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The marine algae of Hluleka (Transkei) and the warm temperate / sub-tropical transition on the east coast of southern Africa

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ABSTRACT: The marine flora of the transition region between the warm temperate south coast and sub-tropical east coast of southern Africa is very poorly documented. The seaweeds of Hluleka Nature Reserve, centrally placed along this transition, are described. 178 species (120 rhodophytes, 33 chlorophytes and 25 phaeophytes) are recorded, including 28 new records for the region, and a new combination, *Tiffaniella schmitziana* (Barton) nov. comb. A biogeographical analysis of those species whose distribution is sufficiently known reveals that 65 % are warm water species, also occurring in tropical seas. Hluleka is thus towards the warmer end of the transition, and the major discontinuity is sharply defined, occurring in the ca 130 km of coastline between Hluleka and the mouth of the Kei River. It is probable that a rapid temperature gradient along this stretch of coast (change of 2 °C in annual mean) is responsible for the discontinuity.

INTRODUCTION

The study of the biogeographical distribution of marine organisms around the coasts of southern Africa was pioneered by Stephenson (1939, 1944, 1948). In his ecological survey of intertidal communities, this author concluded that three distinctive provinces could be delineated, which he described as a cold temperate west coast, warm temperate south coast, and sub-tropical east-coast. These provinces have been accepted in the intervening period (e.g. Brown & Jarman, 1978). However, a re-assessment of the seaweed flora of the west coast (Bolton, 1986) concludes that it is better described as warm temperate, still distinct from the south coast flora, and with a sharp discontinuity in distribution patterns, related to temperature regimes, in the vicinity of Cape Agulhas (for locations cited see Fig. 1). The warm temperate south coast province was considered by Stephenson to be separated from the sub-tropical marine biota of Natal by a transitional region between Cape Padrone and Port Edward (Stephenson, 1948, p. 229). His studies on this section of coast include collections of 50–60 seaweed species in each of the 7 sites documented. The seaweed flora of this region remains little known; as Hommersand (1986) writes "the boundary between the flora of the East Cape and Natal is sharpened by our comparative ignorance of the algae of the 'wild coast' of Transkei. Many species of both provinces probably overlap in this region." This study describes the seaweeds of the region around Hluleka Nature Reserve, Transkei, centrally placed in Stephenson's warm temperate/sub-tropical transition region. The relatively rich flora of this area (178 species) is analysed into its biogeographical components to further our understanding of this transition.

COLLECTION SITES AND METHODS

Hluleka is situated approximately 31° 40′ S, 29° 26′ E (see Fig. 1). The central part of the investigated area is inside the Hluleka Nature Reserve and presents a relatively undisturbed stretch of coast: outside the Reserve the influence of man is readily recognizable, for instance in the harvesting of oysters from the intertidal, although this does not seem to harm the algal vegetation in the sublittoral fringe and in the intertidal rockpools. (For further information concerning human impact on intertidal animal communities on Transkeian shores, see Hockey & Bosman, 1986).

The rocky coasts, if undisturbed, show a zonation pattern generally concurring with

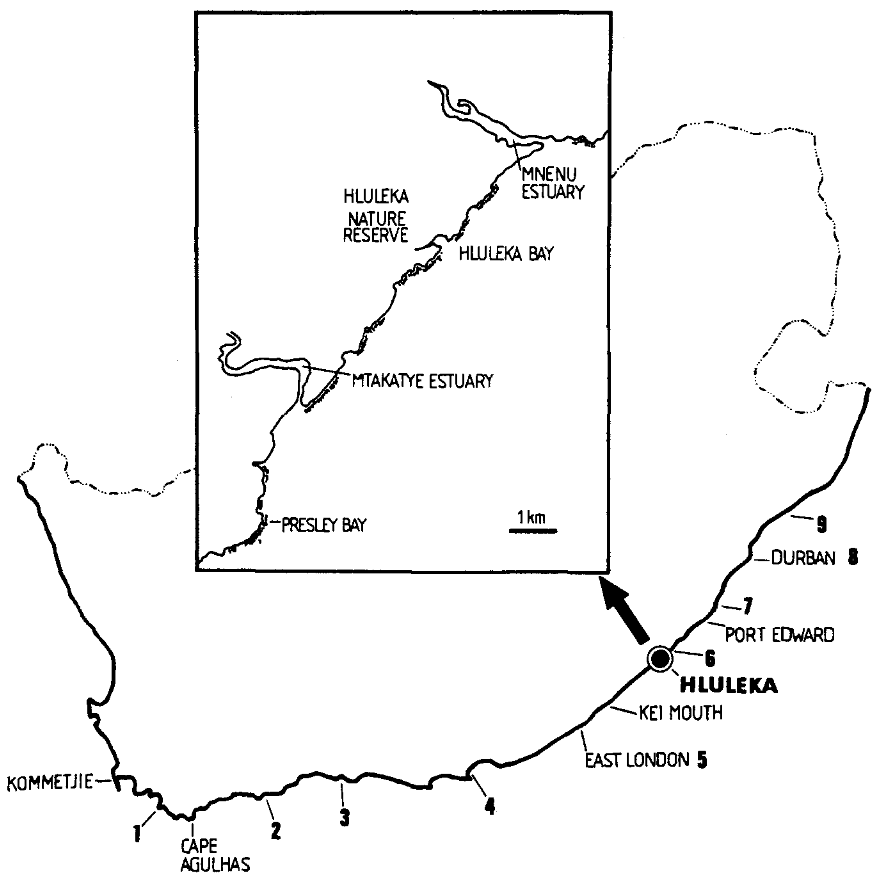

Fig. 1. Map of the southern African coastline, and the Hluleka region (inset). The numbers are sites for which sea water temperature data are shown in Figure 8

the "east coast type" (cf. Branch & Branch, 1981, p. 27), with the upper eulittoral oyster belt *(Saccostrea cucullata)* and large numbers of zoanthids in the lower eulittoral as the most striking features of the animal dominated tidal zone. Truly intertidal algae (not counting species from rockpools) are rather low in numbers and diversity; e.g. *Gelidium pristoides* and *Iyengaria stellata* in the eulittoral zone, some *Bostrychia* spp. in the littoral fringe. Rockpools in the eulittoral zone and sublittoral fringe are often dominated by a number of articulated corallines: *Amphiroa* spp., *Arthrocardia* spp., and *Cheilosporum* spp., although many other species are found. In some of the deeper pools *Ecklonia biruncinata* may be dominant, and rock pools high in the intertidal contain stands of *Sargassum* spp. The sublittoral fringe has no truly dominant species, although the general aspect is very much determined by algae: *Caulerpa racemosa. Gelidium amansii,* and *Hypnea spicifera* are often abundant, and at the deepest levels reached at low spring tides *Codium* spp. (especially *C. platylobium*) are prominent.

The three estuaries are all different. Mtakatye estuary is the largest – even in the dry season there is a continuous flow of fresh water, and an ample influx of sea water at every high tide. About 1 km inland there are rather extensive stands of mangrove, *Avicennia marina* (Forssk.) Vierh. and *Bruguiera gymnorrhiza* (L.) Lam., while the inlets locally have a dense vegetation of eelgrass, *Zostera capensis* Setchell. Hluleka estuary is small, and cut off by a dam a few hundred metres inland, so as to create a permanent freshwater reservoir inside the Nature Reserve. On the seaward side of the dam is a small body of brackish water, cut off from the sea by a sandbar, which is replenished with seawater only at spring high tide. The latter had no significant growth of macroalgae. Mnenu estuary is much larger than Hluleka estuary, but again isolated by a sandbar, and in the dry season reached by the sea only during spring highs. A few species of macroalgae were attached, mainly on overhanging branches. Collections were made at the following sites:

(A) Presley Bay, 27 June 1983: sublittoral fringe and intertidal, including rockpools; wave exposed coast.

(B) Mtakatye estuary. 30 June 1983: about 1 km inland: mainly the epiphytes on mangrove pneumatophores were collected.

(C) Hluleka Nature Reserve, 24 June 1983, 25 June 1983, 26 June 1983, 1 Juli 1983, 2 Juli 1983 and 5 Juli 1983: rocky outcrops, most of them wave exposed: collections were made in the sublittoral fringe and upward including numerous rockpools; one sublittoral sample was made using snorkel in Hluleka Bay.

(D) Mnenu estuary mouth, 29 June 1983, 3 Juli 1983; wave exposed rocks on the east side; a complete collection was not made at this site.

(E) Mnenu estuary, 29 June 1983: loose algae on sand and attached to overhanging branches on south side of lagoon.

Plants were preserved in 5 % formalin in seawater, and after identification mounted on herbarium sheets. Many of the smaller species, including many epiphytes, were preserved in the form of permanent slides. Material is presently stored in the Bolus Herbarium of the University of Cape Town (BOL). There is no general flora covering the seaweeds of this coast. Larger algae could generally be identified using Simons (1976); more or less monographical studies exist for a few genera and families, e. g. *Codium* (Silva, 1959) and *Ceramium* (Simons, 1966); the Acrochaetiaceae from this expedition were treated earlier (Stegenga, 1985). Additional information on southern African algae is to be obtained from various articles, while the use of floras covering other tropical to temperate world regions can be recommended for some groups. Since phycology in this region is still in the pioneer stage, further research may reveal new species among the unidentified material. The species nomenclature, with a few exceptions, follows Seagrief (1984); those entities not mentioned in Seagrief's catalogue have been marked with an asterisk. For each species the localities have been indicated A, B, etc. following the sequence given above.

SEAWEEDS OF THE HLULEKA REGION

Chlorophyta

Acetabularia sp.: 1 juvenile specimen	C
Bryopsis cf. flanagani Barton	D
Bryopsis cf. setacea Hering	A, C
Bryopsis spp.: material of various morphology, probably belonging to more than one species	
Caulerpa brachypus Harvey	C
Caulerpa filiformis (Suhr) Hering	A, C
Caulerpa racemosa (Forssk.) J. Ag.	A, C
*id., var *zeyheri* (Sonder ex. Kütz.) Weber van Bosse	C
Chaetomorpha antennina (Bory) Kütz.	A, C
* *Cladophora coelothrix* Kütz.	A, B
Cladophora rugulosa Martens	A, C
* *Cladophora cf. socialis* Kütz.	C
Codium capitatum Silva	A, C
Codium duthieae Silva	A, C
Codium extricatum Silva	E
Codium lucasii Silva spp. *capense* Silva	A, C
Codium megalophysum Silva	A, C
Codium pelliculare Silva	C
Codium platylobium Aresch.	A, C
Codium pocockiae Silva	A
Codium prostratum Levring	D
Codium tenue (Kütz.) Kütz.	E
Derbesia hollenbergii Taylor (Fig. 2a)	C
Derbesia ryukyuensis Yamada & Tanaka (Fig. 2b)	C
* *Enteromorpha lingulata* J. Ag.	C
* *Enteromorpha multiramosa* Bliding	B
* *Enteromorpha torta* (Mert. in Jürg.) Reinsb.	B
Halimeda cuneata Hering in Krauss	A, C
* *Halimeda cf. tuna* (Ellis & Solander) Lamour.	C
Pseudocodium devriesii Weber-van Bosse	A, C
Ulva cf. capensis Aresch.	A
Ulva rigida C. Ag.	A, C
Ulva sp.: Plants small. Thallus ca 85 μm thick, cells 13–25 μm in diameter, 1–1.5	C

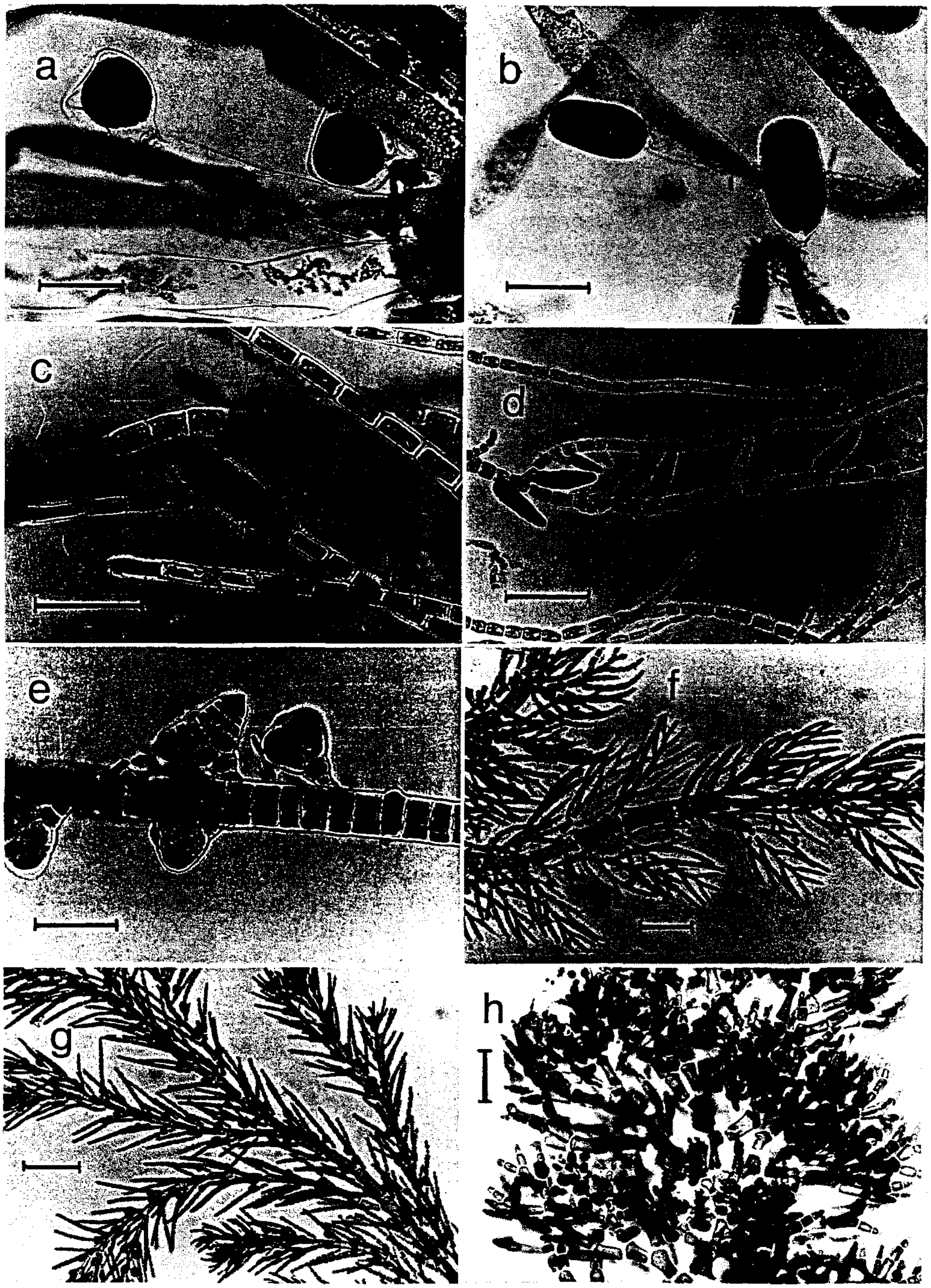

Fig. 2. (a) *Derbesia hollenbergii*, zoosporangia (Scale = 100 μm); (b) *D. ryukyuensis*, zoosporangia (Scale = 100 μm); (c) *Ectocarpus rhodochortonoides*, terminal plurilocular sporangium (Scale = 50 μm); (d) *Giffordia conifera*, plurilocular sporangia (Scale = 100 μm); (e) *Sphacelaria brachygonia*, propagula (Scale = 100 μm); (f) *Antithamnion diminuatum*, detail of thallus showing main axis and decussate branchlets (Scale = 100 μm); (g) *Antithamnionella verticillata*, detail of thallus – note prominent gland cells (Scale = 100 μm); (h) *Callithamnion* cf. *granulatum*, branchlets with tetrasporangia (Scale = 100 μm)

times as high as broad, chloroplast against the peripheral cell wall, with (1)2(3) pyrenoids

Valonia macrophysa Kütz.	C

Phaeophyta

Bachelotia antillarum (Grunow) Gerloff	C
Chnoospora minima (Hering) Papenfuss	C
Colpomenia sinuosa (Roth) Derbes & Solier	C
Dictyopteris longifolia Papenfuss	C
Dictyopteris macrocarpa (Aresch.) Schmidt	D
Dictyopteris serrata (Aresch.) Hoyt	C
Dictyota dichotoma (Hudson) Lamour.	C
Dictyota cf. liturata J. Ag.	A, C
Dictyota sp.	A, C
Dilophus suhrii (Kütz.) Papenfuss	C
Ecklonia biruncinata (Bory) Papenfuss	A, C
• *Ectocarpus rhodochortonoides* Boergesen (Fig. 2c)	A, D
Endarachne binghamiae J. Ag.	C
• *Giffordia conifera* (Boergesen) Taylor (Fig. 2d)	A
Giffordia mitchelliae (Harvey) Hamel	A, D
• *Giffordia rallsiae* (Vickers) Taylor	C
Iyengaria stellata (Boergesen) Boergesen	A, C
• *Rosenvingea intricata* (J. Ag.) Boergesen	E
Sargassum elegans Suhr	C
Sargassum cf. lendigerum (L.) C. Ag.	A, C
• *Sphacelaria brachygonia* Montagne (Fig. 2e)	C
Sphacelaria rigidula Kütz.	A
As *S. furcigera* Kütz. in Seagrief (1984)	
Stypopodium zonale (Lamour.) Papenfuss	A, C
Zonaria subarticulata (Lamour.) Papenfuss	C
Zonaria tournefortii (Lamour.) Montagne	A, C, D

Rhodophyta

• *Acrochaetium hlulekaense* Stegenga	C
• *Acrochaetium moniliforme* (Rosenvinge) Boergesen	A, C
• *Acrochaetium tenuissimum* (Collins) Papenfuss	B
• *Acrosorium cf. amphiroae* Jaasund	A, C
Acrosorium maculatum (Kütz.) Papenfuss	C
Acrosorium uncinatum (Turner) Kylin	C
Aiolocolax pulchella Pocock	C
Amphiroa anceps (Lamarck) Decaisne	A, C
Amphiroa cf. beauvoisii Lamour	A
Amphiroa bowerbankii Harvey	C, D
Amphiroa ephedreae (Lamarck) Decaisne	A, C

Amphiroa sp. C
Anotrichium tenue (C. Ag.) Naegeli: In S. African literature usually referred to as *Griffithsia secunda* Harvey ex. J. Ag. (cf. Seagrief, 1984) A, C
* *Antithamnion diminuatum* Wollaston (Fig. 2f): Apparently the same species as *A.* sp. mentioned by Wollaston (1984) C
Antithamnionella verticillata (Suhr) Lyle (Fig. 2g) C
Arthrocardia palmata (Ellis & Solander) Aresch. C
Arthrocardia spp.: Material belonging to probably 4 different species A, C
* *Bornetia repens* Stegenga C
Bostrychia binderi Harvey f. *typica* Post B
Bostrychia mixta Hooker & Harvey f. *typica* Post C
Bostrychia moritzana (Sonder in Kütz.) J. Ag. B
Bostrychia tenella (Vahl) J. Ag. C
Bostrychia tenuis (Harvey) Post f. simpliuscula Harvey ex. J. Ag. B
Botryocladia madagascariensis G. Feldmann A, C
* *Callithamnion cf. granulatum* (Ducluz.) C. Ag. (Fig. 2h): Plants bushy, main axis corticated, densely clothed with repeatedly dichotomous branchlets. Branchlets tapering towards the apices, to acuminate. Tetrasporangia sessile, nearly globose, ca 50 µm in diameter. Spermatangial clusters semiglobose, ca 60 µm in diameter. Carposporophyte with two rounded gonimolobes. C
Callithamnion stuposum Suhr A, C
Callithamnion sp. I. (Fig. 3a): Plants bushy, up to 10 mm high. Main axis patent, without substantial cortication, up to 100 µm in diameter; cells ca 100 µm long, not increasing in length in older parts of the plant. Branching polystichous; determinate laterals alternately branched. Tetrasporangia adaxial on the branchlets, sessile, ca 60 × 50 µm. No other reproductive structures present. A, C
Callithamnion sp. II. (Fig. 3b): Plants bushy, 4 mm high. Main axis ecorticate, up to 70 µm in diameter; cells ca 70 µm long. Branching polystichous: determinate laterals alternately to pseudodichotomously branched. Apical cells 8–10 µm in diameter. Spermatangial clusters (1)2 or 3 together on a branchlet cell. No other reproductive structures present. A, C
Caloglossa leprieurii (Montagne) J. Ag. B
* *Caloglossa ogasawaraensis* Okamura (Fig. 3c):This species has, in general, narrower thallus lobes than the more common *C. leprieurii* B
Centroceras clavulatum (C. Ag.) Montagne C
Ceramium arenarium Simons C
* *Ceramium byssoideum* Harvey A
* *Ceramium camouii* Dawson C
Ceramium centroceratiforme Simons D
Ceramium glanduliferum Kylin D
Ceramium poeppigianum Grunow A, C
* *Ceramium taylorii* Dawson A, C
Ceramium sp. (Fig. 4a: Plants consisting of ecorticate prostrate filaments, creeping on the surface of *Codium lucasii* ssp. *capense*; each cell of the prostrate filaments provided with an endophytic, generally 2-celled rhizoid, and a short erect axis of typical *Ceramium* morphology. Erect axes A, C

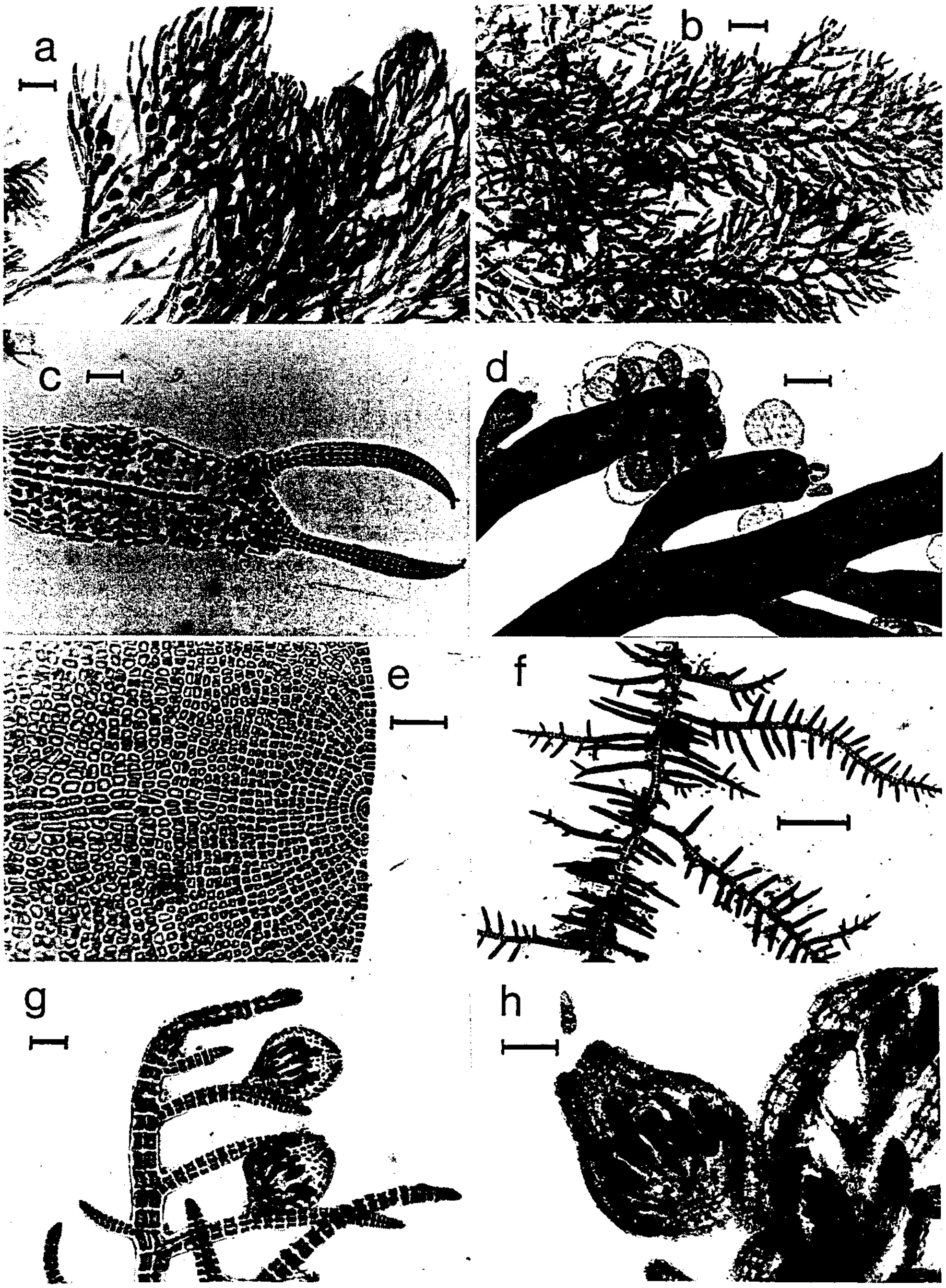

Fig. 3. (a) *Callithamnion* sp. I, thallus apex with tetrasporangia (Scale = 100 µm); (b) *Callithamnion* sp. II, thallus apex with spermatangia (Scale = 100 µm); (c) *Caloglossa ogasawaraensis*, thallus apex with tetrasporangia (Scale = 100 µm); (d) *Chondria dasyphylla*, ramuli with spermatangial stichidia (100 µm); (e) Delesseriacaceae indet., thallus apex (Scale = 100 µm); (f) *Falkenbergiella capensis*, habit of plant from *Amphiroa* sp. (Scale = 500 µm); (g) *F. capensis*, cystocarps (Scale = 100 µm); (h) *Herposiphonia clavata*, mature cystocarps (Scale = 100 µm)

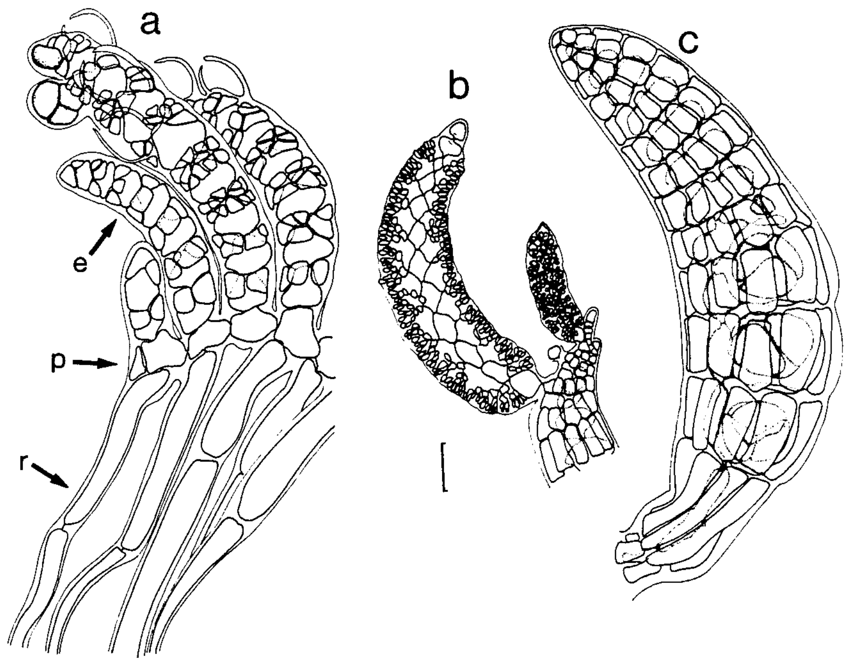

Fig. 4. (a) *Ceramium* sp. plant with tetrasporangia (e = erect axis; p = prostrate filament; r = rhizoids); (b) *Herposiphonia clavata*, spermatangial stichidia; (c) *H. clavata*, tetrasporangia. (Scale = 50 μm)

unbranched, rarely over 200 μm high, 50 μm in diameter. Cortication in discontinuous bands, per segment consisting of 3 tiers of cells. Tetrasporangia exserted, more than one per segment developing successively, ca 40 × 35 μm. Spermatangia developing from cortical cells near the apices of the erect filaments. Carposporophytes subterminal on the erect axes, surrounded by one or two involucral filaments from the underlying segment. Apparently, this species is related to the formerly recognised genus *Ceramothamnion* Richards, although in that genus both creeping and erect filaments have cortication. Corticated prostrate filaments do occur in the Transkei species, but they develop from secondarily attached erect axes.

Champia compressa Harvey C

* *Champia parvula* (C. Ag.) Harvey C

* *Cheilosporum cultratum* (Harvey) Aresch.: This species includes *C. multifidum* (Kütz.) Manza, which is quite often recognizable as a separate form. A, C

Cheilosporum proliferum (Lamour.) De Toni C

Cheilosporum sagittatum (Lamour.) Aresch. C

* *Chondria dasyphylla* (Woodw.) C. Ag. (Fig. 3d) C

Chondrococcus hornemannii (Lyngb.) Schmitz C, D

Chondrococcus tripinnatus (Hering) Delf & Michell A, C, D

Choreonema thuretii (Bornet) Schmitz C

* *Coelothrix irregularis* (Harvey) Boergesen	A
* *Colaconema botryocarpa* (Harvey) Stegenga	C
* *Colaconema daviesii* (Dillw.) Stegenga	C
* *Colaconema seriata* (Boergesen) Stegenga	C
Dasya cf. *scoparia* Harvey ex J. Ag.	C
Dasyclonium palmatifidum (Grunow) Scagel	C
*Delesseriaceae indet. (Fig. 3e): The material consists of a few juvenile plants and one plant bearing tetrasporangia. Blades up to 15 mm high, simple or with few marginal proliferations. Margins smooth, midrib apparent, no lateral veins present. Thallus consisting of three cell layers, thicker in the midrib. The plants fit the description of the genus *Crassilingua* Papenfuss, but the absence of fertile female plants prevents a precise identification.	A, C
Dictymenia stephensonii Papenfuss	C
* *Erythrocladia subintegra* Rosenvinge	C
Falkenbergiella capensis Kylin (Fig. 3f, g): This species is often found on coralline algae, especially *Amphiroa* spp. It has a typical growth form deviating somewhat from the original description (Kylin, 1938). Usually plants have no truly erect parts; the main axis is prostrate, attached by pairs of digitate haptera from every third segment; the determinate laterals, usually two per segment, are appressed against the substrate. Female reproductive plants seem to be more in accordance with the original description (see Fig. 3g).	C
Galaxaura diessingiana Zanardini	A, C
Galaxaura tenera Kjellmann	C
* *Gelidiopsis variabilis* (J. Ag.) Schmitz	C
Gelidium amansii (Lamour.) Lamour	C
Gelidium arenarium Kylin	C
Gelidium caespitosum Kylin	C
Gelidium pristoides (Turner) Kütz.	A, C
Gelidium reptans (Suhr) Kylin	C
Gelidium versicolor (S. G. Gmelin) Lamour	A, C
Goniotrichium alsidii (Zanard.) Howe: In Seagrief (1984) as *G. elegans* (Chauvin) Zanard.: according to Wynne (1985a) *Goniotrichium* is a synonym of *Erythrotrichia*, and should be replaced by *Stylonema*.	A
* *Goniotrichium cornu-cervi (Reinsch) Hauck*	C
Griffithsia confervoides Suhr	C
Gymnothamnion elegans (Schousboe ex C. Ag.) J. Ag.	C
Haliptilon subulata (Ellis & Solander) Johansen	C
* *Herposiphonia clavata* Wynne: This recently described species (Wynne, 1984) is often abundant on *Amphiroa* spp. In addition to Wynne's description of juvenile female reproductive structures we can now give data on the other reproductive organs. Male stichidia are formed on a number of subapical segments (Fig. 4b). Tetrasporangia occur in a maximum number of 4 per determinate lateral, in segment numbers 3–5 (–6) (Fig. 4c); they are up to 75 µm in diameter, tetrahedrally divided. The mature cystocarps are urceolate (Fig. 3h) situated on the sixth or seventh segment of the determinate branchlets (A slight difference from Wynne's observations, who noted procarps on	A, C

the fourth to sixth segment from the apex). It is noteworthy that the branchlets bearing procarps of cystocarps do not show the extremely elongated second segment otherwise so typical of this species.

Herposiphonia insidiosa (Grev.) Falkenberg A, C

Herposiphonia prorepens (Harvey) Schmitz C

Herposiphonia secunda (C. Ag.) Ambronn A, C

id. f. *tenella* (C. Ag.) Wynne: In the Transkei material the differences between the two forms of *H. secunda* are often quite clear; f. *tenella* has determinate axes up to 3 mm and 40 segments high, f. *secunda* 1.5 mm and 30 segments; the number of pericentral cells is ca 12 in f. *tenella*, 8 (–10) in f. *secunda*. Forma *tenella* was found epilithic, and f. *secunda* as an epiphyte on coralline algae. C

Heterosiphonia crispa (Suhr) Falkenberg A, C

Heterosiphonia sp. (Fig. 5a): Plants mainly prostrate, up to several centimetres long. Main axis up to 200 µm in diameter, segments about as long as broad, with 6–7 pericentral cells, without cortication. Branching distichous, one lateral every second or third segment. Determinate laterals largely polysiphonous, only the ultimate three forkings monosiphonous, with relatively short cells. C

Hypnea spicifera (Suhr) Harvey in J. Ag. A, C

Hypnea tenuis Kylin C

Jania adhaerens Lamour. C

•*Jania capillacea* Harvey C

Jania crassa Lamour. A, C

Laurencia complanata (Suhr) Kütz. A, C

Laurencia flexuosa Kütz. A, C

Laurencia glomerata Kütz. C

Laurencia natalensis Kylin C

Laurencia cf. *pumila* (Grunow) Papenfuss C

•*Lophocladia* sp. (Fig. 5b): Plants up to 20 mm tall, main axis sparingly branched, up to 400 µm in diameter. Segments with 4 pericentral cells, only in the older parts with a light cortication. Determinate laterals one per segment, spirally arranged, with repeated dichotomous branching, ca 20 µm in diameter near the base, ca 12 µm apically, the cells 2–3 times longer than broad. Material sterile. C

Martensia elegans Hering C

Melobesia membranacea (Esper) Lamour. C

Melobesia sp.: A miniscule species growing on the utricles of *Codium tenue*. Mature plants apparently little calcified, up to 300 µm in diameter, consisting of a single cell layer. Cells in regularly radiating rows, measuring ca 3 × 5 µm. Thallus thickness ca 15 µm. Female conceptacles conical, ca 60 (–100) µm in inner diameter, with a single ostiole. Sporangial conceptacles semiglobose or somewhat depressed, up to 120 µm in diameter, with several (up to 25) pores. Sporangia ca 25 × 15 µm, type of division not observed. Conceptacle roof consisting of roundish cells, ca 5 µm in diameter. This species differs from *M. membranacea* mainly by its smaller cell sizes. C

•*Microcladia exserta* Wynne (Fig. 5c, d): In Wynne's (1985b) description male C

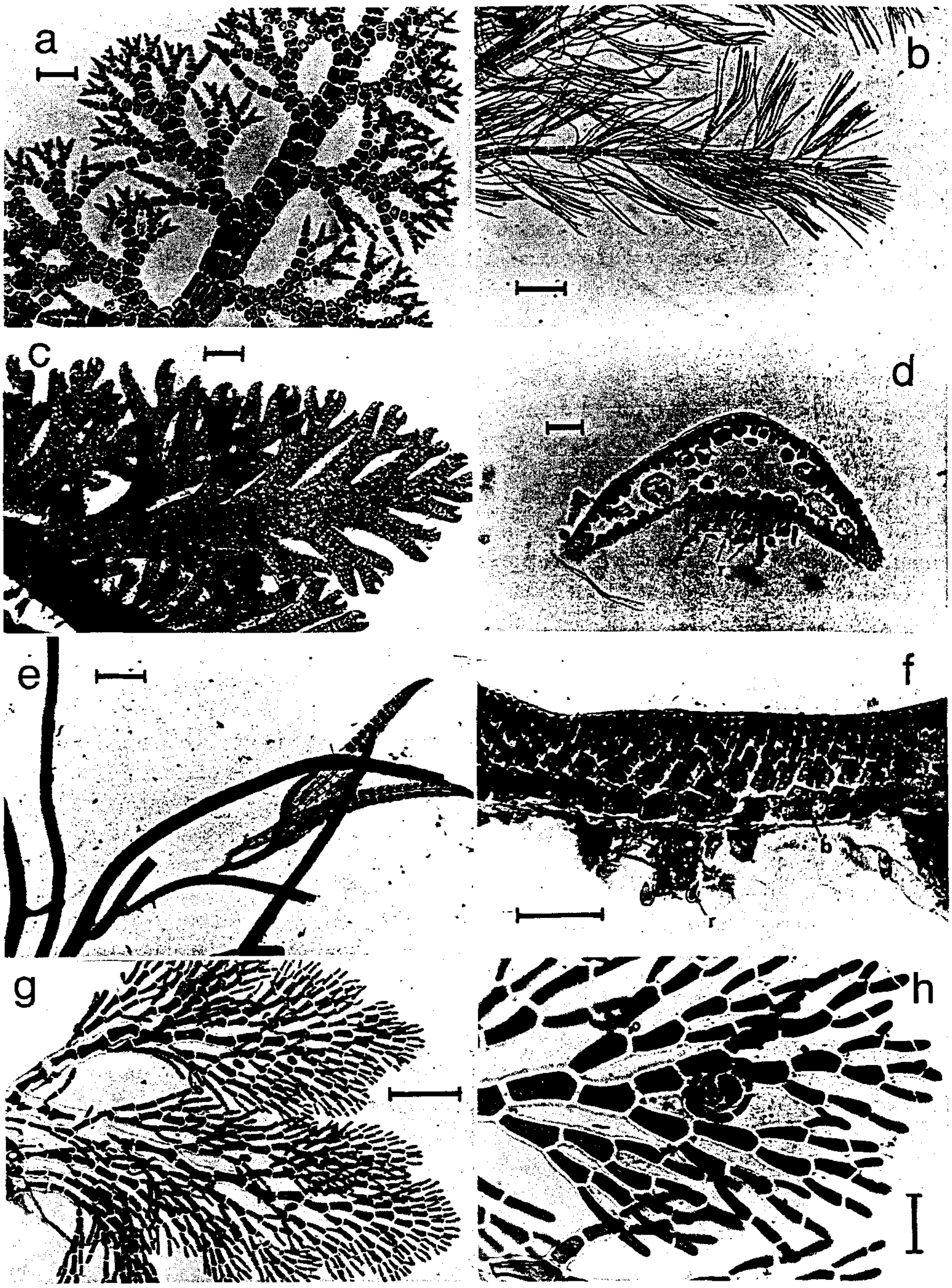

Fig. 5. (a) *Heterosiphonia* sp., detail of thallus showing main axis and laterals (Scale = 100 μm); (b) *Lophocladia* sp., thallus apex showing polysiphonous main axis and monosiphonous branchlets (Scale = 500 μm); (c) *Microcladia exserta*, thallus apex of male plant (Scale = 100 μm); (d) *M. exserta*, cross section of main axis (r = rhizoids) (Scale = 100 μm); (e) *Ophidocladus simpliusculus*, detail of thallus with tetrasporangia (Scale = 500 μm); (f) *Peysonnelia cf. calcea*, radial section (b = basal cell layer, r = rhizoid) (Scale = 100 μm); (g) *Plenosporium filicinum*, thallus apex with polysporangia (Scale = 500 μm); (h) *P. filicinum*, carposporophyte (Scale = 100 μm)

structures were not mentioned; the Transkei material shows that spermatangia are formed on the cortical cells of rather extensive sections of the laterals and main axis.

Nienburgia serrata (Suhr) Papenfuss A, C

Ophidocladus simpliusculus (Crouan) Falkenberg: The material (Fig. 5e) has a relatively high number of pericentral cells, ca 11 in prostrate axes, ca 24 in erect axes, and thus deviates from other descriptions of *O. simpliusculus*; an equally high number of pericentral cells is found in *O. herposiphonioides* Joly & Yamaguishi, a species synonomised with *O. simpliusculus* (see Seagrief, 1984). C

• *Peysonnelia* cf. *calcea* Heydrich (Fig. 5f) C

Peysonnelia capensis Montagne C

Placophora binderi (J. Ag.) J. Ag. A, C

Platysiphonia miniata (C. Ag.) Boergesen A, C

• *Pleonosporium caribaeum* (Boergesen) R. E. Norris. See Norris (1985) for the occurrence of this species in Natal. C

Pleonosporium filicinum (Harvey ex J. Ag.) De Toni: Morphology of this material (Fig. 5g, h) seems to be much the same as ?*Mazoyerella* sp. mentioned by Wollaston (1984) from Southern Mozambique. C

Plocamium beckeri Simons C

Plocamium corallorhiza (Turner) Harvey C, D

Plocamium suhrii Kütz. C

Pollexfenia minuta (Kylin) Papenfuss C

Polysiphonia cf. *incompta* Harvey A, C

Polyzonia elegans Suhr C

Porphyra sp. C

• *Porphyropsis* sp.: Both *Porphyra* sp. and *Porphyropsis* sp. were found as very small plants (a few mm high) growing on *Codium platylobium*. C

Prionitis nodifera (Hering) Barton A, C

Pterosiphonia cloiophylla (C. Ag.) Falkenb. A, C

• *Ptilothamnion subsimplex* Gordon (Fig. 6a) C

• *Ptilothamnion polysporum* Gordon-Mills & Wollaston in Wollaston (Fig. 6b): Recently described from Natal; the Transkei material contains only sporophytes with the characteristic sessile globose polysporangia. C

• *Rhodothamniella floridula* (Dillw.) J. Feldmann C

Rhodymenia natalensis Kylin A

Spyridia cupressina (Harvey) Kütz. A, C

Tayloriella tenebrosa (Harvey) Kylin C

• *Tiffaniella cymodoceae* Boergesen) Gordon (Fig. 6c): Also mentioned from Natal (Norris & Aken, 1985) and the Cape (Stegenga, 1986). C

Tiffaniella schmitziana (Barton) nov. comb. (Fig. 6d, e) C

Basionym: *Spermothamnion schmitzianum* Barton, 1893 (cf. Barton, 1893: Journal of Botany, p. 138). Description: Prostrate filaments ca 35 μm in diameter, the cells up to 200 μm long. Usually each cell with a digitate hapteron and an erect filament. Erect filaments 1–2 mm high, unbranched or with few laterals, 30–40 μm in diameter, the cells up to 130 μm long.

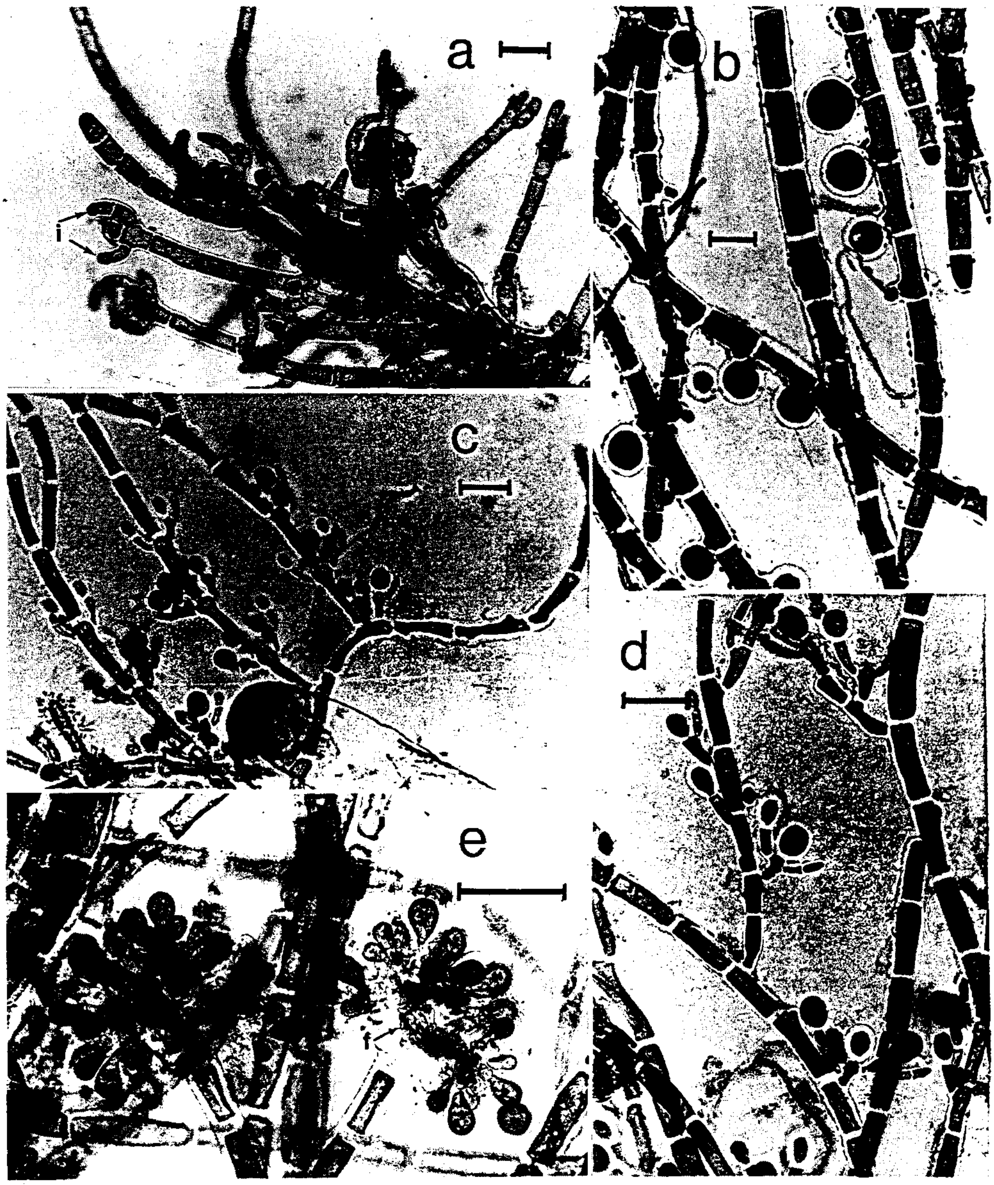

Fig. 6. (a) *Ptilothamnion subsimplex*, erect filaments with procarps and young carposporophytes (i = involucral filaments) (Scale = 100 µm); (b) *Ptilothamnion polysporum*, polysporangia (Scale = 100 µm); (c) *Tiffaniella cymodoceae*, detail of thallus with tetrasporangia (Scale = 100 µm); (d) *Tiffaniella schmitziana*, tetrasporangia (Scale = 100 µm); (e) *T. schmitziana*, carposporophytes (note deltoid fusion cell, f) (Scale = 100 µm)

Tetrasporangia in cymose clusters. One or two clusters on the proximal cells of the erect axes. Tetrasporangia tetrahedrally divided, ca 60 × 50 µm at maturity. Spermatangial stichidia in short secund series on the distal parts of the erect axes. Stichidia ca 75 × 35 µm. Female fertile filaments terminal on the erect axes and laterals; fertile filament consisting of 3 short cells. Structure of procarp and post-fertilization development typical of *Tiffaniella*. Fusion cell, consisting of subapical cell, hypogenous cell, supporting cell, auxiliary cells and proximal gonimoblast cells, broadly deltoid in shape.

This species is in many respects hardly different from *Tiffaniella cymodoceae*, but in the latter species there are often up to 4 tetrasporangial clusters per cell (usually one cluster in *T. schmitzianum*), and the fertile female filament consists of 4 cells in *T. cymodoceae* instead of three in *T. schmitzianum*. The fusion cell in *T. cymodoceae* is T-shaped rather than deltoid. *T. cymodoceae* usually grows on *Codium* sp., at least along the southern African coast.

The type material of this species (in BM, coll. John Farquhar, 1026, Port Elizabeth, 1893) causes some problems. The type sheet contains two different entities, one growing on *Amphiroa bowerbankii*, the other on *Zonaria subarticulata*. On the added drawing, however, it is noted that the material grew on *Halimeda*, as stated on the type description. As for the identity of the actual specimens, the species on *A. bowerbankii* is apparently identical with *Ptilothamnion polysporum* (see above), as evidenced by its cell diameters (40–60 µm) and sessile globose polysporangia.

The plants growing on *Z. subarticulata* clearly belong to *Tiffaniella*, and apparently to the species described above, judging from the female fertile filaments which consist of three short cells, and the tetrasporangia, which occur in clusters that are single, sometimes two together on an erect axis cell. As this material is in close agreement with the added drawing (depicting tetrasporangia and spermatangial stands), the plant on *Z. subarticulata* is closest to the type of *Spermothamnion schmitzianum*. A further argument is that the type description makes mention of terminal "sphaerospores", a description that can be applied to the material on *Zonaria* but not that on *Amphiroa*. Since the material, as earlier suggested by Norris & Aken (1985), belongs to the genus *Tiffaniella*, a new nomenclatural combination becomes necessary: *Tiffaniella schmitziana (Barton) nov. comb.*

Wrangelia purpurifera (Harvey) J. Ag. C

PHYTOGEOGRAPHICAL AFFINITIES OF THE HLULEKA FLORA

Distribution patterns

Figure 7 shows the distributions of those 128 species in the Hluleka flora for which records are considered adequate for analysis. The distributions of the species around 6 sites are presented, these being sites described by previous authors (Stephenson, 1939, 1944, 1948: Brown & Jarman, 1978; Bolton, 1986) as significant in marine biogeographic studies in southern Africa. Although only 128 of the 178 species present have distributions well enough known to be of use, this figure compares very favourably with the 116

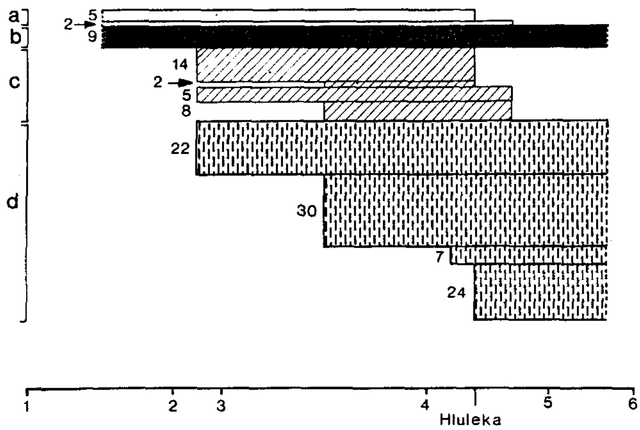

Fig. 7. Distribution of Hluleka seaweed species around six phytogeographically significant sites (1 = Orange river mouth; 2 = Kommetjie; 3 = Cape Agulhas; 4 = Kei mouth; 5 = Durban; 6 = South Africa/Mozambique border). Group a = cold water species; b = ubiquitous species, c = south coast species, d = warm water species (see text)

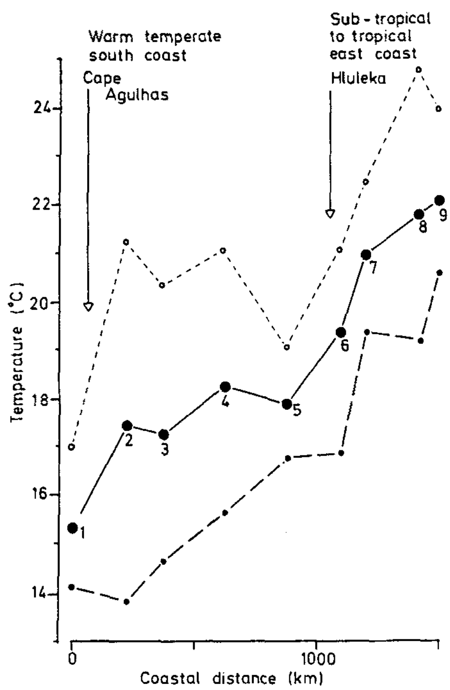

Fig. 8. 10-year annual mean sea-water temperatures at numbered sites in Figure 1 (solid line) framed by mean monthly maxima (upper dotted line) and mean monthly minima (lower dotted line) for the years 1973–83 (Data from the South African Maritime Weather Office)

seaweed species distributions discussed by Stephenson (1944) for the entire coastline of the, then, Union of South Africa. A similar analysis was provided by Bolton (1986) for 205 of the 268 recorded west coast species. It can be seen that the cold water component (i. e. those occurring west of Kommetjie but not east of Durban) comprises only 7 species (5.5 % of the flora). Ubiquitous species, occurring throughout the area under consideration, total 9 (7 %). South coast species are here defined as occurring neither west of Kommetjie nor east of Durban, and these number 29 (22.7 %). The remaining 83 species (64.8 %) are warm water species, occurring in the sub-tropical and/or tropical waters east of Durban, and extending a greater or lesser distance along the south coast. A number of southern African warm water species (22 in this study) occur as far as the region immediately west of Cape Agulhas, as documented by Bolton (1986).

Sea temperatures

Figure 8 shows inshore seawater temperature data for the region under discussion, extracted from Bolton (1986). 10 year annual means are shown, framed by mean temperatures in the warmest and coldest month over the same period. Sites 2 to 5 represent the warm temperate south coast, with annual means from 17.2 to 18.2 °C, and, generally, with a large range between maximum and minimum monthly means (extreme value – Still Bay – range of 7.4 °C). In the region east of the Kei river mouth, where Hluleka is situated, there is a rapid rise in the annual mean, from 17.8 °C (East London) to 19.6 °C (Port St. Johns), over a relatively short coastal distance. This rapid rise continues to site 7 (Southbroom, annual mean 20.9 °C). Durban (site 8) is in the region with a sub-tropical seaweed flora (annual mean 21.7 °C), and at site 9 (Zinkwasi) inshore temperatures are tropical as defined by Eckman (1953), with means in the coldest month above 20 °C.

DISCUSSION

That the Hluleka region is ideally situated for an investigation of the warm temperate/sub-tropical transition can be seen both from Stephenson's studies of the marine provinces, and from the sea temperature data, showing a rapid change on this stretch of coast. Sea temperatures have not been measured in the Hluleka region, but Figure 8 would suggest that the site is centrally situated along the transition. The seaweed flora is, however, predominantly made up of species with warm water affinities [N. B. 71.9 % of the Hluleka species analysed occur in the sub-tropical to tropical region east of Durban, and many (54 species, 42 %) are recorded in the tropical floras of either Tanzania, (Jaasund, 1976) or Tropical West Africa (Lawson & John, 1982)]. Comparing this data with the intertidal animal and plant distributions of Stephenson (1944), the latter found that the most marked transition occurred on the ca 100 mile-long stretch of coast between Qolora (5 km from the Kei river mouth) and Port St. Johns. He found an extreme dominance of warm water over cold water species at Port St. Johns (127:17), but much less so at Qolora (85:47). These figures can be compared with our data (for seaweeds only) giving a ratio of 83:7 for the Hluleka region. This overwhelming predominance of species with warm water affinities at Hluleka would suggest that the transition from a warm temperate to sub-tropical seaweed flora is sharp, and occurs in the region between the Kei river mouth and Hluleka, a distance of only ca 130 km. The close links between sea water temperature regimes and seaweed floras in southern Africa is well documented (Isaac, 1937, 1938; Stephenson, 1948; Bolton, 1986). The probable limiting factor for the eastward spread of cold water and south coast species is thus the rapid changes in temperature regime along this short stretch of coast. The available temperature data indicates an almost 2 °C rise in mean annual temperature in this region. More detailed local temperature data is, however, required before the precise limiting factors for the eastward spread of cold-water species in this region can be determined.

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