Botanica Marina
Vol. XIII, p. 131—139, 1970

Phytogeography of the Fucales and their Seasonal Growth

MOHAMMED NIZAMUDDIN

*Institut für Meereskunde, Kiel**)

(Received: 18. 12. 1969)

I. Introduction

The order Fucales KYLIN emended PETROV comprises to date 36 genera and six families. All the genera are confined to littoral and sublittoral regions. *Cystoseira* C. AGARDH, *Sargassum* C. AGARDH are widely distributed and *Turbinaria* LAMOUROUX is confined to tropical and sub-tropical regions. Other genera are restricted in their geographical distribution. Most of the Fucalean genera and three families — Himanthaliaceae, Hormosiraceae and Seirococcaceae are limited to small regions. Such isolation and restriction of the families and genera or few species to a particular place are of considerable biogeographical interest.

The World distribution of the Fucalean families and genera are shown in figs. 1—3. The known distribution of the genera may be extended by collecting from other regions. The summary of their distribution may give a correct picture of their biogeography. Even there are regions that require a careful observation and recording before a complete picture of biogeography is obtained. The distribution given may mean that particular genus or species grow in suitable ecological habitats within the regions.

Here an attempt has been made to catalogue the reported occurrences and distribution of all the families and their genera to see whether a definite pattern of biogeographical control is evident. Further work may distort or make this pattern more clear. The biogeography of the families and genera are grouped in three major regions: — (i) distribution in southern hemisphere (ii) distribution in norhern hemisphere and (iii) distribution in both hemispheres.

II. Distribution in Southern Hemisphere

The genera *Carpophyllum* GREVILLE, *Marginariella* TANDY and *Landsburgia* HARVEY are endemic to New Zealand inhabiting sub-littoral region. Among five species of *Carpophyllum*, one species *C. scalare* SUHRING is confined to South Africa and abundant at Port Alfred and Dwsea (ISAAC, 1953) and is sub-littoral. This is a unique species in this genus and to my opinion it hardly resembles New Zealand species. A detailed study is needed to determine its systematic position. *C. angustifolium* J. AGARDH, *C. maschalocarpum* (TURNER) GREVILLE, *C. flexuosum* (ESPER) GREVILLE and *C. plumosum* (A. RICHARD) J. AGARDH are endemic to New Zealand inhabiting far North and fewer in the south of Cook Strait.

Landsburgia comprises two species, *L. myricaeformis* J. AGARDH and *L. quercifolia* (HOOKER *et* HARVEY) HARVEY which are endemic to New Zealand including Chatham Island. *Marginariella* is also a small genus comprising two species, *M. boryana* (A. RICHARD) TANDY and *M. urvilliana* (A. RICHARD) TANDY. They grow off rocky coast and in sheltered pools in sub-littoral regions. The former species is a deep water alga whereas the latter one is of shallow water (LINDAUER *et al*, 1961).

There are two genera, *Hormosira* (ENDLICHER) MENEGHINI and *Xiphophora* MONTAGNE, which are confined to Australia and New Zealand. Among the two species of *Xiphophora*, *X. chondrophylla* (R. BROWN *ex* TURNER) MONTAGNE *ex* HARVEY is confined to southern coast of Australia and New Zealand whereas *X. gladiata* (LABILLARDIERE) MONTAGNE *ex* KJELLMAN is confined to south-eastern coast of Australia. This species varies with age and in different habitats. Both the species of *Xiphophora* are sub-littoral. *Hormosira* is monotypic and essentially intertidal (WOMERSLEY, 1959) and represented by *H. banksii* (TURNER) DECAISNE. BERGQUIST (1959) made an extensive study on the ecology of this species.

In Australien waters *Cystophora* J. AGARDH is the largest genus in the Cystoseiraceae and comprises 23 species and the biogeography of which has already been described by WOMERSLEY (1964). Almost all the species of this genus except *C. torulosa* (R. BROWN *ex* TURNER) J. AGARDH are sub-littoral; some occur under rough conditions while others in sheltered waters. Only a few species of this genus also grow in New Zealand *C. platylobium* (MERTENS) J. AGARDH, *C. torulosa*, *C. congesta* WOMERSLEY and NIZAMUDDIN and *C. retroflexa* (LABILLARDIERE) J. AGARDH whereas *C. scalaris* J. AGARDH and *C. distenta* J. AGARDH are endemic to New Zealand.

The genus *Acrocarpia* ARESCHOUG comprises two species, *A. paniculata* (TURNER) ARESCHOUG and *A. robusta* (J. AGARDH) WOMERSLEY. The genus is endemic to Australian waters. *A. paniculata* extends from Cape Spencer, South Australia, around the south east coast (including Tasmania) to Port Stephens, N. S. W. (WOMERSLEY, 1964; NIZAMUDDIN, 1960). *A. robusta* is known only from the southern part of Western Australia.

The genus *Caulocystis* ARESCHOUG is endemic to Australian waters and comprises two species, *C. uvifera* (C.

*) Department of Botany, University of Karachi, Karachi-32, Pakistan.

GENERA	ATLANTIC OCEAN													INDIAN OCEAN														PACIFIC OCEAN																		ANTARCTIC		
	South America	West Indies	Bahama	Caribbean Sea	S. E. N. America	N. E. America	Ice Land	Green Land	Sargasso Sea	W. Africa	W. Europe	Mediterranean Sea	Adriatic Sea	S. Africa	E. Africa	Madagascar	Red Sea	Arabian Sea: India	Arabian Sea: Pakistan	Arabian Sea: Aden	Arabian Sea: Persian Gulf	India (Bay of Bengal.)	Ceylon	Malaya	Singapore	W. Sumatra	S. W. Australia	Japan	Korea	China	Formosa	Hong Kong	Philippines	Pacific Islands	Hawaii	N. E. Australia	Indonesia	New Zealand	Pacific Coast of America: W. Coast of N. America	Pacific Coast of America: Guadalupe Island	Pacific Coast of America: Galapagos Islands	S. E. Australia, N. S. W.	S. Australia	Victoria	Tasmania	S. Shetlands Islands	Auckland Islands	Campbell Islands
Acrocarpia																										+									+						+	+	+	+			
Acystis																			+																												
Ascophyllum										+																																					
Axillariella													+																																		
Bifurcaria										+			+																											+							
Bifurcariopsis													+																																		
Carpoglossum																																										+	+	+			
Carpophyllum													+																								+									+	
Caulocystis																																			+						+	+	+	+			
Coccophora																											+	+																			
Cystophora																										+											+				+	+	+	+		+	+
Cystophyllum														+											+	+	+	+	+	+	+	+	+	+	+	+		+			+	+					
Cystoseira	+									+	+	+	+		+	+	+	+					+			+													+			+	+					
Cystosphaera																																														+		
Fucus							+	+			+	+	+														+												+									
Halidrys							+	+			+																												+									
Hesperophycus																																							+									
Himanthalia						+	+	+	+		+																																					
Hizikia																											+	+			+																	
Hormophysa														+		+	+							+		+																						
Hormosira																										+											+				+	+	+	+			
Landsburgia																																					+										
Marginariella																																					+									+	
Myriodesma																										+																+	+	+			
Pelvetia										+																	+												+									
Pelvetiopsis																																							+									
Phyllospora																																									+	+	+	+			
Platythalia																										+																					
Sargassum	+	+	+	+	+				+	+				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			
Scaberia																										+															+	+	+	+			
Scytothalia																										+																+					
Seirococcus																																										+	+	+			
Stokeyia																	+	+																													
Stolonophora																										w														+							
Turbinaria	+	+	+	+	+									+	+	+						+	+	+		+						+	+			+											
Xiphophora																																					+					+	+	+		+	+

Tab. 1
Distribution of the fucalean genera in the World

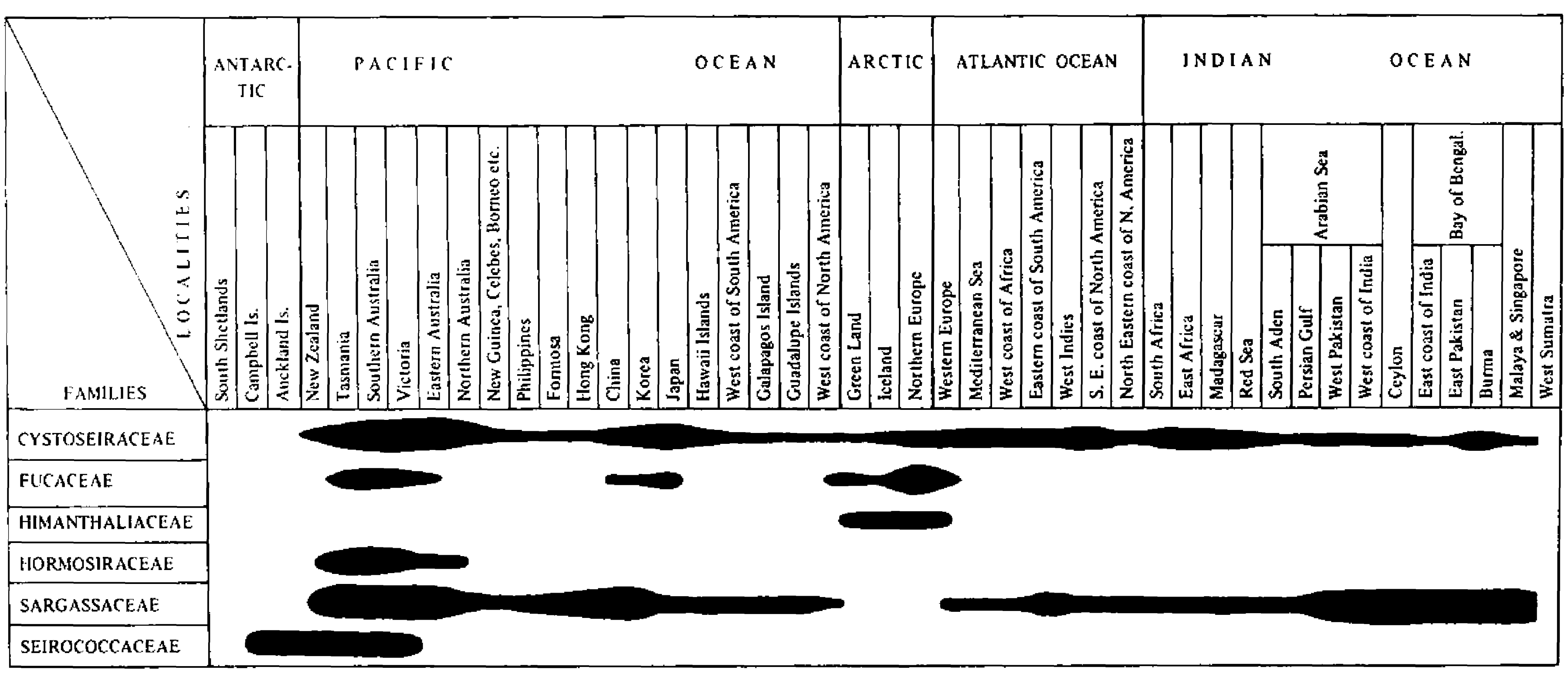
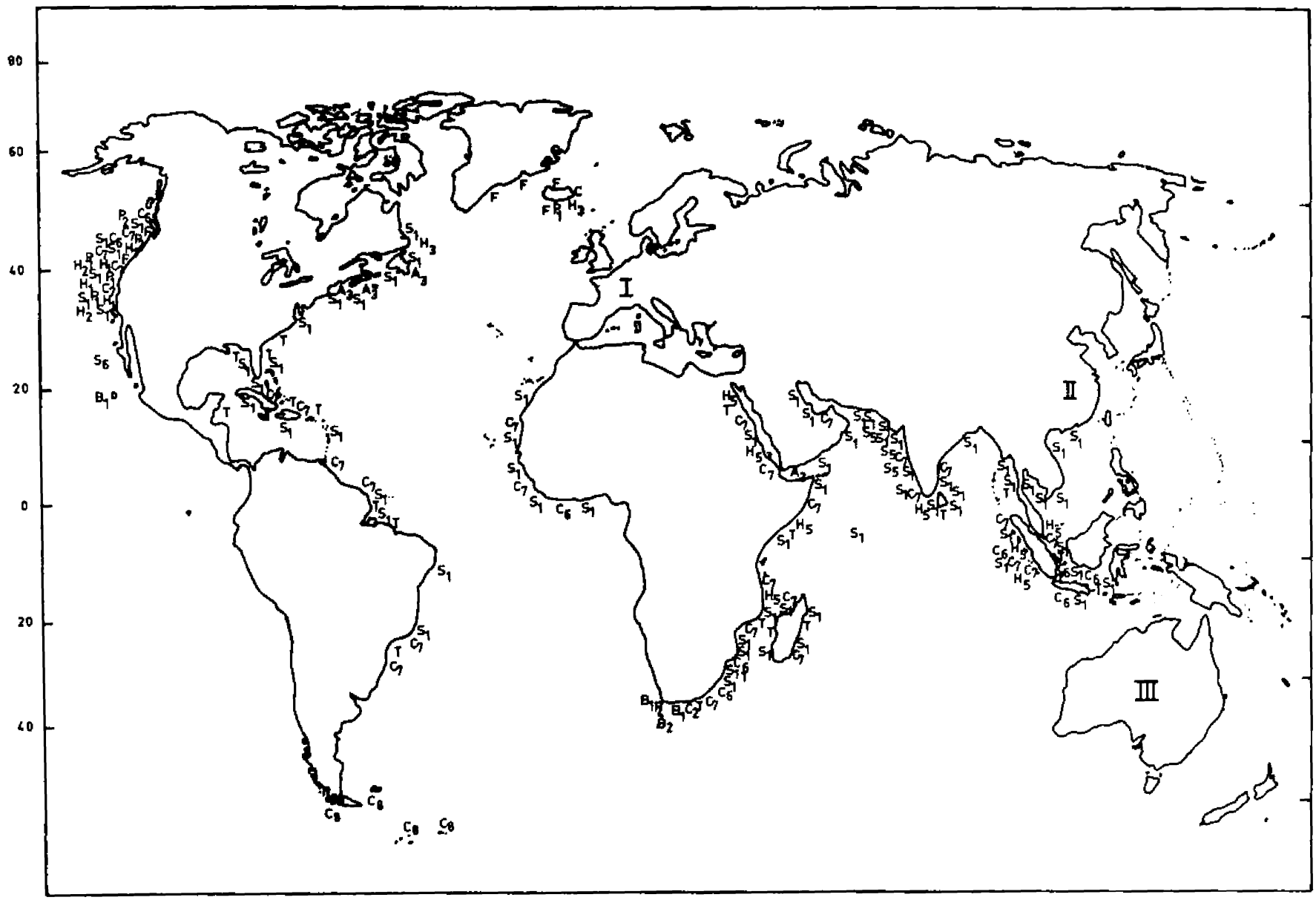


Fig. 2
Distribution of the fucalean families in the world, showing densities



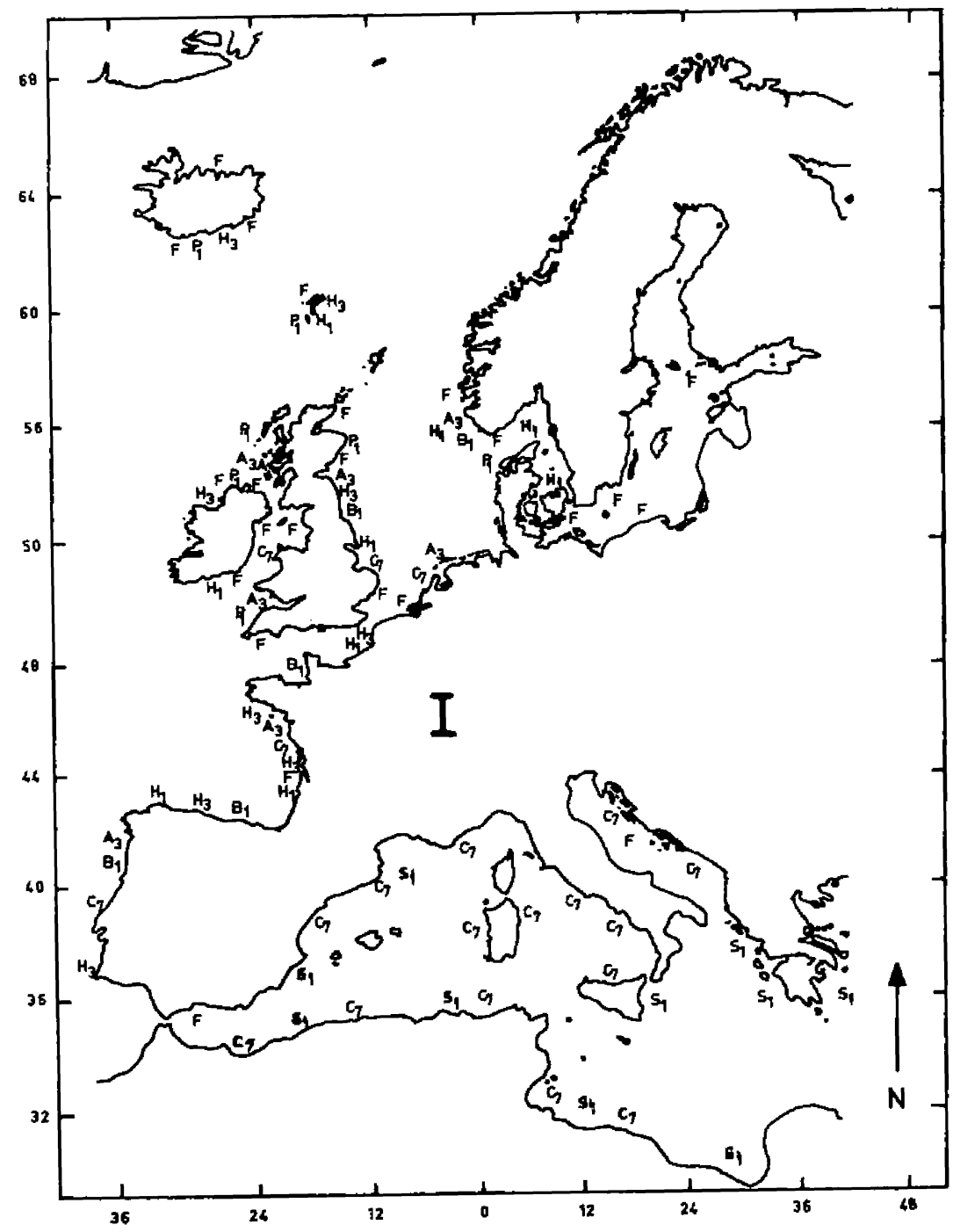


Fig. 3a

Fig. 3
Distribution of the fucalean genera shown along the coast of the world (for detail see the list of the abbreviation of the genera)

a) Distribution of the genera along the Pacific coast

b) Distribution of the genera along the north-east coast of Asia

c) Distribution of the genera in Australian waters

A-1 = *Acrocarpia*
A-2 = *Acystis*
A-3 = *Ascophyllum*
A-4 = *Axillariella*
B-1 = *Bifurcaria*
B-2 = *Bifurcariopsis*
C-1 = *Carpoglossum*
C-2 = *Carpophyllum*
C-3 = *Caulocystis*
C-4 = *Coccophora*
C-5 = *Cystophora*
C-6 = *Cystophyllum*
C-7 = *Cystoseira*
C-8 = *Cystosphaera*
F = *Fucus*
H-1 = *Halidrys*
H-2 = *Hesperophycus*
H-3 = *Himanthalia*
H-4 = *Hizikia*
H-5 = *Hormophysa*
H-6 = *Hormosira*
L = *Landsburgia*
M-1 = *Marginariella*
M-2 = *Myriodesma*
P-1 = *Pelvetia*
P-2 = *Pelvetiopsis*
P-3 = *Phyllospora*
P-4 = *Platythalia*
S-1 = *Sargassum*
S-2 = *Scaberia*
S-3 = *Scytothalia*
S-4 = *Seirococcus*
S-5 = *Stokeyia*
S-6 = *Stolonophora*
T = *Turbinaria*
X = *Xiphophora*

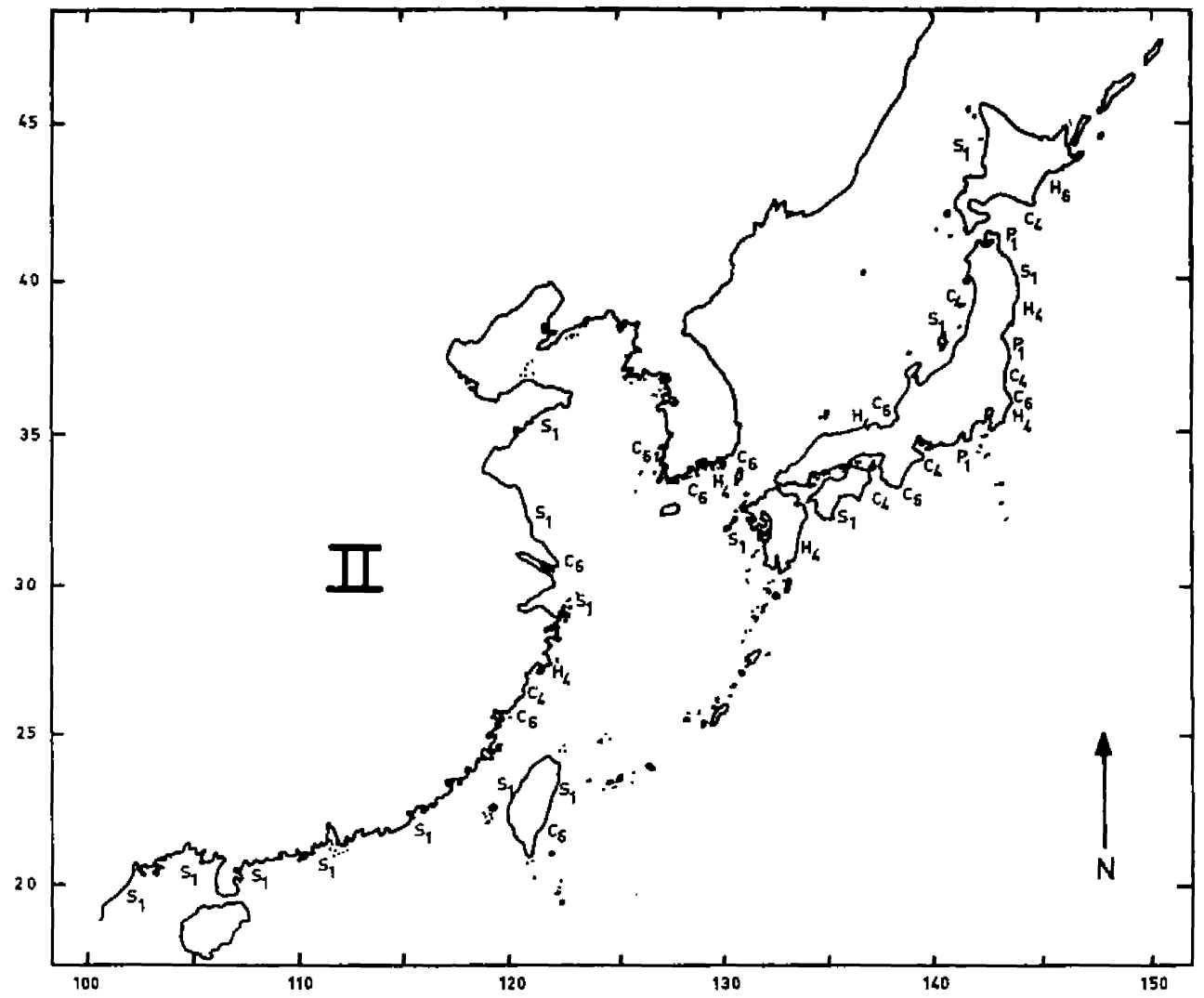


Fig. 3b

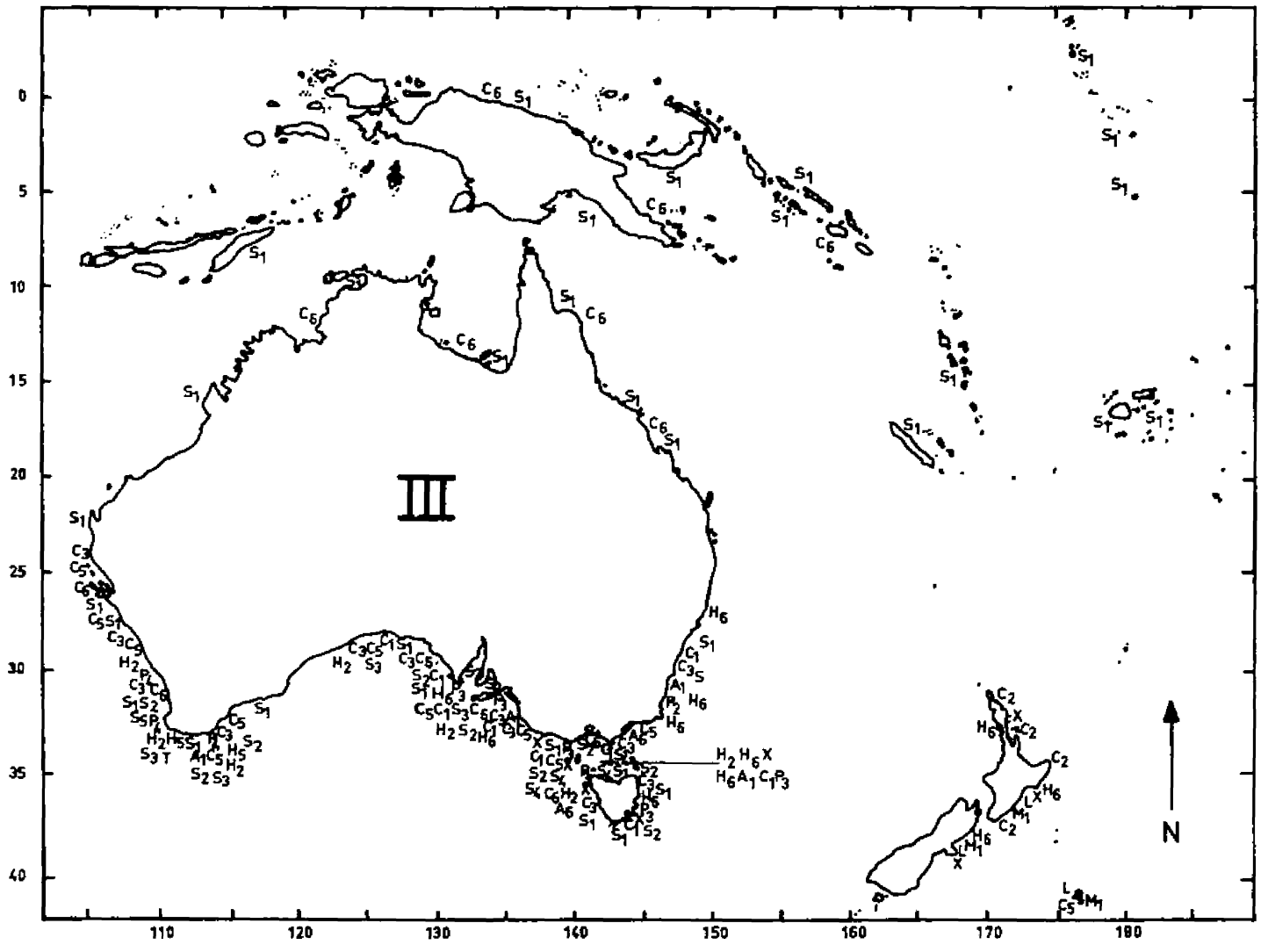


Fig. 3c

AGARDH) ARESCH. and *C. cephalornithos* (LABILLARDIERE) ARESCH. These two species are separated mainly on the shape of the vesicles. They inhabit generally calm to medium rough coasts, from low tide level down but sometimes they may occur in pools. *C. wifera* extends from Shark Bay, W. Australia around southern Australia (including Tasmania) to Long Bay, N. S. W. *C. cephalornithos* is distributed from Eliston, S. Australia, around south eastern coast to Bondi, N. S. W., including Tasmania.

Carpoglossum KÜTZING is monotypic and represented by one species, *C. confluens* (R. BROWN *ex* TURNER) KÜTZING in Australian waters extending from Eliston, South Australia, around south eastern coast (including Tasmania) to Western Port, Victoria. This species inhabits sub-littoral region (NIZAMUDDIN, 1960, 1964).

Myriodesma DECAISNE extraaustralian genus comprises to date eight species which are endemic to Australian waters extending from Western Australia around southern Australia including Tasmania to Victoria (NIZAMUDDIN and WOMERSLEY, 1966). *M. harveyanum* NIZAMUDDIN and WOMERSLEY is confined to South Australia including Kangaroo Island. *M. leptophyllum* J. AGARDH and *M. tuberosum* J. AGARDH are South Australian in origin extending from Eucla, Western Australia, to Port Elliot, South Australia. Eucla is just on the border of Western Australia and South Australia. It is more likely that the specimen found at Eucla may have drifted to this place. *M. integrifolium* HARVEY is distributed from Western Australia (Cottesloe) to Victoria (Western Port) including north coast of Tasmania. *M. quercifolium* (BORY) J. AGARDH is distributed from Geraldton, Western Australia, to Port Elliot. South Australia (NIZAMUDDIN and WOMERSLEY, 1966), *M. serrulatum* (LAMOUROUX) DECAISNE is confined to Western Australia (Dongara to Cape Riche). The other west Australian species, *M. peronii* NIZAMUDDIN and WOMERSLEY is distributed from DONGARA to MANDURAH. *M. callophyllum* J. AGARDH inhabit south eastern coast of Australia (Fishery Bay, S. A. to Port Philips, Vict.).

Phyllospora C. AGARDH, *Scytothalia* GREVILLE and *Seirococcus* GREVILLE are endemic to Australian waters and each genus is monotypic. They grow in sub-littoral region. *P. comosa* (LABILLARDIERE) C. AGARDH is distributed from Encounter Bay, South Australia (including Tasmania), around south east coast to Port Macquarie, N. S. W. *Scytothalia dorycarpa* (TURNER) GREVILLE extends from Rottnest Island, Western Australia, along south coast including Kangaroo Island to Port Elliot, South Australia. *Seirococcus axillaris* (R. BROWN *ex* TURNER) GREVILLE is distributed from Fishery Bay, South Australia, to Cape Paterson, Victoria including Tasmania. *Scy. dorycarpa* is more south western in distribution whereas *P. comosa* and *S. axillaris* are south eastern in distribution.

Platythalia SONDER is endemic to Western Australia extending from Dongara to Cave Islet, Recherche Archipelago. The genus comprises two species, *P. angustifolium* SONDER and *P. quercifolium* (TURNER) SONDER. Each inhabit sub-littoral region.

Scaberia GREVILLE is a unique fucalean member which is monotypic and endemic to Australia extending from Geraldton Bay, Western Australia, along the south east coast to Bondi, N.S.W., including Kangaroo Island and northern coast of Tasmania and also in Lord Howe Island. It is represented by *S. agardhii* GREVILLE which grows in littoral to sub-littoral region (NIZAMUDDIN, 1962).

Antarctica and sub-Antarctica are represented by a single genus, *Cystosphaera* SKOTTSBERG which is endemic as well as monotypic, represented by *C. jacquinotii* SKOTTSBERG. This is confined to West Antarctica growing along the steep rocks. It occurs in Bransfield Strait Harmony Cove on Nelson Island.

South Africa is represented by two monotypic and endemic genera, *Axillariella* (GRÜBER) SILVA and *Bifurcariopsis* PAPENFUSS. *A. constricta* (GRÜBER) SILVA and *B. capensis* (ARESCHOUG) PAPENFUSS grow along the south western corner of the Cape Province (ISAAC, 1942. STEPHENSON, 1947). In addition to the above species two more species, *Bifurcaria brassicaeformis* (KÜTZING) BARTON and *Carpophyllum scalare* SUHRING grow along the coast of South Africa. The ecology of these two species have already been described with the other species of the genus.

III. Distribution in Northern Hemisphere

Japan is represented by two endemic genera, *Coccophora* GREVILLE and *Hizikia* OKAMURA which are monotypic as well. *C. langsdorfii* (TURNER) GREVILLE and *H. fusiformis* OKAMURA inhabit sub-littoral region. The distribution of *H. fusiformis* extends upto Hong Kong. Both the species have also been reported from Korean coast (KANG, 1966).

Along the coast of North America three endemic genera — *Hesperophycus* SETCHELL et GARDNER, *Pelvetiopsis* GARDNER and *Stolonophora* NIZAMUDDIN — grow. *Hesperophycus harveyanus* (DECAISNE) SETCH. et GARDN. is the only species of the genus which grows in the upper littoral region and remains exposed to atmosphere during low tide time. It is distributed from Central California (Montrey Bay) to Ensenada, Baja California (DAWSON 1945, 1946. SETCHELL et GARDNER, 1925). *Pelvetiopsis* is distributed from British Columbia to Central California (Point Carmel). The genus comprises two species, *P. limitata* GARDNER and *P. arborescence* GARDNER and they grow in the upper littoral region. *Stolonophora* is monotypic and represented by *S. brandegeei* (SETCHELL et GARDNER) NIZAMUDDIN which is sublittoral and endemic to Guadalupe island, Mexico (Pacific side).

Species of *Bifurcaria* STACKHOUS, *Fucus* LINNAEUS, *Halidrys* LYNGBYE and *Pelvetia* DECAISNE et THURET are widely separated and isolated from their point of origin. A number of species and varieties were assigned to the

well known genus *Fucus*. POWELL (1963) delimited a number of species and varieties of this genus and only on the basis of ecological aspects he recognised only six species. According to BURROWS (1964) and DIXON (1963) *Fucus* species extend from supra-littoral (Shetland) to sub-littoral region. The distribution of the genus along the European coast of Atlantic Ocean is from upper- to sub-littoral. *F. distichus* LINN. with its two subspecies, is distributed along the Pacific coast of North America with its southern limit, Santa Barbara, California. *F. virsoides* J. AGARDH is endemic to the Adriatic Sea and grows in the littoral regions. *F. ceranoides* LINN., *F. serratus* LINN., *F. spiralis* LINN., and *F. vesiculosus* LINN. are common to the north temperate latitudes and littoral in habit (MC ALLISTER, 1967). *F. vesiculosus* and *F. serratus* grow in the Baltic Sea but *F. vesiculosus* extends upto Finland. The southern limit of the genus is Morocco (GESSNER, 1965).

Bifurcaria STACKHOUS comprises three species and each grows in the lower littoral region. *B. brassicaeformis* (KÜTZING) BARTON is endemic to south west of Cape Province from Cape Town to Cape Agulhas (ISAAC, 1953). This species belongs to the Southern hemisphere. *B. galapagensis* (PICCONE et GRUNOW *in* PICCONE) WOMERSLEY is endemic to Galapagos Islands, Pacific Ocean. The systematic position of this species is still uncertain. It needs further investigations. *B. tuberculata* STACKHOUS is found along the Atlantic shores of Europe.

The genus *Pelvetia* DECAISNE et THURET comprises three species, *P. wrightii* (HARVEY) OKAMURA, *P. canaliculata* (LINN.) DECAISNE et THURET and *P. fastigiata* (J. AGARDH) DE TONI. Each of these species is widely separated geographically in distribution. *P. fastigiata* is common along the Pacific coast of North America, from Oregon to Ensenada. *P. wrightii* occurs along the coast of Japan and Korea. *P. canaliculata* is common along the European coast of Atlantic Ocean. These three species of *Pelvetia* grow in the upper-littoral region.

Halidrys LYNGBYE comprises two species, *H. dioica* GARDNER and *H. siliquosa* (LINN.) LYNGBYE. *H. dioica* is endemic to Californian coast i.e. from Monterey to Ensenada and grows in the lower to sub-littoral regions. *H. siliquosa* is littoral along the north Atlantic shores of Europe and extends eastward to the Baltic Sea upto Kategatt. Its northern limit is north of Norway (TAYLOR, 1954) and southward to Bay of Bikay (CHALON, 1909). Along the coasts of British Isles this species grows from mid- to sub-littoral (BURROWS, 1960, 1964. DIXON, 1963. JONES, 1960 and MC ALLISTER *et al.*, 1967).

Ascophyllum STACKHOUS is monotypic and represented by *A. nodosum* (LINN.) LE JOLLIS which grows in the mid-littoral region and also in sheltered positions. The species grows along the northern part of the Atlantic coast including North America and Western Europe[1]).

Himanthalia LYNGBYE is monotypic and extends from mid- to sub-littoral (BURROWS, 1964. DIXON, 1963. JONES, 1960. MC ALLISTER *et al.*, 1967). The genus is represented by *H. elongata* (LINN.) S. F. GRAY and belongs to Western Europe extending from southern part of Polar region to Spain including Iceland and the Faeroes in the north. Its occurrence along the coast of North America is doubtful as it has not been reported since 1875.

Acystis SCHIFFNER is monotypic and endemic to Aden (PAPENFUSS, 1969). *A. heinii* SCHIFFNER grows in the sub-littoral region.

Stokeyia THIVY and DOSHI is very much restricted in distribution like *Acystis*. *Stokeyia* is monotypic and endemic to the northern Arabian Sea. *S. indica* THIVY and DOSHI grows from lower to sub-littoral region. Plants growing in pools are strongly calcified whereas growing in other habitats lack calcification. This species is common along the coast of Karachi.

IV. Distribution in Both Hemispheres

The genus *Turbinaria* LAMOUROUX is an important alga of reef floras of the tropics and sub-tropics. It grows in the intertidal as well as in the interatidal reefs (TAYLOR, 1964). The well known species of the genus have a wide range of distribution. *T. turbinata* (LINN.) KUNTZE is distributed from Florida to Brasil and *T. alata* (TURNER) J. AGARDH from Bermuda to the West Indies but not in the eastern Atlantic coast. To date *Turbinaria* has not been reported from the west coast of Americas. *T. ornata* (TURNER) J. AGARDH extends from Hawaii Islands, Pacific Ocean, to Somalia, on the east coast of Africa and *T. decurrens* BORY from New Guinea to Madagascar on the east of Africa, including Red Sea where it is very common (NASR, 1939. SIMONSEN, 1968). *T. gracilis* SONDER is endemic to the south west coast of Australia and *T. triquetra* (J. AGARDH) J. AGARDH is native of Red Sea and Somalia. *T. luzonensis* TAYLOR belongs to the Philippines and *T. kenyaensis* TAYLOR to African State (east). *T. elatensis* TAYLOR is endemic to Elat, Gulf of Aqaba and Sinai, on the Gulf of Suez. *T. murrayana* BARTON has been reported from Kenya and Madagascar. This species also occurs in the East Indies, Indonesia, Celebes, New Guinea and Singapore. There is a limited distribution of *T. papenfussii* TAYLOR from Egypt to Ethiopia. There is a wide distribution of *T. conoides* (J. AGARDH) KÜTZING around Kenya, Tanganyka, South India, Andaman islands, Singapore, Indonesia, Philippines and the Pacific islands (Phoenix, Canton Is., Tonga Is., Samoa islands and Fiji islands). *T. crateriformis* TAYLOR belongs to Kenya and *T. filamentosa* YAMADA is endemic to Formosa. The last important species, *T. condensata* SONDER *in* KÜTZING is reported from Kenya, Somalia, Ceylon, Malaya, Indonesia and the Philippines. The genus *Turbinaria* never reaches below the Cape of Good Hope or Western Australia in the south or above China Sea in the north.

The genera *Cystoseira* C. AGARDH and *Sargassum* C. AGARDH are of great biogeographical importance.

[1]) LAKOWITZ (1929) reported the occurrence of *A. nodosum var. scorpiodes* HAUCK from Baltic Sea. SCHWENKE (1969) and my observation show that *Ascophyllum nodosum* does not grow in Baltic Sea.

There is a great need of a monograph of these two genera and therefore at this stage it is not adviseable to discuss their biogeographical importance. A limited account of their distribution is given below.

Cystoseira grows in different habitats from upper to sub-littoral region and most of the species belongs to the northern hemisphere and few species do occur in the southern hemisphere. On the Pacific coast of America three species — *C. neglecta* SETCHELL and GARDNER, *C. osmundacea* (MENZIES) C. AGARDH and *C. setchellii* GARDNER — occur which are littoral to sub-littoral. On the coast of West Africa *Cystoseiras* are present in fairly large amounts forming an important zone especially on the coast of Senegal and Mauritiana (LAWSON, 1966). PAPENFUSS and JENSEN (1967) merged *Cystophyllum* and *Cystoseira* as the former genus was based on variable characters i. e. vesicles. Such variable characters are also present in *Cystoseira*. TAYLOR (1960) reports *C. myrica* (GMELIN) J. AG. from the eastern coast of America (Florida and Bahamas). ROBERTS (1967) reports five British species of *Cystoseiras*, *C. baccata* (GMELIN) SILVA, *C. foeniculacea* (L.) GREVILLE, *C. myriophylloides* SAUVAGEAU, *C. nodicaulis* (WITH.) ROBERTS and *C. tamariscifolia* (HUDSON) PAPENFUSS. Majority of the species occur along the coast of Mediterranean and Adriatic Sea. One species occur in Red Sea (*C. myrica*) and along the east coast of Africa. The phytogeographical distribution of *Cystoseira* now is extended to the far north upto Japan due to the merger of *Cystophyllum* (PAPENFUSS and JENSEN, 1968).

Sargassum the most important genus of the order is widely distributed in the world. It occurs in tropics, sub-tropics and temperate zones in both hemispheres. The number of species is conspicuous in tropics and sub-tropics. *Sargassum* is conspicuous at and below the top of the sub-littoral region of the warm temperate coasts of southern hemisphere (WOMERSLEY, 1959). In the sub-tropical regions of the world *Sargassum* species extend from mid- to sub-littoral regions.

Australia is also the chief centre of certain groups of *Sargassum*. The sub-genus *Phyllotrichia* is mostly confined to Australia and Tasmania although two species are known from outside Australia, one from Canary Islands and the other from Japan. New Zealand is represented by only one species, *S. verruculosum* (LINDAUER, 1947); *Arthrophycus* is largely confined to the southern part of Australia and Tasmania; *S. undulatum* J. AG. and *S. lacerifolium* C. AG. are found in New Zealand whereas *S. heterophyllum* J. AG. and *S. longifolium* J. AG. inhabit South African coast. *Eusargassum* is widely distributed in warm waters. *S. natans* LINN. and *S. hysterix* J. AGARDH are the floating species of the genus which are found in the Sargasso Sea and also along the coast of eastern part of America.

V. Distribution of Genera in a Nutshell

It is evident that a majority of the fucalean genera are restricted to the Australian waters i. e. about 41.3%, so are the majority of *Sargassum* species (tab. 1). It is also interesting to note that the species of *Bifurcaria*, *Fucus*, *Halidrys* and *Pelvetia* are widely separated and isolated from their other counterparts. It is an established fact that such isolation must have taken place in geological era. These genera may be of great importance in the evolution.

Tab. 1
Numerical and percentage distribution of the fucalean genera in different geographical regions of the world

Geographical regions	Number of genera	Occurrence in percentage
Australasia	3 endemic	8.3
Australia	9 endemic	25.0
New Zealand	3 endemic	8.3
Japan	2 endemic	5.5
California, North America	2 endemic	5.5
Guadalupe Island, Pacific Ocean (Mexico)	1 endemic	2.8
Galapagos Islands (Mexico), Europe and South Africa	1 endemic	2.8
North Pacific and North Atlantic coasts	1 endemic	2.8
Europe and North America	1 endemic	2.8
Europe and America (North Atlantic coasts)	1 endemic	2.8
Europe and Pacific coast (California)	1 endemic	2.8
Europe	1 endemic	2.8
South Africa	2 endemic	5.5
Antarctica and sub-Antarctica	1 endemic	2.8
Aden	1 endemic	2.8
Pakistan and India (North Arabian Sea	1 endemic	2.8
Northern and southern hemispheres	5[1])	13.9

[1]) including *Cystophyllum* Total = 36 genera

There are six families of the order Fucales. Cystoseiraceae and Sargassaceae are world wide in distribution and their spread is continuous (fig. 2). The family Himanthaliaceae is endemic to North Atlantic whereas Hormosiraceae and the Seirococcaceae are restricted to Australian waters, Southern Ocean. The family Fucaceae is discontinuously distributed (fig. 2). The phytogeographical distribution of the families with their densities are given in fig. 2. The distribution of the fucalean families in the world gives a definite pattern whereas the generic distribution is more continuous than the family.

VI. The seasonal growth and the reproduction

It has well been established that adult plants of *Ascophyllum nodosum*, *Fucus serratus*, *F. vesiculosus*, *Halidrys siliquosa*, *Himanthalia elongata* and *Marginariella urvilliana* show seasonal periodicity of growth and reproduction. NAYLOR (1953) observed that the first two year's growth in *Marginariella urvilliana* is entirely vegetative resulting in distichously branched axis of leafy-lateral. At the beginning of its third year receptacles and vesicles are produced; the receptacles take about a year to mature, so the plant is three years old by the time it produces the gametes. In this species the fertility period lasts till early August i. e. from the middle of May (NAYLOR, 1953). Moss and LACY (1963) observed that first year's growth of *Halidrys siliquosa* is entirely vegetative producing pinnately branched main axis of leafy-laterals. The second year's growth is differentiated into vesicles and at

the end of the second year receptacles develop. Similar type of growth has also been observed by GIBB (1937) in *Himanthalia elongata*. MOSS and LACY (1963) also observed similar pattern and development of growth in *Fucus serratus* and *F. vesiculosus* in which receptacles did not develop till the plants reached 15—20 cm in length (KNIGHT and PARK, 1950). TAYLOR (1937) described that *Ascophyllum nodosum* is able to persist and regenerate from the basal parts or from the denuded branches. *Stokeyia indica* exhibit similar pattern of growth along the coast of Karachi (personal observations).

NIZAMUDDIN and WOMERSLEY (1966) described the development of annual fronds in *Myriodesma* where each year the frond is lost and only the lower midrib remains. At the start of new growth one to several fronds arise at the summit of the remaining midrib. This process continues every year. So it is possible to count the age of the plant. *Myriodesma* commonly attain an age of 3—6 years.

Vesicles also show a seasonal rhythm of growth and are generally produced in the spring in *Fucus* species. It is also possible to determine the age of the plant by the number of series of vesicles present. In *Halidrys siliquosa* vesicles begin to be formed from about September to November (Moss and LACY, 1963).

The reproductive period from receptacles initiation to gamete discharge followed by the disintegration of receptacles in *Halidrys siliquosa* is about nine months (Moss and LACY, 1950) three months in *F. vesiculosus* (KNIGHT and PARK, 1950) but gamete liberation takes over a period of 2—3 months in the case of *H. siliquosa* but according to Moss and LACY (1963) receptacles mature between May and August i. e. c. 4 months. A similar pattern of development was also observed by KNIGHT and PARK (1950) in *F. vesiculosus* and *Ascophyllum nodosum* by LAMB and ZIMMERMANN (1964). MC ALLISTER *et al.* (1967) observed the conceptable maturation in *F. spiralis* in March, June and September. The release of gametes in *F. vesiculosus* is from March till June whereas in *F. serratus* takes place from October to December. In the case of *Ascophyllum nodosum* shedding of gametes takes place from April to June in Norway (PRINTZ, 1959).

After fruiting and shedding of gametes receptacles disintegrate or cast off down to the point where they join a branch. The basal stalk in *Halidrys siliquosa* is left as tooth-like projections (Moss and LACY, 1963). A series of projections are found each year, so it is quite possible to count the age of the plant.

SKOTTSBERG (1907) described that *Cystosphaera jacquinctii* become fertile from November to January.

Himanthalia elongata becomes fertile from July till January and the release of gametes occur during the late summer and autumn (GIBB, 1937) but MC ALLISTER *et al.* (1967) observed the fertile conceptacles in June on the coast of Scotland. In *Halidrys siliquosa* the gametes are released during the winter. In contrast to Moss and LACY (1963) gametangia are present throughout the year except May and June as described by BLACKLER (1956) in *Halidrys siliquosa*. The factor affecting the periodicity of development are not yet known. Moss and LACY (1963) postulate that temperature and length of day must have their effect but there is an inherent factor which may be specific.

VII. Acknowledgement

The author is grateful to Alexander von Humboldt-Stiftung for awarding "Dozentenstipendium" to carry on research at the Institut für Meereskunde, Universität Kiel.

VIII. References

BERGQUIST, P. L. (1959), A statistical approach to the ecology of *Hormosira banksii*. Bot. Mar. *1* (1/2): 22—53. — BLACKLER, H. (1956), The phenology of certain algae at St. Andrews, Fife. Trans. Bot. Soc. Edinb. *37*: 61—78. — BURROWS, E. M. (1960), A preliminary list of the marine algae of the Galloway coast. Britt. Phycol. Bull. *2* (1): 23—25. — BURROWS, E. M. (1964), A preliminary list of the marine algae of the coast of Dorset. Britt. Phycol. Bull. *2* (5): 364—368. — CHALON, J. (1909), Liste des algues marines recoltes dans les environs de Roscoff. Bull. Soc. Roy. Bot. Belg. *46*: 1. — DAWSON, E. Y. (1945), An annotated list of the marine algae and marine grasses of San Diego County, California, San Diego. Soc. Nat. Hist. Calif. *7*: 1—87. — DAWSON, E. Y. (1946), A guide to the literature and distribution of the marine algae of the Pacific coast of North America. Mem. South Calif. Acad. Sci. *3* (1): 1—134. — DIXON, P. S. (1963), Algal species lists. Marine algae of Shetland. Britt. Phycol. Bull. *2* (4): 236—244. — GESSNER, F. (1965), General aspects in marine plant geography. Karachi Univ. Stud. (Sci. & Tech. No.) *2* (3): 1—10. — GIBB, D. C. (1937), Observations on *Himanthalia lorea* (L.) Lyngb. Jour. Linn. Soc. Lond. Bot. *51*: 11—21. — ISAAC, W. E. (1942), Seaweeds of possible economic importance in the Union of South Africa. Jour. South Afr. Bot. July. Pp. 225—236. — ISAAC, W. E. (1953), South African Seaweeds vegetation and future investigations in this field. Jour. South Afr. Bot. April, Pp. 59—71. — JONES, W. E. (1960), Algal species lists. List of marine algae collected on the Northumberland coast. Britt. Phycol. Bull. *2* (1): 20—22. — KANG, J. WON. (1966), On the geographical distribution of marine algae in Korea. Bull. Pusan Fish. College, *7* (1/2): 125 Pp. 12 Pls. — KNIGHT, M. and M. PARKE (1950), A biological study of *Fucus vesiculosus* L. and *F. serratus* L. Jour. Mar. Biol. Assoc. U. K. *29*: 439—514. — LAKOWITZ, K. (1929), Die Algenflora der gesamten Ostsee. 474 Pp. Danzig. — LAMB, I. M. and M. H. ZIMMERMANN (1964), Marine vegetation of Cape Ann, Essex County, Massachusetts. Rhodora, *66*: 217—254. — LAWSON, G. W. (1966), The littoral ecology of West Africa. Oceanogr. Mar. Biol. Ann. Rev. *4*: 405—498. — LINDAUER, V. W. (1947), An annotated list of the brown seaweeds. Phaeophyceae of New Zealand. Trans. Roy. Soc. N. Z. *76*: 542—566. — LINDAUER, V. W., V. J. CHAPMAN, and M. AIKEN (1961), The marine algae of New Zealand II. Phaeophyceae. Nova Hedwigia *3*: 129—350. — MCALLISTER, H. A., T. A. NORTON, and E. CONWAY (1967), A preliminary list of sublittoral marine algae from the west of Scotland. Britt. Phycol. Bull. *3* (2): 175—184. — MOORE, H. B. (1958), Marine Ecology. 493 Pp. Willy and Sons, New York. — MOSS, B. L. and A. LACY (1963), The developments of *Halidrys siliquosa* (L.) Lyngb. New Phytol. *62*: 67—74. — NASR, A. H. (1947), Synopsis of the marine algae of the Egyptian Red Sea coast. Bull. Fac. Sci. *26*: 1—155. Foud I Univ. Press, Cairo. — NAYLOR, M. (1955), The life-history of *Marginariella urvilliana* (A. RICH.) TANDY. Ann. Bot. *17*:

493—511. — NIZAMUDDIN, M. (1962), The life history of *Scaberia agardhii* GREVILLE. Ann. Bot. *26*: 117—127. — NIZAMUDDIN, M. (1964), Anatomy of *Carpoglossum confluens* (R. BR. *ex* TURNER) KÜTZING. Nova Hedwigia *8*: 415—419. — NIZAMUDDIN, M. and H. B. S. WOMERSLEY (1966), The morphology and taxonomy of *Myriodesma* (Fucales). Nova Hedwigia *12* (3/4): 373—383. — PAPENFUSS, G. F. and JAMES B. JENSEN (1967), The morphology and taxonomy of *Cystophyllum trinode* (FORSSKAL) J. AGARDH (Fucales Cystoseiraceae). Blumea, *15*: 17—24. — POWELL, H. T. (1956), List of marine algae collected at St. Bees Head, Cumberland. Phycol. Bull. Britt. Phycol. Soc. *4*: 18—25. — POWELL, H. T. (1963), Speciation in the genus *Fucus* and related genera in speciation in the Sea. Syst. Assoc. Publ. *5*: 63—77. — PRINTZ, H. (1959), Phenological studies of marine algae along the Norwegian coast. Avh. Norske. Vid. Akad. *4*: 1—28, Oslo. — ROBERTS, M. (1967), Studies on marine algae of the British Isles. 3. The genus *Cystoseira*. Britt. Phycol. Bull. *3* (2): 345—366. — SCHWENKE, H. (1969), Meeresbotanische Untersuchungen in der westlichen Ostsee als Beiträge zu einer marinen Vegetationskunde. Int. Revue gesam. Hydrobiol. *54* (1): 35—94. — SETCHELL, W. A. and N. L. GARDNER (1925), The marine algae of the Pacific coast of North America. Part III. Melanophyceae. Univ. Calif. Publs. Bot. *8* (3): 383—898. — SIMONSEN, R. (1968), Zur Küstenvegetation der Sarso-Inseln im Roten Meer. "Meteor" Forschungsergebnisse, R. D. *3*: 57—66. — SKOTTSBERG, C. (1907), Zur Kenntnis der Süd-Antarktischen und Antarktischen Meeresalgen, I. Phaeophyceae. Wiss. Ergeb. Schwed. Süd-Polar Expedition 1901—1903. *4*: 1—172. — STEPHENSON, T. A. (1947), The constitution of the intertidal fauna and flora of South Africa, III. Ann. Natal Mus. *11*: 207—304. — TAYLOR, WM. R. (1937), Marine algae of the north eastern coast of North America. Univ. Mich. Stud. Sci. Ser. *13*: 1—427. Michi. Univ. Press, Ann Arbor. — TAYLOR, WM. R. (1954), Cryptogamic flora of the Arctic. Bot. Rev. *20*: 363. — TAYLOR, WM. R. (1964), The genus *Turbinaria* in eastern Seas. Jour. Bot. Linn. Soc. *58*: 475—490. — WOMERSLEY, H. B. S. (1954), Australian species of *Sargassum*, sub-genus *Phyllotricha*. Austr. Jour. Bot. *2*: 337—354. — WOMERSLEY, H. B. S. (1959), The marine algae of Australia. Bot. Rev. *25*: 545—614. — WOMERSLEY, H. B. S. (1964), The morphology and taxonomy of *Cystophora* and related genera (Phaeophyta). Austr. Jour. Bot. *12*: 53—110.