Progress of the taxonomic research on the macroalgae (Chlorophyta, Phaeophyta and Rhodophyta) along the East African coast

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ABSTRACT

This paper discusses the phycological research and gives a historical overview of papers dealing with macroalgae from the East African coast. A review of the recent progress towards a marine algal flora of the region is presented. Additionally a limited number of taxonomic problems are discussed, with emphasis on examples from Tanzania and Zanzibar. Problems comprise generic, specific and subspecific distinctions, perpetuation of wrong identifications from 'reference works', and check-lists with doubtful identifications that lack voucher specimens. Finally a list of 91 new species for Kenya (23), Tanzania (24), the East African coast (26) and the Indian Ocean (18) is added.

HISTORY

The earliest records of algae from the East African coast were largely made by German phycologists, who generally depended on collections from amateur botanists or European citizens living in Africa. Sonder (1879) was the first to report a relatively large number of seaweed species (40 spp.) from Zanzibar, collected by Dr A. Roscher. The genus *Roschera* (a taxonomic synonym for *Tolypiocladia*) was erected to honour Roscher. Schmitz (1895) listed 68 species of red algae from Tanzania and Kenya.

In the first half of the 20th century relatively few supplementary species were added by a variety of authors. In the second half of that century there was a renewed interest in phycology along the East African coast. Interesting papers were published by Gerloff (1957) on algae from Dar es Salaam and by Schmidt (1957) providing more general information on the marine vegetation along the East African coast. Taylor gave accounts on *Turbinaria* (1966), including the description of *T. crateriformis* Taylor and *T. kenyaensis* Taylor, both from the Kenyan coast, and on *Caulerpa* (1967) from the Tanzanian and Kenyan coasts. Important progress in Tanzanian phycology was made by Jaasund (1969, 1970a–c, 1976, 1977a–d), who provided both annotated lists of Chloro-, Phaeo- and Rhodophyta, and more importantly a 'Field Guide for the Seaweeds

of Tanzania' (including 291 taxa). The latter at present is the only algal identification work for the East African coast. A set of the Jaasund herbarium is housed at the University of Dar es Salaam (DSM), additional collections are housed in Göteborg (GB) and the Natural History Museum, London (BM). Mshigeni and Chapman (1994) also published an important series of articles on seaweeds: several on *Eucheuma* (Mshigeni 1973), *Hypnea* (Mshigeni and Chapman, 1994) and other economically important genera such as *Sargassum* (Mshigeni and Chapman, 1987); other papers are on life histories of specific species.

In the last 40 years a series of authors mentioned a few seaweeds from Kenya. Gerloff (1960) reported 36 taxa of which 23 were new for that region. Isaac's publications (1967, 1968, 1971), based on his own seaweed collections from the Kenyan coast, are an important contribution to the knowledge of the African coast. The specimens are housed in the herbarium of the National Museums of Kenya in Nairobi (EA).

Whereas the Kenyan and Tanzanian coasts were relatively well studied from a phycological point of view, data on algae from Somalia and Mozambique are scarce. Hauck (1886–1889, 1888) wrote the first account on the algae from Somalia collected by Hildebrandt, describing new records for the region. Later, a few authors added some species and Sacco (1965) reported 20 taxa not previously known from the northern part of that country. Finally Sartoni (1975, 1976, 1978, 1979, 1986, 1992) listed 69 species of green, brown and red algae from the southern part of Somalia.

Except for the Inhaca Island region, marine algae of Mozambique have been less studied, most of the limited publications being from the second half of the 20th century. Isaac (1956, 1957, 1958, 1959) and Isaac and Chamberlain (1958) published a series of papers on the algal flora of Inhaca Island; Pocock (1958) listed 33 taxa from this coast and Critchley et al. (1997) provided an updated species list from that area with 205 taxa, many of which, however, are not identified to species level.

The species of macroalgae mentioned from the entire East African coast were listed by Lawson (1980). This list, however, contains a number of taxa under different synonyms. The publication of the 'Catalogue of Benthic Marine Algae of the Indian Ocean' by Silva et al. (1996) has greatly facilitated the process of checking correct nomenclature, including synonymies. It also mentions the biogeographical distribution of each taxon, although this information has to be used with care as identifications have not been checked but were taken from published data.

Since 1980 the phycology department of the University of Ghent has been carrying out taxonomic, autecological and biogeographical research of macroalgae in the tropical part of the Indo-SW Pacific, with emphasis on the area around Papua New Guinea/ Indonesia. From 1985 onwards Kenya and Tanzania were also included, with supplementary collections around the Seychelles, Socotra, Réunion, Mauritius, the Maldives and Sri Lanka. The collections from the East African coast, of which duplicate specimens have been deposited at the Kenya Marine and Fisheries Institute (Mombasa, Kenya) and the Institute of Marine Sciences (Zanzibar, Tanzania) are largely being

studied within the framework of MSc theses. To date the number of published results is still limited. These include papers on the genus *Caulerpa* (Coppejans and Beeckman, 1989, 1990), the family Codiales (Van den Heede and Coppejans, 1995; Coppejans and Van den Heede, 1996), macroalgae associated with mangroves (Coppejans and Gallin, 1989; De Schryver, 1990) and with seagrasses (Coppejans et al., 1992; Leliaert et al., 2000), and a chapter on seaweeds (Coppejans et al., 1997) in 'A Guide to the Seashores of Eastern Africa and the Western Indian Ocean Islands'.

Annotated checklists of Chlorophyta, Phaeophyta and Rhodophyta for the East African coast, including the citation of voucher specimens are being prepared. The results have not been published as yet due to the numerous taxonomic problems in many groups, not wanting to perpetuate erroneous identifications. A list of new records for the E. African coast has been compiled (Coppejans et al., 2000).

MAJOR TAXONOMIC PROBLEMS ENCOUNTERED

Varying classification systems

Due to ongoing macro-morphological, anatomical, ultrastructural and molecular research, new orders have recently been created, especially within the Rhodophyta (Saunders and Kraft, 1996). Some orders appear to have been merged, such as the Cladophorales and Siphonocladales (Chlorophyta) (van den Hoek, 1982; Olsen-Stojkovich, 1986; Bakker et al., 1994), neither of these orders being monophyletic; while still others (e.g. Cryptonemiales, Rhodophyta) have been abandoned (Kraft and Robins, 1985). The rough comparison of species lists, using different classification systems, can therefore be tricky.

Problems with generic distinction

Within the Cladophorales-Siphonocladales complex the genera *Boodlea* and *Phyllodictyon* are difficult to separate because of the lack of distinct taxonomic characters and their considerable morphological plasticity. *Phyllodictyon*, recently split off from the genus *Struvea* (Kraft and Wynne, 1996), is characterised by netlike stipitate blades in young specimens. In older, well-developed thalli of, e.g. *P. anastomosans* (Harvey) Kraft and Wynne the stipe becomes less conspicuous, resulting in a similar habit to *Boodlea montagnei* (Harvey ex J. Gray) Egerod, which is also characterised by bladelets of oppositely branched filaments. Culture experiments are in progress to determine whether *Boodlea* and *Phyllodictyon* should be regarded as one genus. Recent life history and molecular evidence seem to support this hypothesis (Bodenbender and Schnetter, 1990; Kooistra et al., 1993).

The status of the genera *Cladophora* (polyphyletic according to Bakker et al., 1994), *Cladophoropsis* and *Struveopsis* still have to be elucidated. *Cladophoropsis* only differs from some *Cladophora* species (of the section Repentes) by the postponement of cross wall formation at the insertion point of a lateral. According to van den Hoek

(1982) this may also occur in some *Cladophora* species, albeit to a lesser degree. Rhyne and Robinson (1968) have also observed this phenomenon for some species of *Struveopsis*. The latter differs from both *Cladophora* and *Cladophoropsis* by the formation of distinct blade-like structures. A comparison of previous records of the Siphoncladales-Cladophorales complex with the collection in Ghent is given in Table 1.

Problems with specific distinction

In the past, variability of morphological and anatomical characters induced by ecological or biogeographical factors has been underestimated. The lack of morphometric comparisons with the existing species have led to the description of numerous 'new species', only differing in a single (variable) character. Recent monographic studies have therefore frequently led to the synonymisation of several species. Børgesen (1940, 1946, 1948, 1952), for example, mentions 9 species of *Dictyosphaeria* (Chlorophyta) from Mauritius, of which 3 are new species. The distinction between these species is based on the morphology of the trabeculae in the cells. As this character apparently is highly variable, some of these species most probably will have to be synonymised. In the genus *Valonia* (Chlorophyta) cell morphology and dimensions, as well as the placement of the tenaculae are discriminative characters, but each of them is variable within a wide range. Already half of the 30 described species have been reduced to synonymy (Olsen and West, 1988).

A recent monographic study of the genus *Dictyota* in the Indian Ocean (De Clerck, 1999) was based on a morphometric approach, including 75 vegetative and 26 reproductive characters, combined with genetic analysis. It resulted in reducing the total number of *Dictyota* species from the Indian Ocean from 42 to 23 (including 2 newly described species). Jaasund (1970c) published a detailed account of the genus from the Tanzanian coast, including 9 species. De Clerck's study (1999) included Jaasund's collections housed in the Herbarium of Dar es Salaam (DSM) and the Natural History Museum London (BM) as well as numerous collections by Coppejans and co-workers. He recognised 12 species for the Tanzanian coastline of which only one mentioned by Jaasund (*D. ciliolata* Sonder ex Kützing) remains without nomenclatural or taxonomic changes (Table 2). Some species concepts of Jaasund were too narrow, e.g. the recurved branches of *D. pardalis* Kützing proved to be ecologically induced. Specimens from wave-swept environments tend to form branchlets that offer additional holdfasts while these were absent from plants growing in sheltered lagoons and intertidal pools (and identified as *D. cervicornis* Kützing). All intermediates between both growth forms occur and therefore both entities have been merged.

Another genus where species definition is not always clear cut, at least in some sections, is the genus *Caulerpa*. Silva et al. (1996) still distinguish *C. peltata* Lamouroux as a separate species even though Ohba and Enomoto (1987) induced this growth form in culture experiments from *C. racemosa* (Forsskål) J. Agardh var. *laetevirens* (Montagne) Weber-van Bosse. As a result a number of authors (Coppejans and Beeckman, 1989;

Table 1. Comparison of previous records of the Siphonocladales-Cladophorales complex with the collections in Ghent

Jaasund (1976)	Isaac (1967, 1971); Moorjani and Simpson (1988)	Ghent collections	Note
	Anadyomene stellata (Wulfen) C. Agardh		
Anadyomene wrightii Harvey ex J. Gray	*Anadyomene wrightii* Harvey ex J. Gray	*Anadyomene wrightii* Harvey ex J. Gray	
Boergesenia forbesii (Harvey) J. Feldmann	*Boergesenia forbesii* (Harvey) J. Feldmann	*Boergesenia forbesii* (Harvey) J. Feldmann	
Boodlea composita (Harvey) Brand	*Boodlea composita* (Harvey) Brand	*Boodlea composita* (Harvey) Brand	
Microdictyon montagnei Harvey ex J. Gray	*Boodlea montagnei* (Harvey ex J. Gray) Egerod	*Boodlea montagnei* (Harvey ex J. Gray) Egerod	
	Chaetomorpha aerea (Dillwyn) Kützing	*Chaetomorpha aerea* (Dillwyn) Kützing	
Chaetomorpha crassa (C. Agardh) Kützing	*Chaetomorpha crassa* (C. Agardh) Kützing	*Chaetomorpha crassa* (C. Agardh) Kützing	
		Chaetomorpha gracilis Kützing	new record Tanzania
Chaetomorpha indica Kützing			
		Chaetomorpha cf. *linum* (Müller) Kützing f. *brachyarthra* (Kützing) Børgesen	new record E Africa
		Chaetomorpha spiralis Okamura	new record Kenya
Cladophora sibogae Reinbold		? *Cladophora coelothrix* Kützing	
Cladophora mauritiana Kützing		*Cladophora mauritiana* Kützing	
Cladophora saviniana Børgesen (misapplied name)	*Cladophora prolifera* (Rothpletz) Kützing	*Cladophora prolifera* (Roth) Kützing	
Cladophora patentiramea (Montagne) Kützing f. *longiarticulata* Reinbold	*Cladophora patentiramea* (Montagne) Kützing f. *longiarticulata* Reinbold	*Cladophora socialis* Kützing	
Cladophora fascicularis (Mertens) Kützing	*Cladophora fascicularis* (Mertens) Kützing	*Cladophora vagabunda* (Linn.) van den Hoek	

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Table 1 continued

Jaasund (1976)	Isaac (1967, 1971); Moorjani and Simpson (1988)	Ghent collections	Note
Rhizoclonium grande Børgesen	*Rhizoclonium grande* Børgesen	*Cladophoropsis javanica* (Kützing) P. Silva	
	Cladophoropsis membranacea (Hofman Bang ex C. Agardh) Børgesen		
Cladophoropsis sundanensis Reinbold		*Cladophoropsis sundanensis* Reinbold	
	Chamaedoris auriculata Børgesen	*Chamaedoris auriculata* Børgesen	new record Tanzania
Chamaedoris delphinii (Hariot) Feldmann et Børgesen			
Dictyosphaeria cavernosa (Forsskål) Børgesen	*Dictyosphaeria cavernosa* (Forsskål) Børgesen	*Dictyosphaeria cavernosa* (Forsskål) Børgesen	
	Dictyosphaeria intermedia Weber-van Bosse		
Dictyosphaeria versluysii Weber-van Bosse	*Dictyosphaeria versluysii* Weber-van Bosse	*Dictyosphaeria versluysii* Weber-van Bosse	
	Ernodesmis verticillata (Kützing) Børgesen		
		Microdictyon japonicum Setchell	new genus for Tanzania
	Nereodictyon imitans Gerloff		
	Struvea anastomosans (Harvey) Piccone & Grunow ex Piccone	*Phyllodictyon anastomosans* (Harvey) Kraft & Wynne	new record Tanzania
		Rhizoclonium africanum Kützing	new record Tanzania
		Siphonocladus tropicus (P. Crouan & H. Crouan) J. Agardh	new record Tanzania
Spongocladia vaucheriaeformis Areschoug	*Spongocladia vaucheriaeformis* Areschoug	*Spongocladia vaucheriaeformis* Areschoug	
	Struvea ramosa Dickie		

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Table 1 continued

Jaasund (1976)	Isaac (1967, 1971); Moorjani and Simpson (1988)	Ghent collections	Note
		Struveopsis siamensis (Egerod) P. Silva	new genus for Tanzania
Valonia aegagropila C. Agardh	*Valonia aegagropila* C. Agardh	*Valonia aegagropila* C. Agardh	
Valonia fastigiata Harvey	*Valonia fastigiata* Harvey	*Valonia fastigiata* Harvey	
Valonia macrophysa Kützing	*Valonia macrophysa* Kützing	*Valonia macrophysa* Kützing	
	Valonia utricularis (Roth) C. Agardh	*Valonia utricularis* (Roth) C. Agardh	new record Tanzania
Valoniopsis pachynema (Martens) Børgesen	*Valoniopsis pachynema* (G. Martens) Børgesen	*Valoniopsis pachynema* (Martens) Børgesen	
Valonia ventricosa J. Agardh	*Valonia ventricosa* J. Agardh	*Valonia ventricosa* (J. Agardh) Olsen & J. West	
Total	22 species	27 species	29 species

Coppejans, 1992; Prud'homme van Reine et al., 1996) have reduced this entity to variety level or even to growth form (ecad).

The genus *Sargassum* is the textbook example of extreme morphological variability. As stated by Kilar et al. (1992) the causes of variability are numerous: position of 'bladelets' and air vesicles on the plant (basal parts different from apical ones), sexual dimorphism, seasonality, environmental factors, random phenotypic expression and geographically correlated genotypic differences. Monographic studies using modern techniques (biometrics, culture experiments, outplanting and transplanting, experimental hybridisation, chemotaxonomy, molecular taxonomy) have only recently started. The number of species reported from different regions will therefore most probably be drastically reduced.

A relatively recent problem concerns convergent evolution, i.e. the presence of morphologically and anatomically similar species in different oceans that are genetically distinct, having evolved independently from one another. *Halimeda discoidea* Decaisne is recorded from the Atlantic, the Pacific and the Indian Oceans. Genetic analysis of Atlantic and Pacific specimens from Panama by Kooistra (pers. commun.) shows that both entities are markedly different, although they are morphometrically almost indistinguishable. A supplementary problem is that some growth forms of *H. discoidea* in some parts of the Indian Ocean are difficult to tell apart from *H. tuna* (Ellis and Solander) Lamouroux. Specimens of both species are now being collected from the same sites on Zanzibar and preserved in ethanol for genetic analysis by Kooistra. It is

Table 2. Comparison of *Dictyota* species listed in Jaasund (1970c) and De Clerck (1999)

Jaasund (1970c)	De Clerck (1999)	Note
D. adnata sensu Weber-van Bosse	*D. humifusa* Hörnig, Schnetter & Coppejans	Coppejans (1990) and Hörnig et al. (1992a)
D. bartayresii sensu Vickers *D. friabilis* Setchell	*D. crispata* Lamouroux	De Clerck & Coppejans (1997)
D. cervicornis Kützing D. *pardalis* Kützing	*D. cervicornis* Kützing	
D. ciliolata Sonder ex Kützing	*D. ciliolata* Sonder ex Kützing	
D. divaricata Lamouroux *D. ceylanica* Kützing	*D. ceylanica* Kützing	
D. dichotoma (Hudson) Lamouroux	*D. bartayresiana* Lamouroux	
	D. adnata Zanardini	Coppejans (1990)
	D. friabilis Setchell	new for the East African coast
	D. hamifera Setchell	new for the Indian Ocean
	D. stolonifera Dawson	new for the Indian Ocean
	D. rigida De Clerck & Coppejans	new species
	D. grossedentata De Clerck & Coppejans	new species
9 species	12 species	

not clear yet what the taxonomic status is of entities that are morphometrically indistinguishable but which appear to be genetically different.

Problems with subspecific distinction

In some genera (e.g. *Caulerpa*) numerous varieties and forms have been described. If one examines large collections from different regions, continuous series can be made between the 'typical' varieties making the attribution of isolated specimens to a given subspecific entity subjective. As with *Sargassum* species, transplantation and culture experiments of *Caulerpa* should be carried out. Olsen et al. (1998) and Jousson et al. (1998) are at present conducting genetic analysis on representatives of this genus.

Perpetual wrong identifications from 'reference works'

Jaasund (1970c, 1976) mentions *D. bartayresiana* sensu Vickers (as *D. bartayresii*) and *D. friabilis* Setchell from Tanzania. De Clerck (1999) studied the type specimens of both *D. bartayresiana* and *D. friabilis* as well as Jaasund's material identified as such. Both were misidentified by Jaasund and have therefore resulted in erroneous species descriptions, which have been used subsequently. Both entities belong to the ecologically induced erect and prostrate growth forms of *D. crispata* Lamouroux respectively. The 'real' *D. bartayresiana* is also present along the Tanzanian coast, but was identified as

D. dichotoma (Hudson) Lamouroux by Jaasund. Another example is the entity described by Jaasund (1976) as *D. adnata* sensu Weber-van Bosse. Coppejans (1990) and Hörnig et al. (1992a) proved that this entity was the newly described *D. humifusa* Hörnig, Schnetter and Coppejans, a sublittoral, mostly epiphytic, strongly iridescent species with sporangia scattered over its surface. The 'real' *D. adnata* Zanardini was discovered in Tanzania in the upper intertidal zone, between knee roots and pneumatophores of mangrove trees (or in the Bostrychietum of vertical cliff walls), and is dull dark brown with typical marginal sori. Similar errors in other genera have also been found in other field guides, especially in some recent, nice-looking and easy to use photographic booklets where taxonomic correctness has been subordinated to the beauty of the underwater pictures.

Checklists without reference specimens or with doubtful identifications

During the identification of our collections from the Indian Ocean we also checked specimens of previous collectors in that area, in as far as these are traceable (voucher specimens are rarely mentioned in checklists). The number of misidentifications, especially for some regions, is alarming, hampering biogeographical studies.

Publications including synonymised species

Some publications include the same taxon under two or even three different names, e.g. Lawson (1980) where *Chlorodesmis fastigiata* (C. Agardh) Ducker is also mentioned under *Avrainvillea comosa* (Bailey and Harvey) Murray and Boodle, or *Avrainvillea obscura* J. Agardh also under its synonym *A. capituliformis* Tanaka, etc. In the same publication *Dictyota radicans* Harvey is cited from Kenya after Lind (1956), but she only mentions an unidentified *Dictyota* sp. Rough counts of number of species (biodiversity studies) from such works are as a result biased. Since Silva et al.'s (1996) *magnum opus* this problem can easily be resolved.

RESULTS

Phycological research at the University of Ghent is mainly carried out on taxonomic groups, but ecological topics are also studied. The zonation of seagrasses and the associated algae in Gazi Bay (Kenya) were examined by De Wit (1988) and Coppejans et al. (1992); De Pauw (1990) examined the vegetation of a tidal creek in Gazi Bay; De Schryver (1990) worked on the epiphytes of mangroves (Bostrychietum) in Gazi Bay; Provoost (1992) studied the zonation of intertidal vegetation of Iwatine Bay (Mombasa, Kenya); and Vanreusel et al. (2000) examined the macroalgal epiphytes on seagrasses in Zanzibar. Taxonomic groups being studied include:

Chlorophyta

The family Caulerpaceae (*Avrainvillea, Boodleopsis, Caulerpa, Chlorodesmis, Rhipidosiphon, Rhipilia, Rhipiliopsis, Tydemania, Udotea*) by Coppejans and Beeckman

(1989, 1990); the genus *Caulerpa* is presently being researched in collaboration with de Senerpont Domis (Rijksherbarium Leiden, Netherlands) examining the morphometric part, while Olsen's team (Rijksuniversiteit Groningen, Netherlands) is performing the genetic analysis. The families Bryopsidaceae (*Bryopsis, Trichosolen*) and Codiaceae (*Codium*) have been studied by Van den Heede (1994), Coppejans and Van den Heede (1996) and Van den Heede and Coppejans (1995). The family Halimedaceae was preliminarily studied by Verellen (1990). The genus *Halimeda* is now being studied monographically on a worldwide scale by O. Dargent (1998), Dargent and Coppejans (1998) using morphometrics, in collaboration with W. Kooistra from the Smithsonian Institute, Panama, examining material from a genetic perspective. As stated above, the genus *Halimeda* is problematic: the same morphospecies appear to have evolved several times in different oceans. Although their morphology and anatomy appear to be extremely similar, their genetic information separates them into different clades. The Cladophorales/Siphonocladales complex was preliminarily studied by Vackier (1993) and Verstraete (1993) and is now being worked out in detail by F. Leliaert (Leliaert et al., 1997) (Table 1).

The Ulvales are generally identified with monographs on European representatives (Bliding, 1963, 1969). A worldwide revision (including genetic analysis) is imperative to ascertain whether tropical representatives are identical to the temperate species.

Phaeophyta

Within the order Dictyotales, as stated above in the section on taxonomic problems, the descriptions of most *Dictyota* species from the Indian Ocean were redefined by De Clerck (1999), after study of the respective type specimens. A detailed comparison between Jaasund's account on the genus and the recent revision by De Clerck (1999) is presented in Table 2.

Other genera of the Dictyotales have been studied by Leuci (1995), De Smet (2000) and Muylle (2000). In the genus, *Padina* some specimens have been found to have intermediate characters between described species. The variability of anatomical characters therefore should be studied in more detail.

In the order Fucales the genus *Sargassum* is extremely troublesome: our specimens have tentatively been identified following Jaasund (1976), but it is clear that there are more entities than are mentioned in his field guide.

Rhodophyta

The study of 'difficult groups' within the red algae has only recently been started in collaboration with A. Millar, G. Kraft, J. Huisman (order Nemaliales), M. Wynne (order Ceramiales) and L. Liao (order Gracilariales). Therefore the results on this group are preliminary, but new species and even new genera for the East African coast have been collected.

DISCUSSION

Regional checklists are useful tools in for example, biogeographical studies, but the correctness of the identifications in these works is not always guaranteed. The use of misapplied names, and thus the presence of erroneous species descriptions in field guides may have compounding negative effect in that they perpetuate wrong species concepts. The Southeast Asian Phycology working group therefore decided that the seaweed database for that region would only comprise data that includes voucher specimens. This would allow the identifications from different regions by a specialist in each group.

The need for a seaweed flora for the East African coast, similar to Lawson and John's (1987) for the West African coast or to Stegenga et al.'s (1997) South African coast, is an absolute necessity. Numerous groups are being studied at the University of Ghent, mostly in collaboration with taxonomic specialists from around the world. Large collections from diverse biotopes (mangrove areas, seagrass beds, vertical cliff walls, tide channels and pools, lagoons, reef platforms, seaward slopes of reefs) are already available, allowing the study of *in situ* variability of morphological and anatomical characters. Subtidal collections are still underrepresented because of the general inaccessibility of scuba infrastructure. This habitat contains the largest number of new species still to be discovered.

This paper mentions 91 new records for the area (Table 3), of which 18 are new for the Indian Ocean, 26 are new for the East African coast and 47 are new for either Kenya (23) or Tanzania (24).

In as far as is possible specimens from the African coast are compared with material collected from other regions of the Indian Ocean viz. the Seychelles, the Comores, Mauritius, Socotra, Sri Lanka, Indonesia and Papua New Guinea (SW Pacific).

Large stretches of the Mozambican and Somalian coasts (especially the northern part of both countries) are still under-sampled. Corallines and *Sargassum* have only been sporadically collected and studied. Their identification is a specialisation in itself.

Whereas previous collecting was restricted to herbarium-pressed and formalin preserved specimens, the present collection of living material (for culture experiments on morphological plasticity) and of silica gel-dried or alcohol-preserved samples (for genetic analysis) are also needed, for some recalcitrant groups. The study of type specimens is indispensable for the correct redescription of some species: original descriptions are frequently extremely concise and hardly diagnostic. As has been illustrated with De Clerck's monograph on Indian Ocean *Dictyota,* species studies should include the examination of type specimens, large collections, morphometric analysis and wherever possible, genetic analysis. Such studies result in the synonymisation of some species and a clear description of new species.

Table 3. New records from the collections of Coppejans et al. for Kenya (Ke), Tanzania (Ta), E. Africa (EA) and Indian Ocean (IO), since Isaac (1967, 1971) and Jaasund (1976)

	Ke	Ta	EA	IO
Chlorophyta				
Avrainvillea nigricans Decaisne	X			
Avrainvillea ridleyi A. Gepp & E. Gepp	X			
Bornetella sphaerica (Zanardini) Solms-Laubach			X	
Bryopsis indica A. Gepp & E. Gepp		X		
Caulerpa brachypus Harvey	X			
Caulerpa filicoides Yamada var. *andamanensis* W.R. Taylor			X	
Caulerpa sedoides C. Agardh			X	
Caulerpa serrulata (Forsskål) J. Agardh var. *serrulata* forma *torulosa* (Weber-van Bosse) Coppejans, Leliaert & De Clerck			X	
Caulerpella ambigua (Okamura) Prud'homme van Reine & Lokhorst			X	
Chaetomorpha gracilis Kützing		X		
Chaetomorpha spiralis Okamura	X			
Chamaedoris auriculata Børgesen		X		
Codium cicatrix P. Silva	X			
Codium extricatum P. Silva		X		
Codium lucasii Setchell		X		
Codium pocockiae P. Silva		X		
Codium repens (Crouan) Vickers	X			
Halimeda copiosa Goreau & Graham	X			
Halimeda distorta (Yamada) L.H. Colinvaux				X
Halimeda gracilis Harvey ex J. Agardh	X			
Halimeda macroloba Decaisne	X			
Halimeda melanesica Valet				X
Halimeda micronesica Yamada	X			
Microdictyon japonicum Setchell		X		
Neomeris annulata Dickie	X			
Phyllodictyon anastomosans (Harvey) Kraft & Wynne		X		
Rhipidosiphon javensis Montagne		X		
Rhipilia cf. *orientalis* A. Gepp & E. Gepp			X	
Rhizoclonium africanum Kützing		X		
Siphonocladus tropicus (P. Crouan & H. Crouan) J. Agardh		X		
Struveopsis siamensis (Egerod) P. Silva		X		
Trichosolen sp.			X	
Tydemania expeditionis Weber-van Bosse			X	
Udotea argentea Zanardini			X	
Udotea flabellum (Ellis & Solander) Howe		X		
Udotea glaucescens Harvey ex J. Agardh		X		
Valonia utricularis (Roth) C. Agardh		X		
Phaeophyta				
Dictyota adnata Zanardini (sensu stricto)			X	
Dictyota friabilis Setchell (sensu stricto)			X	
Dictyota grossedentata De Clerck & Coppejans				X
Dictyota hamifera Setchell				X
Dictyota humifusa Hörnig, Schnetter & Coppejans				X
Dictyota rigida De Clerck & Coppejans				X
Dictyota stolonifera Dawson				X

Continued next page

Table 3 continued

	Ke	Ta	EA	IO
Hydroclathrus tenuis Tseng & Lu				X
Stypopodium flabelliforme Weber-van Bosse			X	
Turbinaria tanzaniensis Jaasund	X			
Rhodophyta				
Anotrichium cf. *furcellatum* (J. Agardh) Baldock			X	
Anotrichium secundum (Harvey ex J. Agardh) Furnari			X	
Balliella sp.	X	X		
Callophycus serratus (Harvey ex Kützing) P. Silva				X
Ceramium multijugum Jaasund	X			
Ceratodictyon spongiosum Zanardini	X			
Chamaebotrys boergesenii (Weber-van Bosse) Huisman				X
Champia compressa Harvey		X		
Chondria collinsiana Howe	X			
Chondria dangeardii Dawson			X	
Duckerella ferlusii (Hariot) Wynne			X	
Dudresnaya capricornica Robins & Kraft			X	
Enantiocladia prolifera Falkenberg	X			
Episporium centroceratis Möbius			X	
Euptilota fergusonii Cotton	X			
Gibsmithia hawaiiensis Doty				X
Gibsmithia sp. nov.				X
Haloplegma duperreyi Montagne		X		
Hypoglossum simulans Wynne, I. Price & Ballantine				X
Hypoglossum androlamellare Wynne & De Clerck				X
Laurencia majuscula (Harvey) Lucas		X		
Laurencia poiteaui (Lamouroux) Howe	X			
Lomentaria baileyana (Harvey) Forbes				X
Lophocladia kuetzingii (Kuntze) P. Silva			X	
Microcladia gloria-spei Stegenga				X
Myriogramme marginifructa R. Norris & Wynne			X	
Osmundaria spiralis (C. Agardh) R. Norris				X
Osmundaria sp. nov.				X
Phacelocarpus tristichus J. Agardh		X		
Pleonosporium carıbaeum (Børgesen) R. Norris	X			
Polyopes ligulatus (Harvey ex Kützing) De Toni			X	
Polysiphonia howei Hollenberg in Taylor	X			
Polysiphonia scopulorum Harvey var. *vıllum* (J. Agardh) Hollenberg			X	
Predaea sp.			X	
Predaea sp. nov.				X
Rhodopeltis borealis Yamada			X	
Sebdenia flabellata (J. Agardh) Parkinson		X		
Solieria jaasundii Mshigeni & Papenfuss	X			
Tapeinodasya etheliae Weber-van Bosse			X	
Titanophora pikeana (Dickie) J. Feldmann		X		
Tolypiocladia condensata (Weber-van Bosse) P. Silva		X		
Trichogloea requienii (Montagne) Kützing		X		
Vanvoorstia incipiens De Clerck, Wynne & Coppejans				X
Total numbers	23	24	26	18

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