x 8 - 15 µ. A mature antheridium is composed of two layers of wall — exochite, and endochite (Plate XXIII, fig. Yc). The entire antheridia may detach in the cavity of the conceptacle.

Development of oogonia.

The oogonium arises from an outgrowth of one of the wall-cells of the conceptacle and the outgrowth divides periclinally into a small stalk cell and an oogonium proper (Plate XXIII, fig. M). The stalk cell always remains embedded in the wall of the conceptacle. The oogonium proper, which projects in the cavity of the conceptacle, increases greatly in size and soon becomes ovoid (Plate XXIII, fig. L). There now follows a long period of growth during which the oogonia attain 100 - 170 µ x 50 - 80 µ. The oogonium contains a great quantity of reserve material, many chromatophores, dense cytoplasm and a large granular nucleus with a distinct nucleolus (rarely two). The oogonium is differentiated into three layers — exochite, mesochite and endochite. No nuclear divisions have been observed. The eggs are ovoid (Plate XXIII, fig. P). Oogonia at similar stages of development occur in the conceptacles showing simultaneous maturation of the oogonia.

10. MYRIODESMA Decaisne 1841

(Plates XXIV - XXVII).

Gruber (1896) described the anatomical structure of *Myriodesma integrifolia* but did not find apical growth, he doubtfully placed it under the Cystoseiraceae. The present investigation of the anatomical structure, development and apical growth is based on fresh and preserved material of *M. integrifolia*, *M. latifolia* and *M. quercifolia*.

Structure of the apical and subapical regions.

The vegetative growth in *Myriodesma* is initiated by a single apical cell which is situated at the base of the apical depression. The apical cell is more or less biconvex in longitudinal section (Plate XXIV, fig. B. Plate XXVI, fig. A. Plate XXVII, fig. A), and triangular in transverse section (Plate XXIV, fig. A. Plate XXVI, fig. B. Plate XXVII, fig. B). The sides are more or less equal and slightly curved inwards. In longitudinal section the sides of the apical cell meet at a point at the inner end of the apical cell, while the outer end of the cell remains slightly broader. The apical cell is protected by an accumulation of the mucilage in the apical depression.

Segmentation of the apical cell occurs longitudinally at an early stage and it is followed by the transverse division of the segments to form curved rows of cells; sometimes one of these cells divides longitudinally (Plate XIV, fig. A. Plate XXVII, fig. A). One segment of the apical cell may at one time have 3 or 4 divisions while the other two segments have none, one or two divisions (Plate XXIV, fig. B. Plate XXVI, fig. A. Plate XXVII, fig. A).

The uppermost daughter cells of the segments, cut off from the apical cell, elongate and divide longitudinally forming curved rows of elongate cells which surround the apical furrow. This forrow is deeper in *M. latifolia* than in *M. quercifolia* and *M. integrifolia*. These elongate cells are the meristoderm cells containing dense chromatophores which obscure the nuclei in *M. latifolia*. Nuclei have been observed in the lower parts of the meristoderm cells in *M. integrifolia* and *M. quercifolia* and these nuclei are granular having one nucleolus (occasionally two). meristoderm cells of the three species first divide transversely near their bases thus forming basal cells and upper radially elongate cells which increase the surface growth of the thallus. The basal cells contribute to the cortex. The activity of the meristoderm cells continues indefinitely.

The lowermost cells of the segments divide periclinally, anticlinally and otherwise to form longitudinal rows of rectangular cells in the apical and in the subapical region. The cells become progressively more oblong downwards from the apex. These cells constitute the medulla. The medullary cells are compact and meristematic in the apical and the subapical regions. The lateral walls become thickened while the transverse walls remain thin.

The middle cells of the segments divide in different planes, becoming more or less polygonal or isodiametric. These are the cortical cells which are compact and meristematic. Early thickening of the cell-walls does not hinder the activity of the cells. The outer products of the medullary cells contribute to the cortex.

Mucilage accumulation occurs at an early stage in the apical and the subapical regions. The accumulation of mucilage is relatively less in *M. integrifolia* and *M. quercifolia* than in *M. latifolia* (Plate XXVI, fig. A). Pit formations and cytoplasmic connections do not occur in these regions, but lateral contraction of cytoplasm occurs in the medullary cells of *M. quercifolia* (Plate XXVII, fig. A).

Fucosan vesicles have been observed near the nucleus of the apical cell.

The subapical regions of the three species of *Myriodesma* are differentiated into the meristoderm, the cortex and the medulla. In the subapical region these three zones are distinguishable in longitudinal section but not in transverse section. Vegetative growth and the formation of three zones of tissues are similar in *M. integrifolia*, *M. quercifolia* and *M. latifolia*. In *M. latifolia* the cortical and the medullary cells are comparatively looser than those of *M. integrifolia* and *M. quercifolia*.

Structure of the mature thallus.

The internal structures of the species of *Myriodesma* which have been investigated are composed of 3 layers of tissues — the meristoderm, the cortex and the medulla. (Plates XXIV, figs. C - G, Plate XXVI, figs. C - F. Plate XXVII, figs. C - F).

The meristoderm is a single layer of radially elongate cells (Plate XXIV, fig~~s~~. E. Plate XXVI, figs. C and D, Plate XXVII, figs. C and D). These cells are regular and uniform in shape and contain dense chromatophores and basal granular nuclei. In a young branch of *M. integrifolia* these cells are tangentially elongate (Plate XXIV, fig. H), instead of radially elongate. The meristoderm of the petiole, axis and stipe is composed of 4—6 layers of cells in *M. integrifolia* (Plate XXIV, fig. C), 2 - 3 layers in *M. latifolia* (Plate XXVI, fig. F) and 8 or more layers in *M. quercifolia* (Plate XXVII, fig. I). These cells contain dense chromatophores obscuring the nuclei; and the meristematic activity of the meristoderm cells continues indefinitely. These cells are generally radially elongate but in older parts they become tangentially elongate. The lateral walls are thick and lamellate, while the transverse walls remain thin. Lateral connections were not observed. Pit-formation occurs in the innermost meristoderm cells which adjoin the cortex. The peripheral layer of the meristoderm is covered by a continuous mucilaginous layer, the cuticle.

Immediately below the meristoderm lies the cortex which consists of 2 - 5 layers of more or less isodiametric cells. The inner cells of the cortex are slightly larger than the outer cells which are polygonal or isodiametric cells. The cortical cells of the petiole and the stipe contain dense chromatophores. Cytoplasmic and lateral connections have not been observed. Pit-formation occurs in the cortical cells of these three species of *Myriodesma* and is very prominent. Stronger mucilage accumulation occurs in *M. latifolia*, than in *M. integrifolia* and *M. quercifolia*. The cell walls are strongly thickened and lamellate (Plate XXVII, fig. H). Hyphae occur in the stipe of *M. quercifolia* and *M. integrifolia* only (Plate XXVII, fig. H) and have not been observed in *M. latifolia*. The hyphal cells contain dense chromatophores. The hyphae grow downwards.

Running centrally throughout the length of the plant is a strand of elongate cells forming the medulla. This tissue is composed of 6 or more layers of cells in *M. integrifolia* and 10 - 12 or more layers in *M. latifolia* and in *M. quercifolia*. In the branches the medulla comprises 4-6 layers of cells. Medullary cells are 10 times as long as broad in *M. integrifolia* and 4 or 5 times as long as broad in *M. latifolia* and *M. quercifolia*. In transverse section medullary cells are polygonal or isodiametric. In the stipe, and petiole medullary cells contain dense chromatophores and few empty cells. Accumulation of mucilage occurs in the medulla of three species of *Myriodesma* but *M. quercifolia* contains the densest mucilage. Lateral connections occur in the medullary cells of the stipe; these are more numerous in *M. latifolia*. Pit-formation is common in the three species. No cytoplasmic connections have been observed, but lateral contraction of cytoplasm occurs. Cell walls are strongly thickened and lamellate. In the older parts of *M. quercifolia* division of medullary cells occurs. Hyphae occur in the basal parts of the thallus. These hyphae contain dense chromatophores and run longitudinally downwards (Plate XXVII, fig. G).

Development of the conceptacles.

The development of the conceptacles in *M. integrifolia*, *M. quericfolia* and *M. latifolia* occurs largely in accordance with Bower's (1880), Simons' (1906) and Nienburg's (1913) findings for *Fucus*, *Halidrys*, *Cystoseira* and *Sargassum*. It is initiated by one of the cells cut off from the successive segments of the apical cell, which ceases active division temporarily and becomes depressed due to the active surface growth of the surrounding cells. The initial cell becomes more or less flask shaped in *M. integrifolia* and *M. quercifolia* but is linear in *M. latifolia* (Plate XXV, fig. A. Plate XXVI, fig. G, Plate XXVII, fig. I): Its neck or upper part is surrounded by mucilage. The initial cell divides transversely by a curved wall into two unequal parts — the lower basal cell and the upper tongue cell (Plate XXV, fig. B. Plate XXVI, fig. A. Plate XXVII, fig. K). The basal cell divides longitudinally into two equal cells (Plate XXV, fig. C. Plate XXVI, fig. I. Plate XXVII, fig. L) and is followed by the transverse division of the tongue cell (Plate XXV, figs. D and E. Plate XXVI, fig. I. Plate XXVII, figs. M and N). The derivatives of the basal cell continue to divide longitudinally to form the wall of the conceptacle (Plate XXV, fig. F. Plate XXVI, figs. J and K. Plate XXVII, fig. N). The tongue cell divides transversely to form a uniseriate filament of 4 cells in *M. quercifolia* and 6 or more cells in *M. integrifolia* and *M. latifolia* which project through the ostiole. The cells

(p.t.o.)

near the mouth of the conceptacles are formed from the peripheral layer of the meristoderm. Paraphyses develop as papillae from the wall-cells of the conceptacle and increase in size by the division of the basal cell and the elongation of the upper cells until they project through the ostiole. The cavity of the conceptacle enlarges by the continued division of the wall-cells while the ostiole remains narrow. As the cavity enlarges these hairs come to lie at the centre of the wall of the conceptacle (Plate XXV, fig. G. Plate XXVI, fig. L. Plate XXVII, fig. Q). In the meantime new papillae develop from the wall of the conceptacle on either side of the central parpahyses. These papillae develop paraphyses which are small, septate and unbranched with club-shaped end cells. Conceptacles are bisexual in the spec of *Myriodesma* investigated.

Development of antheridia.

An antheridium develops from the wall of the conceptacle similarly to a hair, but can be distinguished by its dense cytoplasmic contents and a large nucleus. An outgrowth develops from a wall cell of the conceptacle (Plate XXV, fig. Pa, Plate XXVII, fig. Ra). The papilla divides transversely forming the antheridium initial (Plate XXV, fig. Pb. Plate XXVII, fig. Rb), which further divides transversely to form an "antheridium proper" and a "stalk cell". The antheridium gradually elongates becoming club-shaped. Antheridia show considerable variations in their positions; they may be sessile, stalked or on branched hairs (Plate XXV, figs. P - T. Plate XXVI, figs. M and N. Plate XXVI, fig. Rb). A mature antheridium measures 20- 35µ x 10 - 15µ in M. integrifolia, 24 - 48 µ x 6 - 12 µ in M. quercifolia and 24 - 42 µ x 10 - 18 µ in M. latifolia. The antheridial wall is made up of exochite and endochite. Different stages of antheridia occur in the same conceptacles showing successive maturation of antheridia (Plate XXV, figs. Q - T. Plate XXVII, fig. R). Sperms are liberated through the apical pore. Development of antheridia are similar in M. integrifolia, M. quercifolia and M. latifolia.

Development of oogonia.

The cells from which the oogonia will be formed are located on the lower side of the conceptacle and develop from the wall-cells. Oogonial initials are distinguishable from the surrounding cells by their large size and large granular nuclei (Plate XXV, fig. I. Plate XXVII, fig. Sa). The oogonial initial divides transversely forming the oogonial cell proper and a stalk cell (Plate XXV, figs. J and K). The stalk cell remains embedded, in the three species, in the wall of the conceptacle. An oogonium contains dense chromatophores and food reserves. The youhg oogonium is spherical, becoming ovoid when mature and measures 50 - 80 μ x 40 - 50 μ in *M. integrifolia*, 95 - 150 μ x 40 - 108 μ in *M. quercifolia* and 95 - 175 μ x 42 - 108 μ in *M. latifolia*. Different stages of oogonial development occur in one conceptacle indicating successive oogonial maturation. Two to four nucleate stages in the oogonium have been observed (Plate XXV, fig. L. Plate XXVII, fig. S). Oogonia without a stalk are produced in these three species of *Myriodesma*. No paraphyses occur on the wall of the oogonium. The oogonial wall comprises exochite, mesochite and endochite, (Plate XXV, fig. M. Plate XXVI, fig. P. Plate XXVII, fig. Se). Oogonial development is similar in the three species of *Myriodesma*. Oogonia of *M. integrifolia* are smaller than those of *M. latifolia* and *M. quercifolia*.

Embryology.

Eggs of *M. latifolia* and *M. quercifolia* were liberated in sea-water some four hours after collection. They were fertilised within 40 minutes and became attached to the bottom of the dish by the secretion of mucilage. The zygote of *M. latifolia* measures 125 - 175 μ and that of *M. quercifolia* is 100 - 125 μ. The zygote first divides transversely

(Plate XXVI, figs. Q, R, ~~and P~~. Plate XXVII, figs. Tb, Te), within 18 hours to give one nucleus in each segment. The aecond division is vertical (Plate XXVI, figs. S, and T) to the first in the upper segment of the zygote of *M. latifolia* and is transverse in the lower segment of the zygote of *M. quercifolia*, forming a rhizoid cell (Plate XXVII, fig. Td). In the zygote of *M. latifolia* the third division is transverse in the lower segment (Plate XXVI, fig. U) and is vertical to the first in the upper segment of the embryo of *M. quercifolia* (Plate XXVII, fig. Te). The fourth division of the embryo of both *M. latifolia* and *M. quercifolia* is vertical in the middle segment (Plate XXVI, fig. V. Plate XXVII, figs. f, and g). Segmentation up to the fourth division was complete within 28 hours after fertilisation of the egg. The fourth division was followed by vertical divisions of the rhizoid cell in both species, developing four primary rhizoids (Plate XXVI, fig. Yb. Plate XXVII, fig. Th, Ti). By this time the embryo was many celled and it was not possible to observe further segmentation. After a week many rhizoids had been formed from the adjacent cells of the primary rhizoid. Rhizoids were septate and unbranched. In the second week an apical groove was formed in the embryo of *M. latifolia* and a single apical hair had developed from the groove (Plate XXVI, fig. Z). Further studies were not possible as the embryo died.

IV. EMBRYOLOGICAL STUDIES.

1. MATERIAL AND METHODS.

Material collected for embryological studies was brought into the laboratory either immersed in seawater or in plastic bags. Within an hour from the time of collection, receptacles were washed thoroughly in sea-water and placed in petri dishes, or on slides in filtered sea water. The receptacles were removed after 2 - 5 hours and the water was changed. Seawater, filtered three or four times, or Schreiber[1] or Erdschreiber[2] were used as culture media. The zygotes attached on the dishes or slides were shaken gently and were rinsed with the solution to remove debris. Attached zygotes on the dishes or on slides were kept under the following conditions.

A. Room temperature (18°C - 20°C) and under normal indoor conditions away from direct sunlight.

B. In a Cabinet at the following conditions.
    (1) 20 ± 2°C and 900 ft. candles.
    (2) 18 ± 1°C and 500 ft. candles.
    (3) 14 ± 1°C and 250 ft. candles.
    (4) 12 ± 1°C and 160 - 170 ft. candles.

C. The Shaking Apparaths.

(Plate XXVIII).

A shaking apparatus was designed to provide water movement similar to natural conditions of sea roughness in an attempt to culture embryos of the Fucales. It consisted of an electric motor, a carrier tray, six rectangular platforms in series in the tray and five fluorescent tubes (40 w. each) for illumination at a variable height above the cultures. The platforms are oscillated as follows:-

A master rod from the driving shaft connects to the six individual rods which respectively control the six shaking platforms. The far end of each rod is fixed by a cross-strut to the far end of the platform and the rate of platform oscillation can be regulated by means of a sliding connection between the near end of this rod and the upright linkage rod attached to the master rod. This connection may be fixed at any require position by means of a set-screw and when raised allows a greater arc of movement and hence a greater platform oscillation.

Slides carrying attached zygotes were immersed vertically in culture solution in plastic vessels. The platforms, each with one vessel were set to move at different speeds in order to provide varying degrees of roughness, and were lighted from above for 10 hours with dull day light during the day time. Under all conditions of water movement, embryos grew for only about one week.

The zygotes, attached on the slides or in dishes or vessels, were also grown in the cabinet and on laboratory benches at room temperature as well as on the shaking apparatus. The embryos grew well for up to a week in the above conditions without any appreciable difference. After a week those at room temperature in the laboratory and on the shaking apparatus died but most of those in the cabinet continued to grow for a period of almost three months. Embryos of *Cystophora polycystidea* and *C. subfarcinata* were grown in the cabinet at 14 ± 1°C. Young plants of *C. polycystidea* died soon after 6 months of growth, but those of *C. subfarcinata* were still growing after more than nine months in the cabinet.

Embedding.

Embryos were fixed either in 10% chromic acid or in equal parts of 1% chromic acid and 10% formalin. After thorough washing in seawater the embryos were placed on a thin film of 4% agar agar on slides. The agar was cut into small blocks containing groups of embryos and these blocks were dehydrated and embedded in the usual manner. Microtome sections 4 - 8 µ in thickness were cut.

CULTURE SOLUTION.

1. Schreiber's culture solution.

$NaNO_3$	0.1	gm.
Na_2HPO_4..	0.02	gm.
Distilled water	50.0	cc.
Sea water	100.0	cc.

2. Erdschreiber's culture solution.

(as prepared at the Plymouth Laboratory).

Filtered sea water.	1000.0	cc.
Soil extract..	50	cc.
$NaNO_3$....	.2	gm (4 cc. of 5%)
$Na_2HPO_4,12H_2O$.	.03	gm (3 cc. of 1%)

1st Day.

Filter seawater through Whatman No. 1 filter paper and then heat to 73°C. Allow to cool.

2nd Day.

1) Again heat the sea water to 73°C and allow to cool.
2) Autoclave the soil extract at 15 lb. pressure for 30 minutes.
3) Autoclave salt solution (made up in distilled water so that 1 cc. of each solution gives required amount for 1000 cc. of culture solution).

3rd Day.

Add cold salt solution to cold soil extract and then add soil extract to cold seawater. Allow culture solution to reach temperature of cultures to be subcultured before using. Add 1 cc. iron versene solution.

Soil Extract.

1 Kg. finely sieved garden soil to 2000 cc. tap water. Autoclave for 1 hour at 10 lb. pressure. Allow soil to settle and use clear liquid, but if needed quickly centrifuge to clear.

Iron - E.D.T.A. Solution (Jacobsen's)

Dissolve 21.6 gm. E.D.T.A. (ethylene diamine tetracetic acid, (Versene in U.S.A.) in water. Add 24.9 gm. $FeSO_4$, $7H_2O$.

Dilute to 1000 cc. Aerate overnight (active bubbling). pH should then be 5.5.

2. EMBRYOLOGY.

Fertilisation has been observed in Cystophora retorta C. subfarcinata, C. cephalornithos, C. uvifera, C. polycystidea C. intermedia, C. platylobium, Scaberia agardhii, Cystophyllum muricatum, Myriodesma latifolia and M. quercifolia after the extrusion of eggs in filtered sea-water in petri dishes. After fertilisation the zygotes are attached to the substratum by mucilaginous secretion. In each case the zygotes are spherical or ovoid and measure 75 - 100 µ across in Cystophora, 125 - 150 µ across in Scaberia, 130 - 190 µ across in Cystophyllum, and 100 - 175 µ across in Myriodesma. Zygotes remain attached to the receptacles in a mucilaginous sheath in. C. muricatum and this has also been observed in Cystophora moniliformis. The zygotes of C. cephalornithos become horizontally flattened on the petri dish and the surface appears rough due to the aggregation of dead sperms. This has not been seen in other species investigated. Segmentation of the zygotes occurs, in each case, within 18 hours after fertilisation at room temperature (18°C - 20°C). A cross wall is first formed across the zygote, in each case, with the differentiation of upper and lower cells showing polarity

(Plate XIV, figs. C and I, Plate XV, figs. Bb, C2, Db. Plate XX, fig. G. Plate XXII, fig. K. Plate XXVI, fig. G. Plate XXVII, fig. T b, Tc). A second segmentation occurs vertically to the first division in the upper cell of the zygote of *Scaberia agardhii*, *Cystophyllum muricatum* and *Myriodesma latifolia* (Plate XX, fig. H. Plate XXII, fig. L. Plate XXVI, figs. S. and T), but the second division is transverse in the lower cell of the zygote of the species of *Cystophora* studied and *M. quercifolia* (Plate XIV, fig. D) (Plate XV, figs. Bc, C4, De, Plate XVII, fig. Td) forming the rhizoid initial. A third segmentation of the zygote of *S. agardhii*, *C. muricatum* and *M. latifolia* is transverse in the lower cell forming the rhizoid initial (Plate XX, fig. I Plate XXII, fig. M. Plate XXVI, fig. U), whereas it is vertical to the first division in the upper cell of the *Cystophora* specie and *M. quercifolia* (Plate XIV, fig. E. Plate XV, figs. Bd, Dd, Plate XXVII fig. Te). The fourth segmentation is vertical to the middle cell of the zygote in each case (Plate XIV, fig. F. Plate XV, figs. Bf, C5, De, Plate XX, fig. J. Plate XXII, fig. N. Plate XXVI, fig. V. Plate XXVII, figs. Tf and Tg). This is followed by a longitudinal division of the rhizoid initial into 2 halves in the species of *Cystophora* and *Scaberia agardhii* forming 2 primary rhizoid cells (Plate XIV, fig. G. Plate XV, figs. Bg, C6, Dg. Plate XX, fig. J) but in *C. muricatum*

AND *Myriodesma* species there are three successive longitudinal divisions of the rhizoid initial to form 4 primary rhizoid cells (Plate XXII, figs. P - R, Plate XXVI, fig. Yb. Plate XXVII, fig. Th, Ti). Each of these rhizoid cells develops into a rhizoid. Further segmentation of the zygote is less easy to follow because there is heavy pigmentation of the cells. A multicellular body with two rhizoids is thus developed in the case of *S. agardhii* and the species of *Cystophora* (except *C. uvifera* where a single rhizoid is developed first) while 4 rhizoids are developed in *C. muricatum* and *Myriodesma* species. In the meantime the body of the embryo increases in length and breadth, and the rhizoids increase in number in *S. agardhii*, *C. muricatum* and *Myriodesma* species. In most species of *Cystophora* studied the number of rhizoids at early stage is 4 but *C. uvifera* possesses more rhizoids than this (Plate X, figs K). Abnormal development of zygotes may occur in *C. subfarcinata* and *C. retorta*. In these cases occasional zygotes are ellipsoidal and divide along the short axis into two cells (Plate XIV, figs. H and I). The next divisions occur transversely in each cell near the narrow end forming a single rhizoid cell at each end (Plate XIV, fig. J. Plate XV, fig. Dk). Further segmentation has not been observed but a number of rhizoids develop at each end (Plate IX, figs. G and H). This type of embryo has been termed a double embryo spore in *Sargassum piluliferum* (Hiroe and Inoh, (1955) and in *S. sagamianum* (Inoh, 1955).

By this time the embryos are attached to the substratum by means of rhizoids and the body of the embryo is raised up. The rhizoids grow rapidly and the body elongates. The rhizoids are septate and usually unbranched in each case. The mucilage layer of the embryos, in each case is pushed off on one side before the development of the apical groove. First a single hair develops from the apical groove of an embryo and is followed by 2 or more hairs from the same apical groove. In *Scaberia agardhii*, *Cystophyllum muricatum* and *Cystophora* 4 to 8 hairs are common but up to 16 apical hairs have been observed. Only 2 apical hairs were observed in *Myriodesma*. They are delicate, unbranched, with basipetal development from the lining cells of the apical groove. They are fragile and usually break off very soon, but may last for up to 4 or 6 months in *Cystophyllum muricatum*. A swelling of one of the cells of the apical hair occurs in the embryo of *Cystophora subfarcinata*; this has not been reported in other Fucales.

Floating embryos of Cystophyllum muricatum, in culture, grow more rapidly than attached ones. As the embryo grows in length tufts of hairs develop in different places on the body of the embryo, Thus originating branches.

Embryos have been grown up to three months but further growth has been inhibited by bacterial growth. The measurement of the body of the embryos are given below:

Species.	Duration.	Measurement.
Scaberia agardhii	5 months.	300 - 600 µ x 190 - 305 µ
Cystophyllum muricatum	40 days	875 - 2000µ x 175 - 250 µ
Cystophora subfarcinata	75 days	250 - 500 µ x 100 - 125 µ
C. polycystidea	75 days	225 - 350 µ x 100 - 125 µ
C. retorta	75 days	200 - 300 µ x 100 - 125 µ
C. cephalornithos	75 days	250 - 375 µ x 150 - 200 µ
Myriodesma latifolia	10 days	375 - 925 µ x 150 - 225 µ
M. quercifolia	6 days	208 - 260 µ x 100 - 120 µ

The origin of the eapical cell in the embryos has not been observed. A mature triangular apical cell has howeve been observed in the transverse section of the apex of the embryos of C. retorta, C. polycystidea and C. subfarcinata. There is also differentiation into the three usual tissues — the meristoderm, the cortex and the medulla (Plate XIV, figs. R - T).

Embryos of Cystophora polycystidea and C. subfarcinata have been grown successfully in the cabinet at 14 ±1°C up to 4 mm. long and 1.2 mm. broad and 8mm. long, 1.5 mm. broad respectively. The branches of C. polycystidea measured 4 mm. long and 0.3 mm. broad after 6 months growth while those of C. subfarcinata were 13 mm. long, 1 mm. broad after 9 months growth in the cabinet. A discoid holdfast developed in 6 months in both species. Sterile conceptacles with paraphyses projecting through the ostiole developed on the branches in both species, Plate XV A, figs. A - F.

V. DISCUSSION OF ANATOMY AND EMBRYOLOGY.

The Fucales are a widely distributed group of the brown algae and are regarded as having attained the highest level of morphological and anatomical differentiation (Delf, 1939b; Fritsch, 1945b; 1952). This section will be concerned with a general discussion of the anatomy of the Australian species described in the previous section, in relation to the anatomy of other Fucales as described in the literature.

The Apical Cell.

Apical cells of Cystophora, Cystophyllum, Carpoglossum, Myriodesma and Scaberia are situated at the base of the flask or funnel-shaped apical depressions similar to those at the apices of Cystoseira (Valiante, 1883), Sargassum (Oltmanns, 1889), Halidrys (Oltmanns, 1889. Fritsch, 1945a), Carpophyllum (Delf, 1939a). The apical depression in each Australian genus mentioned above contains a single three-sided apical cell which is biconvex in longitudinal section and triangular in transverse section like that of Cystoseira (Gruber, 1896. Valiante, 1883), Himanthalia (Naylor, 1951. Oltmanns, 1889. Rostafinski, 1876), Sargassum (Oltmanns, 1889) (Hansteen, 1892. Gruber, 1896), Halidrys (Fritsch, 1945a. Gruber, 1896. Oltmanns, 1889) and Bifurcaria (Gruber, 1896. Oltmanns, 1889. Rees, 1933). Authors describe apical cells of somewhat varying shape. Reinke (1876) described a large pyramid-shaped apical cell in Cystoseira, Sargassum, Cystophora and Cystophyllum, but Valiante (1883) described the apical cell of Cystoseira as wedge-shaped. Bifurcaria tuberculata (Rees, 1933) possesses an apical cell of "Brazil nut " type and Rees regarded this as the best anology for the shape of the apical cell in longitudinal section. In *Bifurcariopsis capensis* (Laing, 1941), the apical cell, in longitudinal section, is almost a circular structure, quite unlike that of the lens-shape cell in *Bifurcaria tuberculata* (Rees, 1933). The apical cell in *Carpophyllum flexuosum* (Dawson, 1940), is a truncated pyramid in shape rather than spindle shaped. All authors agree that apical cells in the genera discussed above, are triangular in cross sections.

Oltmanns (1889) and Gruber, (1896) regarded three sided apical cell as a diagnostic feature of the Cystoseiraceae, Sargassaceae and Loriformes, but Schmidt (1938) combined the Cystoseiraceae in the Sargassaceae and renamed the Loriformes as the Himanthaliaceae without giving any reasons.

The segmentation of apical cells in *Cystophora*, *Cystophyllum*, *Carpoglossum*, *Myriodesma* and *Scaberia* occurs longitudinally on the three faces, then these segments divide transversely to form curved rows of cells, the uppermost derivatives of which form the meristoderm. The lowermost cells contribute to the medulla and the middle cells build up the cortex. The segmentation of the apical cell and the origin of the tissues in the above genera follow the same course as in *Halidrys siliquosa* (Fritsch, 1945a. Oltmanns, 1889), *Bifurcaria tuberculata* (Rees, 1933), *Bifurcariopsis capensis* (Laing, 1941), *Cystoseira* (Valiante, 1883), and *Himanthalia lorea* (Rostafinski 1876. Oltmanns, 1889, Naylor, 1951, Wille 1910).

Vegetative growth in *Phyllospora*, *Scytothalia*, *Seirococcus* and *Xiphophora* is initiated by 4-sided apical cells which occur at the base of the apical depression as desc ribed by Gruber (1896). Apical cells of the above four genera are similar to the apical cells of *Fucus* and *Pelvetia* (Hansteen, 1892, Holtz, 1903, Kny, 1872, Oltmanns, 1889, Reinke, 1875, Rostafinski, 1876. Subrahmanyan, 1956). However, the present investigation of the growing points of *Phyllospora*, *Scytothalia* and *Seirococcus* ~~and~~ ~~*Xiphophora*~~ shows that there are more than one 4-sided apical cells involved in the apex. The apex of *Scytothalia* and *Seirococcus* possesses 2 apical cells, one in each apical depression on either side of the round apical disc, while *Phyllospora* has more than one apical cell in the single depression. The apex of *Xiphophora* possesses only a single 4-sided apical cell.

In *Phyllospora*, *Seirococcus* and *Scytothalia* longitudinal segmentation occurs on the lower sides and then transverse segmentation towards the base similar to that in *Pelvetia fastigiata* (Holtz, 1903). This contrasts with *Fucus* (Oltmanns, 1889; 1922), and *Pelvetia canaliculata*

(Subrahmanyah , 1956) where transverse segmentation first occurs towards the base, followed by longitudinal segmentation on the narrower faces. The longer segments divide transversely to form rows of cells, the uppermost derivatives of which form the meristoderm and the middle ones form the cortex. The lowermost cells of the longer segments and the derivatives of the basal segment build up the medulla.

In Xiphophora gladiata and X. chondrophylla transverse segmentation occurs first towards the base of the apical cell and then longitudinally on the other faces. Naylor (1954a) describes the segmentation on the convex sides of the apical cell in X. chondrophylla. The present investigation of segmentation in the apical cell of the species of Xiphophora shows it to resemble the segmentation of the apical cell of Fucus as described by Oltmanns (1889, 1904, 1922) and that of Pelvetia canaliculata described by Subrahmanyan (1956). The uppermost cell gives rise to the meristoderm while the lowermost cells contribute to the medulla, and the middle cells form the cortex. Oltmanns (1889), Gruber (1896) and Schmidt (1938) considered a single 4-sided apical cell a characteristic feature of the Fucaceae. Gruber and Schmidt placed the above genera under this family but Oltmanns (1889) placed Phyllospora, Scytothalia and

Seirococcus in the Sargassaceae and Xiphophora doubtfully among the Loriformes.

Meristoderm.

The surface growth of the thallus increases by the meristematic activity of the meristoderm cells. The meristoderm generally consists of a single layer of radially elongate cells in the sub-apical regions and is covered by a thick mucilaginous cuticle which is sometimes lamellate. Usually the meristoderm continues throughout the whole thallus as a single layer of cells, as in Bifurcaria tuberculata (Rees, 1933), but a greater number of layers up to 4 or 6 occurs near the basal part of the axis and in the stipe. Xiphophora gladiata possesses a single layer of meristoderm cells near the apical region and further down but the meristoderm becomes 2-6 layers of cells in the basal parts of the axis and the stipe. Usually a single layer of meristoderm cells occurs throughout the thallus in Xiphophora chondrophylla but occasionally 2 or more layers of cells occur similar to those described by Barton (1893), Heine (1932) Mitchell (1941) and Naylor (1954a).

The lateral walls of the meristoderm cells are thick and lamellate in Scytothalia, Seirococcus and Phyllospora and are strongly thickened in Xiphophora like those of Himanthalia *lorea* (Naylor, 1951, Wille, 1910). In all the genera studied the inner cross walls are thin and pitted in *Himanthalia* (Wille, 1910. Naylor, 1951), *Bifurcaria* (Rees, 1933), *Pelvetia* (Holtz, 1903. Hansteen, 1892), *Fucus* (Hansteen, 1892. Oltmanns, 1889). *Ascophyllum* (Oltmanns, 1889). The lateral walls of the meristoderm cells in *Cystophora*, *Cystophyllum*, *Carpoglossum*, *Myriodesma* and *Scaberia* are thin, similar to those of *Pelvetia fastigiata* (Holtz, 1903) and *Bifurcaria tuberculata* (Rees, 1933).

Cortex.

The cortex is generally composed of many layers of compact and isodiametric cells in *Cystophora*, *Cystophyllum*, *Scaberia*, *Myriodesma* and *Carpoglossum* like those of *Halidrys siliquosa* (Fritsch, 1945a) but in *Scytothalia*, *Seirococcus*, and *Xiphophora* the cortical cells are loosely arranged due to abundant mucilage accumulation. Two distinct regions are often distinguished in the cortical region. Beneath the meristoderm are 2 or 3 layers of small, thin walled cortical cells containing numerous chromatophores; these cells have been derived from the meristoderm. Internal to this is a region about 4 cells deep composed of large cells. The walls of these cells are thick, lamellate and pitted. The innermost cells of the cortical region are more elongate and grade into the medulla as described in other members of the Fucales by Fritsch (1945b, 1952), Naylor (1949a, 1954a), Pennington (1937) and Subrahmanyan, (1956). The inner cortical cells of *Scytothalia*, *Seirococcus* and *Phyllospora* contain dense contents and in *Xiphophora* most of the cortical cells contain dense chromatophores. The cell walls are thick, lamellate and pitted, especially in the lower parts of the plant. In the basal parts of the axis and in the stipe the cortical cells contain dense chromatophores. Hyphae often develope as outgrowths from the inner cortical cells. Wille (1910) and Naylor (1951a) described an outer zone of assimilatory cells and an inner zone of mechanical cells in *Himanthalia lorea*. Such zones have also been observed in *Fucus* (Hansteen, 1892. Moss, 1948. Pennington, 1937), in *Pelvetia* (Hansteen, 1892; Subrahmanyan, 1956) and in *Halidrys siliquosa* (Fritsch, 1945a), as well as in various Laminariales (Sauvageaue, 1918). According to Wille (1910), Rees (1933) and Subrahmanyan (1956) the thick walled inner cortical cells containing dense fucosan are storage as well as mechanical cells. This is probably also true of the thick-walled cells in the basal part of the axis and the stipe of all the genera studied.

Henckel (1912) regards the thickening as functioning as water storage tissue in *Pelvetia canaliculata*.

Medulla.

The medulla is generally composed of many layers of narrowly elongate cells in *Cystophora*, *Cystophyllum*, *Myriodesma*, *Carpoglossum* and *Scaberia* but these cells are large and elongate in *Phyllospora*, *Seirococcus*, *Scytothalia* and *Xiphophora*. The lateral walls of the medullary cells are strongly thickened, lamellate and pitted. The cross walls, however, always remain thin. A little mucilage is formed in the medullary region of *Cystophora*, *Cystophyllum*, and *Scaberia* as is found also in *Bifurcaria* (Rees, 1933), and in *Halidrys* (Fritsch, 1945a. Le Touze, 1912). Mucilage formation is abundant in the medullary region of *Myriodesma*, *Carpoglossum*, *Phyllospora*, *Scytothalia*, *Seirococcus* and *Xiphophora*. The medullary cells become separated due to this mucilage accumulation and this is very pronounced in *Xiphophora* and *Hormosira* as in *Fucus*. Active surface growth stretches the medullary cells, which then tend to be irregularly displaced in *Scytothalia*, *Seirococcus*, *Phyllospora* and *Xiphophora*. The stretching of medullary cells has been observed in *Halidrys siliquosa* (Fritsch, 1945a) and in *Marginariella urvilliana* (Naylor, 1953b). Medullary cells usually contain sparse chromatophores but in *Xiphophora* these are more abundant.

Development and occurrence of hyphae.

Hyphae do not occur in the apical and in the subapical regions of the thallus. Most of the thallus of *Cystophora*, *Cystophyllum*, *Carpoglossum*, *Myriodesma* and *Scaberia* is completely devoid of hyphae but a considerable number of hyphae occur near the basal parts of the axis and the extreme basal parts of the branches. The development of hyphae has been described in *Sargassum bacciferum* (Hansteen, 1892), *Halidrys siliquosa* (Oltmanns, 1889. Fritsch, 1945a), *Himanthalia lorea* (Naylor, 1951. Oltmanns, 1889. Wille, 1910), as well as in *Bifurcaria* ~~and~~ (Rees, 1933) and *Bifurcariopsi* (Laing, 1941).

In *Phyllospora*, *Seirococcus*, *Scytothalia* and *Xiphophora* hyphal growth occurs in most parts ~~but~~ except the apical regions of the plant but in *Fucus* (Oltmanns, 1889. Moss, 1948 Pennington, 1937) and *Pelvetia* (Hansteen, 1892. Subrahmanya 1956) the hyphae occur throughout the thallus. In *Hormosira banksii* (Osborn, 1948) and in *Fucus* (Oltmanns, 1889) hyphae also occur in the medullary region of the embryos.

In the above genera hyphae occur in the inner cortex and the medulla and these hyphae run longitudinally downward following a tortuous course. They are septate and unbranched.

Hyphal cells contain dense brown contents and chromatophores so the cells of hyphae may function as storage cells similar to those described in *Pelvetia* and *Fucus* (Hansteen, 1892. Pennington, 1937. Subrahmanyan, 1956. Wille, 1910). The hyphae may establishe connections with other medullary cells. In the holdfast and in the stipe the medullary cells are outnumbered by the hyphae in all the genera studied.

Development of laterals.

Laterals also grow by means of a single apical cell situated in an apical depression like that of the axis. The apical cells are 4-sided in *Phyllospora*, *Seirococcus*, *Scytothalia*, and *Xiphophora* and 3-sided in *Cystophora*, *Cystophyllum*, *Carpoglossum*, *Myriodesma* and *Scaberia*. Apical cells of laterals of all genera develop from initials situated on the sides of the apical depressions of the main axis as in *Pelvetia canaliculata* (Subrahmanyan, 1956).

Segmentation of apical cells of laterals follow the same course as the apical cells of the main axis. Mature laterals do not have any apical cell. Gruber (1896) describes the development of lateral initials on the sides of the apical depressions in *Seirococcus axillaris* but failed to locate any apical cell in the laterals of *Seirococcus*, Scytothalia and Phyllospora. Young laterals of these genera do however possess apical cells.

Development of receptacles.

Development of the receptacle occurs from a single apical cell similar to the apical cell of the axis, branches and laterals. The receptacles of Cystophora, Cystophyllum, Carpoglossum and Myriodesma possess 3-sided apical cells similar to those of Turbinaria (Barton, 1891. Blomquist, 1945), Carpophyllum, (Dawson, 1940. Delf, 1939a), Himanthalia lorea (Naylor, 1951) and Cystoseira osmundacea (Fensholt, 1955). The 3-sided apical cell, as discussed before, is the characteristic feature of the Himanthaliaceae, Sargassaceae and Cystoseiraceae (Gruber, 1896. Schmidt, 1938). No apical cell has been observed in the receptacles of Phyllospora and Seirococcus though they doubtless occur in very young receptacles. The fertile segment (receptacle), of Xiphophora possesses a single 4-sided apical cell as described by Naylor (1954a), similar to those of Fucus (Nienburg, 1931) and Pelvetia (Subrahmanyan, 1956). It is most interesting to observe in the young receptacle of Scytothalia, however, a 3-sided apical cell, in cross section, which contrasts with the 4-sided vegetative apical cell. Segmentation of the apical cell is similar to that of vegetative apical cell of *Scytothalia*.

Internally the receptacle is composed of meristoderm, cortex and medulla. The meristoderm is always a single layer of oblong cells, as observed in *Himanthalia lorea* (Naylor, 1951). The cortical cells and the medullary cells are loosely arranged in the receptacles of *Scytothalia*, *Seirococcus* and *Xiphophora*. The cortex in the receptacle of *Phyllospora* is differentiated into small cortical cells and large inner cortical cells containing dense contents, and the medullary cells are loosely arranged.

In the receptacles of *Cystophora*, *Cystophyllum*, *Scaberia*, *Myriodesma* and *Carpoglossum* the cortical cells are large and compact, and the medullary cells are elongate. The walls of the cortical cells, and the medullary cells are thick, lamellate and pitted. Scalariform thickening of walls of the medullary cells occurs in the receptacle of *Phyllospora* and *Scytothalia*.

In *Himanthalia lorea* (Naylor, 1951), the cortical cells are thick-walled and the medullary cells are thin-walled. The tissues of the receptacle and the vegetative parts are continuous from one into the other in all the genera studied as has been demonstrated in *Turbinaria* (Barton, 1891), and in *Himahthalia lorea* (Naylor, 1951). Hyphae do not occur in any part of the receptacle of *H. lorea* (Naylor, 1951). Mucilage producing hairs with slightly swollen terminal cells have been reported in the apical depression of the receptacle of *Bifurcariopsis capensis* (Laing, 1941) but this type of hair does not occur in any of the genera studied.

Development of conceptacles.

Earlier authors describe different types of development of conceptacles in the Fucales, not only in different genera but even within one species. These developments are summarised below.

(1) In *Fucus*, *Ascophyllum*, *Halidrys* and *Himanthalia* the initial cell of the conceptacle does not take part in the development of the conceptacle but the cortical basal cell of the initial cell forms the wall of the conceptacle (Bower, 1880).

(2) The conceptacle development in *Cystoseira* is initiated by the surrounding tissues of the initial cell (Valiante, 1883. Dodel-port, 1885).

(3) Disintegration of the initial cell occurs in *Himanthalia* but it is persistent in *Ascophyllum* to form reproductive organs (Oltmanns, 1889).

(4) In *Halidrys siliquosa* the upper part of the initial cell disappears, the middle part forms the hair and

the basal part forms the wall of the conceptacle (Oltmanns, 1889).

(5) Disintegration of one or more meristoderm cells causes the development of conceptacles in Pelvetia fastigiata (Holtz, 1903).

(6) According to Moore (1928) the longitudinal division of the conceptacle initial in P. fastigiata is followed by transverse division of each cell near its base; each tongue cell produces a hair and the basal cell forms the wall of the conceptacle.

(7) In P. canaliculata the tongue cell does not form a hair (Subrahmanyan, 1957a).

(8) In Sargassum filipendula the conceptacle initial may divide by a curved septum to form an upper tongue cell developing a hair and a lower basal cell to form the wall of the conceptacle (Simons, 1906).

(9) In Hormosira, Fucus and Sargassum the conceptacle is formed by the modification of the meristoderm cell; the basal cell of which forms the wall of the conceptacle (Roe, 1916). According to Getman (1914) Hormosira banksii follows Bower's Theory of development of conceptacle but Osborn (1948) follows Simons' and Nienburg's outline.

(10). In *Halidrys dioica* (Doubt, 1928), *Marginariella* (Naylor, 1953b), *Bifurcaria* (Rees, 1933), *Bifurcariopsis* (Laing, 1941), *Cystoseira geminata*, *C. osmundacea* and *Sargassum muticum* (Fensholt, 1955) the tongue cell forms a many-celled hair and the basal cell forms the wall of the conceptacle.

(11). The tongue cell remains undivided in *Carpophyllum maschalocarpum* and *C. elongatum* (Delf, 1939a) but in *C. flexuosum* it forms a small hair (Dawson, 1940) while in *C. plumosum* it disintegrates (Naylor, 1953c).

(12). In *Turbinaria turbinata* the tongue cell disintegrates in the female conceptacles while it produces paraphysis in the male conceptacle (Blomquist, 1945).

Development of the conceptacle was studied in *Cystophora*, *Cystophyllum* and *Myriodesma* but not in other genera of the southern Australian Fucales as suitable developmental stages were not present in the material investigated. The conceptacles in *Cystophora*, *Cystophyllum* and *Myriodesma* develop from an initial cell cut off from a segment of the apical cell. The initial cell is more or less flask-shaped as in Cystoseira (Nienburg, 1913. Valiante, 1883), Sargassum (Simons, 1906. Tahara, 1940a, 1940b) and in Carpophyllum (Delf, 1939. Dawson, 1940). The initial cell divides transversely by a curved wall similar to that of Sargassum filipendula (Simons, 1906) Fucus, Cystoseira, Halidrys, Pelvetia, Bifurcaria, and Ascophyllum (Nienburg, 1910). It is followed by divisions of the basal cell and the products of the basal cell to form the wall of the conceptacle as in the other genera discussed above. Division of the adjacent cells leads to the gradual sinking of the derivatives of the basal cell and to the separation of the tongue cell from the other tissues. In Cystophora and Cystophyllum the tongue cell forms a hair of 3 or 4 cells as in Cystoseira geminata and C. osmundacea (Fensholt, 1955) but in Myriodesma the tongue cell produces a uniseriate hair with a large basal meristematic cell like that of Bifurcaria (Rees, 1933), Bifurcariopsis (Laing, 1941), and Marginariella urvilliana (Naylor, 1953b) and this hair protrudes through the ostiole. The production of hairs in the young conceptacles is regarded as a common feature in the Sargassaceae and the Cystoseiraceae (Schmidt, 1938); they have been also reported in the Fucaceae.

The division of the conceptacle initial and the formation of hairs cannot be regarded as a diagnostic feature in classification of the families as considered by Schmidt (1938) and Naylor (1953b), because of the great variations in the development of the conceptacle. The division of initials and formation of hairs differs not only among the genera, but also among the species in *Pelvetia*, *Bifurcaria*, *Carpophyllum*, *Fucus*, *Turbinaria* and *Cystoseira*.

Sterile conceptacles occur near the base of the receptacle in *Cystophyllum muricatum*, *Carpoglossum confluens* and *Myriodesma*. The vegetative parts of *Cystophora uvifera*, *C. cephalornithos* and the slender leaves and vesicles of *Cystophyllum muricatum* bear sterile conceptacles similar to those of *Sargassum filipendula* (Simons, 1906). Hairs in the sterile conceptacles in *Turbinaria* (Barton, 1891), *Hormosira*, (Getman, 1914. Osborn, 1948), and *Marginariella* (Naylor, 1953b) grow by means of basal meristematic cells.

Reproductive organs.

Reproductive organs are borne within the conceptacles in the Fucales and the distribution of conceptacles varies considerably in different genera and even within one species, as described by Kniep (1925) and Fritsch (1945b, 1952). The southern Australian genera *Carpoglossum* (except *C. quercifolium*)

Cystophyllum, *Myriodesma*, *Scaberia*, *Xiphophora*, *Scytothalia*, *Seirococcus* and *Cystophora* are monoecious and bear bisexual conceptacles . *Phyllospora comosa* is dioecious but has been described as monoecious by Smith (1893), Gruber (1896) and Fritsch (1945b; 1952). *Scytothalia* and *Seirococcus* possess both bisexual and unisexual conceptacles on the same receptacle.

Development of oogonia.

Oogonia develop from lining cells of the conceptacle, which corresponds with the oogonial development in other genera except *Durvillea* (Whitting, 1893. Herriot, 1923. Naylor, 1949b, 1953a, Skotsburg, 1907) where oogonia are usually borne on much branched hairs. The southern Australian genera generally bear oogonia anywhere within the conceptacle, but in *Turbinaria turbinata* Blomquist 1945 (~~Rees, 1933~~) oogonia develop only from the basal region of the conceptacle. The oogonial mother cells are distinguishable from the surrounding cells by their large size and large nuclei. The arrangement of oogonia in the southern Australian genera, does not however, agree with that of *Carpophyllum* (Dawson, 1940, Delf, 1939a) where the oogonia are spirally arranged. The oogonial initial divides transversely into a stalk cell and an upper oogonium mother cell but does not divide further. Delf (1939a) reported that the cutting off the stalk cell is variable in Carpophyllum. The stalk cell does not function as a stalk cell in raising the oogonium as it does in Fucus (Oltmanns, 1889), Xiphophora (Heine, 1932) and in Pelvetia fastigiata (Moore, 1928) but is completely embedded and remains non-functional as found in Sargassum (Nienburg, 1910, Kunieda, 1928) and in Carpophyllum flexuosum (Dawson, 1940). As the oogonium enlarges its contents increase and the stalk cell becomes flat. The oogonium during the process of maturation undergoes three successive nuclear divisions, as in Fucus (Farmer and Williams, 1896. Yamanouchi, 1909), Cystoseira and Sargassum (Nienburg, 1910), Bifurcaria tuberculata, (Rees, 1933), Pelvetia canaliculata (Subrahmanyan, 1957a) and Marginariella urvilliana (Naylor, 1953b). Oogonia generally increase considerably in size and in diameter before the 8-nucleate stage. This has been reported in Hormosira banksii (Osborn, 1948), in Pelvetia fastigiata (Holtz, 1903. Moore , 1928, Roe, 1916), and in Marginariella urvilliana (Naylor, 1953b). The increase in oogonium size is more pronounced in Phyllospora, Scytothalia and Seirococcus than in Cystophora, Cystophyllum, Carpoglossum, Scaberia and Myriodesma. Eight nuclei are more or less centrally placed in the oogonium of Cystophora, Myriodesma, Scaberia and Carpoglossum as also in

Carpophyllum plumosum (Naylor, 1953c) and Bifurcaria tuberculata (Rees, 1933), but the nuclei are scattered in the oogonia of Phyllospora, Seirococcus and Scytothalia. Centrally located nuclei and scattered nuclei may be considered as a diagnostic feature of the Cystoseiraceae and the Seirococcaceae respectively. One of the eight nuclei remains functional at the centre of the oogonium and the other seven nuclei move towards the periphery where they disintegrate. Cystophora, Cystophyllum, Myriodesma, Scaberia, Carpoglossum, Seirococcus, Scytothalia and Phyllospora each produces a single egg as in Sargassum (Abe, 1938. Gruber, 1896. Hansteen, 1892. Kunieda, 1928. Nienburg, 1910. Oltmanns, 1889. Tahara, 1913), Carpophyllum (Dawson, 1940), Himanthalia, Halidrys and Cystoseira (Gruber, 1896. Nienburg, 1910. Oltmanns, 1889).

The oogonia, without exochite, of Cystophyllum muricatum are extruded at the eight nucleate stage and remain attached to the receptacle by the mucilaginous stalk. Degeneration of seven nuclei occurs near the periphery as in Sargassum (Kunieda, 1926), in Bifurcaria (Rees, 1933), and in Marginariella (Naylor, 1953b). Maturation of oogonia of Myriodesma, Scytothalia, Seirococcus and Phyllospora, is successive as in Cystoseira foeniculacea (Dawson, 1941), *Bifurcaria tuberculata* (Rees, 1933), *Hormosira* (Osborn, 1948), *Durvillea* (Naylor, 1949b) and *Cystoseira* (Fensholt, 1955). However the oogonia of *Cystophyllum*, *Carpoglossum* and *Scaberia* mature simultaneously as in *Turbinaria turbinata* (Blomquist, 1945), *Sargassum muticum* (Fensholt, 1955), and *Marginariella urvilliana* (Naylor, 1953b). The maturation of oogonia in *Cystophora* varies from species to species. Mature oogonia are ovoid and the wall of the oogonium in all the Southern Australian genera is composed of exochite, mesochite and endochite, in contrast to *Hormosira* (Osborn, 1948) and *Turbinaria turbinata* (Blomquist, 1945) where only two oogonial walls occur.

In the apical region of the oogonium of *Cystophyllum muricatum*, the mesochite thickens more rapidly than elsewhere and forms a cushion or pad which was first observed in *Sargassum horneri* (Kunieda, 1928) and later in *Cystophyllum* (Delf, 1939a. Inoh, 1937a), *Bifurcaria* (Delf, 1935), *Bifurcariopsis* (Laing, 1941), *Carpophyllum* (Dawson, 1940. Delf, 1939a), *Coccophora* (Tahara, 1928), *Marginariella* (Naylor, 1953b. Delf and Hyde, 1936. Delf, 1937), *Hizikia* (Inoh, 1937b. Tahara, 1929a) and in several species of *Sargassum*. The extruded oogonia, without exochite, of *Cystophyllum muricatum* remain for some days firmly attached to the interior of the conceptacle by means of mesochiton stalks as in *Sargassum* (Kunieda, 1928), *Carpophyllum flexuosum* (Dawson, 1940) and *Cystoseira foeniculacea* (Dawson, 1941).

Mesochiton collars occur near the apical parts of the oogonia of *Phyllospora*, *Scytothalia* and *Seirococcus* as in *Marginariella* (Delf, 1937. Delf and Hyde, 1936). Dawson (1941) reports the growth of hairs on the outer wall of the oogonia of *Cystoseira foeniculacea*, but such hairs do not occur in any of the southern Australian genera.

Submergence and exposure of receptacles of *Cystophora* and *Scaberia* helps in the extrusion of eggs but the liberation is most vigorous when the plants undergo a period of exposure to air of 2 or 3 hours. Oogonia are discharged along the whole length of the receptacle until all the eggs have been extruded, thus differing from *Sargassum enerve*, and *S. horneri* (Tahara, 1913) and corresponding with *Marginariella* (Naylor, 1953b). In most of the collections of *Cystophora muricatum* extruded oogonia, without exochite, attached to the receptacle within mucilage have been found. These oogonia become detached in sea-water within three days due to the dissolution of mucilage. Three distinct zones bf extruded oogonia occur on the receptacle of *Cystophwllum muricatum*, ~~as~~ as ih *Turbinaria turbinata* (Blomquist, 1945). There is a periodic discharge of oogonia in the Japanese *Cystophyllum* (Inoh, 1937a. Tahara, 1913) and in *Hizikia fusiformis* (Tahara, 1929a) but this has not been observed in any of the southern Australian genera.

Xiphophora produces four eggs, as recorded by Barton (1893), Mitchel (1941), Heine (1932) and Naylor (1954a). The production of four eggs in the oogonium of *Xiphophora* is comparable with that of *Ascophyllum* (Oltmanns, 1889), *Bifurcariapsis capensis* (Kutzing, 1860. Laing, 1941), *Hormosira* (Getman, 1914. Gruber, 1896. Osborn, 1948), *Pelvetia fastigiata* (Moore, 1928) and Durvillea (Naylor, (1949b, 1953a).

In *Fucus* eight eggs are produced (Oltmanns, 1889. Thuret et Bornet, 1878. Gruber, 1896). Subrahmanyan (1957a) states that *Pelvetia canaliculata* produces two eggs but occasionally four eggs are produced.

Papenfuss (1951a) and Fritsch (1945b, 1952) regard the production of eight eggs in *Fucus* as primitive among the Fucales. Genera producing two or four eggs are more advanced than those producing eight eggs, and those producing one egg are the most highly specialised among the Fucales.

Development of antheridia.

The development and the origin of antheridia have been studied in detail in *Fucus*, *Ascophyllum* (Oltmanns, 1889, Farmer and Williams 1896; 1898. Strasburger, 1897) and *Sargassum* (Kunieda, 1928. Simons, 1906. Tahara, 1929a).

Kunieda (1928), Tahara (1929a) and Yamanouchi (1909) made comprehensive contributions to the cytological knowledge of antheridia in *Fucus* and *Sargassum*. Antheridial development in *Cystophora*, *Cystophyllum*, *Myriodesma*, *Carpoglossum*, *Phyllospora*, *Seirococcus*, *Scytothalia*, *Scaberia* and *Xiphophora* follows the same course as in *Pelvetia*, *Fucus*, *Turbinaria*, *Bifurcaria*, *Himanthalia*, *Sargassum*, *Cystoseira*, *Hormosira*, *Marginariella* and *Ascophyllum*.

Antheridia may develop directly as papillae from the wall cell of the conceptacle as well as from the branched hairs in the conceptacle. Each papilla divides transversely to form an antheridium proper and a stalk cell. The latter produces a branch which pushes the antheridium to one side and itself gives rise to a second antheridium. This process is repeated indefinitely to form richly branched antheridial clusters. Antheridia are borne on these richly branched filaments in the male conceptacles as well as in the bisexual conceptacle. In the southern Australian genera antheridia develop from all parts of the conceptacle wall in contrast to *Pelvetia canaliculata* (Subrahmanyan, 1957a) in which they are confined to the basal part of the conceptacle and to *Bifurcaria tuberculata* (Rees, 1933) and *Turbinaria turbinata* (Blomquist, 1945) where they are borne above the oogonia. This condition occasionally occurs in *Scytothalia* and

Seirococcus. Antheridia may be stalked as in *Sargassum filipendula* (Simons, 1906), *Pelvetia fastigiata* (Moore, 1928), and *Turbinaria turbinata* (Blomquist, 1945) or terminal or lateral on the branches. In *Pelvetia canaliculata* (Subrahmanyan, 1957a) and in *Himanthalia lorea* (Bower, 1880), antheridia are borne singly on the tip of the paraphyses, in contrast to the southern Australian genera. The maturation of antheridia in South Australian genera is successive as reported in *Turbinaria*, *Cystoseira*, *Sargassum* and *Hormosira*. Antheridia are clavate to subclavate and the antheridial wall is composed of exochite and endochite.

In young antheridia six nuclear divisions occur forming 64 nuclei which develop into sperms. There is no wall formation in the antheridium at any nuclear stage in contrast to *Fucus* (Fritsch, 1945b, 1952) in which each nucleus is separated by a septum. Sperms are liberated through the apical pore in the antheridium as in *Halidrys siliquosa* and *Cystoseira* (Dodel-port, 1885. Savaugeu, 1912).

Embryology.

The extrusion of eggs from the bisexual conceptacles is followed by the liberation of sperms in *Cystophora*, *Scaberia*, *Myriodesma* and *Cystophyllum*. Fertilisation occurs within an hour after liberation in *Cystophora*, *Myriodesma* and *Scaberia*. The zygotes soon attach themselves to the substratum by the secretion of mucilage as in *Durvillea* (Naylor, 1953a). Fertilisation and early segmentation in the zygotes of *Cystophyllum muricatum* occurs while they are attached to the receptacle as in *Carpophyllum* (Dawson, 1940. Delf, 1939a. Naylor, 1953c), and *Marginariella* (Naylor, 1953b). After the liberation of zygotes of *Cystophyllum*, they attach themselves to the substratum by the secretion of mucilage. Segmentation and the early development of the embryo have been studied in numerous genera by various workers.

Zygotes of *Cystophora*, *Cystophyllum*, *Scaberia* and *Myriodesma* divide transversely to form two dissimilar cells — a large upper cell and a small lower cell — as found in other species of the Fucales. The polarity of zygotes may occur before or after the first transverse division as occurs in that of *Marginariella* (Naylor, 1953b), *Xiphophora* (Heine, 1932. Naylor, 1954a), *Hormosira* (Osborn, 1948), *Cystoseira* (Valiante, 1883) and *Sargassum linifolium* (Nienburg, 1910). The second division occurs longitudinally in the upper cell of the embryos of *Scaberia*, *Cystophyllum* and *Myriodesma latifolia* as described for *Sargassum* (Nienburg, 1910), *Xiphophora*, (Heine, 1932. Naylor, 1954a) and *Fucus vesiculosus* (Thuret et Bornet, 1878). In *Cystophora* and *Myriodesma quercifolia* the

the second division is transverse in the lower cell of the embryos similar to that seen in *Marginariella* (Naylor, 1953b), *Fucus spiralis* (Giraud, 1956), *Sargassum thumbergii*, *Hizikia fusiformis* (Inoh, 1929a), *Hormosira* (Osborn, 1948), *Pelvetia wrightii* (Inoh, 1935) and *P. canaliculata* (Subrahmanyan, 1957b). The third division is longitudinal in the uppermost cell of the embryos of *Cystophora* and *Myriodesma quercifolia* as it is in *Hormosira* (Osborn, 1948), *Durvillea* (Naylor, 1953a) and *Fucus spiralis* (Giraud, 1956). In case of *Scaberia*, *Cystophyllum* and *Myriodesma latifolia* it is transverse in the lower cell of the embryos and forms a rhizoid cell similar to that of *Marginariella urvilliana* (Naylor, 1953b) and *Xiphophora* (Naylor, 1954a). The fourth division is longitudinal in the middle cell of the embryo in *Cystophora*, *Cystophyllum*, *Scaberia* and *Myriodesma*. This division was not observed in other species of Fucales by the earlier authors. Two primary rhizoids are produced by the longitudinal division of the rhizoid cell in *Scaberia* and *Cystophora* while *Myriodesma* and *Cystophyllum* produce 4 and 8 primary rhizoids respectively. *Cystoseira barbata* (Nienburg, 1910), *C. foeniculacea* (Dawson, 1941), *C.*ystophyllum *crassipes* (Inoh, 1932; 1937c), *C. hakodatense* (Inoh, 1932), *C. geminata* and *C. osmundacea* (Fensholt, 1955) produce 4 primary rhizoids on the embryo. In *Cystophyllum turneri* (Okabe, 1929. Inoh, 1932), and *C. sisymbrioides*

(Okabe, 1929, Inoh, 1930; 1932; 1937c) 32 primary rhizoids are produced on the embryo. Many species of *Sargassum* (Tahara, 1929a. Inoh, 1932; 1955), *Hizikia fusiformis* (Tahara, 1929a) and *Turbinaria turbinata* produce 8 primary rhizoids. *Carpophyllum* (Naylor, 1953c. Dawson, 1940) produces a tuft of 16 rhizoids at one end of the embryo. *Fucus vesiculosus* (Oltmanns, 1889, Thuret et Bornet, 1878), *Xiphophora* (Heine, 1932, Naylor, 1954a), *Marginariella* (Naylor, 1953b), *Hormosira* (Osbomm, 1948) and *Durvillea* (Naylor, 1953a) each produces one primary rhizoid.

While rhizoidal development is taking place the body of the embryo becomes many-celled and it is then difficult to observe further divisions.

Apical hairs develop from the apical groove and the number varies from 4 to 16, except in *Myriodesma*, in which only one apical hair developed. Variation in the number of apical hairs has been observed in *Hormosira* (Osborn, 1948), *Fucus vesiculosus* (Thuret et Bornet, 1878) and *Cystoseira* (Valiante, 1883). The hairs develop from the basal meristems at the base of the apical groove in *Hormosira* (Osborn, 1948) and *Pelvetia canaliculata* (Subrahmanyan, 1957b). One of the basal meristems may function as the apical cell after the hairs have fallen off as it occurs in *Cystophora*, *Cystophyllum* and *Scaberia* similar to that found in adult plants. Apical cells have been described in the embryo of <u>Hormosira</u> (Osborn, 1948), <u>Pelvetia canaliculata</u> (Subrahmanyan, 1957b) and <u>Fucus</u> (Fritsch, 1945b, 1952. Oltmanns, 1889. Thuret et Bornet, 1878). The three usual tissues — meristoderm, cortex and medulla, develop in the embryos as described in the embryos of <u>Hormosira</u> (Osborn, 1948), <u>Pelvetia canaliculata</u> (Subrahmanyan, 1957b) and <u>Fucus</u> (Oltmanns, 1889. Thuret et Bornet, 1878).

VI. CYTOLOGICAL STUDIES.

1. MATERIALS AND METHODS.

The material for cytological study was fixed in different fixatives (see page 198). Karpenhenko and Okabe's fixatives proved more satisfactory than others. After fixation (18 - 24 hours) the material was throughly washed in running water to make sure that traces of the fixatives were removed, and then transferred to distilled water. Different techniques were used for nuclear staining.

1. <u>Feulgen Reaction</u>.

The material from distilled water was brought up to 60°c. and then hydrolysed in N. HCl at 60°c. for between 10 and 15 minutes. The hydrolysis was stopped by transferring the material to cold distilled water. After a few minutes the material was placed in the Schiff's reagent for 8 - 12 hours (see page 199). The material was bleached in 3 changes of fresh SO_2 water (10 minutes in each) and was then cut into small pieces and squashed on a filmed slide and mounted in 50% Karo.

Cells of the Fucales are strongly pigmented and this technique does not macerate the material for thorough squashing, as was also experienced by Naylor (1959). In order to overcome this difficulty, the material was bleached before hydrolysis in a solution of 20 cc. of 30% H_2O_2 and 1 - 2 drops of strong Ammonium hydroxide for half an hour. The material was then gently and thoroughly wahhed in running water to remove the traces of H_2O_2.

After bleaching the time of hydrolysis was reduced usually to 7½ - 10 minutes (Naylor, 1959). This technique has been successfully used on both resting and dividing nuclei. In Cystophyllum muricatum particularly, this technique has given a good reaction.

2. Aceto - carmine Squashed.

Bleached material was treated with aceto-carmine. Squashes were made on filmed slides as described by Naylor (1957).

3. Acetic - orcein Squash.

Bleached material was stained in 2% orcein in 60% acetic acid. The material was squashed on a filmed slide, in the stain, by the weight of the coverslip or by manual pressure. Excess of stain was removed by applying gentle pressure on the coverslip under several thicknesses of filter paper. It was then examined as a temporary mount or made permanent by removing the coverslip with 45% acetic acid, dehydrating in the usual way, and mounting in Xam. This stain gave a very sharp reaction in the dividing and resting nuclei.

4. Haematoxylin Squashes.

The material was squashed on a filmed slide in distilled water by the pressure of the coverslip or by manual pressure under several thickenasses of filter paper. The coverslip was allowed to come away in water. Then the squashed material on the slide and on the coverslip was mounted in 4% iron alum for 30 minutes.

It was rinsed in running water up to 10 minutes and then stained in 0.5% haematoxylin (Johansen, 1940). The stained material on the slides and the coverslip was rinsed in running water up to 5 minutes and destained in 2% iron alum for 2 minutes. The destained material on the slides and coverslip was rinsed in running water for 30 minutes, dehydrated as usual and mounted in Xam.

5. Sections.

Gradual dehydration of the material for embedding was carried out as recommended by Johansen (1951). Microtome sections were cut at various thickness between 4 and 12 μ and stained in iron alum - Haematoxylin or Feulgen Reaction (as described above).

Fixatives.

(i) Karpechenko:-

A.	Chromic acid	1 gm.
	Glacial acetic acid..	5 gm.
	Sea water...	65 cc.
B.	Commercial formalin..	40 cc.
	Sea Water...	35 cc.

Equal parts of solutions A and B used when needed.

(ii) Okabe's Solution:-

Stock solution of chromic acid (seawater - 98cc. plus saturated water solution of chromic acid - 2cc.)	50 cc.
2% osmic acid...	5 cc.
Glacial acetic acid..	2.5 cc.
Sea water..	50 cc.

(iii) Acetic-alcohol:-

Glacial acetic acid...	1 part.
Absolute alcohol.	3 parts.

(iv) Formalin-acetic-alcohol:-

Formalin...	40 cc.
Glacial acetic acid...	7 cc.
Absolute alcohol.	100 cc.

(v) Bradley's Solution:-

Absolute alcohol.	3 parts
Glacial acetic acid...	1 part
Pure chloroform..	4 parts

Stains.

1. Schiff's Reagent-(Leucobasic fuchsin (Darlington and la Cour, 1950))

(a) Dissolve 1 gm. basic fuchsin by pouring over it 200 cc. of boiling distilled water. Shake well and cool to 50°C. Filter: Add 30 cc. N.HCl to filtrate. Add 3 gm. $K_2S_2O_5$.

Allow solution to bleach for 24 hours in a tightly stoppered bottle in the dark; add 0.5 gm. decolorizing carbon (Norit).

Shake well for about a minute and filter rapidly through coarse filter paper.

Store in tightly-stoppered bottle in the dark.

(b) SO_2 water:-

Normal HCl... ... ... 5 cc.
$K_2S_2O_5$ 10%.. ... ... 5 cc.
Distilled water... ... ... 100 cc.

2. Aceto-carmine (Darlington and la Cour, 1950).

Glacial acetic acid... ... 45 cc.)
Distilled water.. ... ... 55 cc.) Heat to boiling

Add 0.5 gm. of carmine. Shake well and filter when cool. A drop or two of 45% acetic acid saturated with iron acetate was added.

2. CYTOLOGY

(Plate XXIX).

Cytological observations were made on antheridia, oogonia, paraphyses, vetetative cells and embryos. In each case the resting nuclei gave an intense reaction with the stains used as observed in Halidrys siliquosa (Moss and Elliot, 1957. Naylor, 1958b). These nuclei possess deeply staining granules (i.e. chromocentres) which vary usually from 5 to 8 in number although up to 16 have been counted. The nuclei are granular in all the species investigated.

Paraphyses.

Dividing nuclei were observed in the basal part of the paraphyses of Cystophyllum muricatum, showing 16 - 20 chromosomes at the metaphase plate in polar view (PlateXXIX, fig. A). The chromosomes were crowded and clumped together making the count difficult. It is quite possible that there may be over 20 chromosomes.

In *Cystophora uvifera* counts of 30 - 36 chromosomes were made in the basal cell of the paraphyses at the metaphase plate in polar view (Plate XXIX, fig. F).

Antheridia.

At the 4-nucleate stage of the developing antheridia, of *C. cephalornithos* counts of up to 32 chromosomes were made at the metaphase plate in polar view (Plate XXIX, fig. H) but difficult to count at the anaphase stage (Plate XXIX, fig. G). In the developing antheridia of *C. platylobium* at the 8-nucleate stage counts of over 24 chromosomes were made at the metaphase plate in polar view (Plate XXIX, fig. X).

Oogonium.

Counts of chromosomes were possible only in the oogonia of *C. moniliformis* and *C. intermedia* and counts of somewhat over 16 or 30 chromosomes respectively were made (Plate XXIX, figs. C and Z).

Vegetative parts.

In the somatic nuclei of *Cystophyllum muricatum* between 32 and 48 chromosomes were counted (Plate XXIX, fig. B). In the apical cell of *Cystophora moniliformis* with difficulty counts of up to 48 chromosomes were made (Plate XXIX, fig. D). In *Cystophora polycystidea* counts of up to 56 chromosomes were made at the metaphase plate in the polar view (Plate XXIX, fig. E), and between 48 and 55 chromosomes were counted in the apical cell of *C. intermedia*.

The resting nuclei of the embryos of *C. retorta* and *C. subfarcinata* contain (7-) 10 - 16 chromocentres (Plate XXIX, figs. I, M, U and W). The number of chromocentres vary from nucleus to nucleus depending on the size of the nuclei. In *C. subfarcinata* counts of up to 45 chromosomes were obtained at the metaphase plate in polar view (Plate XXIX, fig. J) but counts were difficult at other stages (Plate XXIX, figs. K, L). Different stages of nuclear divisions were observed in the body of the embryo of *C. retorta* (Plate XXIX, figs. N to T and V). In the nucleus of the body cells of the embryo of *C. retorta* counts of between 48 - 50 chromosomes were made but in one case 64 chromosomes were counted. In the nucleus of the rhizoid cell of the embryo of *C. retorta* counts of 50 or more chromosomes were obtained.

In the nucleus of a body cell of the embryo of *C. platylobium* counts of up to 45 chromosomes were made (Plate XXIX, fig. Y).

TABLE VI. CHROMOSOME COUNTS MADE ON MEMBERS OF THE FUCALES.

					Embryo.	
	Apical cell	Paraphysis	Antheridium	Oogonium	Body	Rhizoid
Cystophyllum muricatum	32 - 48	16 -20	-	-	-	-
Cystophora uvifera	-	30 -36	-	-	-	-
C. cephalornithos	-	-	about 32	-	-	-
C. platylobium	-	-	-	over 24	about 45	-
C. moniliformis	about 48	-	-	over 16	-	-
C. subfarcinata	about 45	-	-	-	-	-
C. polycystidea	about 56	-	-	-	-	-
C. retorta	-	-	-	-	48-59 (-64)	about 50
C. intermedia	48 - 55	-	-	about 30	-	-

The above chromosome counts are listed in Table VI. The variability of these counts may be partly due to crowding and clumping together of the chromosomes or due to their small sizes or lack of uniform staining. Nevertheless, the number of chromosomes indicates that the value of n probabily lies between 16 and 32. These figures indicate that paraphysis, antheridia and oogonia are haploid; apical cell and embryo are diploid.

3. DISCUSSION ON THE CYTOLOGY

The nuclei in the species of the South Australian Fucales studied are granular and show chromocentres, as observed in other species of Fucales. These chromocentres vary in size and in some cases probably only large chromocentres have been counted. Variation in chromocentre numbers have been reported and these are 2 to 9 in *Halidrys siliquosa* (Le Touze, 1912 , Naylor, 1958b. Roy, 1938),4to 5 in *Cystoseira ericoides*, 12 to 16 in *Fucus lutarius* and 5 to 11 in *Bifurcaria tuberculata* (Roy, 1938). Naylor (1958b) says that these granules in the nuclei of *H. siliquosa* vary in number and bear no relationship to the number of chromosomes so it is unlikely that they are prochromosomes as suggested by Roy (1938). However, according to Swanson (1958) the prochromosomes and chromocentres are the same. Darlington and La Cour (1941) regard the variation as due to the condensation of the chromatin threads and the fusion of the granules; contraction and fusion of the granules being greater in the smallest nuclei.

In South Australian Fucales the nucleus contains 1 or 2 nucleoli, which are distinguished from the chromocentre by being larger in size and more uniform in shape. A similar number of nucleoli has been observed in *Pelvetia canaliculata* (Roy, 1938, Subrahmanyan, 1956, 1957), *Bifurcaria rotunda* (Giraud, 1956), *Fucus* species, *Cystoseira* species, *Ascophyllum*, And *Halidrys siliquosa* (Roy, 1938). Le Touze (1912) considered uninucleolate nuclei as a characteristic feature of the Fucaceae, but this does not seem to be true. Le Touze also considers a granular nucleus as a feature of the Cystoseiraceae. Roy (1938) found 1 or 2 nucleoli in either reticulate or granular nuclei. From these observations Roy suggested that reticulate nuclei occur in the Fucaceae and granular ones in the Cystoseiraceae. Even in reticulate nuclei Roy has observed fine ganular structures.

Naylor (1958b) states that granular nuclei are not uncommon in the Cystoseiraceae, but their occurrence is not as consistent as originally suggested by Le Touze. It appears that this separation of the Fucaceae and the Cystoseiraceae on nuclear structure does not hold.

The chromosomes are very small, crowded and compact together in nearly all the species studied, making chromosome counts difficult. Such difficulties have been encountered by Naylor (1957; 1958b), Giraud (1956), Walker (1931), Roy (1938) and Subrahmanyan (1956; 1957). Mitotic stages were observed in all the species studied by Roy (1938) but she could not make any chromosome counts due to clumping of the numerous chromosomes. Much the same difficulty was encountered by Giraud (1956) in the embryo of *Bifurcaria rotunda*. Cytological observations have been made by various authors in other species of Fucales (see Table II) and more recently have been discussed by Hiroe and Inoh (1955) and Naylor (1958b). In most cases a basic number ($n = 32$) has been reported with the exceptions of *Sargassum horneri* (Kunieda, 1928), *Hormosira banksii* (Osborn, 1948), *Hesperophycus harveyanus* (Walker, 1931), and *Bifurcaria rotunda* (Giraud, 1956), where the number of chromosomes is small. According to Fritsch (1945b; 1952), the data suggests that there may be a greater measure of uniformity than is at present apparent.

In the present investigation definite counts have not been ~~not~~ possible due to the large number, small size and crowded mature of the chromosomes of most species. However the figures obtained are sufficient to suggest that the thallus is diploid and that reduction occurs in the developing antheridia and oogonia.

Counts of chromosomes in the paraphysis were made for the first time in the species of the Fucales. In *Cystophyllum muricatum* the number of chromosomes in each apical cell was 32 - 48 while there were 16 - 20 in the paraphyses. These figures suggest however that the paraphyses are haploid and the apical cells diploid. In *C. muricatum* further investigations are necessary to find out whether reduction also occurs in the developing antheridia and oogonia as in other members of the Fucales investigated. Counts of chromosomes were also made in the paraphysis of *Cystophora uvifera* but counts in other parts were not made. In *C. uvifera* it is not possible to come to any definite conclusion regarding where ~~counts~~ reduction occurs but on the basis of chromosome counts in other members of the Fucales, it is possible that vegetative parts of *C. uvifera* may be diploid and paraphyses haploid.

VII. TAXONOMICAL STUDIES.

This chapter deals essentially with the Southern Australian Fucales, although many have not been investigated anatomically. The following account deals with the taxonomy of the whole of the Fucales. The taxonomy of Sargassum is not included, as it is a very large and specialized genus of the Fucales and it needs a special study of its own.

1. KEY TO THE FAMILIES OF FUCALES.

1. Reproductive bodies in chains... ... Ascoseiraceae
   Reproductive bodies not in chains ... 2
   2. Growth by apical cells... ... 3
      Growth neither by apical cells nor by intercalary meristems, but diffuse growth occurs.... ... Durvilleaceae
3. Apical cell 3-sided in transverse section... 4
   Apical cell 4-sided in transverse section... 5
   4. Growth by a single 3-sided apical cell 6

4. Growth by a group of four three-sided apical cells... ... ... Hormosiraceae

5. Growth involving 2 or more 4-sided apical cells... ... ... Seirococcaceae fam. nov.

Growth involving a single 4-sided apical cell... ... ... Fucaceae

6. Thallus differentiated into upper fertile and lower sterile parts; fertile parts strap-shaped and dichotomous; lower sterile parts cup-shaped.... Himanthaliaceae

Thallus not differentiated as above; plants radial or bilateral; conceptacles on receptacles or on branch-segments of thallus... .. 7.

7. Receptacles and vesicles axillary...... Sargassaceae

Receptacles and vesicles not axillary.. Cystoseiraceae

2. DISCUSSION OF THE FAMILIES.

(1) ASCOSEIRACEAE Skottsberg, 1907.

Holdfast discoid. Stipe solid and forked. Branches terminating in a long narrow leathery segment. Conceptacles on both surfaces, scattered. Chains of reproductive bodies, each with 8- bodies of unknown nature. The structure and development of Ascoseira has not yet been studied, so it is not possible to make any further comment on the mode of growth in Ascoseiraceae.— Ascoseira Skottsberg.

(2) DURVILLEACEAE Oltmanns, 1889.

Plants large, Holdfast solid conico-discoid, stipe terete to compressed above. Frond divided into strap-like segments, leathery. No vesicles. Inflated air chambers present or absent in the frond. Diffuse growth occurs. Conceptacles scattered over the whole frond. Neither apical cells nor intercalary meristems occur. Hyphae short and horizontal in the medulla. Plant dioecious. Antheridia mostly on branched hairs. Oogonia parietal or on branched hairs, with 4 eggs.— Durvillea Bory and Himanthothallus Skottsberg.

(3) HORMOSIRACEAE (Gruber) Fritsch, 1945.

Plants moniliform, segments hollow. Holdfast small and discoid with a short terete stipe. Branching di or trichotomous. Growth by a group of 4 apical cells. Conceptacles scattered on the vesicles. Plant dioecious. Antheridia on branched hairs. Oogonia without stalk and borne directly on the wall of the conceptacle, with 4 eggs. Single primary rhizoid on the embryo -- Hormosira (Endl.) Meneghini.

(4) SEIROCOCCACEAE fam. nov.

Holdfast discoid or divided, with short terete stipe. Axis compressed with central thickening. Laterals flat, bilateral, distichous, ecostate. Vesicles present or absent. Receptacles axillary or marginal or conceptacles in fertile laterals. Plant monoecious or dioecious. Mesochiton collar near the apical part of the oogonium. Growth by 2 or more apical cells (4-sided). Antheridia on the wall of the conceptacles or on branched hairs. Oogonia without stalk, directly on the wall of the conceptacles, with one egg. — Seirococcus Greville, Scytothalia Greville and Phyllospora C. Agardh.

(5) FUCACEAE Decaisne, 1842.

Plants flat, radial, bilateral or dorsiventral and dichotomous. Holdfast discoid with terete to subterete stipe. Frond with or without midrib. Vesicles present or absent. Conceptacles on transformed segments. Plant monoecious or dioecious. Growth by a 3-sided apical cell at the embryo stage and 4-sided apical cell at the adult stage. Antheridia on the wall of the conceptacle or on branched hairs. Oogonia with or without stalk, on the wall of the conceptacles, with 1, 2, 4 or 8 eggs. Production of single primary rhizoid on the embryo - *Ascophyllum* Stackhouse, *Axillariella* Silva, *Cystosphaera* Skottsberg, *Fucus* L., *Hesperophycus* Setchell et Gardner, *Pelvetia* Decaisne, *Pelvetiopsis* Gardner and *Xiphophora* Montagne. *Axillariella*, *Hesperophycus*, *Pelvetiopsis* and *Cystosphaera* are the only four genera which produce a single egg.

(6) HIMANTHALIACEAE Kjellman, 1891.

Holdfast discoid with a terete stipe. Plants differentiated into sterile and fertile parts. Lower sterile part Peziza-like cup or top-shaped. Upper fertile part arising from the centre of the cup, strap-shaped and dichotomous.

No vesicles. Conceptacles numerous and scattered on the receptacles. Horizontal hyphae occur in the medulla. Growth by a single 3-sided apical cell. Plant dioecious. Antheridia on branched hairs. Oogonia without stalk, on the wall of the conceptacles, with one egg.— *Himanthalia* Lyngbye.

(7) SARGASSACEAE Decaisne, 1842.

Holdfast discoid or divided, with a short terete stipe. Plants bushy, bilateral or radial with monopodial branching. Basal leaves linear or blade-like or turbinate. Branch systems arising in the axils of the leaves. Receptacles and vesicles axillary. Growth by a single 3-sided apical cell throughout the life of the plant. Plant monoecious or dioecious. Antheridia on branched hairs or directly on the wall of the conceptacles. ~~Oogonia without stalk, borne directly on the wall of the conceptacles.~~ Oogonia without stalk, borne directly on the wall of the conceptacle, with one egg. Degeneration of supernumery nuclei of oogonia in situ. Tufts of rhizoids produced on the embryo — *Carpophyllum* Greville, *Hizikia* (Harvey) Okamura, *Sargassum* C. Agardh and *Turbinaria* Lamouroux.

(8) CYSTOSEIRACEAE Kuetzing, 1843.

Holdfast discoid or divided, with a terete stipe. Plants bushy, radial or bilateral. Basal leaves present or absent. Vesicles present or absent, rare or immersed in the frond. Receptacles bear the conceptacles. Growth by a single 3-sided apical cell throughout the life of the plant. Plant monoecious or dioecious. Antheridia directly on the wall of the conceptacle or on branched hairs. Oogonia without stalk, on the wall of the conceptacles, with one or 4 eggs. Production of 2-8 primary rhizoids on the embryo. — Acystis Schiffner, Bifurcaria Stackhouse, Bifurcariopsis Papenfuss, Carpoglossum Kuetzing, Coccophora Greville, Cystophora J. Agardh, Cystophyllum J. Agardh, Cystoseira C. Agardh, Halidrys Lyngbye, Hormophysa Kuetzing, Landsburgia Harvey, Marginariella Tandy, Myriodesma Decaisne, and Scaberia Greville.

Bifurcariopsis is the only genus known to produce 4 eggs in the Cystoseiraceae but it possesses a single 3-sided apical cell (Laing, 1941).

Earlier authors Dumortier (1822), C. Agardh (1824), Endlicher (1836; 1843), J. Agardh (1848) and Harvey (1849) have used Fucaceae as the name of one of the orders of brown algae while Sonder (1846) used Fucaceae as a sub-order and divided it into tribes (i) Fucoideae and (ii) Cystoseireae. Lamouroux (1813) was the first to use Fucées in the sense of an order (also referred to by him as a family in certain places). Decaisne (1840) and Kuetzing (1843; 1849) contributed more in the classification of families, which have already been discussed. These families were largely based on morphological characters but Oltmanns (1889) made an important contribution towards the classification of the Fucales. He placed more emphasis on the apical cells and the number of eggs produced in each oogonium. The presence of apical cells was known to the earlier authors such as Naegeli (1847) and Rostafinski (1876) but they did not make use of them in classification. Oltmanns (1889) divided the order Fucaceen into groups (i) Durvilleae (ii) Loriformes (iii) Fucaceae (iv) Cystosireen and (v) Sargaseen. Kjellman (1891) established the family Hymanthaliae. De Toni (1891 ; 1895) orthomutated Durvilleae (= Durvilleaceae), Sargasseae (= Sargassaceae), Cystoseireae (= Cystoseiraceae), Hymanthaliae (= Himanthaliaceae). In agreement with Oltmanns, Gruber (1896) established the Hormosira-group and put most of the doubtful genera of Oltmanns into their correct families. Skottsberg (1907) created a new family Ascoseiraceae on the presence of reproductive bodies in chains in the conceptacles. Schmidt (1938) agreed with Oltmanns and Gruber. On the presence of 3-sided apical cells Schmidt absorbed Cystoseiraceae in Sargassaceae as well as forming a new family Notheiaceae (now removed from the Fucales). More recent algologists Delf (1935; 1939a), Dawson (1940; 1941), Fristch (1945b; 1952), Rees (1933), Naylor (1951; 1953) and Schmidt (1938) are in agreement with Oltmanns and Gruber on the classification of the Fucales. Fritsch (1945b; 1952) and Papenfuss (1951a; 1955) recognise 7 families. Both authors differ only in the nomenclature of Hormosiraceae and Notheiaceae. Fritsch favours Hormosiraceae whereas Papenfuss retains Notheiaceae. This difference of opinion is now solved by excluding the Notheiaceae from the Fucales, leaving Hormosiraceae as one of the families of the Fucales. In agreement with Oltmanns, Gruber and Schmidt, the emphasis is laid on the number and shape of apical cells, as well as on distinctive morphological features. The Fucales are divided into 8 families.

1 *Ascoseiraceae*. — *Ascoseira* is the only genus of the family, whose reproduction and development has not been studied in detail, but reproductive bodies of unknown nature occur in the conceptacles scattered in the segments.

2 *Durvilleaceae*. — Apical cells or intercalary meristems do not occur in Durvillea, growth being diffuse. Four eggs are produced in each oogonium of *Durvillea*.

3 Hormosiraceae. — This is a distinctive family of the Fucales, where a group of 4 apical cells occur and 4 eggs are produced in each oogonium. It is re~~a~~lated to the Fucaceae in producing 4 eggs and a single primary rhizoid on the embryo but differs from other families by being moniliform and hollow. This family is represented by a single genus Hormosira.

4 Fucaceae.— In this family the plants are mostly dichotomous, and flat and possess a single 4-sided apical cell when adult, but a 3-sided apical cell occurs at the embryo stage. Fucaceae produce 1, 2, 4 or 8 eggs in each oogonium, the number varying in different genera, and a single primary rhizoid develops on the embryo. The medulla consists of intertwined hyphae. This family differs from the Durvilleaceae in having apical growth whereas it is diffuse in the Durvilleaceae. The Fucaceae also differs from the Sargassaceae and the Cystoseiraceae in possessing hyphae throughout the medulla. The latter two families possess a single 3-sided apical cell throughout the life of the plant, but in the Fucaceae a single 3-sided apical cell occurs only at the embryo stage and a 4-sided one at the adult stage. There is a range of 1, 2, 4 or 8 eggs in the Fucaceae whereas a single egg (except 4 eggs in Bifurcariopsis) is produced in both Cystoseiraceae and Sargassaceae.

5 *Seirococcaceae.* — This family is characterized by having two or more 4-sided apical cells which are either in groups or one on either side of the round apical disc. On the other hand the Fucaceae possess a single 4-sided apical cell. Seirococcaceae produce one egg whereas in the Fucaceae 1, 2, 4 or 8 eggs are produced. Hyphae are mostly limited near the basal parts of the plant of the Seirococcaceae whereas they are scattered throughout the medullary parts of the plant of the Fucaceae. Marginal or axillary receptacles occur in the Seirococcaceae but the terminal segments of the plant become receptacles in the Fucaceae. Himanthalieaceae, Sargassaceae and Cystoseiraceae each produces a single egg and each possesses a single 3-sided apical cell. Horizontal hyphae occur in the medulla of *Himanthalia* and longitudinal ones occur near the basal parts of members of the Sargassaceae and the Cystoseiraceae. In *Himanthalia* the upper strap-shaped and dichotomous part is fertile and the lower cup-shaped part is sterile. On the other hand plants of the Sargassaceae and the Cystoseiraceae are radial or bilateral and the conceptacles are borne on receptacles or on the thallus segments

6 *Sargassaceae* differs from the Cystoseiraceae in morphological characters. Receptacles and vesicles are axillary in the Sargassaceae, while receptacles in the Cystoseiraceae consist of ultimate branches, or the conceptacles may be scattered on the

flat segments of on the ramuli, and vesicles are lateral in position or immersed in the Cystoseiraceae. A tuft of rhizoids is produced on the embryo of the Sargassaceae while 2 - 4 primary rhizoids occur on the embryo of the Cystoseiracae.

3. GENERAL KEY TO THE SOUTHERN AUSTRALIAN GENERA OF THE FUCALES.

1. Oogonia with 4 eggs only... 2
Oogonia with 1 egg only 3
    2. Plants moniliform, segments hollow. _Hormosira_
    Plants neither moniliform nor hollow but solid.... 4
3. Holdfast discoid with radiating terete processes, leafy laterals marginal or lateral, more than one 4-sided apical cell, mesochiton collar present near the apical part of the oogonium... 5
Holdfast discoid or divided, leaves alternate or radial, one single 3-sided apical cell, no mesochiton collar on the oogonium. ... 6

4. Plants palmate, conceptacles scattered, no apical cell... ... *Durvillea*

Plants dichotomous, conceptacles in rows, one single 4-sided apical cell *Xiphophora*

5. Leafy laterals marginal, serrate, vesicles present, leafy laterals transformed into receptacles, more than one apical cell in the apical depression. No apical disc.. ... *Phyllospora*

Leaves alternate, entire, vesicles absent, receptacles axillary or marginal, two apical cells present — one on each side of a round apical disc in the apical depression.... 7

6. Vesicles in concatenate series... 8

Vesicles absent or present, not in concatenate series... 9

7. Receptacles cylindrical and tuberculate.. *Seirococcus*

Receptacles compressed, lanceolate or ensiform or rostellate... . ... *Scytothalia*

8. Vesicles on the ultimate branchlets, oogonia embedded, zonal discharge of eggs... ... ... *Cystophyllum*

Vesicles as dilations on the leaves or branchlets, oogonia not embedded, successive but not zonal discharge of eggs.. *Cystoseira*

9. Conceptacles borne on branch segments... 10

Conceptacles on receptacles... 11

10. Plants terete, irregularly branched, segments compressed, externally warted, densely imbricate, vesicles present... . ... <u>Scaberia</u>

Plants flat, segments flattened, alternate, pinnate, vesicles always absent... 12

11. Leaves absent, vesicles absent or lateral, ultimate ramuli transformed into receptacles... .. .. <u>Cystophora</u>

Leaves present, vesicles and receptacles axillary... .... <u>Sargassum</u>

12. Plants not dichotomous, near the base, flat, thick, segments alternate, pinnate simultaneous maturation of oogonia.... ... ... <u>Carpoglossum</u>

Plants dichotomous near the base, segments thin, membranous, pinnate, successive maturation of oogonia. <u>Myriodesma</u>

4. GENERAL ACCOUNT OF THE SOUTHERN AUSTRALIAN FUCALES.

This section deals mainly with the Southern Australian Fucales but a few species of Cystophora and Durvillea occurring elsewhere are included.

In this section under the heading "Specimens examined" are included the material examined by the author, references to location in the literature and the specimens in other herbaria examined by Dr. H.B.S. Womersely.

Type references and type localities have been obtained from type photos in AD or from manuscript of Dr. H.B.S. Womersley 1952 or from the original literature where type species are described unless otherwise stated in the text.

(1) DURVILLEACEAE Oltmanns, 1889.

(a) Durvillea Bory 1826

J. Agardh 1848: 187. Areschoug 1854: 14 (340). Decaisne 1840: 410; 1841: t. 5; 1842:330. De Toni 1895: 219. Endlicher 1843: 29. Gruber 1896: 3. Herriot 1923: 55. Kjellman 1897: 279. Kuetzing 1849: 585. Lindauer 1957: 69. Montagne 1845: 52. Naylor 1949a: 286. Skottsberg 1907: 139. Tilden 1937: 304

Durvillaea Bory 1826: 192. Areschoug 1854: 14 (340). Bory in Duprrey 1828: 65. De Toni 1891: 173; 1895: 219. Kuetzing 1843: 350; 1849: 585.

Sarcophycus Kuetzing 1843: 392; 1849: 587. J. Agardh 1848: 189. De Toni 1891: 173; 1895: 222. Kjellman 1897: 279. Lucas 1936: 82. Lindauer 1947: 564. May 1939: 202. Whitting 1893: 38.

Holdfast large, solid, conico-discoid. Stipe subterete to compressed above, simple or proliferous. Fronds flat, thick, coriaceous, broadly expanded, divided into wider or narrower segments, palmate, dark brown, solid or with inflated medullary air-chambers. Conceptacles numerous, scattered on the whole frond, unisexual. Plant dioecious. Oogonia with 4 eggs, parietal or on branched hairs.

Bory (1826) described the genus *Durvillea* with *D. utilis* Bory but this plant was already known as *Fucus antarcticus* Chamisso (1822). In 1892 Hariot changed the name to *D. antarctica* (Chamisso) Hariot. Skottsberg (1907) made the same mistake as Bory did but later in 1921 Skottsberg agreed with Hariot.

Kuetzing (1843) established *Sarcophycus* from Australian waters (*S. potatorum*) describing the oogonia as tetraspores, and he placed it under Chaetangiaceae although he believed that it was very close to *Durvillea*. The two genera have always been separated on the basis of the insertion of the oogonia and the manner of divisions of the frond, and the character of either solid or chambered thalli. Oogonia are parietal in *Durvillea antarctica* but those of *Sarcophycus* occur as well on branched hairs. Oogonia are parietal in *D. willana* (Naylor, 1953a), but they also occur on branched hairs in *D. antarctica* (Herriot, 1923 . Naylor, 1949b . Skottsberg, 1907) and *D. harveyi* (Hooker and Harvey, 1847). Decaisne (1841) figures them as exclusively parietal in *D. antarctica*. It appears that oogonial insertion is a variable character for the separation of the two genera as stated by Naylor (1953a). Agardh (1848) and De Toni (1895) separated *Sarcophycus* and *Durvillea* using the manner of subdivisions of the frond and the character of either solid or chambered thalli as a basis for the separation. In *Durvillea* the frond is "palmate" and the thallus chambered while the frond is pinnate and the thallus solid in *Sarcophycus*. The frond is primarily palmate in *Sarcophycus* developing primary segments narrowed at their bases. These further develop proliferations in irregular fashion. Areschoug (1854) doubted the stipitate nature of segments as a specific feature, and suggested that *D. potatorum* might be a form of *D. utilis* (= *D. antarctica*), found in

Australian waters and which lacked central air-chambers. Subdivision of the frond appears to be a distinguishing feature between Durvillea and Sarcophycus but D. willana is an intermediate species possessing the broad basal palm (as in D. antarctica and D. harveyi), which form the main portion of the frond and a number of stipitate proliferations from the stipe, which are pinnately arranged. It appears that palmate, pinnate and stipitate proliferation characters are unsatisfactory for the separation of these genera as discussed by Naylor (1953a). Harvey (1863), Kjellman (1897), Skottsberg (1907) and Fritsch (1945b; 1952) brought the genus Sarcophycus under Durvillea because of their minor and variable character differences. The present author agrees with Naylor (1953a) that the similarity of the oogonial structure and extrusion of eggs may also be considered satisfactory for the union of the two genera. The structure of oogonia and extrusion of eggs of D. antarctica (Naylor, 1949b), D. willana (Naylor, 1953a), and S. potatorum (Whitting, 1893) have already been discussed in detail by Naylor (1949b; 1953a) and Whitting (1893).

Durvillea occurs in the Southern Hemisphere and includes (i) D. antarctica (ii) D. potatorum (iii) D. willana and (iv) D. caepestipes.

Durvillea potatorum is a sublittoral alga in Australian waters from Robe, South Australia to Pambula, New South Wales, and Tasmania while *D. antarctica* is lower littoral in New Zealand (Womersley, 1959), and in other subantarctic countries (Womersley and Edmonds, 1958). Skottsberg (1907; 1941) reports *D. antarctica* from central Chile to Cape Horn, Falkland Islands, Kerguelen Islands, Chatham Islands, Auckland and Campbell Islands.

(b) KEY TO THE SPECIES OF DURVILLEA

1. Stipe proliferous, oogonia parietal.... *D. willana*
   Stipe not proliferous, oogonia generally on branched hairs... 2
   2. Frond strongly inflated by central air-chambers...... ... ... *D. antarctica*
      Frond not chambered 3
3. Holdfast discoid, frond once or twice forked... ... . *D. potatorum*
   Holdfast fibrous, frond scarcely divided *D. caepestipes* (= *D. Harveyi*)

D. antarctica and *D. potatorum* are described here.

(c) DURVILLEA ANTARCTICA (Chamisso) Hariot 1892.

Cotton 1915: 165. Hariot 1892: 1432. Harvey 1867: 654. Herriot 1923: 549. Laing 1927: 141. Lindauer 1947: 563. Moore and Cribb 1952: 1100. Naylor 1949b: 285; 1953a: 277; 1954b: 653. Oliver 1923: 496. Skottsberg 1907: 140; 1941: 57. Womersley 1959: 566.

(Plate XXX).

Fucus antarcticus Chamisso 1822: 7.

Durvillaea utilis Bory 1826: 292. Bory in Duprrey 1828: 65. J. Agardh 1848: 188. Areschoug 1954: 15 (341). Askenasy 1889: 23. Bailey and Harvey 1874: 156. Decaisne 1841: t. 5; 1842: 330. De Toni 1895: 220. Hooker and Harvey 1845: 528. Hooker 1847: 454. Laing 1885: 308; 1899: 66. Montagne 1845: 53.

Plant thick, coriaceous, brown, turning darker on drying, up to 15 meters long. Holdfast conico-discoid, up to 25 cm. in diameter. Stipe terete to compressed above, up to 90 cm. long and 12.5 cm. across. Frond flat, thick palmate, divided into numerous ligulate segments tapering to points, up to 45 cm. broad in its widest part, inflated by central air chambers. Apices of the segments light in colour and meristematic. No special vesicles and receptacles. Conceptacles numerous, scattered on the whole frond, unisexual. Antheridia 13 - 27 µ x 5 - 10 µ, on tufted branched hairs.

SPECIMENS EXAMINED:

W. Aus.-Cape Leeuwin (Wollaston, 11-2-1957, Drift).

Nornalup, 70 miles west of Albany (Moore in Moore and Cribb. Drift).

Kangaroo Island. - Stanley Beach, Pennington Bay (Womersley, 4-2-1957. Drift).

Tasmania. - Taroona (Moore in Moore and Cribb. Drift). Port Arthur, Tasman Peninsula (Cribb in Moore and Cribb. Drift).

GEOGRAPHICAL DISTRIBUTION:

From central Chile to Cape Horn, off Kerguelen Island, The Falklands, Campbell Island, Auckland Island, Chatham Island, and New Zealand.

D. antarctica has not yet been found growing along the South Coast of Australia (Womersley, 1959).

Type locality and type of *D. antarctica* has not been located.

(d) *DURVILLEA POTATORUM* (Labillardiere) Areschoug 1954.

Areschoug 1854: 17 (333). Harvey 1863: pl. 300. Naylor 1953a: 296. Sonder 1880: 5. Womersley and Edmonds 1958: 247.

Plate XXXI .

Fucus potatorum Labillardiere 1806: 112, t. 258. Turner 1811: 106, t. 242.

Laminaria potatorum Lamouroux 1813: 42. C. Agardh 1821: 115; 1824: 270. Hooker 1847: 456.

Sarcophycus potatorum Kuetzing 1843: 392; 1849: 587; 1860: t. 7, f. 2. J. Agardh 1848: 190. De Toni 1891: 173; 1895: 222. Harvey 1859b: 286. Lindauer 1947: 564. Lucas 1909: 14; 1936: 82. May 1939: 206. Whitting 1893: 38.

Type Locality. - "Cape Van Diemen" - Tasmania (Labillardiere).

Type — Fl.

Plants tough, leathery, brown, turning darker on drying, up to 10 meters long. Holdfast discoid, up to 18 cm. in diameter. Stipe solid, terete below, compressed above, up to 30 cm. long and 15 cm. across. Frond flat, digitate, up to 40 cm. broad at its widest part and up to 6 mm. thick, simple or forked. Segments flat, strap-shaped, producing laterals. Sometimes divisions of fronds or segments dichotomous. Laterals flat, lanceolate, tapering at both ends, Simple or forked or dichotomous. Margin entire. No vesicles, nor air chambers, nor specialised receptacles. Conceptacles numerous, scattered over the whole frond, unisexual. Oogonia parietal or on the branched hairs, 53 - 107 µ x 13 - 40 µ. Antheridia on tufted branched hairs, 13 - 34 µ x 4 - 10 µ.

SPECIMENS EXAMINED:

S. Aus. — Robe (Womersley, 29-8-1948. Nizamuddin, 16-4-1959). Victoria. — Shelly Beach, Discovery Bay (Muir, January 1950). Bridgewater Bay (Beauglehole, 24-7-1948. Womersley, 21-8-1953. Nizamuddin, 14-4-1959). Lawrence Rock, Portland (Beauglehole, 13-1-1954). Warrnambool (Nizamuddin, 13-4-1959). Apollo Bay (Nizamuddin, 11-4-1959). Point Roadknight (Nizamuddin, 11-4-1959). Anglesea (Nizamuddin, 11-4-1959). Point Lonsdale and Queenscliff (Nizamuddin, 8-4-1959). Half Moon Bay, The Nobbies and Cat's Bay, Phillip Island (Nizamuddin, 10-4-1959). Walkerville, Wilson's Promontory (Pope and Bennett, 19-5-1949). Tasmania. — Three Hummocks (Bennett, 17-1-1954). Port Arthur, Tasman Peninsula (Cribb, February 1951). Swansea (Womersley, 19-1-1949).

New South Wales. — Eden amd Pambula (in May, 1939).

GEOGRAPHICAL DISTRIBUTION:

From Robe along south east coast to Pambula, New South Wales, and along the coast of Tasmania.

D. potatorum is a sublittoral brown alga growing along the south eastern coast of Australia and is a characteristic of the upper sublittoral with strong wave action.

D. potatorum grows only in Australian waters whereas D. antarctica is an inhabitant of subantarctic regions. D. antarctica is a lower littoral alga but D. potatorum is a sublittoral one. The frond of D. antarctica is very much divided and palmate whereas D. potatorum is simple or forked or dichotomous. In D. antarctica the frond is strongly inflated by central air-chambers but it is solid in D. potatorum.

(2) HORMOSIRACEAE (Gruber) Fritsch, 1945.

(a) HORMOSIRA (Endlicher) Memeghini 1838.

Nom. cons.

J. Agardh 1848: 197. Bergquist 1959: 22. Cotton 1935: 86. Decaisne 1842: 331. De Toni 1891: 173; 1895: 186. Endlicher 1836: 10; 1843: 29. Gruber 1896: 4. Kjellman 1897: 280. Kuetzing 1849: 586. Lucas 1936: 80. May 1939: 201. Naylor 1954b; 653. Silva 1952: 261. Tilden 1937: 311.

Moniliformia Lamouroux ex Bory 1825: 71. Bory in Duprrey 1828: 132.

Plants moniliform, dichotomous or trichotomous, inflated with vesicles, No leaves nor special receptacles. Conceptacles numerous, scattered on the vesicles. Plant dioecious. Oogonia with 4 eggs.

Hormosira was first proposed as a section of Cystoseira by Endlicher (1836) and was raised to generic rank by Meneghini (1838) as discussed by Silva (1952). It is a monotypical genus and is endemic to Australasian waters.

(b) HORMOSIRA BANKSII (Turner) Decaisne 1842.

(Plate XXXII).

J. Agardh 1848: 198. Areschoug 1854: 13 (339). Askenasy 1889: 23. Decaisne 1842: 331. De Toni 1895: 187. De Toni et Forti 1923: 71. Getman 1914: 264. Harvey 1855: 215; 1859b: 285; 1860: pl. 135, 1863: Synop. 66. Kuetzing 1849: 586; 1860: t. 3, f. 1. Laing 1885: 309; 1899: 66; 1900: 300; 1927: 142. Levering 1945: 11. Lindauer 1947: 563; 1957: 67. Lucas 1909: 13; 1936: 80. May 1939: 206. Mollet 1880: 318. Moore 1950: 48. Oltmanns 1922: 189. Osborn 1948: 47. Silva 1952: 261. Sonder 1852: 667, 1853: 511; 1880: 5. Womersley 1950: 158.

Fucus moniliformis Labillardiere 1806: 114, t. 262.

Fucus banksii Turner 1808: 1, t. 1. Mertens 1819: 190.

Cystoseira banksii C. Agardh 1821: 60; 1824: 284.

Moniliformia banksii Bory in Duprrey 1828: 134.

Moniliformia billardierii Bory in Duperrey 1828: 133. Bailey and Harvey 1874: 156. Hooker and Harvey 1845: 528.

Hormosira sieberi Bailey and Harvey 1874: 155. Hooker and Harvey 1845: 528.

Type Locality.— "Novae Hollandiae" — Australia.

Type. — FI.

Holdfast discoid, up to 4 mm. in diameter. Stipe terete, up to 1 cm. long and 2 mm. in diameter. Plants up to 45 cm. long and 16 - 25 mm. broad, brown, coriaceous, cartilaginous dichotomously or trichotomously or irregularly branched, with inflated segments (vesicles) and terete stalk, segments up to 10 - 15 (-25) mm. long and (2-) 4 - 10 (-25) mm. broad, spherical, ovoid, obconic or cylindrical, hollow, stalks up to 3 mm. long and 2 mm. broad. Conceptacles numerous, scattered over the whole surface of the segments, unisexual. Antheridia 33 - 68 µ x 14 - 26 µ. Oogonia 108 - 200 µ x 75 - 150 µ.

SPECIMENS EXAMINED:

W. Aus. — North Twin Peak Island, Recherche Archipelago (Willis, 20-11-1950). Figure of Eight Island, Recherche Archipelago (Willis, 7-11-1950).

S.Aus. — Point Drummond (Womersley, 11-1-1951). Fishery Bay (Nizamuddin, February 1959). Sleaford Bay (Nizamuddin, February 1959). Investigator Strait (Davey). Sturt Bay. Port Augusta (Womersley, 31-12-1950). Henley Beach, Adelaide, St. Vincent Gulf (1925). Willunga (Shepley, 13-10-1954). Sellick's Beach Reef (Hale, 19-1-1936). Petrel Cove, West of Bluff, Victor Harbour (Nizamuddin, 8-3-1959). Victor Harbour (Nizamuddin, 8-3-1959). Encounter Bay (1928. Harris, May 1943. Cleland. Womersley, 4-6-1943). Robe (Nizamuddin, 16-4-1959). Ocean Coast, Robe (Nizamuddin, 16-4-1959). ~~Portland (Nizamuddin, 14-4-1959)~~

Kangaroo Island. — Pennington Bay (Womersley, 28-1-1944 and 4-1-1948). American River (Womersley, 24-1-1944 and 6-1-1948). Rocky Point (Womersley, 24-1-1944 and 18-1-1948).

Victoria. — Bridgewater Bay (Beauglehole, 5-6-1949. Nizamuddin, 14-4-1959). Nelson Bay (Muir, January 1950). Lawrence Rock, Portland Bay (Beauglehole, 13-1-1954). Portland (Hale, August 1944). Port Fairy (Muir, January 1950). Near Point Roadknight (Davis, 1-2-1956. Nizamuddin, 11-4-1959). Queenscliff (Nizamuddin, 7-4-1959).

Tasmania. — Three Hummocks (Bennett, 17-1-1954). Sandy Cape (Bennett, 15-1-1954). Cape Sorrell (Bennett, 4-2-1955). Taroona, Hobart (Womersley, 13-1-1949).

New South Wales. — Eden, Bermagui, Lake Illawara, Botany Bay, Bondi, Long Bay, Sydney, Lake Macquarie, Forster and Port Macquarie (in May, 1939).

GEOGRAPHICAL DISTRIBUTION:

From Recherche Archipelago, W. Aus., around south east coast to Port Macquarie, New South Wales, and along the coast of Tasmania; Lord Howe Island, Norfolk Island, the Kermadee Islands, Chatham Islands and New Zealand.

Fucus moniliformis Labillardiere (1806) is predated by *F. moniliformis* Esper (1804) [= *Cystophora moniliformis* (Esp.) sp. nov]. According to the Paris Code Art 64 (2) *F. moniliformis* Labillardiere must be rejected as illegitimate and the next earliest legitimate name *F. banksii* Turner 1808 is adopted.

Four different forms of *Hormosira* (f. *labillardieri* (Bory) Harvey; *f. sieberi* (Bory) Harvey; f. *gracilis* Harvey and f. *pumila* Sonder have been recognised by authors. These forms are the result of local causes (depth of water or exposur to open sea or sheltered in bays or harbours). Intermediates between these forms are also found. Harvey (1860) combines four forms under one species. Moore (1950) described a "loose-lying" form *Hormosira banksii* ecad *libera* from Picton, New Zealand, without a holdfast. These forms are distinct from each other and are worth recognising as forms.

KEY TO THE FORMS OF HORMOSIRA BANKSII.

1. Plants free floating without holdfast.. f. *libera*
Plants attached to rocks by means of
discoid holdfast... 2
    2. Plants robust, vesicles ovoid. f. *labillardieri*
    Plants slender, vesicles not
    ovoid... 3
3. Plants fastigiate, vesicles obconic ... f. *sieberi*
Plants not fastigiate, vesicles not
obconic... 4
    4. Plants very slender, vesicle tapering
    at each end.... ... ... f. *gracilis*
    Plants not very slender, vesicles
    spherical... . ... f. *pumila*

1. f. *libera* Moore 1950.

Moore 1950:48.

~~Moore 1950: 48.~~ Plants massive not attached in any way, many branches from vesicles, vegetative multiplication. No parts float in seawater.

This form has been reported from Picton, New Zealand.

2. f. *labillardieri* (Bory) Harvey 1860.

Harvey 1860: pl. 135. Womersley 1950: 158.

Moniliformia labillardieri Bory 1828: 133

Hormosira billardierii Montagne 1845: 62. J. Agardh 1848: 199. De Toni 1895: 188. Kuetzing 1849: 586; 1860: t. 3, f. 2. Sonder 1852: 667.

Plants up to 16 cm. long. di-trichotomous with narrow axils. Vesicles ovoid 12 mm. long and 10 mm. broad, rounded at each end. Plants occur in deep water.

3. f. *sieberi* (Bory) Harvey 1860.

Harvey 1860: Pl. 135. Womersley 1950: 158.

Moniliformia sieberi Bory 1828: 134. A. Richard 1834: 139.

Hormosira sieberi Decaisne 1842: 330. J. Agardh 1848: 199. De Toni 1895: 189. Endlicher 1843: 30.

Hormosira obconica Kuetzing 1849: 586; 1860: t. 9, f. 1. Plants up to 20 cm. long, dichotomous, fastigiate, vesicles obconic, up to 8 mm. long and 6 mm. broad, growing on exposed tidal rocks or in small rock pools exposed to sea.

4. f. gracilis (Kg.) Harvey 1860.

De Toni 1895: 187. Harvey 1850: Pl. 135. Womersley 1950: 158.

Hormosira gracilis Kuetzing 1849: 586. Sonder 1852: 668.

Vesicles fusiform, tapering at each end, up to 3 mm. long and 2 mm. broad. Growing on exposed tidal rocks or in rock pools exposed to sea.

5. f. pumila Sonder 1852.

De Toni 1895: 189. Kuetzing 1860: t. 4, f. 2. Sonder 1852: 667. Womersley 1950: 158.

Plants short up to 6 cm. long. Vesicles spherical, 2 - 7 mm. broad.

(3) SEIROCOCCACEAE fam. nov.

(a) KEY TO THE GENERA OF THE SEIROCOCCACEAE.

1. Leaves serrate, marginal, vesicles marginal, conceptacles on leafy laterals...... Phyllospora

   Leaves entire, alternate, vesicles absent. Receptacles axillary or marginal.... 2

   2. Receptacles cylindrical, tuberculate Seirococcus

      Receptacles compressed, lanceolate or ensiform or rostellate.... ... Scytothalia

(b) PHYLLOSPORA C. Agardh 1839.

C. Agardh 1839: 311. J. Agardh 1848: 252. Decaisne 1842: 331. De Toni 1891: 174; 1895: 181. Endlicher 1843: 32. Gruber 1896: 15. Kjellman 1897: 282. Kuetzing 1843: 353; 1849: 592. Lucas 1936: 77. May 1939: 205. Schmidt 1938: 225. Tilden 1937: 328.

Holdfast a conical disc. Thallus compressed, distichous, alternate and pinnate. Axis and branches fringed with marginal leafy laterals, ciliary processes, vesicles and leaf-like receptacles. Conceptacles numerous and scattered. Plant dioecious. Oogonia with one egg only.

Phyllospora was established as a genus by C. Agardh in 1839 and he described three species i.e. P. comosa, P. menziesii, and P. chamissoi. Areschoug (1876) transferred P. menziesii and P. chamissoi to a new genus Egregia which grows on the Western coast of North America and the Atlantic ocean. P. comosa remains the only species in the genus.

(c) PHYLLOSPORA COMOSA (Labillardiere)

C. Agardh 1839.

C. Agardh 1839: 311. J. Agardh 1848: 253. Bailey and Harvey 1874: 155. Decaisne 1842: 331. De Toni 1891: 174; 1895: 181; 1896: 230. De Toni et Forti 1923: 70.

Gruber 1896: 15. Harvey 1855: 214; 1859b:283; 1860: pl. 153; 1863: Syhop. 36. Hooker and Harvey 1845: 524; 1847: 413. Kuetzing 1843: 353; 1849: 592; 1860: t. 24, f. 1. Kjellman 1897: 282. Laing 1927: 142. Levering 1946: 218. Lucas 1936: 77. May 1939: 205. Oltmanns 1889; 64. Sonder 1852: 671; 1853: 512. Svedelius 1911: 180. Williams 1923: 639.

Plate XXXIII.

Fucus comosus Labillardiere 1806: 112. Mertens 1819: 188. Turner 1811: 142, t. 18.

Macrocystis comosa C. Agardh 1821: 48. A. Richard 1834: 142.

Type Locality.— "Cape van Diemen" — Tasmania (Labillardiere).

Type. — FI.

Holdfast massive, composed of a large number of robust, simple, closely imbricating processes, radiating from a central concave disc (up to 25 mm. in diameter) from the middle of which develops a single axis. Stipe terete up to 7 cm. long and 12 mm. broad. Plants up to 9 meters long, pinnately branched. Axis and branch axes ligulate, up to 15 mm. wide, compressed, somewhat thicker in the middle, densely crowded with marginal leaves, together with small ciliary processes which may develop into leafy laterals and vesicles. Axis smooth when young. Leafy laterals up to 22 cm. long and 7 mm. broad, petiolate, lanceolate, tapering at each end, serrate or more or less entire. Young leafy laterals sickle-shaped, entire, apex acute or divided. Vesicles elliptical, up to 25 mm. long and 18 mm. broad, pedicellate, mucronate, or bearing a terminal leaflet which is up to 11 cm. long and 5 mm. broad. Conceptacles numerous, scattered on the fertile leafy laterals (receptacles). Receptacles shorter and broader than the vegetative leaves, up to 19 cm. long and 7 mm. broad. Antheridia (26 - 47 µ × 8 - 13 µ), borne on branched hairs. Oogonia (132 - 275 µ × 78 - 180 µ), borne directly on the wall of the conceptacle.

SPECIMENS EXAMINED:

Kangaroo Island.— Pennington Bay (Womersley, 26-1-1956. Drift).

S. Aus. — Encounter Bay (Harris. Drift). Robe (Womersley, 30-8-1949 and 19-8-1957). Rivoli Bay (in Sonder, 1852). Victoria. — Bridgewater Bay (Beauglehole , 5-6-1949 and 24-6-1949), Cape Nelson (Pope and Bennett, 13-8-1949). Lawrence Rocks, Portland Bay (Beauglehole, 13-1-1954). Portland (Muir, April 1947). Walkerville (Bennett and Pope, 19-5-1949). Wilson's Promontory (in Sonder, 1853), Tasmania. — Currie River Mouth (Womersley, 28-1-1949). Low Head, North Tasmania (Perrin, August 1948). Georgetown (Gunn, in Hooker and Harvey, 1847). Three Hammocks (Bennett, 17-1-1954). Hunter Island (Bennett, 14-1-1954). Sandy Cape (Bennett, 15-1-1954). Sloop Rocks (Bennett, 8-2-1955). Bruny Island (Womersley, 15-1-1949). Missionary Bay (Womersley, 15-1-1949). Bicheno (Bennett, 6-2-1955). New South Wales. — Pambula, Bateman Bay and Nowra (in May, 1939). Long Reef (Womersley, 19-3-1949). Port Hacking, Botany Bay, Bondi, Sydney, Woy Woy, Hawkesbury River, Lake Macquarie, Newcastle, Port Stephens, Manning River and Port Macquarie (in May, 1939).

GEOGRAPHICAL DISTRIBUTION:

From Pennington Bay, Kangaroo Island and Encounter Bay, South Australia around the south-east coast to Port Macquarie New South Wales. Laing (1927) doubts the occurrence of *Phyllospora comosa* in New Zealand, although it has been reported by Hooker and Harvey (1845). Since then it has not been collected in New Zealand, and Lindauer (1947; 1957) does not include it in his list of New Zealand algae.

(d) *SEIROCOCCUS* Greville 1830.

J. Agardh 1848: 260. Decaisne 1842: 331. De Toni 1891: 174; 1895: 131. Endlicher 1836: 10; 1843: 33. Greville 1830: Synop. 34. Gruber 1896: 19. Kjellman 1897: 285. Lucas 1936: 68. Montagne 1842: 11; 1845: 85. Schmidt 1938: 226. Svedelius 1911: 180.

Holdfast discoid. Plants flat, distichous, alternate, producing a flat ribbed axis and branches and leafy laterals. Leafy laterals linear, flat, ecostate, entire and falcate. No vesicles. Receptacles cylindrical to torulose, in the axils of the laterals. Plant monoecious. Conceptacles unisexual or bisexual . Oogonia with one egg only.

Greville (1830) established two genera, *Seirococcus* and *Scytothalia*, differing in the structure of the receptacles. As there is great morphological resemblance between the two genera, Montagne (1842; 1845) and Kuetzing (1849) included them in the same genus considering that the receptacle difference was not a character of generic importance. J. Agardh (1848), De Toni (1895) and Harvey (1858), however considered that this difference in receptacle structure is of sufficient importance to justify placing them in separate genera. In addition to the receptacle character there are two other minor differences between the two genera (i) *Scytothalia* exudes an immense quantity of slimy mucus when steeped in fresh water; this does not happen in *Seirococcus* as reported by Harvey (1858), (ii) flattened parts of the axis of *Seirococcus* are costate while they are ~~not~~ ecostate in *Scytothalia*, ~~being ecostate.~~ *Scytothalia* is a genus of the south-west coast of Australia (from Port Elliot, South Australia, to Rottnest Island, Western Australia), and *Seirococcus* occurs on the south-east coast of Australia (from Fishery Bay, Port Lincoln, South Australia to Cape Paterson along the north coast of Tasmania). *Scytothalia* and *Seirococcus* are here considered as separate genera, since the receptacles differ in form so markedly. There is only one species of *Seirococcus*, i.e. *S. axillaris*, based on *Fucus axillaris* R. Brown ex Turner.

(e) *SEIROCOCCUS AXILLARIS* (R. Brown ex Turner)
Greville 1830.

J. Agardh 1848: 260. Decaisne 1842: 331. De Toni 1891: 174; 1895: 131; 1896: 229. De Toni et Forti 1923: 67. Greville 1830: Synop. 34. Gruber 1896: 11. Harvey 1858: pl. 4; 1859b: 283; 1863: Synop. 37. Hooker and Harvey 1847: 413. Kjellman 1897: 285. Lucas 1909: 12;

1936: 68. Smith 1893: 32. Sonder 1853: 512. Svedelius 1911: 181. Womersley 1950: 159.

PLATE XXXIV.

Fucus axillaris R. Brown ex Turner 1811: 28, t. 146.

Cystoseira axillaris C. Agardh 1821: 80; 1824: 291.

Scytothalia axillaris Kuetzing 1849: 593; 1860: t. 26, f. 1.

Type Locality. — Port Dalrymple, North Tasmania (R. Brown).

Type. — K.

Holdfast conico-discoid up to 6 mm. across, closely imbricated with branched, simple terete processes. Thallus up to 2 metres long, flexuous, coriaceous and dark brown. Axis flat, linear, indistinctly ribbed, distichously and alternately branched. Branches flat, flexuous, pinnate, up to 50 cm. long and up to 4 mm. broad. Laterals (leaves) up to 17 cm. long and up to 10 mm. broad, distichous, alternate, linear, flat, falcate, ecostate, entire (occasionally one or two teeth) and apex acute or obtuse sometimes furcate. Receptacles in the axils of the laterals, up to 6 mm. long and up to 0.7 mm. broad, cylindrical to torulose, simple or branched, pedicellate and apiculate. Plant monoecious. Conceptacles unisexual or bisexual.

Receptacles generally monoecious but occasionally dioecious. Antheridia (24 - 40 μ x 8- 14 μ) on branched hairs. Oogonia (90 - 275 μ x 60 - 150 μ) on the walls of the conceptacles. Hairs in conceptacles simple and moniliform.

SPECIMENS EXAMINED:

S. Aus. — Fishery Bay (Nizamuddin, 17-2-1959). Sleaford Bay (Nizamuddin, 16-2-1959). Wanna (Nizamuddin, 19-2-1959). Investigator Strait (Davey, in Reinbold, 1899). Encounter Bay (Harris, May 1943. Cleland 1939. Macklin. Womersley, 4-6-1943). Victor Harbour (Womersley, 4-6-1943 and 7-10-1948). Port Elliot (Nizamuddin, 5-10-1958). Robe (Womersley, 18-8-1957). Stinky Bay, Nora Creina (Womersley, 19-8-1957).

Kangaroo Island. — Middle River (Womersley, 8-1-1946). Pennington Bay (Womersley, 25-1-1946, 3-6-1947 and 4-1-1948). Cape Willoughby (Womersley, 16-1-1946).

Victoria. -- Portland Bay (Hale, August 1944. Beauglehole, 15-5-1949 ; 8-7-1951. Muir, January 1950). Near Point Roadknight (Womersley, 31-12-1946 and 6-6-1953). Cape Paterson (in Sonder 1853).

Tasmania. — Bombay Rock, Tamar East (Womersley, 27-1-1949). Low Head (Perrin, August 1948). Georgetown (Gunn, in Harvey, 1859. De Toni et Forti). Latrobe Bay (De Toni et Forti).

GEOGRAPHICAL DISTRIBUTION:

From Fishery Bay, South Australia along the south coast to Cape Paterson, Victoria and along the north coast of Tasmania.

Plants of Seirococcus axillaris, from west of Robe to Fishery Bay, West of Port Lincoln and Kangaroo Island, are slender with linear, narrow leaves, up to 8 cm. long and 5 mm. broad while those from Robe eastwards to Tasmania possess wider leaves, up to 10 mm. broad with a distinct midrib in the upper parts of the axis and branches. These two forms appear to be geographical variations only.

(f) SCYTOTHALIA Greville 1830

J. Agardh 1848: 257. Decaisne 1842: 331. De Toni 1891: 174; 1895: 132. Endlicher 1836: 10; 1843: 33. Greville 1830: Synop. 34. Gruber 1896: 19. Kjellman 1897: 285. Kuetzing 1849: 592. Lucas 1936: 69. Montagne 1842: 11; 1845: 85.

Holdfast discoid with branched processes. Thallus flat, coriaceous, distichous and pinnate. Leafy laterals linear, lanceolate, falcate, ecostate and entire. No vesicles. Receptacles supra-axillary, marginal, linear, ensiform or rostellate. Conceptacles numerous, unisexual or bisexual. Receptacles unisexual or bisexual. Plant monoecious. Oogonia with one egg only.

Six species have been described under *Scytothalia*. *S. jacquinotii* Montagne, has been transferred to *Cystosphaera* Skottsberg, and *Scytothalia axillaris* Kuetzing to *Seirococcus*. Of the remainder *S. xiphocarpa* J. Agardh and *S. rhynchocarpa* Kuetzing have been placed under *S. dorycarpa* Greville by J. Agardh and Kuetzing respectively. Dickie (1875) described *S. obscura* from Heard Island, based on the linear form of the leaves.

S. dorycarpa, *S. rhynchocarpa* and *S. xiphocarpa* differ in size and form of the receptacles but these characters vary much, even in the same axil of a lateral. Harvey (1858) states that such features depend upon the depth of the water in which the plant grows. These forms are not worth recognising even as varieties.

(g) SCYTOTHALIA DORYCARPA (Turner) Greville 1830.

J. Agardh 1848: 258. Decaisne 1842: 331. De Toni 1891: 174; 1895: 132; 1896: 230. De Toni et Forti 1923: 67.

Greville 1830: Synop. 34. Gruber 1896: 15. Harvey 1854: 534; 1858: Pl. 9; 1859b: 283; 1863: Synop. 34. Kjellman 1897: 285. Kuetzing 1849: 592; 1860: t. 25, f. 3. Lucas 1909: 12; 1936: 69. Naylor 1949a: 135. Sonder 1846: 166. Womersley 1950: 73.

PLATE XXXV.

Fucus dorycarpus Turner 1811: 22, t. 143.

Cystoseira dorycarpa C. Agardh 1821: 80; 1824: 292.

Scytothalia xiphocarpa J. Agardh 1848: 259. Kuetzing 1849: 593; 1860: t. 25, f. 2.

Scytothalia rhynchocarpa Kuetzing 1860: t. 25, f. 1.

Scytothalia dorycarpa β. xiphocarpa. Harvey 1854: 534; 1863: Synop. 34.

Type Locality. — King George Sound, W. Aus. (Menzies).

Type. — K.

Holdfast discoid, upto 2 cm. across, with rigid, curved, terete processes. Plants up to 90 cm. long, with linear, flat, alternately distichously branched segments. Axis flat, slightly thickened in the middle, without midrib and up to 6 mm. broad. Branches up to 60 cm. long and up to 5 mm. broad, alternate, subflexuous and flat. Leafy laterals flat, linear, alternate, ecostate, entire (rarely 1 or 2 teeth) falcate, apices either acute or furcate upto 25 cm. long and up to 7 mm. broad. Mature receptacles commonly 3 (- 5) cm. long and up to 4 mm. broad, situated along the margin of the axis, and in a supra-axillary position, pedicellate, flat, from ovate-acuminate to linear - lanceolate, apices acute and sterile. Plant monoecious. Conceptacles on both surfaces, unisexual or bisexual. Antheridia (24 - 42 μ x 8 - 14 μ), on branched hairs. Oogonia 162 - 276 μ x 60 - 150 μ. Paraphyses in oogonial conceptacles simple and moniliform.

SPECIMENS EXAMINED:

W. Aus. — Rottnest Island (Harvey, 1854). Middleton Bay (Harvey, 1858). Waterman's Bay (Royce, 9-5-1945). Point D'Entrecastreaux (Smith, 20-3-1946). King George Sound (Harvey, 1854). Cape Riche (Harvey, 1858). Figure of Eight Island, Recherche Archipelago (Womersley, 7-11-1950). S. Aus. — East of Eucla (Womersley, 3-2-1954). Head of the Great Australian Bight (Womersley, 4-2-1954). Point Sinclair (Womersley, 25-1-1954 and 8-2-1954). Clare Bay, Penong (Chambers, May 1849). Venus Bay (Womersley, 12-2-1954) Fishery Bay and Sleaford Bay (Nizamuddin, February 1959), Elliston (Womersley, 13-1-1954, Nizamuddin, 27-2-1959). Stenhouse, Yorke Peninsula (Womersley, 9-4-1950). Victor Harbour (Womersley, 17-10-1948). Port Elliot (Nizamuddin, 25-10-1958). Encounter Bay (Cleland, January 1928. Harris, May 1943).

Kangaroo Island. — Western River (Cruickshank, 24-1-1945). Vivonne Bay (Womersley, December 1945, January 1948 and January 1949). Pennington Bay (Womersley, 12th. and 17th. January 1944, 15th. January 1946, 14th. and 22nd. January 1948).

GEOGRAPHICAL DISTRIBUTION:

From Rottnest Island, W. Aus. along the south coast to Port Elliot, S. Aus., and along the coast of Kangaroo Island.

(4) FUCACEAE Decaisne, 1842.

(a) XIPHOPHORA Montagne 1842

De Toni 1891: 173; 1895: 213. Endlicher 1843: 29. Gruber 1896: 19. Kjellman 1897: 281. Lucas 1936: 81. Montagne 1842: 12; 1845: 59. Svedelius 1911: 179. Tilden 1937: 322.

Holdfast discoid. Frond flat and dichotomous. No vesicles. Conceptacles on terminal segments of the frond, unisexual. Plant monoecious. Oogonia with 4 eggs. Hyphae present in the medulla.

Montagne (1842) established *Xiphophora* as a genus based on *Fucus gladiatus* Labillardiere and named it *X. billardierii*, which is illegitimate, because Montagne did not adopt the earliest legitimate specific epithet. Kjellman (1897) was the first to use the correct combination of *X. gladiata* and he credited it to Montagne. A second species *X. chondrophylla*, is based on *Fucus chondrophyllus* R. Brown ex Turner. Harvey (1855a) was the first to use the correct combination *X. chondrophylla* (R. Brown ex Turner) which he credited to Montagne.

(b) KEY TO THE SPECIES.

1. Receptacles ligulate, up to 56 cm. long,
conceptacles in 4 or more longitudinal
rows... .... *X. gladiata*
Receptacles narrow linear up to 15 cm. long,
conceptacles in 1-3 longitudinal rows
(rarely irregular) ... ... *X. chondrophylla*

(c) *XIPHOPHORA GLADIATA* (Labillardiere)
Montagne ex Kjellman 1897.

Heine 1932: 557. Kjellman 1897: 281. Laing 1927: 142. Tilden 1937: 322. Silva 1959: 64.

PLATE XXXVI.

Fucus gladiatus Labillardiere 1806: 111, t. 256. C. Agardh 1821: 97; 1824: 279. Lamouroux 1813: 36. Turner 1819: 102, t. 240.

Himanthalia gladiata Kuetzing 1849: 587; 1860: t. 7.

Fucodium gladiatus J. Agardh 1848: 202. Bailey and Harvey 1874: 156. Harvey 1858: pl. 53, 1863: Synop. 63.

Xiphophora billardierii Montagne 1842: 12; 1845: 59. Barton 1893: 35. De Toni 1891: 173; 1895: 213. Harvey 1855: 215; 1859b: 285. Harvey and Hooker 1847: 176. Hooker and Harvey 1845: 528; 1847: 413. Kuetzing 1860: t. 7, f. 1. Lucas 1936: 81. Sonder 1852: 668. Svedelius 1911: 181.

Type Locality. — "Cape van Diemen" — Tasmania (Labillardiere).

Type. — Fl.

Holdfast discoid. Stipe subterete. Plants up to 73 cm. long. Segments up to 8 mm. broad, flat, linear dichotomous, ecostate and cartilaginous. Dichotomy regular and axils rounded. Terminal segments elongate and branched, ligulate (short and simple when young) up to 56 cm. long and up to 10 mm. broad. Plant monoecious. Conceptacles in 4 or more longitudinal rows, unisexual, male ones in single row towards the periphery. Antheridia on branched and septate hairs, 20 - 31 μ x 10 - 14 μ. Oogonia 200 - 276 μ x 108 - 162 μ. Hairs, in conceptacles, simple and moniliform.

SPECIMENS EXAMINED:

Victoria. — Western Port (Harvey, 1859).

Tasmania. — Georgetown (Gunn). Sandy Cape (Bennett, 15-1-1954). Cape Sorrell (Bennett, 4-2-1955). Sloop Rocks (Bennett, 8-2-1955). Taroona, Hobart (Womersley, 13-1-1949). Port Arthur (Harvey, 1859). Blowhole (Bennett, 8-3-1958). Green point (Bennett, 29-1-1958). Sleepy Bay (Bennett, 12-3-1958). Bicheno (Womersley, 19-1-1949; 6-2-1955).

GEOGRAPHICAL DISTRIBUTION:

Western Port, Victoria; along the coast of Tasmania. Lindauer (1947) does not include X. gladiata among the algae of New Zealand, but Kuetzing (1860) and Hooker and Harvey (1847) report X. gladiata from Auckland. Harvey (1855) reports it from Lyall's Bay, Cook Straits and Bay of Islands. These specimens may be X. chondrophylla var. maxima as discussed by J. Agardh (1877) and Heine (1932).

X. gladiata varies greatly with age and in different habitats. When young the thallus is frequently dichotomous and fastigiate.

(d) XIPHOPHORA CHONDROPHYLLA (R. Brown ex Turner)

(Montagne ex Harvey 1855).

De Toni 1895: 213. Harvey 1855: 215; 1859b; 285. Heine 1932: 558. Kjellman 1897: 281. Laing 1927: 142. Levering 1945: 11. Lindauer 1947: 559; 1957: 70. Lucas 1936: 81. Mitchell 1941: 49, 65. Naylor 1954a: 155; 1954b; 653. Womersley 1950: 159.

PLATE XXXVII.

Fucus chondrophyllus R. Brown ex Turner 1819: 69, t. 222. Kuetzing 1860: t. 17, f. 1.

Fucodium chondrophylla J. Agardh 1848: 203. Harvey 1863: Synop. 64. Laing 1899: 66.

Sphaerococcus chondrophyllus C. Agardh 1821: 251.

Type Locality. — Port Dalrymple, North Tasmania (R. Brown).

Type. — BM.

Holdfast discoid. Stipe distinctly flattened. Plants up to 33 cm. long, segments up to 13 mm. broad, flat, linear, ecostate, entire, dichotomous and branching in one plane. Axils acute. Segments terminating in long tapering points. Receptacles up to 15 cm. long and 7 mm. broad, near the base, flat, sword-like ending in long slender points.

Plant monoecious. Conceptacles in 1-3 longitudinal rows. Oogonia 228 - 270 µ x 108 - 228 µ. Antheridia 26 - 34 µ x 13 - 16 µ. Hairs, in conceptacles, simple and moniliform.

SPECIMENS EXAMINED:

S. Aus. — Port Elliot (Hussey, Drift).

Kangaroo Island. — Pennington Bay (Womersley, 30-1-1956, 2-2-1956 and 27-1-1957).

Victoria. — Bridgewater Bay (Beauglehole, 14-5-1951 and 18-8-1951, Muir, January 1956. Nizamuddin, 13-4-1959). Apollo Bay (Nizamuddin, 11-4-1959). Queenscliff Beach (Nizamuddin, 7-4-1959). The Nobbies, Phillip Island (Bennett, 15-11-1949).

Tasmania. — Currie River Mouth (Womersley, 28-1-1949). Burnie (Womersley, 26-1-1949). Wivenhoe Point(Bennett, 31-1-1955). Stanley. West Head (Bennett, 30-1-1955).

GEOGRAPHICAL DISTRIBUTION:

From Pennington Bay, Kangaroo Island, and Port Elliot, South Australia along the south coast of Australia to the Nobbies, Victoria, to the north coast of Tasmania, and New Zealand.

The basal part of X. chondrophylla is flat and the dichotomy is not as regular and uniform as in X. gladiata. The axils are much more acute in X. chondrophylla than in X. gladiata. Receptacles of X. gladiata are extremely elongate and more strap shaped than those of X. chondrophylla.

Conceptacles in *X. gladiata* are in 4 or more longitudinal rows, while they are in 1 - 3 longitudinal rows in *X. chondrophylla*. *X. gladiata* is usually a larger plant than *X. chondrophylla*. In New Zealand a number of specimens of *Xiphophora chondrophylla* were found possessing sword like receptacles. This resulted in a great controversy among earlier authors on the presence of *X. gladiata* in New Zealand. J. Agardh (1877), discussed this controversy and concluded by establishing 2 varieties of *X. chondrophylla*, var. *minus* and var. *maxima*.

X. chondrophylla var. *minus* agrees well with Brown's description and *X. chondrophylla* var. *maxima* resembles *X. chondrophylla* in all respects except the receptacles which are sword like, as discussed by Heine (1932).

X. CHONDROPHYLLA VAR. CHONDROPHYLLA

X. chondrophylla var. *minus*. J. Agardh 1877: 7. Heine 1932: 560. Lindauer 1947: 560. Womersley 1950: 159.

Plants smaller, narrower than var. *maxima* J. Ag. and up to 27 cm. long. Conceptacles in a single row in centre of receptacle.

This variety grows in patches in the upper sublittoral and also in small patches on reefs at Pennington Bay, Kangaroo Island.

X *CHONDROPHYLLA VAR. MAXIMA* J. Agardh.

J. Agardh 1877: 7. Heine 1932: 560. Lindauer 1947: 559.

Plants thick, flat, leathery, dichotomous up to 45 cm. (- 1 metre) long. Receptacles sword-like. Conceptacles in 2 - 3 longitudinal rows (slightly irregular)

This variety grows in pools or forms a horizontal fringe above the *Durvillea* or *Carpophyllum* associations in New Zealand (Lindauer, 1947).

(5) *CYSTOSEIRACEAE* Kuetzing, 1843.

(a) KEY TO THE GENERA OF THE SOUTHERN AUSTRALIAN CYSTOSEIRACEAE.

1. Conceptacles on the receptacles... 2
   Conceptacles on branch-segments 3
    2. Vesicles in concatenate series on branches... 4
       Vesicles absent or lateral, not in concatenate series... .... *Cystophora*

3. Plants terete with warty, densely imbricate segments, vesicles present. .... *Scaberia*
   Plants flat, vesicles always absent 5

4. Vesicles on the ultimate branchlets; oogonia embedded, zonal discharge of eggs... ... ... Cystophyllum

Vesicles as dilations on the leaves or branchlets, oogonia not embedded, successive but not zonal discharge of eggs..... ... .. Cystoseira

5. Plants not dichotomous near the base, flat, thick, alternate and pinnate segments. Simultaneous maturation of oogonia. Carpoglossum

Plants dichotomous near the base, thin segments, pinnate, successive maturation of oogonia... ... ...Myriodesma

(b) CYSTOPHORA J. Agardh 1841.

J. Agardh 1841; 3; 1848: 238; 1896: 44. Cotton 1935: 119. De Toni 1895: 136. Gruber 1896: 30. Kjellman 1897: 284. Lindauer 1957: 70. Lucas 1936: 70. Schmidt 1938: 228, 230. Silva 1952: 279. Svedelius 1911: 180, 182.

Blossevillea Decaisne 1840: 410; 1841: 147; 1842: 331. Areschoug 1854: 10 (336). Endlicher 1843: 30. Gardner 1913: 325. Kuetzing 1849: 628. May 1939: 204. Montagne 1845: 64. Reinke 1876: 362. Taylor 1945: 112.

Platylobium Kuetzing 1849: 605. De Toni 1891: 173.

Neurothalia Sonder 1853: 511.

Caulocystis Areschoug 1854: 8 (334). De Toni 1891: 175.

Acrocarpia Areschoug 1854: 9 (335). De Toni 1891: 175.

Neoplatylobium Schmidt 1938: 229.

Holdfast discoid usually, occasionally divided (rhizomatous in *C. brandegeei*). Axis flat or terete, branches usually retroflex, leaves absent. Vesicles distinct, lateral, pedicellate, inserted on the axis or branches, variable in shape and occurrence (absent or rare or numerous), mutic or apiculate. Ultimate ramuli developing into receptacles. Receptacles terete, compressed or strongly flattened (rarely angular), moniliform or smooth or torulose. Conceptacles scattered or in 2 or more rows, bisexual or unisexual. Plant monoecious. Oogonia with one egg.

This account of *Cystophora* has been extended to include all known species, viz. those from New Zealand and also single species from the Galapagos and Guadalupe Islands.

Cystophora J. Agardh (1841) and *Blossevillea* Decaisne (1840) have long been considered by the majority of algologists as synonyms. Neither Decaisne nor J. Agardh however, recognised at first any particular species either for the type or in the genus originally proposed. In each case they apparently intended to separate these southern forms from the northern forms, all of which had previously been included by C. Agardh (1821) under *Cystoseira*. Decaisne (1840) segregated *Blossevillea* from *Cystoseira* on the basis of branches from the flat face of the axis and 2 rows of conceptacles on each receptacle. J. Agardh (1841) separated *Cystophora* from *Cystoseira* on the basis of vesicles and retroflexed branches. In 1842 Decaisne first published a list of five species of *Blossevillea* (*B. paniculata*, *B. torulosa*, *B. spartioides*, *B. dumosa* and *B. platylobium*) all of which are retained under *Cystophora*, but J. Agardh did not publish his list of species of *Cystophora* until 1848. Since Decaisne's diagnosis of the genus appeared before that of J. Agardh and the publication of Decaisne's list of species of *Blossevillea* antidates the publication of J. Agardh's list of species of *Cystophora*. *Blossevillea* Decaisne is the earliest legitimate name for the genus.

Schmidt (1938) retains *Cystophora* and *Blossevillea* as separate genera. According to Schmidt *Cystophora* is characterized by radial branches arising from the terete axis and by irregularly arranged conceptacles on the receptacles, whereas in *Blossevillea* the branches arise only from the edges of the flat axis and the conceptacles are regularly arranged in 2 rows on the receptacles. There is a large number of species of *Cystophora* in which branches arise from the face of the axis, which do not fit into either of these two categories. Receptacle characters of a large number of species of *Cystophora* also do not fit in either genera. It appears that Schmidt's classification of these two genera is not satisfactory and it should be rejected; its validity has already been doubted (Silva, 1952).

Cystophora is in such common use that conservation is justified, as proposed by Cotton (1935). Silva (1952) discussed and advocates the conservation of *Cystophora* against *Blossevillea* and selected *B. torulosa* (Turner) Decaisne as lectotype of *Blossevillea* while De Toni (1891) had selected *C. brownii* (Turner) J. Agardh as lectotype for *Cystophora*.

In discussing *Cystophora* and *Blossevillea* five genera (*Platylobium* Kg., *Neurothalia* Sonder, *Caulocystis* Aresch., *Acrocarpia* Aresch., and *Neoplatylobium* Schmidt) are relevant. Kuetzing (1849) established a new genus *Platylobium* (based on *Fucus platylobium* Mertens 1819) on the basis of compressed, distichous, siliqua-form like receptacles with a simple pedicellate vesicle at the base of each branchlet. Such characters, to varying degrees, are also found in other species of *Cystophora* (*C. racemosa*, *C. xiphocarpa* and *C. scalaris*), so that *Platylobium* does not comprise a well defined genus. Sonder (1853) renamed *Platylobium* Kg., as *Neurothalia*, because *Platylobium* Smith had already been given to a leguminous plant. OC. Schmidt (1938) without knowledge of Sonder's *Neurothalia* gave a new name *Neoplatylobium* to *Platylobium* Kg. (Non Smith 1793). The name *Neoplatylobium* O.C. Schmidt was illegitimate and superfluous when published because *Neurothalia* Sonder (1853) predates the publication of O.C. Schmidt. *Neurothalia* was based on *Platylobium mertensii* (= *Fucus platylobium* Mertens 1819).

Areschoug (1854) separated *Caulocystis* and *Acrocarpia* from *Blossevillea* (= *Cystophora*) on the position of vesicles and the form of the receptacles. *Caulocystis* and *Acrocarpia* possess terete axes with radial branches. Vesicles normally develop on the axis of *Caulocystis* but they are absent in *Acrocarpia*. Ramuli in both the genera are transformed into receptacles. The receptacles are linear, and terete in *Caulocystis* whereas they are verrucose, terminal and paniculate in *Acrocarpia*. These characters are also found among other species of *Cystophora*. In *C. brownii* there are no vesicles and receptacles are terete and in panicles. The axis of *C. brownii* is flat with distichous branches, differing from *Acrocarpia* which possesses a terete axis with radial branches. *Caulocystis* is comparable with *Cystophora grevillei* where the axis is terete with radial branches. Vesicles are present on the branches of *C. grevillei* but they are borne on the main axis of the species of *Caulocystis*. In the species of *Caulocystis* vesicles also occur on the branches. The presence or absence, and position of vesicles and the form of the receptacles are the chief characters of these three genera. It appears that *Caulocystis*, *Acrocarpia* and *Cystophora* cannot be maintained as distinct genera. *Cystophora* antidates the publication of *Caulocystis* and *Acrocarpia*.

Cystophora grows on the Australian coast from Shark's Bay, Western Australia, to Port Stephens, New South Wales. Distribution of the species of *Cystophora* is discussed individually in detail and is summarised in Table VII. Only *C. brandegeei* and *C. galapagensis* occur outside Australasian waters. *C. galapagensis* occurs on the Galapagos Islands, at the Equator, west of Ecuador and *C. brandegeei* on Guadalupe Island, off Lower California at 30°N. Lat. It is difficult to account for their presence so far away from the other members of the genus and this distribution is a matter of no little interest and importance in geographical distribution. Table VIII gives an analysis of the distribution of the species, divided into western Australian, southern Australian and eastern Australian elements and a limited number of species known from other places. The Southern and Eastern groups contain 84% of the Australian species and the Western contains 12%. Only 2 (7%) of the species which are endemic occur in New Zealand waters. *C. hookeri* and *C. elongata* are restricted in distribution. *C. distenta* and *C. scalaris* are endemic in New Zealand and the Chatham Islands. *C. xiphocarpa* occurs only in Tasmania. Most species of *Cystophora* grow on rocks, but *C. elongate* grows only on

Cymodocea in Portland Bay, Victoria, while *Cystophora monilifera* and *C. moniliformis* also occasionally grow on *Cymodocea*.

In many species of *Cystophora* the age and habitat may cause considerable morphological variation.

Holdfasts are generally discoid in *Cystophora* but are divided in *C. paniculata*, rhizomatous in *C. brandegei* and lobed in *C. galapagensis*. The diameter of the holdfast increases with the age of the plant, and the maximum breadth reaches 3 cm. in *C. moniliformis*.

The stipe of *Cystophora* is terete or subterete and gradually compressed upwards in the species which possess flat axes. Axes are either terete, compressed or strongly flattened and vary greatly in length. *C. moniliformis*, *C. botryocystis* and *C. platylobium* reach 4 meters in length and other species reach 2 meters. In *C. moniliformis*, *C. platylobium* and *C. brandegei* the central parts of the flattened axes are strongly thickened and taper gradually towards the edges. *C. polycystidea* and *C. siliquosa* possess quadrangular axes. *C. uvifera* and *C. cephalornithos* possess cylindrical axes. Axes are also terete in *C. grevillei*, *C. paniculata* and

C. galapagensis but in *C. intermedia* and *C. pectinata* they are more ovoid. Other species of *Cystophora* possess flattened axes. In rare cases the basal part of *C. siliquosa* becomes terete but the quadrangular axis is prominent above.

Branches are radial, alternate, irregular or distichous, produced from terete axes (*C. uvifera*, *C. cephalornithos*, *C. paniculata*, *C. galapagensis*, *C. pectinata*, *C. intermedia* and *C. grevillei*), but the branches are retroflex, pinnate and distichous from the faces of the flat axes (*C. xiphocarpa*, *C. racemosa*, *C. cuspidata*, *C. scalaris*, *C. retroflexa*, *C. siliquosa*, *C. retorta*, *C. torulosa*, *C. botryocystis*, *C. distenta*, *C. congesta*, *C. subfarcinata*, *C. thysanocladia*, *C. brownii*, *C. gracilis*, *C. monilifera*, *C. polycystidea*, *C. expansa* and *C. elongata*).

C. platylobium, *C. hookeri*, *C. moniliformis* and *C. brandegei* possess alternate pinnate distichous branches from the edges of the flat axes.

Vesicles are discrete organs which vary in occurrence and shape. They are generally spherical to ovoid, lateral in position, pedicellate, mutic or apiculate. *C. uvifera* and *C. cephalornithos* bear vesicles on the main axes as well as on branches, but in other species they are borne on the branches only. A few species do not possess vesicles at all (e.g. *C. brandegeei*, *C. moniliformis*, *C. xiphocarpa*, *C. pectinata*, *C. galapagensis*, *C. brownii*, *C. paniculata*, *C. intermedia*, *C. cuspidata*, *C. siliquosa*, and *C. gracilis*). In a few species (*C. retorta*, *C. racemosa*, *C. congesta*, and *C. subfarcinata*) vesicles may be either present or absent. Vesicle bearing plants of *C. subfarcinata* grow in sheltered places whereas non-vesicle forms occur on rough coasts. In *C. botryocystis* vesicles occur in clusters at the base of the branches.

Ramuli are either filiform, terete or flat, alternate, pinnate and distichous. They are strongly or entirely flattened, pinnate and distichous in *C. platylobium*, *C. xiphocarpa*, *C. racemosa*, *C. brandegeei* and *C. pectinata*. Other species of *Cystophora* possess either terete or filiform ramuli. Ultimate ramuli of *C. moniliformis*, *C. brownii*, and *C. intermedia* divide dichotomously or subdichotomously.

Ultimate ramuli are transformed into receptacles in all species. The basal part of the ramuli remains sterile and only the upper parts become fertile. Receptacles are of different sizes and shapes among different species. They vary from compressed or strongly flattened to terete or moniliform to torulose. *C. platylobium*, *C. racemosa*, *C. xiphocarpa*, *C. brandegeei* and *C. pectinata* bear alternate, pinnate and strongly distichous receptacles. *C. paniculata* bears receptacles in crowded panicles. *C. brownii* possesses terminal, short, terete receptacles less than 6 mm. long. In *C. grevillei* the receptacles are ensiform, ovoid in section, up to 8 (-15) cm. long and 2 mm. across. In *C. cuspidata* angular receptacles occur due to the development of much swollen conceptacles in rows. Short tufts of receptacles develop in *C. congesta*. Conceptacles of *C. subfarcinata* are compact near the base of the receptacle and loose above with a prominent terminal sterile awn. The receptacles are either unisexual or bisexual. Conceptacles may be scattered or in 2 or more rows. In *C. torulosa* and *C. cuspidata* 2 or 3 rows of conceptacles occur. In *C. platylobium*, *C. brandeegeei*, *C. xiphocarpa* and *C. racemosa* conceptacles are in 2 rows on the margins of the receptacles. They are markedly swollen and irregular in *C. subfarcinata*. Bisexual or unisexual conceptacles occur but in *C. thysanocladia* they are always unisexual.

Antheridia are borne in fasicles on branched hairs or directly on the wall of the conceptacles. Oogonia are without a stalk and always bear a single egg. ~~always~~

Effect of drying on the form of the receptacle.

Flat receptacles of *C. pectinata*, *C. platylobium*, *C. xiphocarpa* and *C. racemosa* on drying become strongly flattened with distinct wavy margins while compressed receptacles of *C. scalaris*, *C. retroflexa*, *C. siliquosa*, *C. distenta* and *C. gongesta* become flattened. Occasionally the compressed receptacles of *C. scalaris* and *C. distenta* become moniliform or tuberculate respectively. Moniliform receptacles of *C. intermedia*, *C. hookeri*, *C. moniliformis*, *C. thysanocladia*, *C. monilifera*, *C. polycystidea*, *C. expansa*, *C. gracilis* become distantly moniliform and the conceptacles become compressed or flattened. Terete-ovoid receptacles of *C. grevillei* become compressed or flattened while the torulose receptacles of *C. retorta* become distantly moniliform. The terete receptacles of *C. cuspidata* and the torulose receptacles of *C. subfarcinata* on drying become flattened near the base and distantly moniliform in the upper parts. The mature receptacles of *C. cuspidata* and *C. subfarcinata* are compressed at the base due to conceptacles and on drying they become flattened. The terete receptacles of *C. paniculata* and

C. galapagensis and *C. brownii* become moniliform or occasionally tuberculate. The Cylindrical and terete receptacles of *C. uvifera*, *C. cephalornithos* and *C. botryocystis* become verrucose while the terete receptacles of *C. torulosa* become tuberculate or flattened. The flat receptacles of *C. brandegeei* become flattened. The terete elongate, receptacles of *C. elongata* become compressed near the base and distantly scattered in the upper parts.

TABLE VII. DISTRIBUTION OF CYSTOPHORA.

	W.A.	S.A.	Tas.	Vic.	N.S.W.	New Zealand	Chatham Is.	Guadalupe Is.	Galapagos Is.
C. uvifera	+	+	+	+	+	-	-	-	-
C. cephalornithos	-	+	+	+	+	-	-	-	-
C. paniculata	-	+	+	+	+	-	-	-	-
C. galapagensis	-	-	-	-	-	-	-	-	+
C. pectinata	+	+	-	-	-	-	-	-	-
C. intermedia	-	+	-	+	-	-	-	-	-
C. grevillei	+	+	+	+	-	-	-	-	-
C. platylobium	-	+	+	+	+	+	-	-	-
C. brandegeei	-	-	-	-	-	-	-	+	-
C. moniliformis	-	+	+	+	+	-	-	-	-
C. hookeri	-	-	-	-	+	-	-	-	-
C. xiphocarpa	-	-	+	-	-	-	-	-	-
C. racemosa	+	+	-	+	-	-	-	-	-
C. cuspidata	-	+	-	+	-	-	-	-	-
C. scalaris	-	-	-	-	-	+	+	-	-
C. retroflexa	-	+	+	+	+	+	-	-	-
C. siliquosa	+	+	-	+	+	-	-	-	-
C. retorta	+	+	+	+	-	-	-	-	-
C. torulosa	-	-	+	+	-	+	-	-	-
C. botryocystis	+	+	+	+	-	-	-	-	-
C. distenta	-	-	-	-	-	+	+	-	-
C. congesta	+	+	+	+	-	+	-	-	-
C. subfarcinata	+	+	+	+	-	-	-	-	-
C. thysanocladia	+	-	-	-	-	-	-	-	-
C. brownii	+	+	-	-	-	-	-	-	-
C. gracilis	-	+	-	-	-	-	-	-	-
C. monilifera	+	+	+	+	+	-	-	-	-
C. polycystidea	-	+	+	+	+	-	-	-	-
C. expansa	+	+	-	+	-	-	-	-	-
C. elongata	-	-	-	+	-	-	-	-	-

TABLE VIII

RELATIONSHIP OF THE SPECIES OF CYSTOPHORA

Distribution	Species in the world	Species in Australian waters
Western Australia	3 (10%)	3 (12%)
Southern Australia	10 (33%)	10 (38%)
South eastern Australia	12 (40%)	12 (46%)
Endemic to N.S.W.	1 (3%)	1 (4%)
N.Zealand	2 (7%)	—
Other Places	2 (7%)	—
Total	30	26

(c) KEY TO THE SPECIES OF CYSTOPHORA.

1. Vesicles on the axis and on the branches... ... 2
Vesicles absent or on the branches only 3

    2. Vesicles (when adult), spherical,
    up to 6 (-8) mm. broad... ... *C. uvifera* (1)
    Vesicles elongate tapering at both
    ends, up to 5 (-10) mm. long and
    3 (-5) mm. broad.... .... *C. cephalornithos* (2)

3. Axis terete or ovoid in section 4
Axis flattened... 5

    4. Branching radial 6
    Branching always basically distichous ... 7

5. Branches from the face of the axis... 8
Branches from the edge of the axis... 9

    6. Branching radial (rarely distichous).
    Receptacles up to 4 mm. long and
    1 mm. broad... ... ... *C. paniculata* (3)
    Branching always alternate (partly bilateral when young). Receptacles up to
    4 cm. long and 1 mm. broad. *C. galapagensis* (4)

7. Receptacles decidedly flattened, up to 2
(-3) cm. long and 2 mm. broad. ... *C. pectinata* (5)
Receptacles terete or ovoid in section 10

8. Receptacles flattened, conceptacles in rows... 11
Receptacles terete or irregular, or angular due to conceptacles... ... 12

9. Receptacles flattened 13
Receptacles terete... 14

10. Axis ovoid, with regular pinnate branches, vesicles absent, receptacles terete up to 15 mm. long. C. intermedia (6)
Axis terete, vesicles subglobose, mutic. Receptacles ovoid in section, up to 8 (-15) cm. long... ... C. grevillei (7)

11. Receptacles strongly flattened, 0.7 - 9 cm. long and 2 - 10 mm. broad 15
Receptacles compressed but not strongly flattened, 2 - 8 cm. long and 1-2 mm. broad 16

12. Conceptacles in rows 17
Conceptacles scattered... 18

13. Holdfast discoid, vesicles present, receptacles up to 3 cm. long and 7 mm. broad. C. platylobium (8)
Holdfast rhizomatous, vesicles absent, receptacles up to 2 cm. long and 3 mm. broad... ... ...C. brandegeei (9)

14. Axis up to 16 mm. broad and 3 mm. thick, branch bases rough due to scars. Receptacles crowded in fascicles, moniliform, up to 1.2 cm. long and 0.4 mm. broad...<u>C. moniliformis</u> (10)

Axis up to 3 mm. broad and 2 mm. thick, branch bases smooth. Receptacles loosely arranged, closely moniliform, up to 3 cm. long and 1 mm. broad...<u>C. hookeri</u> (11)

15. Receptacles ensiform up to 9 cm. long and 10 mm. broad, vesicles absent. ... .<u>C. xiphocarpa</u> (12)

Receptacles lanceolate, 0.7 - 3 cm. long and 2 - 4 mm. broad. Vesicles spherical. <u>C. racemosa</u>(13)

16. Axis strongly zigzag and robust. Receptacles 2 to 5 cm. long.... 19

Axis straight. Receptacles up to 8 cm. long, torulose... 20

17. Conceptacles in 2-3 rows, irregular. Receptacles up to 8 cm. long and 3 mm. broad, angular or flattened near the base due to conceptacles. Vesicles absent ... ...<u>C.cuspidata</u>(14)

Conceptacles in 2 or 3 rows. Receptacles torulose, ~~up to~~ 2-8 cm. long and 2-3 mm. broad. Vesicles absent or rare or abundant 21

18. Vesicles present and abundant... 22

Vesicles absent or rare.... 23

19. Axis very coarse, with bases of branches prominent and crowded. Receptacles lanceolate, crowded, up to 2.3 cm. long, vesicles present... ... ...*C. scalaris* (15)

Axis not unduly coarse and bases of secondary branches not crowded. 24

20. Axis strongly flattened, vesicles present. Receptacles siliquaform, up to 6 cm. long with crowded conceptacles.... ... ...*C. retroflexa* (16)

Axis quadrangular. No vesicles. Receptacles up to 8 cm. long, closely pinnate.. ... ... *C. siliquosa* (17)

21. Plants strongly distichous, axils of branches strongly rounded. Vesicles absent or very rare. Receptacles simple or apiculate (3-) 5 - 7 (-8) cm. long and 1-2 mm. broad. Conceptacles in two rows... ... ...*C. retorta* (18)

Plants distichous, with crowded tufts of receptacles, simple, terete, up to 2 (-6) cm. long with blunt apices, (3 mm. broad). Conceptacles in 2-3 rows. Vesicles abundant or rare... ... ... *C. torulosa* (19)

22. Vesicles clustered at the base of the tertiary branches..... ... *C. botryocystis* (20)

Vesicles scattered on the tertiary branches.... 25

23. Mature receptacles 1.5 - 5 cm. long loosely or distichously arranged.. 26

Mature receptacles 2 - 12 mm. long, crowded... 27

24. Branching loose and axils rounded. Receptacles lanceolate, simple or branched, distantly arranged in alternate series up to 3 (-5) cm. long with short apiculation. Vesicles spherical, up to 6 (-8) mm. broad. *C. distenta* (21)

Branching dense and axils less rounded. Dense short tufts of receptacles up to 3 cm. long with long apiculation. Conceptacles crowded, vesicles ovoid up to 10mm. long and 8 mm. broad... ... . *C. congesta* sp. nov. (22)

25. Receptacles moniliform, ~~up to~~ 18-20 mm. long..... 28

Mature receptacles 0.5 - 8 cm. long, conceptacles crowded or distantly scattered... ....29.

26. Receptacles compact at the base, loose above, with a prominent sterile awn, up to 5 cm. long and 2 mm. broad. Vesicles obovoid. Conceptacles irregular and swollen, bisexual. ... ... *C. subfarcinata* (23)

Receptacles distantly moniliform, strongly distichous, up to 15 mm. long and ½ mm. broad. Vesicles spherical. Conceptacles unisexual ... ... *C. thysanocladia* (24)

27. Branching stiff, axils rounded, receptacles terete terminal, in panicles, up to 6 (-14) mm. long .... *C. brownii* (25)

Branching laxer, axils less rounded, receptacles terete, crowded but not in panicles, up to 12 mm. long

C. gracilis sp. nov. (26)

28. Basal part strongly retroflexed, branching loose, branch bases strongly rounded with narrow attachments to the axis; Vesicles generally spherical, up to 5 (-7) mm. broad, mutic. Receptacles distinctly moniliform, up to 18 mm. long and 1 mm. broad..*C. monilifera* (27)

Axis quadrangular, branching dense. Vesicles elongate, tapering at both ends, ~~up to~~ (2-) 4-5 (-6) mm. long and less than 2 mm. broad, mutic or apiculate. Receptacles distantly moniliform upto 2 cm. long and less than 1 mm. broad... C. polycystidea (28)

29. Axis coarse, vesicles scattered, elongate, ellipsoid, up to 6 mm. long and less than 2 mm. broad. Receptacles terete with crowded conceptacles, 0.5 - 2 cm. long... C. expansa nov. comb.. . . . (29)

Axils strongly flattened, growing on Cymodocea. Vesicles numerous, and spherical to elongate, up to 10 cm. long and 5 mm. broad. Receptacles elongate up to 8 cm. long with conceptacles irregularly and distantly scattered... ... ... C. elongata sp. nov. (30)

1. *CYSTOPHORA UVIFERA* (C. Agardh)
J. Agardh 1848

J. Agardh 1848: 246. De Toni 1895: 317. Harvey 1859b: 284; 1860: pl. 175; 1863: Synop. 53. Laing 1906: 424. Lucas 1909: 12; 1936: 70. Reinbold 1899: 42. Sonder 1852: 671. Womersley 1950: 161.

PLATE XXXVIII. PLATE LXXXIII, Fig. A.

Sargassum uviferum C. Agardh 1824: 306. Gaudichaud 1826: 165. Sonder 1846: 165.

Caulocystis uvifera Areschoug 1854: 9 (335). Sonder 1880: 4.

Blossevillea uvifera Hooker and Harvey 1847: 414. Kuetzing 1849: 630; 1860: t. 80, f. 1. May 1939: 204.

Type Locality. — "Baie de Chien Marin" — Sharks Bay, W. Aus. (Gaudichaud).

Type. — LD. (Herbarium Agardh No. 2475).

Plants brown, turning darker on drying, flexible, coriaceous, up to 60 cm. long. Holdfast discoid, up to 10 mm. in diameter. Occasionally several fronds arise from the same disc. Axis terete, up to 3 mm. in diameter with secondary branches from all sides. Secondary branches up to 16 cm. long and 1 mm. in diameter, flexible. Lower parts of axis and secondary branches are rough due to the branch remains. Tertiary branches up to 4 cm. long, and 1mm. broad, with alternate cylindrical ramuli. Ramuli up to 3 cm. long and ½ mm. in diameter. Vesicles spherical, up to 6 (-8) mm. broad (occasionally sub-spherical), stalked, mutic (rarely apiculate), arising directly from the axis or secondary branches. Ultimate ramuli developing into receptacles. Receptacles terete, simple (rarely branched), smooth, up to 10 mm. (-4 cm) long and 1 (-3) mm. broad. Conceptacles numerous, scattered and bisexual. Antheridia 30 - 40 μ x 10 - 16 μ. Oogonia 90 - 156 μ x 36 - 66 μ.

SPECIMENS EXAMINED:

W. Aus. — Sharks Bay (October, 1877 in MEL., as *Caulocystis muelleri* Sond.). Murchison River Estuary (Oldfield, in K.) Abrolhos Is. (Broadhurst, in LD.). Pelsart Island (Womersley, 2-9-1947). Champion Bay (Spalding, in LD.). Rottnest Island (Cribb, 9-8-1950, Webb, in LD.). Cottesloe, Perth (Smith, 17-6-1947). Fremantle and Geographe Bay (in Sonder 1880). Busselton (Royce, 3-9-1949), Eucla (in LD.).

S.Aus. — 10 miles east of Eucla (Womersley, 3-2-1954). Head of the Great Australian Bight (Womersley, 4-2-1954). Sceales Bay (Womersley, 11-2-1954). Venus Bay (Womersley, 17-1-1951). Spencer's Gulf (in LD., and in MEL.). Wallaroo Beach

(Harris, 24-6-1945). Investigator Strait (Davey, in Reinbold). Port Vincent (Womersley, 8-4-1950). Port Adelaide (in L.). Holdfast Bay (Harris, May 1943 and in Sonder 1880). Port Noarlunga (Harris, August 1943). Encounter Bay (Cleland. in MEL. Harris, May 1943. in Sonder, 1880).

Kangaroo Island. — Pennington Bay (Womersley 28-1-1944, 24-5-1945, 28-1-1946, 30-1-1946, 24-9-1946, 22-1-1948 and 29-12-1948). Antechamber (Womersley, 18-8-1948).

Victoria. — Bridgewater Bay (Beauglehole, 29-5-1949). Portland (Muir, January 1950). Port Fairy (Harvey , in TCD., and in LD.). Warrnambool (Walts, in LD.). Point Lonsdale (Mathieson, 21-9-1946). Enclosure Anchorage Buoy, Port Phillip Bay (Macpherson, 23-6-1957). Pope'e Eye, Port Phillip (Macpherson, 10-11-1957). Queenscliff (Hanndsford in MEL. Nizamuddin, 8-4-1959). St. Kilda, Port Phillip (1882. MUB.[1] in Sonder 1880). Brighton Beach, Port Phillip (Womersley, 29-5-1948). Beaumaris, Port Phillip (Thomas, 20-10-1931. in MUB.). Portsea (Macpherson, 15-9-1957). Summerland (Ducker, 24-2-1952 in MUB.). The Nobbies, Phillip Island. (Pope and Bennett, 13-5-1949). Wilson's Promontory

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[1] MUB = Melbourne University, Botany Department.

(in MEL., as Caulocystis brevifolia Sonder). Sealers Cove, east of Wilson's Promontory (in MEL.).
Tasmania. — Low Head (Perrin, August 1948). Bombay Rock, Tamar East (Womersley, 27-1-1949), Georgetown (Gunn, in TCD. in Sonder 1880). Oyster Bay (March 1914 in MEL.). Adventure Bay, Bruny Island (in K.).
New South Wales. — Twofold Bay (Rose, in MEL.). Eden (in May 1939). Jervis Bay (in May 1939). Bondi (in May 1939). Long Bay, Sydney (in May 1939).

GEOGRAPHICAL DISTRIBUTION:

From Sharks Bay, Western Australia, around the south east coast to Long Bay, Sydney, New South Wales, and along the coast of Tasmania.

Laing records Cystophora uvifera for New Zealand but Lindauer (1947) does not include it among the New Zealand algae. A slender form of C. uvifera occurs on Norfolk Island, Pacific Ocean (Womersley m.s. 1952).

Receptacles of C. uvifera are generally up to 10 mm. long and 1 (-3) mm. broad, with the conceptacles confined to the uppermost part of the ramuli. The "typical" mutic, spherical vesicles may be rare in plants on rock platforms under relatively rough conditions, which cause the juvenile forms of vesicles (elongate and mucronate) to be largely retained and only the old vesicles are spherical with a small mucro (Womersley, 1948).

2. *C. CEPHALORNITHOS* (Labillardiere)
J. Agardh 1848.

J. Agardh 1848: 246. De Toni 1895: 138. Harvey 1859b: 284; 1859a: pl. 116; 1863: Synop. 51. Laing 1927: 143. Lucas 1909: 12; 1936: 70. Sonder 1852: 671; 1853: 511. Womersley 1950: 160.

PLATE XXXIX.
PLATE LXXXIII, Fig. B.

Fucus cephalornithos Labillardiere 1806: 114, t. 261. Lamouroux 1813: 37.

Cystoseira cephalornithos C. Agardh 1824: 291. Greville 1830: Synop. 33.

Blossevillea cephalornithos Kuetzing 1849: 631; 1860: t. 83, f. 1. ~~K,~~ May 1939: 204.

Caulocystis cephalornithos Areschoug 1854: 9 (335). Sonder 1880: 4.

Type Locality. — Tasmania (Labillardiere).

Type. — Fl. (No. 206).

Plants brown, turning darker on drying, coriaceous, flexible, up to 1 meter long. Holdfast discoid, up to 2 cm. in diameter. Axis terete, up to 4 mm. in diameter, with sec~~p~~ondary branches from all sides and lower parts rough, due to branch scars. Secondary branches up to 15 cm. long and 1 mm. in diameter. Tertiary branches up to 3 cm. long and 1 mm. in diameter, with alternate filiform ramuli. Ramuli up to 4 cm. long and less than a millimetre in diameter. Vesicles ovoid - elongate, tapering at both ends, stalked, apiculate, arising directly from the axis or secondary branches, up to 5 (-10) mm. long and 3 (-5) mm. broad. Ramuli developing into receptacles. Receptacles clyindrical, smooth, simple or branched, up to 14 mm. long and as much as 1 mm. broad. Conceptacles scattered and bisexual. Antheridia 25 - 40 µ x 10 - 20 µ. Oogonia 100 - 150 µ x 40 - 70 µ.

<u>SPECIMENS EXAMINED</u>:

S. Aus. — Elliston (Nizamuddin, 27-2-1959). Fishery Bay (Nizamuddin, February 1959). Port Augusta (Womersley, 31-12-1950), Wallaroo (Harris, 24-6-1945. Womersley, 26-3-1950). Sturt

Bay (Womersley, 8-4-1950). Port Vincent (Womersley, 8-4-1950). Yorke Peninsula (Tepper, 1879 in MEL.). Outer Harbour (Womersley, 16-7-1950). Marino (Womersley, 21-5-1953). Port Noarlunga, Sellick's Beach (Hale, 19-1-1936). Encounter Bay, Port Elliot (Hussey, May 1898). Lacepède Bay and Guichen Bay (Davey, in Reinbold). Robe (Cleland. Harris, May 1943). MacDonnel Bay (Wehl, in MEL., in Sonder 1880). Kangaroo Island. — Kingscote (Cruickshank, 31-1-1945. Womersley, 3-1-1944). Head of the inlet, American River (Womersley, 24-1-1948 and 2-6-1947. Schodde, February 1956). Victoria. — Whalers Point, near Lighthouse, Portland (Muir; 17-1-1950). Double Corner Beach[1], Portland Bay (Beauglehole, 14-7-1951). Port Fairy (Harvey, in TCD. and in LD). Point Lonsdale (Mathieson, 21-9-1946; and in MUB.). Queenscliff (Nizamuddin, 7-4-1959). St. Kilda (1883 and 1884 in MUB.). Rickett's Point, Port Phillip Bay (June 1948 in MUB.) in Sonder 1880). Off Mentone, Beaumaris Bay, Port Phillip (Macpherson, 26-6-1957). Port Phillip Heads (Wilson, in LD.) . Ocean Beach, Sorrento (Womersley, 2-6-1953) Western Port (Harvey, in TCD.). Wilson's Promontory (in

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[1] Double Corner Beach = Dutton Beach, off Dutton Bluff.

MEK.; in Sonder 1880).

Tasmania. — Georgetown (Gunn in Sonder 1880). Hunter Island. (Bennett, 14-1-1954). Sandy Cape (Bennett, 15-1-1954). Taroona, Hobart (Womersley, 13-1-1949). Eaglehawk Neck (Moore, 15-1-1949). Port Arthur (in LD.). Swansea (Womersley, 19-1-1949).

New South Wales. — Twofold Bay (in LD.). Bondi, Sydney (in May 1939).

GEOGRAPHICAL DISTRIBUTION:

From Elliston, South Australia, around the south-eastern coast to Bondi, Sydney, New South Wales and along the coast of Tasmania. Laing (1927) records it from Bluff, New Zealand but Lindauer (1947) does not include it among the New Zealand algae.

C. cephalornithos resembles *C. uvifera* in its terete axis with radial branches, terete receptacles with scattered conceptacles and vesicles from its axis and branches, but differs in its ovoid - elongate and mucronate vesicles. Intermediate juvenile forms of vesicles may occur in *C. uvifera* (e.g. from the Pennington Bay reefs) which bears elongate, mucronate or spherical mucronate vesicles.

3. C. PANICULATA (Turner) J. Agardh 1848.

J. Agardh 1848: 248; 1870: 448; 1896: 47. De Toni 1895: 149. De Toni et Forti 1923: 69. Harvey 1859b: 285; 1863: pl. 247; 1863: Synop. 57. Laing 1927: 143. Lucas 1909: 13; 1936: 74. Sonder (1852: 671; 1853: 511. Womersley 1950: 160.

PLATE XL. PLATE LXXXIII, Fig. C.

Fucus paniculatus Turner 1811: 100, t. 176.

Cystoseira paniculata C. Agardh 1821: 76; 1824: 290. Greville 1830: Synop. 33.

Acrocarpia paniculata Areschoug 1854: 10 (336). Sonder 1880: 5.

Blossevillea paniculata Decaisne ~~1841: 147;~~ 1842: 330. Kuetzing 1849: 629, Hooker and Harvey 1845: 527. May 1939: 204.

Type Locality. — Kent Island, Bass Strait (R. Brown).

Type. — BM.

Plants dark brown turning darker on drying, coriaceous, tough, up to 65 cm. long. Holdfast divided. Axis terete, up to 7 mm. in diameter and radially branched (occasionally bilateral). Secondary branches up to 42 cm.

long and 2 mm. in diameter, terete. Tertiary branches up to 5 cm. long and as much as one millimetre in diameter. Ramuli filiform, up to 3 (-5) cm. long and up to 0.5 mm. in diameter. Vesicles absent. Ultimate ramuli subdichotomous and developing in to receptacles. Receptacles terete, verrucose, simple, crowded and in close panicles, up to 4 mm. long and 1 mm. broad. Conceptacles scattered and bisexual. Antheridia 20 - 26 µ x 13 - 23 µ. Oogonia 126 - 240 µ x 90 - 192 µ.

SPECIMENS EXAMINED:

S.Aus. — Cape Spencer (Davey). Stenhouse Bay (Womersley, 9-4-1950). Sturt Bay. Encounter Bay (Cleland. Womersley, 4-6-1943. Harris, May 1943). Port Elliot (Harris, December 1943. Hussey in AD., and in LD.). Lacepede Bay (in Sonder 1880). Guichen Bay (Womersley, 1-9-1949.in Sonder 1852). Robe (Macklin, 30-8-1949). Stinky Bay, Nora Creina (Womersley, 19-8-1957). Port MacDonnel. McDonnell Bay (in Sonder 1880).

Kangaroo Island. — Middle River (Womersley, 21-1-1948). Western River (Womersley, 7-1-1946. Cruickshank, 24-1-1945). Cape de Couedie (Womersley, 3-1-1944). Vivonne Bay

(Womersley, 31-12-1945, 23-5-1945, 2-1-1946 and 2-1-1949). Pennington Bay (Womersley, 23-1-1944, 28-1-1946, 5-1-1947, and 4-1-1948. Schodde, February 1956). Cape Willoughby (Womersley, 16-1-1946, 12-1-1947, and 25-1-1948).

Victoria. — Bridgewater Bay (Beauglehole, 5-6-1949). Garden Beach, Portland (Beauglehole, 18-8-1951). Henty Beach, Portland (Muir, January 1950). Portland Bay (in Sonder 1880). Port Fairy (Harvey, in LD., and in TCD.). Peterborough (Pope and Bennett, 17-8-1949). Near Point Roadknight (Davis, 1-2-1946). Queenscliff (1882 in MEL., and in LD.). Pope's Eye, Port Phillip (Mueller, in AD., and in LD.). Port Phillip (in Sonder 1880). Wilson's Promontory (in Sonder 1853, and in Sonder 1880).

Flinders Islands, Bass Strait (Mueller, in LD.).

Tasmania. — Currie River Mouth (Womersley, 28-1-1949), Wivenhoe Point (Bennett, 31-1-1955). Bombay Rock, Tamar East (Womersley, 27-1-1949). Georgetown (Gunn in LD., and in TCD.). Low Head (Cribb, 14-9-1950. Perrin, August 1948). Latrobe Bay (De Doni et Forti). Burnie (Womersley, 26-1-1949). Three Hammocks (Bennett, 17-1-1954). Cape Sorrel (Bennett, 4-2-1955). Taroona, Hobart (Womersley, 13-1-1949). Eaglehawk

Neck (Moore, 15-1-1949). Swansea (Womersley, 19-1-1949). New South Wales. — Twofold Bay (Reader 1880). Tilba-Tilba (in Sonder, 1880). Jervis Bay (in May 1939). Bateman's Bay (in LD.). Illawara (in May, 1939). Bondi (Lucas, 1901 in AKU[1], in May 1939). Long Reef (Womersley, 19-3-1949). Tuggerah (in May, 1939), Newcastle and Port Stephens (in May).

GEOGRAPHICAL DISTRIBUTION:

From Cape Spencer, South Australia, around the south east coast to Port Stephens, New South Wales, and along the coast of Tasmania. Laing (1927) reports the presence of C. paniculata from New Zealand but Lindauer (1947) does not include it among the New Zealand algae.

C. paniculata differs from all other species except C. uvifera and C. cephalornithos, in its radial branching, and from the latter two species in the absence of vesicles and the shorter, densely paniculate receptacles. The divided holdfast of C. paniculata is also distinctive, being found only in this species and in C. galapagensis and C.

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1. AKU = Auckland University, New Zealand.

brandegeei. Occasional deep water specimens of *C. paniculata* do show partially distichous branching, showing that the type of branching (distichous or radial) is not satisfactory to separate groups within the genus *Cystophora*.

4. *C. GALAPAGENSIS* (Piccone and Grunow
in Piccone) nov. comb.
PLATE XLI. PLATE LXXXIII, Fig. D.

Fucodium galapagense Piccone and Grunow in Piccone 1886: 40, pl. 1, f. 1, Pl. 2, f. 3.

Fucodium galapagense Farlow 1902: 90.

Pelvetia ? galapagense De Toni 1895: 215.

Blossevillea galapagensis Taylor 1945: 112, t. 23, f.1.

Type Locality. — Marcacci, Galapagos Islands, West of Ecuador, Pacific Ocean.

Type. —

Plants brown, becoming darker on drying, upto 40 cm. long, slender and flexible. Holdfast irregularly lobed, producing several axes. Axis terete, up to 2 mm. in diameter, with alternate branches (partly bilateral when young). Secondary branches arising from the sides of the axis, alternate, filiform, up to 3 cm. long. Ramuli slender, filiform, up to 2 cm. long and ½ mm. diameter, irregularly dichotomous, developing into receptacles.

Vesicles absent. Receptacles terete, verrucose, up to 4 cm. long and 2 mm. broad, simple or branched, apiculate and subfasciculate. Cohceptacles scattered, bisexual. Antheridia 30 - 49 μ x 12 - 20 μ, in fascicles on branched hairs. Oogonia 120 - 180 μ x 48 - 104 μ.

SPECIMENS EXAMINED:

Black Beach Anchorage, Santa Maria Island (Taylor, 17-18th January, 1934). Charles Island, Galapagos Island (Schmidt, 1933).

GEOGRAPHICAL DISTRIBUTION:

Ecuador; Marcacci, Chatham Island and Charles Island (in Taylor 1945.) Farlow (1902) reports that *C. galapagensis* is endemic to Charles and Chatham Islands.

Type of *C. galapagensis* has not been located.

C. galapagensis resembles *C. paniculata* in possessing a divided holdfast and in the absence of vesicles, but differs in having a very slender axis, long moniliform receptacles and alternate branching.

5. C. PECTINATA (Greville et C. Agardh ex Sonder 1846) J. Agardh 1848.

J. Agardh 1848: 244; 1870: 441; 1896: 48. De Toni 1895: 139. Harvey 1863: Synop. 47. Lucas 1909: 12; 1936: 71. Sonder 1880: 4. Womersley 1950: 160.

PLATE XLII. PLATE LXXXIII, Fig. E.

Cystoseira pectinata Greville et C. Agardh in Greville 1830: Synop. 33. Sonder 1846: 160.

Blossevillea pectinata Kuetzing 1849: 629; 1860: t. 74, f. 2.

Type Locality. — "ad litus meridionale Novae Hollandiae". — South Coast of Australia.

Type. — E.

Plants brown, darker on drying, coriaceous, up to 45 cm. long. Holdfast discoid, up to 3 cm. in diameter, with a short terete stipe. Axis terete to ovoid in section, up to 5 mm. broad, and distichously branched. Secondary branches terete, distichous, upto 18 cm. long and 2 mm. in diameter. Tertiary branches pinnate, distichous, up to 6 cm. long and 1 mm. in diameter. Quaternary branches flat, up to 8 cm. long and 3 mm. broad, with central thickening, bearing strongly distichous, pinnate ramuli up to 2 (-3) cm. long and 1 mm. broad. Vesicles absent. Ramuli developing into receptacles. Receptacles flat up to 2 (-3) cm. long and 2 mm. broad, pinnate, distichous, simple (rarely branched), and lanceolate, apiculate. Conceptacles in 2 rows on the margins, bisexual. Antheridia 30 - 53 µ x 13 - 20 µ. Oogonia 120 - 150 µ x 60 - 132 µ.

SPECIMENS EXAMINED:

W. Aus. — Rottnest Island (in MEL.). Swan River (Mylne in TCD.). Cottesloe (Smith, August 1944). Fremantle (in Sonder 1880). Geographe Bay (in LD., in TCD., and in MEL.). Bunkers Bay (Wollaston, 9-2-1957). Between Cape Leeuwin and King George's Sound (Maxwell, 1874 in MEL.). Cape Leeuwin (in Sonder 1880). King George's Sound (in Sonder 1880). Trigg's Island (Royce, 3-7-1949). Figure of Eight Island (Willis, 7-11-1950). Esperance (Dempster, 1881 in MEL.). Eucla (Womersley, 2-2-1954).

S.Aus. — 10 miles East of Eucla (Womersley, 3-2-1954). Head of the Great Australian Bight (Womersley, 4-2-1954). Scott's Bay, 4 miles west of Fowlers Bay (Womersley, 27-1-1951). Elliston (Womersley, 17-1-1951). Fishery Bay (Nizamuddin, February 1959). Gulf of St. Vincent (Dutton, in MEL. in Sonder 1880).

Kangaroo Island. — Western River (Womersley, 7-1-1946). Cape de Couedic (Womersley, 12-1-1948). Vivonne Bay (Womersley, 17-1-1950). Pennington Bay (Womersley, 20-5-1945, 25-1-1946 and 4-1-1948). Point Tinline (Womersley, 2-2-1956).

GEOGRAPHICAL DISTRIBUTION.

From Rottnest Island, Western Australia, around the south coast to Gulf of St. Vincent, South Australia, and along the coast of Kangaroo Island.

Greville (1830) published Cystoseira pectinata Grev. et C. Ag. as "Species ineditae", and the first valid description of the species is that of Sonder (1846) who credited the species to Greville et C. Agardh. Sonder described this species in "Plantae Preissianae" in a footnote. The type is not in MEL. (which contains Sonder's Herbarium) and has not been located. Sonder may not have had a Preiss specimen. Greville's collections are in E., and probably his specimen can be taken as a type.

C. pectinata resembles C. racemosa and C. brandegeei, in its strongly flattened receptacles with conceptacles in 2 rows on the margin, and resembles C. brandegeei in the absence of vesicles but differs in its terete axis. C. pectinata also differs in its discoid holdfast from C. brandegeei.

6. C. INTERMEDIA. J. Agardh 1897.

J. Agardh 1897: 102. Womersley 1950: 160.

PLATE XLIII. PLATE LXXXIII, Fig. F.

Type Locality. — Port Elliot, S. Aus. (Hussey).

Type. — LD. (Herbarium Agardh No. 1049).

Plants dark brown, coriaceous, cartilaginous, reaching a height of 85 cm. Holdfast discoid, up to 2.5 cm. in diameter. Axis up to 8 mm. broad, ovoid in section, pinnately and distichously branched. Secondary branches terete, alternate, arising from the edge of the axis, up to 30 cm. long and 2 mm. broad, lower part often denuded. Tertiary branches up to 7 cm. long and 1 mm. broad. Vesicles absent. Ramuli 1 (-2) cm. long and ½ mm. broad, subdichotomous. Ultimate ramuli developing into receptacles. Receptacles simple, terete, closely moniliform, subfasciculate, up to 15 cm. long and 1 mm. broad. Conceptacles scattered and bisexual. Antheridia on branched hairs, 30 - 54 µ x 13 - 19 µ. Oogonia 66 - 132 µ x 66 - 120 µ.

SPECIMENS EXAMINED:

S. Aus. — Point Sinclair (Womersley, 26-1-1951 and 8-2-1954). Point Westall (Womersley, 19-1-1951). Venus Bay (Womersley, 12-2-1954). Elliston (Nizamuddin, 27-2-1959). Cape Carnot (Womersley, 8-1-1951). Wanna (Nizamuddin, 19-2-1959). Cape Jervis (Shepley, 29-8-1954). Petrel Cove, West of Bluff, Victor Harbour (Womersley, 10-12-1944). Port Elliot (Hussey, December 1897).

Kangaroo Island. — Middle River (Womersley, 8-1-1946). Harvey's Return (Womersley, 5-1-1949). Cape de Couedic (Womersley, 23-1-1944, 8-1-1945, 28-1-1946, and 7-11-1948. Schodde, February 1956). Cape Willoughby (Womersley, 17-5-1949).

Victoria. — Lawrence Rock, Portland Bay, (Beauglehole, 13-1-1954). Wilson's Promontory (Pope and Bennett, 17-5-1949).

GEOGRAPHICAL DISTRIBUTION:

From Point Sinclair, South Australia, along south coast to Wilson's Promontory, Victoria. C. intermedia is common in the west of Port Elliot, rarer on the south east coast in Victoria.

C. intermedia grows in the sublittoral fringe on rough coasts exposed to extreme wave action and is an indicator species of rough to very rough conditions, disappearing if local shelters occur~~s~~, whereas *C. moniliformis* occurs in sublittoral pools on rough coasts as well as on sheltered coasts of moderate wave action (Womersley and Edmonds, 1958).

C. intermedia resembles *C. moniliformis* in its moniliform, fasciculate receptacles and in the absence of vesicles but differs in its ovoid axis.

C. intermedia also resembles *C. brandegeei* in its method of branching and in the absence of vesicles but differs in its discoid holdfast, terete or ovoid axis and in its terete, moniliform receptacles with scattered conceptacles.

7. *C. GREVILLEI* (C. Agardh in Sonder) J. Agardh 1848.

J. Agardh 1848: 245; 1870: 446; 1896: 48. De Toni 1895: 144. Harvey 1862: pl. 183; 1863: Synop. 50. Levering 1946: 218. Lucas 1909: 13; 1936: 73. Reinbold 1899: 42. Sonder 1853: 511; 1880: 4. Womersley 1950: 160.

PLATE XLIV. PLATE LXXXIII, Fig. G.

Cystoseira grevillei C. Agardh in Greville 1830: Synop. 33. Sonder 1846: 160.

Blossevillea grevillei Kuetzing 1849: 629; 1860: t. 79, f. 1.

Type Locality. — "Ad litus occidentale Novae Hollandiae". — W. Aus.

Type. —

Plants dark brown, darker on drying, up to 90 cm. long. Holdfast discoid, up to 11 mm. in diameter with a short terete stipe. Axis terete, up to 7 mm. in diameter, alternately distichously branched. Secondary branches up to 30 cm. long, up to 2 mm. in diameter. Tertiary branches up to 15 cm. long and 2 mm. in diameter, denuded of ramuli in the lower half but with scars of fallen ramuli. Ramuli alternate, distichous, ultimately developing into receptacles. Vesicles sub-globose, mutic, usually one near the base of each secondary branch, pedicellate, up to 12 mm. long and 10 mm. broad. Receptacles ensiform, ovoid, smooth up to 8 (-15) cm. long and 2 mm. across. Conceptacles in 2 rows, bisexual. Antheridia 35 - 48 μ x 12 - 22μ. Oogonia 120 - 150 μ x 60 - 120 μ.

SPECIMENS EXAMINED:

W. Aus. — Swan River, Perth (Harvey, in TCD., Fraser, in E.). Cottesloe (Smith, 12-6-1947). North Fremantle (Royce, 23-7-1949). Fremantle (Harvey in Sonder 1880). Rockingham (Cribb, 14-8-1950). Geographe Bay (in MEL. and in LD. in Sonder, 1880). Augusta (Lucas, September 1928). Point D'Entrecastreaux (Smith, 20-3-1946). Point Malcolm, South west of Israelite Bay (Willis, 28-11-1950). Israelite Bay (Algae Muellerianae in L.). Eucla (Womersley, 2-2-1954. in L., and in LD.).

S.Aus. — 10 miles east of Eucla (Womersley, 3-2-1954). Head of the Great Australian Bight (Womersley, 4-2-1954). Fowler's Bay (Mrs. Richards, 1880 in MEL.). Scott's Bay, West of Fowler's Bay (Womersley, 27-1-1951). Denial Bay (Cleland). Investigator Strait (Davey, in Reinbold). Encounter Bay (Cleland). Robe (Nizamuddin, 16-4-1959).

Kangaroo Island. — Middle River (Womersley, 13-1-1950). Vivonne Bay (Womersley, 23-5-1945 and 3-1-1946). Rocky Point Beach (Womersley, 4-6-1947) Pennington Bay (Womersley, 23-1-1944, 13-4-1947, and 29-12-1948).

Victoria. — Bridgewater Bay (Beauglehole, 24-7-1949). Port Phillip Bay (Nizamuddin, 8-4-1959). Wilson's Promontory (in Sonder, 1880).

Tasmania. — Swansea (Womersley, 19-1-1949).

GEOGRAPHICAL DISTRIBUTION.

From Swan River, Western Australia, along south coast, including Kangaroo Island, to Wilson's Promontory, Victoria and at Swansea, Tasmania. The distribution of *C. grevillei* is not restricted to the west coast of Australia as reported by Harvey (1862).

Greville (1830) first published *Cystoseira grevillei*, C. Agardh as a "species ineditae" and the first valid publication of the species was made by Sonder (1846) who credited it to C. Agardh. There is no type specimen of *Cystophora grevillei* in MEL. (with which is incorporated Sonder's herbarium), and the type has not been located.

C. grevillei resembles *C. pectinata* in its general features but differs in its branching, ovoid receptacles and in the presence of vesicles.

8. C. PLATYLOBIUM (Mertens) J. Agardh 1848

J. Agardh 1848: 245; 1870: 440; 1896: 49. De Toni 1895: 138. Harvey 1859b: 284; 1863: Synop. 48. Laing 1899: 67; 1927: 143. Lucas 1909: 12; 1936: 71. Naylor 1954: 653. Sonder 1880: 4. Womersley 1950: 160.

PLATE XLV. PLATE LXXXIII, Fig. H.

Fucus platylobium Mertens 1819: 182, pl. 14.

Cystoseira platylobium C. Agardh 1824: 288. Greville 1830: Synop. 33.

Cystophora lyallii Harvey 1855: 214.

Platylobium mertensii Kuetzing 1849: 606. Oltmanns 1889: 50. Reinke 1876: 361. Sonder 1852: 667.

Neoplatylobium mertensii O.C. Schmidt 1938: 229.

Neurothalia mertensii Sonder 1853: 511.

Blossevillea platylobium Decaisne 1841: 147; 1842: 330. May 1939: 204. Lindauer 1947: 561.

Type Locality. — "Novae Hollandiae littora" — Australia.

Type. — PC.

Plants dark brown, turning very dark on drying, coriaceous, robust, flexuous, up to 4 meters long. Holdfast discoid up to 2 cm. in diameter, with a short terete stipe. Axis flat, up to 14 mm. broad, thickened in the middle, distichously and pinnately branched; flattening increases gradually upwards. Secondary branches alternate, pinnate, arising from the edge of the axis, narrow below, broad above, up to 14 cm. long and 4 mm. broad. Tertiary branches up to 10 cm. long and 1 mm. broad and alternately branched. Quaternary branches flattened above, becoming leaf-like (4-) 6 - 10 (-15) cm. and (2-) 4 - 6 (-11) mm. broad, thickened in the middle (midrib-like), developing ramuli. Vesicles spherical, up to 9 (-13) mm. diameter and pedicellate, mutic. Ramuli developing into receptacles. Receptacles strongly flattened, with central thickening, lanceolate, ensiform or rostellate, alternate, pinnate, up to 3 cm. long and 7 mm. broad. Conceptacles in 2 rows on the margin of the receptacles. Antheridia 18 - 24 µ x 6 - 8 µ. Oogonia 66 - 156 µ x 54 - 90 µ.

SPECIMENS EXAMINED:

S.Aus. — 10 miles east of Eucla (Womersley, 3-2-1954). Head of the Great Australian Bight (Womersley, 4-2-1954). Point Sinclair (Womersley, 25-1-1951). Elliston (Nizamuddin, 27-2-1959). Point Drummond (Womersley, 11-1-1954). Fishery Bay (Nizamuddin, February 1959). Port Lincoln (in MEL.). Spencer's Gulf (in MEL.). Stenhouse Bay (Womersley, 9-4-1950). Investigator Strait (Davey in AKU; in AD). Port Adelaide (in Sonder, 1880). Adelaide (in MEL.). Victor Harbour (Womersley, 17-10-1948). Granite Island (Harris, May 1943). Encounter Bay (Cleland, 1928). Middleton (Davey, in AD.). Lacepede Bay (1887 in MEL., 1880 in MEL. in Reinbold). Guichen Bay (Womersley, 1-9-1949. in MEL. in Sonder 1880. in Reinbold). Robe (Womersley, 30-8-1949). Stinky Bay, Nora Creina (Womersley, 19-8-1957. Nizamuddin, 17-4-1959). Rivoli Bay (in Sonder 1880; 1848 in MEL.). McDonnell Bay (Wehl, in TCD. in Sonder 1880).

Kangaroo Island. — Middle River (Womersley, 8-1-1946 and 21-1-1948). Cape de Couedie (Womersley, 12-1-1948). Vivonne Bay (Womersley, 23-5-1945, 3-1-1946, 2-1-1949, 29-8-1950 and 4-1-1950). Seal Beach (Womersley, 24-1-1957). Pennington Bay (Womersley, 24-5-1945 and 23-1-1944). Cape Willoughby (Womersley, 6-1-1946 and 25-1-1948).

Victoria. — Bridgewater Bay (Beauglehole, 26-12-1950). Narrowong Beach, Portland (Beauglehole, 15-5-1949). Portland Bay (in MEL., and in LD.). Port Fairy (Harvey, in MEL., in LD., and in TCD.). Lorne (Bemmett, 20-11-1949). Point Lonsdale (Mathieson, 21-9-1946. Mclennon, January 1941 in MUB). Queenscliff (Grunow, December 1884; in MEL. 1881). Port Phillip (Mueller, 1873 in MEL., and in LD. in Sonder 1880). Port Phillip Heads (Wilson, 3-1-1884 in MEL., and in LD.). Sorrento (Womersley, 2-6-1953. Coleman, January 1929 in AKU.). Summerland (Dücker, 24-2-1952 in MUB.). Woodbourne (February 1947 in MUB.). Wilson's Promontory (in MEL.). Sealers Cove, east of Wilson's Promontory (in MEL.).

Tasmania. — Low Head (Perrin, August 1948). Georgetown (Harvey in TCD.). Leven, Devon (1889 in MEL.). Port Arthur (Harvey, in TCD.). Tasmania (in Sonder, 1880).

New South Wales. — Bondi, Sydney (in May, 1939). New South Wales (in Sonder, 1880).

GEOGRAPHICAL DISTRIBUTION:

From east of Eucla, South Australia, around south east coast to Bondi, New South Wales and along the coast of Tasmania and New Zealand.

Harvey (1855a) established a new species — Cystophora lyallii — closely related to C. platylobium, but in 1863 he considered it as a synonym of C. platylobium. Kuetzing (1849) established Platylobium mertensii (= Fucus platylobium Mertens) using the specific epithet as a generic name. Platylobium as a genus was already occupied in the Leguminosae by Smith (1793), so Sonder (1853) changed Platylobium Kg., to Neurothalia. Neoplatylobium mertensii OC. Schmidt is superfluous and illegitimate as Neurothalia mertensii Sonder antidates the publication of O.C. Schmidt and is based on the same type.

C. platylobium resembles C.racemosa,C.xiphocarpa and C. pectinata in its flat receptacle, and also resembles C. racemosa and C. xiphocarpa in its flat axis, and C. racemosa in the presence of vesicles, but differs from C. racemosa and C. xiphocarpa in its alternate, distichous branches from the edge of the flat axis. It also resembles C. pectinata in its central thickening of the branches bearing flat receptacles with conceptacles in 2 rows.

9. C. BRANDEGEEI (Setchell et Gardner) nov. comb.

Blossevillea brandegeei Gardner 1913: 325, Pl. 46, figs. 48 - 50, Setchell and Gardner 1925: 705. Dawson 1945: 24.

PLATE XLIV. PLATE LXXXIII, Fig. I.

Type Locality — Guadalupe Island, off Lower California, (Brandegee, 1897).

Type. — UC. No. 163378.

Holdfast rhizomatous, basal part of the plant terete, up to 2 mm. thick, upper part gradually becoming flattened with strong central thickening. Axis up to 54 cm. long and up to 6 mm. broad. Secondary branches alternate, pinnate, arising from the edge of the axis, up to 4 cm. long and up to 2 mm. broad. Ramuli terete to flat, alternate. Ultimate ramuli developing into receptacles. Vesicles absent. Receptacles cylindrical (when young) to flat and up to 2 cm. long and 3 mm. broad. Conceptacles in 2 rows on the margin of the receptacle, bisexual. Antheridia 27 - 40 μ x 7 - 12 μ. Oogonia 89- 229μ, x 50 - 102 μ.

SPECIMENS EXAMINED:

West Anchorage, Guadalupe Island (Silva , 30-1-1950). Guadalupe Island, Baja, California (Station 758 - 37, 18 - 7-1937). Beach Club, La Jolla, California (in Dawson 1945).

GEOGRAPHICAL DISTRIBUTION:

Guadalupe Island and California.

Type information has been located from Gardner (1913).

In possessing a rhizomatous holdfast *C. brandegeei* shows some resemblance to *Bifurcaria* but differs in the method of branching (*Bifurcaria* is irregularly dichotomous and terete) and in the flat, distichous receptacles with bisexual conceptacles in 2 rows along their margins. (*Bifurcaria* possesses bisexual, terete receptacles, with male conceptacles above and female ones below.).

C. brandegeei resembles *C. racemosa* and *C. pectinata* in its flat receptacles with conceptacles in 2 rows along the margin, and also resembles *C. pectinata* in the absence of vesicles and *C. racemosa* in its flat axis, but differs in its method of branching and in its rhizomatous holdfast.

10. *C. MONILIFORMIS*. (Esper).

nov. comb.

PLATE XLVII. PLATE LXXXIII, ~~PLATE~~

fig. K.

Fucus moniliformis Esper 1804: 80, pl. 148.

Fucus spartioides Turner 1819: 86, t. 232.

Cystoseira spartioides C. Agardh 1821: 77; 1824: 291.

Cystophora spartioides (Turner) J. Agardh 1848: 244; 1870: 446; 1896: 47. De Toni 1895: 145. Harvey 1859b: 284; 1859a: pl. 76; 1863: Synop. 46. Levering 1846: 218. Lucas 1909: 13; 1936: 72 . Reinbold 1899: 42. Sonder 1880: 4. Womersley 1950: 161.

Blossevillea penicilifera Kuetzing 1860: t. 78, f.2.

Blossevillea intermedia Kuetzing 1860: t.77, f.1. Grunow 1870: 53.

Phyllotricha spartioides Areschoug 1854: 8 (334).

Type Locality. — "South Seas".

Type. — **ER.**

Plants dark brown, becoming darker on drying, up to 4 meters long. Holdfast discoid, up to 3 cm. across, Stipe short, terete, up to 2 cm. long and 8mm. broad. Axis flat, up to 16 mm. broad with central thickening (up to 3 mm. in thickness) with distichous and alternate branches. Secondary branches from the edge of the axis, alternate, up to 27 (-90) cm. long and 4 mm. broad with distichous, alternate, tertiary branches. Tertiary branches up to 3 cm. long and 2 mm. broad with filiform ramuli. Branch bases rough due to scars. Ramuli alternate, irregularly dichotomous and ultimately developing into receptacles. Vesicles absent. Receptacles crowded, terete, simple (rarely branched), moniliform, up to 12 cm. long and 0.4 mm broad tapering or blunt at the apices. Conceptacles scattered, bisexual. Antheridia 24 - 36 µ x 12 - 18 µ. Oogonia 72 - 210 µ x 36 - 72 µ.

SPECIMENS EXAMINED.

S. Aus. — Point Fowler (Womersley, 6-2-1954). Fowler's Bay (Richards, 1880in MEL.). Point Sinclair (Womersley, 8-2-1954). Scealers Bay (Womersley, 11-2-1954). Elliston (Womersley, 14-2-1954; Nizamuddin, 27-2-1959). Point Drummond (Womersley, 11-1-1951). Cape Carnot (Womersley, 8-1-1951). Fishery Bay (Nizamuddin, February 1959). Sleaford Bay (Nizamuddin, February 1959). Wanna (Nizamuddin, 19-2-1959). Investigator Strait (Davey, in Reinbold). Stenhouse Bay (Womersley, 9-4-1950). Sturt Bay (Davey, April 1897). St. Vincent Gulf (Tepper). Semaphore (Harris, July 1943). Glenelg (Grunow, 1884). Hallett's Cove, Port Noarlunga (Harris, August 1943). Port Willunga (Womersley, 12-10-1953). Willunga Reef (Shepley, 29-9-1954). Second Valley (Womersley, 7-12-1946). Encouhter Bay (Cleland). Port Elliot (Womersley, 10-8-1957). Lacepede Bay and Guichen Bay (in Reinbold). Robe (Macklin).

Kangaroo Island. — Emu Bay (Womersley, 11-1-1946). Middle River (Womersley, 8-1-1946). Vivonne Bay (Womersley, 2-1-1946, 16-1-1947, and 4-1-1950). Pennington Bay (Womersley, 28-1-1944, 25-5-1945, 7-1-1948 and 4-1-1948). Antechamber Bay (Womersley, 12-1-1947). Cape Willoughby (Womersley, 16-1-1946 and 12-1-1947).

Victoria. — Bridgewater Bay (Beauglehole, 12th. and 19th. June 1949). Lawrence Rock, Portland (Beauglehole, 13-1-1954). Whaler's Point, Portland (Muir, 17-1-1950). Double Corner Beach, Portland Bay (Beauglehole, 8th. and 14th. July 1951). Portland Bay (Mueller in MEL., in Sonder 1880). Port Fairy (Harvey, 1859 ih TCD., in LD). Point Lonsdale (Womersley, 21-9-1946) Queenscliff (in LD.). Port Phillip (Mueller in MEL., in Sonder, 1880).

Tasmania. — Currie River Mouth (Womersley, 28-1-1949). Low Head (Perrin, September 1948). Georgetown (Gunn, in Harvey 1859). Sandy Cape (Bennett, 15-1-1954). Penguin (Curtis, 22-1-1954). Derwent (Oldfield, in Harvey 1859). Derwent River (in Sonder, 1880). Taroona, Hobart (Womersley, 13-1-1949). Eaglehawk Neck (Moore, 15-1-1949).

New South Wales. — Twofold Bay (in LD.). Bermagui River, Kiama, Illawara, Thirroul, Coogee, Long Bay, ~~Port Jackson,~~ Neutral Bay, Port Jackson, Sydney District, and Port Stephens (in May, 1939).

GEOGRAPHICAL DISTRIBUTION:

From Point Fowler, South Australia, around the south-east coast to Port Stephens, New South Wales and along the coast of Tasmania.

Kuetzing (1860) established two new species — *Blossevillea intermedia* and *B. penicilifera*. They possess flat axes with alternate, pinnate, distichous branches, from their edges. Ramuli are dichotomous in *B. intermedia*, but are dense, peniciliform as well as dichotomous in *B. penicilifera*. Receptacles have been described ~~as moniliform~~ as moniliform with pointed apices in *B.intermedi* and as small, moniliform with obtuse apices in *B. penicilifera*. *B. intermedia* is only a young and slender form of *B. penicilifera*, and both are identical with the earlier described *Cystophora moniliformis*.

C. moniliformis resembles *C. platylobium* in its flat axis and the branches from its edges but differs in its moniliform receptacles with scattered conceptacles and in the absence of vesicles. It also resembles *C. galapagensis* in its moniliform receptacles and in the absence of vesicles but differs in its discoid holdfast and flat, stout axis.

Esper (1804) described *Fucus moniliformis*, from a fragment sent to him from the Banksian Herbarium by Turner. Silva (1952) referred *F. moniliformis* Esper to *Cystophora* *brownii* (Turner) J. Ag. when discussing *Fucus moniliformis* Lab. 1806. (= *Hormosira banksii* (Turner) Decaisne 1842). Silva is certainly incorrect in considering *F. moniliformis* Esper = *C. brownii* (Turner) J. Ag. Since *F. moniliformis* has very much longer and laxer receptacles than *C. brownii* and also differs in habit.

F. moniliformis Esper agrees with *F. spartioides* (= *C. spartioides*) in its method of branching and in possessing alternate irregularly dichotomous filiform ramuli developing into receptacles. Both taxa possess terete, simple or branched, moniliform receptacles, tapering or blunt apex. It appears that *F. moniliformis* Esper and *C. spartioides* are not distinct. *F. moniliformis* Esper antedates the publication of *F. spartioides* Turner 1819 (= *C. spartioides*). The correct combination is thus *C. moniliformis* (Esper) nov. comb. *C. moniliformis* has previously been known almost entirely as *C. spartioides* (Turner) J. Ag.

Type and Type locality have been located from the photo of the type of *C. moniliformis* (= *F. moniliformis* Esper) in AD. Type consists of a small branch of ~~6~~ 6·7 cm. long and receptacles up to 7 mm. long and 3 mm. broad.

11. C. HOOKERI sp. nov.

PLATE XLVIII.

PLATE LXXXIII, Fig. J.

Type Locality. — Gunnamatta Bay, near C.S.I.R.O. Boatsheds, Port Hacking, New South Wales (Womersley, 22-8-1945).

Type. — AD. A 1985.

Holdfast discoid, up to 6 mm. in diameter. Axis flat, up to 25 cm. long and 3 mm. broad and 2 mm. thick, alternately distichously loosely branched. Secondary branches arising from the edge of the axis, up to 8 cm. long and 1 mm. across, alternate. Branch bases smooth. Ramuli loose, filiform, up to 2 cm. long and less than ½ mm. across, dichotomous or alternate, developing into receptacles. Vesicles absent or present, obovate, pedicellate, mutic or apiculate, up to 6 mm. long and 2 mm. broad. Receptacles terete, loosely arranged, alternate, closely moniliform, apiculate, upto 3 cm. long and 1 mm. broad, simple or branched. Conceptacles scattered and bisexual. Antheridia 24 - 40 μ x 10 - 20 μ, on branched hairs or directly on the wall of the conceptacles. Oogonia 90 - 144 μ x 54 - 102 μ, without stalk.

SPECIMENS EXAMINED:

New South Wales. — Gunnamatta Bay, Port Hacking (Womersley, 22-8-1945). Port Jackson (Hooker).

GEOGRAPHICAL DISTRIBUTION.

Known only from the above localities. ~~C. hookeri~~ C. hookeri resembles *C. moniliformis* in its flat axis and in its method of branching and moniliform receptacles, but differs in its breadth of axis (up to 3 mm), loosely arranged branches, ~~smooth~~ branch bases smooth, receptacles, ~~bases~~ and in the presence of obovate vesicles.

Type specimen does not possess any vesicles. The photo of the specimen of *C. hookeri* from Port Jackson, N.S.W. (Harvey) shows obovate vesicles.

12. *C. XIOPHOCARPA* Harvey 1859

J. Agardh 1870: 441; 1896: 48. De Toni 1895: 140. Harvey 1859b: 284; 1863: Synop. 49. Lucas 1909: 12. Sonder 1880: 4.

PLATE XLIX. PLATE LXXXIII, Fig. L.

Blossevillea xiphocarpa Harvey ex Kuetzing 1860: t. 85, f. 2.

Type Locality. — Port Arthur, Tasmania (Harvey),

Type. — TCD. (Alg. Austr. Exsicc. No. 9).

Plants dark brown on drying, coriaceous, flexuous, up to 1 meter long. Holdfast discoid, up to 7 mm. across, with a distinct short terete stipe. Axis flat, up to 6 mm.

wide with alternate, retroflex branches, their basal part subterete. Secondary branches from the face of the axis , up to 26 cm. long and 2 mm. broad, lower parts terete, distichous, alternate pinnate. Tertiary branches up to 9 cm. long and 2 mm. broad, lower parts terete. Quaternary branches subterete, up to 3 cm. long and 9 mm. broad, bearing ramuli. Vesicles absent. Receptacles strongly flattened, ensiform, up to 9 cm. long and 10 mm. broad. Plant monoecious. Conceptacles in 2 rows on the margin of the receptacles. Antheridia 30 - 40 μ x 12 - 16 μ. Oogonia 126 - 204 μ x 60 - 102 μ.

SPECIMENS EXAMINED:

Tasmania. — Three Hammocks (Bennett, 17-1-1954). Cape Sorrell (Bennett, 4-2-1955). Adventure Bay, Bruny Island (Perrin, September 1948). Port Arthur (Cribb, 8-2-1951. Harvey in TCD. in Sonder 1880). Bicheno (Womersley, 19-1-1949). Brown's River (in Harvey 1859. in Sonder 1880).

GEOGRAPHICAL DISTRIBUTION:

Along the coast of Tasmania.

C. xiphocarpa is endemic on Tasmanian coasts. Harvy (1859b) in his original description of the species mentions Port Arthur (Harvey) and Brown's River (Gunn) as original localities. Harvey's specimen No. 9 from Port Arthur is in

TCD and Gunn's specimen with locality "Tasmania" is only in LD (Womersley, m.s. 17-6-1952). Harvey's specimen No. 9 from Port Arthur is selected as the type.

In C. xiphocarpa and C. racemosa the receptacles are strongly flattened with conceptacles in two rows on the margins of the receptacles. In C. xiphocarpa these receptacles are ensiform, up to 9 cm. long and 10 mm. broad but in C. racemosa they are lanceolate, up to 3 cm. long and 4 mm. broad. Spherical vesicles are present in C. racemosa but absent in C. xiphocarpa. C. xiphocarpa differs essentially from C. platylobium in having retroflex branches borne on the face of the axis, and in being devoid of vesicles.

13. C. RACEMOSA (Harvey ex Kuetzing)
J. Agardh 1870.

J. Agardh 1870: 441; 1896: 48. De Toni 1895: 140. De Toni et Forti 1923: 69. Lucas 1936: 71. Reinbold, 1889: 42. Womersley 1950: 160.

PLATE L. PLATE LXXXIII, Fig. M.

Blossevillea racemosa Harvey ex Kuetzing 1860: t. 85, f. 1.

Type Locality. — "Nova Hollandia" Australia (Harvey).

Type. —

Plants brown, becoming darker, on drying, up to 70 cm. long. Holdfast discoid, up to 3 cm. in diameter. Axis flat, up to 6 mm. broad with distichous branches. Secondary branches retroflex, arising from the face of the axis, up to 30 cm. long and 3 mm. broad. Tertiary branches up to 17 cm. broad. Tertiary branches up to 17 cm. long and 2 mm. broad. Quaternary branches up to 8 cm. long and 1 mm. broad, with alternately arranged, distichous, ramuli. Vesicles spherical, up to 5 (-8) mm. broad, pedicellate, mutic. Ramuli developing into receptacles. Receptacles strongly flattened, lanceolate, pinnately arranged, 0.7 - 3 cm. long and 2 - 4 mm. broad. Conceptacles in 2 rows on the margin of the receptacles, bisexual. Antheridia 30 - 38 μ x 13 - 20 μ. Oogonia 120 - 240 μ x 60 - 180 μ.

SPECIMENS EXAMINED:

W. Aus. — Geographe Bay (Terine, in MEL., and in LD). Augusta (Lucas, 1928 in AKU.). Point D'Entrecastreaux (Sheard, January 1946. Smith, 20-3-1946). Cape Riche (Harvey in MEL.). Israelite Bay (Moore, in LD.). Eucla (Womersley 2-2-1954. in MEL.).

S.Aus. — Head of the Great Australian Bight (Womersley, 4-2-1954). Scott's Bay, 4 miles west of Fowlers Bay

(Womersley, 27-1-1951). Fowler's Bay (Richards, 1880 in MEL. in Sonder 1880). Clare Bay, Penong (Chambers, May 1929). Point Sinclair (Womersley, 25-1-1951). Denial Bay (Cleland). Point Drummond (Womersley, 11-1-1951). Fishery Bay (Nizamuddin, February 1959). Spencer's Gulf (Davey, in MEL. in Sonder 1880. Tepper, in MEL.). Sturt Bay (in AD.). Investigator Strait (Davey, in Reinbold). Brighton Beach (Womersley, May 1944). Marino (Womersley, 21-5-1953). Port Noarlunga (Harris, August 1943). Victor Harbour (De Toni et Forti). Lacepede Bay (Mueller in 1877. in MEL. in Sonder 1880. in Reinbold). Guichen Bay (in Reinbold).

Kangaroo Island. — Pennington Bay (Womersley, 4-9-1946 and 3-6-1947). Rocky Point (Womersley, 26-8-1950). Seal Beach (Womersley, 24-1-1957). Point Tinline (Womersley, 2-2-1956).

Victoria. — Portland Bay (Mueller, 1878 in MEL.). Queenscliff (Mueller in LD.).

GEOGRAPHICAL DISTRIBUTION:

From Geographe Bay, Western Australia, around the south coast to Queenscliff, Port Phillip Bay, Victoria. Harvey never published a description of Cystophora racemosa but other authors have credited the name to him. Kuetzing (1860) was the first to publish a description of C. racemosa, which he credited to Harvey. Type has not been located.

C. racemosa resembles *C. platylobium* in its flat axis, flat receptacles with conceptacles in 2 rows on the margins and also in the presence of vesicles, but differs in its retroflex branches from the face of the axis and in the size of the receptacles.

14. *C. CUSPIDATA* J. Agardh 1896.

J. Agardh 1896: 48.

Type Locality. — Encounter Bay, South Australia (Hussey).

Type. — LD. (Herbarium Agardh No. 1130).

PLATE LI. PLATE LXXX, Fig. N.

Plants dark brown turning darker on drying, up to 60 cm. long. Holdfast discoid, up to L0 mm. in diameter, with a short subterete stipe. Axis flat, alternately distichously branched, up to 6 mm. broad, with retroflexed branches from the face of the axis. Secondary branches flat, alternate, distichous, up to 10 (-25) cm. long and 2 mm. broad; tertiary branches flat, alternate, distichous, up to 4 cm. long with scars near their bases and ramuli developing into receptacles. Vesicles absent. Receptacles terete (when young) or angular or flattened near the base due to the conceptacles, verrucose, apiculate, up to 6 (-8) cm.

long and 3 mm. broad, simple or branched, crowded in fascicles. Conceptacles in 2 or 3 rows (in some cases irregular but close together), bisexual and up to 1 mm. broad. Antheridia 23 - 40 μ x 9 - 13 μ. Oogonia 54 - 180 μ x 54 - 108 μ.

SPECIMENS EXAMINED:

S.Aus. —Point Sinclair (Womersley, 25-1-1951 and 8-2-1954). Elliston (Womersley, 13th and 15th January, 1951). Marino (Womersley, 21-5-1953). Port Noarlunga (Womersley, 15-10-1950). Victor Harbour (Womersley, 23-4-1951). Port Elliot (Womersley, 17-10-1948, 23-5-1953 and 10-8-1957).

Victoria. — Warrnambool (Womersley, 16-8 -1949). Apollo Bay (Womersley, 18-8-1949). Brighton Beach, Port Phillip Bay (Womersley, 29-5-1948).

GEOGRAPHICAL DISTRIBUTION.

From Point Sinclair, South Australia, around south coast to Port Phillip Bay, Victoria.

C. cuspidata resembles C. subfarcinata in its discoid holdfast, flat axis with retroflex branches from the face and in the flattening of the receptacles due to the conceptacles being in rows, but it differs in the absence of vesicles, the angular receptacles without prominent sterile awn, and the broader conceptacles.

15. C. SCALARIS J. Agardh 1870.

J. Agardh 1870 : 442; 1896: 48. De Toni 1895: 141. Laing 1899: 67; 1927: 143. Lucas 1909: 12. Naylor 1954b: 653. Sonder 1880: 4.

PLATE LII. PLATE LXXXIII, Fig.O.

Blossevillea scalaris (J.Ag.) Lindauer 1947: 561.

Type Locality. — Chatham Island (Travers. No. 108).

Type. — LD. (Herbarium Agardh No. 1113.).

Plants brown, becoming darker on drying, stout, up to 65 cm. long. Holdfast discoid, up to 2.7 cm. in diameter. Axis flat, up to 18 mm. broad and 3 mm. thick, very coarse and zigzag alternately pinnately branched, with bases of branches prominent and crowded. Secondary branches retroflex, arising from the face of the axis, up to 27cm. long and 10 mm. broad. Tertiary branches up to 6 cm. long and 5 mm. broad. Ramuli developing into receptacles. Vesicles ovoid, up to 7 mm. (-11) mm. long and 5 - 7 (-9) mm. broad, pedicellate, mutic, near the base of the branches. Receptacles lanceolate, compressed (up to 1 mm. thick), simple (rarely branched) crowded, up to 2.3 cm. long and 2 mm. broad. Conceptacles in 2 rows on the margin of the receptacles, bisexual. Antheridia 32 - 43 μ x 9 - 14 μ. Oogonia 132 - 180 μ x 108 - 150 μ.

SPECIMENS EXAMINED:

New Zealand. —

North Island. — Lyall Bay, Wellington (Womersley, 9-3-1949). South Island. — Kaikoura (Womersley, 17-2-1949). New Brighton, Christchurch (Lindauer, 14-5-1939). Oahoa Bay, Bank Peninsula (Scarf, Herbarium Laing December 1906). Akaroa (Laing, July 1928). Brighton, Otago (Laing's collection) . Cape Saunders (in MEL.). Dunedin (Lindauer, 20-7-1945). St. Clair, Dunedin (Womersley, 7-3-1949). (Laing, April 1895). Portbello near Dunedin (Womersley, 4-3-1949). Bluff, Foveaux Strait (Moore, 4-1-1940). Half Moon Bay, Stewart Island (Womersley, 9-3-1949).

GEOGRAPHICAL DISTRIBUTION:

From Lyall Bay, North Island, to Bluff, South Island; at Half Moon Bay, Stewart Island and at Chatham Island.

Sonder (1880) gives the distribution of C. scalaris as Tasmania and later Lucas (1909) and Lindauer (1947), followed him. Lindauer also reports C. scalaris from Australia. It has not been collected recently from Australia and Tasmania and Sonder's and Lindauer's records need further confirmation.

C. scalaris resembles *C. distenta* in its flat axis with branches from its face and in the presence of vesicles, but differs in its close, dense branches, with their axils less rounded, its strongly zigzag axis with the bases of the branches crowded and in its crowded receptacles.

16. *C. RETROFLEXA* (Labillardiere) J. Agardh 1848

J. Agardh 1848: 242; 1870: 443; 1896: 49. De Toni 1895: 142. De Toni et Forti 1923: 69. Delf 1941: 161. Harvey 1855: 214; 1859b: 283; 1863: Synop. 43. Laing 1899: 67; 1927: 143. Lucas 1909: 12; 1936: 72. Naylor 1954b: 653. Sonder 1852: 670; 1853: 511: 1880: 4.

PLATE LIII. PLATE LXXXIII, FIG. P.

Fucus retroflexus Labillardiere 1806: 113, t. 260. Mertens 1819: 85.

Cystoseira retroflexa C. Agardh 1821: 74; 1824: 289. Greville 1830: Synop. 33.

Blossevillea retroflexa Kuetzing 1843: 364; 1849: 629. Hooker and Harvey 1845: 527; 1847: 414. Lindauer 1947: 561. May 1939: 204. Montagne 1845: 64.

Blossevillea campylocoma Kuetzing 1860: t. 81, f.1. Sonder 1880: 106.

Blossevillea caudata Hooker and Harvey 1847: 414. Kuetzing 1849: 629; 1860: t. 76, f.1.

Type Locality. — "Cape van Diemen" — Tasmania. (Labillardiere).

Type. — Fl.

Plants brown, becoming darker on drying, coriaceous, flexuous, up to 90 cm. long, loose and spreading. Holdfast discoid, up to 15 mm. in diameter, with a short terete stipe. Axis, flat, up to 9 mm. broad, with loose, alternate retroflex branches. Secondary branches up to 17 cm. long and 2 mm. broad, with alternate, distichous tertiary branches. Tertiary branches up to 6 cm. long and 1 mm. broad, with alternate, simple, filiform ramuli. Ramuli up to 2 cm. long and ½ mm. broad. Vesicles spherical or ellipsoid, scattered, pedicellate, mutic. Ellipsoid vesicles up to 10 mm. long and 6 mm. broad, spherical vesicles up to 7 mm. broad. Ramuli developing into receptacles. Receptacles siliquaform, up to 6 cm. long and 2 mm. broad, compressed, apiculate, simple (rarely branched). Conceptacles crowded in 2 rows on the margin of the receptacle, bisexual. Antheridia 20 - 27 µ x 16 - 20 µ. Oogonia 90 - 132 µ x 72 - 108 µ.

SPECIMENS EXAMINED:

S. Aus. — St. Vincent Gulf (Mueller, in Kuetzing 1860 as Bl. campylocoma). Somerton (Womersley, 29-5-1949). Rivoli Bay (Mueller, in Sonder 1852 in Sonder 1880).

Victoria. — Queenscliff (in Sonder 1880). Brighton Beach, Port Phillip Bay (Womersley, 29-5-1948). Wilson's Promontory (in Sonder 1853 and 1880).

Tasmania. — Low Head (Perrin, August 1948, Cribb, 14-9-1950). Georgetown (Harvey, 1859 in Sonder 1880. Gunn in LD.). Bombay Rock, Tamar East (Womersley, 27-1-1949). Latrobe Bay (De Toni et Forti). Cape Sorrell (Bennett, 4-2-1955). Missionery Bay, Bruny Island (Womersley, 15-1-1949), Sandy Bay, Queenborough (in TCD.). Port Arthur (Cribb, 22-6-1950).

New South Wales. — Eden (in May, 1939). Tathra (Cribb, 5-10-1950). Tilba-Tilba (in Sonder 1880). Point Dromedary (Bate), Kiama (in May, 1939). Bulli and Bondi (in May, 1939). Sydney (in Sonder 1880).

GEOGRAPHICAL DISTRIBUTION:

From St. Vincent Gulf, South Australia, around south east coast to Bondi, Sydney, New South Wales and along the coasts of Tasmania; New Zealand and Chatham Island.

Sonder (1880) reports C. retroflexa from Geographe Bay, Western Australia. Since then it has not been collected from Geographe Bay or any part of Western Australia. Sonder's report may be considered erroneous.

Vesicles are lateral and not axillary in *C. retroflexa* as given in the type description of Labillardiere (1806).

Comparison of the type description and Kuetzing's figure of *B. caudata* Hooker and Harvey indicate that the latter is not different to *C. retroflexa*.

Type description and the figure of *B. campylocoma* Kg. (from St. Vincent Gulf) indicate that it is not distinct from *C. retroflexa*.

Delf (1941) states that the crowded tufts of receptacles and abundant vesicles near the base of the branches are the characteristic feature of *C. retroflexa*. These are certainly not the features of *C. retroflexa* but of *C. torulosa*, and Delf's description applies to the latter species.

C. retroflexa resembles *C. siliquosa* in its method of branching and compressed receptacles with conceptacles in 2 rows on the margin but differs in its presence of Vesicles and more strongly flattened axis.

17. *C. SILIQUOSA* J. Agardh 1870.

J. Agardh 1870: 445; 1896: 49. De Toni 1895: 149. Lucas 1909: 12; 1913: 58; 1936: 72. Sonder 1880: 4. Womersley 1950: 160.

PLATE LIV.PLATE LXXXIII,Fig.Q.

Blossevillea siliquosa (J. Ag.) May 1939: 204.

Type Locality. — Port Phillip (Mueller).

Type. — LD. (Herbarium Agardh No. 1194).

Plants dark brown, becoming darker and brittle on drying, coriaceous, up to 2.5 meters long. Holdfast discoid, up to 13 mm. across. Stipe terete, up to 12 mm. long and 2 mm. in diameter. Axis flat, quadrangular in section, up to 5 mm. broad, with retroflexed branches from its face, basal part terete. Secondary branches up to 30 cm. long and 2 mm. broad, alternate, distichous. Tertiary branches up to 4 cm. long and 1 mm. broad, with filiform and densely crowded ramuli. Vesicles absent. Ramuli developing into receptacles. Receptacles compressed but not strongly flattened, closely pinnate, up to 8 cm. long and 2 mm. broad, simple, attenuated at both ends. Conceptacles in 2 rows on the margin, uni- or bisexual. Antheridia 24 - 42 µ x 12 - 18 µ. Oogonia 60 - 150 µ x 36 - 96 µ.

SPECIMENS EXAMINED:

W. Aus. — Cottesloe, near Perth (Royce, 12-6-1951). Reefcole, West Beach, Esperance (7-1-1935).

S. Aus. — Venus Bay (Womersley, 12-2-1954). Elliston (Nizamuddin, 27-2-1959). Cape Carnot (Womersley, 8-1-1951). Sleaford Bay (Womersley, 6-1-1951. Nizamuddin, February 1959). Fishery Bay (Nizamuddin, February 1959). Stenhouse Bay (Womersley, 9-4-1950). Encounter Bay (in Sonder 1880). Kangaroo Island. — Emu Bay (Womersley, 18-1-1945). Vivonne Bay (Womersley, 23-5-1945). Pennington Bay (Womersley, 14-1-48, 28-1-1946 and 12-1-1945. Schodde, February 1956). Antechamber (Womersley, 12-1-1947), Cape Willoughby (Womersley, 12-1-1947 and 16-1-1946). Middle River (Womersley 8-1-1946). Western River (Womersley, 7-1-1946).

Victoria. — Bridgewater Bay (Beauglehole, 29-5-1949. Nizamuddin, 14-4-1959). Port Fairy (in MEL.) Warrnambool (Nizamuddin, 13-4-1959). Peterborough (Pope and Bennett, 17-8-1949). Point Roadknight, near Anglesea (Womersley, 6-6-1953. Davis, 1-2-1946). Port Phillip (in MEL. and in TCD. in Sonder 1880). Queenscliff Beach (Nizamuddin, 8-4-1959). Woodbourne (Dücker, 1947 in MUB). Sorrento (Coleman, 1929 in AKU. Womersley, 2-6-1953). Portsea (Macpherson, 15-9-1957). Half Moon Bay, near Penguin Reserve, Phillip Island (Nizamuddin, 10-4-1959). The Nobbies, Phillip Island (Nizamuddin, 10-4-1959). Cat's Bay, Phillip Island (Nizamuddin, 10-4-1959). Walkerville, Waratah Bay (Bennett, November 1949). Sealer's Cove, east Wilson Promontory (MEL.).

New South Wales. — Jervis Bay (in May 1939).

GEOGRAPHICAL DISTRIBUTION. — From Cottesloe, Perth, Western Australia, around the south east coast to Jervis Bay, New South Wales.

C. siliquosa resembles *C. retorta* in its general features but differs in its quadrangular axis, in the complete absence of vesicles and in its compressed receptacles.

18. *C. RETORTA* (Mertens) J. Agardh 1848.

J. Agardh 1848: 243; 1870: 443; 1896: 49. Bailey and Harvey 1874: 156. De Toni 1895: 141. Harvey 1855: 214; 1863; Synop. 44. Laing 1927: 143. Lucas 1909: 12; 1936: 72. Sonder 1852: 670; 1880: 4. Womersley 1950: 160.

PLATE LV. PLATE LXXXIII, Fig. R.

Fucus retortus Mertens 1819: 185.

Cystoseira retorta C. Agardh 1821: 74; 1824: 289. Greville 1830: Synop. 33.

Blossevillea retorta Montagne 1845: 64. Hooker and Harvey 1845: 527; 1847: 414. Kuetzing 1849: 629.

Type Locality. — "Novae Hollandiae" Australia.

Type. — PC.

Plants brown, becoming darker on drying, flat, distichously alternately branched, up to 1.2 metres long. Holdfast discoid, up to 14 mm. across. Axis strongly flattened, distichously and alternately branched, up to 7 mm. broad and 2 mm. thick. Secondary branches arising from the face of the axis, retroflex, up to 12 cm. long and 3 mm. broad, flexuous. Odd branches up to 48 cm. long. Ramuli developing from the secondary branches, several times dichotomous with broadly rounded axils. Vesicles absent or rare, ellipsoid, up to 12 mm. long and 10 mm. broad, pedicellate, mutic or apiculate, and single or rarely 2 near the base of the secondary branches. Receptacles developing from the ramuli, linear-elongate, torulose, simple (3-) 5 - 7 (-8) cm. long and 1 - 2 mm. broad, with apiculate apices in fascicles. Conceptacles in 2 rows on the receptacles, bisexual. Antheridia 24 - 42 µ x 12 - 20 µ. Oogonia 102 - 162 µ x 54 - 96 µ.

SPECIMENS EXAMINED:

W. Aus. — Busselton (Preiss). Geographe Bay (Mueller), Cape

Leeuwin (in Sonder, 1880). Between Cape Laeuwin and King George Sound (Maxwell, 1874).

S. Aus. — 10 miles east of Eucla (Womersley, 3-2-1954). Head of the Great Australian Bight (Womersley, 4-2-1954). Fowler's Bay (Richards, 1880 in MEL.). Point Fowler (Womersley, 6-2-1954). Scott's Bay (Womersley, 27-1-1951). Sceales Bay (Womersley, 11-2-1954). Point Drummond (Womersley, 11-1-1954). Investigator Strait (Davey). Stenhouse, Yorke Peninsula (Womersley, 9-4-1950). St. Vincent Gulf (Cleland, November 1936, in Sonder 1880). Glenelg (Womersley, 14-4-1948). Marino (Womersley, 21-5-1953). Port Noarlunga (Harris, **August** 1953). Port Willunga (Womersley, 13-5-1945 and 24-4-1948). Willunga Reef (Shepley, 4-4-1954). Sellick's Beach Reef (Hale, 19-1-1936). Encounter Bay (January 1928). Victor Harbour (Womersley, 23-5-1953). Port Elliot (Womersley, 10-8-1957). Lacepede Bay (Mueller, in Sonder 1880).

Kangaroo Island. — Vivonne Bay (Womersley, 14-1-1948). Seal Beach (Womersley, 24-1-1945,). Pennington Bay (Womersley, 28-1-1944; 24-5-1945; 28-7-1947, 22-1-1948, 14-1--1948 and 31-12-1949).

Victoria. — Portland (Muir, January 1950). Portland Bay (in Sonder 1880). Port Fairy (Harvey in TCD.). Point Lonsdale (Mathieson, 21-9-1946). Port Phillip Bay (Mueller, August 1854). Safety Bay, Port Phillip Bay (Macpherson, 14-5-1957). Brighton Beach, Port Phillip Bay(29-5-1948). Sorrento (2-6-1953). The Nobbies, Phillip Island (Pope and Bennett, 13-5-1949). Walkerville, Waratah Bay (Pope and Bennett, 19-5-1949). Wilson's Promontory (Mueller, June 1853. in Sonder 1880).

Tasmania. — Currie River Mouth (Womersley, 28-1-1949). Bombay Rock (Womersley, 27-1-1949). Emu Bay (1880). Burnie (Womersley, 26-1-1949). Taroona, Hobart (Womersley, 13-1-1949). Swansea (Womersley, 19-1-1949). Tasmania (in Sonder 1880).

GEOGRAPHICAL DISTRIBUTION:

From Busselton, Western Australia, around the south coast to Wilson's Promontory, Victoria and on the coast of Tasmania.

Laing (1927) reports that C. retorta has not been collected recently in New Zealand and he considers the original records apply to C. retroflexa. Lindauer (1947) does not include C. retorta among New Zealand algae.

C. retorta resembles C. retroflexa and C. distenta in general features but differs in its torulose receptacles and strongly rounded axils of branches.

19. C. TORULOSA (R. Brown ex Turner)
J. Agardh 1848.

J. Agardh 1848: 243; 1870: 445; 1896: 48. De Toni 1895: 143. De Toni et Forti 1923: 70. Harvey 1855: 214; 1859b: 284; 1860: pl. 123; 1863: Synop. 45. Laing 1899: 67; 1927: 143. Lucas 1909: 13; 1913: 58; 1936: 72. Naylor 1954b: 653. Sonder 1853: 511; 1880: 4.
PLATE LVI. PLATE LXXXIV, Fig. A.

Fucus torulosus R. brown ex Turner 1811: 52, t. 157. Mertens. 1819: 185.

Cystoseira torulosa C. Agardh 1821: 75; 1824: 290. Greville 1830: Synop. 33.

Blossevillea torulosa Decaisne ~~1841: 147;~~ 1842: 330. Hooker and Harvey 1845: 527; 1847: 414. Lindauer 1947: 561. Kuetzing 1849: 628; 1860: t. 72, f. 2.

Type Locality. — Kent Island, Bass Strait (R. Brown).

Type. — K.

Plants brown, becoming darker on drying, coriaceous, up to 60 cm. long. Holdfast discoid, up to 15 mm. across with a short and subterete stipe. Axis flat, up to 10 mm. broad, distichous with short retroflexed secondary branches. Secondary branches up to 5 (-21) cm. long and 5 (-7) mm. broad. Tertiary branches retroflex, (1-) 2-4 cm. long and 1 (-2) mm. broad, flexuous, alternatley tuberculate at their bases. Ramuli subfascichlate, simple or forked, clavate, developing into receptacles. Vesicles abundant or rare near the bases of secondary or tertiary branches, simple, pedicellate, mutic, spherical (when young) or ellipsoid, up to 10 mm. long and 7 mm. broad. Receptacles terete, simple, apices blunt, alternately arranged up to 2 (-6) cm. long and 3 mm. broad, in crowded tufts. Conceptacles in 2 (-3) rows, bisexual. Antheridia 27 - 40 μ x 10 - 16 μ. Oogonia 120 - 162 μ x 48 - 96 μ.

SPECIMENS EXAMINED:

Victoria. — The Nobbies, Phillip Island (Nizamuddin, 10-4-1959). Apollo Bay (Nizamuddin, 12-4-1959). Point Roadknight (Womersley, 6-6-1953). Anglesea (Macpherson, 23-11-1957). Torquay (McLennan, in MUB.). Port Phillip (in Sonder 1880). Point Lonsdale (Mathieson, 21-9-1946. September 1948 in MUB.). Woodbourne (Dücker, February, 1947 in MUB.). Western Port (Harvey, 1860). Walkerville, Waratah Bay (Pope and Bennett, 16th. and 19th. May, 1949). Tidal River, Wilson's Promontory (Sonder, 1853). Sealer's Cove, east of Wilson's Promontory (in Sonder 1880). Tasmania. — Low Head (Perrin, August 1948). Georgetown (Gunn, in Hooker and Harvey 1847). Bomaby Rock (Womersley, 27-1-1949). Burnie (Womersley, 26-1-1949. De Toni et Forti). Three Hammocks, Hunter Island, (Bennett, 14th. and 17th. January 1954). West Head (Bennett, 30-1-1954). Wivenhoe Point (Bennett, 31-3-1954). Tasmania (in Sonder 1880).

GEOGRAPHICAL DISTRIBUTION:

From Apollo Bay, Victoria to Sealer's Cove, Wilson's Promontory and on the coast of Tasmania and at Kent Island; New Zealand.

Sonder (1880), reports C. torulosa from Encounter Bay S.Aus. Since then it has not been collected from Encounter Bay or any part of South Australia. Sonder's report may be considered as erroneous.

In Australian waters this species, as far as known, occurs on the north and south coast of Bass Strait. It grows in upper sublittoral pools. *C. torulosa* may be exposed to air during very low tides. Plants growing in tidal pools are dwarf and become extremely bushy. Harvey (1860) reports the presence of solitary vesicles near the base of the branchlets but up to five vesicles occur near the base of the secondary branches or tertiary branches. In most cases plants bear only secondary branches.

C. torulosa resembles *C. retorta* and *C. grevillei* in its terete receptacles with conceptacles in 2 rows (rarely in 3 rows in *C. torulosa*) and also resembles *C. retorta* in its general features but differs in its crowded tufts of receptacles, abundant vesicles and in thickness of the receptacles.

20. *C. BOTRYOCYSTIS* Sonder 1852.

J. Agardh 1870: 446; 1896: 47. Areschoug 1875: 1. De Toni: 1895: 144; 1896: 230. Harvey 1858: pl. 56; 1863: Synop. 53. Lucas 1909: 13; 1936: 72. Reinbold 1899: 42. Sonder 1852: 670; 1880: 4. Womersley 1950: 159.

PLATE LVII. PLATE LXXXIV, Fig. B.

Blossevillea botryocystis Kuetzing 1860: t. 73, f. 2.

Blossevillea myosuroides Areschoug 1854: 12 (338)

Type Locality. — Holdfast Bay, St. Vincent Gulf, South Australia.

Type. — MEL.

Plants brown, turning darker on drying, flexuous, pinnately branched, up to 4 meters long. Holdfast discoid, up to 15 mm. in diameter. Axis compressed, up to 5 mm. broad and 3 mm. thick, with retroflexed branches. Secondary branches retroflex, arising from the face of the axis, up to 30 cm. long and 3 mm. broad, with rounded axils. The lower parts of the axis and secondary branches are usually denuded and are distantly tuberculate. Tertiary branches up to 10 cm. long and 1 mm. broad, densely pinnate with terete ramuli. Vesicles spherical (up to 4 mm. broad), to slightly elongate (to 6 mm long and 4 mm broad), pedicellate, mutic, clustered at the base of the secondary branches. Ramuli developing into receptacles. Receptacles terete, smooth, simple or branched, up to 18 mm. long and 1 mm. broad. Conceptacles scattered (rarely in 3 rows), bisexual. Antheridia 33 - 44 μ x 10 - 18 μ. Oogonia 132 - 168 μ x 42 - 132 μ.

SPECIMENS EXAMINED:

S. Aus. — Cape Donnington (Shepley, February 1959). Investigator Strait (Davey. Davey, in Reinbold). Port Vincent (Womersley, 8-4-1950). Adrossan (Ban Becking, in NBV). Gulf of St. Vincent (February 1948, in Sonder 1880). Lefevre Peninsula (Mueller, July 1852). Semaphore Beach (Harris, July 1943). Henley Beach (May 1925). Glenelg (Grunow, inUC.). Somerton Beach (Womersley,). Holdfast Bay (Mueller, in Harvey). Encounter Bay (Cleland). Port Elliot (Hussey, in LD.). Lacepede Bay (Reinbold, in NBV). Guichen Bay (Reinbold, in NBB). Robe (Womersley, 30-8-1949).

Kangaroo Island. -- Rocky Point (Womersley, 21-8-1948). Eastern Cove (Womersley, 27-1-1949). American River (Womersley, 22-5-1945 and 2-6-1947). Emu Bay (Womersley, 10-1-1946). Red Banks (Womersley, 25-8-1950).

Victoria. — Port Phillip (Mueller, in UC. in Sonder 1880. Harvey, in TCD.). Corio Bay, Geelong (in E.). Brighton Beach, Port Phillip (Harvey, 1858 and in LD.).

Tasmania. — (Gunn in LD.).

GEOGRAPHICAL DISTRIBUTION:

From Cape Donnington, South Australia, around the south coast to Brighton Beach, Port Phillip Bay, Victoria and Tasmania.

Sonder (1880) reports *C. botryocystis* from Geographe Bay, Western Australia. Since then it has not been collected from Geographe Bay, or from any part of Western Australia, Sonder's report may be considered as erroneous.

Areschoug (1854) described *Blossevillea myosuroides* but in 1875 he placed it as a synonym of *C. botryocystis*. Sonder (1852) in describing *C. botryocystis* refers to Holdfast Bay as the type locality, but there is no type specimen of *C. botryocystis* in Plantae Muellerianae from St. Vincent Gulf, in MEL. St. Vincent Gulf may be considered as the type locality, as Holdfast Bay is within St. Vincent Gulf. Kuetzing (1860) also refers to "St. Vincent Gulf" as the type locality when describing *Blossevillea botryocystis*.

C. botryocystis resembles *C. torulosa* in general features but differs in its short terete receptacles, in its vesicles which are clustered at the base of the secondary branches and in the thickness of the receptacles.

21. *C. DISTENTA* J. Agardh 1870.

J. Agardh 1870: 443; 1896: 48. De Toni 1895: 141.
Laing 1899: 67; 1927: 143. Lucas 1909: 12; Sonder 1880: 4.

PLATE LVIII. PLATE LXXXIV, FIG. C.

Blossevillea distenta (J. Ag.) Lindauer 1947: 5630.

Type Locality. -- Chatham Island (Travers No. 109).

Type. — LD. (Herbarium Agardh No. 1118).

Axis flat, up to 4 mm. broad, with retroflex, loose branches from the face of the axis. Secondary branches up to 15 cm. long and 2 mm. broad with rounded axils and bases of branches not crowded. Tertiary branches up to 4 cm. long and 1 mm. broad with alternate distichous ramuli. Vesicles spherical, 6 (-8) mm. broad, pedicellate, near the base of the tertiary branches. Ramuli developing into receptacles. Receptacles compressed, simple or branched, lanceolate, apiculate, distantly arranged in alternate series, up to 3 (-5) cm. long and 2 mm. broad. Conceptacles in 2 rows on the margin of the receptacles, bisexual. Antheridia 27 - 47 µ x 13 - 20 µ. Oogonia 120 - 162 µ x 90 - 108 µ.

SPECIMENS EXAMINED:

New Zealand. — South Island. — Stewart Island (Lindauer, July and November 1943 . Willa, in Lindauer). Bluff (Berggren, in LD.). Banks Peninsula (Raoul, 1833. in MEL.). North Island. — Auckland (Capt. Fairchild, in MEL.). Wellington (Kellaway, 22-1-1868 in MEL.). Chatham Island (Lindauer, August 1941. Travers in MEL.. Gilpin, in Lindauer).

GEOGRAPHICAL DISTRIBUTION:

From Auckland, North Island, to Bluff, South Island; Stewart Island and Chatham Island.

Sonder (I880) records *C. distenta* from Geographe Bay, Western Australia, and later Laing (I927) and Lindauer (I947) followed him. Sonder's record needs investigation because since that time no specimen of *C.distenta* has been collected in Australia.

C.distenta resembles *C. retroflexa* in general features but differs in its strongly zigzag axis with loose branching and loose conceptacles.

22. *C.CONGESTA* sp.nov.

Plate LIX. Plate LXXXIV, Fig. D.

Blossevillea dumosa Decaisne I842: 330.Kuetzing I860: t.73, f. I. Lindauer I947: 56I. Sonder I846: I60.

Cystoseira dumosa Greville and C.Agardh in Greville I830: Synop. 33.

Cystophora dumosa (Greville and C.Agardh in Greville)J.Agardh I848: 24I; I870: 444; I896 ; 49. De Toni I895 : I42. Laing I899 : 67.

Type Locality. — Robe, near the slipway (Nizamuddin, 16-4-1959).

Type. — AD, A. 23,980.

Plants dark brown, becoming darker on drying, coriaceous, up to 1.2 metres long with dense branching. Holdfast discoid up to 2 cm. in diameter. Stipe terete up to 10 mm. long and 7 mm. in diameter. Axis flat, up to 14 mm. broad and 3 mm. thick, strongly developed, with alternate, distichous, pinnate branches. Secondary branches retroflex, from the face of the axis, up to 26 cm. long and 4 mm. broad, and bases of branches not crowded. Tertiary branches up to 6 cm. long and 2 mm. broad, crowded with terete ramuli. Ramuli to 2 cm. long and 1 mm. broad, crowded, dichotomous and developing into receptacles. Vesicles ovoid, up to 10 mm. long and 8 mm. broad, spherical. 10 mm. diameter, numerous, rare or absent, one at the base of each ramulus, pedicellate, mutic. Receptacles compressed, crowded, alternate, apiculate, simple (occasionally branched) up to 3 cm. long and 1 mm. broad. Conceptacles crowded, in 2 rows on the margins of the receptacles, bisexual. Antheridia 27 - 40 µ x 11 - 15 µ. Oogonia 90 - 186 µ x 48 - 102 µ.

SPECIMENS EXAMINED:

S.Aus.— Point Drummond (Womersley, 11-1-1951). Investigator Strait (Davey, in Reinbold). Stenhouse Bay (Womersley, 9-4-1950). Sturt Bay, Encounter Bay (Harris, December 1943. in Sonder 1880). Port Elliot (Womersley, 17-10-1948, Harris, December 1948.). Guichen Bay (Womersley, 1-9-1949). Robe (Womersley, 30-8-1949. Nizamuddin, 16-4-1959). Stinky Bay, Nora Creina (Womersley, 19-8-1957. Nizamuddin, 16-4-1959). Port MacDonnell (Nizamuddin, 14-2-1959).

Kangaroo Island. — Vivonne Bay (Womersley, 23-1-1945, 3-1-1946 and 4-1-1950). Seal Beach (Womersley, 24-1-1957). Pennington Bay (Womersley, 12-1-1945, 24-5-1945, 28-1-1946, 13-4-1947, 28-7-1947, 22-1-1947, 7-1-1948, 29-12-1948 and 31-12-1948).

Victoria. — Bridgewater Bay (Beauglehole, 24th. and 29th. July 1949). Shelly Beach, Bridgewater Bay (Beauglehole, 10-8-1951). Portland (Muir, January 1950). Narrowang Beach, Portland Bay (Nizamuddin, 13th and 14th April, 1959). Port Fairy (Harvey, No. 6. in LD.). Warrnambool (Nizamuddin, 13-4-1959). Point Roadknight (Womersley, 6-6-1953. Nizamuddin, 11-4-1959). Queenscliff (Grunow, 1884 in LD. Nizamuddin, 8-4-1959). Sorrento (Bennett, November 1949). Half Moon Bay, Phillip Island, (Nizamuddin, 10-4-1959). The Nobbies, Phillip Island (Nizamuddin, 10-4-1959). Cat's Bay, Phillip Island (Nizamuddin, 10-4-1959).

Tasmania. — Low Head (Perrin, August 1948).

New Zealand. — North Island. — Lyall's Bay, Wellington (Berggren, in LD.).

South Island. — Kaikoura (Womersley, 17-2-1949; Lucas, Laing, 1-7-1930; September 1928). New Brighton, Christchurch (Lindauer, 14-5-1939). Banks Peninsula (Berggren). Ohoa Bay, Banks Peninsula (Laing, April 1930). Timaru (Womersley, 24-2-1949). Brighton, Otago (Laing, 16-1-1933). Shag Point, Dunedin (Womersley 6-2-1958). Cape Saunder, Bluff (Berggren, in LD.). Stewart Island. —Half Moon Bay (Laing, 17-1-1934).

GEOGRAPHICAL DISTRIBUTION:

From Point Drummond, South Australia, around the south coast to The Nobbies, Victoria, at Low Head, Tasmania and in New Zealand (from Lyall's Bay to Stewart Island).

C. congesta resembles C. distenta and C. subfarcinata in its general features, and also resembles the former in its compressed receptacles with conceptacles in 2 rows on the margin but differs in its dense branching with axils less rounded on the margin, and in short crowded tufts of receptacles with crowded, compact conceptacles.

C. dumosa is based on Sonder's specimen since his description of the species is the first valid publication (1846). Previously only the name of the species was published by Greville and C. Agardh and its name was a "nomen nudum". Sonder's sheet from Preiss is in MEL. and consists of several poor fragments comprising (1) basal part of *C. monilifera* and (2) fragments with a few receptacles which are of *C. brownii*. It is evident that the characters of *C. dumosa* were derived from poor fragments of *C. monilifera* and *C. brownii*. According to the Paris Art. No. 66 (Lanjouw, 1956) the name *C. dumosa* is rejected as a "nomen dubium".

In Greville's Herbarium (E) there are four specimens from Swan River, Western Australia, collected by Fraser and on which the name has been based. Two of these are inadequate and the other two appear to be a form of *C. monilifera*. The vesicles are small, spherical, sparse and the receptacles are not properly developed. Branches are closely zigzag near the axis. The lowest part of the axis is more or less terete (Womersley, m.s. 1952).

In LD. (Herbarium Agardh) there are two specimens (Nos. 1211 and 1212) under *C. dumosa*. C. Agardh's original specimen No. 1212, from Greville's Herbarium is sterile and appears to be *C. monilifera*. The other specimen, No. 1211 (Harvey's No. 6) is fertile *C. congesta* (= *C. dumosa*).

23. *C. SUBFARCINATA* (Mertens) J. Agardh 1848.

J. Agardh 1848: 240; 1870: 447; 1896: 47. De Toni 1895: 147. Harvey 1863: Synop. 39. Levering 1946: 218. Lucas 1909: 13; 1936: 74. Sonder 1852: 670; 1880: 4. Womersley 1950: 161.

PLATE LX. PLATE LXXXIV, Fig. E.

Fucus subfarcinatus Mertens 1819: 184.

Cystoseira subfarcinata C. Agardh 1821: 83; 1824: 289: Sonder 1846: 160.

Blossevillea subfarcinata Kuetzing 1849: 628; 1860: t. 72, f.1.

Type Locality. — "Terra Van Diemen" Tasmania.

Type. — (Type fragments in Herbarium Agardh Lund).

Plants brown, becoming darker on drying, coriaceous, flexuous, up to 2 metres long. Holdfast discoid, up to 12 mm. across. Axis flat, alternate, densely pinnate and distichously branched, up to 5 mm. across with retroflexed branches. Secondary branches flat upto 13 cm. long and 2 mm. across. Tertiary branches upto 5 cm. long and 1.5 mm. broad, bearing ramuli. Ramuli cylindrical, alternate, pinnate, up to 4 cm. long and ½ mm. in diameter. Vesicles present or absent, spherical (up to 4 mm. broad), or obovoid up to (3-) 5 mm. long and 3 mm. broad. Receptacles torulose, compact at the base due to conceptacles, loose above, apiculate (prominent sterile awn) simple or often branched, up to 5 cm. long and 2 mm. broad. Plant monoecious. Conceptacles markedly swollen (up to ½ mm. broad) irregularly scattered and bisexual. Antheridia 36 - 43 μ x 13 - 18 μ. Oogonia 120 - 162 μ x 90 - 114 μ.

<u>SPECIMENS EXAMINED</u>:

W. Aus. — Fremantle (in Sonder 1880). Nichol Bay (1880 in MEL.). Cape Leeuwin (in Sonder 1880). Between Cape Leeuwin and King George Sound (Maxwell , 1874). Albany (1881 in MEL.). Israelite Bay (in TCD., and in LD.). North Twin Peak Island, Recherche Archipelago (Willis, 20-11-1950). Eucla (Womersley, 2-2-1954).

S. Aus. — Head of the Great Australian Bight (Womersley, 4-2-1954). Scott's Bay, 4 miles west of Fowler's Bay (Womersley, 27-1-1951). Point Sinclair (Womersley, 25-1-1951 and 7-2-1954). Venus Bay(Womersley, 12-2-1954).

Elliston (Womersley, 15-1-1951. Nizamuddin, 27-2-1959). Point Drummond (Womersley, 11-1-1951). Fishery Bay and Sleaford Bay (Nizamuddin, February 1959). Wanna (Nizamuddin, 19-2-1959). Louth Bay (Womersley, 4-1-1951). Investigator Strait (Davey). Sturt Bay (Davey). Port Neill (Womersley, 31-1951). Holdfast Bay (Mueller, in MEL. in Sonder 1880). Port Noarlunga (Harris, August 1943). Womersley, 2-10-1944. Shepley, 29-9-1954). Willunga Reef (Shepley, 4-4-1954). Second Valley (Womersley, 7-12-1946). Cape Jervis (Shepley, 29-8-1954). Encounter Bay (Cleland. Harris, May 1943. Mueller in MEL. in Sonder 1880). Port Elliot (Womersley, 17-10-1948). Middletown Beach, Encounter Bay (Harris, December 1943). Robe (Womersley, 29th and 30th August 1949, 15-3-1955 and 18-8-1957. Macklin).

Kangaroo Island. — Rocky Point (27-1-1944, 8-1-1947, 23-1-1947 and 18-1-1948). American River (19-5-1945 and 2-6-1947), East side of Bllast Head (3-1-1948) and Emu Bay (18-1-1945)..... Vesicle form (Womersley). ~~Middle River~~ Middle River (8-1-1946), Western River (16-1-1946), Cape de Couedie (8-1-1945), Ellen Point, Vivonne Bay (23-5-1945, 2-1-1946 and 14-1-1948), Pennington Bay (23-1-1944, 12-1-1945, 25-5-1945, 28-1-1946, 4-1-1948 and 23-8-1950), Cape

Willoughby (16-1-1946 and 12-1-1947) and Antechamber (10-1-1945 and 12-1-1947) ·—·· Non vesicle form (Womersley).

Victoria. — Cape Bridgewater (Pope and Bennett, 14-8-1949). Bridgewater Bay (Beauglehole, 29-5-1949). Lawrence Rock (Beauglehole, 13-1-1954). Portland Bay (Mueller, in MEL. in Sonder 1880). Port Fairy (Harvey, No. 2 and Algae Mullerianeae in MEL., TCD., and LD. Muir, January 1950). Peterborough (Womersley, 17-9-1949). Lorne (Womersley, 20-11-1949). Point Roadknight (Womersley, 6-6-1953). Point Lonsdale (Mathieson, 21-9-1946). Queenscliff (Mueller, in LD.). Port Phillip (Macpherson, 15-9-1957, Ex. Herb. Areschoug. in LD.). ~~Port Phillip (Macpherson,~~ Mathieson, September 1941 in MUB. in Sonder 1880). Brighton Beach, Port Phillip (Womersley, 29-5-1948). Beaumaris (Thomas, 20-10-1931 in MUB.). Port Phillip Heads (Wilson, in LD.). Sorrento (Womersley, 2-6-1954. Coleman, January 1929 in AKU.). Walkerville, Waratah Bay (Bennett, November 1949). Wilson's Promontory.

Tasmania. — Low Head (Cribb, 14-9-1950). Hunter Island (Bennett, 14-1-1954). Sandy Cape (Bennett, 15-1-1954). Cape Sorrell (Bennett, 4-2-1955). Port Arthur (Harvey, in TCD.). Swansea (Womersley, 19-1-1949). Currie River Mouth (Womersley, 28-1-1949).

GEOGRAPHICAL DISTRIBUTION:

From Nichol Bay, Western Australia, along the south coast to Wilson's Promontory and on the coast of Tasmania.

There are two forms of C. subfarcinata — one, which grows along calm coasts, possesses vesicles and large receptacles up to 5 cm. long; the other form growing on rough coast is devoid of vesicles and the receptacles are shorter (up to 3 cm. long) and much branched.

Type has not been located in PC (Womersley, m.s. 1952).

C. subfarcinata resembles C. thysanocladia in its general features but differs in its torulose receptacles with conceptacles compact at the base and loose above, with a prominent sterile awn and bisexual conceptacles.

24. C. THYSANOCLADIA J. Agardh 1894.

J. Agardh 1894b: 97; 1896: 47. De Toni 1895: 147.

PLATE LXI. PLATE LXXXIV, FIG. F.

Type Locality. — Eucla, Western Australia.

Type. — LD. Herbarium Agardh No. 999.

Axis flat, up to 3 mm. broad and 2 mm. thick, emitting alternate, distichous, branches from its face. Secondary branches retroflex, up to 12 cm. long and ½ mm. broad, strongly distichous. Ramuli filiform, alternately arranged, distichous, dichotomously branched, up to 1.5 cm. long and ½ mm. broad, developing into receptacles. Vesicles spherical to 7 mm. broad, pedicellate, mutic. Receptacles distantly moniliform, apiculate, simple or branched, up to 1.5 cm. long and ½ mm. broad except where conceptacles occur. Conceptacles irregularly scattered and unisexual. Antheridia 22 - 40 µ x 13 - 19 µ. in fascicles on branched hairs. Oogonia 72 - 150 µ x 60 - 132 µ, without stalk.

SPECIMENS EXAMINED:

W. Aust. — Figure of Eight Island, Recherche Archipelago (Willis, 7-11-1950).

GEOGRAPHICAL DISTRIBUTION:

Only known from Figure of Eight Island and Eucla, Western Australia.

C. thysanocladia resembles *C. monilifera* in its general features but differs in its axis, more strongly distichous branches and irregularly scattered unisexual conceptacles.

25. C. BROWNII (Turner). J. Agardh 1848.

J. Agardh 1848: 241; 1870: 447; 1896: 48; 1897: 447. De Toni 1895: 146. Harvey 1860: pl. 169; 1863: Synop. 40. Lucas 1909: 13. Reinbold 1899: 42. Sonder 1880: 4.

PLATE LXII. PLATE LXXXIV, Fig. G.

Fucus brownii Turner 1819: 2, t. 197.

Cystoseira brownii C. Agardh 1821: 73; 1824: 288. Bory 1828: 132. Greville 1830: Synop. 30. Sonder 1846: 159.

Blossevillea brownii Kuetzing 1843: 364; 1849: 628; 1860: t. 74, f. 1.

Type Locality. -- King George Sound, W. Aus. (R. Brown).

Type. -- BM. (no. 208).

Plants brown, coriaceous, up to 60 cm. long with compact, dense and stiff branching. Holdfast discoid, up to 15 mm. in diameter with a short, terete stipe up to 1 cm. long and 5 mm. across. Axis flat, up to 1 cm. broad, with strongly developed branches. Secondary branches from the face of the axis, flat, up to 12 cm. long and 5 mm. broad, with bare basal parts showing the scars of tertiary branches.

Tertiary branches up to 6 cm. long and 2 mm. broad, bearing terete ramuli. Ramuli dichotomously branched, up to 6 mm. long. Vesicles absent. Ultimate ramuli developing into receptacles. Receptacles terminal, terete, simple (rarely branched), up to 6 (-14) mm. long and 1 mm. broad, and in panicles. Conceptacles compact, bisexual and scattered (occasionally in rows). Antheridia 30 - 42 µ x 12 - 18 µ. Oogonia 114 - 150 µ x 48 - 120 µ.

SPECIMENS EXAMINED:

W. Aus. — Port Denison (Womersley, 31-8-1947). Fremantle (Preiss, in Sonder 1880). Swan River (Mylne, in TCD., and in LD.). Rottnest Island (Lucas, 1928 in AKU. Watson in LD.). Geographe Bay (Mueller, in LD., in Sonder 1880). King George Sound (Harvey, in TCD. Menzie, in E.). Figure of Eight Island, Recherche Archipelago (Womersley, 7-11-1950).

S. Aus. — Point Sinclair (Womersley, 8-2-1954). Streaky Bay (Dawling, in LD.). Sceales Bay (Womersley, 11-2-1954). Wanna (Nizamuddin, 28-2-1959). Cape Carnot (Womersley, 8-1-1951). Investigator Strait (Davey, in Reinbold). Sturt Bay (Womersley, 8-4-1950). St. Vincent Gulf (in Sonder 1880). Glenelg (Grunow). Hallet's Cove (Tepper, 12-4-1882).

Port Noarlunga (Harris, August 1943. Womersley, 13-5-1945). Willunga Reef (Womersley, 24-3-1944). Cape Jervis (Shepley, 29-8-1954).

Kangaroo Island. —

Middle River (Womersley, 8-1-1946, 3-6-1947 and 21-1-1948). Vivonne Bay (Womersley, 2-1-1946, 16-1-1947, 14-1-1948, 2-1-1949 and 4-1-1950). Pennington Bay (Womersley, 22-1-1947).

GEOGRAPHICAL DISTRIBUTION:

From Port Denison, Western Australia, around the south coast to Cape Jervis, South Australia.

Specimens of *C. brownii* from Port Denison possess longer receptacles (up to 14 mm. long and less than 1 mm. broad) than specimens from other localities.

Turner (1819) in the type description of this species describes obovate, pedicellate, mutic vesicles on the lower branches. The branch of the plant, on which the presence of vesicles is based, does not look like *C. brownii* and it is too poor to say to which species it belongs.

In Kew there are several specimens collected by Menzies and placed under *Fucus brownii* by Turner. These include *C. brownii*, *C. moniliformis*, *C. paniculata* and *C. monilifera*. There are two specimens on the type sheet of *C. brownii*; the lower specimen is the type of *C. brownii* and the upper specimen is probably *C. monilifera*.

In the Botanical Museum and Herbarium, Copenhagen, is a specimen named *Fucus brownii* Turner and *Cystoseira brownii* C. Agardh, from "de la Concepcion an Chile". This may be the specimen on which the Chile record of *C. brownii* is based. The specimen is a fragment about 3 cm. high, certainly not *Cystophora brownii*, and too poor to be determined. The Chile record can probably be eliminated (Womersley, m.s. 1952).

C. brownii resembles *C. paniculata* in its short receptacles arranged in panicles and in the absence of vesicles but differs in its flat axis with retroflex branches.

26. *C. GRACILIS* sp. nov.

Type Locality. — South side of Ellen Point, Vivonne Bay, Kangaroo Island (Womersley, 16-1-1947).

Type. — AD. A 4247.

PLATE LXIII. PLATE LXXXIV, Fig. H.

Plants light brown, becoming darker on drying, cartilaginous, erect, slender, up to 72 cm. long. Holdfast discoid up to 1 cm. in diameter. Stipe short, terete, up to 2 cm. long and 2 mm. broad. Axis flat, up to 5 mm. broad, and 2 mm. thick. Secondary branches from the face of the axis, retroflex, laxly arranged, alternate, distichous, axils rounded, up to 12 cm. long and up to 1.5 mm. broad. Tertiary branches alternate, distichous, up to 3 cm. long and 1 mm. broad, bearing alternate, filiform ramuli. Ramuli up to 14 mm. long and 1 mm. across. Vesicles absent. Receptacles torulose, apiculate, up to 12 mm. long and 1 mm. broad. Conceptacles crowded, bisexual, Antheridia 40 - 60 µ x 12 - 20 µ. Oogbnia 50 - 90 µ x 36 - 48 µ.

SPECIMENS EXAMINED:

S. Aus. — Point Sinclair (Womersley, 8-2-1954 and 25-1-1951). Wanna (Nizamuddin, 192-1959). Fishery Bay (Nizamuddin, February 1959).

Kangaroo Island. — South side of Ellen Point, Vivonne Bay (Womersley, 2-1-1946, 16-1-1947, 2-1-1949, 4-1-1950, and 29-1-1957). Seal Beach (Womersley, 24-1-1957).

GEOGRAPHICAL DISTRIBUTION:

Known from the above localities only.

C. gracilis resembles C. brownii in its general features but differs in its slender axis, laxer branching with less rounded axils and longer torulose receptacles, with crowded conceptacles.

This species needs further investigations of fertile material, as only few receptacles have been examined. All the plants collected were sterile except the type bearing 12 receptacles.

27. C. MONILIFERA J. Agardh 1848

J. Agardh 1848: 241; 1870: 447; 1896: 47. Bailey and Harvey 1874: 155, 156. De Toni 1895: 146. De Toni et Forti 1923: 68. Harvey 1855: 214; 1859b: 283; 1863: pl. 245; 1863: Synop. 42. Laing 1927: 143. Lucas 1909: 13; 1936: 73. Reinbold 1899: 42. Sonder 1852: 670; 1880: 4. Womersley 1950: 160.

PLATE LXIV. PLATE LXXXIV, Fig. I.

Fucus retroflexus Turner 1811: 48, t. 155. non Labillardiere.

Cystoseira retroflexa A. Richard 1834: 12. Sonder 1846: 160.

Blossevillea retroflexa Kuetzing 1860: t. 76, f. 2.

Blossevillea monilifera May 1939: 205. Lindauer 1947: 561.

Type Locality. — "Occidentale Novae Hollandiae"-- Western Australia (Preiss).

Type. — LD. (Herbarium Agardh No. 1023).

Plants dark brown, becoming darker on drying, coriaceous, flexuous, up to 1 metre long. Holdfast discoid, up to 20 mm. across. Axis flat, up to 6 (-8) mm. broad, alternately pinnately branched. Secondary branches strongly retroflex near their basal parts, up to 13 cm. long and 3 mm. broad, flat, pinnate, distichous, and divided near their bases. Branch bases strongly rounded with attachments on the axis. Tertiary branches slender, cylindrical and loose. Vesicles spherical, up to 5 (-7) mm. broad, or rarely ellipsoid (up to 7 mm. long and 4 mm. broad), pedicellate, mutic, scattered or few near the bases of the branchlets. Ramuli developing into receptacles. Receptacles up to 18 mm. long and 1 mm. broad, moniliform, apiculate, simple or branched. Conceptacles scattered, bisexual. Antheridia 20 - 40 µ x 12 - 16 µ. Oogonia 96 - 144 µ x 48 - 102 µ.

SPECIMENS EXAMINED:

W. Aus. — Fremantle (in Sonder 1880). Champion Bay (Mueller, in MEL.). Salmon Bay, Rottnest Island (Smith, 12-1-1945). Geographe Bay (Bunbur, 1880 in MEL. in Sonder 1880). Busselton (Royce, 12-10-1949). Point D'Entrecastreaux (Smith, 20-3-1946). Between Cape Leeuwin and King George Sound (Maxwell, 1875 in MEL.). Albany (ex Herb. Sonder in MEL.). Figure of Eight Island, Recherche Archipelago (Willis, 7-11-1950). Israelite Bay (Mueller in MEL.). Eucla (Womersley, 2-2-1954; Mueller, in MEL.). S. Aus.— Fowler's Bay (Richard, 1880 in MEL.). Point Sinclair (Womersley, 8-2-1954). Wittlebee Point, near Ceduna (Womersley 22-1-1951). Point Drummond (Womersley, 11-1-1951). Louth Bay (Womersley, 5-1-1951). Port Neil (Womersley, 3-1-1951). Arno Bay (Womersley, 11-1-1951). Stenhouse Bay (Womersley, 9-4-1950). Investigator Strait (Davey, in Reinbold). Sturt Bay. Brown Point (Womersley, 10-4-1950). Port Vincent (Womersley, 8-4-1950). St. Vincent Gulf (Sonder, 1880). Holdfast Bay (Mueller, in MEL.). Port Noarlunga (Harris, September 1943). Second Valley (Womersley, 7-12-1946). Encounter Bay (Harris, May 1943. Cleland, January 1928. Mueller in MEL.). Lacepede (Reinbold). Guichen Bay (Reinbold. Womersley, 1-9-1949).

Kangaroo Island. — Hog Bay (Womersley, 8-1-1950). Rocky Point (Womersley, 26-8-1950). American River Inlet (Womersley, 23-8-1948, 2-6-1947 and 19-5-1945). Muston (Womersley, 27-7-1947). Emu Bay (Womersley, 10-1-1946). Middle River (Womersley, 21-1-1948 and 19-1-1947). Western River (Womersley, 7-1-1946). West Bay (Womersley, 6-1-1948). Cape de Couedie (Womersley, 12-1-1948). Vivonne Bay (Womersley, 4-1-1950, 14-1-1948 and 3-1-1946). East end of D'Estrees Bay (Womersley, 11-1-1950). Pennington Bay (Womersley, 23-1-1944, 28/ 30-1-1946, 3-6-1947, 13-4-1947 and 28-7-1947). Cape Willoughby (Womersley, 12-1-1947). Antechamber (25-1-1948).

Victoria. — Garden Beach, Portland Bay (Beauglehole, 8-8-1951). Double Corner Beach, Portland Bay (Beauglehole, 8-8-1951 and 14-8-1951). Portland (Muir, January 1950). Ocean Beach, Sorrento, (Womersley, 2-6-1953). Port Phillip Bay (Macpherson, 10-11-1957). Wilson's Promontory (in MEL.).

Tasmania. — Georgetown (in Sonder 1880). Currie River Mouth (Womersley, 28-1-1949). Bay of Latrobe (January 1909. De Toni et Forti). Burnie (Womersley, 26-1-1949). Cape Portland (Banduct, in MEL.). Swansea (Womersley, 19-1-1949).

New South Wales. — Jervis Bay (Lucas, July 1899 in AKU). Illawara (in MEL. in Sonder 1880). Bondi (Lucas, July 1901 in AKU). Sydney (Grunow, December 1884).

GEOGRAPHICAL DISTRIBUTION:

From Champion Bay, Western Australia, around the south east coast to Sydney, New South Wales and along the coast of Tasmania; New Zealand.

Lindauer (1947) questions its existence in New Zealand, although Laing (1927) records it from Pelorus Sound.

Fucus retroflexus Turner possesses moniliform receptacles whereas *F. retroflexus* Labillardiere possesses elongate torulose receptacles. Vesicles in *F. retroflexus* Turner, are spherical but they are obovate in *F. retroflexus* Labillardiere. The name *Fucus retroflexus* was a source of error as it was applied to two species (*C. retroflexa* and *C. monilifera*). J. Agardh (1848) retained *Fucus retroflexus* Lab. (= *Cystophora retroflexa*) and rejected the name *Fucus retroflexus* Turner and renamed it *Cystophora monilifera*.

C. monilifera resembles *C. polycystidea* in its general features, but differs in its strongly flattened axis, branch bases, strongly rounded with narrow attachments to the axis; in its distinctly moniliform receptacles as well as in its scattered spherical vesicles.

28. C. POLYCYSTIDEA Areschoug in J. Agardh 1848.

J. Agardh 1848: 240; 1870: 448; 1896: 47. De Toni 1895: 148. Lucas 1909: 13; 1936: 74. Reinbold 1899: 42. Sonder 1852: 670; 1880: 4. Womersley 1950: 160.

PLATE LXV. PLATE LXXXIV, Fig. J.

Blossevillea polycystidea Areschoug 1854: 336. Kuetzing 1849: 631; 1860: t. 84, f.2. May 1939: 205.

Type Locality. — Port Phillip, Victoria.

Type. — LD. (Herbarium Agardh No. 1010).

Plants brown, turning darker on drying, Holdfast discoid up to 15 mm. in diameter, with short and terete stipe. Axis flat, up to 7 mm. broad, quadrangular, alternately distichously and densely branched. Secondary branches retroflex, arising from the face of the axis, up to 20 cm. long and 2 mm. broad. Tertiary branches up to 8 cm. long and 2 mm. broad, with filiform ramuli. Ramuli up to 15 mm. long and less than a millimetre thick, distichously and pinnately branched. Vesicles near the base of the tertiary branches, numerous, elongate, tapering at both ends, mutic or apiculate, stalked, (2-) 4-5 (-6) mm.

long and less than 2 mm. broad. Ultimate ramuli developing into receptacles. Receptacles irregularly and distantly moniliform, simple or branched, up to 2 cm. long and less than a millimetre across. Conceptacles scattered and bisexual. Antheridia 30 - 42 µ x 12 - 18 µ. Oogonia 108 - 150 µ x 90 - 108 µ.

SPECIMENS EXAMINED:

S. Aust. — Point Fowler (Womersley, 6-2-1954). Wittelbee Point, near Ceduna (Womersley, 22-1-1951). Elliston (Womersley, 14-2-1954. Nizamuddin, February 1959). Point Drummond (Womersley, 11-1-1951). Port Lincoln, (Womersley, m.s.). Louth Bay (Womersley, 4-1-1951). Port Neil (Womersley, 31-1951). Lowly Point (Womersley, 1-1-1951). Spencer Gulf (Algae Muellerianae; in Sonder 1880). Sturt Bay (Davey). Investigator Strait (Davey. Davey, in Reinbold). Yorke Peninsula (Tepper). Edith Bay (Womersley, 8-4-1950). Holdfast Bay (in Sonder 1852). St. Vincent Gulf (Algae Muellerianae). Holdfast Bay (in Sonder 1880). Port Willunga (Womersley, 12-10-1953 and 24-4-1948). Willunga Reef (Womersley, 24 -3-1949. Shepley, 4-4-1949). Second Valley (Womersley, 7-12-1946). Encounter Bay

(Cleland, Harris, May 1943). Port Elliot (Hussey, in LD.). MacDonnel Bay (Wehl, in MEL.).

Kangaroo Island. — East of Blast Head (Womersley, 31-10-1947). Rocky Point (Womersley, 23-1-1947 and 8-1-1947). Emu Bay (Womersley, 18-1-1945). Middle River (Womersley, 21-1-1948). Western River (Womersley, 7-1-1946). Pennington Bay (Womersley, 22-1-1948).

Victoria. — Cape Bridgewater (Pope and Bennett, 14-8-1949). Bridgewater Bay (Beauglehole, 5-6-1949). Port Fairy (Harvey, ih TCD., and in LD.). Cape Otway (Pope and Bennett, 19-8-1949). Port Phillip (Mueller in Sonder 1880). St. Kilda, Port Phillip Bay (in MUB., 1883). Sorrento (Womersley, 2-6-1953). The Nobbies, Phillip Island (Pope and Bennett, 13-5-1939).

Tasmania. — Currie River Mouth (Womersley, 28-1-1949). Bombay Rock, Tamar East (Womersley, 7-1-1949). Torquay (Algae Muellerianae).

New South Wales. -- Bateman's Bay (in May, 1939). Jervis Bay (in May 1939. Lucas July 1899 in AKU.). Long Bay, Sydney, (in May, 1939).

GEOGRAPHICAL DISTRIBUTION:

From Point Fowler, South Australia, around the south east coast to Long Bay, New South Wales and on the

North coast of Tasmania.

The first valid description of *C . polycystidea* is that of J. Agardh (1848) who credited the species to Areschoug. The concept of the species is, therefore, based on J. Agardh's description and specimens. In Herbarium Agardh there are two specimens of Areschoug's from Port Phillip. One has a label in Areschoug's writing, reading "*Blossevillea polycystidea* Aresch". J. Agardh's description seems to apply mainly to this plant, and it is, therefore, taken as the type. The other specimen labelled as from Herbarium Areschoug, Port Phillip, in J. Agardh's writing, is a smaller and fragmentary specimen of *C. expansa* (no. 1006). Areschoug's material clearly included these two species but J. Agardh failed to separate them. In Herbarium J. Agardh Lund, Nos. 1005, 1011 (Harvey, Port Fairy), 1002, 1003, (Hussey, Port Elliot), 1008 (Spencer Gulf) and 1013 are *C. polycystidea* (Womersley, M.S. 28-8-1952).

C. polycystidea resembles *C. expansa* in its general features but differs in its more slender, quadrangular axis with closer and more compact ramuli and in its irregularly, distantly moniliform receptacles with scattered conceptacles. It also differs from the latter in its numerous vesicles near the base of the tertiary branches.

29. *C. EXPANSA* (Areschoug) nov. comb.

Blossevillea expansa Areschoug 1854: 11 (337). Kuetzing 1860: t. 84, f.2

PLATE LXVI. PLATE LXXXIV, FIG. K.

Type Locality. — Port Phillip, Victoria.

Type. — S.

Plants dark brown, becoming darker on drying, cartilaginous, up to 60 cm. long. Holdfast discoid, up to 3 cm. in diameter. Axis thick, coarse, zigzag, flat, up to 5 mm. broad, with loose branching. Secondary branches from the face of the axis, retroflex, up to 18 cm. long and 3 mm. broad, distichously branched. Tertiary branches up to 9 cm. long and 1 mm. broad, with filiform ramuli. Ramuli up to 15 mm. long and less than 1 mm. in diameter, alternately arranged. Vesicles elongate or ellipsoid, scattered or absent on tertiary branches, pedicellate, apiculate, up to 6 mm. long and less than 2 mm. broad. Ultimate ramuli developing into receptacles. Receptacles terete, with crowded conceptacles, 0.5 - 2 cm. long and less than 1 mm. broad, simple or branched, apiculate. Conceptacles crowded, uni or bisexual. Antheridia 13 - 33 μ x 10 - 19 μ. Oogonia 66 - 90 μ x 42 - 66 μ.

SPECIMENS EXAMINED:

W. Aus. — Augusta (Royce, 21-10-1949). Cowaramup, Royce).

S. Aus. — Scott's Bay, 4 miles west of Eucla (Womersley, 27-1-1950). Point Sinclair (Womersley, 25-1-1951). Elliston (Womersley, 13-1-1951). Port Neil (Womersley, 3-1-1951). Spencer's Gulf (Davey, in LD.). Stenhouse (Womersley, 9-4-1950). Marion Bay (Womersley, 9-4-1950). Sturt Bay (Womersley, 8-4-1950). Brown's Point, Yorke Peninsula(Womersley, 10-4-1950). Investigator Strait (Davey, in Laing's collection New Zealand). Port Adelaide (Areschoug, in S.). St. Vincent Gulf (Tepper, in LD.). Marino, Holdfast Bay (Womersley, 21-5-1953). Port Willunga (Womersley, 12-10-1953 and 24-4-1948). Willunga Reef (Shepley, 4-4-1954). Port Elliot, (Hussey in LD.).

Victoria. — Double Corner Beach, Portland Bay (Beauglehole, 14-7-1951), Port Fairy (Harvey, in LD.). Dutton Beach, north of Dutton Bluff, Portland Bay (Nizamuddin, 13-4-1959).

GEOGRAPHICAL DISTRIBUTION:

From Augusta, Western Australia, around the south coast to Port Phillip, Victoria.

In Riksmusuem, Stockholm (S) among six specimens of Blossevillea expansa Aresch. five are from Port Phillip and one from Port Adelaide. These specimens are good, large and fertile. The best of the Port Phillip ones are chosen as the type (Womersley, m.s. 1952).

C. expansa resembles C. monilifera in general features, but differs in its zigzag axis, elongate — ellipsoid vesicles and in its terete receptacles with crowded conceptacles.

30. C. ELONGATA sp. nov.

PLATE LXVII. PLATE LXXXIV, Fig. L.

Type Locality. — Dutton Beach, north of Dutton Bluff, Portland Bay, Victoria (Nizamuddin, 13-4-1959).

Type. — AD. A 23,981.

Plants brown, becoming darker on drying, up to 1 metre long, flexuous, coriaceous, growing on Cymodocea antarctica. Holdfast clasping the stem of Cymodocea, up to 1 cm. across with a short terete stipe up to 7 mm. broad and 2 mm. thick, emitting alternate distichous branches. Secondary branches flat, retroflex, from the face of the axis, alternate, at about 3 cm. distance, lax, up to 20 cm. long and 3 mm. broad. Tertiary branches alternate, up to 2 cm. long and ½ mm. broad. Ramuli filiform up to 8 cm. long and less than ½ mm. in diameter, alternate, or subdichotomously branched, developing into receptacles. Vesicles numerous on the tertiary branches, broadly elongate, or ovate or spherical up to 1 cm. long and 5 mm. broad, pedicellate, mutic or apiculate, more narrow above, sometimes apiculation developing into receptacles or lower parts of the receptacles transformed into vesicles. Receptacles elongate, terete, up to 8 cm. long and 1 mm. broad, simple or branched, apiculate. Conceptacles irregularly, distantly scattered, bisexual. Antheridia 22 - 47 µ x 12 - 20 µ, on branched hairs in fascicles. Oogonia 84 - 120 µ x 60 - 96 µ, without stalk.

SPECIMENS EXAMINED:

Victoria. — Dutton Beach, north of Dutton Bluff, Portland Bay (Nizamuddin, 13th and 14th April 1959). Double Corner Beach (← Dutton Beach), Portland Bay (Beauglehole, 8-7-1951).

GEOGRAPHICAL DISTRIBUTION:

Known only from the Type Locality.

C. elongata resembles *C. polycystidea* and *C. expansa* in general features but differs in its more strongly flattened axis, with clasping holdfast, laxer branches , vesicles and in its elongate receptacles with irregular , scattered conceptacles.

(d) *SCABERIA* Greville I830

J.Agardh I848: 25I; I894b: 94. Decaisne I84I: I75; I842: 359, 363. De Toni I89I: I74; I895: I79. Endlicher I836: IO. Greville I830: Synop. 36. Gruber I896: 30. Kjellman: I897: 76. May I939: 205. Schmidt I938: 228. Svedelius I9II: I80.

Castraltia A.Richard I834: I43. Endlicher I843: 30. Kuetzing I849: 636.

Encophora J.Agardh I894a: II5.

Plants much branched, with terete axis and ~~irregula~~ irregular branches. Three types of segments occur (i) long slender segments near the base of the axis (ii) scale-like segments and (iii) compressed ovoid externally warted, densely imbricate segments, irregularly arranged.Spherical vesicles occur. Conceptacles on the lower surface of the verruciform segments.Plant monoecious.

(p.t.o)

~~monoecious.~~ Conceptacles bisexual and scattered. Antheridia in fascicles in conceptacles. Oogonia with one egg.

J. Agardh (I894) described a second species *S.rugulosa* which is a slender and young form of *S.agardhii* (Womersley, I950).

(e) *SCABERIA AGARDHII* Greville I830

J.Agardh I848: 252; I894b; 97. Areschoug I854: 5(33I). Decaisne I84I: I76; I842: 359.De Toni I89I: I74; I895:I79; I896: 230. De Toni et Forti I923: 68. Greville I830:Synop. 36. Harvey I854: 534; I859b: 283; I860: Pl. I64; I863: Synop. 37. Hooker and Harvey I845: 527; I847: 4I3. Kjellman I897 : 282. Kuetzing I843 : 369. Laing I927: I42. Lucas I936 : 76. May I939 : 205. Sonder I846 : I59;I852:67I Svedelius I9II : I82. Womersley I950 : I62.

Castraltia salicornioides A. Richard I834: I43. Endlicher I843 : 30. Kuetzing I849 : 636.

Scaberia rugulosa J. Agardh I894b: 97. Womersley I950 : I62.

Encophora rugulosa J.Agardh I894a : II5.

Type Locality.-- Swan River Settlement,Perth(Fraser).

Type.--- E.

Plants brown, becoming darker on drying. Holdfast discoid up to 5 mm. in diameter. Stipe terete, short up to I2 mm. long and 3 mm.broad. Plants rigid and tough, up to I2 metres long, with I to several terete axes up to I(-3) mm. broad, flexuous, alternately or irregularly branched, becoming smooth and slender below. Three types of leaves occur (i) long, slender, verticillately arranged segments near the base in whorls of five sometimes becoming furcate, up to 7 cm. long and 0.7 mm.broad, with cryptostomata (ii) scale-like segments, deltoid-acuminate, up to I mm. long and up to 0.5 mm. broad near the bases (iii) warty or verruciform segments, peltate, cartilaginous, compressed and irregularly inserted round the axis and branches. Vesicles spherical, irregularly arranged, up to 6 mm. broad, subsessile. Conceptacles on the under-surface of the verruciform segments scattered and bisexual. Antheridia 30- 46 μ x 9 - I6 μ. Oogonia ovoid, 95 - 24Iμx 60 - 90 μ.

SPECIMENS EXAMINED:

W, Aus. — Geraldton Bay (in De Toni et Forti,) Rottnest Island (Cribb, 9-8-1950). Point Peron (Royce, 12-6-1951). Esperance (Firman, December 1951). Figure of Eight Island, Recherche Archipelago (Womersley, 7-11-1950). North Twin Peak Island (Womersley, 20-11-1950). Eucla (Womersley, 2-2-1954).

S. Aus. — Head of the Great Australian Bight (Chambers). Point Fowler (Womersley, 6-2-1954). Sceales Bay (Womersley, 11-2-1954). Venus Bay (Womersley, 3-2-1951; 17-1-1951). Elliston (Nizamuddin, 27-2-1959). Marion Bay (Womersley, 9-4-1950). Port Vincent (Womersley, 8-4-1950). Port Augusta (Womersley, 31-12-1950). Henley Beach, Holdfast Bay (Macbeth, 10-7-1943). Holdfast Bay (Sonder, 1852). Port Noarlunga (1924). Willunga Reef and Aldinga Reef (Womersley, 24-3-1944). Sellick's Beach (Hale, 19-1-1936). Granite Island, Victor Harbour (Harris, May 1943). Port Elliot (Womersley, 24-3-1944). Guichen Bay (Sonder, 1852). Robe (Womersley, 18-1-1948).

Kangaroo Island. — Emu Bay, (Womersley, 18-1-1945). Vivonne Bay (Womersley, 3-1-1946). Pennington Bay (Womersley, January 1946, 28-7-1947 and 4-1-1948).

Victoria. — Portland Bay (Beauglehole, 15-5-1949, 8-7-1951 and 14-7-1951. Muir, January 1950. Nizamuddin, 14-4-1959). The Nobbies, Phillip Island (Nizamuddin, 10-4-1959).

Tasmania. — Currie River Mouth (Womersley, 28-1-1949). Low Head (Cribb, 14-9-1950). Georgetown (Gunn, in Harvey 1847).

New South Wales. — Bondi and Sydney (in May, 1939).

GEOGRAPHICAL DISTRIBUTION:

From Geraldton Bay, W. Aus., along the south east coast to Bondi, N.S.W.; along the north coast of Tasmania; Lord Howe Island.

S. agardhii is one of the most unusual forms among the Australian Fucales. The genus is monotypic since S. rugulosa J. Ag. is not distinct from S. Agardhii. The plant generally grows in the upper sublittoral zone and extends to 10 - 20 fathoms (Harvey, 1854). Laing doubts the exidtence of S. agardhii in New Zealand, although recorded from there by Rabenhorst (1878) and De Toni et Forti (1923). Lindauer (1947; 1957) does not list S. agardhii from New Zealand and apparently considers the early record to be erroneous.

(f). CYSTOPHYLLUM J. Agardh 1848

J. Agardh 1848: 228. De Toni 1895: 152. Endlicher 1843: 31. Fensholt 1955: 369. Gruber 1896: 26. Kjellman, 1897: 283. Lucas, 1936: 74. May 1939: 205. Schmidt 1938: 228. Setchell and Gardner 1925: 706. Silva 1950: 262; 1952: 279. Svedelius 1911: 180. Tilden 1937: 329.

Spongocarpus Kuetzing 1843: 365; 1849: 631.
Myagropsis Kuetzing 1843: 368; 1849: 634.
Sirophysalis Kuetzing 1843: 368; 1849: 602.

Holdfast discoid, producing 1 to several terete axes. Leaves alternate, ecostate, slender with numerous cryptostomata. Vesicles simple or concatenate, pedicellate, apiculate, or coronated with a leaflet at the apices and borne on the ultimate branchlets. Receptacles terminal, ovate-lanceolate, verrucose, racemose on the upper part of the ramuli. Plant monoecious or dioecious. Conceptacles unisexual or bisexual. Oogonia with one egg.

Cystophyllum was established as a genus in 1848 by J. Agardh who considered the position and the type of the vesicle as the basis for removing certain species from Cystoseira. But Endlicher (1843) had already established a subgenus Cystophyllum to include Cystoseira phyllamphora

C. Agardh. This species was transferred by J. Agardh (1848) to *Coccophora* Greville. Silva (1950) states that Yendo considered it to be a sterile form of *Coccophora langsdorfii* (Turner) Greville.

Yendo (1907) proposed a key based on vesicle~~s~~ characteristics and suggested the transfer of certain species from *Cystoseira* to *Cystophyllum*. In *Cystophyllum* vesicles are borne on ultimate branchlets whereas in *Cystoseira* vesicles develop as dilations on the frond or branches. Gardner (1917) did not consider vesicle~~s~~ character to be a generic distinction and suggested the recombination of the two genera unless a more satisfactory basis for separation could be established. Fensholt (1955) was influenced by Gardner and she recognised two lines of development in the *Cystoseira* - *Cystophyllum* complex. According to Fensholt the *Cystoseira* type is characterized by (i) conceptacle development in which a tongue filament of several cells is formed (ii) successive discharge of relatively small oogonia (iii) the presence of one functional egg nucleus and seven supernumery nuclei and (iv) the formation of 4 primary rhizoids on the embryo.

The *Cystophyllum*-type is characterized by (i) conceptacle development in which the tongue cell remains undivided (ii) simultaneous discharge of large oogonia (iii) the presence of one functional nucleus in the oogonium and (iv) the formation of 32 primary rhizoids on the embryo.

Accepting the ontogenetic development of the reproductive structures as generic characters, Fensholt transferred *Cystophyllum geminatum* (C.Ag.) J. Ag., *C. crassipes* (Turner) J.Ag., *C. osmundacea* (Turner) J. Ag. *C. foeniculacea* (L). Grev. emend Sauv. and *C. hakodatense* Yendo, to *Cystoseira* because of their *Cystosiera*-type of development. *Cystophyllum sisymbrioides* (Turner) J. Ag., and *C. turneri* Yendo , were transferred to *Cystophyllum*, as they possess the *Cystophyllum*-type of development.

Inoh (1930; 1932) based his findings on Okabe's data (1929a) and thus he placed *Cystophyllum* in a higher systematic position than *Sargassum*, because of the larger eggs and the number of rhizoids on the embryo, this assumption was based on observations made on *Cystophyllum sisymbrioides* and *C. turneri*. Gardner (1917), Inoh (1930; 1932) and Fensholt (1955) suggest that vesicles should not be considered as a distinctive feature for generic distinction between *Cystoseira* and *Cystophyllum*.

The development of conceptacles, size of oogonia, oogonial discharge and the presence of non-fuctional or supernumary nuclei should not be considered as diagnostic features because similar developmehts also occur in *Bifurcaria* (Rees,1933), *Bifurcariopsis* (Laing, 1941), *Carpophyllum* (Delf,1939a, Naylor,1953c) and *Marginariella* (Naylor, 1951b). In consideration with *Cystophyllum muricatum*, the vesicle character appears to be a diagnostic criterion on the generic level.

Myagropsis, *Spirophysalis* and *Spongocarpus*, come into consideration as possible names for the genus, which includes only one Southern Australian species, *Cystophyllum muricatum*. These three genera were proposed by Kuetzing (1843) on the basis of different types of vesicles — elongate pyriform, mucronate pyriform and concatenate. J. Agardh (1848) noticed these forms of vesicles in the same plant and thus he recombined these genera with *Cystophyllum*.

Spongocarpus Kuetzing (1943) was based on three species, two of which (*S. enervis* Kg. and *S. horneri* Kg.) were transferred to *Sargassum* and the third one *S. sisymbrioides* Kg. to *Cystophyllum* by J. Agardh (1848). The name

Spongocarpus is illegitimate because it is an orthogfaphic variant and is the homonym of *Spongiocarpus* Greville (1824) as discussed by Fensholt (1955) and Silva (1950; 1952).

Myagropsis Kuetzing (1843) was originally based on *M. turneri* Kuetzing (= *Fucus myagroides* Turner) and *M. camelina* Kuetzing. J. Agardh united them with *Cystophyllum sisymbrioides* (= *Fucus sisymbrioides* Turner 1809).

Sirophysalis Kuetzing (1843) was originally based on *S. muricatum* (= *Fucus muricatus* Turner 1809) and J. Agardh (1848) placed it as *Cystophyllum muricatum*. This species exhibits simultaneous development of oogonia in the same conceptacle, and the size of the oogonia is ½ to 1/3 that of the oogonia of *C. sisymbrioides* J. Agardh and of *C. turneri* Yendo. In *C. muricatum* 4 primary rhizoids are formed but 32 primary rhizoids develop on the embryo of *C. sisymbrioides* and *C. turneri*. *Sirophysalis* was completely absorbed in *Cystophyllum*, as was *Myagropsis*, as discussed by Silva (1950). When the genus *Cystophyllum* was established the oldest legitimate epithet of the three generic names (*Myagropsis*, *Spongocarpus* and *Sirophysalis*) should have been retained as stated by Silva (1950) and by Fensholt (1955). It thus appears that *Myagropsis* is the earliest legitimate name for a genus that includes *Cystophyllum sisymbrioides* and *C. turneri* as discussed by Fensholt (1955), but the genus *Cystophyllum* has become so large and well-known that conservation of *Cystophyllum* is justified. It has already been proposed for conservation by Silva (1950).

(g) *CYSTOPHYLLUM MURICATUM* (Turner) J. Agardh 1848.

J. Agardh 1848: 231. Askenasy 1889: 23. Bailey and Harvey 1874: 155. De Toni 1895: 154. Gruber 1896: 26. Harvey 1854: 534; 1859b: 285; 1860: pl. 139; 1863: Synop. 60. Kjellman 1897: 282. Lucas 1913: 50. May 1939: 205. Svedelius 1911: 182. Womersley 1950: 61.

PLATE LXIX.

Fucus muricatus Turner 1809: 108, t. 112.

Cystoseira muricata C. Agardh 1821: 66.

Cystoseira trinodis C. Agardh 1821: 67. Sonder 1846: 159.

Sirophysalis binodis Kuetzing 1860: t. 59, f. 2.

Type Locality. — Straits of Sunda, Indonesia (Watts).

Type. —

Holdfast discoid, up to 2 mm. in diameter, with a short, terete stipe up to 5 mm. long and 3 mm. in diameter. Plants much branched, up to 1 metre long. Several terete axes from the holdfast, branched on all sides. Secondary axes terete, radial, flexible. Basal leaves present or absent. Upper leaves linear, slender, ecostate, with cryptostomata, up to 4 cm. long and 1 mm. broad. Vesicles stalked, single or in a short chain of 2-3 (rarely 4), with cryptostomata, apiculate (occasionally with a leafy corona). Axis and secondary axes muricate due to short processes, up to 2 mm. long, these processes gradually become broad and round, their apices becoming depressed into cavities with sterile hairs. Receptacles pedicellate, cylindrical, verrucose, racemose, on the terminal ramuli, simple or branched, up to 5 mm. long and 2 mm. broad, usually monoecious, occasionally dioecious. Conceptacles unisexual or bisexual and scattered. Antheridia in clusters in conceptacles, 30 - 40 μ x 9 - 15 μ. Oogonia ovoid, sessile on the wall of the conceptacle, 120 - 204 μ x 100 - 150 μ.

SPECIMENS EXAMINED:

W.Aus. — Pelsart Island (Womersley, 2-9-1947). Rottnest Island (November 1945). Swan River (Royce, 26-3-1951). Perth to Fremantle, Princess Royal Harbour and Kihg George

Sound (Harvey, 1854).

S. Aus. — Point Fowler (Womersley, 6-2-1954), Sceales Bay (Womersley, 11-2-1954). Venus Bay (Womersley, 17-1-1951). Drummond Point (Womersley, 11-1-1951). Coffin Bay (Womersley, 10-1-1951). Inlet of Kelledie Bay, Coffin Bay (Nizamuddin, February 1959). Port Augusta (Womersley, 31-12-1950). Willunga Reef (Womersley, 24-3-1944 and 4-3-1945). Sellick's Beach Reef (Hale, 19-1-1936). Petrel Cove, **west** of Bluff, Victor Harbour (Womersley, 10-12-1944). Encounter Bay (Cleland, January 1928).

Kangaroo Island. — Rocky Point (Womersley, 12-1-1945 and 18-1-1948). American River (Womersley, 28-1-1944 and 26-1-1946). Pig Island, Pelican Lagoon (Womersley, 10-1-1948). Red Banks (Womersley, 28-12-1949). Ballast Head (Womersley, 3-2-1956). Kingscote (Womersley, 3-1-1944). Emu Bay (Womersley, 11-1-1946 and 18-1-1946) Middle River (Womersley, 21-1-1948).

Victoria. — Geelong (Lucas, 1913). Port Phillip (Mueller). Port Phillip Heads and Western Port (Wilson).

New South Wales. — Port Hacking, Botany Bay, Port Jackson, Lake Macquarie (in May, 1939). Port Stephens (in May 1939). Clarence River (Sonder, Lucas, 1913).

Queensland. — Dunwich (Womersley, 27-5-1951). Redcliff (17-4-1949 and 26-9-1948). Moreton Bay (Lucas, 1913). Elliot Heads (McKeon, 12-9-1948 and 21-6-1949). Elliot River (McKeon, 9-6-1949). Port Whitsunday Island. Port Denison. Rockingham Bay. Cooketown (Sonder). Gulf of Carpentaria (16-9-1867).

Northern Territory. — Yirrkala, Arnhem Land (Specht, 10-8-1948).

GEOGRAPHICAL DISTRIBUTION:

Cystophyllum muricatum occurs throughout the coast of Australia. It is also recorded from Admiralty Islands and New Caledonia. Harvey (1858) states that it grows throughout the Indian Ocean.

Type information has not been located.

In Australia it grows generally in sheltered places in the upper sublittoral zone. There is considerable variation in the growth of the plant under different conditions. Plants growing in rough conditions are stunted and reach a height of 10 - 15 cm.

The basal part of a stunted plant is not muricated and the receptacles are small and slender. Plants growing in sheltered places bear muricate processes throughout and the plants reach a height of 30 cm. or even up to 1 metre in very calm places. Such plants bear numerous prominent vesicles and few receptacles on the upper branches.

Plants from the Northern Territory, Queensland and New South Wales possess basal leaves as in the type specimen but plants from Southern Australia possess slender leaves only. This appears to be a geographical variation and it is not worth recognising as a variety.

In C. muricatum, the initial cell of the conceptacle develops a tongue filament of 3 cells and the conceptacle wall is radially arranged around the tongue cell in transverse section. There is one functional nucleus at the centre and 7 supernumary nuclei along the periphery of each oogonia. The oogonium measures 120 - 204 µ x 100 - 150 µ. The oogonia are embedded in the conceptacles and mature simultaneously within each conceptacle, and they are discharged in three zones. Eight primary rhizoids are produced on each embryo. In the development of the reproductive structures C. muricatum approaches Sargassum muticum (Yendo) Fensholt, where simultaneous oogonial development occurs within each conceptacle. Zonal discharge of eggs and formation of 8 primary rhizoids occur. C. muricatum differs greatly in development, size of oogonia and number of rhizoids from its allied species of

Cystophyllum in which the reproductive structures have been studied. Species of *Cystophyllum* are apparently less advanced than *Sargassum* with the exception of *C. turneri* and *C. sisymbrioides* which are more highly advanced than *Sargassum*. On the other hand in *Cystoseira* there are 6 - 8 cells in the tongue filament and successive discharge of spherical oogonia (70-78 µ) occurs. In *Cystoseira* oogonia are borne directly on the wall of the conceptacle rather than embedded as in *Cystophyllum muricatum* and *Sargassum muticum*. Only 4 primary rhizoids develop on the embryo of *Cystoseira* as well as ~~whereas 8 primary rhizoids develop~~ on the embryo of *Cystophyllum muricatum*, 8 -16 in *Sargassum* and 32 in *Cystophyllum sisymbrioides* as well as in *C. turneri*. It appears that *C. muricatum* lies between *Cystoseira* and *Sargassum*.

(h) *CYSTOSEIRA* C. Agardh 1821.

C. Agardh 1821: 50. J. Agardh 1841: 3; 1848: 213; 1896: 34. Bory in Duperrey 1828: 131. Chapman 1941: 204. De Toni 1895: 159. Endlicher 1836: 10; 1843: 30. Gruber 1896: 25, 29. Harvey 1852: 65. Kjellman 1897: 282. Kuetzing 1843: 356; 1849: 598. Lucas 1936: 75. Newton 1931: 226. Setchell and Gardner 1925: 708. Schmidt 1938: 228. Taylor 1945: 113. Tilden 1937: 329. Valiante 1883: 150.

Holdfast discoid or divided. Axis terete or compressed with alternate or irregular branches becoming slender above. Leaves present or absent near the base, broad or linear, pinnate, serrate or entire, divided above into more or less terete ramuli bearing receptacles at their ends. Secondary branches bear receptacles and vesicles. Vesicles serrate, concatenate, occurring as dilations in the branches or immersed, coronate, rarely solitary. Receptacles terminal on the ramuli, terete or angular, smooth or verrucose or serrate, unisexual or bisexual, frequently subtended by vesicles. Conceptacles numerous, scattered, unisexual or bisexual, occasionally borne on vesicles. Plant monoecious or dioecious. Oogonia with one egg.

C. Agardh (1821) established Cystoseira as a genus on the basis of innate or lateral vesicles, thus separating it from the related genus Sargassum where vesicles are axillary. He enumerated 57 species including those bearing no vesicles. Vesicle character was so variable that he did not strictly adhere to it. The type of the genus Cystoseira is Fucus ericoides Linn.

J. Agardh (1848) used the position and type of vesicles as the distinguishing feature of Cystoseira. In

Cystophyllum vesicles are borne on ultimate branches whereas those of *Cystoseira* are dilations of the branches or leaves.

Cystoseira is mostly a genus of the Northern Hemisphere but a few species of *Cystoseira* do occur in the Southern Hemisphere.

(i) KEY TO SOUTHERN AUSTRALIAN SPECIES OF CYSTOSEIRA.

1. Vesicles concatenate, angular. Plant slender and axis smooth... ... ... *C. nodularia*
   Vesicles absent. Plant robust, and axis muricated... ... ... *C. robusta*

(j) CYSTOSEIRA NODULARIA (Mertens) C. Agardh, 1821.

C. Agardh 1821: 60; 1824: 284.

PLATE LXX.

Fucus nodularius Mertens 1819: 189, Pl. 15.

Hormosira nodularia Decaisne 1842: 330. J. Agardh 1848: 199. De Toni 1895: 188. Endlicher 1843: 30. Kuetzing 1860: t. 5, f. 1. Lucas 1909: 14. Sonder 1846: 158; 1880: 5.

Sirophysalis nodularia Kuetzing 1849: 603.

Type Locality. — "Ad Novae Hollandiae oras" — Australia.

Type. — PC. Fragment in AD. A18,434.

Plants coriaceous, flaccid, radial, pinnate. Axis terete. Secondary branches terete, up to 12 cm. long and 2 mm. broad. Vesicles concatenate (3-11 in chains), up to 2 (-4) cm. long, simple or branched at the constriction, strongly serrate, angular, coronated with serrate leaflets, conceptacles scattered on vesicles and on leaflets. Plant monoecious. Antheridia 24 - 42 µ x 12 - 18 µ. Oogonia 108 - 162 µ x 48 - 90 µ.

SPECIMENS EXAMINED:

W. Aus. — Port Augusta (Womersley, 31-12-1950).

~~W. Aus. —~~ Fremantle (in Sonder).

GEOGRAPHICAL DISTRIBUTION:

Known only from the above localities.

The concatenate series of vesicles of Fucus nodularius have caused most authors to place it under Hormosira. It is now considered as a species of Cystoseira due to the possession of radial, terete branches, with concatenate series of vesicles as dilations in the branches. Further investigation of more material is needed.

(k) CYSTOSEIRA ROBUSTA J. Agardh 1896.

J. Agardh 1896: 41.

PLATE LXXI.

Type Locality. — Israelite Bay, W. Aus. (Brooke).

Type. — LD. (Herbarium Agardh No. 00708).

Holdfast conical and divided. Axis terete, up to 11 cm. long and 4 mm. in diameter, muricate. Secondary branches up to 4 cm. long and 1 mm. in diameter, slender, flexible, terete, distantly alternate with irregularly arranged ramuli. Ramuli up to 7 mm. long, less than a millimetre in diameter, terete. Vesicles absent. Receptacles unknown.

SPECIMENS EXAMINED:

W. Aus. — Cave Islet, Recherche Archipelago, (Willis, 20-11-1950). Israelite Bay (Brooke).

GEOGRAPHICAL DISTRIBUTION:

Known only from the above localities.

J. Agardh (1896) described *C. robusta* from a sterile plant without vesicles.

The axis of *C. robusta* is stout and muricate but that of *C. nodularia* is slender, flaccid and smooth. Vesicles of *C. nodularia* function also as receptacles and are ~~tri~~angular in shape. Receptacles and vesicles have not been observed in C. robusta. Branching in C. robusta is distantly alternate and ramuli are densely crowded, while the branching is radial and pinnate in C. nodularia.

The description and identification of C. robusta and C. nodularia is based in each case on a fragmentary specimen. Further studies of more material are necessary.

(1) CARPOGLOSSUM Kuetzing 1843.

Agardh 1848: 192. De Toni 1895: 181, Gruber 1896: 23. Kjellman 1897: 281. Kuetzing 1843: 352; 1849: 591. Lucas 1936: 78. Oltmanns 1889: 50. Schmidt 1938: 227. Svedelius 1911: 181.

Platythalia Sonder 1845: 51; 1846: 158. De Toni 1891: 173.

Holdfast discoid with a short terete stipe. Thallus flat with alternate segments. Segments linear, costate or ecostate, entire or dentate. Vesicles absent. Conceptacles in longitudinal rows or scattered on both surfaces of the segments. Plant monoecious or dioecious. Antheridia in clusters on the wall of the conceptacles. Oogonia sessile with one egg. Simultaneous maturation of oogonia.

Carpoglossum was established as a genus by Kuetzing

(1843) based on *Fucus confluens* R. Brown ex Turner. J. Agardh (1848) included two new species — *C. angustifolium* and *C. quercifolium* in the genus. Kuetzing (1849) added a new species *C. constrictum* based on *Fucus constrictus* Harvey from South Africa. Gruber (1896) established a new genus *Axillaria* based on *C. constrictus* and placed the new genus in the Fucaceae. Silva (1959) named it *Axilariella* because *Axillaria* is already occupied as a generic name in Liliaceae.

Sonder (1845) described a new genus *Platythalia* based on its flat thallus with distichous, costate, lateral segments, pluriseriate conceptacles and absence of vesicles. Two species, *P. quercifolia* and *P. angustifolia* have been included in the genus. These characters, to varying degrees, are also found in *Carpoglossum confluens*. It appears that *Carpoglossum* and *Platythalia* are not distinct from each other. *Carpoglossum* antedates the publication of *Platythalia*. In 1848 J. Agardh considered *P. quercifolia* and *P. angustifolia* as synonyms of *C. quercifolium* and *C. angustifolium* respectively. De Toni (1891) regarded *Platythalia* as synonym of *Carpoglossum*.

(m) KEY TO THE SPECIES OF CARPOGLOSSUM.

1. Branch segments simple, entire,
ecostate... ... ... *C. confluens*
Branch segments simple, runcinate or
entire, costate... 2
   2. Segments narrow, entire, conceptacles in two rows... ... *C. angustifolium*
   Segments broad, runcinate,
   conceptacles numerous,
   scattered... .. .. *C. quercifolium*

(n) CARPOGLOSSUM CONFLUENS (R. Brown ex Turner) Kuetzing 1843.

J. Agardh 1848: 195. De Toni 1895: 182. De Toni et Forti 1923: 71. Gruber 1896: 23. Harvey 1859b: 286; 1860: pl. 159. Kuetzing 1843: 352; 1849: 591; 1860: t. 18, f. 1. Lucas 1936: 78. Oltmanns 1889: 50. Womersley 1950: 159.

PLATE LXXII.

Fucus confluens R. Brown ex Turner 1811: 16, t. 141.
C. Agardh 1821: 95. Hooker and Harvey 1847: 413.

Type Locality. — Port Dalrymple, North Tasmania (R. Brown).

Type. -- BM.

Holdfast discoid, up to 18 mm. across. Stipe subterete, up to 25 mm. long and 8 mm. across, becoming strongly compressed upwards. Plants brown, blackening on long exposure to sun or on drying, up to 88 cm. long, flat and bilateral. Segments constricted towards the base, broader upwards. Axis tapering at both ends. Segments up to 10 mm. broad, simple, linear, entire, ecostate, cuneate near the base, apex notched, axils rounded. Segments bear bisexual conceptacles which are scattered. Plant monoecious. Antheridia 25 - 40 μ x 8 - 15 μ, in clusters. Oogonia 100 - 170 μ x 50 - 80 μ.

<u>SPECIMENS EXAMINED</u>:

S. Aus.- Elliston (Womersley, 13-1-1951). Fishery Bay (Nizamuddin, 27-2-1959). Wanna (Nizamuddin, 28-2-1959). Encounter Bay (Cleland. Harris, December 1943). Cape Jaffa (Womersley, 31-8-1949). Stinky Bay, Nora Creina (Womersley, 19-8-1952). Port MacDonnell (Nizamuddin, 14-4-1959).

Kangaroo Island. — Middle River (Womersley, 8-1-1946). West Bay (Womersley, 6-1-1946). Vivonne Bay (Womersley, 23-5-1945, 19-1-1948, and 2-1-1949). Seal Beach (Womersley, 24-1-1957). Pennington Bay (Womersley, 28-1-1944, 24-5-1945 and 4-1-1948).

Victoria. — Portland Bay (Beauglehole, 18-8-1951). Point Roadknight (Davis, 1-2-1946. Womersley, 6-6-1953). Port Phillip Bay (Harvey, 1859). Queenscliff (Nizamuddin, 10-4-1959). Port Phillip Heads and Western Port (De Toni, 1895).

Tasmania. -- Low Head, Northern Tasmania (Perrin, August 1948). Port Arthur, Tasman Peninsula (De Toni, 1895).

GEOGRAPHICAL DISTRIBUTION:

From Elliston, South Australia, around the south coast to Western Port, Victoria and along the coast of Tasmania. Fertile segments of *C. confluens* from Robe and Point Raadknight are constricted below and have developed from old broken segments. This is also found in *Ascophyllum*, and *Axillaria* (= *Axillariella* Silva), but *C. confluens* is distinct from *Ascophyllum* due to the lack of intercalary vesicles. *C. confluens* shows similarities with the type figure and description of *Axillariella constricta* (Gruber) Silva. Both possess bilateral and monopodial branches with similar apical growth. A further study of the material and the type of *A. constricta* (Gruber) Silva is necessary to judge the identity or not of these two taxa.

C. confluens resembles *C. quercifolium* in possessing scattered conceptacles but differs in its entire ecostate segments. *C. confluens* also differs from *C. angustifolium* in possessing scattered conceptacles.

(O) *CARPOGLOSSUM ANGUSTIFOLIUM* (Sonder) J. Agardh 1848.

J. Agardh 1848: 194. De Toni 1895: 183. Harvey 1854: 534; 1860: pl. 128.

PLATE LXXIII

Platythalia angustifolia Sonder 1845: 51; 1846: 158.

Myriodesma angustifolia Kuetzing 1849: 588; 1860: t. 10, f. 1.

Type Locality. -- Western Australia (Preiss)

Type. — MEL.

Holdfast discoid with divided processes, producing several axes. Stipe short, flat. Plants up to 80 cm. long, coriaceous, and black on drying. Axis flat, up to 6 mm. broad with alternate laterals of limited growth, broader near the base than the upper parts, with scars of old branches near the base. Segments simple or bifurcate, distichous, alternate, costate, linear lanceolate, entire, up to 8 cm. long and 5 mm. broad. Plant monoecious with unisexual conceptacles. Conceptacles in a single row on either side of the midrib. Antheridia 22 - 27 µ x 8 - 10 µ, borne directly on the wall of the conceptacle. Oogonia 120 - 144 µ x 60 - 96 µ.

SPECIMENS EXAMINED:

W. Aus.– Dongarra (Royce, February 1944). Port Denison (Womersley, 30-8-1947). Yallingup (Royce, 24-5-1950). Fremantle (Harvey, 1854). Point D'Entrecastreaux (Smith, 20-3-1946). Cape Riche (Harvey, 1854).

GEOGRAPHICAL DISTRIBUTION:

From Dongarra, Western Australia, around the south west coast to Cape Riche, Western Australia.

(p) *CARPOGLOSSUM QUERCIFOLIUM* (R. Brown ex Turner) J. Agardh 1848.

J. Agardh 1848: 193. De Toni 1891: 173; 1895: 182. De Toni et Forti 1923: 71. Harvey 1854: 534; 1858: pl. 43. Lucas 1936: 78.

PLATE LXXIV.

Fucus quercifolius R. Brown ex Turner 1811: 38, t. 151.

Cystoseira quercifolia C. Agardh 1821: 70. A. Richard 1834: 139.

Platythalia quercifolia Sonder 1845: 51; 1846: 158.

Phyllospora quercifolia Hooker and Harvey 1845: 525.

Myriodesma quercifolium Kuetzing 1849: 588; 1860: t. 9, f. 1.

Type Locality. — South Coast of Australia. (Brown).
Type. — BM.

Holdfast discoid, up to 6 mm. across, with a short terete stipe up to 5 mm. long and 3 mm. in diameter. Thallus thick, coriaceous, black on drying, up to 60 cm. long. Axis flat, up to 7 mm. broad with lateral segments. Main segments petiolate, flat, lanceolate, pinnate, costate, runcinate, up to 14 cm. long and 8 mm. broad. In the upper segments the runcination developing into bilateral secondary segments. Secondary segments linear, acuminate, flat, up to 10 mm. long and 3 mm. broad. These segments rarely subdivide. Conceptacles numerous on segments. Plant dioecious. Antheridia 30 - 38 µ x 12 - 18 µ, on branched hairs. Oogonia 70 - 84 µ x 36 - 40 µ, ovoid, borne directly on the wall of the conceptacle and without stalk.

SPECIMENS EXAMINED:

W. Aus. — Rottnest Island (Harvey, 1854 and 1858. Cribb, 9-8-1950). Fremantle (Preiss in Harvey, 1858). Safety Bay (Womersley, 23-8-1947). Cave Islet, Recherche Archipelago (Willis, 20-11-1950). Figure of Eight Island (Willis, 7-11-1950).

GEOGRAPHICAL DISTRIBUTION:

From Rottnest Island to Cave Islet, Recherche Archipelago, Western Australia.

C. quercifolium grows in deep rock pools and on coastal reefs (Harvey, 1858).

C. quercifolium resembles *C. angustifolium* in general features but differs in its runcinate segments and scattered conceptacles.

(q) *MYRIODESMA* Decaisne 1841

J. Agardh 1848: 190; 1891: 5; 1894b:90; 1897: 100. Decaisne 1841: 148. De Toni 1895: 189. Endlicher 1843: 29. Gruber 1896: 25. Kjellman 1897: 280. Kuetzing 1849: 588. Lucas 1936: 78. Schmidt 1938: 225. Svedelius 1911: 181. Tilden 1937: 311.

Myriadena Decaisne 1842: 330. De Toni 1891: 173.

Holdfast discoid or divided, with a subterete to flat axis, fronds membranous, linear, oblong, costate, serrate or entire or with irregular teeth, simple or dichotomous. Vesicles and receptacles absent. Conceptacles numerous, scattered or in rows on both surfaces of the segments, bisexual. Plant monoecious. Antheridia borne directly on the wall of the conceptacle or in clusters on branched hairs. Oogonia with one egg only. Successive maturation of oogonia.

Decaisne established *Myriodesma* in 1841, based on *Dictyopteris serrulatum* Lamouroux (1813). Since then 11 species of *Myriodesma* have been described, all purely Australian. De Toni (1895) transferred *M. quercifolium* Kg. and *M. angustifolium* Kg. to *Carpoglossum*. Eight of the remaining species of *Myriodesma* are known from south Australian waters. The type species, *M. serrulata*, is only known from Western Australia. The number of previously described species of *Myriodesma* is here reduced to six and two new species (*M. peronii* and *M. portlandia*) are described. The distribution of species is discussed separately and is also summarised in TableIX.

TABLE IX.

DISTRIBUTION OF MYRIODESMA SPECIES

Species.	Locality.		
	Western Australia	South Australia	Victoria
M. peronii	+	—	—
M. serrulata	+	—	—
M. integrifolia	—	+	+
M. tuberosa	+	+	—
M. leptophylla	+	+	—
M. portlandia	—	—	+
M. latifolia	+	+	—
M. quercifolia	—	+	+

M. quercifolia J. Ag. was reported from New New Zealand in 1825. Since then it has not been recorded in any part of New Zealand. Laing (1927) states that *M. quercifolia* is a doubtful inhabitant of New Zealand and Lindauer (1947) does not accept *M. quercifolia* as a New Zealand alga.

There has been duplication of species within *Myriodesma* due to a lack of an adequate range of specimens and field knowledge by previous authors. The present studies of most species of *Myriodesma* have been made on liquid-preserved material. The solid terete to subterete axis arises from the holdfast, and develops into dichotomous terete to subterete laterals which produce fronds. Flattening and swelling of the axis, old petioles and new petioles are common in *Myriodesma*.

It appears that each year fronds are lost and then old petioles become active and divide dichotomously or trichotomously to form new laterals. These new laterals further develop into fronds. It seems that this process is repeated every year. In some species it may be possible to estimate the age of the plant from the number of di or trichotomies.

J. Agardh (1848; 1894b), Kuetzing (1849) and De Toni (1895) described *Myriodesma* and *Carpoglossum* as separate genera on the basis of branching and thickness of the thallus.

Myriodesma resembles *Carpoglossum* in its flat, entire or serrate segments with conceptacles in rows or scattered but differs in its dichotomous branching near the base of the thallus, the thickness of the thallus and the maturation of oogonia.

These characters provide sufficient evidence to retain them as separate genera.

(r) KEY TO THE SPECIES OF MYRIODESMA.

1. Fronds spirally twisted... 2
   Fronds not twisted... 3

   2. Conceptacles scattered and numerous.
      M. peronii sp. nov.
      Conceptacles in a single row on each
      side of the midrib... ... *M. serrulata*

3. Plants slender, axis up to 3 mm. broad,
   fronds up to 5 mm. broad.. 4
   Plants robust, main axis up to 6 mm. broad,
   segment (13-) 25 - 40 (-60) mm. broad.... 5

4. Conceptacles numerous, scattered.. M. integrifolia.

Conceptacles in 1 - 3 rows... ... 6

5. Axis terete, swollen, up to 7 cm. long and 5 mm. broad, main segment developing directly from the axis, up to 14 cm. long and 13 mm. broad... ... ... M. tuberosa

Plants up to 60 cm. long. axis terete - ovoid, up to 6 mm. broad, main segment (16-) 25 - 40 (-60) mm. broad, developing from the end of the dichotomous branches.. 7

6. Conceptacles in a single row... M. leptophylla

Conceptacles in 2 - 3 rows M. portlandia sp. nov

7. Holdfast much divided, segment strongly dentate 16 (-25) mm. broad... .. M. latifolia

Holdfast discoid, segment serrate, rarely entire, up to 4 (-6) cm. broad... M. quercifolia

1. MYRIODESMA PERONII sp.nov.

Type Locality. — Point Peron, Western Australia (Wollaston, 3-2-1957).

Type. — AD.A, 22245.

PLATE LXXV

Frond spiral, much divided, petiolate, cuneate near the base, costate, without lateral veins, pinnatifid, strongly serrate, up to 10 cm. long and 10 mm. broad. Main segments linear, oblong, prominently serrate. Costate, without veins, pinnatifid, alternate, spiral, up to 9 cm. long and 5 mm. broad. Secondary segments oblong, spiral, serrate, ecostate, up to 2 cm. long and 7 mm. broad. Conceptacles dense, scattered on both surfaces especially on main segments and secondary segments, but sparse on the older frond, bisexual. Antheridia 26 - 33 µ x 12 - 14 µ. Oogonia ovoid, sessile on the wall of the conceptacles, 96 - 132 µ x 54 - 90 µ.

GEOGRAPHICAL DISTRIBUTION:

Known only from the type locality.

M. peronii resembles other species of Myriodesma in general features but differs from them, except M. serrulata, in its spirally twisted frond. It differs from

M. serrulata in possessing numerous conceptacles whereas M. serrulata possesses a single row of conceptacles on either side of the midrib.

2. MYRIODESMA SERRULATA (Lamouroux)

Decaisne 1841.

PLATE LXXVI

J. Agardh 1848: 191; 1891: 6; 1894b: 92. Decaisne 1841: 148; 1842: 330. De Toni 1891: 173; 1895: 190. Harvey 1854: 534; 1862: pl. 219. Kuetzing 1849: 588; 1860: t. 8, f. 2. Sonder 1846: 157. Tilden 1937: 312.

Dictyopteris serrulata Lamouroux 1813: t. 5, f. 6.
Halyseris serrulata C. Agardh 1821: 144.
Rhodomela serrulata C. Agardh 1824: 197.
Dictyomenia serrulata Greville 1830: synop. 5.
Type Locality. — Western Australia.
Type. — CN.

Thallus dark brown, coriaceous, dichotomously branched, up to 22 cm. long with terete stipe. Axis terete to flat, swollen up to 4 mm. broad, irregularly and alternately branched. Main segments linear, flat, membranous, petiolate, cuneate near the base, pinnatifid, costate, strongly serrate, spiral, up to 15 cm. long and

4. mm. broad . Secondary segments oblong, serrate, subcostate, alternate, up to 6 cm. long and 3 mm. broad. Conceptacles bisexual in a single row on either side of the midrib. Antheridia 25 - 40 µ x 10 - 15 µ. Oogonia ovoid, sessile, 100 - 140 µ x 60 - 90 µ.

SPECIMENS EXAMINED:

Fremantle (Harvey, 1854). Leighton Estuary, Mandura and West coast of Penguin Island (Wollaston, 3-2-1957). Cape Riche (Harvey, 1854).

GEOGRAPHICAL DISTRIBUTION:

From Fremantle to Cape Riche, Western Australia.

Decaisne (1841) described *M. serrulata* by a figure ~~based on~~ (=*Dictyopteris serrulata* (Lamouroux 1813).

M. serrulata resembles other species of *Myriodesma* in general features but differs from them , except *M. peronii* in its spirally twisted frond. *M. serrulata* differs from *M. peronii* in possessing scattered conceptacles.

3. MYRIODESMA INTEGRIFOLIA Harvey 1859.

J. Agardh 1891: 6; 1894b: 92. De Toni 1895: 191. Harvey 1859b: 286. Kuetzing 1860: t. 10, f. 2. Lucas 1936: 79. Womersley 1950: 158.

PLATE LXXVII.

Type Locality. — Georgetown, Tasmania (Harvey).

Type. — CD.

Holdfast discoid, with a terete stipe up to 13 mm. longand 2 mm. broad, producing 1 - 5 axes. Plants up to 36 cm. long. Axis terete to subterete, up to 5 mm. broad. Segments developing from the end of the laterals, linear, petiolate, costate, entire, flat, membranous, distichous, upto 22 cm. long and 5 mm. broad. Midrib prominent near the base, fading away near the apex. Secondary segments linear, pinnatifid, with rounded axils, entire, ecostate, up to 6 cm. long and 6 mm. broad, tertiary segments linear, entire, ecostate, up to 12 mm. long and 3 mm. broad. Conceptacles numerous, scattered on both surfaces, bisexual. Antheridia 20 - 35 μ x 10 - 15 μ, in clusters. Oogonia 50 - 80 μ x 40 - 50 μ.

SPECIMENS EXAMINED:

S. Aus. — Wanna (Nizamuddin, 27-2-1959) Investigator Strait (Davey). West Beach, Holdfast Bay (Womersley, 14-2-1947). Port Willunga Reef (Womersley, 5-9-1954). Port Elliot (December 1943). Womersley, 17-10-1948 and 10-8-1957). Robe (Nizamuddin, 17-4-1959).

Kangaroo Island. — Vivonne Bay (Womersley, 2-1-1949). Pennington Bay (Womersley, 4-1-1948). Stanley Beach (Womersley, 27-1-1956).

Victoria. — Port Phillip (Harvey, Sonder. Macpherson, 16-6-1950 and 13-10-1957). Geelong (Harvey, 1859). Western Port (Harvey, 1859).

GEOGRAPHICAL DISTRIBUTION:

From Wanna, South Australia, around the south coast to Western Port, Victoria.

Two forms occur in *M. integrifolia*.

(1) Secondary segment entire............*M. integrifolia* f. *integrifolia*

(2) Secondary segments strongly serrate. *M. integrifolia* f. *pinnatifida* J. Ag.

J. Agardh (1891) described f. *pinnatifida* only. In f. *integrifolia* the frond is membranous and the segments are entire but the frond is slightly coriaceous and the segments are serrate in f. *pinnatifida*.

M. integrifolia resembles *M. leptophylla* and *M. portlandia* in its slender axis and segments but differs from them in possessing scattered conceptacles.

4. MYRIODESMA TUBEROSA J. Agardh 1894.

J. Agardh 1894b: 93. De Toni 1895: 192.

PLATE LXXVIII.

Type Locality. — Eucla, Western Australia, (Mueller, 1892).

Type. — LD. (Herbarium Agardh No. 2411).

Axis terete, swollen, up to 7 cm. long and 5 mm. broad. Main segment developing directly from the main axis, petiolate, linear-oblong, pinnate, serrate, costate, without lateral veins, cuneate near the base, up to 14 cm. long and 13 mm. broad. Midrib prominent near the base fading away in the upper parts of the segment. Secondary segments linear oblong, alternate, costate, without veins, serrate, up to 6 cm. long and 10 mm. broad. Tertiary segments oblong, acuminate, ecostate, serrate, alternate, up to 13 mm. long and 4 mm. broad. Conceptacles on the older parts of the segments but dense on the upper half of the main and secondary segments, bisexual. Antheridia 18 - 24 µ x 6 - 12 µ, borne directly on the wall of the conceptacles. Oogonia ovoid, 78 - 150 µ x 30 - 75 µ.

SPECIMENS EXAMINED:

S. Aus. — Port Elliot (Hussey, November 1891).

GEOGRAPHICAL DISTRIBUTION:

Known only from Eucla, W. Aus., and Port Elliot, S. Aus.

M. tuberosa differs from the rest of the species of *Myriodesma* in the main segments being developed directly from the main axis but in other species of *Myriodesma* they develop from the end of the dichotomous branches.

Further studies of more material are necessary to retain it as a separate species.

5. *MYRIODESMA LEPTOPHYLLA* J. Agardh 1891

J. Agardh 1891: 6; 1894b: 92. De Toni 1895: 191.

PLATE LXXIX.

Scaenophora australis J. Agardh 1899: 155. Svedelius 1911: 180, 182. Womersley, m.s. 1952.

Type Locality. — Israelite Bay, W. Aus. (Brooks).

Type. — LD. (Herbarium Agardh No. 2385).

Axis up to 25 cm. long and 4 mm. broad, terete, alternately, dichotomously branched. Main segments linear, narrow, ecostate, entire, acuminate, upto 2 cm long, compressed near the base of the dichotomy. Conceptacles in a single row along the median line of the segments.

SPECIMENS EXAMINED:

W. Aus. — Israelite Bay (in LD.). Eucla (in LD.).

S. Aus. — Encounter Bay (Hussey, in LD).

GEOGRAPHICAL DISTRIBUTION:

From Israelite Bay, Western Australia, along the south coast to Encounter Bay, South Australia.

In the type of *Scaenophora australis* the segments are slightly more compressed than in *M. leptophylla* and taper gradually towards the apices. Otherwise *Scaenophora australis* is identical with *M. leptophylla*.

M.leptophylla resembles other species of *Myriodesma* in general features but differs in its narrow linear, ecostate segments and in possessing a single row of conceptacles along the median line of the segment.

6. *MYRIODESMA PORTLANDIA* sp. nov.

PLATE LXXX.

Type Locality. — Double Corner Beach (=Dutton Beach), north of Dutton Bluff, Portland Bay, Victoria (Beauglehole, 14-7-1951).

Type. — AD., A 21,769.

Plants up to 22 cm. long, with a terete stipe up to 1 cm. long and 3 mm. broad. Axis up to 3 mm. broad, producing 2 to 3 dichotomous, slender laterals. Main segments petiolate, alternate, distichous, flat, membranous, pinnatifid, costate, entire, up to 6 cm. long and 2 mm. broad. Secondary segment oblong, alternate, subcostate or ecostate, entire (rarely serrate). Conceptacles minute, slightly darker than the frond and segments, in 2 to 3 rows. Reproductive organs not known.

GEOGRAPHICAL DISTRIBUTION:

Only known from the Type Locality.

This species needs further examination of fertile material.

M. portlandia is comparable to M. integrifolia and M. leptophylla. M. integrifolia possesses ecostate, entire or serrate segments but those of M. portlandia are entire and costate. There are 2 - 3 rows of conceptacles in M. portlandia but the conceptacles are numerous and scattered in M. integrifolia. M. leptophylla possesses ecostate, linear main segments up to 1 mm. broad, whereas they are oblong up to 2 mm. broad and costate in

M. portlandia. Conceptacles are in a single median row in M. leptophylla but they are in 2-3 rows in M. portlandia.

7. MYRIODESMA LATIFOLIA Harvey 1854

J. Agardh 1891: 7; 1894b: 92. De Toni 1895: 192.
Harvey 1854: 534; 1858: pl. 24. Kuetzing 1860: t. 9, f. 2.

PLATE LXXXI.

Myriodesma bipinnatum J. Agardh 1897: 100.

Type Locality. — Fremantle (Harvey, 1854).

Type. — TCD.

Holdfast much divided. Stipe subterete to terete, up to 15 mm. long and 8 mm. broad. Axis terete to ovoid. Plant coriaceous, dark brown on drying, up to 41 cm. long, robust and branched. Several dichotomous laterals from the axis, up to 5 mm. broad, passing directly into the main segments, which are linear - oblong, petiolate, pinnate, costate, strongly dentate, up to 34 cm. long and 16 (-25) mm. broad. Petiole thick and swollen, becoming flat on drying, up to 5 mm. broad. Secondary segments linear, oblong, serrate, costate or subcostate, up to 17 cm. long and 8 mm. broad. Midrib thick near the base of the main segment, fading away near the apices. Conceptacles sparsely or densely scattered without order, darker than the main segments, bisexual. Antheridia 24 - 42 μ x 10 - 18 μ, in clusters on branched hairs. Oogonia ovoid, 95 - 175 μ x 42 - 108 μ.

SPECIMENS EXAMINED:

W. Aus. — Dongarra (Smith, February 1944). Port Denison (Womersley, 31-8-1947). Leighton Estuary, near Mandura (Wollaston, 4-2-1947). Geographe Bay (in J. Agardh 1891). Cowaramup Bay (Royce, 5-6-1950). Point D'Entrecastreaux (Smith, 20-3-1946).

S. Aus. -- Elliston (Nizamuddin, 27-2-1959). Point Drummond (Womersley, 11-1-1951). Cape Carnot (Womersley, 8-1-1951). Wanna (Nizamuddin, 19-2-1959).

Kangaroo Island. — Cape du Couedic (Womersley, 12-1-1948). Vivonne Bay (Womersley, 2-1-1949, 4-1-1950, 30-1-1956 and 29-1-1957).

GEOGRAPHICAL DISTRIBUTION:

From Dongarra, Western Australia, around the south coast to Wanna, South Australia and to the south coast of Kangaroo Island.

J. Agardh (1894b) described three forms — f. *linearis*, f. *oblonga* and f. *duriuscula* — on the basis of the form of the laciniae (segments). In the same plant linear and oblong forms of laciniae (segments) occur. Young segments appear to be oblong and old segments are linear. These features are considered as age variations so that f. *linearis* and f. *oblonga* are merged into a single form which includes the type of *M. latifolia* Harvey and thus becomes *M. latifolia* Harvey f. *latifolia*.

1. *M. latifolia* Harvey f. *latifolia*.

   M. latifolia Harvey f. linearis J. Agardh 1894b: 92. De Toni 1895: 192.

   M. latifolia Harvey f. *oblonga* J. Agardh 1894b: 92.

   Secondary segments linear, oblong, alternate, up to 18 cm. long and up to 11 (-25) mm. broad, membranous and smooth.

2. *M. latifolia* Harvey f. *duriuscula* J. Agardh 1894.

   J. Agardh 1894b: 92. De Toni 1895: 192. Womersley 1950: 158.

   Secondary segments sublinear, subopposite up to 5 cm. long, and up to 5 mm. broad, thick, rough and strongly serrate.

Conceptacles in f. *duriuscula* are densely scattered and the fronds are thick, dark brown and strongly serrate whereas the conceptacles are sparsely scattered and fronds are smooth, light brown and distinctly serrate in f. *latifolia*.

J. Agardh (1897) described *M. bipinnatum* which is based on the bipinnate, character of the fronds. *Myriodesma latifolia* possesses both pinnate and bipinnate fronds. Bipinnate branches generally occur in older plants of *M. latifolia*. These two characters appear to be age variations and not worth recognising as distinct species or form. Therefore *M. bipinnatum* is merged into *M. latifolia*.

8. *MYRIODESMA QUERCIFOLIA* (Bory) J. Agardh 1848.

J. Agardh 1848: 192; 1891: 7; 1894b: 93. De Toni 1895: 193. Harvey 1855: 213. Laing 1927: 142. Womersley 1950: 158.

PLATE LXXII.

Lessonia quercifolia Bory in Duperry 1828: 79.

Myriodesma grandifolium J. Agardh 1897: 101.

Myriodesma calophyllum J. Agardh 1894b: 94. De Toni 1895: 194.

Myriodesma boryanum Kuetzing 1849: 588.

Type Locality. — Southern coast of Australia.

(Lesueur,I802).

Type. __ PC.

Plants light brown, dark brown on drying, up to 60 cm. long. Holdfast discoid, up to I4 mm. in diameter, with a terete stipe. Axis up to 6 mm.broad, terete-ovoid in section, robust, producing subterete- terete laterals. Laterals dichotomous, producing main segments terminally. Main segments linear oblong or lanceolate, petiolate, pinnate,costate, serrate (rarely entire), cuneate near the base,up to 45 cm. long and 4 (-6) cm. broad. Petiole up to 5 cm. long and 3 mm. broad, terete or ovoid in section. Midrib prominent near the base, fading away near the apex or near the middle part of the frond. Secondary segments linear, oblong, alternate, costate to ecostate, serrate or rarely entire, up to 25 cm. long and 5 mm. broad. Conceptacles densely or sparsely scattered over both surfaces of main segments and secondary segments,bisexual. Antheridia, 24 - 48µx 6 - I2µ, borne in clusters on branched hairs or directly borne on the wall of the conceptacles. Oogonia 95 - I50 µ x 40 - I08 µ.

SPECIMENS EXAMINED:

S. Aus. — 10 miles east of Eucla (Womersley, 3-2-1954). Head of the Great Australian Bight (Womersley, 4-2-1954). Elliston (Womersley, 13-1-1951, Nizamuddin, 27-2-1959). Port Elliot (Hussey in LD. Herb. Agardh No.2419 as *M. grandifolium*).

Kangaroo Island. — Vivonne Bay (Womersley, 14-1-1948, 2-1-1949 and 30-1-1956). Pennington Bay (Womersley, 23-1-1944, 22-1-1947, 4-1-1948, 29-12-1948, 3-12-1949 and 27-1-1956). Stanley Beach (Womersley, 26-1-1956 and 27-1-1957). Cape Willoughby (Womersley, 16-1-1946 and 14-1-1947).

Victoria. — Port Phillip Heads (Wilson, 2-1-1891, in LD. Herb. Ag. No. 2417. as *M. calophyllum*).

GEOGRAPHICAL DISTRIBUTION.

At east of Eucla, ~~around south to~~ Elliston and at Port Elliot, South Australia; south coast of Kangaroo Island and at Port Phillip Heads, Victoria.

M. calophylla J. Agardh differs from *M. quercifolia* J. Ag. in having entire segments not serrated, Most of the specimens of *M. quercifolia* and *M. calophylla* in MEL. are entire, some with few serrations (Womersley, 1950). Kangaroo Island specimens are mostly entire, some with one or two teeth. Elliston specimens of *M. quercifolia* possess strongly serrate~~d~~ segments as well as entire segments. Sometimes only a few serrations are present. It appears that *M. calophylla* and *M. quercifolia* are not distinct species (see also Womersley, 1950). *M. grandifolia* differs from *M. quercifolia* by being larger in size and more deeply serrate~~d~~ than the latter. Elliston specimens of *M. quercifolia* show gradations of sizes and serrations. It appears that *M. grandifolia* is not distinct from *M. quercifolia* but is an old form of *M. quercifolia*. Kuetzing (1849) described *M. boryanum* as differing from *M. quercifolia* in having sparse conceptacles and obtuse denticulation. Specimens of *M. quercifolia* show gradations in which sparse to dense conceptacles and denticulations occur. It thus appears that *M. boryanum* and *M. quercifolia* are also not disdinct. Kuetzing established *M. boryanum* to distinguish it from those species of *Myriodesma* which have conceptacles in series. Earlier authors established *M. calophylla*, *M. grandifolia* and *M. boryanum* on minor characters which now, due to field observations, appear to be age or ecological variations and they are not worth recognising as distinct species.

P.T.O.

M. quercifolia shows some features in common with *M. latifolia*. Harvey (1854) distinguished *M. latifolia* from *M. quercifolia* on having narrower segments with dense numerous conceptacles. The density of conceptacles is variable in both species. *M. quercifolia* possesses broad segments (up to 4 (-6) cm.) and *M. latifolia* has narrow segments (up to 16 (-25) mm.). The holdfast in *M.* latifolia is divided whereas that of *M. quercifolia* is discoid.

VIII. SUMMARY AND CONCLUSION.

The anatomy, development and taxonomy of *Phyllospora*, *Seirococcus*, *Scytothalia*, *Xiphophora*, *Cystophora*, *Cystophyllum muricatum*, *Scaberia*, *Myriodesma* and *Carpoglossum* and the taxonomy only of *Durvillea*, *Hormosira* and *Cystoseira* are described and discussed in detail. All these are southern Australian genera of Fucales.

Anatomical Aspects.

Members of the families Durvilleaceae, Hormosiraceae, Fucaceae, and Cystoseiraceae have been investigated. The shape and number of apical cells, development of oogonia and embryo has been used in the classification of the Fucales. On the basis of these characters, one new family (Seirococcaceae) has been established.

The Durvilleaceae includes only one genus, *Durvillea*, which has diffuse growth, oogonia generally on branched hairs and four eggs in each oogonium.

The Hormosiraceae possessas a monotypic genus *Hormosira* which grows by a group of four apical cells and which develops oogonia with four eggs.

The Fucaceae is characterised by a single 4-sided apical cell and is represented by a single genus *Xiphophora* in Australasian waters. This genus produces four eggs in each oogonium.

The Seirococcaceae is represented by *Phyllospora*, *Seirococcus* and *Scytothalia*, each of which possesses more than one four sided apical cell and produce one egg in each oogonium. Each oogonium has a mesochiton collar. The Cystoseiraceae is characterised by possessing a single 3-sided apical cell, oogonia with one egg and two, four or eight primary rhizoids on the embryos. In Southern Australia this family is represented by *Cystophora*, *Scaberia*, *Cystophyllum*, *Carpoglossum*, and *Myriodesma*.

The tissues of the thallus, in all the species investigated, are built up by the segmentation of the apical cell and division of the meristoderm cells. These meristoderm cells increase the surface of the thallus and function as assimilatory tissues due to the presence of dense chromatophores, while the cortical and medullary cells give rise to hyphae which function as mechanical and storage tissues. Hyphae generally occur near the basal parts of the thallus in the Cystoseiraceae, but in *Xiphophora* they occur throughout the cortex and the medulla from the apex downwards.

Growth of the receptacles, in all the species investigated, occurs by an apical cell similar to the vegetative apical cell. In *Scytothalia* however the growth is initiated by a single 3-sided apical cell, in contrast to the four-sided cells of the vegetative apex.

A detailed account of the origin and the development of the conceptacle of *Cystophora*, *Cystophyllum* and *Myriodesma* is given. The conceptacle initial divides transversely in each case producing a miseriate hair.

Antheridia are borne directly on the wall of the conceptacle or more often on branched hairs. Sixty four sperms are produced in each antheridium. The antheridial wall is composed of exochite and endochite.

The oogonia of *Xiphophora* are pedicellate and produce four eggs only. In *Phyllospora*, *Seirococcus*, *Scytothalia* *Cystophora*, *Scaberia*, *Carpoglossum* and *Myriodesma* the oogonia are sessile and borne directly on the wall of the conceptacle but in *Cystophyllum muricatum* the oogonia are embedded. In each case an oogonium produces one egg only. Maturation of oogonia in *Seirococcus*, *Scytothalia*, *Phyllospora* and *Myriodesma* is successive while in *Cystophyllum*, *Carpoglossum* and *Scaberia* it is simultaneous. Maturation of oogonia in *Cystophora* differs from species to species. A mesochiton collar occurs on the oogonia of *Phyllospora*, *Seirococcus* and *Scytothalia*. The oogonial wall is composed of exochite, mesochite and endochite.

In all the members of the Fucales known three nuclear divisions occur in the oogonium resulting in the production of eight nuclei. The peripheral disintegration of seven of the eight nuclei is a feature of the Cystoseiraceae. In the Sargassaceae and the Seirococcaceae, the 8 nuclei remain scattered for a short time and then 7 of them disintegrate in situ.

In *Cystophora moniliformis*, *C. monilifera*, *C. platylobium* and *Cystophyllum muricatum* extruded eggs or ~~embedded~~ embryos may remain attached to the receptacle, as found in other species of the Sargassaceae and the Cystoseiraceae.

Fertilization occurs after the extrusion of eggs and sperms in *Cystophora*, *Scaberia*, *Cystophyllum* and *Myriodesma*.

The development of rhizoids on the embryo differs in the respective families of the Fucales. In the genera *Cystophora*, *Scaberia*, *Cystophyllum*, and *Myriodesma*, 2, 4, or 8 primary rhizoids are produced on each embryo and this is considered as a characteristic feature of the Cystoseiraceae. In the Sargassaceae a tuft of primary rhizoids develops while only one primary rhizoid is formed in the Fucaceae, Hormosiraceae, and Durvilleaeeae.

In all the species studied, the nuclei, in the vegetative parts, paraphyses, antheridia oogonia and zygote are granular with one or two nucleoli.

All species investigated appear to be diploid and reduction division probably occurs in the developing antheridia and oogonia.

Counts of 48 (in *Cystophora moniliformis*), 56 (in *C. polycystidea*), 45 (in *C. retorta*), 50 - 54 (in *C. subfarcinata*), 22 - 36 (in *C. uvifera*) and 32 - 48 in (*Cystophyllum muricatum*) chromosomes have been made in their vegetative parts. Chromosome counts of 16 and 24 have been made in the respective antheridia of *Cystophora cephalornithos* and *C. platylobium* while in the oogonium of *C. moniliformis* 16 chromosomes have been counted. Counts of 45 (in *C. subfarcinata*) and 50 - 64 (in *C. retorta*) chromosomes have been made in their embryos.

Taxonomic Aspects.

A brief history of the Fucales and its families is given and their relationships discussed. A Key to the families, genera and species is included and lists showing distribution of each species.

In separating the genera and species morphological characters such as the presence of vesicles and arrangment and form of the receptacles have been used. Vesicle features are used in distinguishing the genera *Cystoseira* and *Cystophyllum*.

The synonomy of *Durvillea* with *Sarcophycus*; *Cystophora* with *Blossevillea*, *Platylobium*, *Neoplatylobium*, *Neurothalia*, *Caulocystis* and *Acrocarpia*; *Carpoglossum* with *Platythalia* and *Myriodesma* with *Scaenophora* are discussed in detail.

In delimiting the species of *Cystophora*, axes, receptacles, arrangement of conceptacles and receptacles, vesicles, are used as distinguishing criteria. In *Cystophora* four new species and 4 new combinations are made. The name *C. dumosa* is rejected as a "nomen dubium". *Hormosira nodularia* is merged with *Cystoseira nodularia*; *Scaenophora australis* is considered as a syhonym of *Myriodesma leptophylla*; *M. bipinnata* is a synonym of *M. latifolia*; *M. calophyllum*, *M. grandifolium* and *M. boryanum* are synonyms of *M. quercifolia*.

Relationship between *Cystoseira* and *Cystophyllum* and the validity of *Cystophyllum* over *Myagropsis*, *Sirophysalis* and *Spongocarpus* are discussed in detail.

Myriodesma and *Carpoglossum* are characterised by respectively basal dichotomous character and monopodial branching and differ in the texture of the thallus. Species in both genera are separated by the form of segments and arrangement of conceptacles.

The genera *Phyllospora*, *Seirococcus* and *Scytothalia* are characterised by the form of leafy-laterals and the presence or absence of vesicles and receptacles. Species of *Xiphophora* are distinguished by form and size and the arrangement of conceptacles in segments.

The union of *Durvillea* and *Sarcophycus* is justified as discussed by Naylor. The species of *Durvillea* are separated on the form of holdfast, stipe and by the presence or absence of air-chambers. The family Hormosiraceae is now represented by a monotypic genus *Hormosira* since *Notheia* is now excluded from the Fucales.

Phyllospora comosa is endemic to the south east of Australia. *Seirococcus*, *Scytothalia*, *Scaberia*, *Carpoglossum* and *Myriodesma* are endemic along Southern Australia. *Cystophora* (except *C. brandegeei* and *C. galapagensis*) and *Hormosira* are endemic to the southern Australian waters. *Durvillea potatorum* and *D. willana* occur respectively on the south east coast of Australia and in New Zealand.

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B. NOTHEIA ANOMALA Harvey and Bailey 1851.

I. INTRODUCTION

Notheia is endemic and monotypic to Southern Australia and New Zealand. The genus has been studied previously by Bailey and Harvey (1874), Barton (1899), Gruber (1896), Mitchell (1893) and Williams (1923) from morphological and anatomical viewpoints, but they have not contributed to the knowledge of its development and cytology. Their studies have been based mainly on dry or preserved material. There is thus a need for detailed and thorough studies of fresh material.

This study was undertaken to obtain detailed information on morphology, anatomy, development and cytology of *N. anomala* and to clarify its systematic position.

II. REVIEW OF PREVIOUS STUDIES ON NOTHEIA ANOMALA.

(a) Classification.

Notheia anomala which grows exclusively on *Hormosira banksii* f. *sieberi* was collected for the first time from the Bay of Islands, New Zealand, during the United States Exploring Expedition 1838 - 1842. The species was described by Harvey and Bailey in 1851. Harvey first considered the species as a metamorphic state of *Hormosira* but in 1874 he described *N. anomala* as a parasite on *Hormosira*. Due to the presence of sperms and 8 eggs Bailey and Harvey (1874) and Harvey (1851; 1854b) placed the genus under the Fucoidearum. Later, Harvey (1854a; 1859), Kjellman (1897) and Laing (1885; 1899; 1927) placed it in the order Fucaceae. In 1863 Harvey included *Notheia* in the family Fucaceae. De Toni (1895), Lucas (1936) and May (1939) included the genus under Durvilleaceae. Gruber (1896) established the "Hormosira-gruppe" due to the presence of a group of 3 - 4 apical cells and 4 or 8 eggs. This group included *Hormosira* and *Notheia*. Oltmanns (1904; 1922) established a tribe Anomalae in the family Fucaceae in which he included these two genera. Svedelius (1911) followed Oltmanns in this classification. Kuckuck (1929) established the Notheiaceae under the Polystichales of the Phaeospreae but without description. Schmidt (1938) validly published the family Notheiaceae in the order Fucales on the presence of a group of 3 - 4 apical cells and 8 eggs. Fritsch (1945; 1952), Lindauer (1947), Naylor (1954) and Womersley (1950) included *Notheia* in the Hormosiraceae while Papenfuss (1951; 1955) placed it in the family Notheiaceae. *Notheia anomala* has always been considered as a member of the Fucales due to the presence of a group of 3 apical cells and 8 eggs.

(b) The apical growth and structure of the thallus.

The apex of *Notheia anomala* exhibits a compact group of 3 apical cells which segment anterio-posteriorly (Barton, 1899. Gruber, 1896). According to these authors the segments cut off from the apical cells divide and develop three distinctive tissues —— the peripheral layer, the cortex and the medulla. In the mature thallus Barton (1899), Gruber (1896) and Williams (1923) described the three tissues but used different terminology. Barton also described secondary cells (= hyphae) arising from the medullary cells.

The earlier authors describe an altogether different type of branching from that found in the Fucales. The branches develop from one of the wall cells of the conceptacle, and this cell divides to form a group of 3 cells which continue development as apical cells (Barton, 1899. Gruber, 1896). Barton thus reports up to 3 branches developing from the same conceptacle, but generally one branch is more common.

(c) The conceptacles.

Conceptacles are scattered throughout the surface of the plant. Reproductive organs, paraphyses and branches develop from the conceptacles (Barton, 1899, Gruber 1896, Williams, 1923).

According to Barton and Gruber the conceptacle is initiated by one of the peripheral cells which functions as a conceptacle initial which does not divide at first, but becomes depressed due to the overgrowth of the dividing peripheral cells adjacent to it. The products of the peripheral cells cause the gradual sinking of the initial cell. According to these authors the initial divides transversely to form a uniseriate hair.

Gruber (1896) and Williams (1923) describe the development of oogonia, paraphyses and branches from the wall cells of the conceptacle. Barton (1899) describes the development of antheridia and oogonia in the same conceptacle. She reported 64 sperms in the antheridium and 8 eggs in the oogonium. Production of 8 eggs in the oogonium has been described by most of the previous authors. Fritsch (1945; 1952) and Papenfuss (1951) regarded *Notheia* as primitive among the Fucales because of the development of 8 eggs in an oogonium.

III. ANATOMICAL STUDIES

PLATES LXXXV -LXXXVII

Structure of the apical and subapical regions.

In *Notheia anomala* gowth is initiated by a group of 3 apical cells at the tip of the axis. These are seen clearly in transverse section (plate LXXXV, Fig. A), but only two of the apical cells are observed in longitudinal section (Plate LXXXV, figs. C and D). The apical cells are covered by a thick lamellate mucilaginous layer.

The apical cells segment latero-posteriorly and each segment divides transversely near its base. The basal cell, cut off from each segment, enlarges and then continues to divide to form axial filaments. Transverse and longitudinal sections near the apical region show the three sectors which are separated by thick mucilaginous regions (Plate LXXXV, fig. B). It appears that each sector is formed from one of the apical cells. The axial filaments lose their identity, becoming compact and forming pseudoparenchymatous tissue (medulla).

The uppermost cell of each segment divides transversely into a basal cell and an upper peripheral cell (Plate LXXXV, fig. E). The basal cells contribute to the cortex. The peripheral cell divides by an oblique wall (Plate LXXXV, fig. F) and the newly formed septum thickens so that the small daughter cell is gradually pushed sideways; meanwhile a pit connection becomes obvious between the two daughter cells. The large daughter cell divides by a transverse wall near the base. This transverse septum thickens and the upper cell and the lower cell are joined by a pit connection (Plate LXXXV, fig. G). These divisions continue and result in loose dichotomous branching of the outer tissue (Plate LXXXV, figs. H - J). The division of the peripheral cells increases the thickness of the thallus. In the subapical region the peripheral layer is a single layer of oblong cells containing dense chromatophores and cytoplasmic contents. Mucilage formation is abundant.

Structure of the mature parts.

The mature thallus is differentiated into the peripheral layer, the cortex and the medulla (Plate LXXXV, figs. H - J). The peripheral layer consists of a single layer of oblong cells containing dense chromatophores and protected on the outside by a thick lamellate mucilaginous cuticle about 7 μ thick.

The cortex consists of many layers of cells which are oblong - ovoid or isodiametric. The outer cortical cells are oblong containing dense chromatophores and the cell walls are up to 4 μ thick. The outer cortex is composed of up to 6 layers of cells and the inner cortex consists of up to 4 layers of cells which are more or less isodiametric. These cells contain comparatively fewer chromatophores. The cell walls are lamellate and up to 10 μ in thickness. The cytoplasmic connections and pit connections are very distinct, and are common in the cortical cells. These cortical cells are loosely, dichotomously branched (Plate LXXXV, figs. H - J). Mucilage formation is abundant in the cortical region.

The medulla is composed of many layers of cells which are elongate in longitudinal section (Plate LXXXV, fig. H), and irregular or isodiametric in transverse section. These cells are more or less colourless (occasionally they contain very few chromatophores). The cell walls are very strongly thickened (up to 18 µ) and lamellate (Plate LXXXV, fig. J). Pit connections and cytoplasmic connections are very distinct and well developed. The mucilage is so strongly developed that the medullary cells appear loosely arranged. Hyphae develop from the walls of the medullary cells and these hyphae descend longitudinally becoming intertwined among themselves. The hyphae are simple, septate and contain dense chromatophores (Plate LXXXV, fig. H). In transverse section they are scattered around the medullary cells. Barton (1899) referred to these hyphae as secondary cells arising from the medullary cells.

Development of the conceptacle.

The conceptacles develop from one of the peripheral cells near the apex. This peripheral cell (" initial cell") does not divide and become depressed due to the overgrowth of the peripheral cells adjacent to it (Plate LXXXVI, fig. D). The initial cell divides transversely to form an upper tongue cell and a lower basal cell (Plate LXXXVI, fig. Ca). The basal cell divides longitudinally and its derivatives form the wall of the conceptacle. Meanwhile the division of the peripheral cells adjacent to the tongue cell continues and the products of this division lead to the gradual sinking of the derivatives of the basal cell and to the separation of the tongue cell from other cells (Plate LXXXVI, fig. Cb). The tongue cell divides transversely to form a long septate paraphysis (Plate LXXXVI, fig. D); meanwhile each of the lining cells of the conceptacle produces a paraphysis (Plate LXXXVI, fig. E). Thus a thick tuft of long hairs protrudes through the ostiole (Plate LXXXVI, fig. A).

The basal cell of each paraphysis is large and contains dense cytoplasmic contents with a large granular nucleus with 1 or 2 nucleoli.

In the formation of paraphyses, each lining cell of the conceptacle protrudes towards the cavity to form a papilla (Plate LXXXVI, fig. Fa), which divides transversely into an upper cell and a basal cell (Plate LXXXVI, figs. Fb and Fc). The upper cell elongates and divides transversely to form a long septate hair (Plate LXXXVI, fig. H). The hairs grow by basal meristems (Plate LXXXVI, figs. E and H). The hairs which develop near the ostiole are small in size. The long hairs generally fall off or only their basal parts are left as the conceptacles become old. Previous authors (Barton, 1899, Gruber, 1896) have described the development of branches from one of the wall cells of the conceptacle. According to these workers this cell divides in such a way as to form a group of 3 cells which continue as apical cells. These cells segment to form a young branch in each conceptacle. The conceptacles are scattered so that the branches arise irregularly from all sides of the thallus.

Present investigation indicates that these branches may be new plants developing from the conceptacle, as gametophytes have been observed growing in the conceptacles. In the conceptacles generally one plant is developed (Plate LXXXVI, fig. B) but up to 3 plants have been observed.

Structure and development of reproductive organs.

Reproductive organs are borne directly on the wall of the conceptacle. They are linear-oblong, unilocular and of two types — macrozoosporangia and microzoöid producing bodies. They measure 48 - 78 µ x 12 - 30 µ and develop in the same conceptacles. They develop as a protuberance from one of the lining cells of the conceptacle (Plate LXXXVI, fig. Ia). This outgrowth divides by a transverse wall forming an upper initial cell and a basal cell. The initial cell gradually elongates and broadens becoming a club-shaped body (Plate LXXXVI, fig. Ib) containing dense contents. In the developing macrozoosporangia 1 - 8 nucleate stages have been observed (Plate LXXXVI, figs. I - K). These reproductive organs are easily distinguishable when they attain maturity. Each macrozoosporangium produces 8 macrozoospores (Plate LXXXVII, figs. A - D) and each microzooid producing bod~~ies~~y develops 64 microzooids, rarely 48 (Plate LXXXVII, figs. H, I and L). Both types of zooids are biflagellate and pear shaped. The flagella~~e~~ are anterio-laterally attached, with a long anterior flagella and short posterior one. The zooids are liberated apically, laterally or distally in a mucilaginous envelope formed by the rupture of the wall (Plate LXXXVII, figs. C, D, I and L). The macrozoospores liberate one by one into the mucilage envelope. On the dissolution of the envelope the macrozoospores move actively becoming pear-shaped (occasionally tapering at both ends) on liberation measuring 12 - 27 µ x 5 - 12 µ and after a while become rounded measuring 13 - 16 (-20) µ across (Plate LXXXVII, figs. E and F). The anterior flagellum is about 40 µ long and the posterior one is about 27 µ long. Each macrozoospore possesses a crescent-shaped eye spot and a few chromatophores. In some cases one macrozoospore may remain in the sporangium and may germinate in situ (Plate LXXXVII, fig. G).

Microzooids are liberated en mass in the mucilaginous envelope and move actively on the dissolution of the mucilaginous envelope (Plate LXXXVII, figs. I and L). They are 6 - 10 μ x 4 - 6 μ and each microzooid possesses a crescent-shape eye spot and one pale coloured chromatophore. The anterior flagellum measures about 20 μ and posterior one is about 13 μ in length (Plate LXXXVII, fig.J). ~~J and L).~~

Germination.

In culture after swimming for some time macro- and microzooids lose their original shape and become rounded. They become attached on the substratum. Fusion has not been observed although material has been carefully watched on numerous occasions. Microzooids have never been seen to germinate but macrozoospores have been observed germinating in culture media (see page 159) as well as in sporangia. Within two days the macrozoospore puts out a tubular prolongation into which most or all of the contents pass (Plate LXXXVII, fig. N) and the prolongation is cut off by a transverse septum (Plate LXXXVII, fig. O). The increase of contents in the germ tube is followed by the increase in length of the tube and a further transverse division occurs to produce the microscopic filamentous gametophyte (Plate LXXXVII, figs. R - T). Colourless hairs and uniseriate erect reproductive organs develop on the gametophyte within two weeks (Plate LXXXVII , figs. U - W). Reproductive organs produce zooids successively and these zooids are liberated from the apex of the reproductive organ one by one (Plate LXXXVII, fig. W). Each cell produces one zooid which is pyriform, biflagellate and measures about 8 x 6 µ, being similar in form to the macrozoospores. The flagella are laterally attached; the anterior flagellum is long and the posterior one is short. Further development has not been observed.

IV. CYTOLOGICAL STUDIES.

PLATE LXXXVIII

Material fixed in Karpechenko (see page 198) showed mitotic figures. Nuclear divisions were frequently seen in the peripheral cells, paraphyses, apical region and in the macro-zoosporangia. Generally the nucleus is spherical and measures 5 - 7 µ in diameter but the nucleus of the apical cell is about 8 µ across. The resting nuclei in the vegetative parts are about 4 µ across and the nucleolus measures up to 2 µ across. In the nucleus 6 - 11 chromocentres have been observed (Plate LXXXVIII, fig. A).

Chromosomes are crowded and clumped together making the counting difficult. In the peripheral cells at metaphase plate in polar view counts of 30- 40 chromosomes have been made (Plate LXXXVIII, figs. B and C) but at telophase it was difficult to make an accurate count (Plate LXXXVIII, fig. D). In cortical cells, counts of 30 chromosomes were made (Plate LXXXVIII, fig. J).

In paraphyses counts of 20 - 24 chromosomes were made at metaphase plate in polar view (Plate LXXXVIII, figs. E and K), but it was not possible to make counts of chromosomes at the metaphase plate in side view and at anaphase (Plate LXXXVIII, figs. F, G and I). The nucleolus generally disappears at the metaphase stage but may persist a little longer. The nuclear membrane disappears at the late metaphase. The spindle is formed after the disappearance of the nuclear membrane (Plate LXXXVIII, figs. F, G and I). During anaphase two sets of daughter chromosomes move towards the poles and counts of chromosomes could not be made because they form a compact mass (Plate LXXXVIII, fig. I).

In macrozoosporangia different stages of mitosis have been observed and counts of 12 - 15 chromosomes have been made at the metaphase plate in polar view (Plate LXXXVII, fig. H). No counts of chromosomes have been made in microzooid producing bodies, but it is likely that they are haploid.

These data show that reduction division probably occurs in the unilocular macrozoosporangium, as in most brown algae (Fritsch, 1945; 1952. Papenfuss, 1951; 1955, Parke, 1933).

V. DISCUSSION.

The present investigation shows that *Notheia* distinctly differs from the members of the Fucales in the shape, position and segmentation of the apical cells as well as in the formation of unilocular sporangia which produce macro- and microzooids. Reproduction by means of spores does not occur in the Fucales. This shows that *Notheia* is definitely not a member of the Fucales.

Macrozoospores produce a microscopic filamentous gametophyte. Hence *Notheia* possesses an alternation of heteromorphic generations.

The apical cells of *Notheia* divide latero-posteriorly and these segments divide transversely to form axial filaments which lose their identity, becoming compact and forming pseudo-parenchymatous tissues.

Notheia shows similarity with Chordariales (Spermatochnaceae) in apical growth. The apical growth in the Spermatochnaceae is secondary and is derived from a trichothallic mode of growth. *Notheia* also resembles *Splachnidium* in the production of unilocular sporangia in the conceptacles but differs in its two types of sporangia — the macrozoosporangia and the microzooid producing bodies. In *Notheia* these reproductive organs produce 8 macrozoospores and 64 microzooids (very rarely 48) but in *Splachnidium rugosum* the sporangia produce 500 - 600 zoospores in each sporangium.

Notheia shows similarity with *Spermatochnus paradoxus* (Papenfuss, 1935) in the production of a microscopic filamentous gametophyte with the formation of uniseriate reproductive organs producing motile zooids from each cell.

Until the nature of the microzooids and the zooids from the uniseriate gametophytic reproductive organs is known the full life cycle of *Notheia* will remain uncertain.

It seems likely that the macrogametophytes bear uniseriate gametangia producing a single gamete per cell. The behaviour of the microzooids towards these gametes has not yet been observed.

It appears likely the macrozoospores germinate into macrogametophyte largely within the conceptacles, and possibly fertilisation also occurs within the conceptacles, giving rise to a zygote which grows from the wall of the conceptacle. If macrogametophytes develop outside the conceptacles and fertilisation occurs externally, the zygote probably is unable to develop without being associated with Notheia or Hormosira.

Branching occurs largely but not entirely within the conceptacles resulting in a profusely and irregularly branched plant. The branches are constricted within and immediately outside the conceptacle, but broaden outside. These characters are comparable to the proliferations from the wall of the conceptacle in Fucus ceranoides (Skrine et al, 1932). The branches arising from the conceptacle are probably new plants and not real branches as gametophytes have been observed developing within the sporangium in the conceptacle. This would mean that the gametophytic stage of *Notheia* is entirely endophytic within the conceptacles, and that *Notheia* is essentially a simple or occasionally truly branched plant; the normal *Notheia* plant is actually a compound plant, consisting of numerous individuals of possibly several successive generations. Occasional establishment of new *Notheia* plants from *Hormosira* conceptacles might occur by macrozoospores escaping from *Notheia* conceptacles and developing near or inside adjacent *Hormosira* conceptacles, with subsequent fertilisation (?) and development of the zygote within the *Hormosira*.

Brown algae forming zoosporangia normally produce numerous zoospores. The reduction to 8 macrozoospores is noteworthy, as well as the production of two morphologically distinct zoospores. *Notheia* may well indicate the possible origin of the Fucales, since were the macro and microzooids to function as gametes (gametophytes being eliminated) and the apical cells become sunk in a depression, the resultant alga would undoubtedly agree well with the Fucales. It is quite possible that the microgametophyte has been eliminated already, and the microzooids function as male gametes. This however is still speculation and awaits further examination.

The sum of the characters of *Notheia* so expressely excludes it from any existing families that there is no other case open than to establish the family Notheiaceae, under the order Chordariales. The main characters are the presence of three apical cells, production of microzooids and macrozoospores in different reproductive organs which are borne in the same conceptacles.

VI. TAXONOMICAL STUDIES

NOTHEIACEAE Schmidt, 1938.

(a) *NOTHEIA* Harvey and Bailey 1851

Bailey and Harvey 1874: 157. De Toni 1895: 224. Harvey and Bailey 1851: 371. Harvey 1854: 534; 1855: 215. Kjellman 1897: 278. Lucas 1936: 82. May 1939: 206. Svedelius 1911: 179. Tilden 1937: 311.

Plants terete, solid, branched, growing exclusively on *Hormosira banksii* f. *sieberi*. Conceptacles scattered on the axes and the branches, containing micro zooid producing bodies and macrozoosporangia and simple paraphyses. Macrozoosporangium producing 8 biflagellate macrozoospores. Microzooid producing body producing 64 (rarely 48) biflagellate microzooids.

The plant was first collected by the naturalist on "Captain Wilke's Exploring Expedition". Harvey and Bailey described the monotypic species *Notheia anomala* growing on *Hormosira banksii* f. *sieberi* from New Zealand.

(b) *NOTHEIA ANOMALA* Harvey and Bailey 1851.

Bailey and Harvey 1874: 157, t. 9, f. 3 - 6. Barton 1899: 417. De Toni 1895: 224. Gruber 1896: 6. Harvey and Bailey 1851: 371. Harvey 1854: 534; 1855: 216; 1859: 287; 1862: pl. 213: 1863: Synop. 77. Hooker 1864: 653. Kjellman 1891: 280; 1897: 280. Kuetzing 1860: t. 2, f. 2. Laing 1885: 308; 1899: 66; 1927: 142. Lindauer 1947: 563. Lucas 1913: 38; 1936: 82. May 1939: 206. Mitchell 1893: 8. Naylor 1954: 653. Oltmanns 1922: 189, 208. Svedelius 1911: 179. Tilden 1937: 311. Williams 1923: 635. Womersley 1950: 158.

PLATE LXXXIX

Type Locality. — Bay of Islahds, New Zealand.

Type. — TCD.

Plants attached on the surface of *Hormosira banksii* f. *sieberi*. Axis terete, solid, up to 13 cm. long and up to 2 mm. broad with a few true branches, up to 7 cm. long and 1 mm. broad. Conceptacles scattered on the axis and branches, bearing simple paraphyses, protruding through the ostiole, 1 to 3 axes and reproductive organs. Reproductive organs linear-oblong, borne directly on the wall of the conceptacle, measuring 48 - 78 μ x 12 - 30 μ. Macrozoosporangium producing 8 biflagellate macrozoospores, and microzooid producing body produces 64 (rarely 48) microzooids. Both types of reproductive bodies borne in the same conceptacles. Macrozoospores are 12 - 27 μ x 5 - 12 μ and microzooids are 6 - 10 μ x 4 - 6 μ.

Earlier authors describe the linear-oblong bodies as antheridia or oogonia producing many sperms or 8 eggs respectively. Laing (1885) describes the plant as dioecious while Barton (1899) reports it as monoecious with bisexual conceptacles. The present investigation shows that the linear oblong bodies are zoosporangia and not antheridia or oogonia.

SPECIMENS EXAMINED:

W. Aus. — Princess Royal Harbour, near Cape Riche (Harvey, 1854).

S. Aus. — Sceales Bay (Womersley, 11- 2-1954). Elliston (Womersley, 14-1-1951). Fishery Bay (Nizamuddin, February 1959). Sleaford Bay (Nizamuddin, February 1959). Petrel Cove, near Bluff, Victor Harbour (Nizamuddin, 7-3-1959). Encounter Bay (Womersley, 4-6-1943. Cleland Harris, May 1943). Ocean Beach, Robe (Nizamuddin, 18-8-1957). Robe, near the slipway (Nizamuddin, 17-4-1959). Kangaroo Island.— Vivonne Bay (Womersley, 2-1-1949). Pennington Bay (Womersley, 12-1-1944; 17-1-1944, 28-1-1944, 28-1-1944. Schodde, February 1956. Nizamuddin, January 1957).

Victoria. — Bridgewater Bay (Beauglehole, 5-6-1949 and 13-1-1954). Portland Bay (Muir, January 1950).

Tasmania. — Port Arthur (Cribb, 6-3-1950).

New Soyth Wales. — Twofold Bay (Lucas, 1913). Long Reef, Crookhaven Head, Newcastle, Port Stephens (in May, 1939).

GEOGRAPHICAL DISTRIBUTION:

From Princess Royal Harbour, King George Sound, W. Aus., along south and south-east coast to Port Stephens, N.S.W.; at Port Arthur, south Tasmania and at New Zealand.

Notheia anomala grows exclusively on *Hormosira banksii* f. *sieberi* on rough coasts of Southern Australia and New Zealand and appears to be more plentiful on male plants of *Hormosira* than on female ones. *Notheia anomala* is monotypic and endemic.

VII. SUMMARY.

The anatomy, development and taxonomy of *Notheia anomala* are described and discussed in detail. Growth is initiated by means of a group of 3 apical cells. The tissues —— the peripheral layer, cortex and medulla —— are formed by the segmentation of the apical cells. Dichotomous branching of the peripheral and outer cortical cells occurs.

The development of the conceptacles is initiated by a peripheral cell near the apex. The tongue cell of the conceptacle initial forms a uniseriate hair.

Microzooid producing bodies and macro-zoosporangia develop in the same conceptacles, producing 64 and 8 biflagellate zooids respectively. Each zooid produces long anterior and short posterior flagellae, attached anteriolaterally.

Macrozoospores germinate in culture media as well as in sporangia. Microzooids have not been observed germinating. Germinating macrozoospores produce gametophytes liberating zooids successively from the apex of the reproductive organ one by one.

In the peripheral cells, cortical cells and the paraphyses respectively counts of 30 - 40 and 20 - 24 chromosomes have been made. In macrozoosporangia counts of 12 - 15 chromosomes have been made. Reduction probably occurs in the unilocular macrozoosporangia.

Notheia anomala grows exclusively on Hormosira banksii fi. sieberi along the Southern Australian and New Zealand coasts. True branching occurs and is reported for the first time. Plants also develop from the conceptacles on the axis of Notheia.

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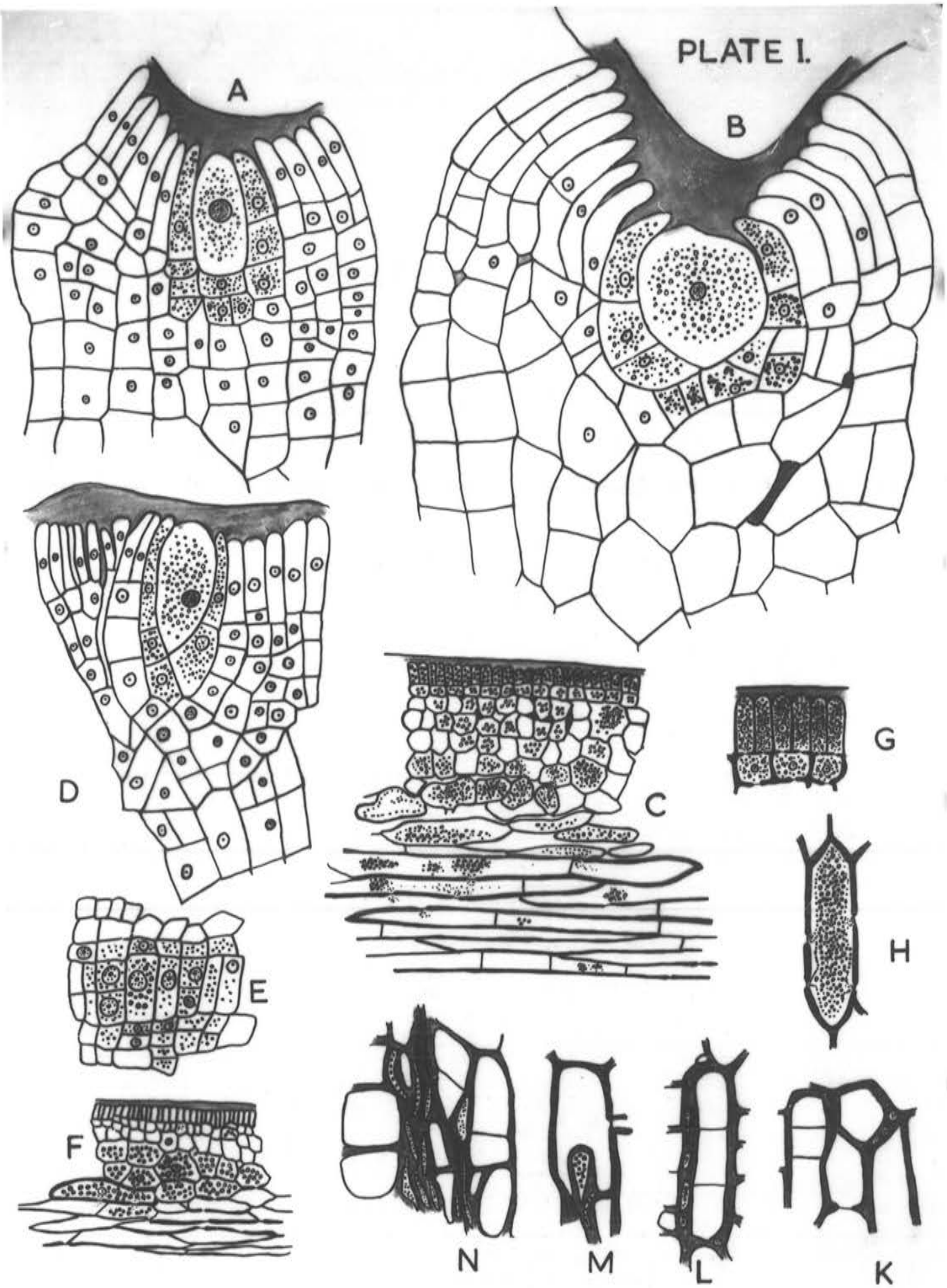
PHYLLOSPORA COMOSA.

PLATE I

Fig. A.	L.S. parallel to the flat surface of the ciliary process at the apex showing the apical cell	X 455
B.	LS. perpendicular to the flat surface of the axis at the apex showing apical cell	X 455
C.	L.S. perpendicular to the axis showing tissues and pit connections...	X 110
D.	L.B. perpendicular to the flat surface of the ciliary process at the apex showing apical cell ...	X 455
E.	T.S. at the apex of ciliary process showing apical cell ...	X 455
F.	L.S. perpendicular to the flat surface of a leafy lateral showing tissues and pit connections ...	X 110
G.	Meristoderm cells and basal cells showing pit connections.	X 330
H.	A cortical cell showing dense contents, pit connections and lamellations...	X 760
K - N.	Hyphal Development.. ...	X 450

PLATE I.

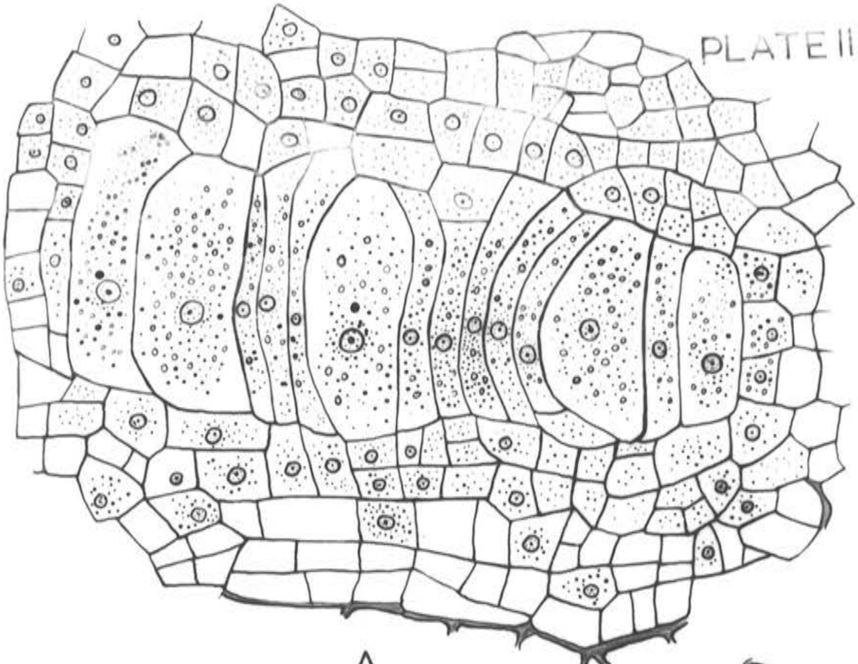


PHYLLOSPORA COMOSA.

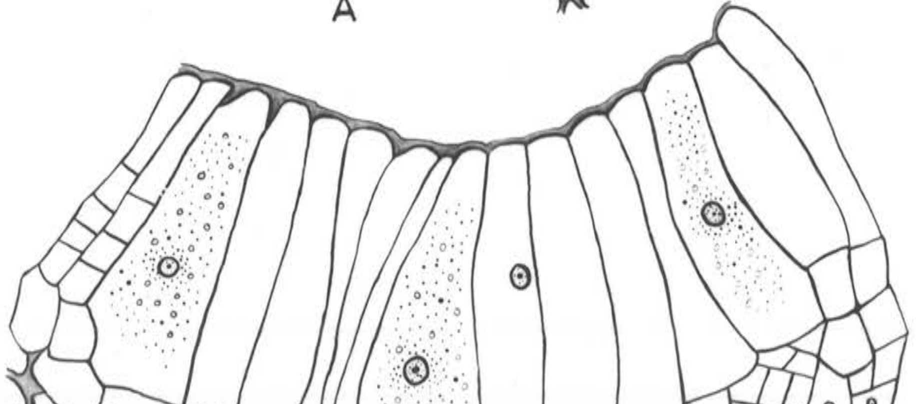
PLATE II

Fig. A.	T.S. at the apex of an axis showing apical cells... ... ... X 415
B.	L.S. parallel to the flat surface of an axis at the apex showing apical cells ... ... X 415

PLATE II.



A



B

PHYLLOSPORA COMOSA.

PLATE III

Fig. A. T.S. of a receptacle showing tissues X 87

B. L.S. of a female receptacle showing tissues, scalariform thickening and pit connections... ... ... X 87

C. L.S. of a medullary cell showing scalariform thickening. ... ... X 364

D. Development of antheridia... ... X 364

- (a) An outgrowth from the lining cell of the conceptacle.
- (b) First transverse division of the outgrowth forming antheridium and basal cell.
- (c) A young antheridium.
- (d) Two-nucleate antheridium.
- (e) Four-nucleate antheridium.
- (f) Eight-nucleate antheridium.
- (g) Sixteen-nucleate antheridium.
- (h) A mature antheridium with a stalk.

E. Tuft of antheridial hairs... ... X 364

F- L. Development of oogonia... .. ... X 364

F and G. Oogonial initials... ... .

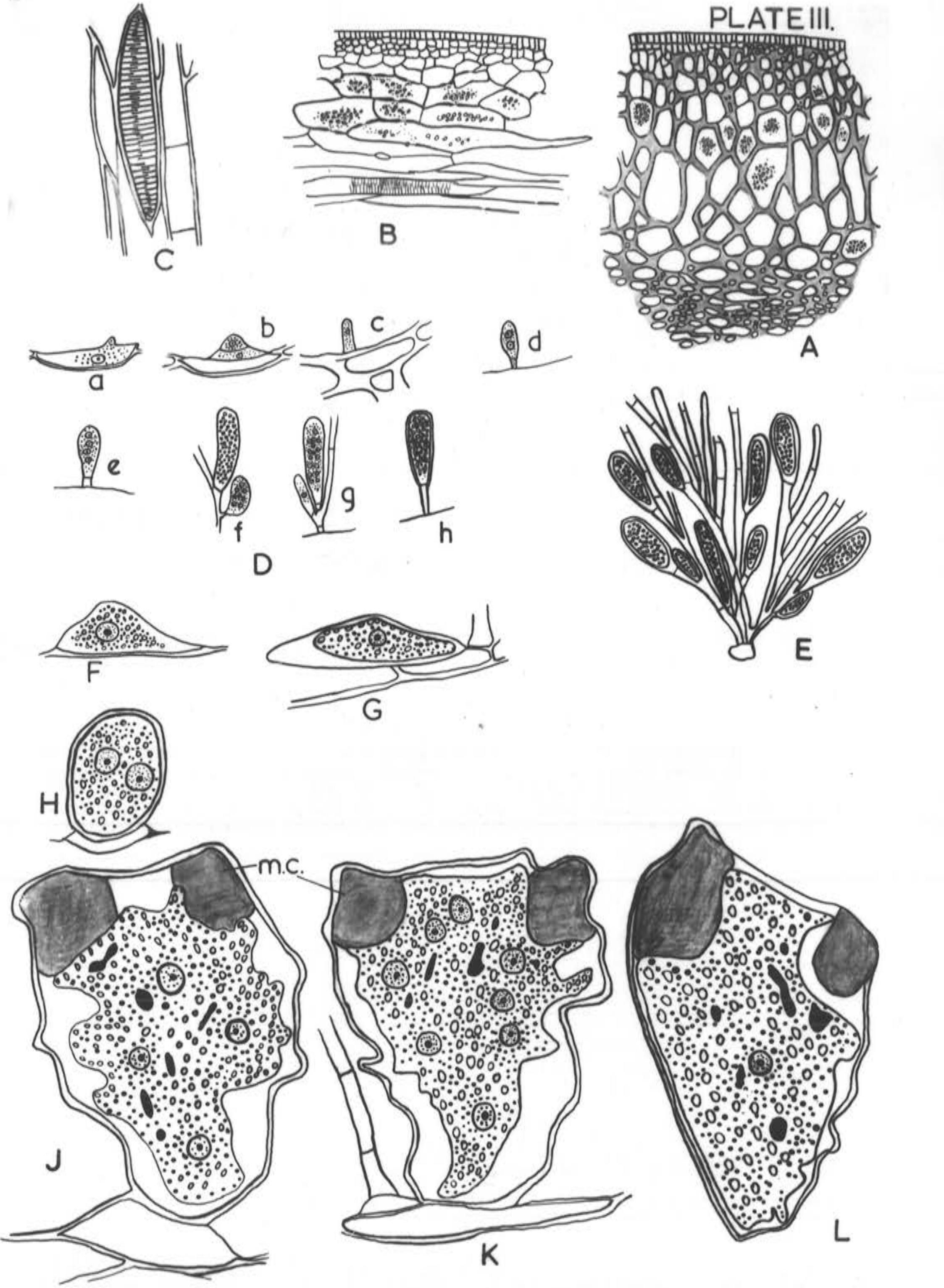
H. Two nucleate oogonium.... .. ...

J. Four-nucleate oogonium with mesochiton collar.

K. Eight-nucleate oogonium with mesochiton. collar.

L. A mature oogonium with mesochiton collar, showing two walls only.

PLATE III.



SEIROCOCCUS AXILLARIS

PLATE IV.

Fig. A.	L.S. parallel to the flat surface of an axis at the apex showing apical cell, lateral initial and mucilage...	X 300
B.	L.S. parallel to the flat srface of an axis at the apex showing round apical disc (d) and 2 apical cells, one on either side of the disc.....	X 75
C.	L.S. perpendicular to the flat surface at the apex showing apical cell...	X 300
D.	T.S. at the apex of an axis showing apical cell and its segments...	X 300
E.	L.S. perpendicular to the flat surface of the axis showing tissues and mucilage...	X 75
F.	T.S. of the axis showing tissues	X 75
G.	Development of hyphae....	X 75
H.	T.S. of a stipe showing tissues and hyphae	X 75
I.	L.S. perpendicular to the flat surface of a leafy lateral showing tissues and pit connections	X 75

Fig. J. T.S. of a leafy lateral showing tissues... ... ... X 75.

K. Development of antheridia X 300

- (a) An outgrowth.
- (b) Antheridium proper and stalk cell.
- (c) Two-nucleate antheridium.
- (d) Four-nucleate antheridium.
- (e) Eight-nucleate antheridium.
- (f) Thirtytwo-nucleate antheridium and empty ones.
- (g) Sixty four-nucleate antheridium and mature ones on branched hairs.

L - Q. Development of oogonia .... X 300

L Oogonial initial.

M. Young oogonium.

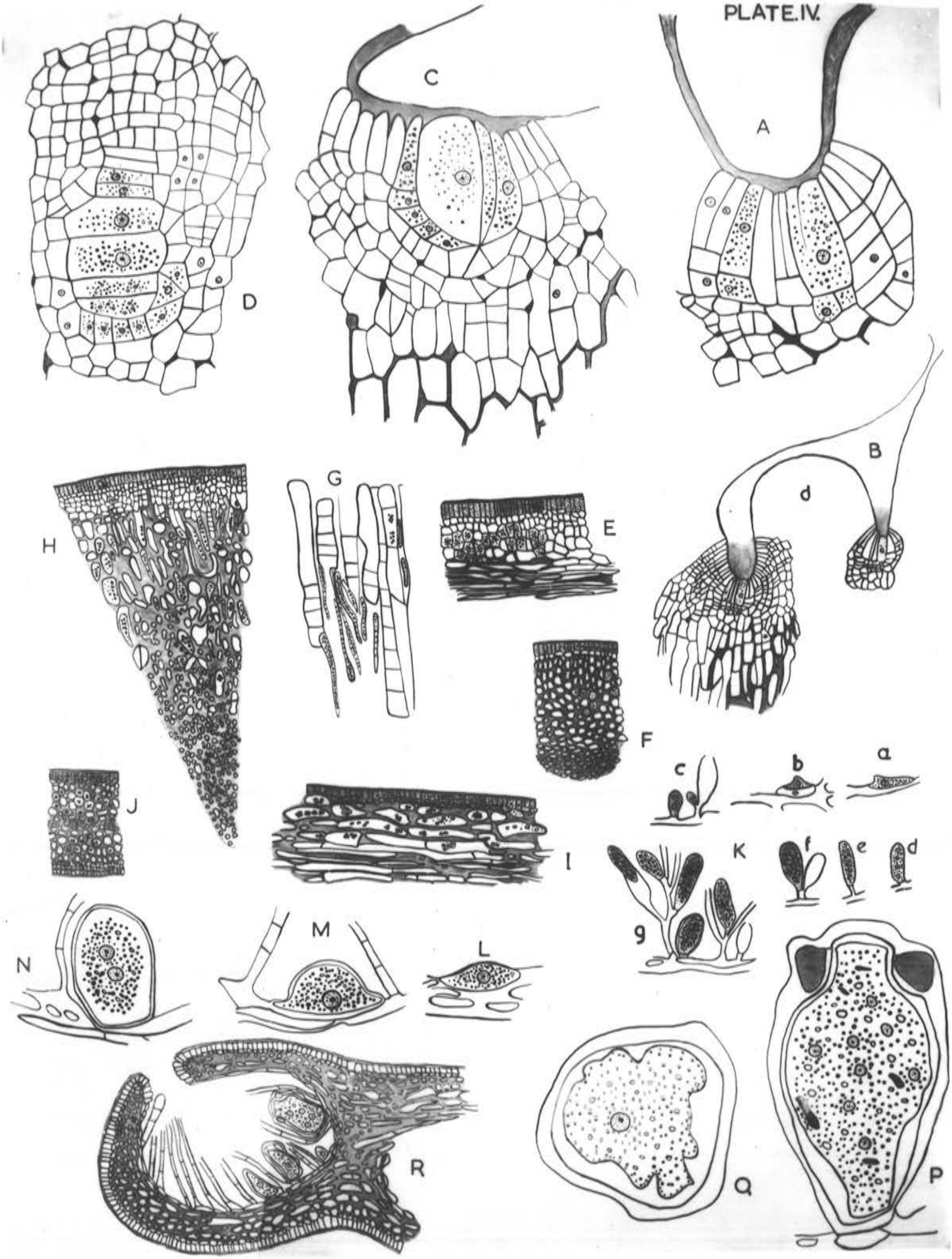
N. Two-nucleate oogonium.

P. Eight-nucleate oogonium with mesochiton collar, showing two walls only.

Q. An egg.

R. T.S. of a receptacle showing oogonia, simple paraphyses and tissues... X 75

PLATE. IV.



SCYTOTHALIA DORYCARPA.

PLATE V

Fig. A.	L.S. parallel to the flat surface of an axis at the apex showing round apical disc (d) and two apical cells one on either side of the disc	X 26
B.	L.S. parallel to the flat surface of an axis at the apex showing apical cell...	X 260
C.	L.S. perpendicular to the axis at the apex showing apical cell...	X 260
D.	T.S. at the apex of an axis showing apical cell.	X 260
E.	L.S. parallel to the flat surface of an axis at the apex showing lateral initial...	X 260
F.	T.S. at the apex of a lateral showing apical cell	X 260
G.	L.S. perpendicular to the flat surface of an axis showing tissues and pit-connections.	X 75
H.	T.S. near the apex of an axis showint tissues.....	X 75

Fig. J. L.S. parallel to the flat surface of a receptacle at the apex showing an apical cell... ... ... X 260

K. L.S. parallel to the flat surface of an axis passing through the axil showing apical cell of receptacle.. ... X 260

L. T.S. at the apex of a receptacle showing apical cell. ... ... X 260

M. T.S. passing through the sterile part of a receptacle showing tissues ... X 75

N. L.S. of a mature receptacle showing tissues and pit connections... ... ... X 75

P. T.S. of a mature receptacle showing tissues... . ... X 75

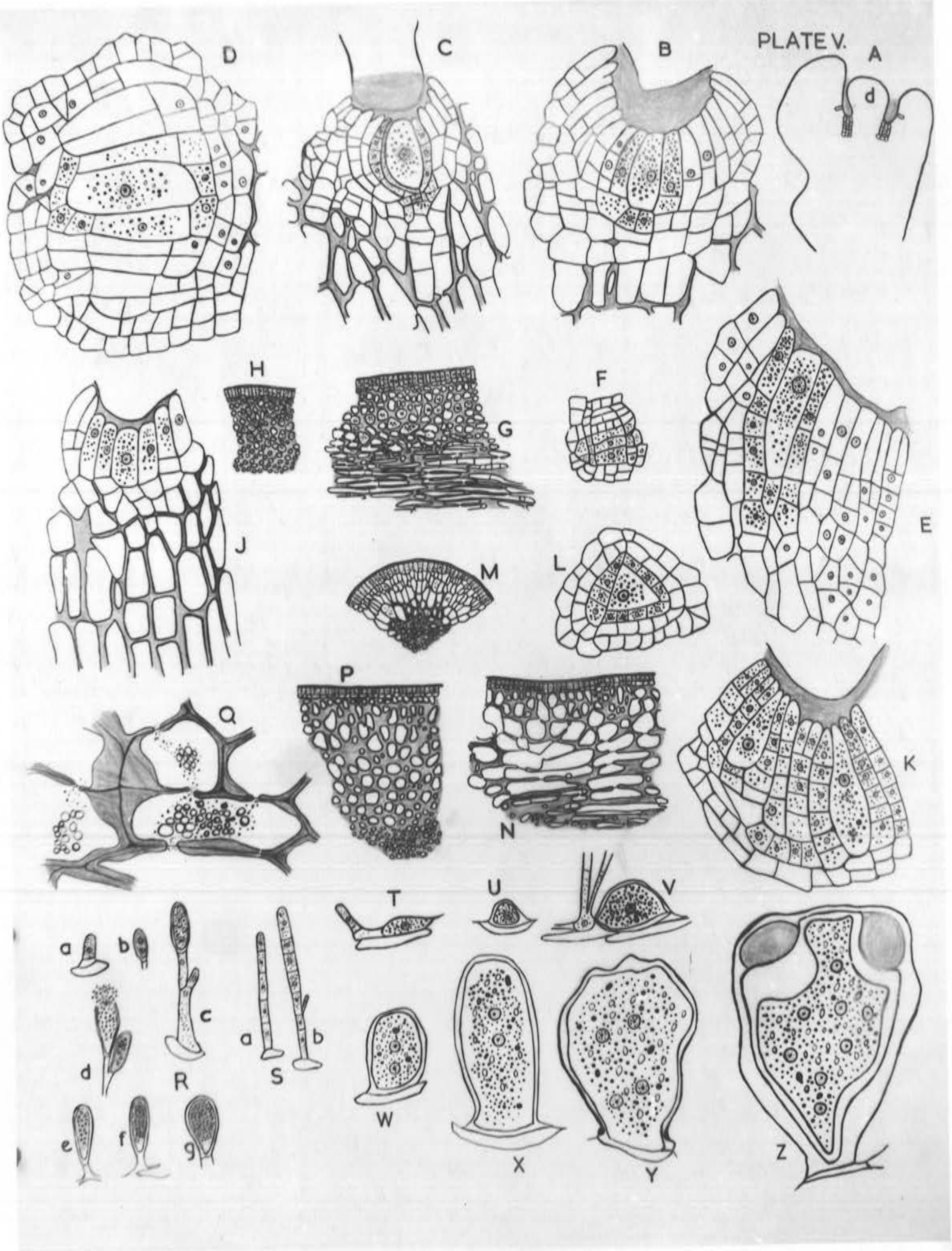
Q. Cortical cells of a female receptacle showing pit connections, lamellations, mucilage and storage material... X 260

R. Development of antheridia.. ... X 260

- (a). Young antheridium.
- (b) Two-nucleate antheridium.
- (c) Showing uninucleate and four-nucleate antheridia on hairs.
- (d) Showing eight-nucleate antheridium and extrusion of sperms.

Fig. R. (e) Sixteen-nucleate antheridium.
(f) Thirty-two nucleate antheridium.
(g) Sixty-four nucleate antheridium.
S. Simple and branched paraphyses... X 260
T - Z. Development of oogonium... . .... X 260
T. Oogonial initial.
U and V. Young oogonia.
W and X. Two-nucleate oogonia.
Y. Four-nucleate oogonium.
Z. Eight-nucleate oogonium with mesochiton collar, showing two walls only.

PLATE V.



XIPHOPHORA CHONDROPHYLLA

PLATE VI

Figs. A. L.S. parallel to the flat surface of an axis at the apex showing apical cell... ... ... X 260

B; L.S. perpendicular to the flat surface of an axis at the apex showing apical cell. ... ... X 260

C. T.S. at the apex of an axis showing apical cell. ... ... X 260

D. L.S. perpendicular to the flat surface of a segment showing tissues X 60

E. T.S. of a segment showing different tissues... . ... X 60

F. T.S. of the basal part of an axis showing tissues, hyphae and pit connections. ... ... X 60

G. L.S. perpendicular to the flat surface of an axis at the basal part showing tissues, hyphae (h) and pit connections ... ... X 60

I -J. Development and lateral connections of hyphae... ... ... X 60

K. Cortical cells showing pit connections and lamella. ... ... X 260

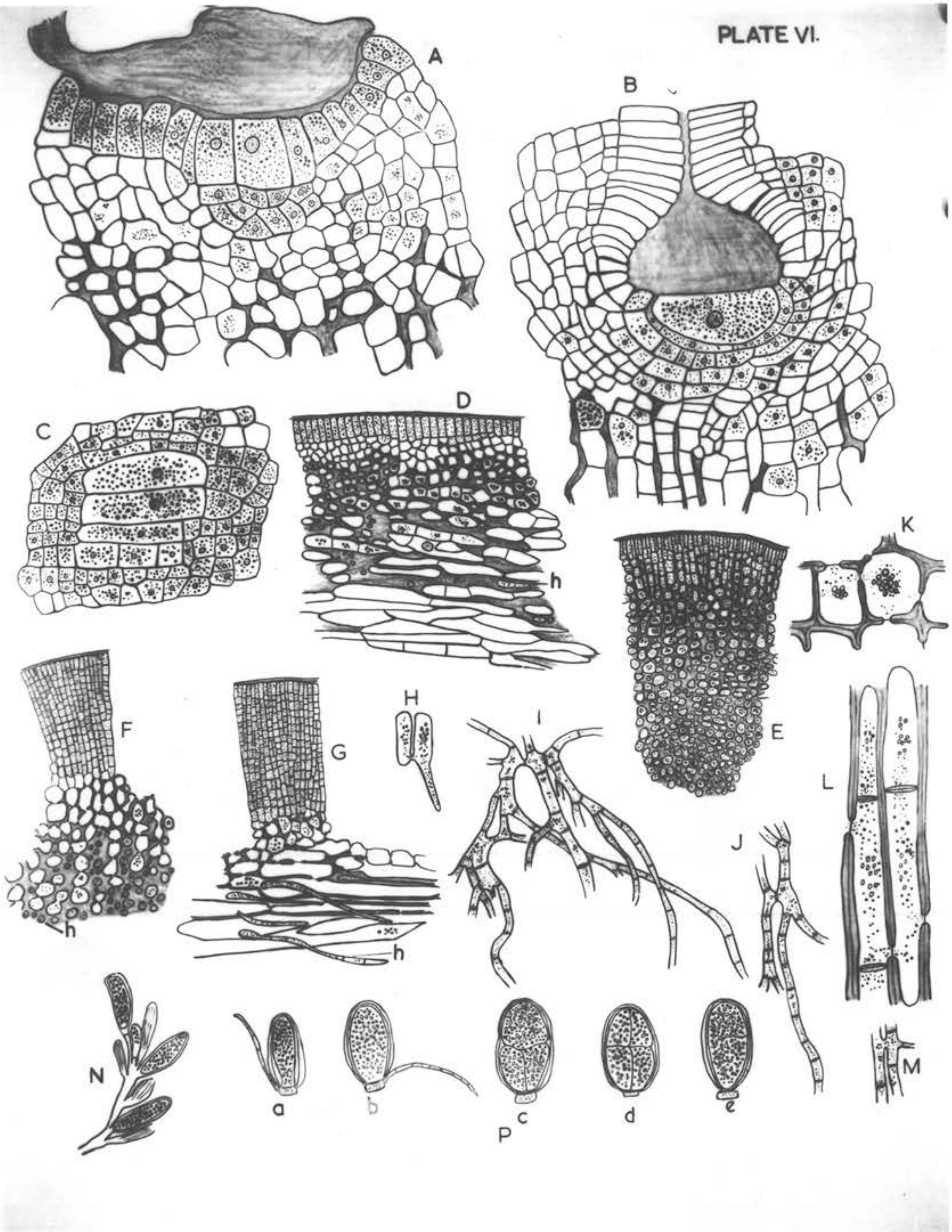
Figs. L. Medullary cells showing pit and cytoplasmic connections... ... X 260

H and M. Medullary cells showing lateral connections... .. ... X 60

N. Antheridia on branched hairs X 260

P. Different stages of oogonia showing stalk ~~showing~~ and two walls only X 60

PLATE VI.



XIPHOPHORA GLADIATA.

PLATE VII

Figs. A. L.S. parallel to the flat surface of an axis at the apex showing apical cell X 260

B. L.S. perpendicular to the flat surface of an axis at the apex showing apical cell... ... ... X 260

C. T.S. at the apex of an axis showing apical cell. ... ... X 260

D. L.S. perpendicular to the flat surface of a segment showing tissues and pit connections. ... ... X 60

E. T.S. of a segment showing tissues X 60

F. T.S. of the basal part of an axis showing tissues and hyphae ... ... X 60

G. L.S. perpendicular to the flat surface of an axis at the basal part showing tissues, hyphae and pit connections... ... X 260

H. Cortical cell showing dichotomy and pit connections... ... . X 260

I. Medullary cells showing branched hyphae..X.60.

J. Medullary cells showing lateral connections and cytoplasmic connections with perforated septa... ... ... X 260

K. Antheridia on branched hairs. ... X 260

L. Different stages of oogonia. ... X 60

(a) and (b) Young oogonium.

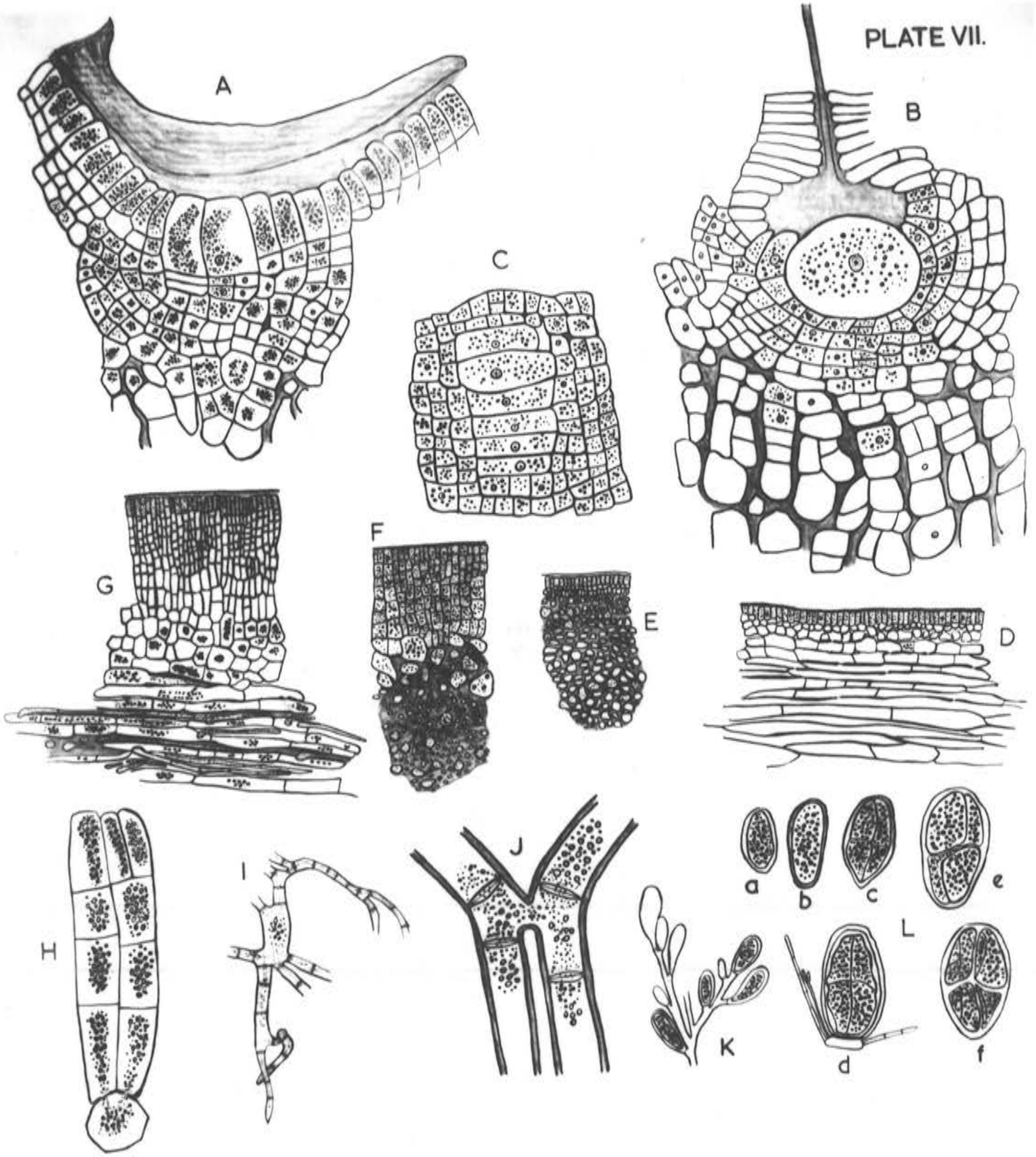
(c) Oogonia showing 4 compartments.

(d) Oogonium with stalk and paraphyses, showing two walls only.

(d) Oogonia containing 4 eggs.

(e) and (f) Oogonium with 4 eggs.

PLATE VII.



CYSTOPHORA.

PLATE VIII

. . . X 230

Figs. A. L.S. to the apex of the axis of *C. paniculata* showing apical cell ~~X 230~~

B. T.S. at the apex of the axis of *C. paniculata* showing apical cell.

C. L.S. to the apex of the axis of *C. moniliformis* showing apical cell

D. T.S. at the apex of the axis of *C. moniliformis* showing apical cell.

E. T.S. at the apex of the axis of *C. xiphocarpa* showing apical cell.

F. L.S. to the apex of the axis of *C. xiphocarpa* showing apical cell.

G. L.S. to the apex of the axis of *C. siliquosa* showing apical cell.

H. T.S. at the apex of the axis of *C. siliquosa* showing apical cell.

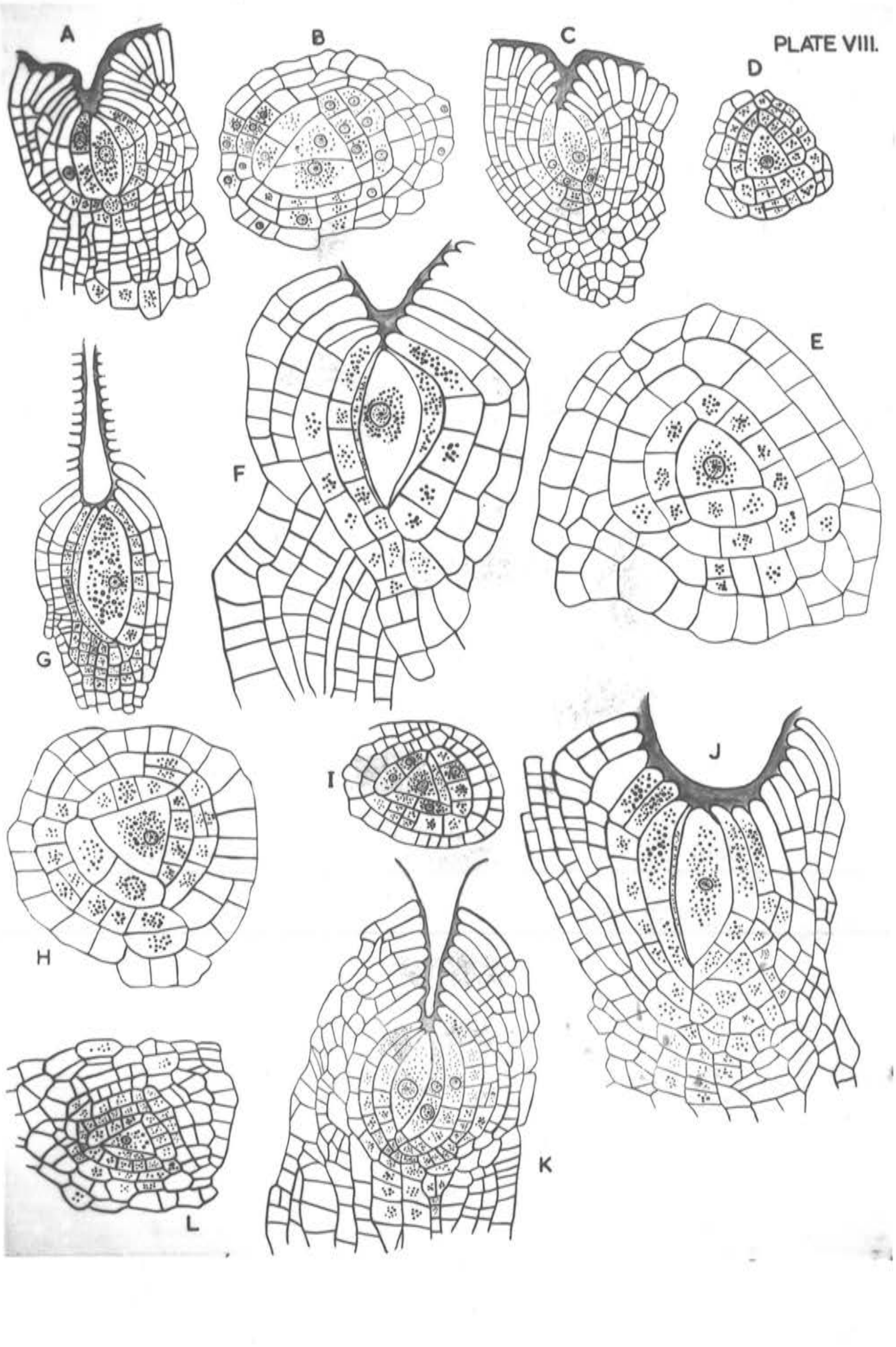
I. T.S. at the apex of the axis of *C. cuspidata* showing apical cell.

J. L.S. to the apex of the axis of *C. cuspidata* showing apical cell.

Fig. K. L.S. to the apex of the axis of C. racemosa showing apical cell.

L. T.S. at the apex of the axis of C. racemosa showing apical cell.

PLATE VIII.



CYSTOPHORA

PLATE IX X 300

Figs. A – F . . . .

Figs. A. L.S. to the apex of the axis of *C. retorta* showing apical cell.

B. T.S. at the apex of the axis of *C. retorta* showing apical cell.

C. T.S. at the apex of the axis of *C. polycystidea* showing apical cell.

D. L.S. to the apex of the axis of *C. polycystidea* showing apical cell.

E. T.S. at the apex of the axis of *C. botryocystis* showing apical cell.

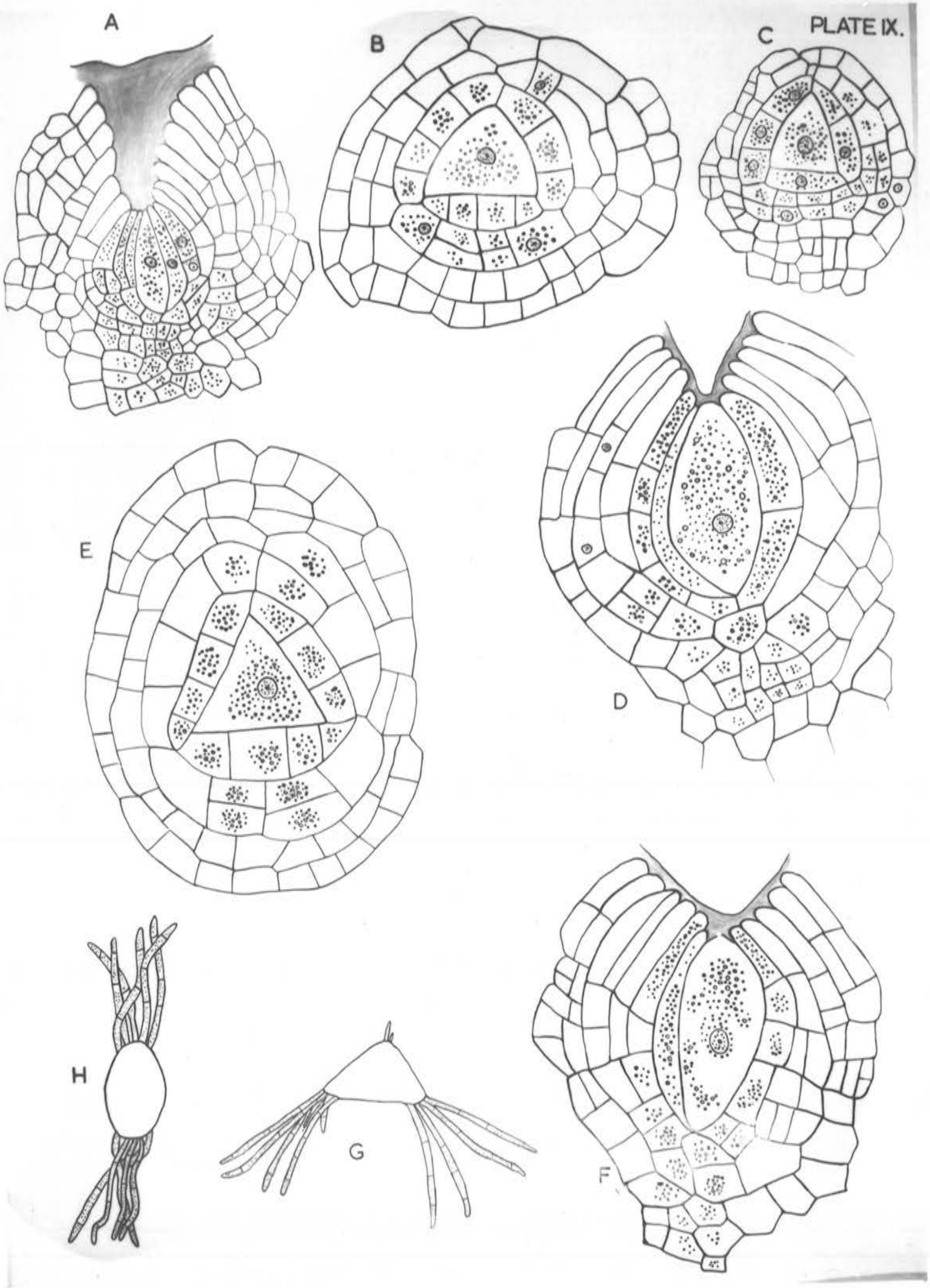
F. L.S. to the apex of the axis of *C. botryocystis* showing apical cell.

G. and H. Double embryo of *C. subfarcinata*. X 75

G. Showing rhizoids at both ends.

H. Showing apical hairs and rhizoids.

PLATE IX.



CYSTOPHORA

PLATE X

Figs. A. L.S. to the apex of the axis of *C. uvifera* showing apical cell and lateral initials... ... ... X 125

B. T.S. at the apex of *C. uvifera* showing apical cell ... ... X 125

C. L.S. to the apex of *C. cephalornithos* showing apical cell.. ... ... X 100

D. T.S. at the apex of *C. cephalornithos* showing apical cell.. ... ... X 100

E. T.S. of the receptacle of *C. uvifera* showing tissues... . ... X 100

F. L.S. of the receptacle of *C. uvifera* showing tissues... .. . . X 100

G. Meristoderm cell in the receptacle of *C. uvifera*.... .. . . X 450

H. T.S. of receptacle of *C. uvifera* showing reproductive bodies . ... X 120

I. Development of hyphae in *C. uvifera* X 100

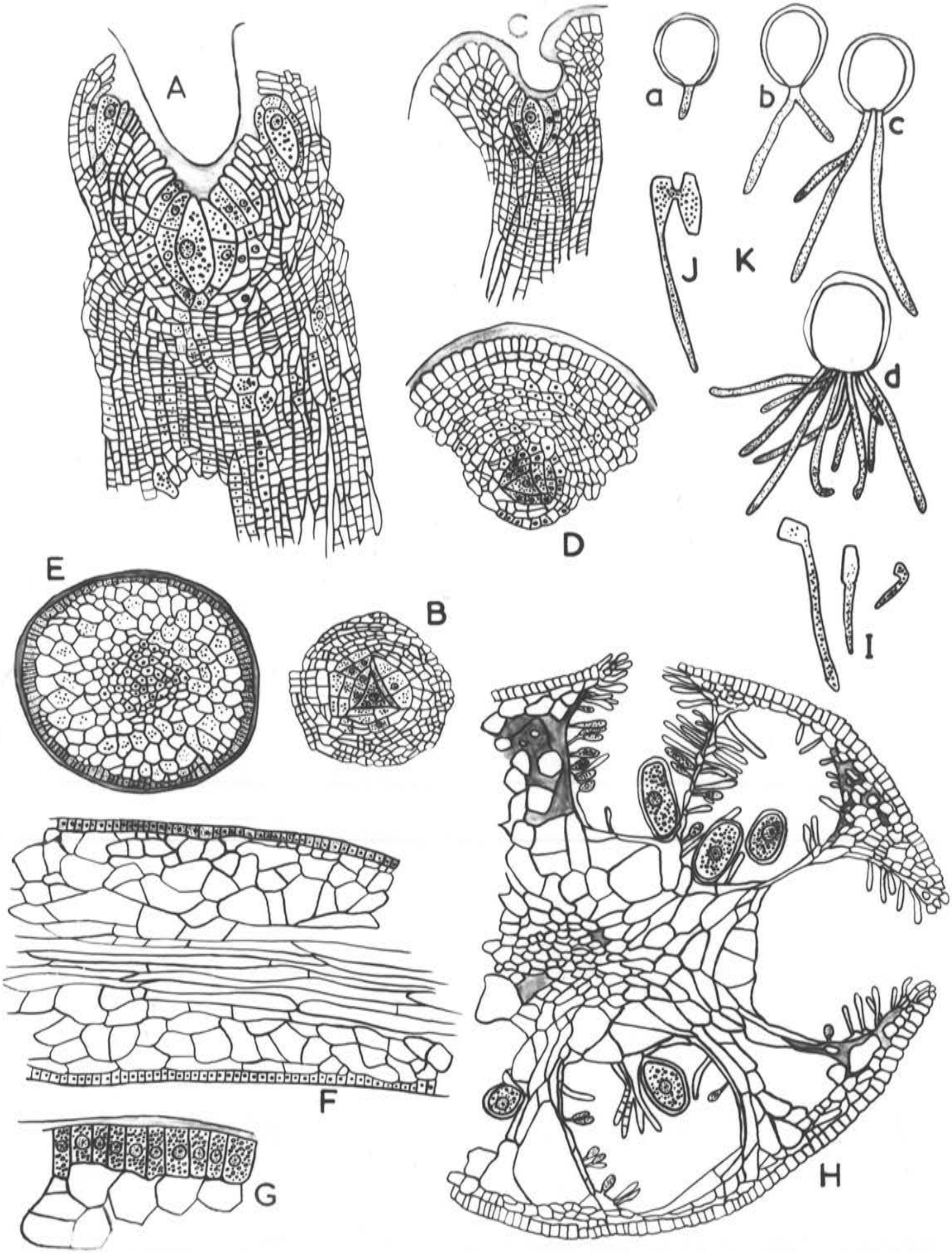
J. Medullary cells showing lateral connections and hyphae in *C. uvifera*.. X 100

K. Embryo development of *C. uvifera* X 80

(a) 4 days old embryo.

(b) - (d) 18 days old embryo.

PLATE X.



CYSTOPHORA UVIFERA.

PLATE XI

Figs. A. L.S. to the apex of a receptacle showing apical cell... ... ... X 230

B. T.S. at the apex of a receptacle showing apical cell ... ... X 230

C — I. Development of conceptacles X 230

C. Conceptacle initial.

D. First transverse division of conceptacle initial forming tongue cell and basal cell.

E. First longitudinal division of basal cell~~s~~.

F. Further division of basal cell.

G. Divisions of basal cell and transverse division of tongue cell.

H. Lining cells of the conceptacle and uniseriate hair.

I. Uniseriate hairs in the conceptacles.

J. A simple paraphysis... ... . X 230

K. Development of antheridia.. . X 230

- (a) Papilla from wall cell of the conceptacle.
- (b) Young antheridium.

Fig. K. (c) Uninucleate antheridium with basal cell... ... ... X 230

(d) Two nucleate antheridium.

(e) Four nucleate antheridium.

(f) Eight nucleate antheridium.

(g) Sixteen nucleate antheridium.

(h) Thirty two nucleate antheridium.

(i) Sixty four nucleate antheridium.

L — P. Development of oogonia... ... X 230

L. Oogonium initial.

M. Transverse division of oogonium initial.

N. Uninucleate young oogonium.

P. Two nucleate oogonium.

Q. Four nucleate oogonium.

R. A mature oogonium with a nucleus showing 2 nucleoli ~~showing~~ and two walls only... X 160

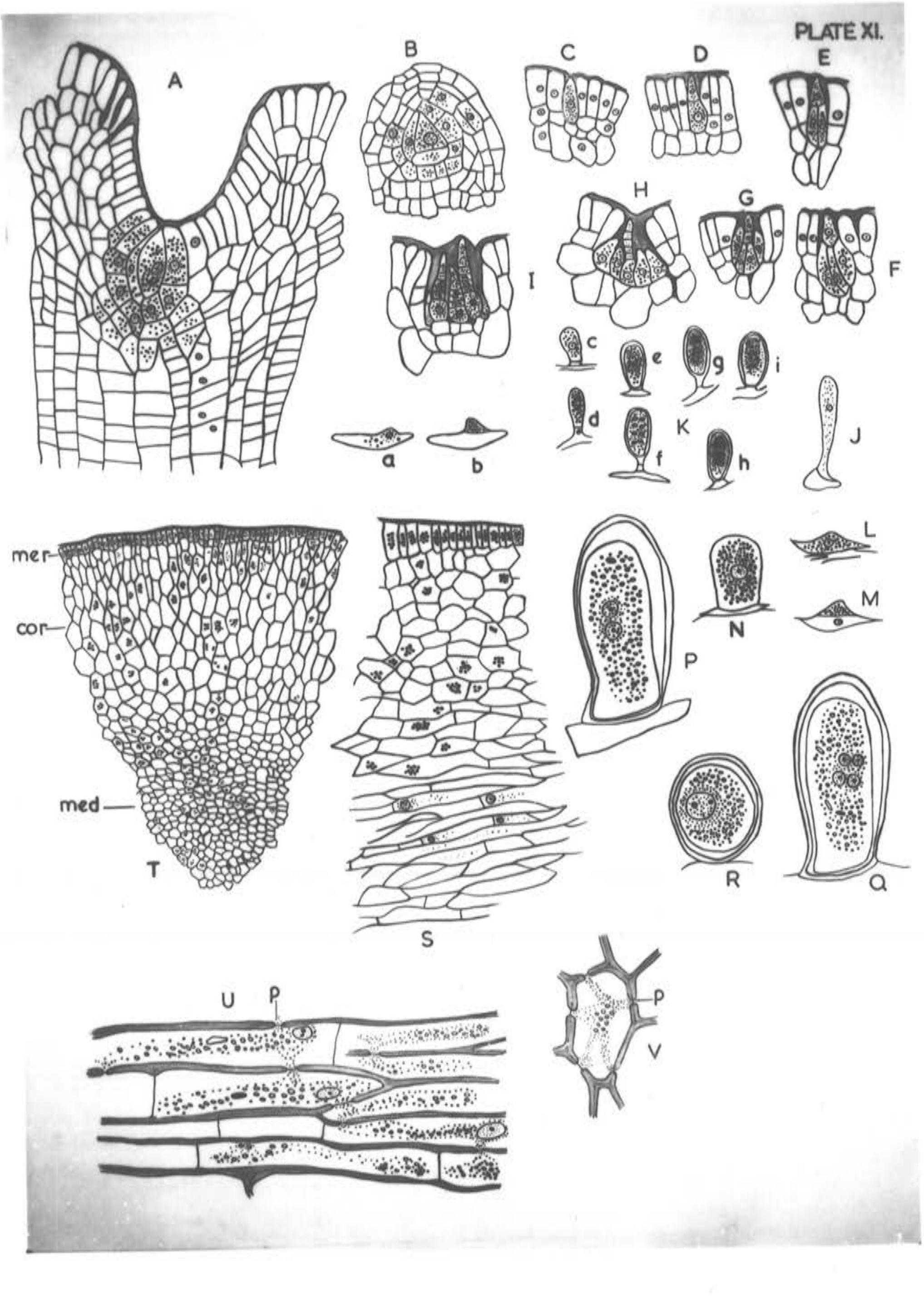
S. L.S. of the axis showing tissues.. X 55

T. T.S. of the axis showing tissues X 55

U. Medullary cells showing lamellae and pit connections... ... ... X 230

V. Cortical cell showing lamellae and pit connections... ... ... X 230

PLATE XI.

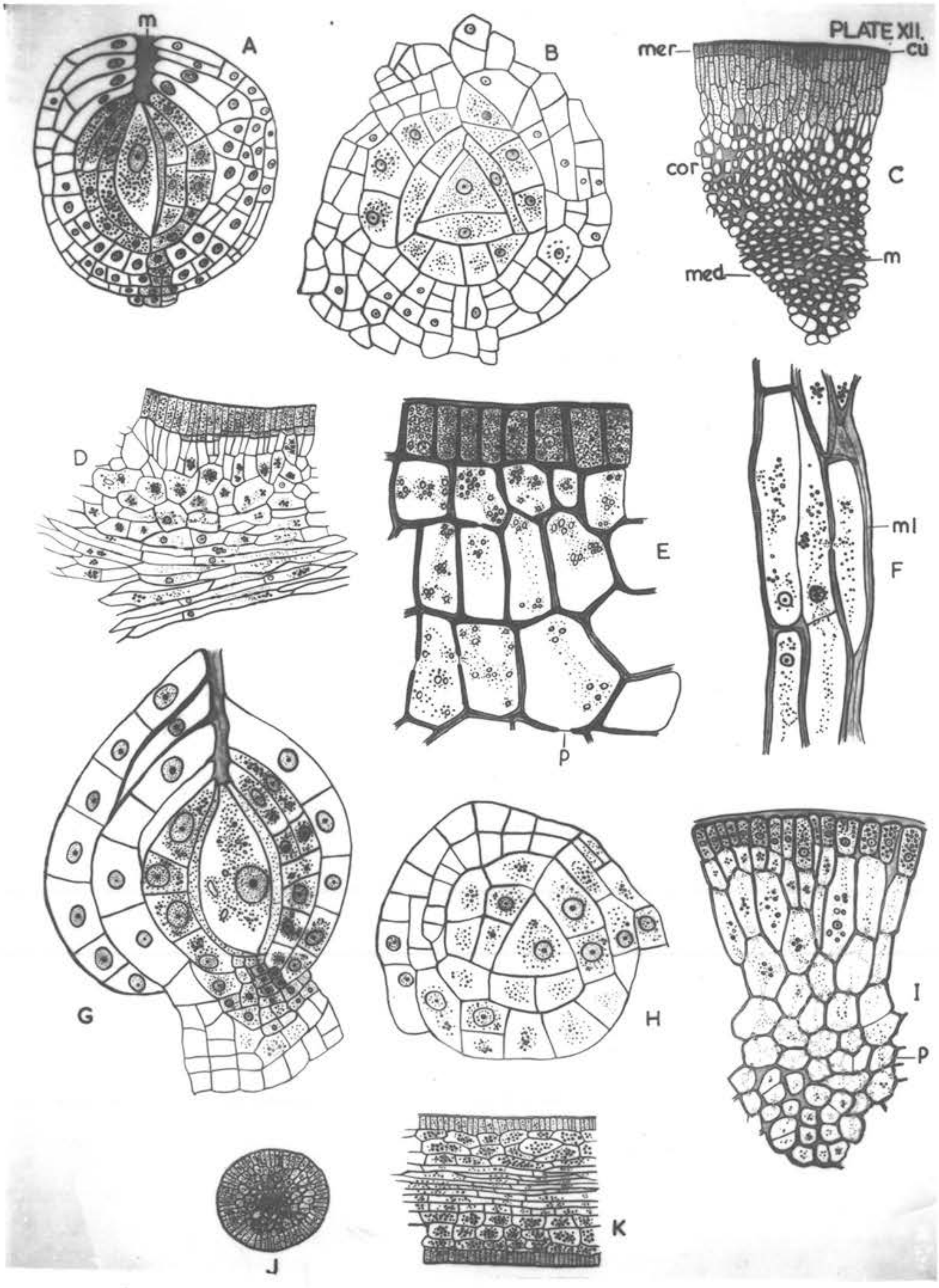


CYSTOPHORA SUBFARCINATA.

PLATE XII

Figs. A.	L.S. to the apex of the axis showing apical cell	X 230
B.	T.S. at the apex of the axis showing apical cell	X 230
C.	T.S. of an axis showing tissues	X 55
D.	L.S. of an axis showing tissues and pit connections	X 55
E.	L.S. of an axis showing meristoderm, cortex and pit connections and lamellae	X 230
F.	Medullary cells showing pit connections and lamellae	X 230
G.	L.S. to the apex of a receptacle showing apical cell	X 500
H.	T.S. at the apex of a receptacle showing apical cell	X 500
I.	T.S. of an awn of a receptacle~~s~~ showing tissues.	X 230
J.	T.S. of a stalk of a receptacle showing tissues	X 55
K.	L.S. of a sterile stalk of a receptacle showing tissues	X 55

PLATE XII.



CYSTOPHORA SUBFARCINATA

PLATE XIII.

Figs. A. T.S. of a receptacle showing reproductive organs and tissues... ... ... X 100

B. Cortical cell of a receptacle showing pit connections and lamellae.. ... X 570

C. Development of conceptacles.... X 300

- (a) Conceptacle initial.
- (b) T.S. of the basal cell of the conceptacle initial.
- (c) First division of the conceptacle initial showing tongue and basal cell.
- (d) Divisions of basal cell and elongation of tongue cell.
- (e) and (f). Further divisions of basal cells and tongue cells.
- (g) and (h) T.S. of conceptacle initial showing tongue cell at the centre.
- (i) T.S. of the conceptacle above the tongue cell showing cavity.
- (j) An empty conceptacle.

Fig. D. Development of oogonia... ... X 200

(a) A papillar outgrowth from the lining cell of a conceptacle.

(b) Oogonial initial.

(c) A young oogonium.

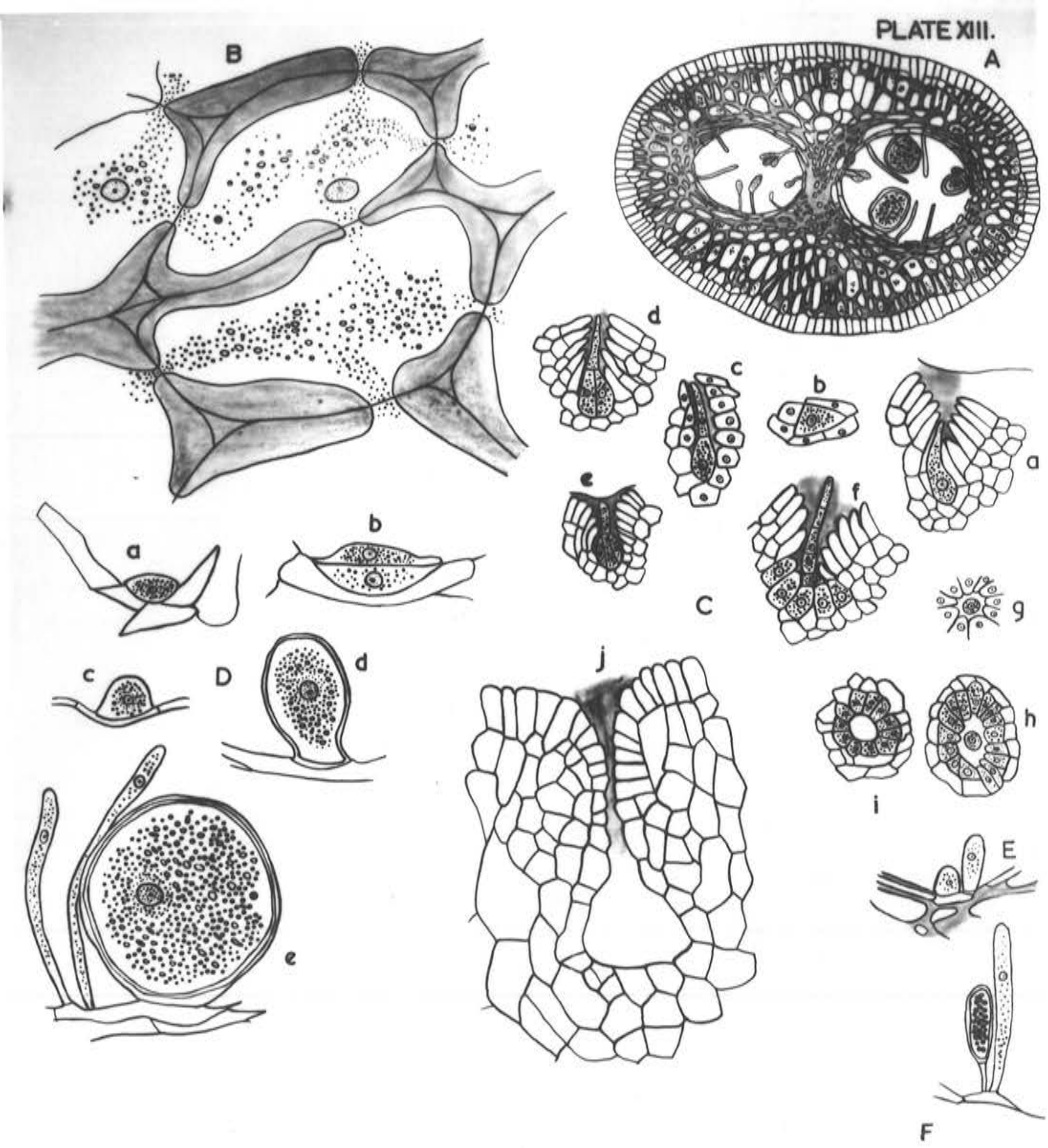
(d) An oogonium.

(e) A mature oogonium and paraphyses, showing two oogonial walls only.

Eq A young simple paraphysis..... X 260

F. A mature antheridium and paraphysis... ... ... X 260

PLATE XIII.



EMBRYOLOGICAL DEVELOPMENT OF CYSTOPHORA SUBFARCINATA

PLATE XIV

Figs. A - Q... ... ... X 120

A. An egg.

B. A zygote, showing polarity.

C. First transverse division of a zygote.

D. Second transverse division in the lower segment forming rhizoid initial.

E. Vertical division in the uppermost segment.

F. Vertical division in the middle segment and formation of two rhizoids by longitudinal division of rhizoid initial.

G. An embryo with two rhizoids.

H. Ellipsoidal zygote.

I. Transverse division of the zygote.

J. Rhizoid cell formation at each end.

K. Two days old embryo with four rhizoids.

L. Three days old embryo showing apical groove and septate rhizoid.

M. Emrbyo with 2 apical hairs and mucilage membrane on one side.

N. Embryo with four apical hairs, and mucilage membrane on one side.

P. A hair developed on one side of the body of the embryo.

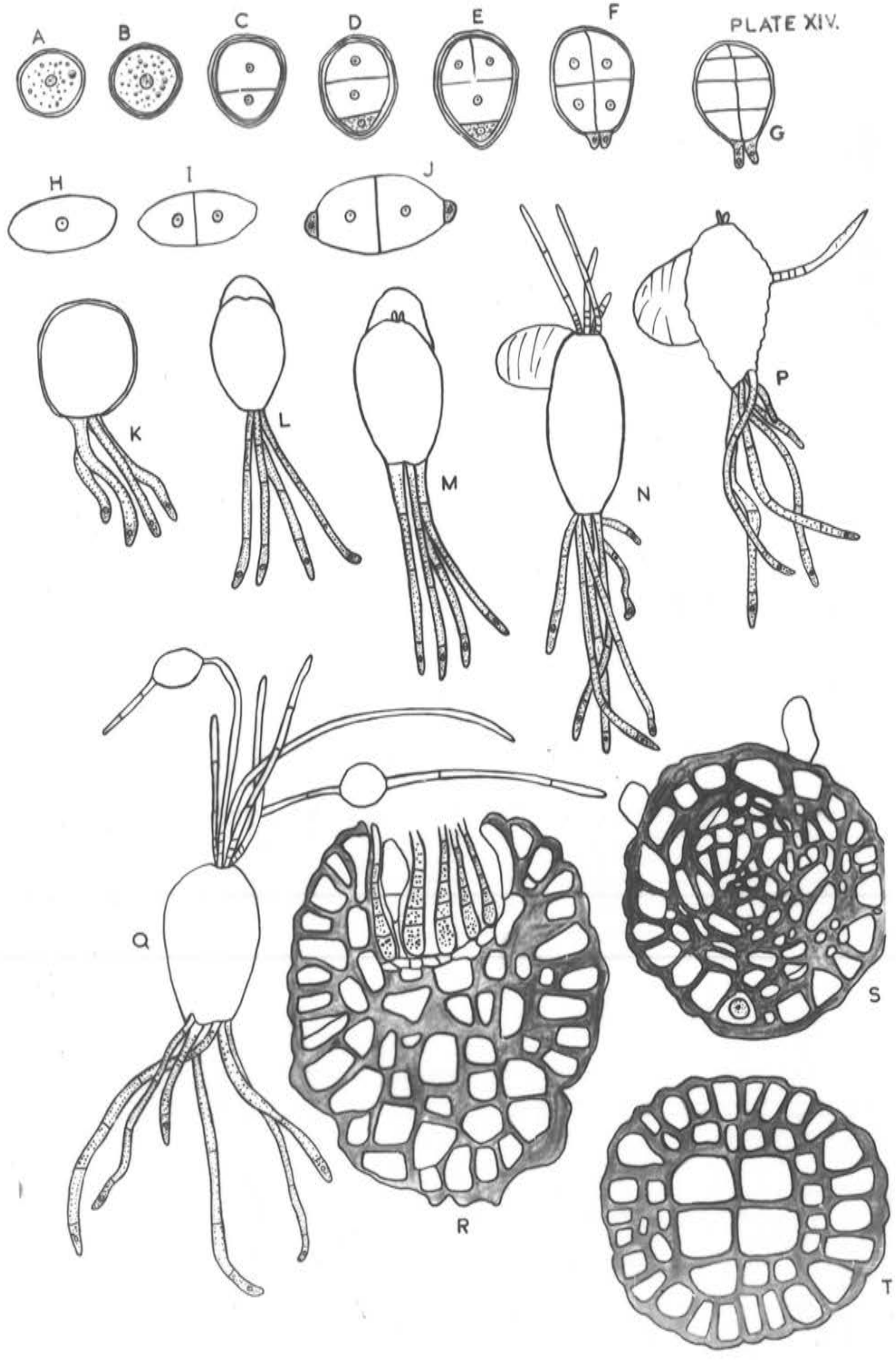
Fig. Q. Six days old embryo showing swelling on apical hairs.

R. L.S. of the embryo showing apical hairs in apical groove and tissues... ... ... X 450

S. T.S. of the embryo near rhizoids showing tissues... ... ... X 450

T. T.S. of embryo showing 4 large mudullary cells, cortical and meristoderm cells X 450

PLATE XIV.



EMBRYO DEVELOPMENT OF THE SPECIES OF CYSTOPHORA.

PLATE XV

Figs. A. Embryo of *C. intermedia*.

- (a) A zygote... ... ... X 100
- (b) 18 days old embryo with 2 rhizoids X 35
- (c) Eighteen days old embryo with 4 rhizoids... ... ... X 35
- (d) Eighteen days old embryo with 8 rhizoids... ... ... X 35

B. Embryo of *C. cephalornithos*.

- (a) A zygote... ... ... x 100
- (b) First transverse division in the lower segment forming rhizoid initial X 100
- (c) Second transverse division in the lower segment forming rhizoid initial... ... ... X 100
- (d) Third vertical division in the uppermost segment... ... ... X 100
- (e) Longitudinal division of the rhizoid initial... ... ... X 100
- (f) Longitudinal division of the middle segment... ... ... X 100

Fig. B. (g) Embryo with 2 rhizoids..... X 100

(h) Embryo with 4 rhizoids..... X 100

(i) Embryo showing eptate rhizoids and apical groove... ... ... X 50

(j) and (k) Embryo with 2 apical hairs... ... ... X 50

C. Embryo of <u>C. polycystidea</u>.

(1) A zygote... ... ... X 100

(2) First transverse division of the zygote... .... X 100

(3) Embryo showing polarity... X 100

(4) Transverse division of the lower segment forming rhizoid initial. X 100

(5) Longitudinal division ofthe lower segment forming rhizoid initial... ... ... X 120

(6) Embryo with two rhizoids X 100

(7) Embryo with four rhizoids X 100

(8) Embryo with 4 septate rhizoids X 35.

Fig. C. (9) Embryo with 8 rhizoids... .. X 45

(10) Embryo showing apical groove and mucilage.membrane ... . X 60

(11) Embryo with 2 apical hairs and rhizoids... ... ... X 60

Fig. D. Embryo of <u>C. retorta</u>.

(a) A zygote... ... ... X 120

(b) First transverse division of the zygote showing polarity.... X 100

(c) Second transverse division in the lower segment forming a rhizoid initial... ... ... X 100

(d) Longitudinal division in the upper segment... ... ... X 100

(e) Longitudinal division in the middle segment... ... ... X 100

(f) Longitudinal division in the rhizoid initial... ... ... X 100

(g) A many celled embryo with 2 rhizoids X 100

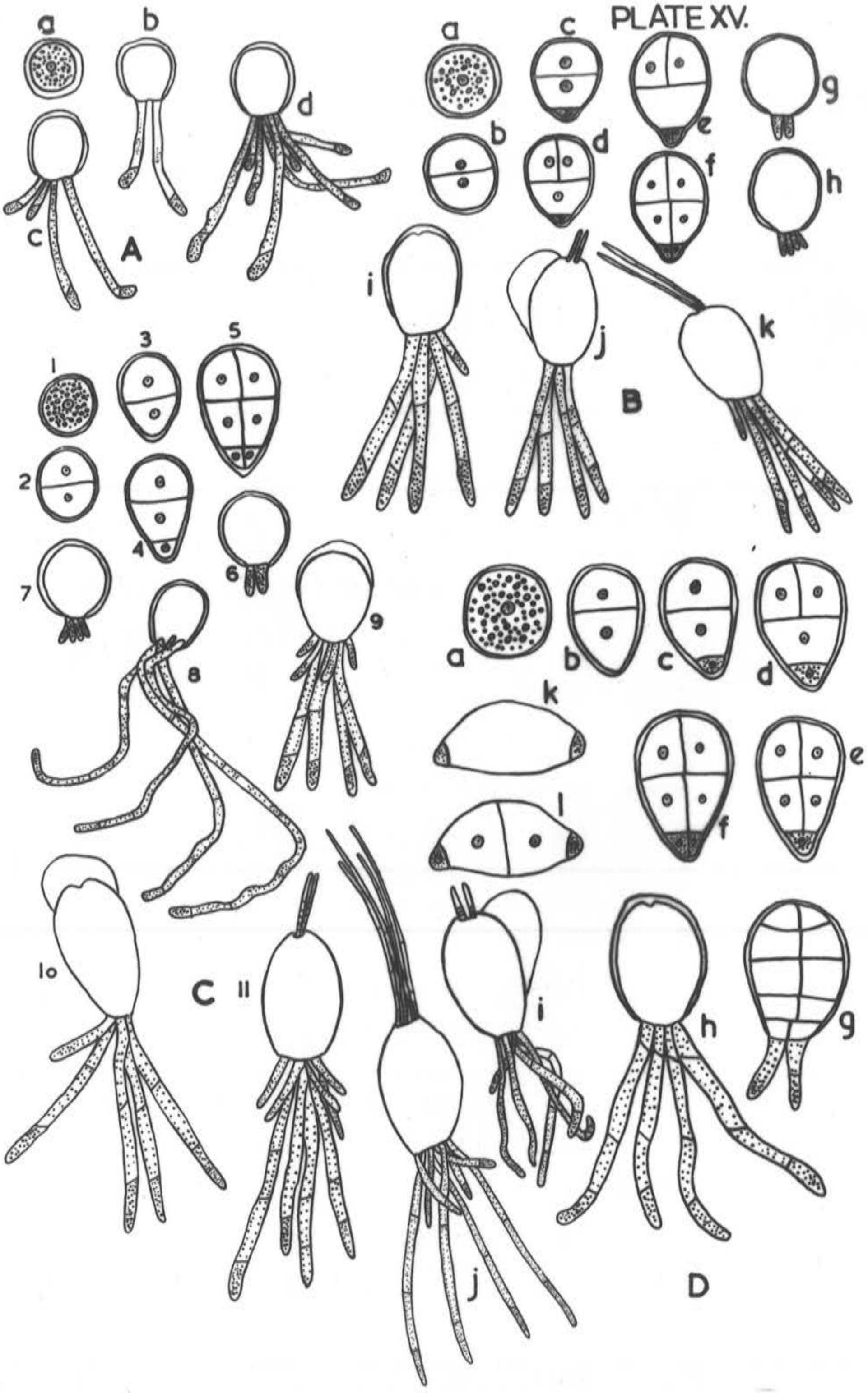
(h) Embryo with apical groove and 4 septate rhizoids... ... ... X 90

(i) and (j) Embryos with 2 and 4 apical hairs respectively... ... X 90

(k) Ellipsoidal embryo with 2 rhizoid initials on each end... ... . X 90

(l) Transverse division of the middle segment of ellipsoid embryo... X 90

PLATE XV.



CYSTOPHORA.

PLATE XVA

C. POLYCYSTIDEA

Figs. A. Four months old embryo showing dichotomous branch and sterile conceptacles with protruding paraphyses.

B. Six months old embryo showing branches and paraphyses.

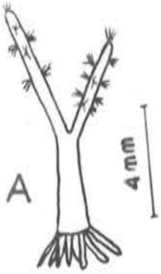
C. SUBFARCINATA.

C. Four months old embryo showing dichtomous branch and paraphyses protruding from the conceptacle.

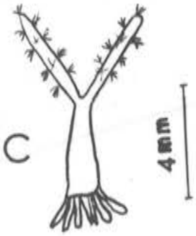
D and E. Seven months old embryo showing branches, apex and paraphyses protruding from the conceptacles.

F. Eight months old embryo with branches and apex.

PLATE XVA.


A


B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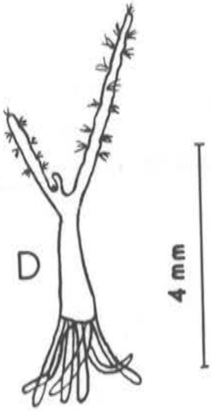
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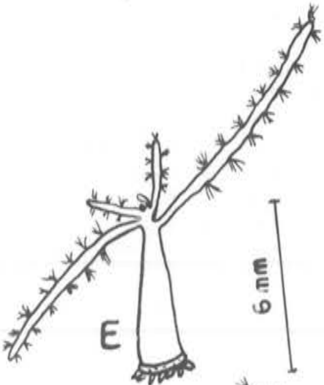
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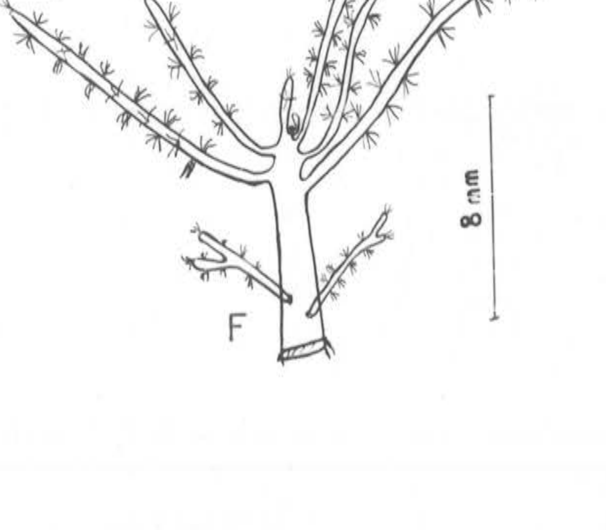

F

CYSTOPHORA.

PLATE XVI

Figs. A. Conceptacle of C. cephalornithos showing antheridia and oogonia... ... X 100

B. Development of oogonia in C. cephalornithos... ... ... X 100

- (a) and (b) Young oogonia.
- (c) Two nucleate oogonium, showing two walls only.

C. Development of antheridia in C. cephalornithos... ... . X 415

- (a) An outgrowth from the lining cell of the conceptacle.
- (b) Transverse divisions of the outgrowth.
- (c) Uninucleate young antheridia.
- (d) Two nucleate antheridium.
- (e) Four nucleate antheridium and paraphysis.
- (f) Eight nucleate antheridium with paraphysis.
- (g) Sixteen nucleate antheridium.
- (h) Thirty two nucleate antheridium and paraphysis.

Fig. C. (i) A mature and empty antheridia with paraphyses... ... ... X 415

(j) Extrusion of antheridium.

D. C. xiphocarpa.

(a) An oogonium with paraphyses with two oogonial walls... ... ... X 100

(b) Antheridia and paraphyses.. X 415

E. C. racemosa.

(a) An oogonium, showing two walls only... ... ... X 100

(b) Empty oogonium showing exochite X 100

(c) Oogonium and paraphysis... X 100

(d) A mature antheridium... . X 450

F. C. moniliformis.

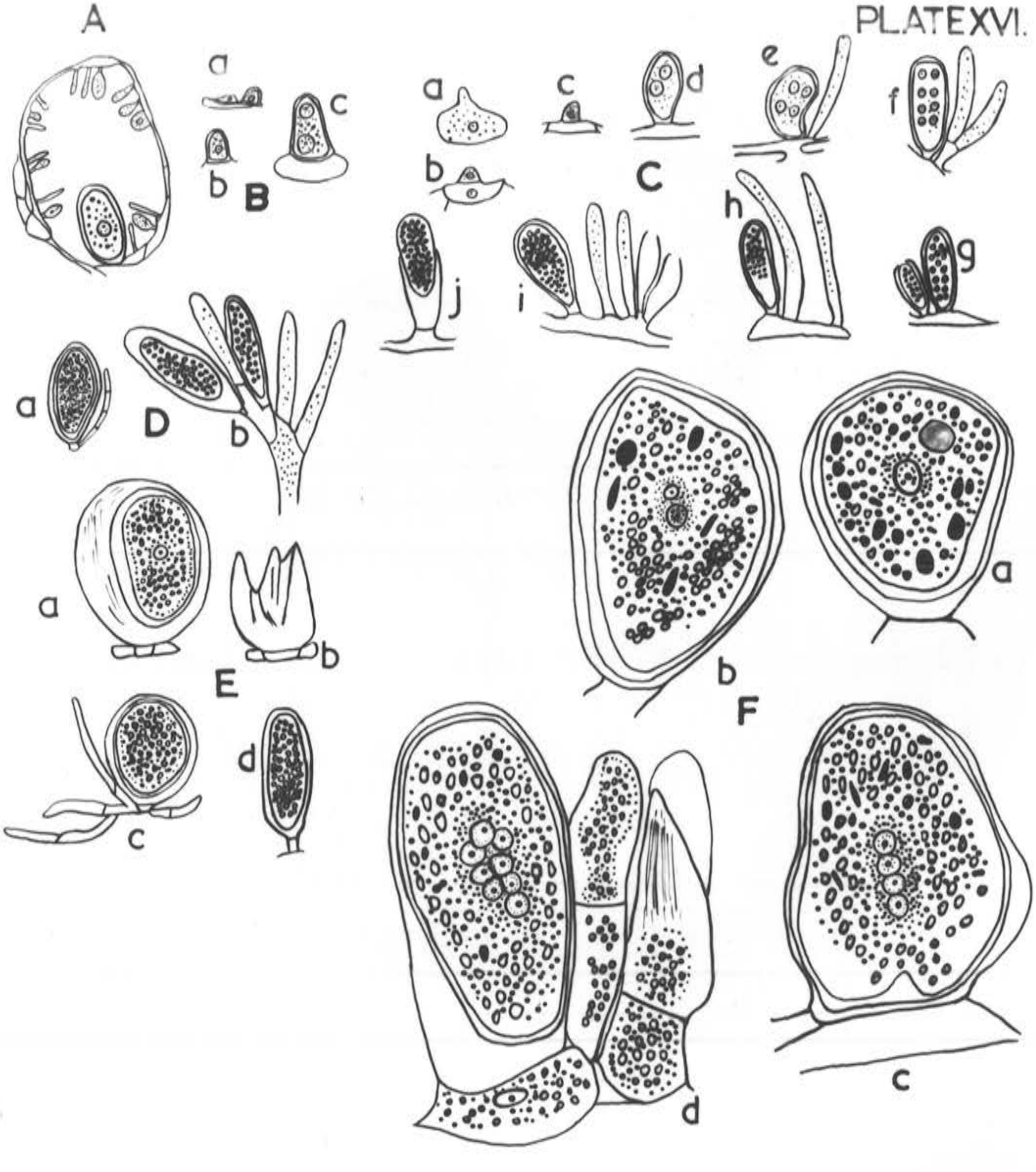
(a) A mature oogonium... ... X 450

(b) Two nucleate oogonium.... X 450

(c) Four nucleate oogonium... X 450

(d) Eight nucleate oogonium with a barrel shaped paraphysis, showing two oogonial walls only... .. X 450

PLATE XVI.



CYSTOPHORA INTERMEDIA

PLATE XVII

Figs. A. L.S. to the apex of the axis showing apical cell... ... ... X 120
B. T.S. at the apex of the axis showing apical cell... ... ... X 120
C. T.S. perpendicular to the axis showing tissues... .. .. X 100
D. L.S. to the apex of the receptacle showing apical cell..... ... X 120
E. T.S. at the apex of the receptacle showing apical cell..... ... X 120
F. L.S. ofthe receptacle showing tissues... .. .. X 100
G. T.S. of the receptacle showing tissues... .. .. X 100
H. L.S. of the basal part of the axis showing meristoderm and cortex.. ... X 100
I. L.S. of the basal part of the axis showing medullary cells and hyphae... X 100
J. T.S. of the stalk of a receptacle showing tissues... .. .. X 100
K. T.S. of a receptacle showing tissues and reproductive organs..... ... X 100
L. and M. Showing antheridia and paraphyses .. .. X 250

Figs. N. Antheridium developing on the wall of the conceptacle... ... ... X 250

P. Barrel-shaped paraphysis and an antheridium... ... ... X 250

Q - U. Development of oogonium.. X 400

Q. Uninucleate oogonium.

R and S. Two nucleate oogonia.

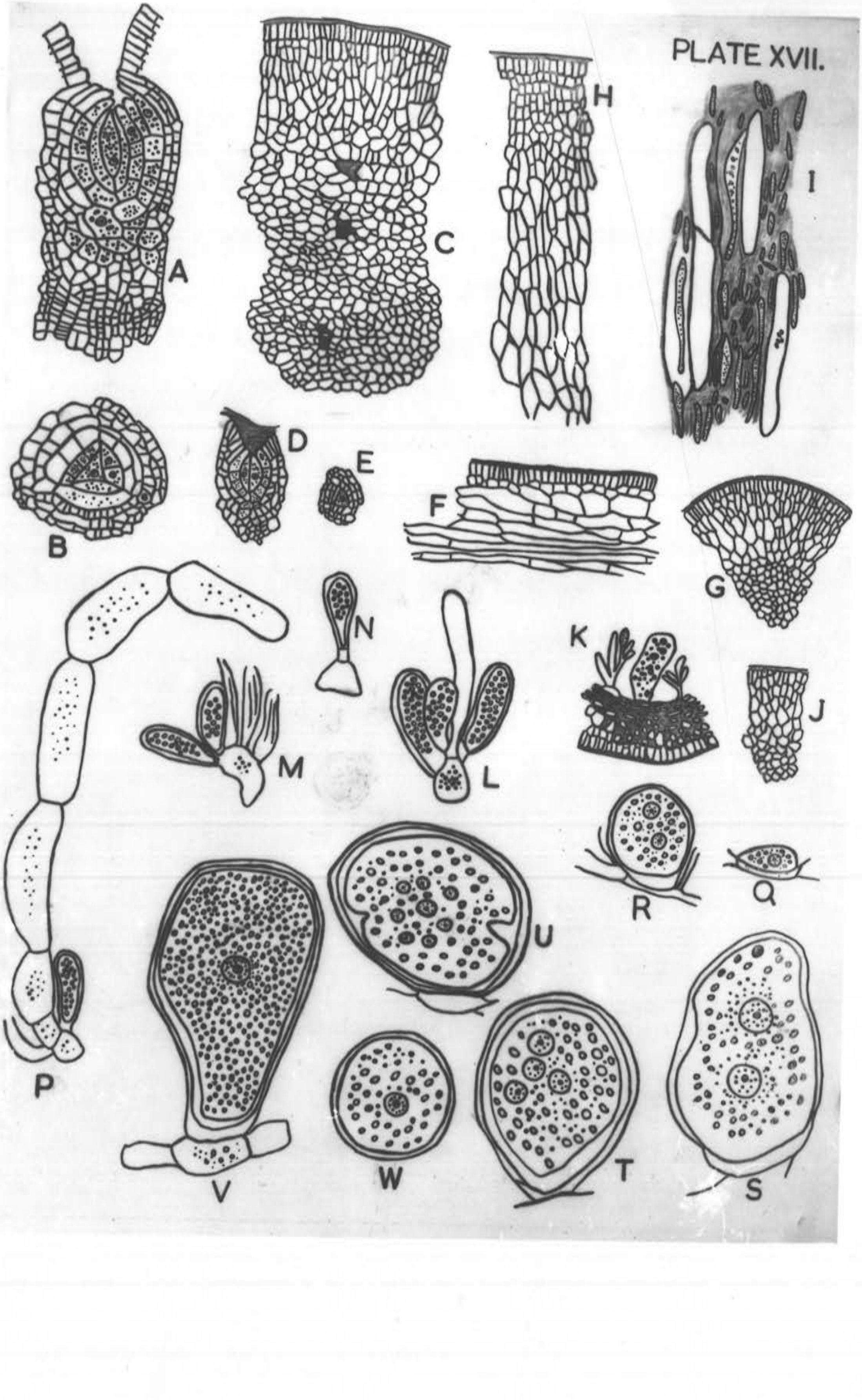
T. Four nucleate oogonium.

U. Eight nucleate oogonium.

V. A mature oogonium, showing two walls only.

W. An egg.

PLATE XVII.



CYSTOPHORA PLATYLOBIUM.

PLATE XVIII

Figs. A. L.S. perpendicular to the apex of the axis showing apical cell.... X 120

B. T.S. at the apex of the axis showing apical cell... ... . X 120

C. T.S. of the basal part of the axis showing meristoderm. ... .. X 100

D. T.S. of the basal part of the axis showing cortex and medulla.. X 100

E. Medullary cells showing lamellae and pit connections.

F. Medullary cells showing hyphae X 100

G. T.S. of the receptacle showing tissues... ... ... X 120

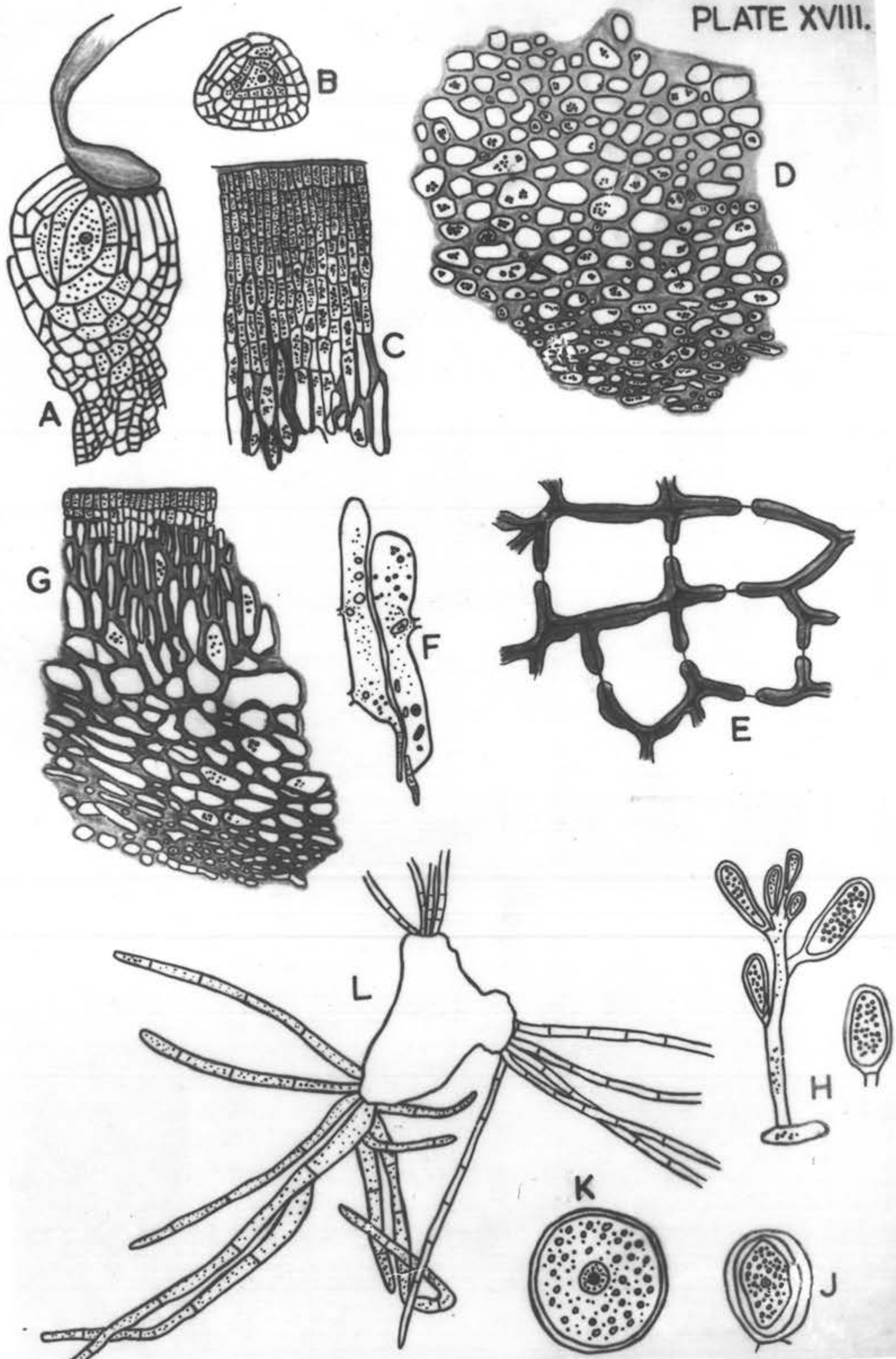
H. Showing clustered antheridia X 415

J. A mature oogonium, showing two walls only... ... ... X 145

K. An egg. ... ... X 415

L. A twenty four day old embryo showing apical hairs and rhizoids... X 100

PLATE XVIII.

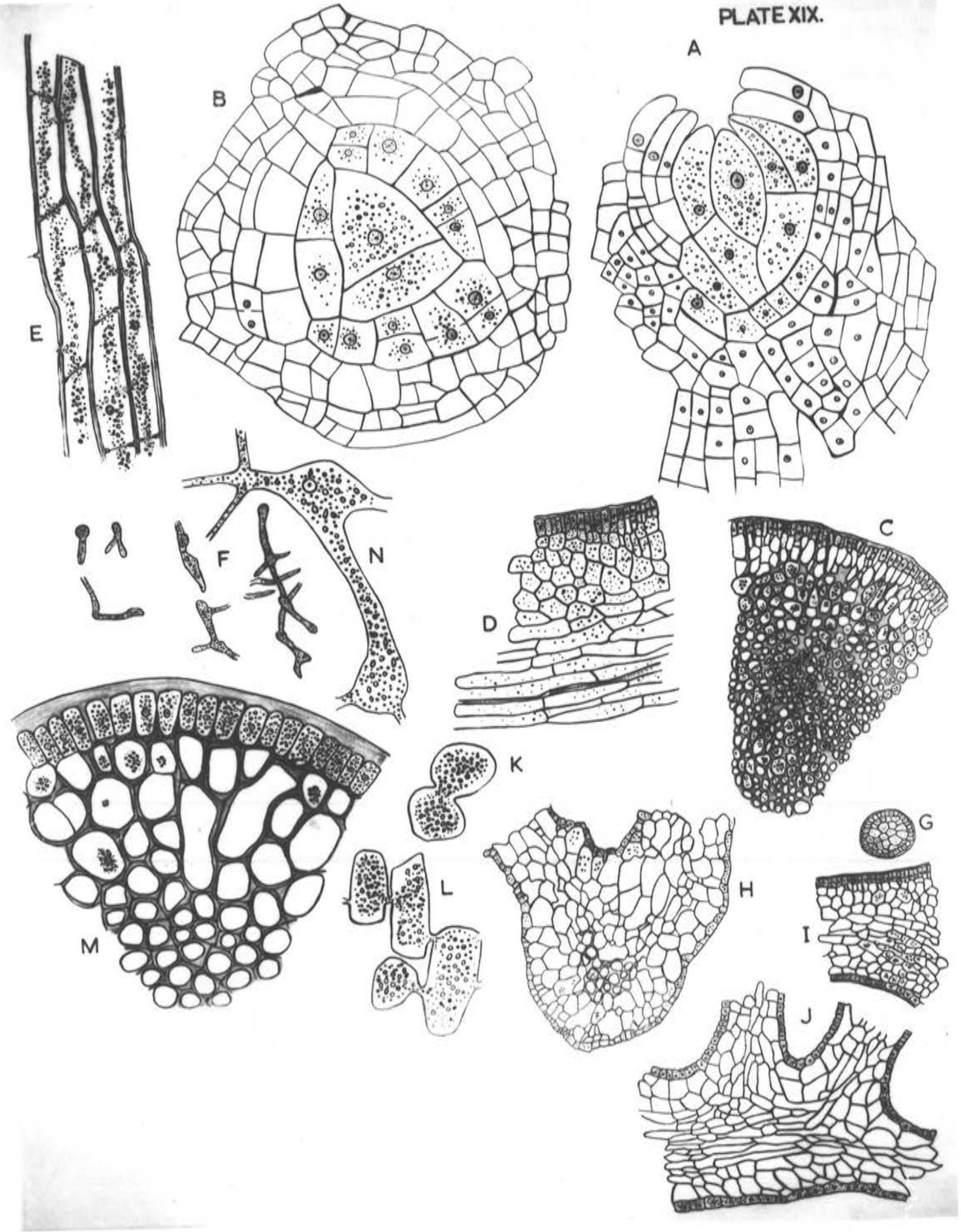


SCABERIA AGARDHII.

PLATE XIX

Figs. A.	L.S. of an axis at the apex showing apical cell	X 260
B.	T.S. of an axis at the apex showing apical cell	X 260
C.	T.S. of an axis showing tissues.	X 62
D.	L.S. of an axis showing tissues and hyphae.	X 62
E.	Medullary cells showing pit connections, cytoplasmic connections and lamellae	X 260
F.	Development of hyphae.	X 62
G.	T.S. of young verruciform leaf showing tissues	X 62
H.	T.S. of mature verruciform leaf showing tissues	X 62
I.	L.S. of young verruciform leaf showing tissues	X 62
J.	L.S. of a mature verruciform leaf showing tissues.	X 62
K and L.	Cortical cell showing cytoplasmic and lateral connections	X 260
M.	T.S. of a filiform leaf showing tissues	X 260
N.	Anastomosing hyphae	X 260

PLATE XIX.



SCABERIA AGARDHII.

PLATE XX

Figs. A. Development of antheridia X 300
- (a) Young antheridium.
- (b) Two and sixteen nucleate antheridia
- (c) Four nucleate antheridium.
- (d) Eight nucleate antheridium.
- (e) Sixteen nucleate antheridium.
- (f) Thirty two nucleate antheridium
- (g) Sixty four nucleate antheridium

B. Antheridia on branched hairs. X 300

C. Simple paraphyses X 300

D. Development of oogonia.·· ··· X 100
- (a) A young oogonium.
- (b) Two nucleate oogonium.
- (c) Four nucleate oogonium.
- (d) Eight nucleate oogonium.
- (e) Latero-apical extrusion of oogonial contents.
- (f) An immature egg.
- (g) A mature oogonium, showing two walls only... ... ... X 300

Figs. E. Conceptacle containing antheridia and oogonia... ... ... X 100

F. A mature egg... ... ... X 100

G - N. Development of embryo. ... X 120

G. First transverse division showing polarity.

H. Vertical division in the upper segment and 2 nuclei in the lower segment.

I. Transverse division in the lower segment forming rhizoid initial.

J. Longitudinal division in middle segment.

K. Many-celled embryo with 2 rhizoid cells.

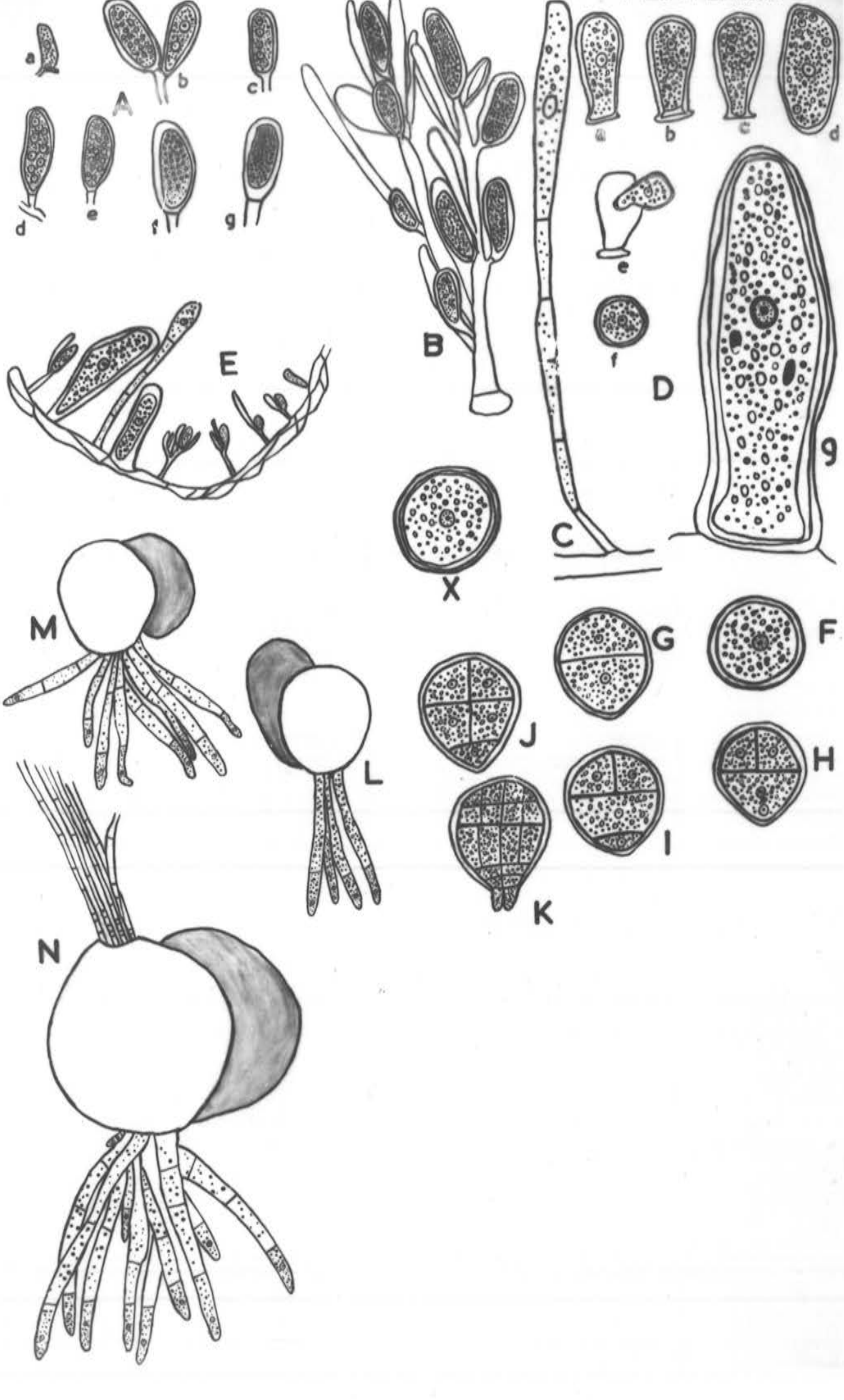
L. An embryo with 4 rhizoids and mucilage membrane.

M. An embryo with 8 rhizoids and mucilaginous membrane.

N. An embryo with rhizoids and apical hairs.

X. A zygote... ... ... X 100

PLATE XX.



CYSTOPHYLLUM MURICATUM.

PLATE XXI

Figs. A. L.S. of an axis at the apex showing apical cell... ... ... X 260

B. T.S. at the apex of an axis showing apical cell... ... ... X 260

C. T.S. of an axis showing tissues X 62

D. L.S. of an axis showing tissues X 62

E. T.S. of an axis showing meristoderm and cortex... ... . X 260

F. L.S. of a filiform leaf showing apical cell... ... ... X 260

G. T.S. at the apex of a filiform leaf showing apical cell... .. x 260

H. T.S. of a filiform leaf passing through apical region, showingtissues X 62

I. T.S. passing through the middle part of a filiform leaf... ... X 62

J. L.S. of medullary cell in the apical region showing cytoplasmic connections... ... . X 260

K. T.S. atthe apex of a receptacle showing apical cell... ... . X 260

Figs. L. L.S. of a receptacle at the apex showing apical cell... ... ... X 62

M - V. Development of conceptacles X 260

M. Conceptacle initial.

N. First division of conceptacle initial forming tongue cell and basal cell.

P. First division of basal cell.

Q, R and U. Further divisions of basal cell.

S. Transverse section passing through tongue cell.

T. Transverse section passing through basal cells.

U. Lining cells of the conceptacle and uniseriate hair.

V. Transverse section of an empty conceptacle showing lining cells.

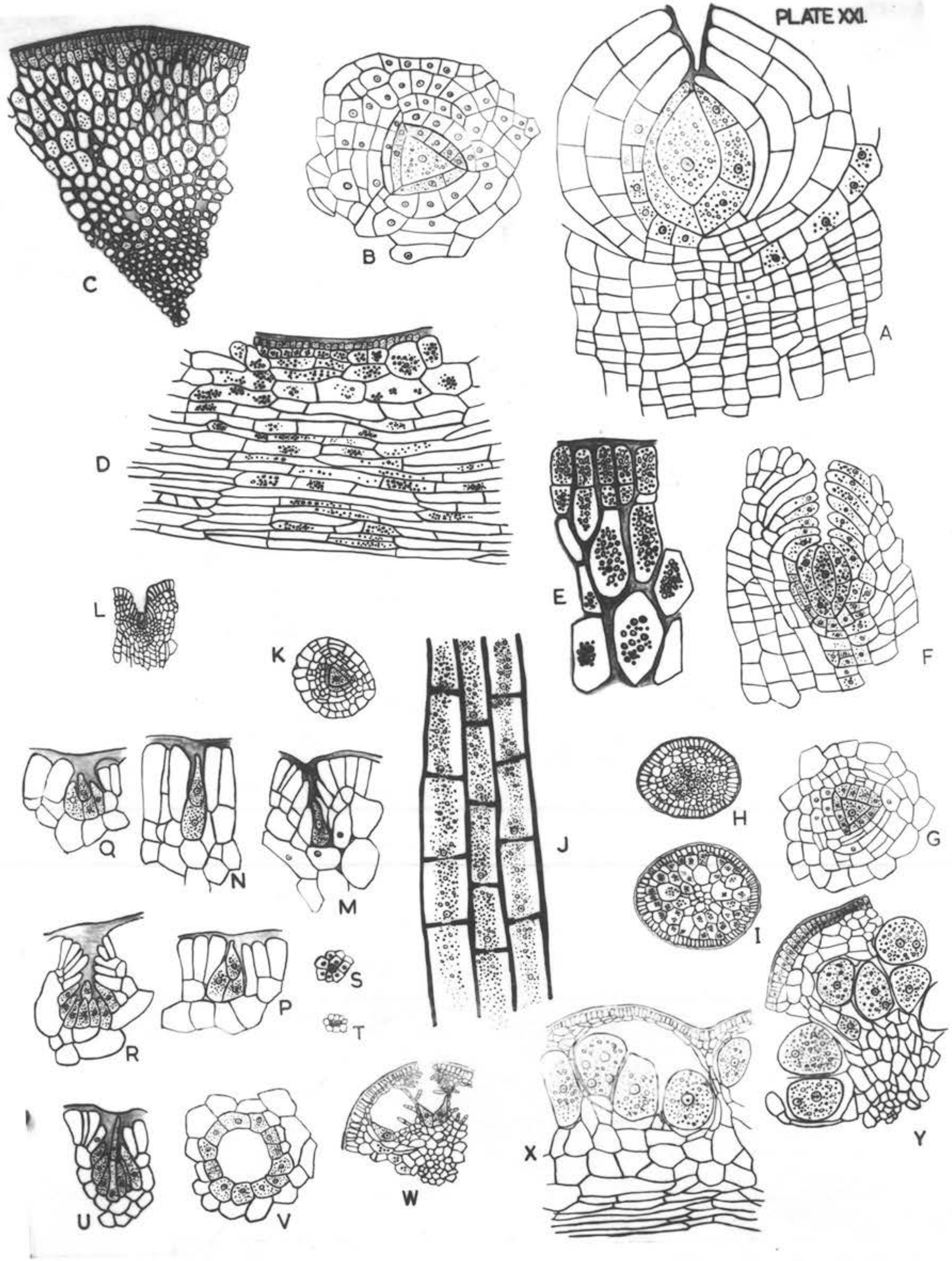
W - Y. Oogonial development... ... X 62

W. T.S. of a receptacle showing oogonial initial and its first division and tissues.

X. L.S. of a receptacle showing tissues and four-nucleate oogonium.

Y. T.S. of a receptacle showing embedded oogonium.

PLATE XXI.



CYSTOPHYLLUM MURICATUM.

PLATE XXII

Fig. A. Conceptacle showing antheridia and paraphyses... ... ... X 90

B. Branched antheridial hair... X 300

C. Antheridia borne directly on the wall of a conceptacle. ... ... X 300

D - I. Extruded oogonia showing nuclei;.. ... . X 95

D. An extruded oogonium.

E. 2-nucleate oogonium.

F. Four nucleate oogonium.

G. Eight nucleate oogonium.

H. Seven supernumery nuclei at the periphery of the oogonium.

I. A mature egg.

J - N. Development of embryo... X 95

J. A zygote.

K. First transverse segmentation of a zygote.

L. Second vertical segmentation wall in the upper segment.

M. Third transverse segmentation wall forming rhizoid initial.

N. Fourth vertical segmentation of the middle cell and longitudinal division of rhizoid initial.

Figs. P - R. Showing four primary rhizoid cells... ... ... X 95

S. One week old embryo with four rhizoids. ... ... X 75

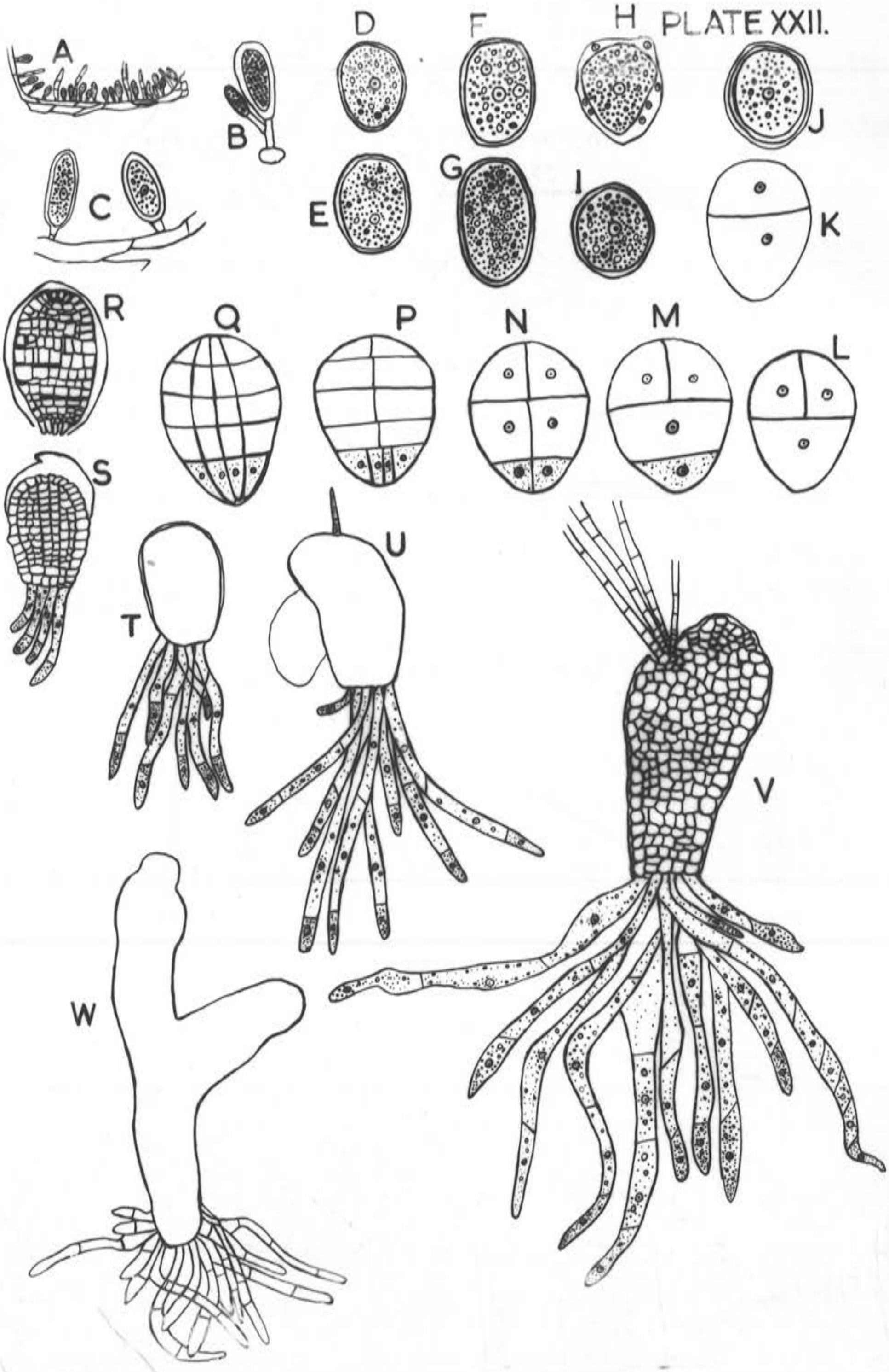
T. Embryo with seven rhizoids.. X 95

U. Eleven days old embryo with mucilaginous membrane on one side and apical hair... ... ... X 80

V. Eighteen days old embryo with apical hairs.. ... ... X 95

W. Three months old embryo showing branching.... ... ... X 35

PLATE XXII.



CARPOGLOSSUM CONFLUENS.

PLATE XXIII.

Figs. A. T.S. at the apex of an axis showing apical cell... ... ... X 90

B. L.S. parallel to flat surface of an axis at the apex showing apical cell. X 90

C. L.S. perpendicular to the flat surface of an axis at the apex showing apical cell... ... ... X 90

D. T.S. perpendicular to the flat surface showing tissues ... ... X 90

E. L.S. parallel to the flat surface of an axis showing meristoderm cells.. X 380

F. Meristoderm cell showing division X 380

G. Cortical cells showing lamellae and swollen lateral walls.... ... ... X 380

H. Cortical cells showing mucilage and lamellations ... ... X 380

I. Medullary cell showing pit connections.

J. L.S. perpendicular to the flat surface of a segment showing tissues.. ... X 90

K. Hyphae.

L. Conceptacle showing oogonia and antheridia... .. .. X 90

Figs. M. Oogonium proper and basal cell. X 380

N. A young oogonium... ... . X 380

P. Eggs... ... . X 90

X - Z. Development of antheridia. . X 380

X. Different stages of antheridia on a hair.

Y. (a) Outgrowth from the lining cell of
a conceptacle.

(b) Division of the outgrowth from
antheridium to basal cell.

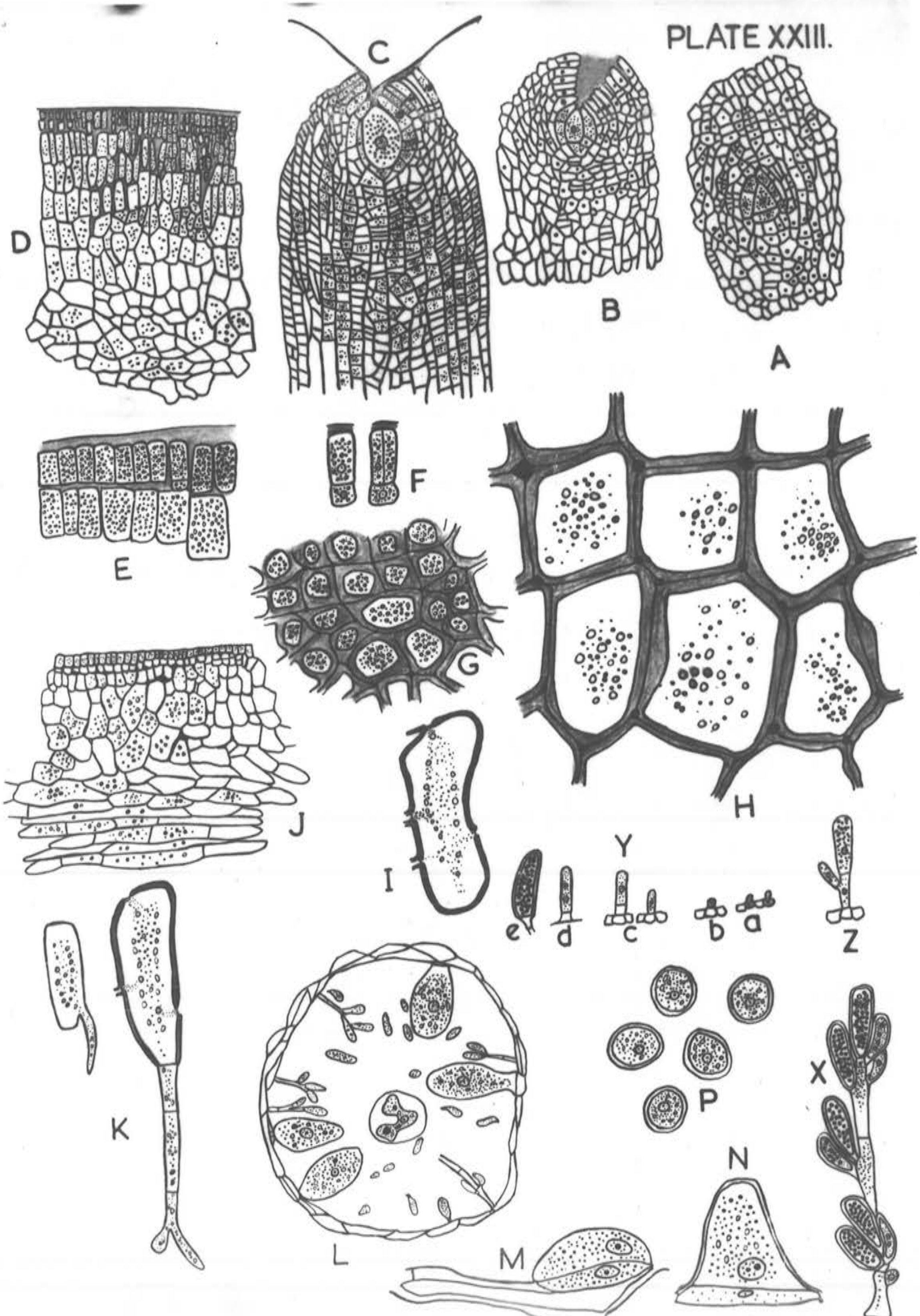
(c) Young antheridia.

(d) Two nucleate antheridia.

(e) A mature antheridium.

Z. Antheridial hairs.

PLATE XXIII.



MYRIODESMA INTEGRIFOLIA

PLATE XXIV.

Figs. A. T.S. at the apex of an axis showing apical cell... ... ... X 395.

B. L.S. perpendicular to the flat surface of an axis showing apical cell;. X 395

C. T.S. of the basal part of an axis showing tissues.. .. .. X 95

D. L.S. ofthe basal part of an axis showing tissues and pit connections ... X 95

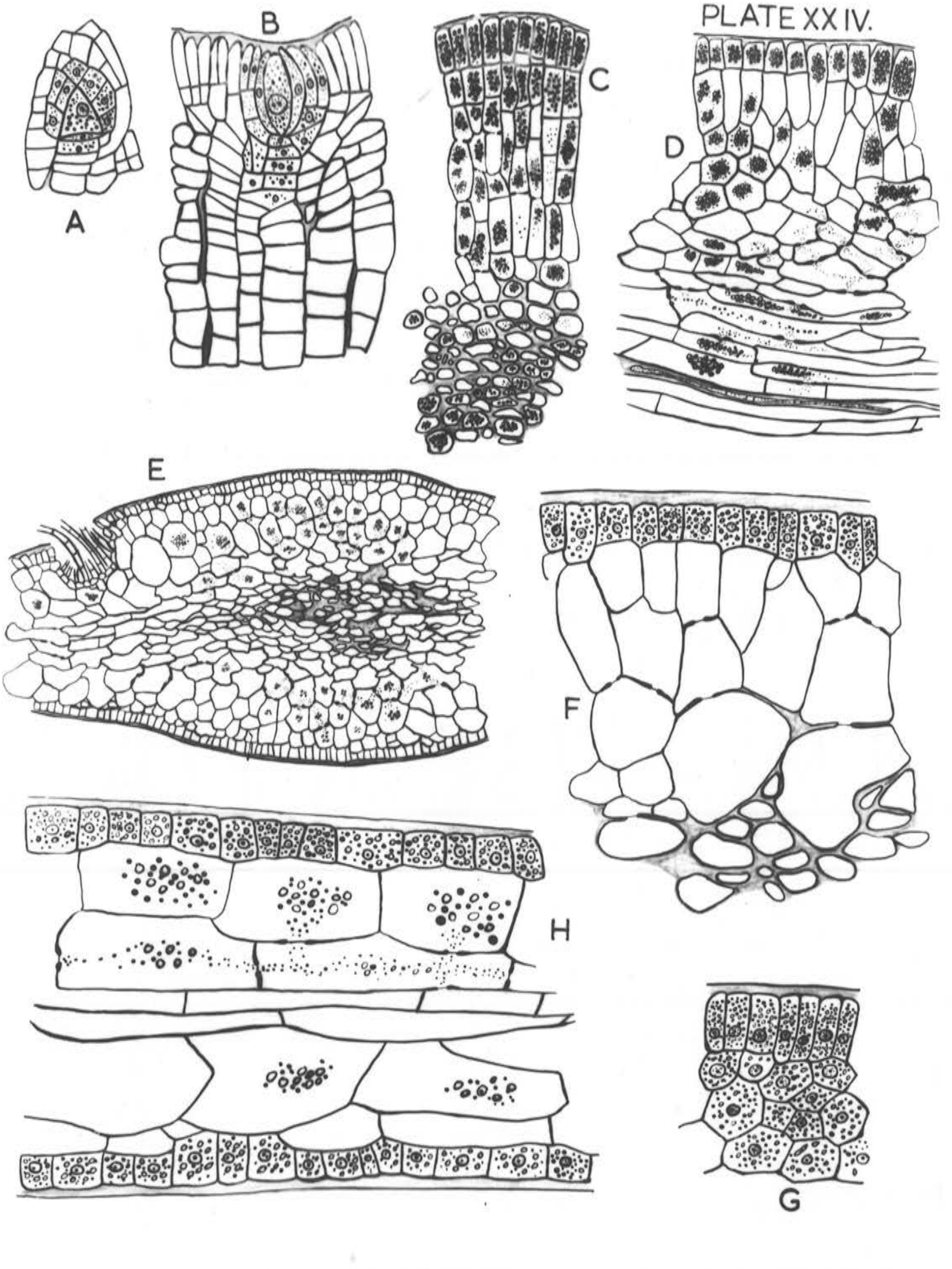
E. T.S. of a segment showing tissues and cryptostomata.... ... ... X 95

F. Meristoderm and cortex of the basal parts of an axis showing pit connections X 395

G. Meristoderm and cortex of a segment near the apex... ... ... X 395

H. L.S. perpendicular to the flat surface of a young segment showing pit connections..... ... ... X 395

PLATE XXIV.



MYRIODESMA INTEGRIFOLIA.

PLATE XXV

Figs. A - G.	Development of conceptacles.. X 380
A.	Conceptacle initial.
B.	First division of the initial forming a tongue cell, and a basal cell... ... ...
C.	First division of the basal cell
D, E and F.	Further divisions of the basal cells and the tongue cells.
G.	Empty conceptacle with central hairs.
H.	Conceptacles showing oogonia, antheridia and central hairs ... . X 90
I - N.	Development of oogonia ... . X 380
I.	Oogonial initial.
J.	First division of oogonium initial.
K.	A young oogonium.
L.	Two nucleate oogonium and paraphyses.
M.	A mature oogonium showing two walls only.
N.	An egg.
P - T.	Development of antheridia... . X 380

P. (a) An outgrowth from a lining cell of a conceptacle.

(b) First division of the outgrowth forming antheridium and a basal cell.

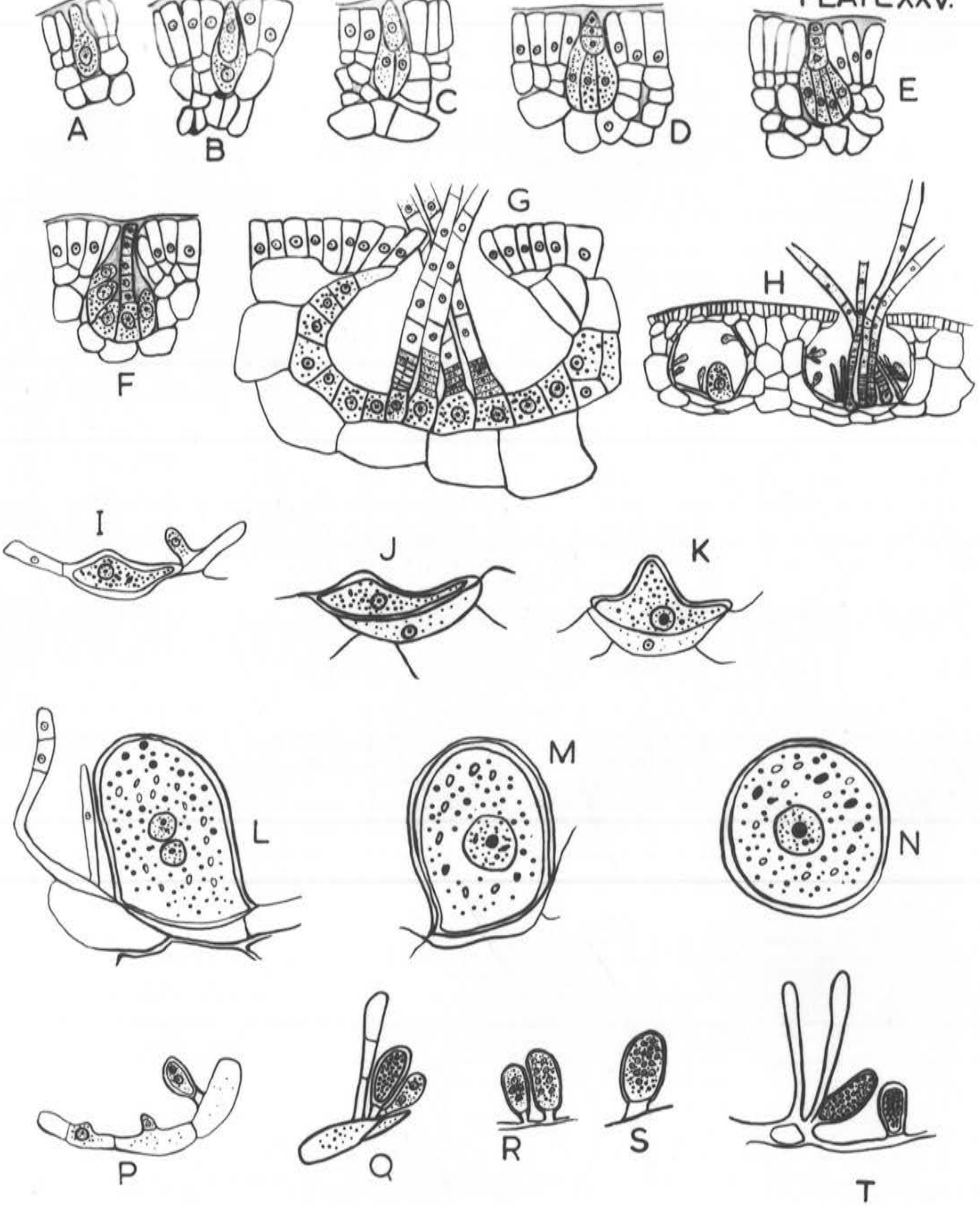
Q. Two nucleate antheridium.

R. Four and eight nucleate antheridia.

S. Sixteen nucleate antheridia.

T. Antheridium and paraphyses.

PLATE XXV.



MYRIODESMA LATIFOLIA.

PLATE XXVI

Figs. A. L.S. perpendicular to the flat surface of an axis showing apical cell. X 300

B. T.S. at the apex of an axis showing apical cell... ... ... X 300

C. L.S. perpendicular to the flat surface of a young segment showing tissues X 75

D. T.S. of a segment showing central hairs, antheridia and oogonia. X 75

E. T.S. of the petiole of a segment showing different tissues.. ... ... X 75

F. L.S. of the petiole of a segment showing tissues and pit connections.. X 75

G - L. Development of conceptacles X 300

G. Conceptacle initial.

H. First division of the initial showing a tongue cell and a basal cell.

I. First division of the basal cell and divisions of tongue cells.

J and K. Further divisions of basal cell and tongue cell forming lining of the conceptacle and hair respectively.

Fig. L. L.S. of a segment showing empty conceptacles with central hairs... ... X 75

M. Ceonceptacles showing central hairs and antheridia... ... ... X 75

N. Antheridia... ... ... X 300

(a) Antheridia on branched hair.
(b) Liberation of antheridium.
(c) Empty antheridium.

P. A mature oogonium showing two walls only... ... ... X 300

Q - Z. Development of embryo.. ... X 90

Q. A zygote.

R. First transverse division of a zygote

S. Two-celled embryo with 2 nuclei in upper segment.

T. Second vertical segmentation in the upper segment of the embryo.

U. Third division of the embryo in the lower segments forming rhizoid initial.

V. Two nuclei in the middle segment of the embryo.

W. Vertical division in the middle segment and rhizoid initial of the embryo.

Fig. X. Longitudinal divisions in the rhizoid initial forming 4 rhizoid cells.

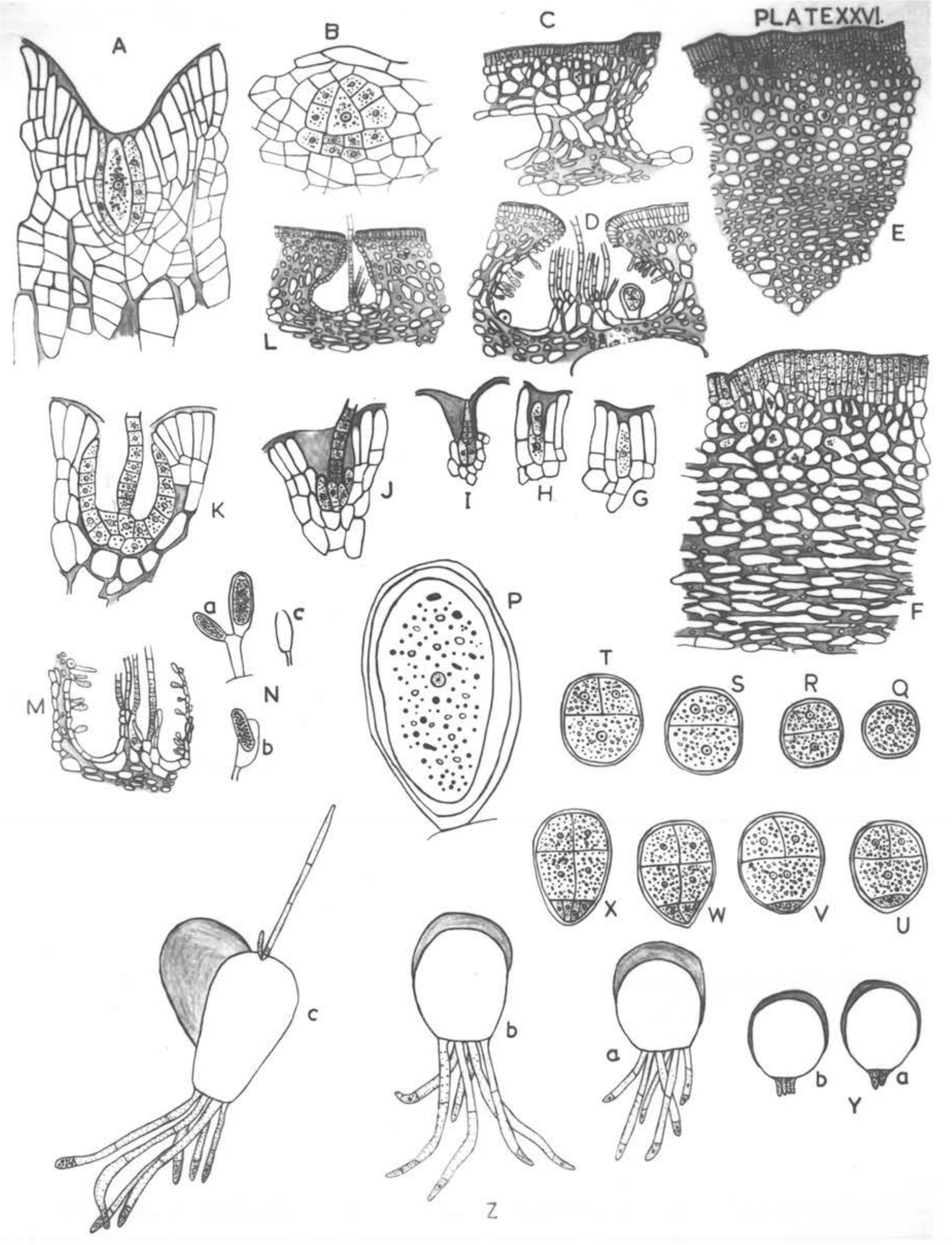
Y. Many celled embryos.

- (a) Embryo with two rhizoids.
- (b) Embryo with four rhizoids.

Z. Many celled embryos with septate and simple rhizoids.

- (a) Three days old embryo.
- (b) Four days old embryo.
- (c) Ten days old embryo showing apical hair~~ed~~ and mucilaginous membrane.

PLATE XXVI.



MYRIODESMA QUERCIFOLIA.

PLATE XXVII

Figs. A.	L.S. perpendicular to the flat surface of an axis showing apical cell..	X 260
B.	T.S. atthe apex of an axis showing apical cell...	X 260
C.	T.S. of a segment showing tissues	X 260
D.	T.S. of a segment showing meristoderm and cortex...	X 260
E.	T.S. of a segment showing medulla with lamella...	X 260
F.	L.S. perpendicular to the flat surface of a youngsegment showing tissues .	X 62
G.	Medulla showing hyphae...	X 62
H.	Cortical cells of the stipe showing lamellations and hyphae..	X 260
I.	Meristoderm cells of the stipe	X 62
J - N.	Development of conceptacles	X 260
K.	First division of the initial forming a tongue cell and a basal cell.	
L.	First division of the basal cell and tongue cell.	
M and N.	Further divisions of basal cells and tongue cell.	

Fig. P. L.S. of a segment showing conceptacle with antheridia and oogonia... ... X 62.

Q. Conceptacle showing antheridia and central hairs... ... ... X 62.

R. Development of antheridia ... X 260

(a) An outgrowth from lining cell of the conceptacle.

(b) Transverse division of the outgrowth

(c) Young antheridium.

(d) Two and sixty four nucleate antheridia with empty ones.

(e) Four nucleate antheridia.

(f) Eight nucleate antheridium.

(g) Sixteen nucleate antheridium.

(h) Thirty two nucleate antheridium.

(i) and (j) Extrusion of sperms and antheridia.

S. Development of oogonia... ... ... X 260

(a) Oogonial initial.

(b) Transverse division of oogonial initial forming upper oogonium and lower basal cell.

(c) Two nucleate oogonium.

(d) Four nucleate oogonium.

(e) A mature oogonium and antheridium Only two oogonial walls shown.

Fig. T. Development of embryos... ... X 120

(a) An egg.

(b) A zygote.

(c) Transverse division of the zygote

(d) Second transverse division in the lower segment forming a rhizoid initial.

(e) Four celled embryo. Vertical division in the uppermost segment.

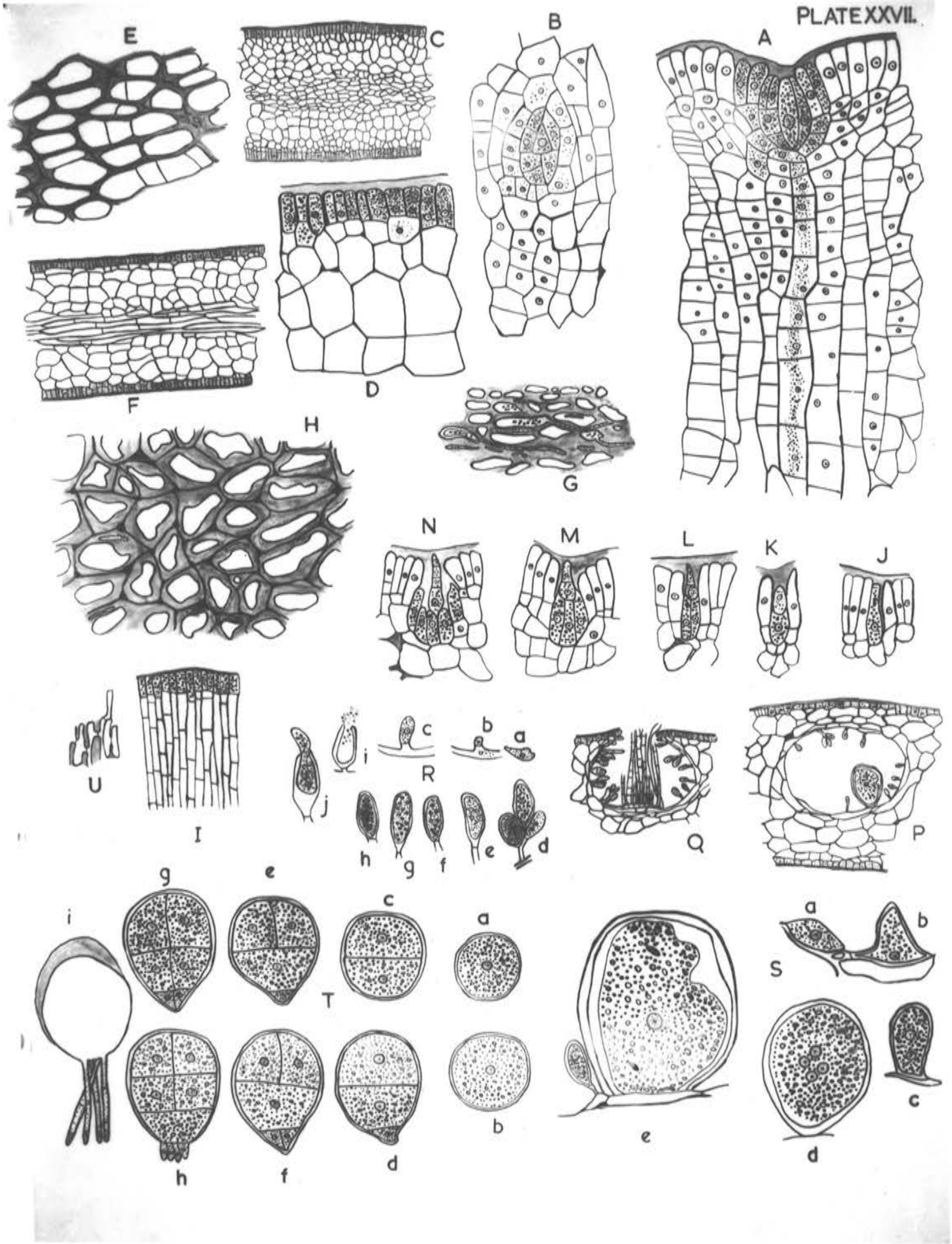
(f) Five-celled embryo showing longitudinal division of rhizoid initial.

(g) Five celled embryo showing longitudinal division in the middle segment.

(h) and (i) Many celled embryo with four rhizoids.

U. Showing pit connection... ... X 62

PLATE XXVII.



THE SHAKING APPARATUS

PLATE XXVIII.

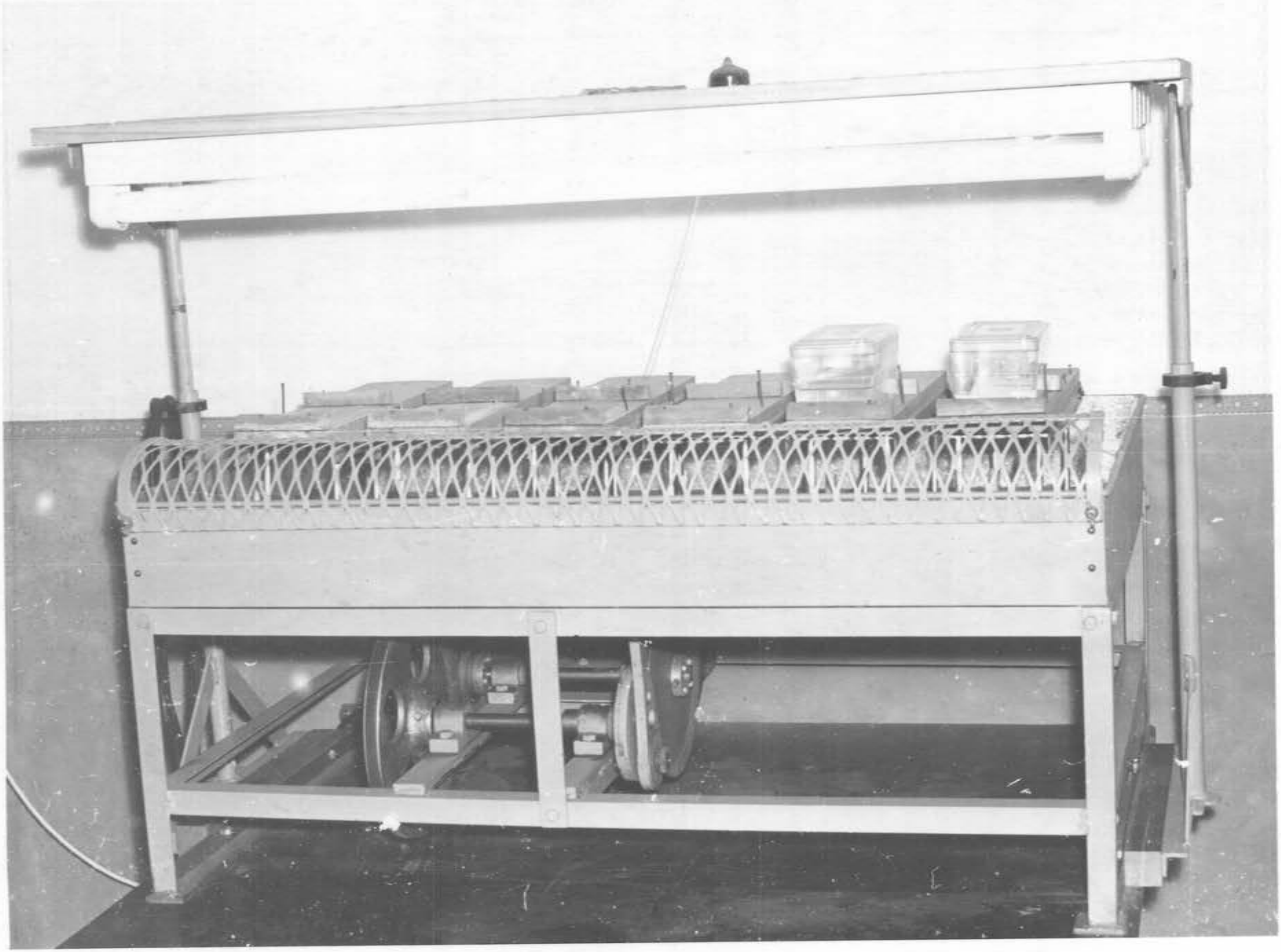


PLATE XXVIII.

CYSTOPHORA AND CYSTOPHYLLUM.

PLATE XXIX

Figs. A. Metaphase plate in polar view in the paraphysis of *Cystophyllum muricatum*... X 750

B. Metaphase plate in polar view in the apical cell of *Cystophyllum muricatum*..... X1000

C. Metaphase plate in polar view in the oogonium of *Cystophora moniliformis*...X 500

D. Metaphase plate in polar view in the apical cell of *Cystophora moniliformis*.... X1000

E. Metaphase plate in polar view in the apical cell of *Cystophora polycystidea*.....X1300

F. Metaphase plate in polar view in the paraphysis of *Cystophora uvifera*... ...X 750

G. Anaphase in the antheridium of *Cystophora cephalornithos*... ... ...X 400

H. Metaphase in polar view in the antheridium of *Cystophora cephalornithos*... .. X 450

I. Nucleus showing chromocentres in the meristoderm cell of the embryo of *Cystophora subfarcinata*... ... ... X1000

J. Metaphsee plate in polar view in the meristoderm cell of the embryo of *C. subfarcinata*... ... ... X 665

Figs. K. Metaphase plate in side view in the meristoderm cell of the embryo of *C. subfarcinata* X 665

L. Anaphase stage in the meristoderm cell of the embryo of *C. subfarcinata*... ... . X 665

M. Nucleus in the rhizoid cell of the embryo of *C. subfarcinata* showing chromocentre X 585

N. Metaphase plate in polar view in the meristoderm cell of the embryo of *C. retorta* X 860

O. Anaphase in the meristoderm cell of the embryo of *C. retorta*... ... .X 860

P and R. Metaphase plates in side view in the body cell of the embryo of *C. retorta* X 1000

Q. Metaphase plate in polar view in the meristoderm cell of the embryo of *C. rebrta* X 715

S. Anaphase in the body cell of the embryo of *C. retorta*... ... ...X 715

T. Telophase in the meristoderm cell of the embryo of *C. retorta*... ... ... X 1000

U. Nucleus of the rhizoid cell of *C. retorta* showing chromocentres.. ... .X 890

V. Metaphase plate in the rhizoid cell of *C. retorta*... ... ... X 1400

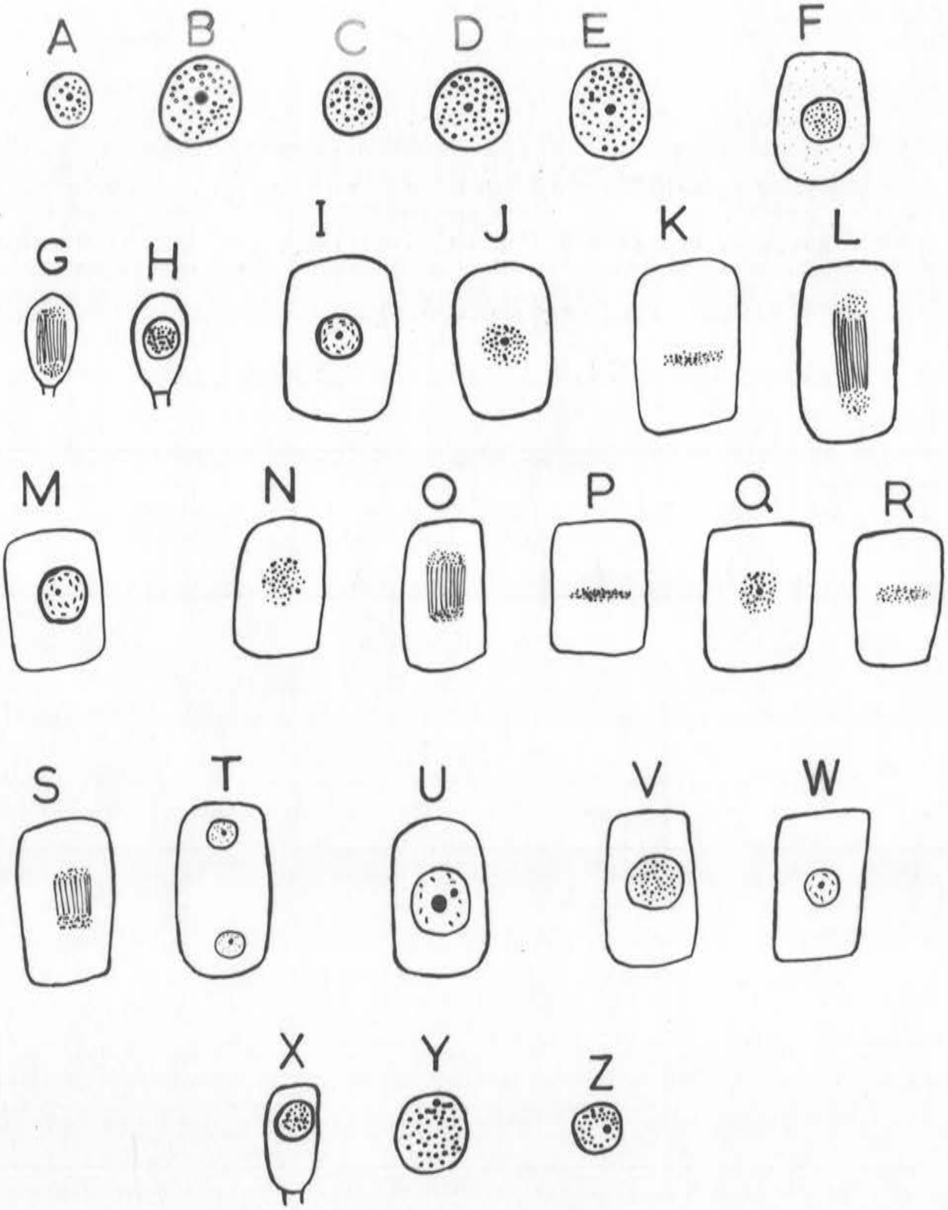
Figs. W. Nucleus in the meristoderm cell of *C. subfarcinata* showing chromocentres X 1250

X. Metaphase plate in polar view in the antheridium of *C. platylobium*... ... X 700

Y. Metaphase plate in polar view in the apical cell of *C. platylobium*.. X 1000

Z. Metaphase plate in polar view in the oogonium of *C. intermedia*.. ... X 1000

PLATE XXIX.



DURVILLEA ANTAR$\overset{c}{\wedge}$TICA (Cham.) Hariot

PLATE XXX

PLATE XXX.

A 11,242.

Durvillea antarctica (Cham.) Hariot.
Kaikoura, S. Is., New Zealand.
Upper Sublittoral
17/2/1949.

Coll. & Det. H. B. S. Womersley.

DURVILLEA POTATORUM (Lab.) Areschoug.

PLATE XXXI

PLATE XXXI.

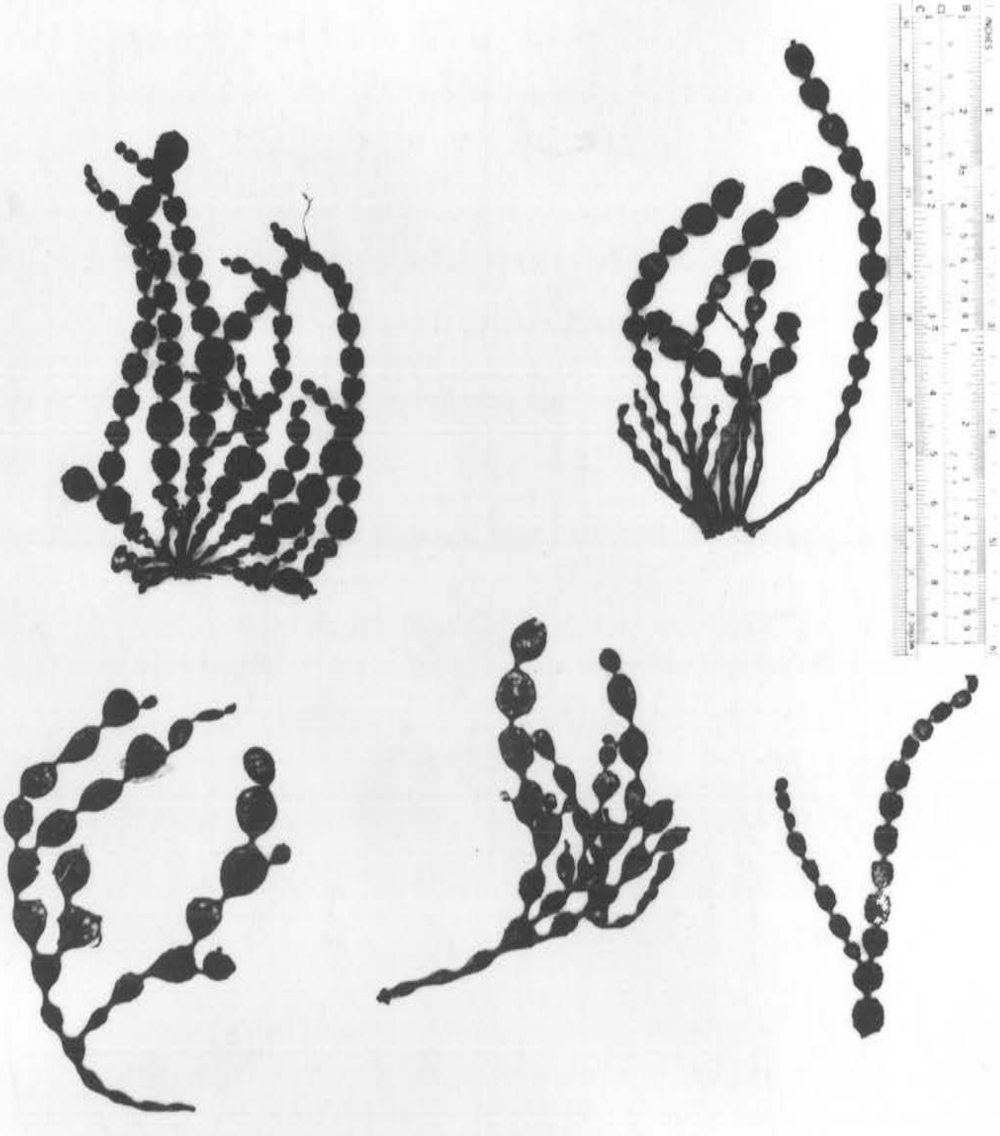

A18,959
Durvillea
Sarcophycus potatorum (Lab.) ~~Kütz~~ Aresch.
Flat Rock, Bridgewater Bay, Vic.
upper sublittoral
21/X/1953
Coll. & Det. H. B. S. WOMERSLEY
INCHES

HORMOSIRA BANKSII (Turn.) Decaisne.

BLATE XXXII

A, 19,806

PLATE XXXII



Hormosira banksii (Turn), Dcne
Citadel Is, Glennies Group, ~~Aus~~ Vic.
17/6/1954
Lower littoral

PHYLOSPORA COMOSA (Lab.) C.Agardh.

PLATE XXXIII

A21, 192

PLATE XXXIII.

Phyllospora comosa (Lab.) Ag.
Robe, S Aus
Drift
19/8/1957
Coll & Det. H.B.S. Womersley

SEIROCOCCUS AXILLARIS (R.Br.ex Turn.) Grevi

PLATE XXXIV

A21,193

PLATE XXXIV.

Sirococcus axillaris (Turn.) Grev.
Stinky Bay, Nora Creina, S. Aus.
Drift
11/8/1957

[illegible] Det. H.B.S.Womersley

SCYTOTHALIA DORYCARPA (Turn.) Grev.

PLATE XXXV

A19,540

PLATE XXXV.

Scytothalia dorycarpa (Turn.) Grev

Point Sinclair, S. Aus
U.S.L. on rough reef
8/1/1954

Coll & Det.

XIPHOPHORA GLADIATA (Lab.)Montagne ex Kjellman.

PLATE XXXVI

AM,804

PLATE XXXVI.

Xiphophora gladiata (Lab)
Maatinyher Is, Tas.
U.S.L.
26/6/1954
Coll. I Bennett No. 1.
Det H B.S.W.

XIPHOPHORA CHONDROPHYLLA (R.Br.ex Turn.)Montagne
ex Harvey.

PLATE XXXVII

PLATE XXXVII.

Xiphophora chondrophylla (R. Br.) Mont.
Queenscliff, Vic
Drift
5.9.1954
Coll. & Det. H.B.S. Womersley

CYSTOPHORA UVIFERA (C.Agardh)J.Agardh.
PLATE XXXVIII

PLATE XXXVIII.

Cystophora uvifera (Ag) J Ag

Bombay Rock, Tamar Est, Tas

Upper S.L.

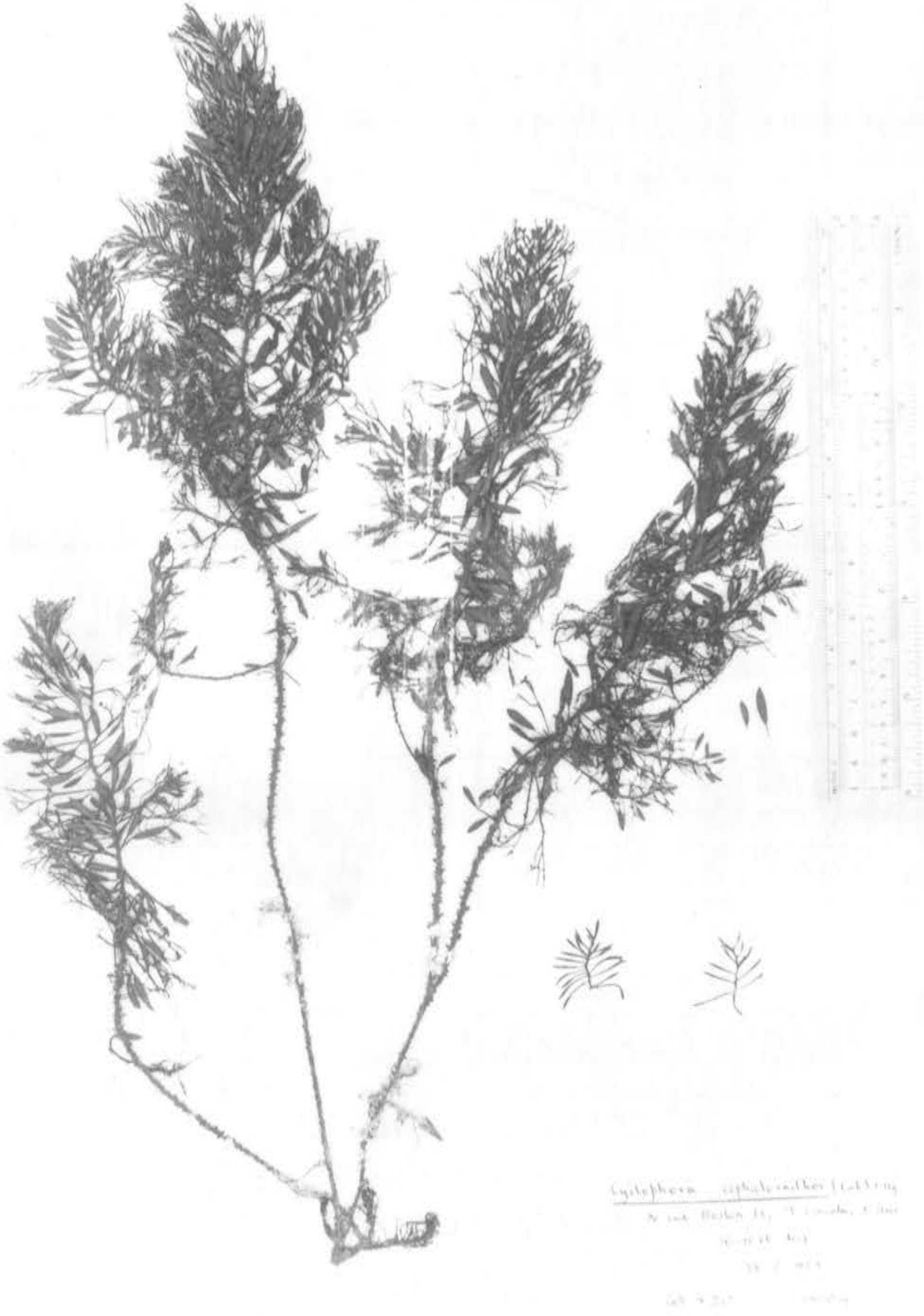
27/1/1949

Coll. & Det.

CYSTOPHORA CEPHLORNITHOS (Lab.)J.Agardh.

PLATE XXXIX

PLATE XXXIX.



CYSTOPHORA PANICULTA (Turn.) J.Agardh.
PLATE XL

PLATE XL.

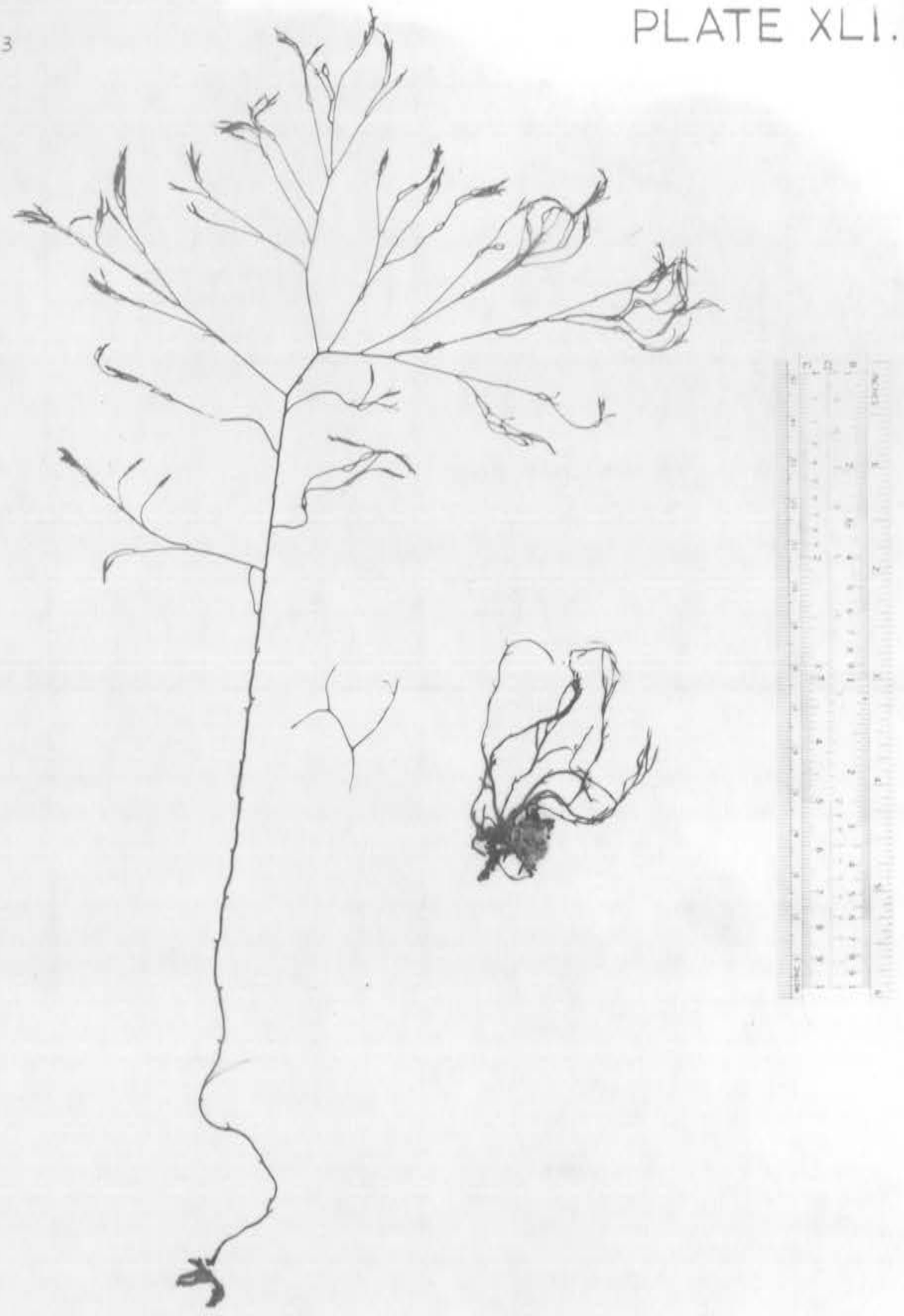

HOMEOTYPE
Cystophora paniculata (Turn
J. Ag
Robe, S. Aus
Drift
30/8/1949
Coll. + Det. H. B. S. WOMERSLEY

CYSTOPHORA GALAPAGENSIS (Piccone and Grunow in
in Piccone) nov.comb.

PLATE XLI

A 23,973

PLATE XLI.



Cystophora galapagensis (Picc & Grun) nov. comb.

Charles Is., Galapagos Is.
1934
Coll & Det. W. R. Taylor.

CYSTOPHORA PECTINATA(Grev.et C.Agardh ex Sonder) J.Agardh.

PLATE XLII

PLATE XLII

Cystophora pectinata (Grev. & Ag.) J. Ag.

Scotts Bay (4 m. W. Fowlers Bay), S. Aust.

Drift

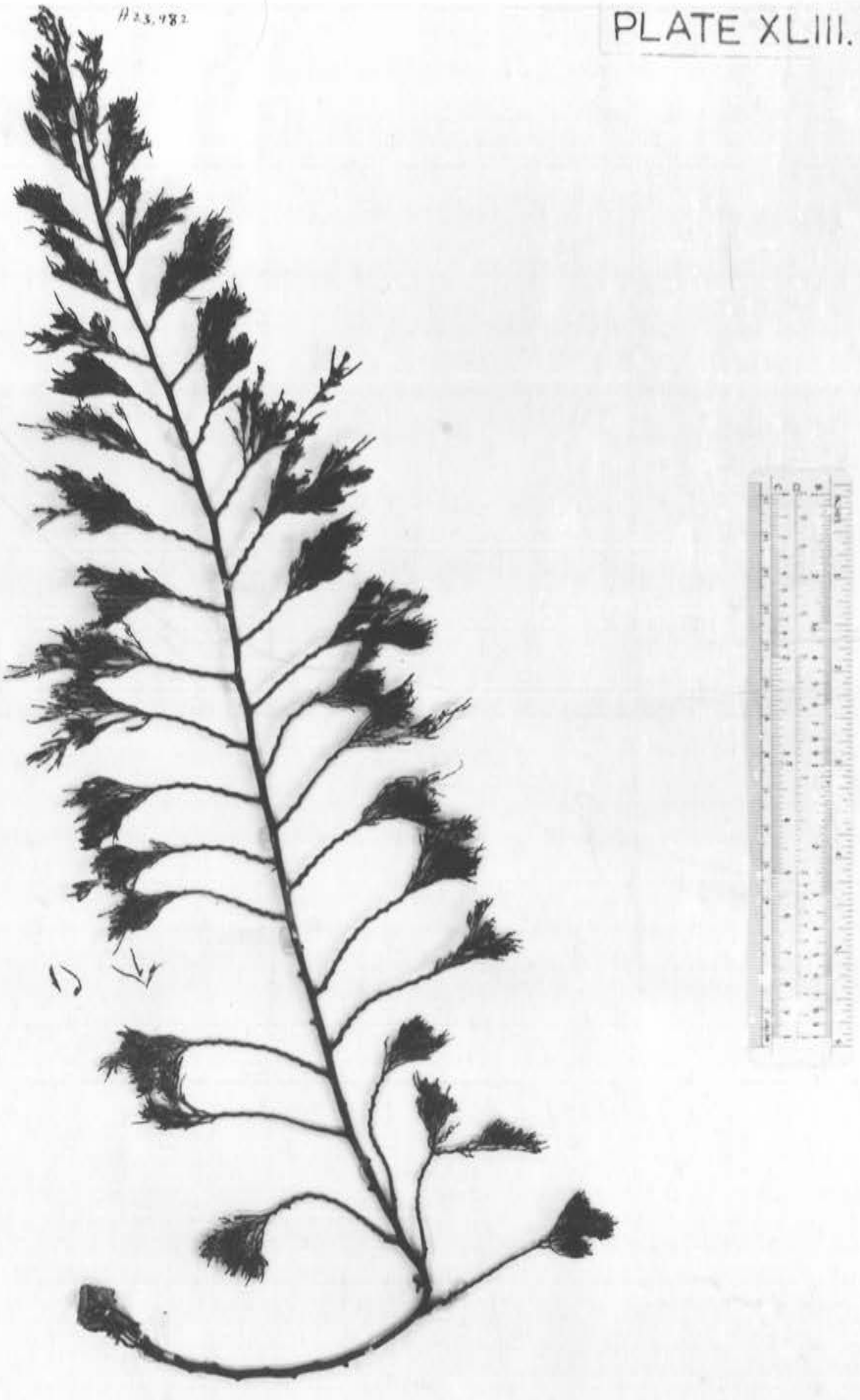
27/1/1951

Coll. & Det. H. B. S. WOMERSLEY

CYSTOPHORA INTERMEDIA J. Agardh.

PLATE XLIII

PLATE XLIII.



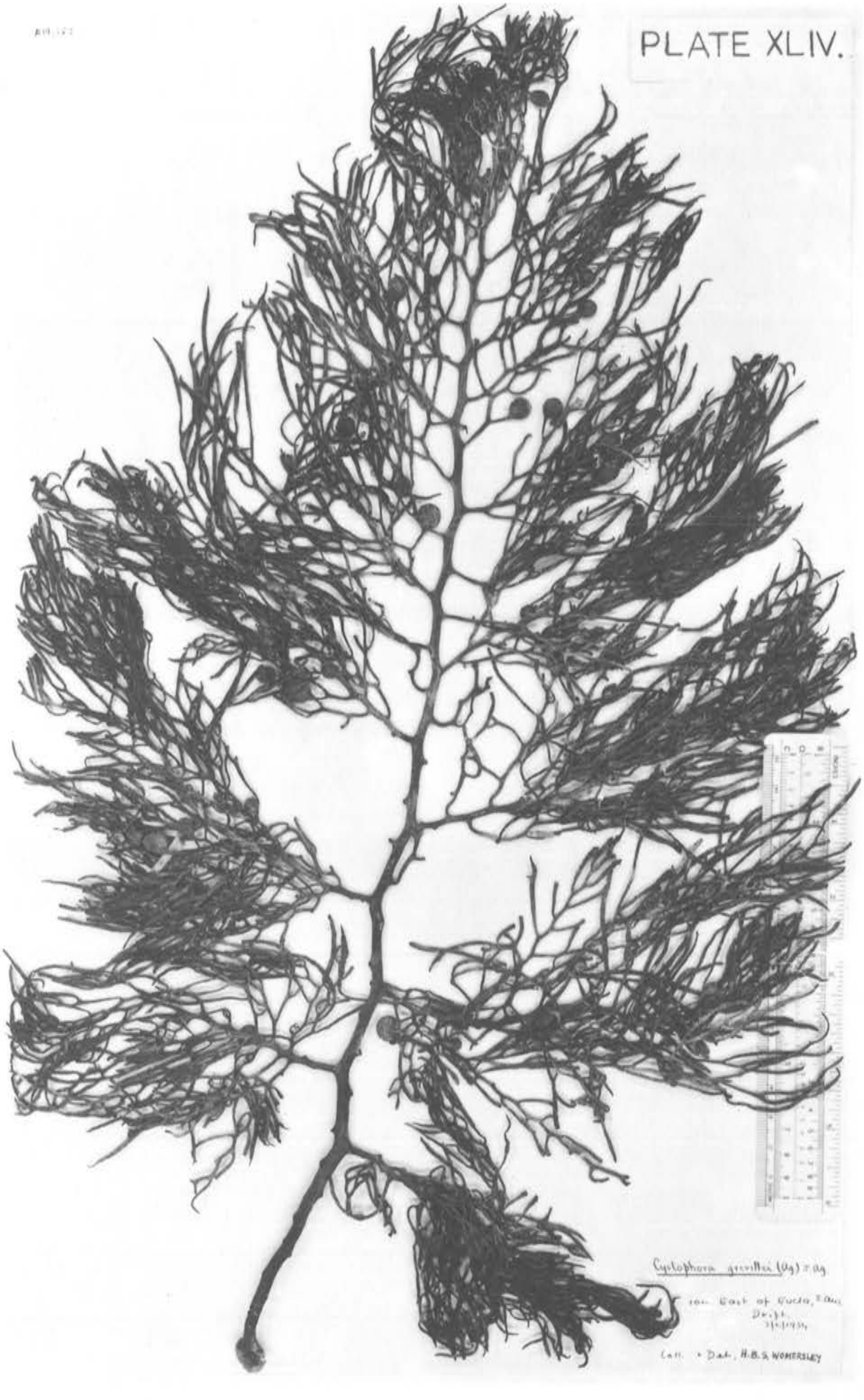
Cystophora intermedia J. Ag

Petrel Cove (N. of Bluff, V.H.)
Washed up - but growing on rocks subject
to surf action.
10/12/44.
H. B. S. Womersley (ey)

CYSTOPHORA GREVILLEI (C.Agardh in Sonder)J.Agardh.

PLATE XLIV

PLATE XLIV.



Cystophora grevillei (Ag) J. Ag

10m East of Eucla, S. Aus.
Drift.
3/1/1954

Coll. + Det. H.B.S. WOMERSLEY

CYSTOPHORA PLATYLOBIUM (Mertens)J.Agardh.

PLATE XLV

PLATE XLV.


Cystophora platylobium (Mert.) J. Ag.
Stinky Bay, Nora Creina, S. Aus.
Drift
14/8/1957
Coll. & Det. H. B. S. Womersley

CYSTOPHORA BRANDEGEEI(Setchell et Gardner)nov.comb.

PLATE XLVI

PLATE XLVI.

A 23,472

Cystophora brandegeei (S + G) nov. comb

West Anchorage, Guadalupe I

30-1-1950

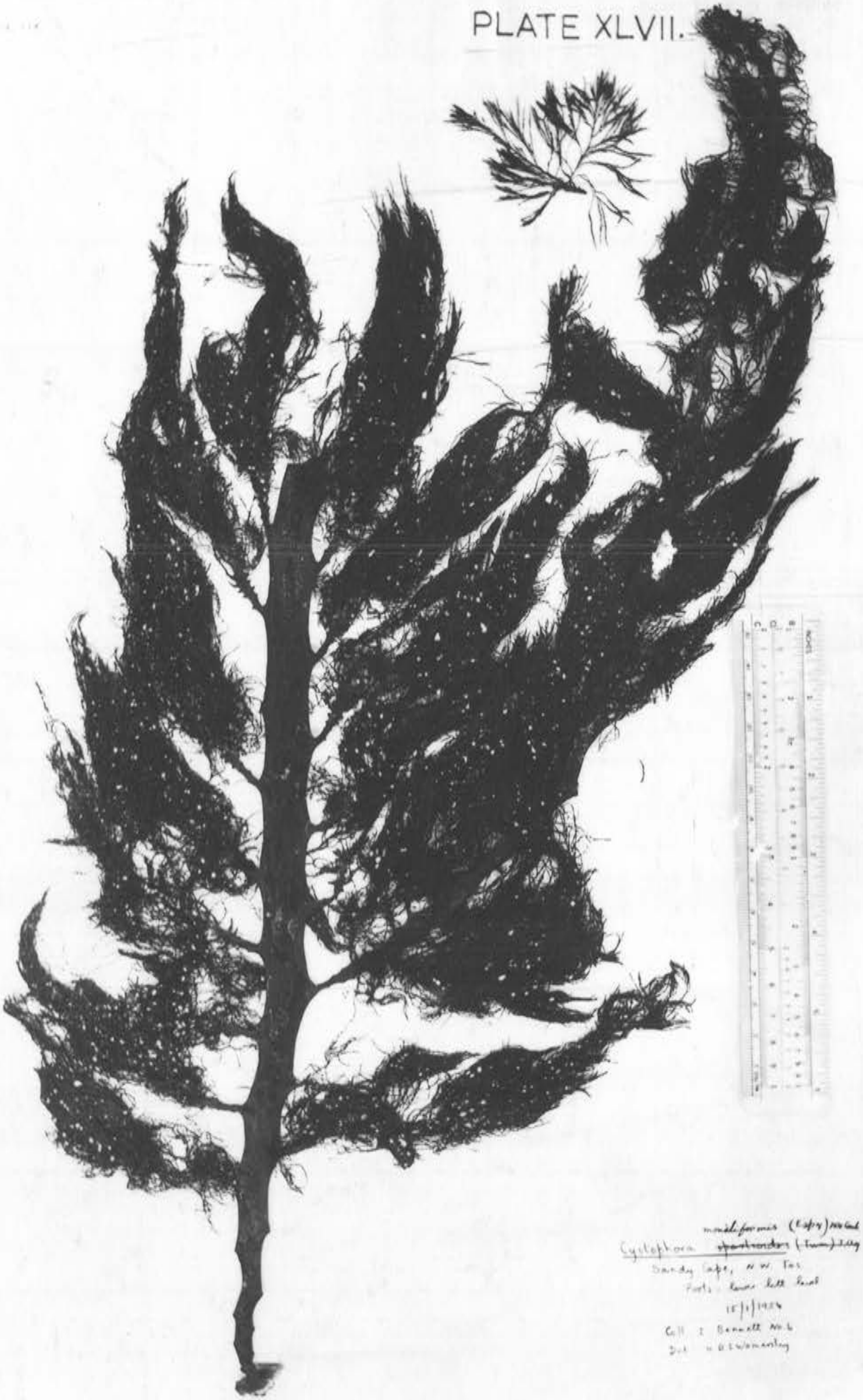
coll Paul Silva

Del

CYSTOPHORA MONILIFORMIS (Esper) nov. comb.

PLATE XLVII

PLATE XLVII.



moniliformis (Esper) Wom.
Cystophora ~~spartioides~~ (Turn.) J.Ag.
Sandy Cape, N.W. Tas.
Pools - lower tidal level
15/1/1954
Coll. I. Bennett No.6
Det. H.B.S. Womersley

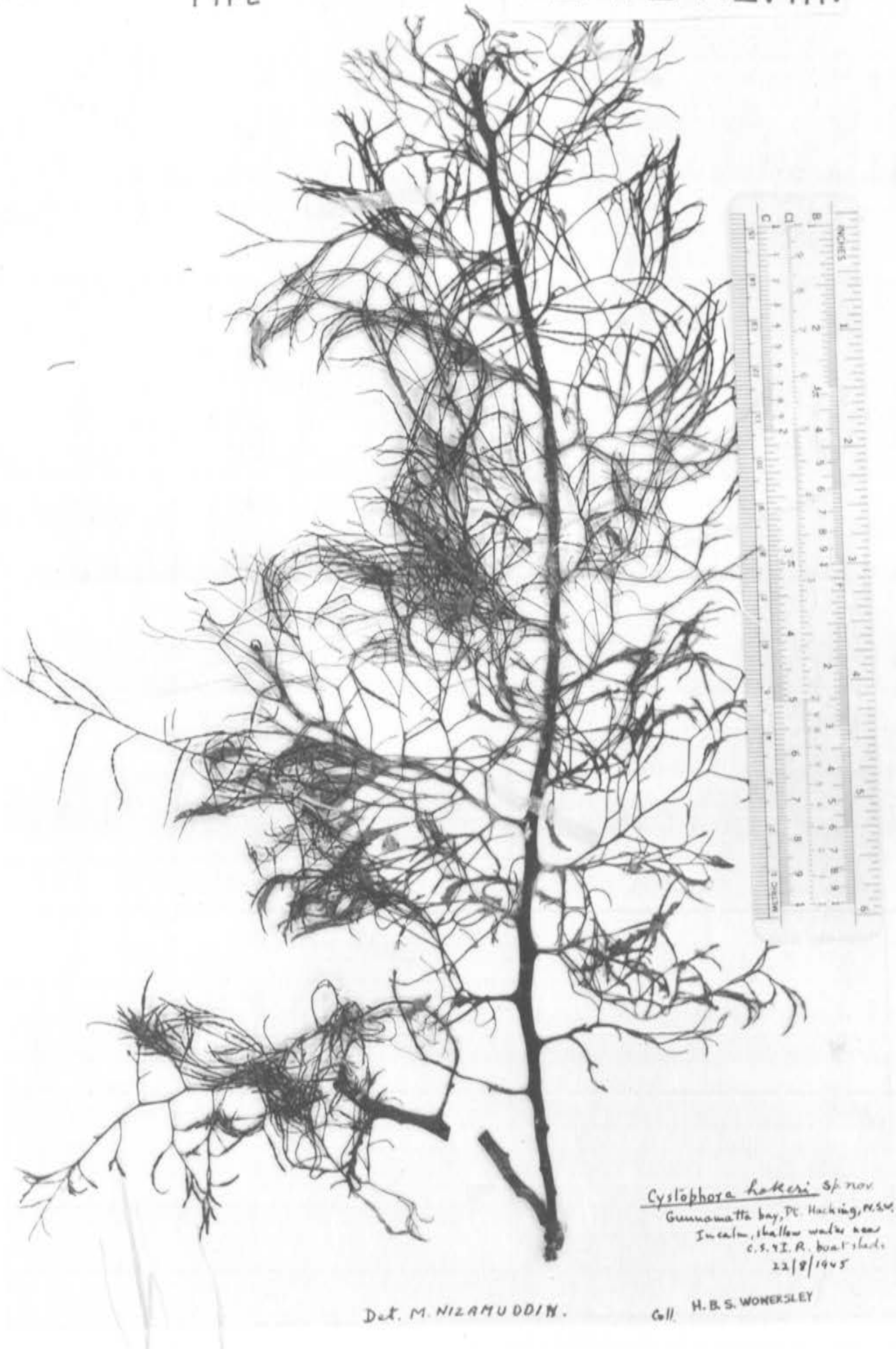
CYSTOPHORA HOOKERI Sp.nov.

PLATE XLVIII

7 1985 a

TYPE

PLATE XLVIII.



Cystophora hakeri sp. nov.
Gunnamatta bay, Pt. Hacking, N.S.W.
In calm, shallow water near
C.S.&I.R. boat sheds.
22/8/1945

Det. M. NIZAMUDDIN.

Coll. H. B. S. WOMERSLEY

CYSTOPHORA XIPHOCARPA Harvey.

PLATE XLIX

PLATE XLIX.

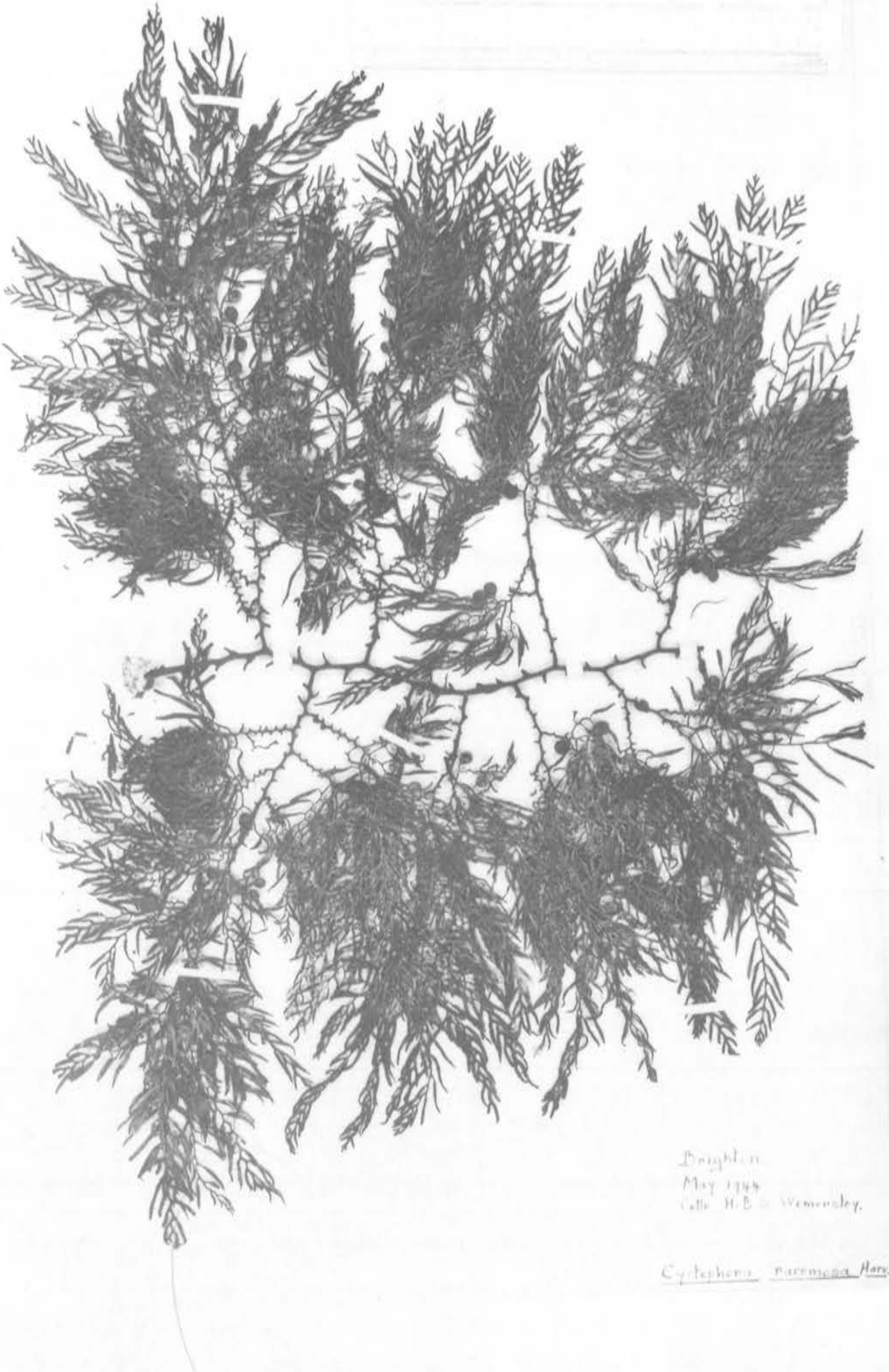

A10,3126
Cystophora xiphocarpa Harv.
Bicheno, Tasmania
Low pools
19/1/1949
Coll. et Det., H. B. S. WOMERSLEY

CYSTOPHORA RACEMOSA(Harvey ex Kuetzing)J.Agardh.

PLATE L

A1086

PLATE L.



Brighton
May 1944
Coll. H.B.S. Womersley.

Cystophora racemosa Harv.

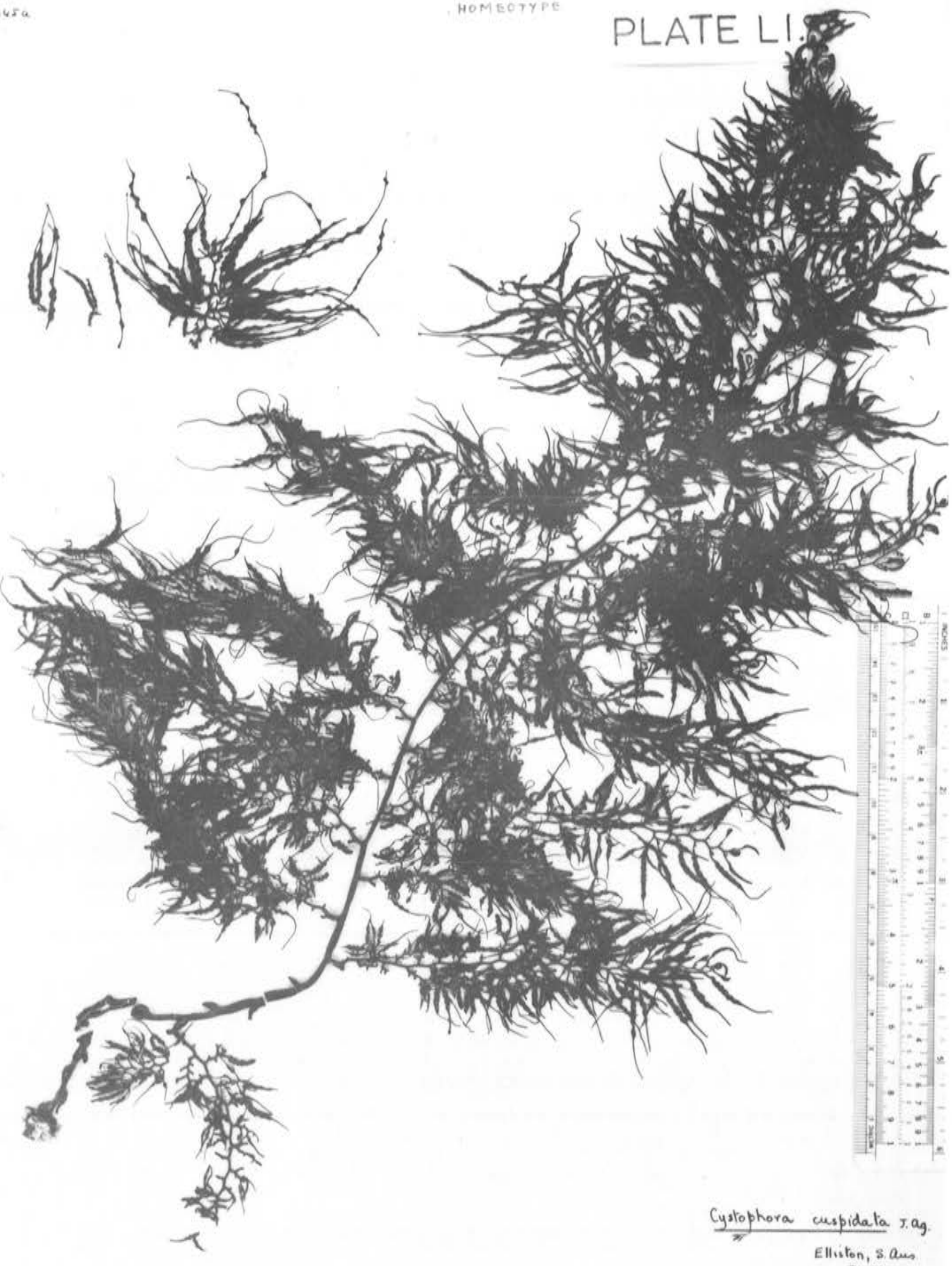
CYSTOPHORA CUSPIDATA J.Agardh.

PLATE LI

A13,445a

HOMEOTYPE

PLATE LI.



<u>Cystophora cuspidata</u> J. Ag.

Elliston, S. Aus
Drift
13/1/1951

Coll. & Det. H. B. S. WOMERSLEY

CYSTOPHORA SCALARIS J.Agardh.

PLATE LII

PLATE LII.

Cystophora scalaris J. Ag.

Kaikoura, S. Is., New Zealand
upper sublittoral
17/2/1949

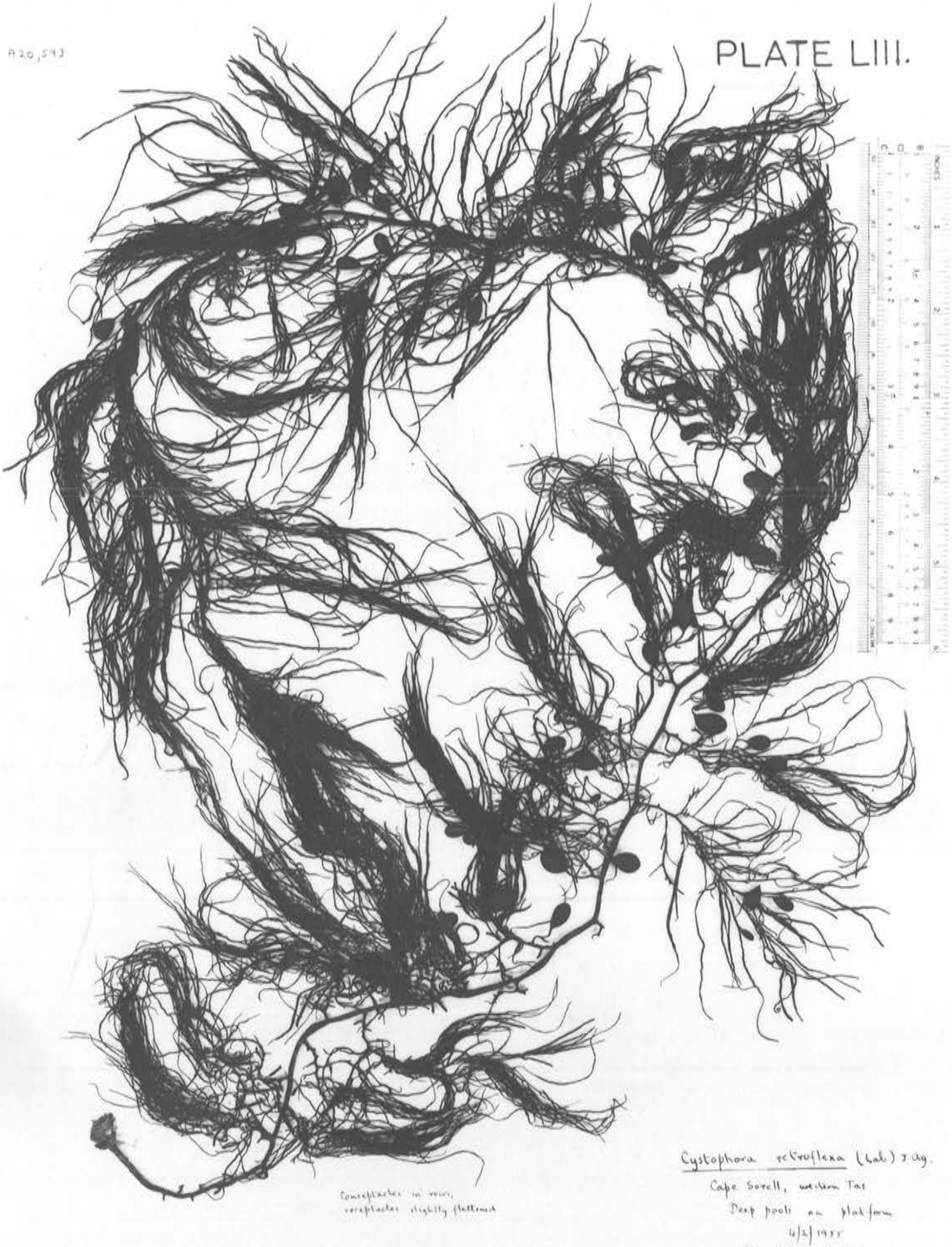
Coll & Del. H. B. S. WOMERSLEY

CYSTOPHORA RETROFLEXA (Lab.) J. Agardh.

PLATE LIII

A20,543

PLATE LIII.



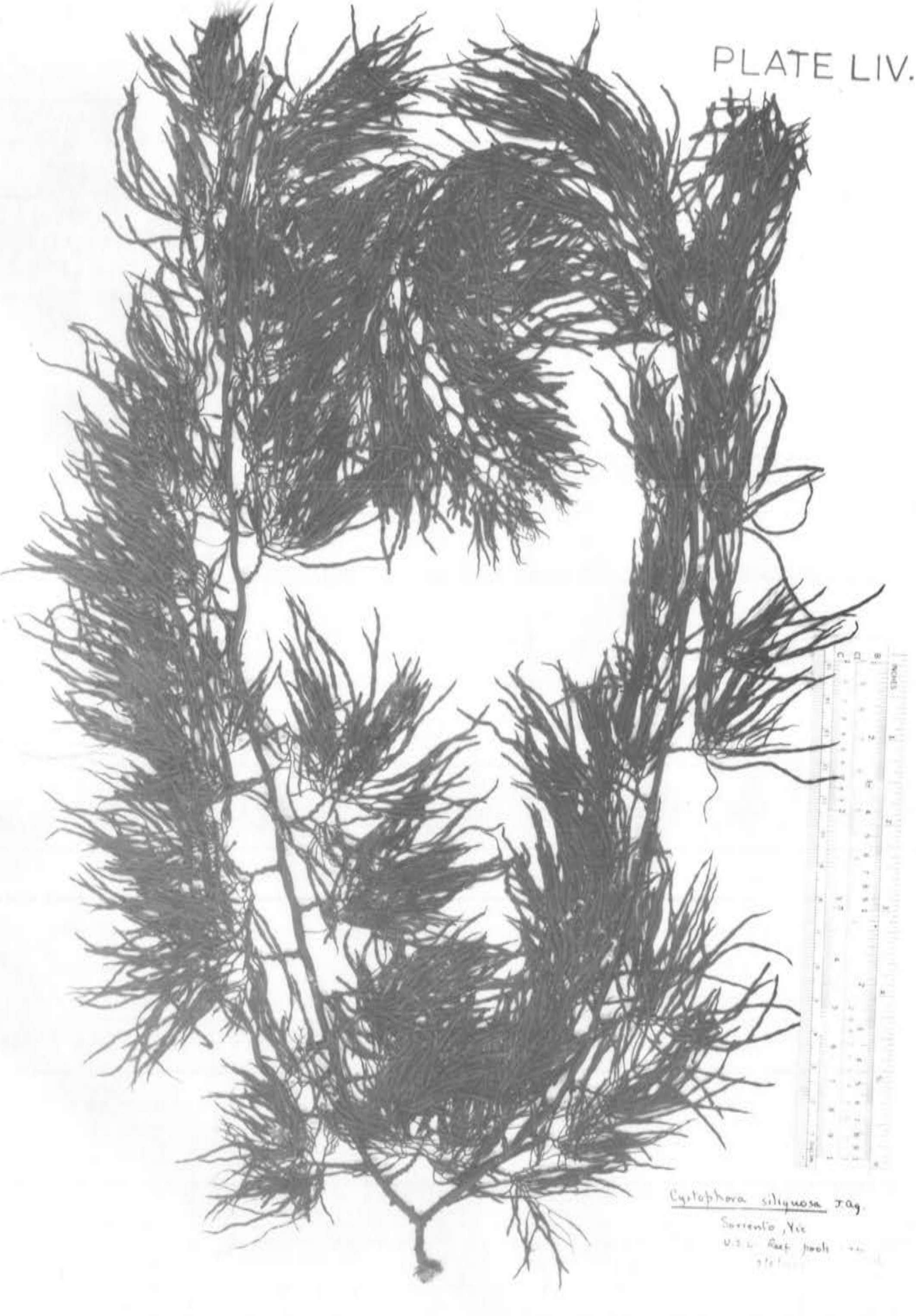
Conceptacles in rows,
receptacles slightly flattened

Cystophora retroflexa (Lab.) J. Ag.
Cape Sorell, western Tas
Deep pools on platform
4/2/1955
Coll. I. Bennett No.5
Det. H.B.S.W.

CYSTOPHORA SILIQUOSA J.Agardh.

PLATE LIV

PLATE LIV.

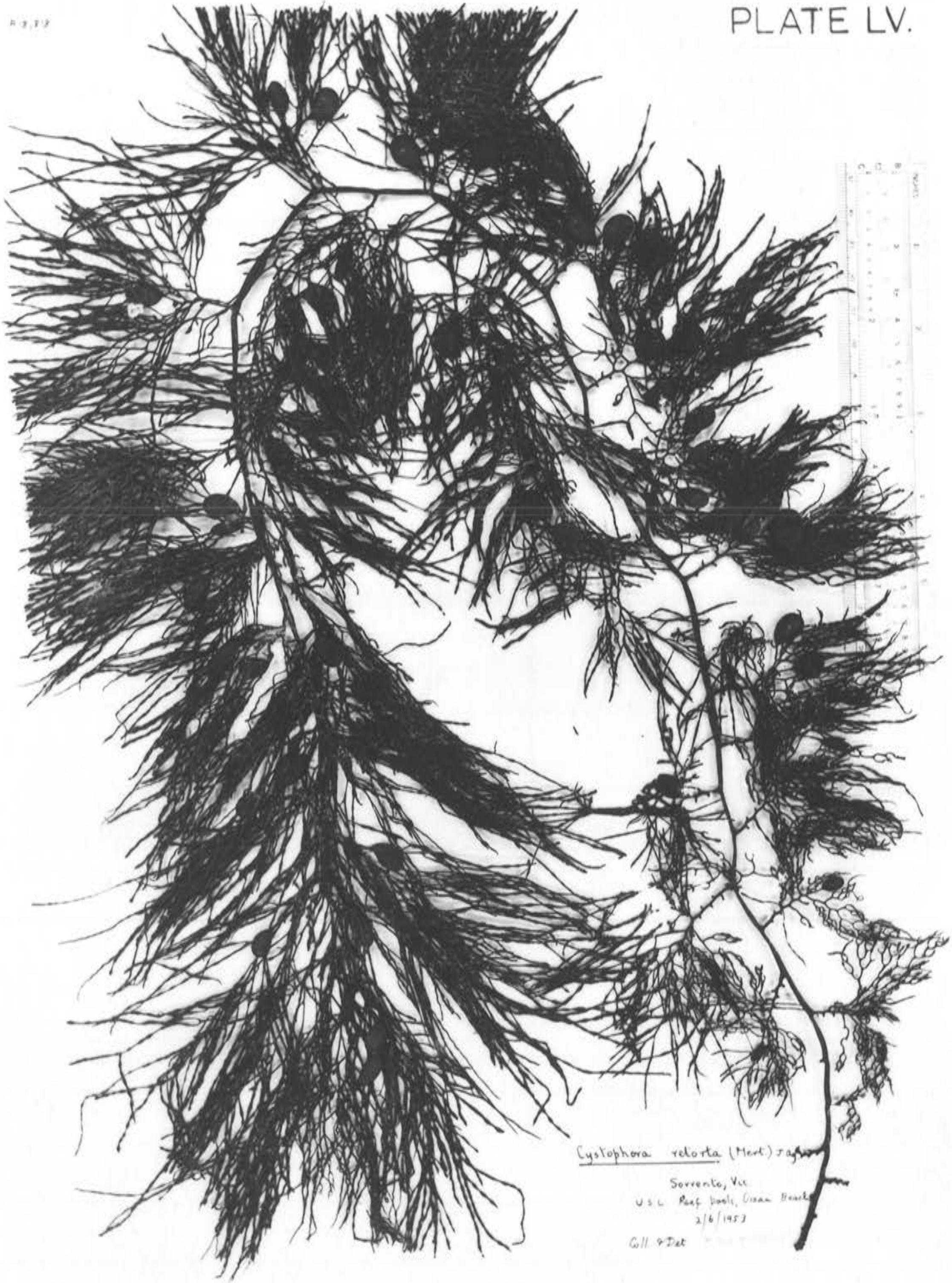

Cystophora siliquosa J.Ag.
Sorrento, Vic
U.T.L. Reef pools
INCHES

CYSTOPHORA RETORTA (Mertens)J.Agardh.

PLATE LV

8 9,3 7

PLATE LV.



<u></u>Cystophora retorta (Mert.) J.Ag.

Sorrento, Vic.
U S L Reef pools, Ocean Beach
2/6/1953

Coll. & Det.

CYSTOPHORA TORULOSA(R.Br.ex Turn.) J.Agardh.

PLATE LVI

A9317a

PLATE LVI.

Cystophora torulosa (R. Br.) J. Ag.

Low Head, Tas.
On rocks at low tide
Aug. 1948

Coll. & Det. F. Perrin

CYSTOPHORA BOTRYOCYSTIS Sonder.

PLATE LVII

PLATE LVII.

<u>Cystophora botryocystis</u> Sonder
Cape Donnington Aus.
35 ft deep
23 II 1959
Coll. E. A. Shepley
Det. H. B. S. Womersley

CYSTOPHORA DISTENTA J.Agardh.

PLATE LVIII

PLATE LVIII.

Cystophora distinta J. Ag.
Stewart Island
20-11-1943.

CYSTOPHORA CONGESTA Sp.nov.

PLATE LIX

A 23,980

TYPE

PLATE LIX.

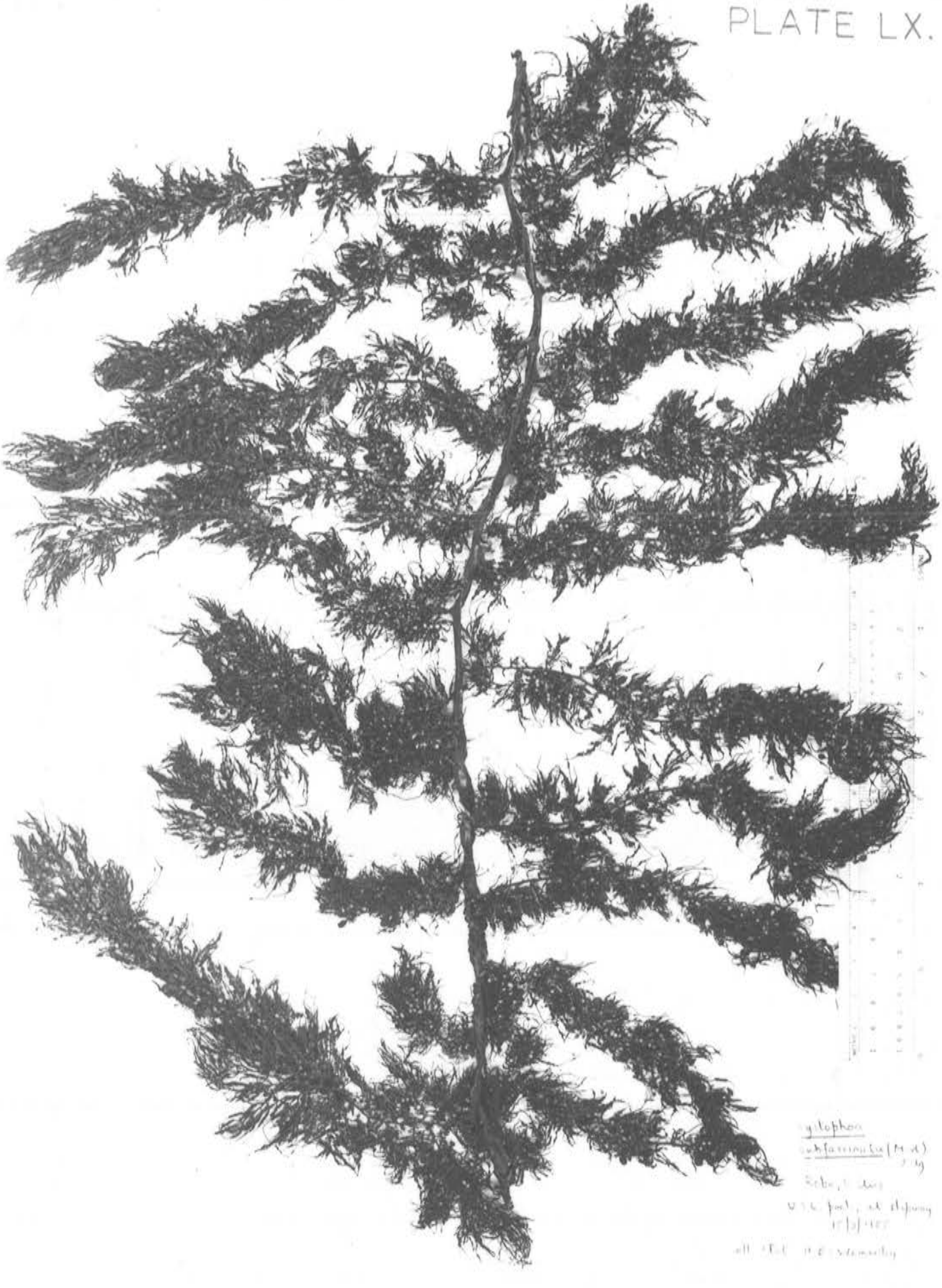
Cystophora congesta sp. nov.
Sublittoral pools
Robe, near slipway
16-4-1959

Coll & Det. M. NIZAMUDDIN.

CYSTOPHORA SUBFARCINATA (Mertens) J.Agardh.

PLATE LX

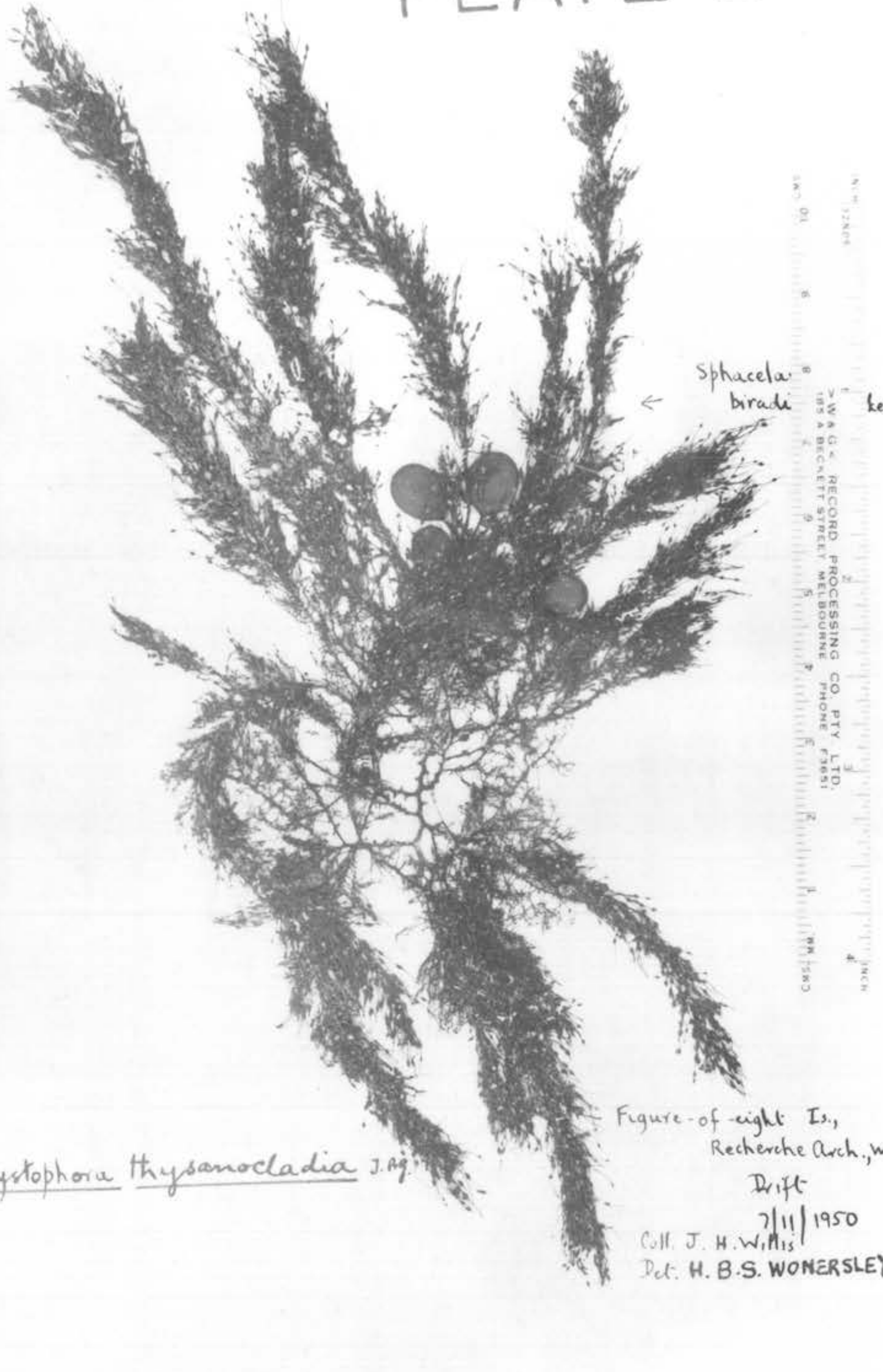
PLATE LX.



CYSTOPHORA THYSANOCLADIA J. Agardh.

PLATE LXI

PLATE LXI.



Sphacela
biradi ken.

Cystophora thysanocladia J.Ag.

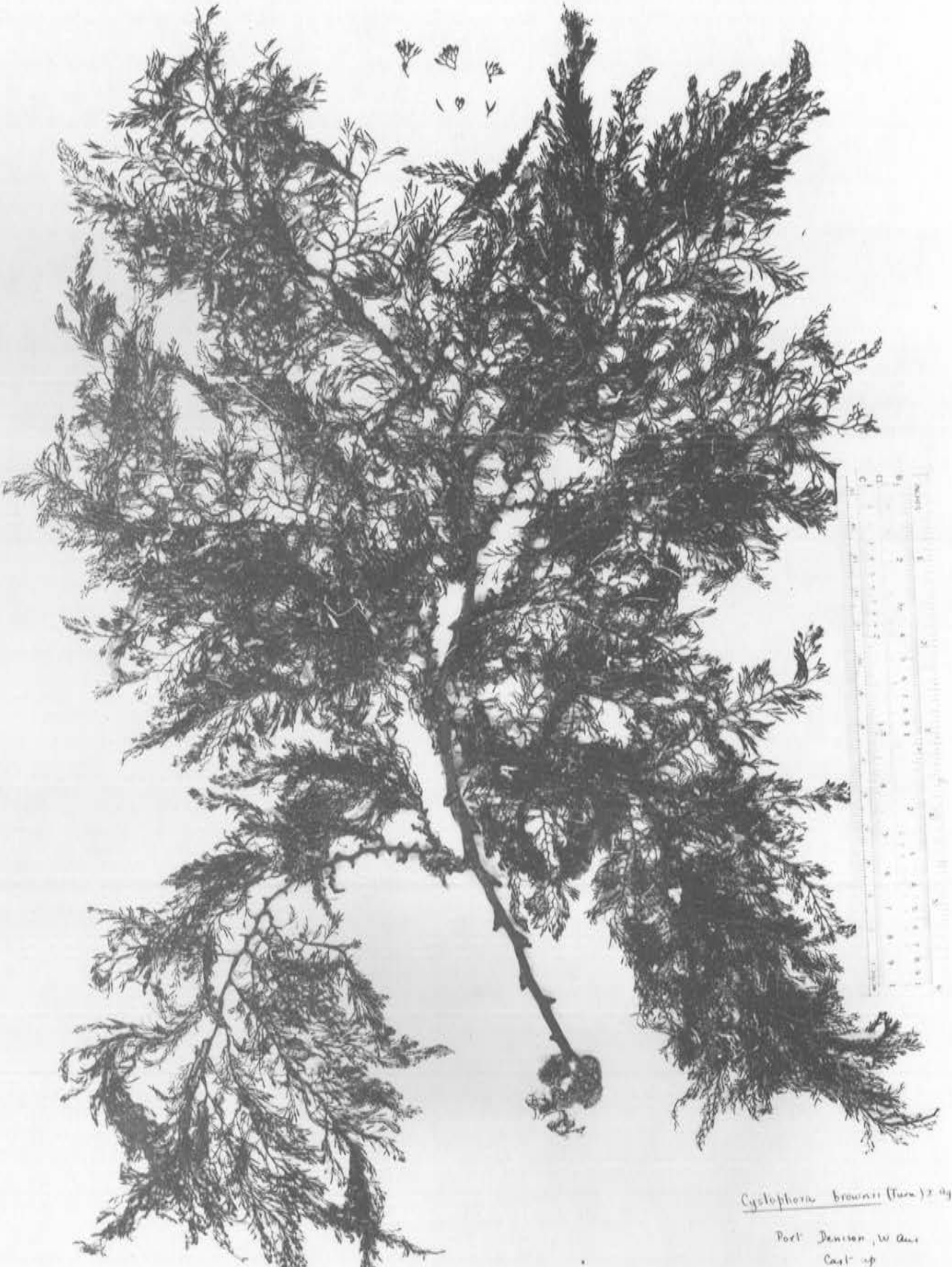
Figure-of-eight Is.,
Recherche Arch., W. Aus
Drift
7/11/1950
Coll. J. H. Willis
Det. H. B.S. WOMERSLEY

CYSTOPHORA BROWNII (Turn.) J.Agardh.

PLATE LXII

A 58634

PLATE LXII.



Cystophora brownii (Turn.) J. Ag

Port Denison, W. Aus.
Cast up
11/8/1947

CYSTOPHORA GRACILIS Sp.nov.

PLATE LXIII

A4247 C

K.I. 1481 C

TYPE

PLATE LXIII.

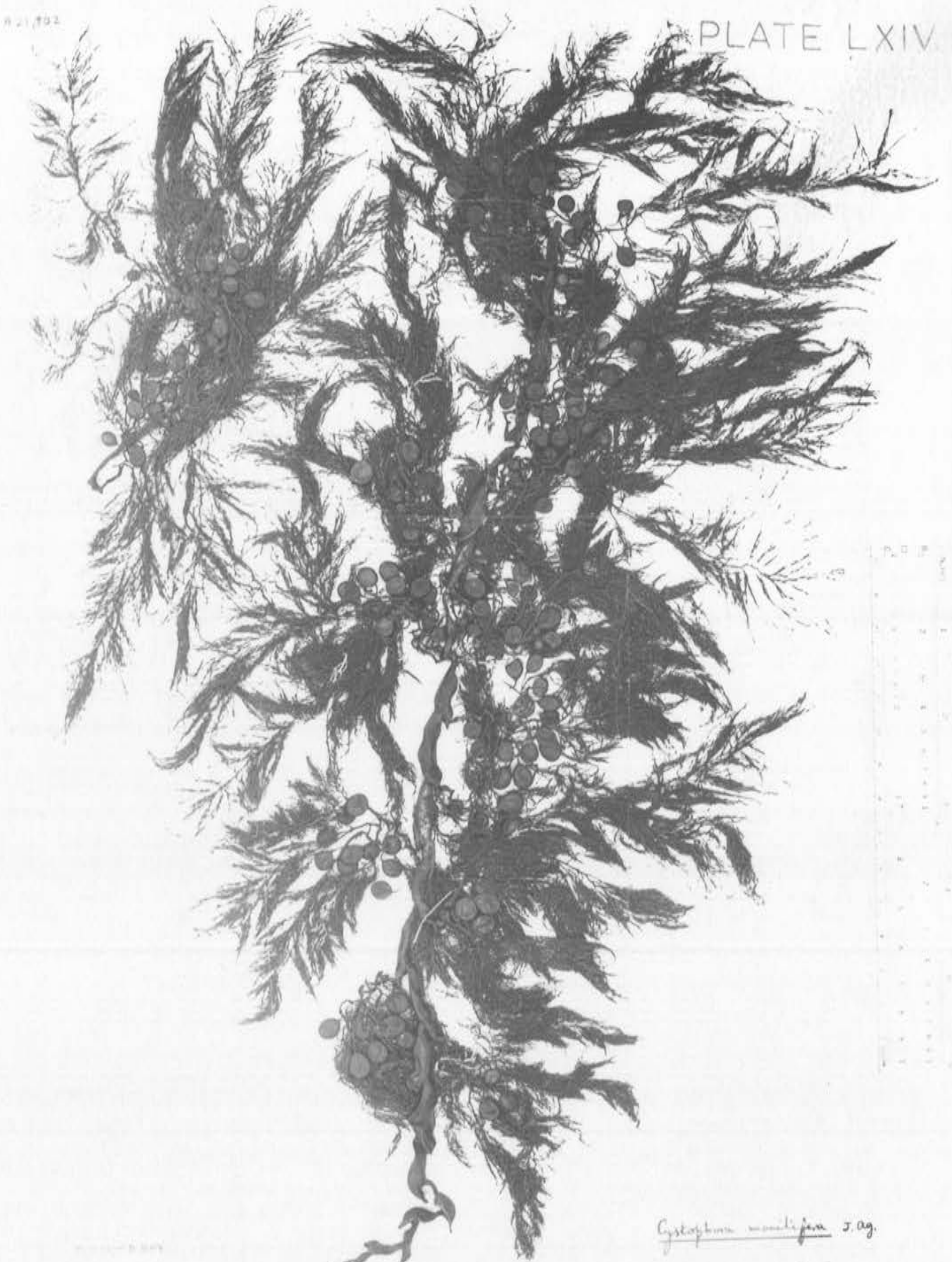
Cystophora gracilis sp. nov.

Vivonne Bay, K. I
Large littoral pool, S.S. Ellen Pt.
16/1/1947

CYSTOPHORA MONILIFERA J.Agardh.

PLATE LXIV

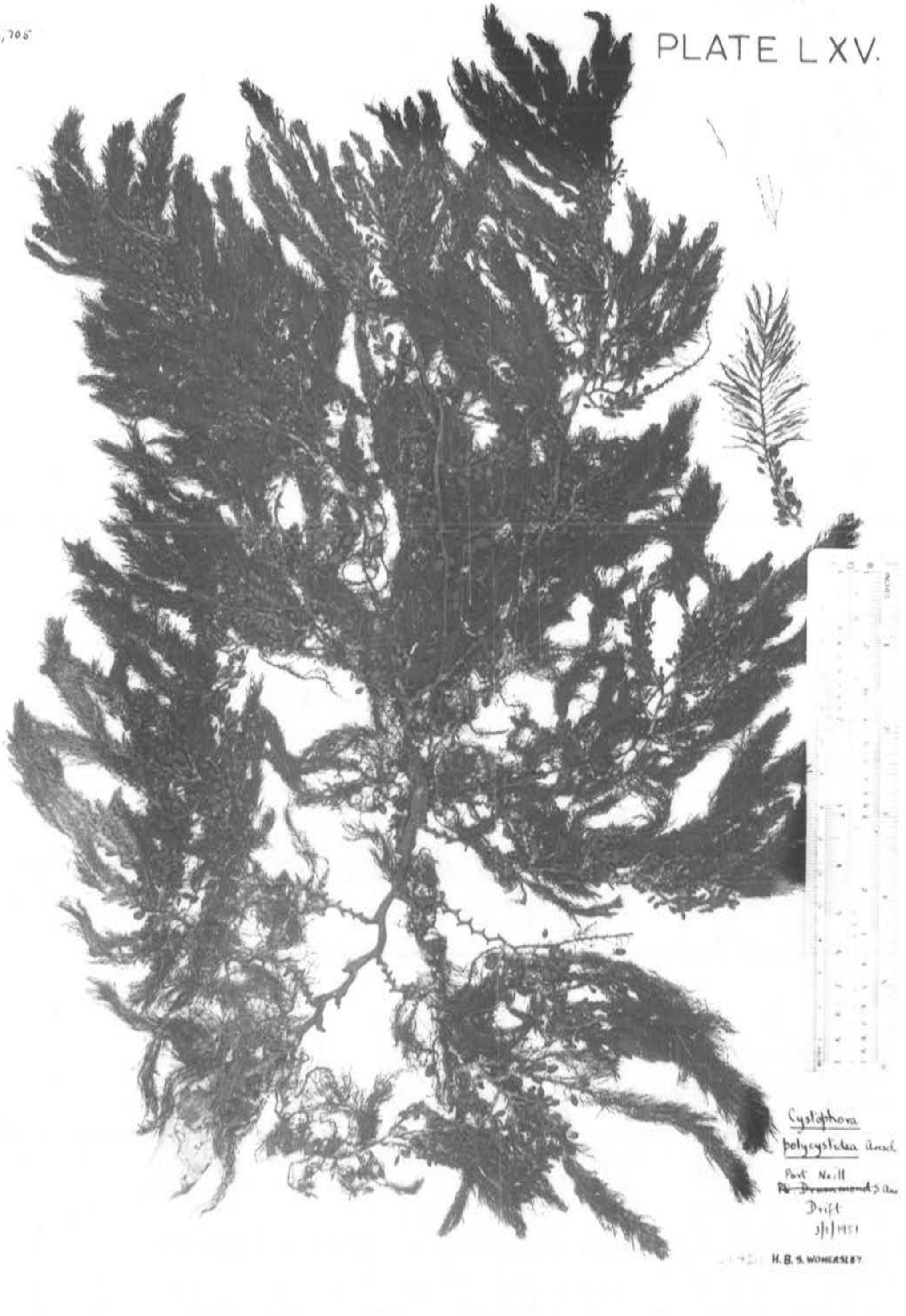
PLATE LXIV



CYSTOPHORA POLYCYSTIDEA Areschough in J.Agardh.

PLATE LXV

PLATE LXV.


Cystophora
polycystidea Aresch.
Port Neill
~~Pt Drummond~~ S Aus
Drift
3/1/1951
H. B. S. WOMERSLEY

CYSTOPHORA EXPANSA (Areschough) nov.comb.

PLATE LXVI

[illegible]

PLATE LXVI.

Cystophora expansa
(Areschoug).
nov. comb.
Yorke Pen.,
Brown's Point, S. Aus.
Upper sub littoral pools
10/4/1950

H. B. S. WOMERSLEY

CYSTOPHORA ELONGATA Sp.nov.

PLATE LXVII

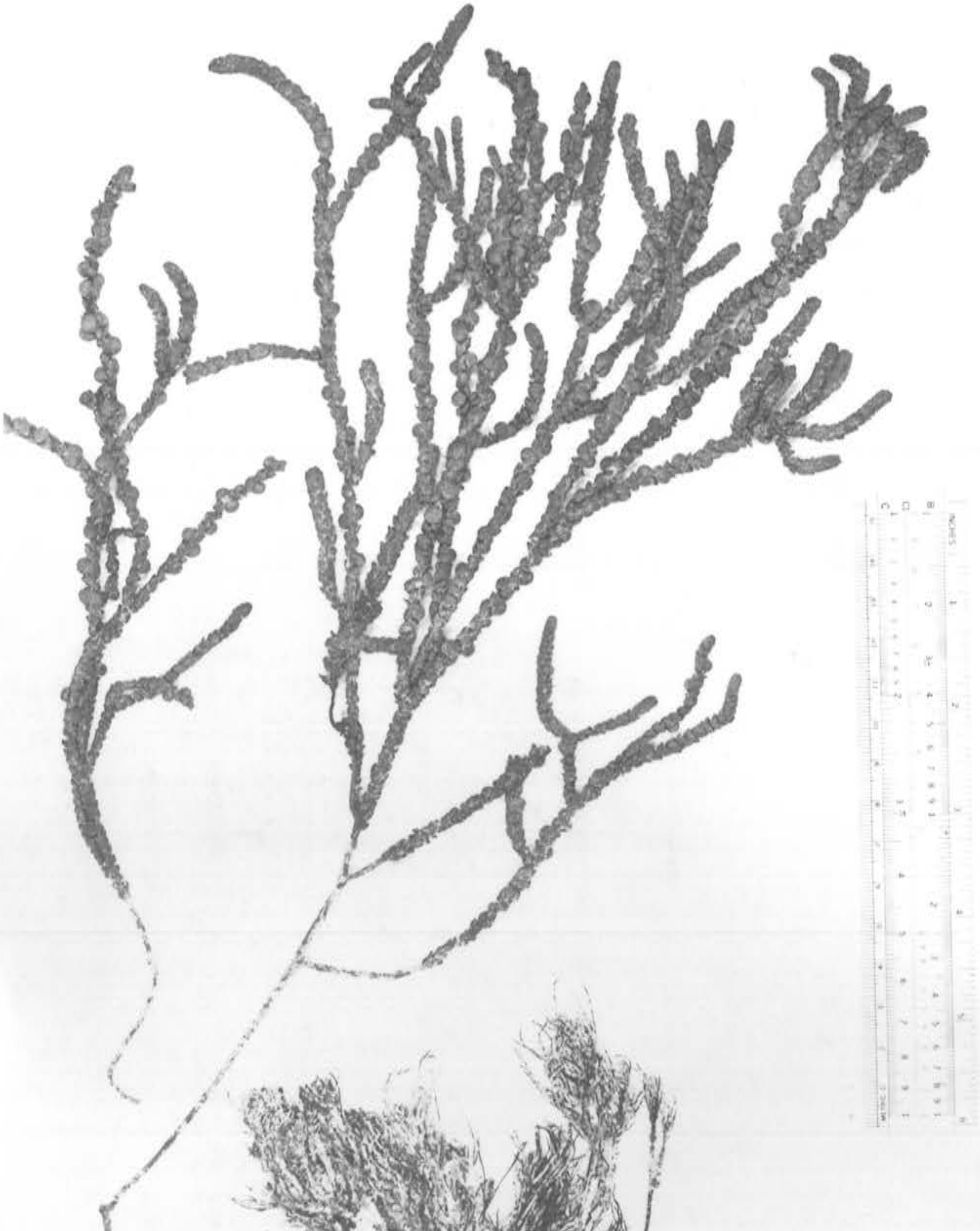
PLATE LXVII.


TYPE
Cystophora elongata sp. nov
Drift
Dutton Beach, north of Dutton Bluff
Portland Bay Victoria
13. 4. 1959
Coll & Del M NIZAMUDDIN

SCABERIA AGARDHII Grev.

PLATE LXVIII

PLATE LXVIII.

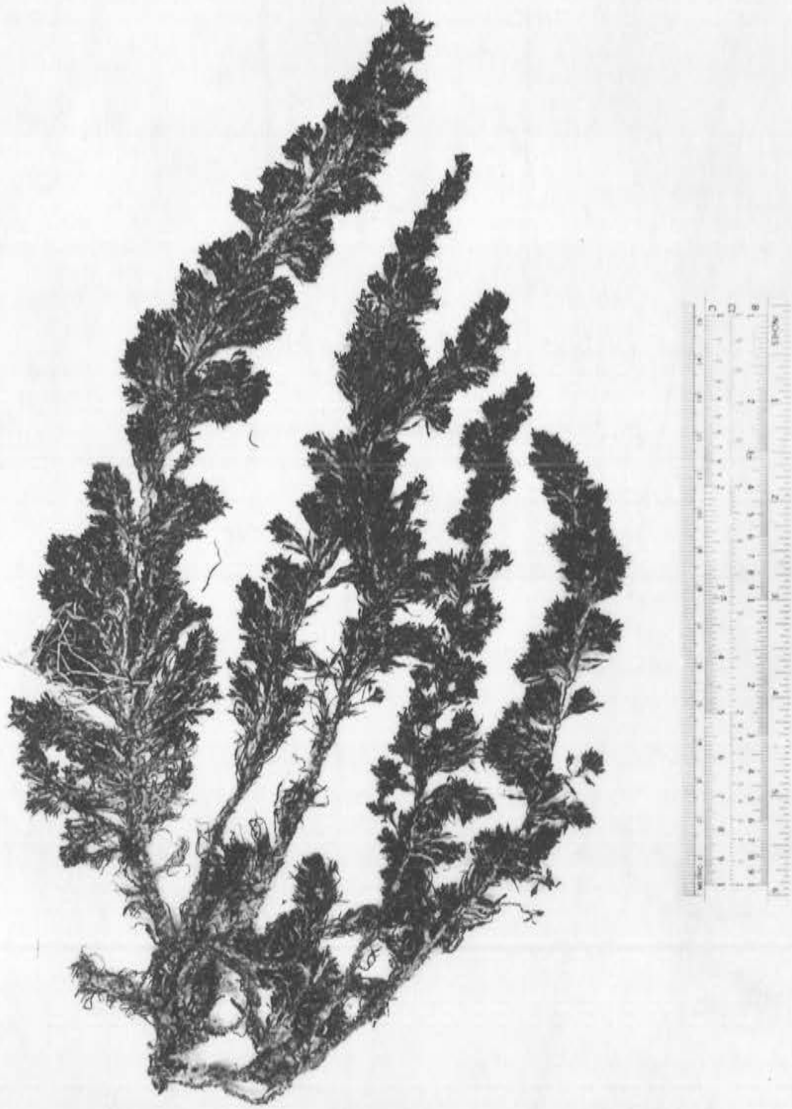


Scaberia agardhii Grev.
Cape Donnington, S. Aus
35 ft deep
Coll. E.A Shepley
23 II 1954
Det. H.B.S. Womersley

CYSTOPHYLLUM MURICATUM (Turn.) J.Agardh.

PLATE LXIX

PLATE LXIX.



Cystophyllum muricatum (Turn.) J. Ag.

Sceales Bay, S. Aus.

U.S.L. on granite

18/2/1954

Coll. & Det. H. B. S. Womersley

CYSTOSEIRA NODULARIA (Mertens) C.Agardh.

PLATE LXX

A 13,825

PLATE LXX.

Cystosiera nodularia C. Ag
C. Ag

Pt. Augusta, ~~S. Aus.~~
S. Aus.
Drift
31/12/1950

Coll. & Det.

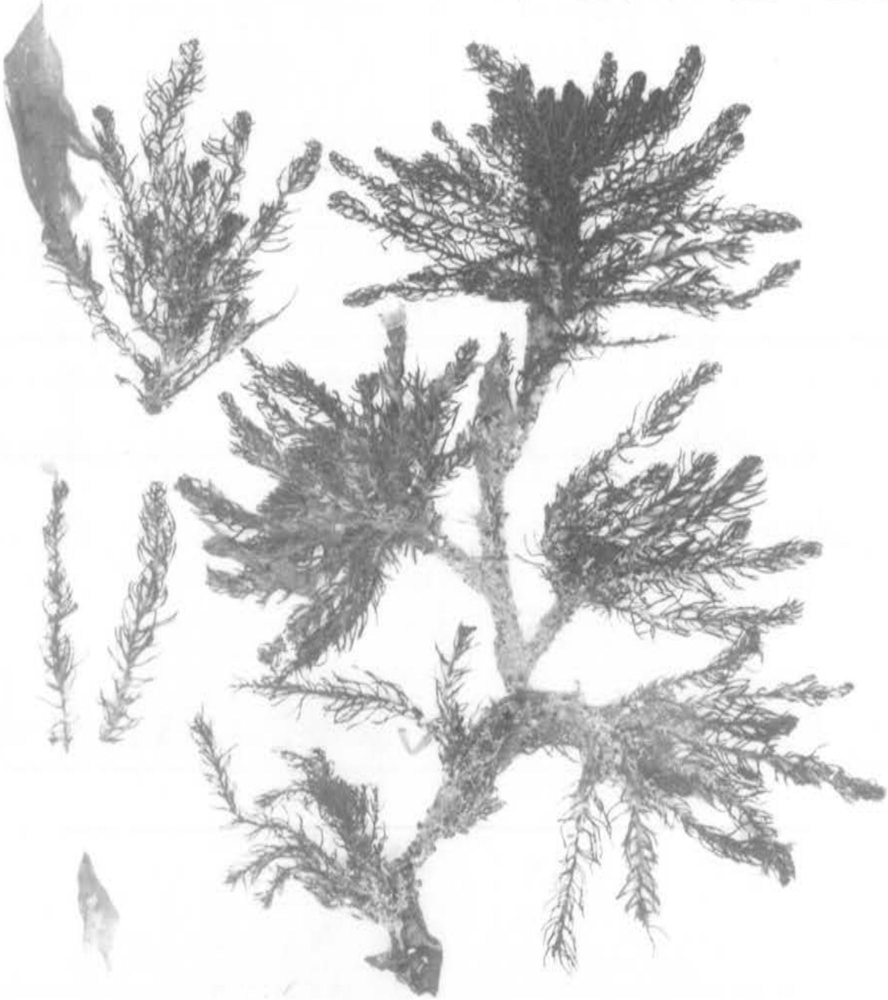
CYSTOSEIRA ROBUSTA J.Agardh.

PLATE LXXI

A 15,877

HOMEOTYPE

PLATE LXXI.



Cystoseira robusta J. Ag.

Cave Islet, Recherche Arche, W Aust

Rock Pool. 20-11-1950

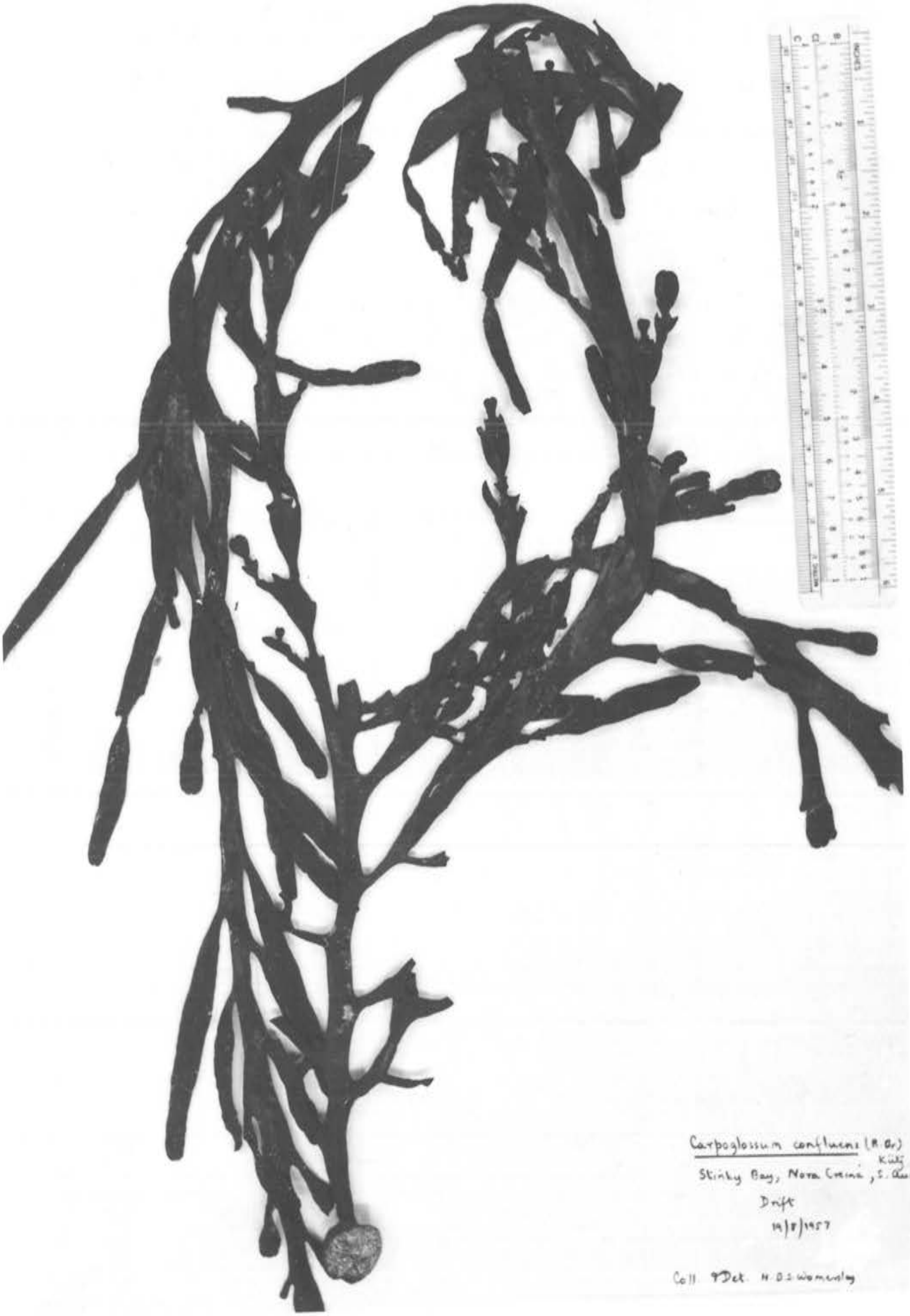
Coll. J. H. Willis.

Det. H. B. S Womersley

CARPOGLOSSUM CONFLUENS (R.Br.ex Turn.) Kuetzing.

PLATE LXXII

PLATE LXXII.



Carpoglossum confluens (R. Br.) Kütz

Stinky Bay, Nora Creina, S. Aus

Drift

19/8/1957

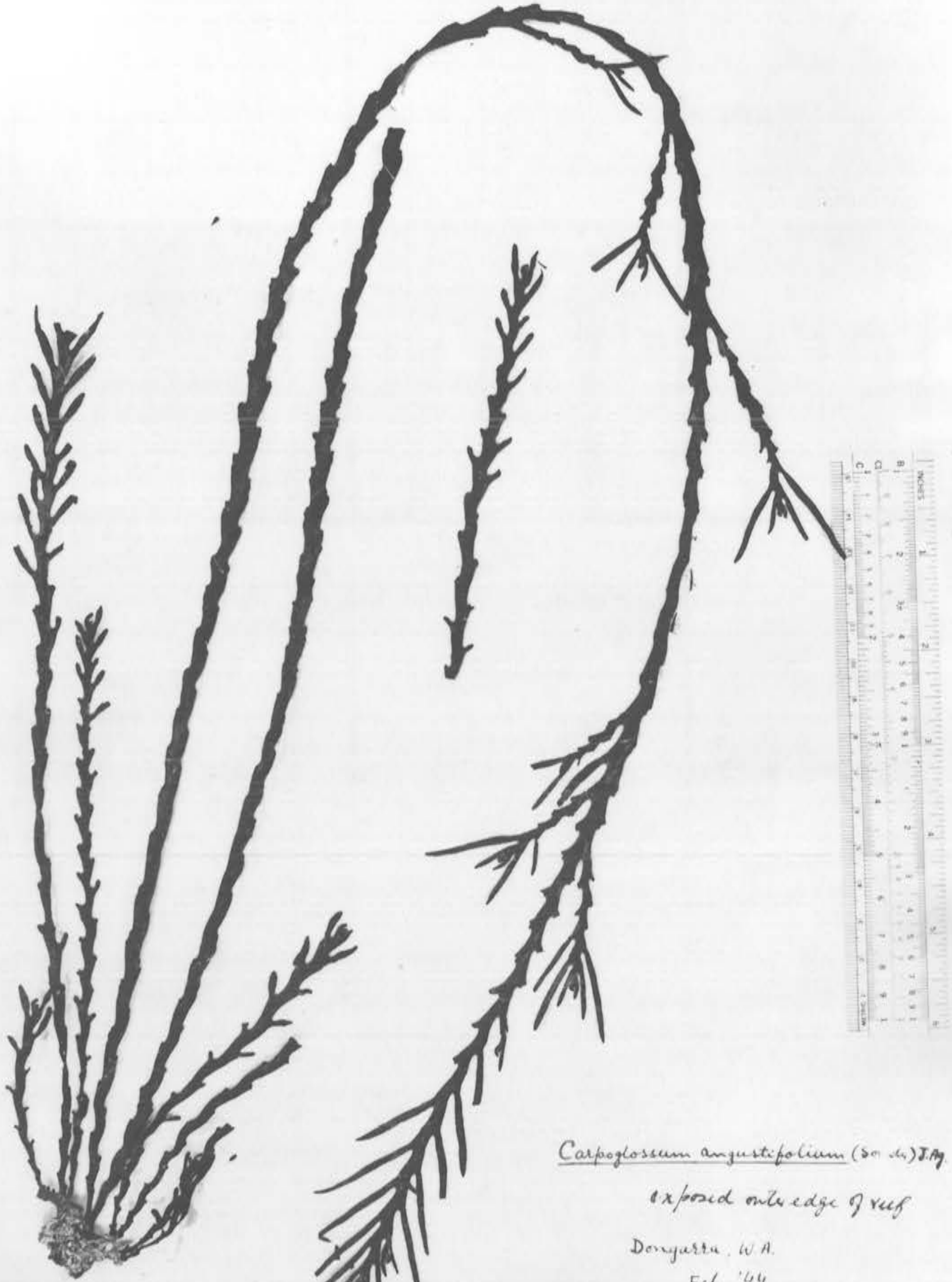
Coll. & Det. H. B. S. Womersley

CARPOGLOSSUM ANGUSTIFOLIUM (Sonder)J.Agardh.

PLATE LXXIII

PLATE LXXIII.

A 2042



Carpoglossum angustifolium (Sond.) J.Ag.

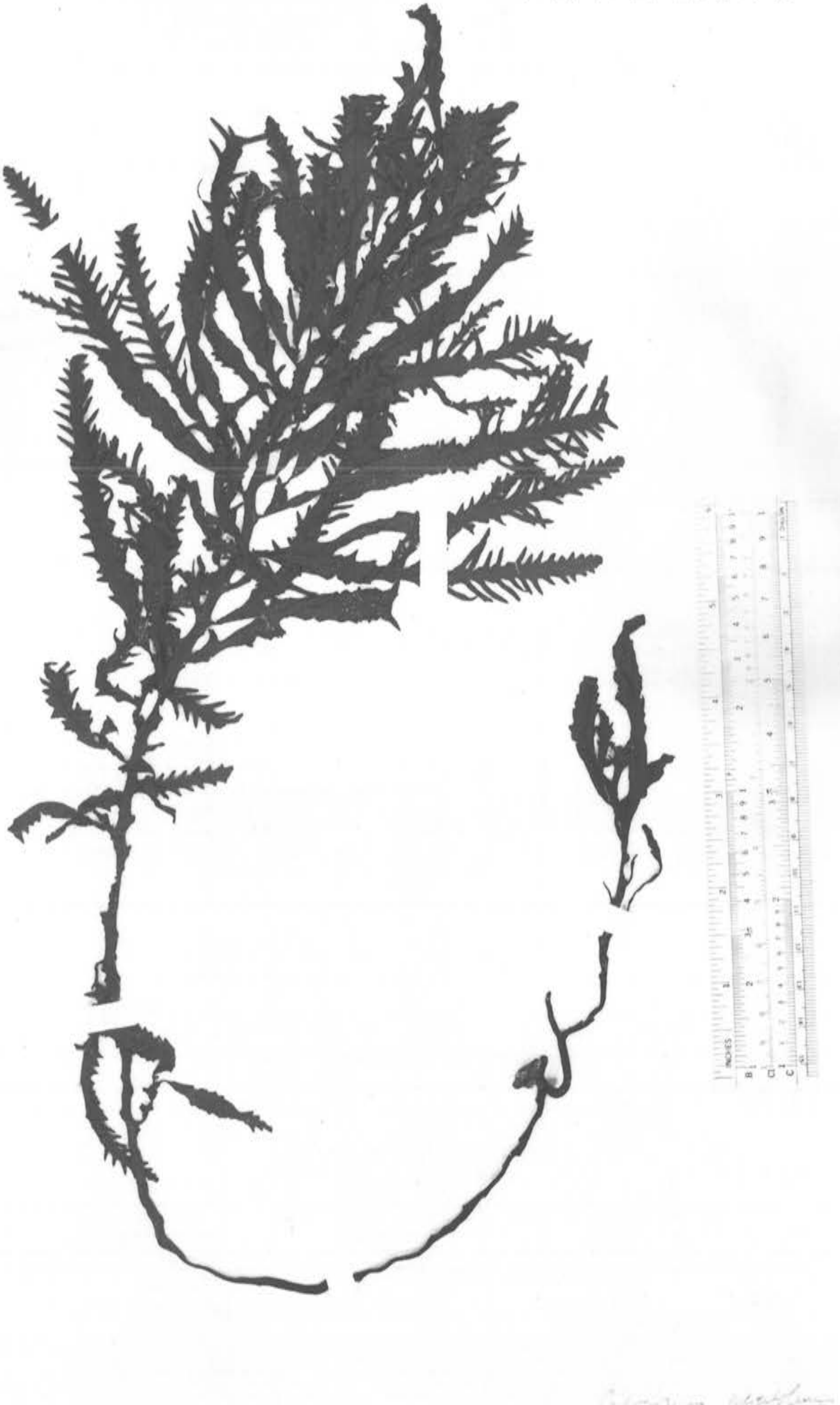
exposed outer edge of reef

Dongarra, W.A.
Feb. '44

CARPOGLOSSUM QUERCIFOLIUM (R.Br.ex Turn.)J.Agardh..

PLATE LXXIV

PLATE LXXIV.



MYRIODESMA PERONII sp.nov.

PLATE LXXV

A22245

TYPE

PLATE LXXV.

Myriodesma peronii sp. nov.
Point Peron, W. A. 3-2-1957.
Drift
Coll. Miss. E. M. Wollaston
Det. M. Nizamuddin

MYRIODESMA SERRULATA (LAMOUROUX)DECAISNE.

PLATE LXXVI

PLATE LXXVI.

Myriodesma serrulata (Lamx) Decaisne

Leighton Estuary, Mandura, W A
Drift.
Coll. Miss. E. M. Wollaston. 4-2-1957.
Det. M. Nizamuddin.

MYRIODESMA INTEGRIFOLIA Harvey
f. INTEGRIFOLIA.

PLATE LXXVII

A21,936

PLATE LXXVII.

MYRIODESMA INTEGRIFOLIA Harvey
f.PINNATIFIDA J.Agardh.
PLATE LXXVII

A 6587

PLATE LXXVII.

Myriodesma integrifolia Harv.
f. *pinnatifida* J. Ag.

PENNINGTON BAY
KANGAROO IS.
Cast up
4/1/1948

[illegible]

Coll. & Det. H. B. S. WOMERSLEY

MYRIODESMA TUBEROSA J.Agadh.

PLATE LXXVIII

A276

HOMEOTYPE

PLATE LXXVIII.

Myriodesma-tuberosum

"found only once before" J. Ag

Loc. Port Elliot

Coll. Jessie L Hussey

Date Nov 1897

MYRIODESMA LEPTOPHYLLA J.Agardh.

PLATE LXXIX

A 18392

PLATE LXXIX.

Myriodesma leptophylla J. Ag.

~~*Scaenophora australis*~~ J. Ag.

Encounter Bay, S. australia.
J. Hussey

MYRIODESMA PORTLANDIA sp.nov.

PLATE LXXX

A21,769

TYPE

PLATE LXXX.

Myriodesma *portlandia* sp. nov.

~~[illegible]~~

Double Corner Beach

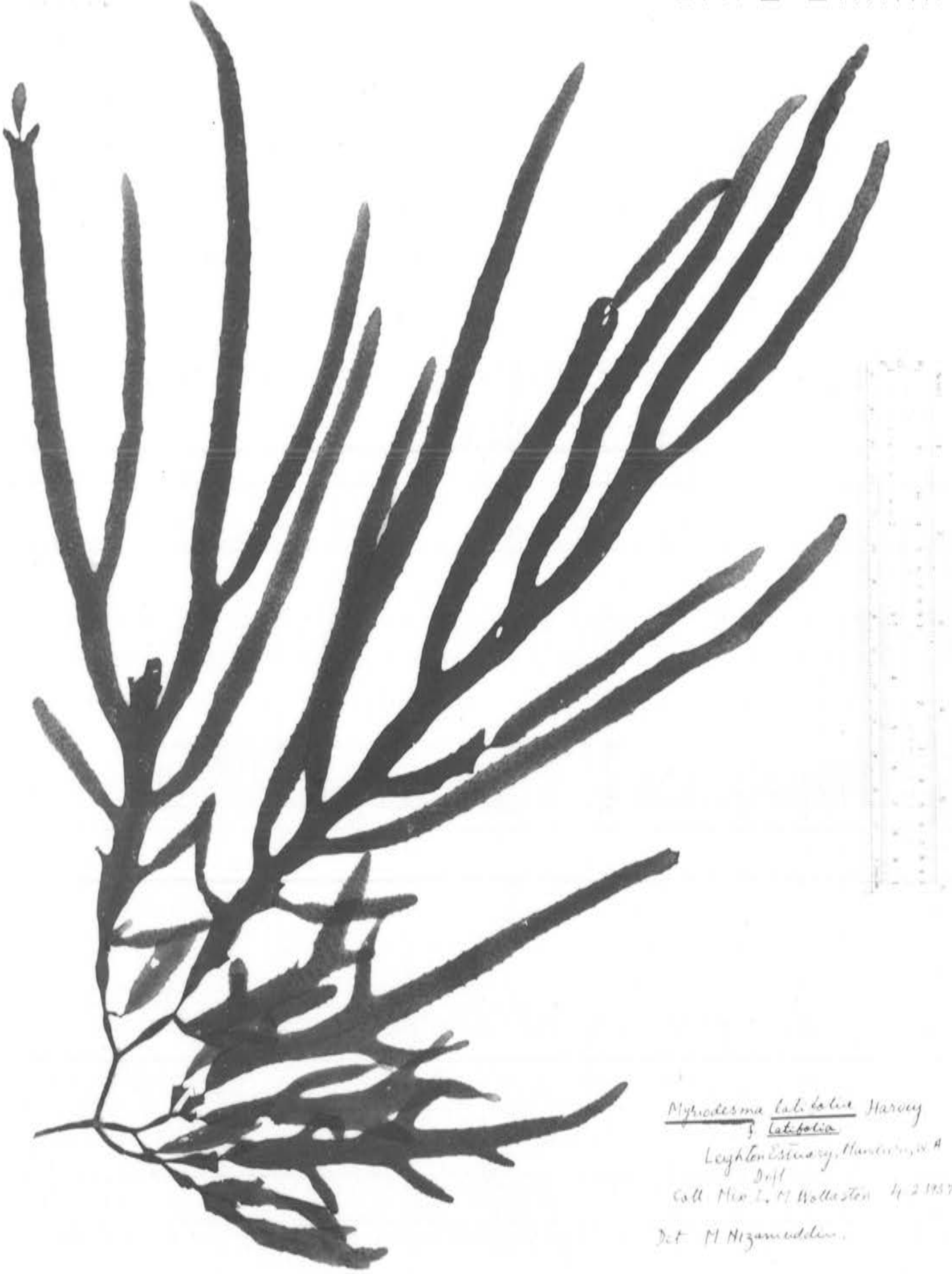
Cast up.

COLL. CLIFF BEAUGLEHOLE.
DET. M. NIZAMUDDIN.

MYRIODESMA LATIFOLIA Harvey f.LATIFOLIA.

PLATE LXXXI

PLATE LXXXI.

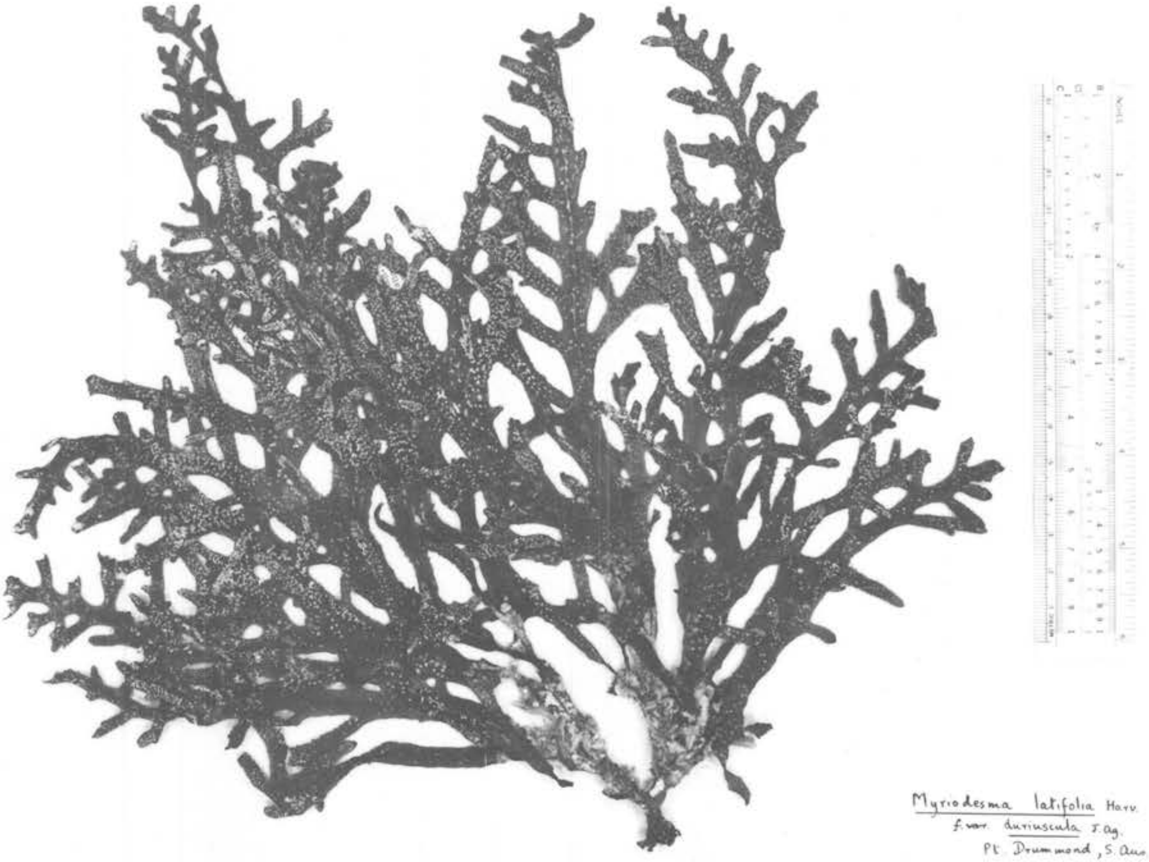

Myriodesma latifolia Harvey
f. latifolia
Leighton Estuary, Mandurah, W.A.
Drift
Coll Miss I. M. Wollaston 4 2 1957
Det M Nizamuddin.

MYRIODESMA LATIFOLIA Harvey f.DURIUSCULA J.Agardh.

PLATE LXXXI A

A 13,735 b

PLATE LXXXI.A.



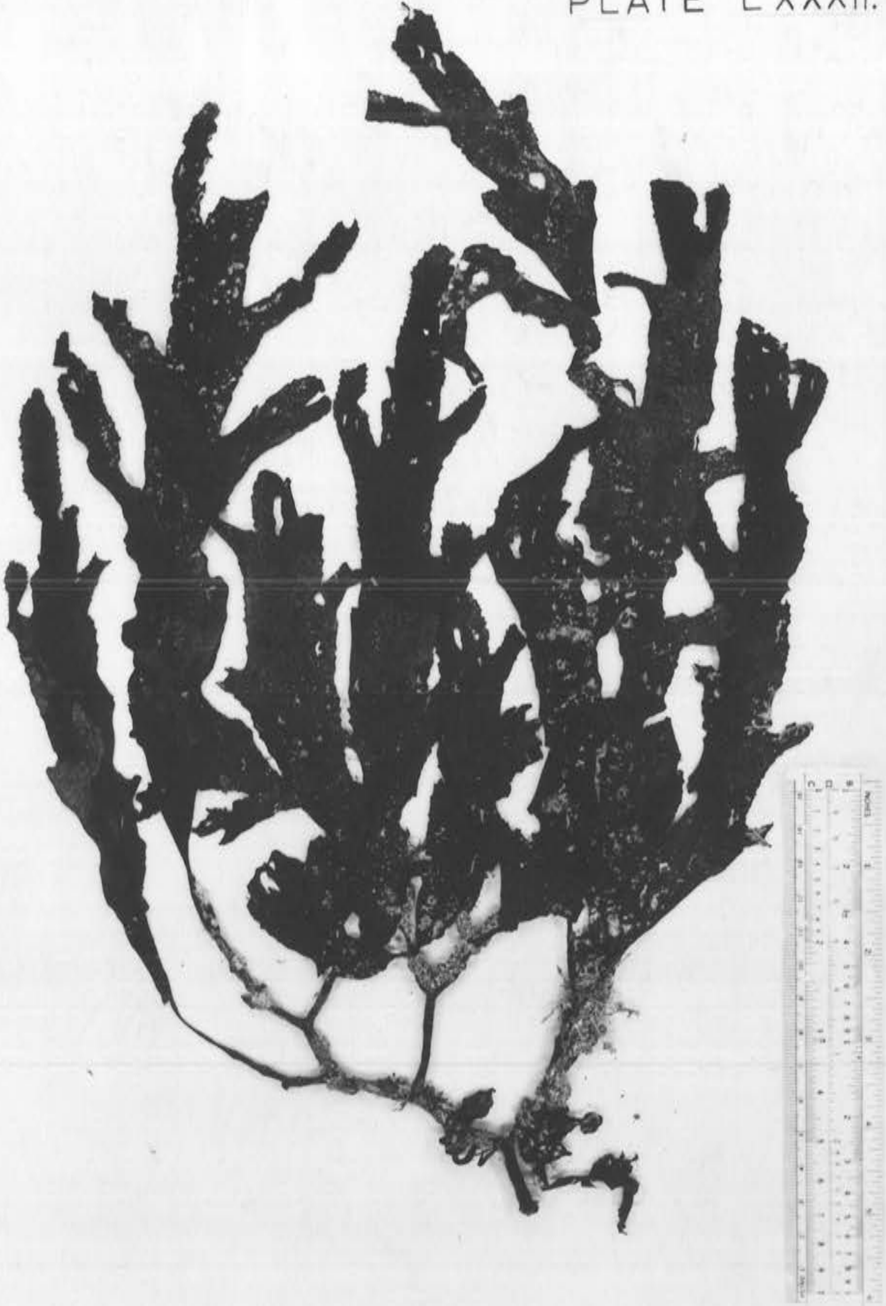
Myriodesma latifolia Harv.
f. ~~var.~~ *duriuscula* J. Ag.
Pt. Drummond, S. Aus
U.S.L. pool
11/1/1951

Coll. & Det. H.B.S. WOMERSLEY

MYRIODESMA QUERCIFOLIA (Bory) J.Agardh.

PLATE LXXXII

PLATE LXXXII.



Myriodesma quercifolia (Bory) J.Ag.

10m. East of Eucla, S. Aus.
Drift
11/1/1954

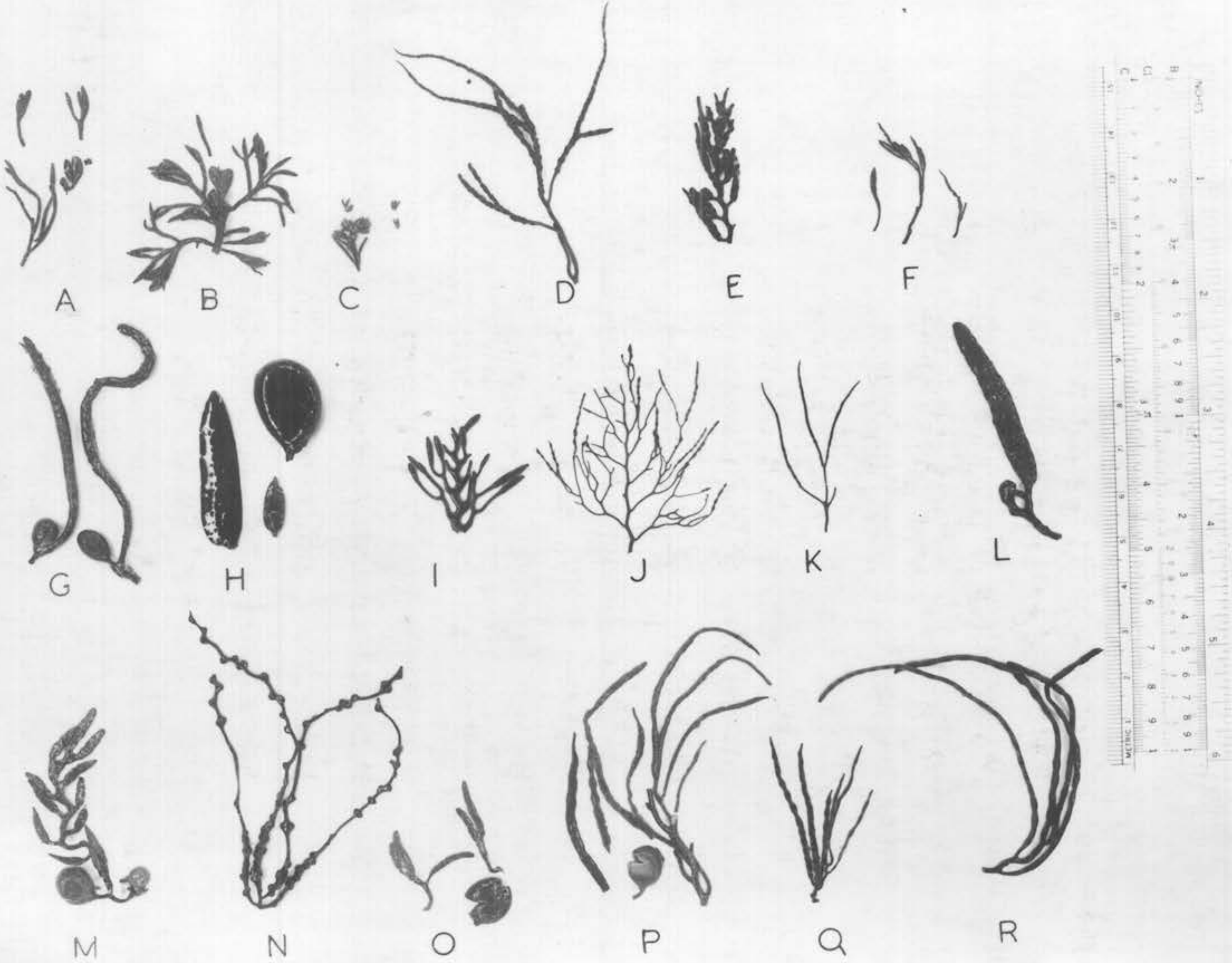
Coll + Det. H.B.S. WOMERSLEY

CYSTOPHORA.

PLATE LXXXIII.

Figs. A. Receptacles and vesicles of *C. uvifera*
B. Receptacles and vesicles of *C. cephalornithos*.
C. Receptacles of *C. paniculata*.
D. Receptacles of *C. galapagensis*.
E. Receptacles of *C. pectinata*.
F. Receptacles of *C. intermedia*.
G. Receptacles of *C. grevillei*.
H. Receptacles and a vesicle of *C. platylobium*
I. Receptacles of *C. brandegeei*.
J. Receptacle of *C. hookeri*.
K. Receptacles of *C. moniliformis*.
L. Receptacle of *C. xiphocarpa*.
M. Receptacles and vesicles of *C.racemosa*.
N. Receptacles of *C. cuspidata*.
O. Receptacles and a vesicle of *C. scalaris*.
P. Receptacles and vesicle of *C. retroflexa*.
Q. Receptacles of *C. siliquosa*.
R. Receptacles of *C. retorta*.

PLATE LXXXIII.

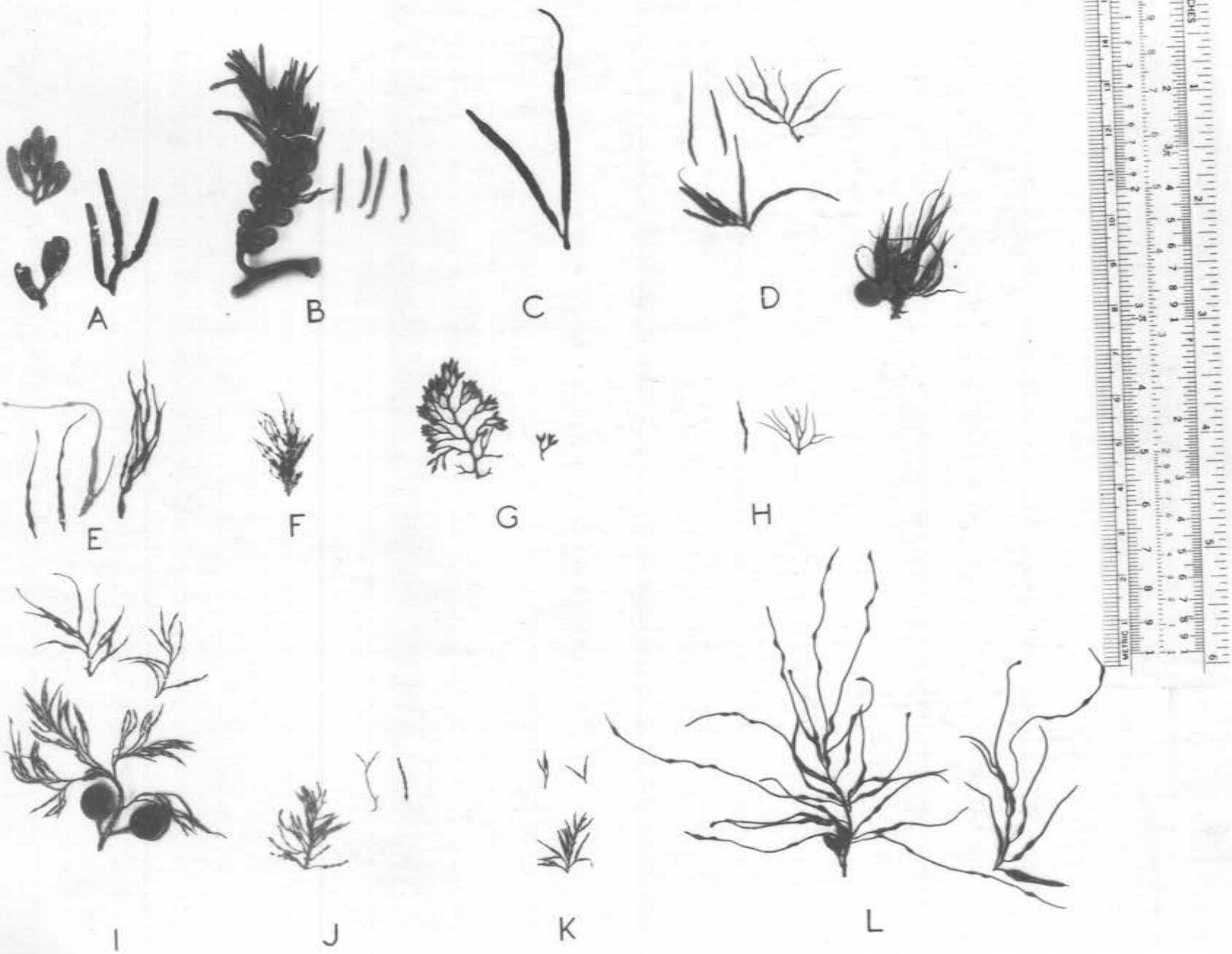


CYSTOPHORA.

PLATE LXXXIV

Figs. A. Receptacles and a vesicle of *C. torulosa*.
B. Receptacles and vesicles of *C. botryocystis*
C. Receptacles of *C. distenta*.
D. Receptacles and vesicles of *C. congesta*.
E. Receptacles of *C. subfarcinata*.
F. Receptacles of *C. thysanocladia*.
G. Receptacles of *C. brownii*.
H. Receptacles and ramuli of *C. gracilis*.
I. Receptacles and vesicles of *C. monilifera*.
J. Receptacles of *C. polycystidea*.
K. Receptacles of *C. expansa*.
L. Receptacles of *C. elongata*.

PLATE LXXXIV.

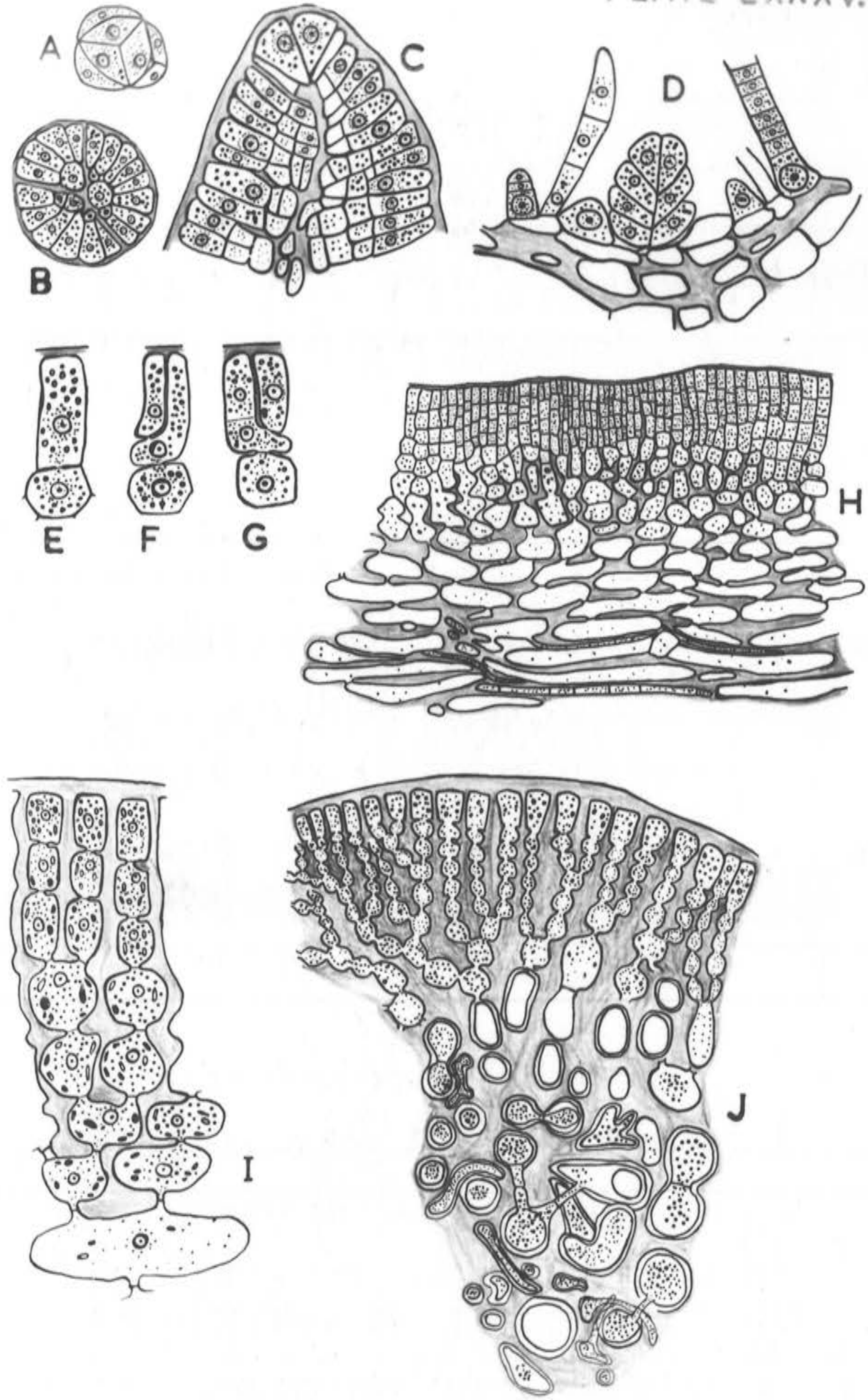


NOTHEIA ANOMALA.

PLATE LXXXV

Figs.	A.	T.S. at the apex of an axis showing a group of apical cells... ... X 395
	B.	T.S. near the apex of an axis showing three sectors... ... . X 395
	C.	L.S. of an axis at the apex showing two apical cells... ... . X 395
	D.	L.S. of an axis passing through the conceptacle showing paraphyses and apical cells of an axis developing from the conceptacle... ... ... X 395
	E - G.	Division of peripheral cells showing pit connections... ... ... X 560
H.	H.	L.S. of an axis showing tissues and hyphae (microtome section).. X 95
	I.	Showing dichotomous branching of cortical cells in longitudinal section... ... ... X 455
	J.	T.S. of the basal part of an axis showing tissues and hyphae... X 145

PLATE LXXXV.



NOTHEIA ANOMALA.

PLATE LXXXVI

Figs. A. T.S. of an axis showing tissues and conceptacles with paraphyses... ... X 95

B. T.S. of an axis passing through the conceptacle showing an axis developing on the wall of the conceptacle (axis is diagrammatic)... ... ... X 95

C. L.S. of an axis showing apical cell and development of conceptacle... .. X 395

  (a) Transverse division of an initial forming basal cell and tongue cell.

  (b) Conceptacle with a uniseriate hair.

D. T.S. of an axis showing development of conceptacle... ... ... X 395

  (a) Initial cell

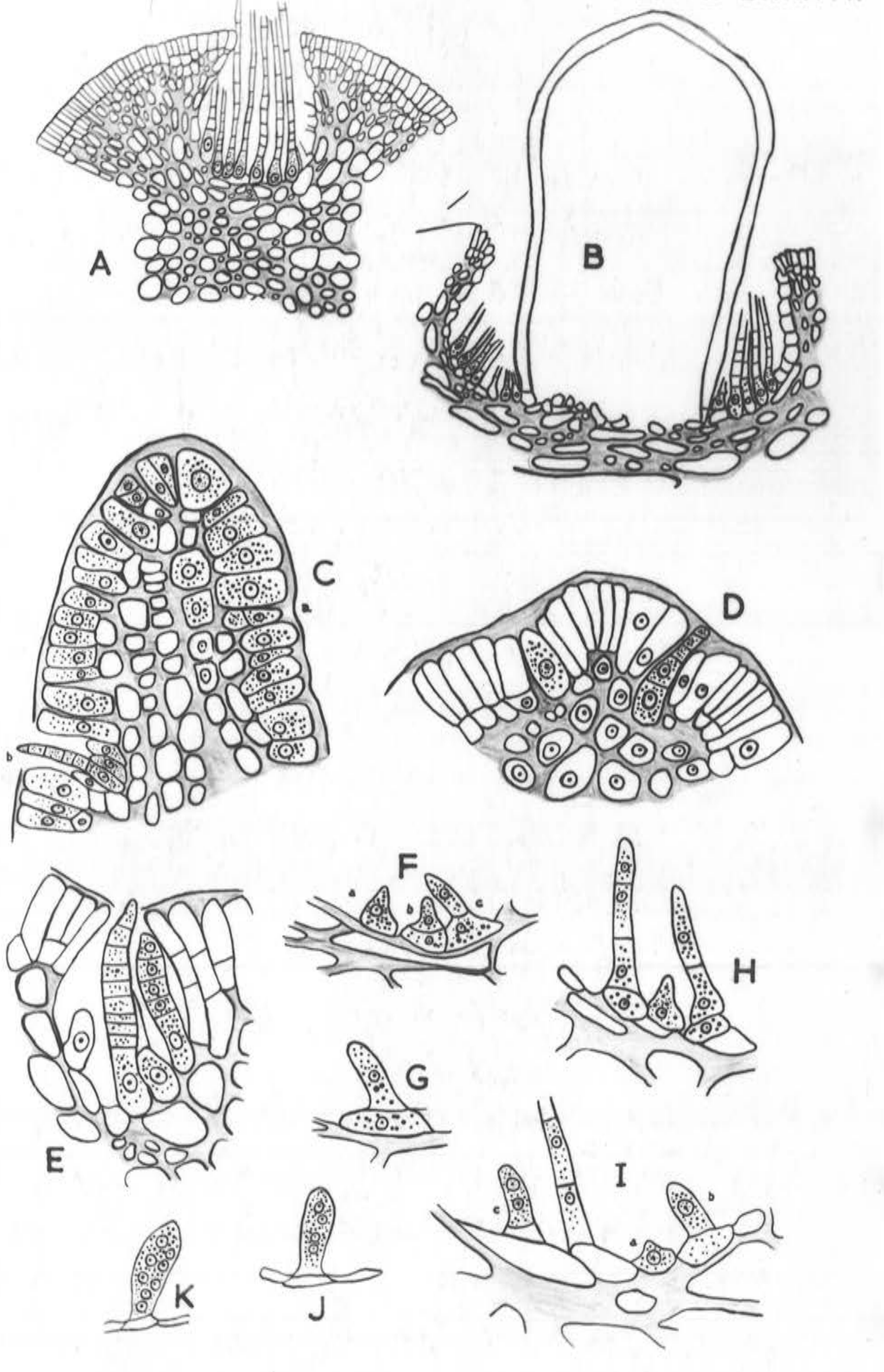
  (b) Series of transverse divisions of the tongue cell.

E. L.S. passing through the conceptacle showing paraphyses... ... ... X 395

F, G. and H. Showing development of paraphyses X 395

I, J, and K. Showing development of sporangia X 395

PLATE LXXXVI.



NOTHEIA ANOMALA.

PLATE LXXXVII

Figs. A and B.	Macrozoosporangia showing development of macrozoospores...	X 480
C.	Lateral liberation of macrozoospores in a mucilaginous envelope.. ...	X 480
D.	Distal liberation of macrozoospores in the mucilaginous envelope.. ..	X 480
E.	Macrozoospore with two flagella	X 650
F.	Macrozoospore becomes round...	X 800
G.	Apical liberation of macrozoospores and germination in situ...	X 400
H.	Microzooid producing body and paraphyses...	X 400
I.	Lateral liberation of microzooids in a mucilaginous envelope... ...	X 400
J.	Microzooid with two flagella.	X1200
K.	Microzooid becoming round...	X 600
L.	Distal liberation of microzooids in a mucilaginous envelope... ...	X 400
M - R.	Germination of macrozoospore	
M	Macrozoospore (rounded)......	X 300
N	A tubular prolongation.......	X 300

Figs. O. Formation of transverse septum in the prolongation... ... ... X 300

P. Elongation of germ tube...... X 300

Q. Germinating macrozoospore.... X 300

R. Further transverse division of germ tube... ... ... X 300

S - X. Macrogametophyte.

S. Filamentous gametophyte... ... X 160

T. Gametophyte — 8 days old.. .. . X 500

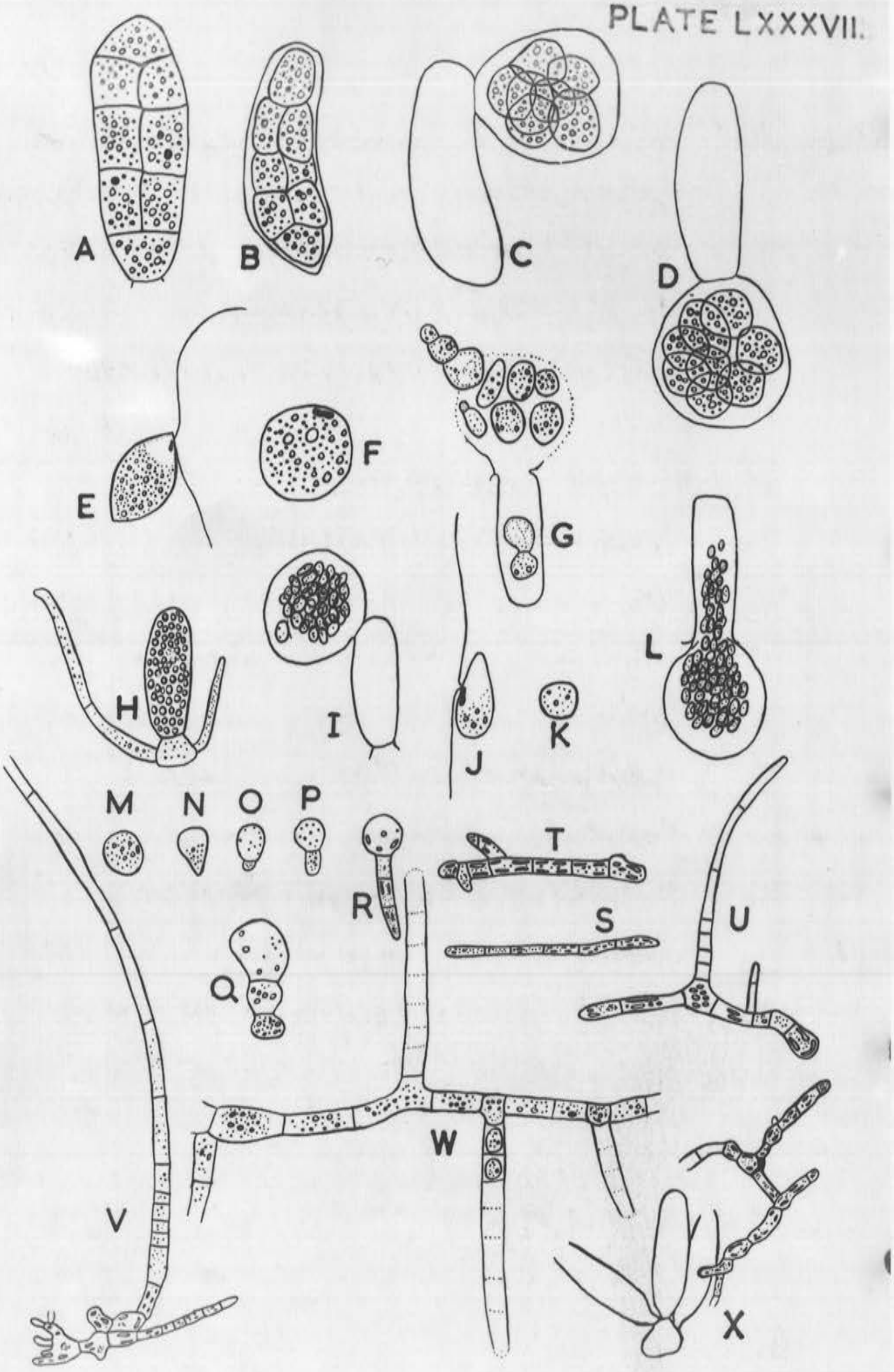
U. Gametophyte developing colourless hair... ... ... X 545

V. Gametophyte developing colourless hairs... ... ... X 360

W. Gametophyte with erect reproductive bodies... ... ... X 725

X. Gametophyte developing in the sporangium within the conceptacle X 300

PLATE LXXXVII.



NOTHEIA ANOMALA.

PLATE LXXXVIII

Figs. A. Nucleus of the apical cell showing nucleolus and chromocentres. X 1875

B. Nucleus of the peripheral cell showing chromosomes at metaphase in polar view... ... ... X 4000

C. Peripheral cell with nucleus showing chromosomes at metaphase in polar view... ... ... X 2500

D. Peripheral cell with two daughter nuclei at telophase... . ... X 1500

E. Paraphysis cell with nucleus showing chromosomes at metaphase in polar view X 3500

F. Metaphase plate in side view and spindle in the nucleus of a paraphysis cell X 2000

G. Early anaphase in the nucleus of a paraphysis cell... ... ... X 1500

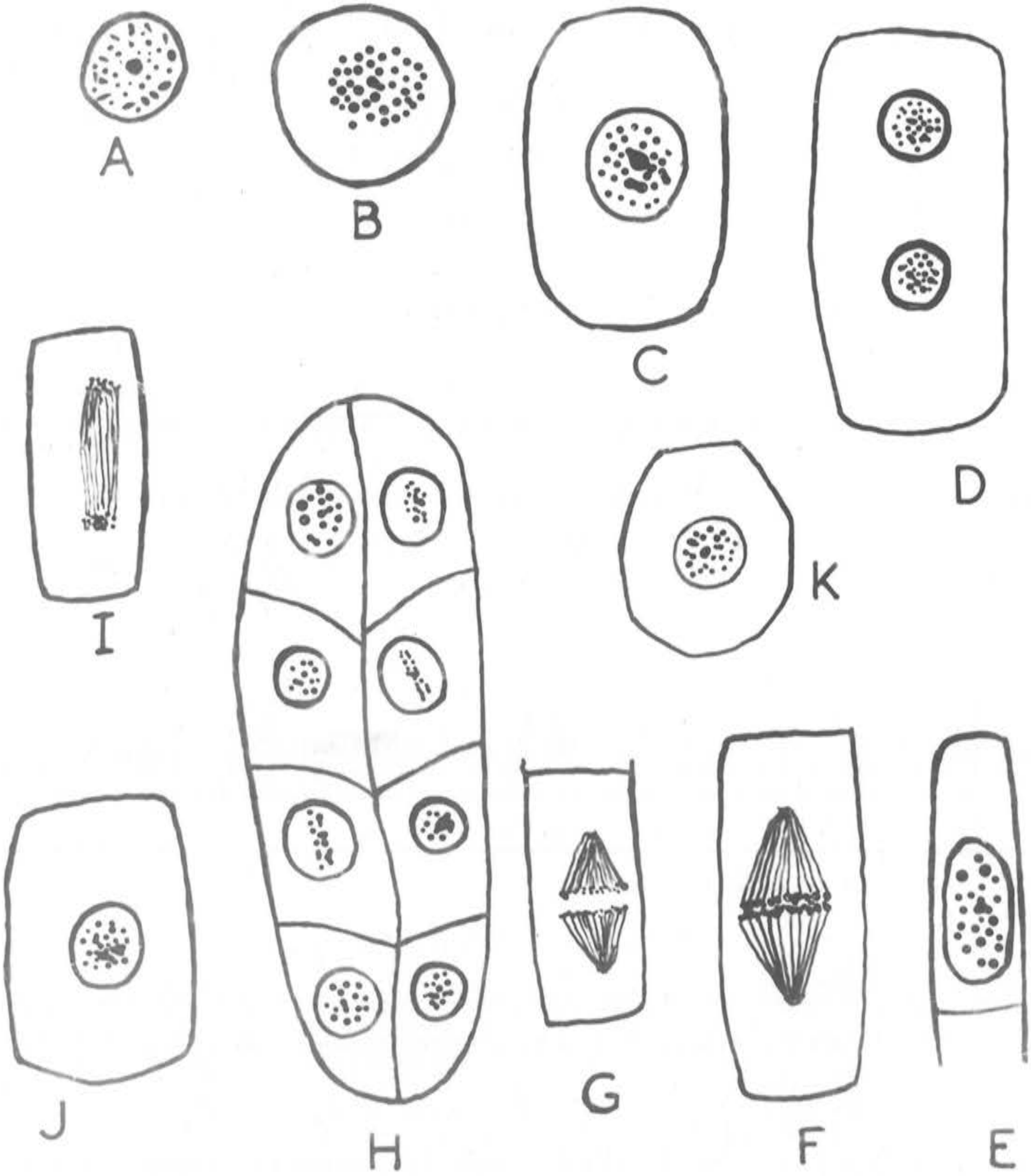
H. Nuclear divisions in the macrozoosporangium... ... . X 1500

I. Late anaphase in the nucleus of a paraphysis cell... ... . X 1500

J. Metaphase in polar view in the cortical cell... ... ... X 2000

K. Metaphase in polar view in the basal cell of a paraphysis... ... ... X 1500

PLATE LXXXVIII.



NOTHEI ANOMALA Harvey and Bailey.

PLATE LXXXIX

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PLATE LXXXIX.

Notheia anomala Harvey & Bailey

On Hormosira banksii f. sieberi (Bory) Thur

Petrel Cove, near Bluff, Victor Harbour
7-3-1959.
Coll & Det M. NIZAMUDDIN.