Cladophorales and *Siphonocladales* (*Chlorophyta*) from Bimbarras Island, Todos os Santos Bay, Bahia State, Brazil[1]

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ABSTRACT – A morpho-taxonomic study was undertaken of the *Cladophorales* and *Siphonocladales*, from bimonthly collections in the intertidal zone of Bimbarras Island, State of Bahia, between September/2008 and July/2011. A total of 12 taxa were identified: *Boodlea composita* (Harv.) F.Brand, *Chaetomorpha aerea* (Dillwyn) Kütz., *Chaetomorpha brachygona* Harv., *Chaetomorpha ligustica* (Kütz.) Kütz., *Chaetomorpha vieillardii* (Kütz.) M.J.Wynne, *Cladophora brasiliana* G.Martens, *Cladophora laetevirens* (Dillwyn) Kütz., *Cladophora socialis* Kütz., *Cladophoropsis membranacea* (Bang *ex* C.Agardh) Børgesen, *Dictyosphaeria versluysii* Weber Bosse, *Rhizoclonium africanum* Kütz., and *Rhizoclonium riparium* (Roth) Harv. The geographic distribution of *Cladophora socialis* is extended to the South Atlantic, and *Chaetomorpha ligustica* is an addition to the marine flora of Bahia. Descriptions, illustrations, and comparisons to related taxa are presented.

Key words: biodiversity, marine algae, taxonomy

RESUMO – ***Cladophorales e Siphonocladales* (*Chlorophyta*) da Ilha Bimbarras, Baía de Todos os Santos, Estado da Bahia, Brasil.** O trabalho trata do estudo morfo-taxonômico de *Cladophorales* e *Siphonocladales*, a partir de coletas bimestrais realizadas na região de entremarés na ilha Bimbarras, estado da Bahia, no período de setembro de 2008 a julho de 2011. Um total de 12 táxons foram identificados: *Boodlea composita* (Harv.) F.Brand, *Chaetomorpha aerea* (Dillwyn) Kütz., *Chaetomorpha brachygona* Harv., *Chaetomorpha ligustica* (Kütz.) Kütz., *Chaetomorpha vieillardii* (Kütz.) M.J.Wynne, *Cladophora brasiliana* G.Martens, *Cladophora laetevirens* (Dillwyn) Kütz., *Cladophora socialis* Kütz., *Cladophoropsis membranacea* (Bang *ex* C.Agardh) Børgesen, *Dictyosphaeria versluysii* Weber Bosse, *Rhizoclonium africanum* Kütz. e *Rhizoclonium riparium* (Roth) Harv. Destes, *Cladophora socialis* teve a sua distribuição geográfica ampliada para o Atlântico Sul e *Chaetomorpha ligustica* é adição à flora marinha da Bahia. Descrições e ilustrações bem como comparações com táxons afins são apresentadas.

Palavras-chave: algas marinhas, biodiversidade, taxonomia

INTRODUCTION

Todos os Santos Bay (TSB) is located on the coast of Bahia State, Brazil, and is the second largest geographical feature on the Brazilian coastline. Despite its importance to biodiversity maintenance and to provide resources for the livelihoods of thousands of people living along the coast, the TSB has supported intensive anthropogenic impacts, receiving urban and industrial pollution that impair its ability to furnish critical ecological services (Amado Filho *et al*., 2008; Hatje *et al*., 2009). Its ecological and economic value, combined with its geochemical, geophysical, and biological characteristics, led the Bahia state government to create in 1999 the Todos os Santos Bay Environmental Protection Area (EPA). The Ministry of the Environment of the Brazilian government considered the TSB-EPA to be of significant biological importance, and it was given priority among conservation efforts along the Brazilian coast (Ministério do Meio Ambiente, 2004).

Although the coast of Bahia State is one of the best studied areas along the northeastern Brazilian shoreline in terms of its phycological flora (Moura *et al.*, 2012), the macrophytobenthos of the TSB-EPA

are relatively poorly known in spite of their ecological importance to marine ecosystems.

There are 45 islands in the Todos os Santos Bay, but few have been the focus of floristic studies, which have generally been limited to point sampling efforts. Most studies have taken placed near the largest one, Itaparica Island, especially: Nunes & Paula (2000, 2001, 2006); Alves & Moura (2005); Alves *et al*. (2009, 2010, 2011, 2012a,b); Santos (2010) and Santos & Moura (2010). Additional data had also been reported by Barros-Barreto *et al*. (2004), Marins *et al*. (2008), and Nunes & Guimarães (2008) for Frades, Maré and Itaparica islands, especially a study by Alves *et al.* (2009, 2010, 2011, 2012a,b) of members of the *Cladophorales* and *Shiphonocladales* on the coast of Bahia state.

The present work undertook a detailed morpho-taxonomic study of the members of the *Cladophorales* and *Siphonocladales* on Bimbarras Island as a contribution to our understanding of the macrophytobenthos in Todos os Santos Bay, Bahia, Brazil.

MATERIAL AND METHODS

The study area included the waters around Bimbarras Island, in Todos os Santos Bay (TSB), Bahia State, Brazil, covering a maximum area of 1.223 km^2, with an average depth of 9.8 m (Cirano & Lessa, 2007). TSB contains important reef formations as well as other environments, as sandy and rocky shores and mangrove swamps, all of high ecological importance (Barros-Barreto *et al*., 2004).

The material was obtained along the coast of Bimbarras Island in the northern part of the TSB, in the municipality of São Francisco do Conde, Bahia State, Brazil (12º43'29.4''S and 38º38'09.0''W) (Fig. 1). The island itself covers an area of 174 hectares (Freitas, 2008) with extensive tracts of mangroves

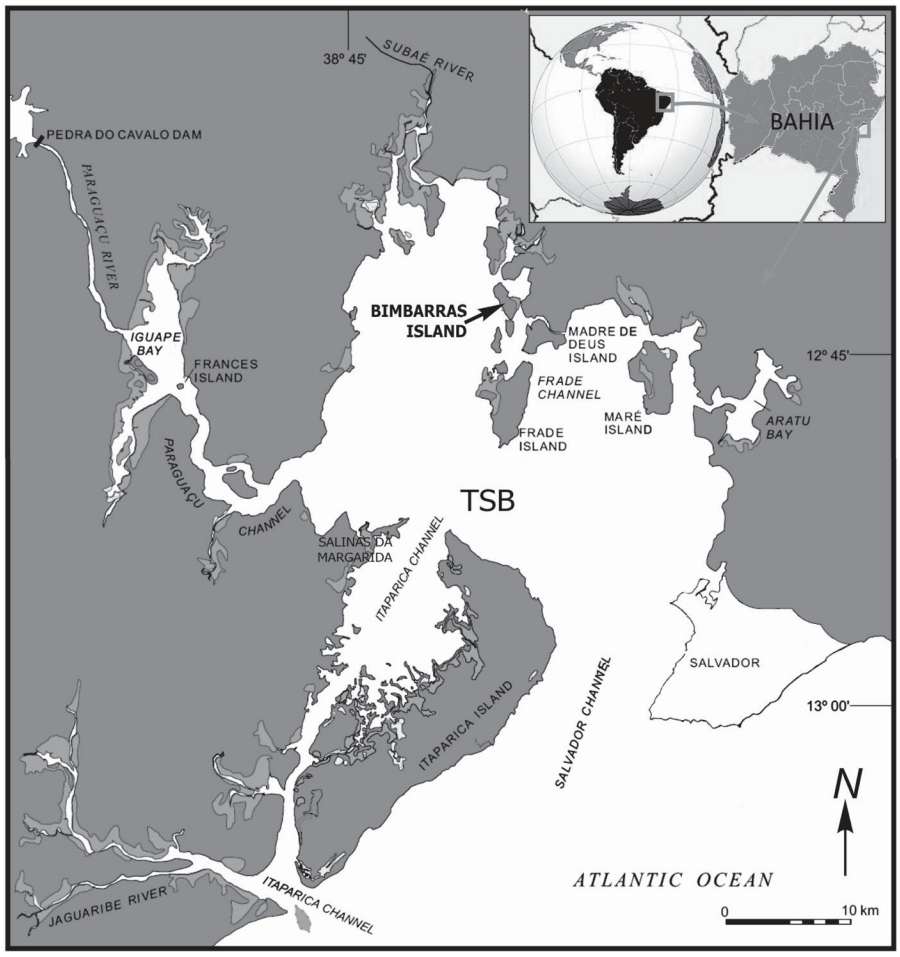

Fig. 1. Map of Todos os Santos Bay showing the localization of Bimbarras Island (arrow). (modified from Lessa *et al*., 2001).

and sandstone cliffs with stony coral colonies at their base, which provide the substrate for the development of marine benthic macroalgae. The material was obtained during bimonthly collections undertaken during the period between September/2008 and July/2011 by random surveys of the intertidal region (reef plateau and borders, and mangrove swamp environments) during diurnal low tides.

Morphological and anatomical characteristics of the specimens were examined using stereo and compound microscopes equipped with ocular micrometers and a digital camera (Sony model Cyber-shot DSC-W7, Tokyo, Japan). The dimensions (diameters and lengths) of all of the structures were established from 10 to 20 measurements taken of each specimen. The measures presented correspond to the minimum, maximum and median in parentheses.

The taxonomic arrangement follows Wynne (2011a) and taxon author names follow Brummitt & Powell (1992). The specimens were deposited in the Herbarium of the Universidade Estadual de Feira de Santana (HUEFS).

RESULTS AND DISCUSSION

The order *Cladophorales* was represented by the family *Cladophoraceae*, with nine taxa (*Chaetomorpha aerea*, *Chaetomorpha brachygona*, *Chaetomorpha ligustica*, *Chaetomorpha vieillardii*, *Cladophora brasiliana*, *Cladophora laetevirens*, *Cladophora socialis*, *Rhizoclonium africanum*, and *Rhizoclonium riparium*); *Siphonocladales* was represented by three taxa: *Boodlea composita*, *Cladophoropsis membranacea*, and *Dictyosphaeria versluysii* (the first two being representatives of *Boodleaceae* and the latter of *Siphonocladaceae*).

Identification key for the *Cladophoraceae*, *Boodleaceae*, and *Siphonocladaceae* taxa on Bimbarras Island, Todos os Santos Bay, Bahia State, Brazil

1. Filamentous thalli..... 2
1. Non-filamentous thalli.....*Dictyosphaeria versluysii*
2. Branching absent..... 3
2. Branching present..... 8
3. Thalli with lateral rhizoids..... 4
3. Thalli without lateral rhizoids..... 5
4. Filaments robust with rough texture and median cells 80-(110)-170 µm in diameter..... *Rhizoclonium africanum*
4. Filaments flaccid with soft texture and median cells 22-(27)-36 µm in diameter…..... *Rhizoclonium riparium*
5. Thalli erect, basal cells present.....…....*Chaetomorpha aerea*
5. Thalli entangled with other algae, basal cells absent…..... 6
6. Filaments with cells up to 370 µm in diameter ....*Chaetomorpha vieillardii*
6. Filaments with cells up to 130 µm in diameter…..... 7
7. Median cells 67-(95)-130 µm in diameter ....…….…..…..…. *Chaetomorpha brachygona*
7. Median cells 37-(42)-55 µm in diameter ....*Chaetomorpha ligustica*
8. Presence of tenacular cells …..... 11
8. Tenacular cells absent 9
9. Thalli prostate, cells with unicellular rhizoids from the basal poles, entangled with prostrate portion…*Cladophora socialis*
9. Thalli erect, cells without unicellular rhizoids from the basal poles ….....…….…..…..... 10
10. Thalli with short unicellular branches, apical cells with rounded tips, 230-(365)-540 µm long and 100-(130)-150 µm in diameter.…..... *Cladophora laetevirens*
10. Thalli without short unicellular branches, apical cells with rounded to tapering tips, 102-(167)-590 µm long and 15-(22)-37 µm in diameter…..... *Cladophora brasiliana*
11. Opposite or unilateral branching, apical cells 350-(660)-1.500 µm long and 100-(140)-220 µm in diameter..... *Boodlea composita*
11. Unilateral or irregular branching, apical cells 650-(1.620)-2.840 µm long and 100-(140)-280 µm in diameter.....*Cladophoropsis membranacea*

Cladophorales
Cladophoraceae

Chaetomorpha aerea (Dillwyn) Kütz., Sp. Alg., p. 379. 1849. *Conferva aerea* Dillwyn, Brit. Conferv., fasc. 11, pl. 80. 1806.

(Fig. 2 A-D)

Thallus dark green, erect to curved, growing isolated or in tufts, up to 5 cm tall. Grows by intercalary cell division. Filament attached to substrate by basal cells with rhizoidal extensions forming a lobed disk. Basal cells 173-(222)-320 µm long, 62-(75)-80 µm in diameter at base, and 77-(100)-100 µm in diameter at tip. Cylindrical suprabasal cells 82-(105)-158 µm long, 87-(97)-135 µm in diameter; quadratic median cell 72-(112)-167 µm long, 92-(102)-165 µm in diameter; laminated cell wall 10-(17)-35 µm thick in apical cells, and 20-(26)-50 µm thick in median cells; constrictions present between the septa. Apical cells 90-(100)-112 µm long, 100-(145)-150 µm in diameter.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 28.III.2008, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 146498); 03.XI.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 159229).

Chaetomorpha aerea was found growing on grains of sand, isolated or in tufts, and in association with *Cladophoropsis membranacea*. The studied material had cell dimensions that were similar to those described by Alves *et al*. (2009), but their maximum lengths corresponds to the minimum lengths reported by Taylor (1960), Littler & Littler (2000), and Barata (2004). Taylor (1960), and Littler & Littler (2000) described individuals up to 30 cm tall, whereas the material studied here was less than 5 cm tall, and may represent young thalli.

Some authors have treated *Chaetomorpha aerea* as a synonym of *Chaetomorpha linum* (O.F.Müller) Kütz. considering it a fixed form of the latter (Abbott & Hollenberg, 1976, Kapraun, 1984, Lawson & John, 1987, Burrows, 1991, Leliaert & Boedeker, 2007). Other authors recognized *Chaetomorpha aerea* as an independent species based on morphological (Nizamuddin & Begum, 1973; Womersley, 1984; Schneider & Searles, 1991; Coppejans, 1995; Littler & Littler, 2000; Rull Lluch, 2002; Alves *et al*., 2009; Norris, 2010), cytological (Sinha, 1958; Patel, 1971), and biochemical studies (Blair *et al*., 1982) as well as laboratory cultures (Kornmann, 1972).

Chaetomorpha linum is described in the literature as having thallus (which may or may not be attached to the substrate) composed of short cylindrical cells with long cells above them and short cells below them due to unequal cell division, whereas *C. aerea* is characterized as having an erect thallus attached to the substrate by basal cells with quadratic and globular to subglobular cells uniformly sized along the thallus, and with evident constrictions between the septa. According to Leliaert & Boedeker (2007), the existence of attached and detached forms of this taxon and its pronounced degrees of morphological variation have led to taxonomic controversies.

Chaetomorpha aerea has been recorded for Bimbarras Island (present study), Salinas da Margarida (Alves *et al*., 2009), and Itaparica Island (Alves *et al*., 2009; Santos, 2010) in the TSB.

Chaetomorpha brachygona Harv., Ner. bor.-amer., 3: 87-88, pl. 46A. 1858.

(Fig. 2 E-G)

Thallus light green, slender, densely entangled with other macroalgae, and marine phanerogams. Basal cells absent. Thallus growth by intercalary cell division. Filaments with quadratic and elongated median cells 75-(120)-220 µm long, 67-(95)-130 µm in diameter; uniform diameter along the filament; laminated, thin cell wall 2-(15)-30 µm thick. Apical cell 62-(118)-180 µm long, 80-(93)-100 µm in diameter.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 28.IX.2008, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 146508); 21.VI.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 148610); 19.VIII.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 155843); 11.VII.2010, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 170383); 11.VIII.2010, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 170389); 18.V.2011, *C.W.N. Moura et al. s/nº* (HUEFS 170382); 03.VII.2011, *E.B.S. Neto & W.R. Almeida s/nº* (HUEFS 170385).

This species was previously recorded in the TSB only on Itaparica Island and Saubara (Alves *et al*., 2009). *Chaetomorpha brachygona* was found to form large tangles growing in protected locations of the study area, attached to muddy substrates. It was found in association with *Chaetomorpha vieillardii*, *Cladophora laetevirens*, *Cladophoropsis membranacea*, *Halimeda opuntia* (L.) J.V.Lamour., *Dictyota* sp., *Dictyopteris jamaicensis* W.R.Taylor, *Padina* sp., *Acanthophora spicifera* (M.Vahl) Børgesen, *Amphiroa fragilissima* (L.) J.V.Lamour., *Centroceras* sp., *Palisada perforata* (Bory) K.W.Nam, *Dasya* sp., *Hypnea musciformis* (Wulfen) J.V.Lamour., and *H. spinella* (C.Agardh) Kütz. The species is epiphytized by *Erythrotrichia carnea* (Dillwyn) J.Agardh, and *Stylonema alsidii* (Zanardini) K.M.Drew.

The material studied was consistent with the descriptions and illustrations provided by Taylor (1960), Schneider & Searles (1991), and Alves *et al*. (2009), who all described *Chaetomorpha brachygona* as having thalli composed of flexible filaments and devoid of basal cells entangled with other algae.

Among the studied *Chaetomorpha* Kütz., *Chaetomorpha brachygona* is most similar to *Chaetomorpha ligustica* based on their tendency to entangle their thalli with other algae, but the latter has thinner median cells.

Chaetomorpha ligustica (Kütz.) Kütz., Sp. Alg., p. 376. 1849. *Conferva ligustica* Kütz., Phycol. General., p. 259. 1843.

(Fig. 2 H-I)

Thallus light green, slender, entangled with thalli of other algae. Basal cells absent. Thallus growth by intercalary cell division. Filaments with median cells

100-(141)-195 µm long, 37-(42)-55 µm in diameter; filament cells of uniform diameter; laminated cell wall 7-(12)-15 µm thick.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 27.II.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 146511).

Additional material examined: BRAZIL, BAHIA, Vera Cruz, Itaparica Island, Conceição Beach, 13.I.2009, *C.W.N. Moura et al. s/nº* (HUEFS 155357).

Chaetomorpha ligustica was found to form tangled mats together with *Caulerpa fastigiata* Mont. Silva *et al*. (1987) described the nomenclatural confusion concerning the name *Rhizoclonium tortuosum* (Dillwyn) Kütz. and proposed *Chaetomorpha ligustica* as the valid name for the taxon. According to Leliaert & Boedeker (2007), *C. ligustica* differs from species of the genus *Rhizoclonium* Kütz. by lack of lateral rhizoids, having coiled filaments with shorter cells, and larger numbers of nuclei per cell (>20 in *C. ligustica* compared to 2-4 in *Rhizoclonium*); according to the authors, molecular data further support the separation of the taxon from *Rhizoclonium* species.

Authors such as Silva *et al*. (1996), Norris (2010) and Guiry & Guiry (2012), however, still consider *Rhizoclonium tortuosum* to be a distinct and a valid taxon.

The cells in the studied material had larger dimensions than those reported by Joly (1965) and Kanagawa (1984) for *Rhizoclonium tortuosum*, but were within the limits reported by Leliaert & Boedeker (2007), who described the species as having cells that were 1-2-(4) times as long as broad. This is the first record of the species along the coast of Bahia State.

Chaetomorpha vieillardii (Kütz.) M.J.Wynne, Pacific Science, 65(1):112. 2011. *Bangia vieillardii* Kütz., Diagn. u. Bemerk., p. 10. 1863.

(Fig. 2 J-L)

Thallus light green, rough, densely entangled with the thalli of other macroalgae. Basal cells absent. Thallus growth by intercalary cell division. Filaments with quadratic to elongate cells 125-(260)-380 µm long, 200-(300)-370 µm in diameter; quadratic apical cell 180-(235)-290 µm long, 250-(280)-320 µm in diameter; laminated cell wall 17-(56)-90 µm thick.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 28.IX.2008, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 146505); 14.XII.2008, *C.W.N. Moura et al. s/nº* (HUEFS 146507); 19.VIII.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 155847); 17.X.2009, *W.R. Almeida s/nº* (HUEFS 155849); 27.V.2010, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 170386); 11.VII.2010, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 170391); 18.V.2011, *C.W.N. Moura et al. s/nº* (HUEFS 170353).

The species was found in the present study area growing in shallow water on sediments or entangled with thalli from other marine macroalgae species. *Chaetomorpha vieillardii* was found associated with *Chaetomorpha brachygona*, *Cladophoropsis membranacea*, *Halimeda opuntia*, *Dictyota* sp., *Dictyopteris jamaicensis*, *Padina* sp., *Acanthophora spicifera*, *Amphiroa fragilissima*, *Centroceras* sp., *Dasya* sp., *Hypnea musciformis*, *H. spinella,* and *Palisada perforata*. The species is epiphytized by *Erythrotrichia carnea,* and *Herposiphonia* sp.

Chaetomorpha vieillardii has robust filaments that contain quadratic cells that can easily be distinguished in the field with naked eye. The analyzed material agreed with the descriptions and illustrations provided by Alves *et al*. (2009 as *C. crassa*) and Littler & Littler (2000 as *C. crassa*), but differed in relation to the maximum diameters of the filament described by these authors (up to 750 µm and 1000 µm respectively).

Leliaert & Boedeker (2007) demonstrated that *Chaetomorpha linum* and *Chaetomorpha crassa* (which have type localities in Europe) are conspecific and display genetic and morphological differences from specimens collected in tropical waters and identified as "*C. crassa*". Based on this observation, Wynne (2011b) proposed the name *Chaetomorpha vieillardii* (Kütz.) M.J.Wynne to designate *Chaetomorpha* specimens with large cells from tropical seas.

Chaetomorpha vieillardii was first reported in Brazil by Lourenço *et al*. (2005, as *C. crassa*), while Alves *et al*. (2009) first described and illustrated this species on the Brazilian coast from specimens collected from Todos os Santos Bay (in mangrove swamps at Salinas da Margarida and Itaparica Island).

Cladophora brasiliana G.Martens, Tange Ost-Asien, 16:299-300, pl. 3, fig. 2. 1870.

(Fig. 3 A-D)

Thallus light green, slender, erect, up to 3 cm tall, attached to the substrate by basal cells that form a disk with lobed attachments. Growth by intercalated cell division followed by cell elongation. Pseudo-dichotomous to unilateral branching, sparse at the distal portion of the thallus. Main axis with cylindrical

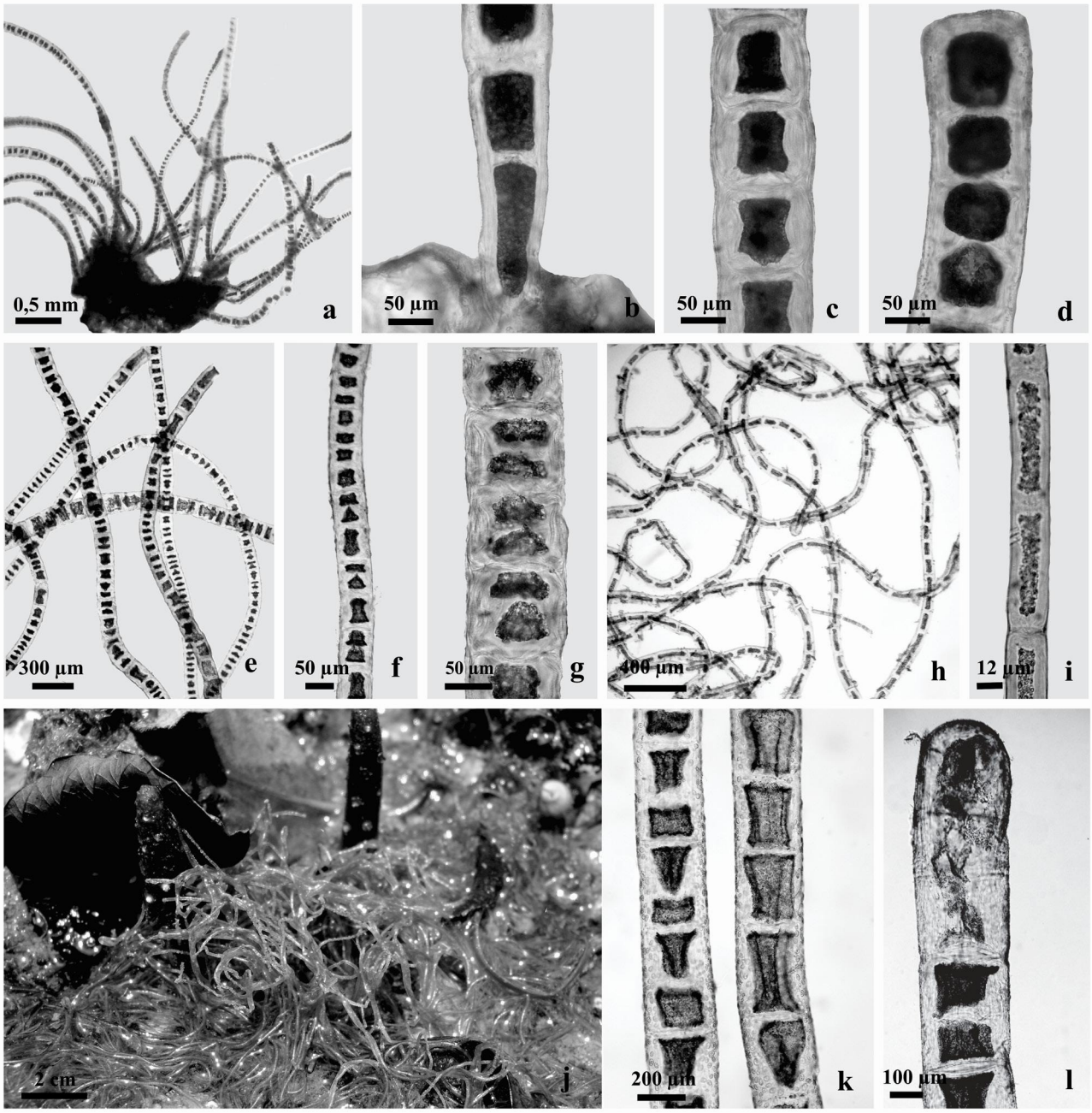

Fig. 2 A-D. *Chaetomorpha aerea*. **A.** General aspect of the thallus; **B.** Detail of basal cells; **C.** Detail of the quadratic median cells; **D.** Detail apical cell; **E-G.** *Chaetomorpha brachygona*. **E.** Detail of the entangled filaments; **F-G.** Quadratic median cells; **H-I.** *Chaetomorpha ligustica*. **H.** Detail of the entangled filaments; **I.** Detail of filament with long median cells; **J-L.** *Chaetomorpha vieillardii*. **J.** General aspect of the thallus; **I.** Quadratic medians cells; **L.** Detail of apical cell.

cells 290-(540)-780 µm long and 50-(100)-150 µm in diameter; terminal branch cells 105-(177)-270 µm long and 20-(27)-50 µm in diameter; apical cells with rounded to tapered tips, 102-(167)-590 µm long and 15-(22)-37 µm in diameter; laminated cell wall 2-(5)-7 µm thick in the apical region and 10-(20)-37 µm thick in the lower portions.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 14.XII.2008, *C.W.N. Moura et al. s/nº* (HUEFS 146500); 27.II.2009, *C.W.N. Moura & W.R. Almeida s/nº*

(HUEFS 146501); 27.IV.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 159227); 19.VIII.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 159226); 03.VII.2011, *E.B.S. Neto & W.R. Almeida s/nº* (HUEFS 170393).

Cladophora brasiliana was found growing on rocky substrates and on *Boodlea composita* and *Cladophoropsis membranacea*. The species was epiphytized by *Stylonema alsidii*. The specimens studied here were in agreement with the descriptions and illustrations provided by Hoek (1982), Gestinari *et al*. (2010), Alves *et al.* (2012a), and Santos (2010), with the exception of the larger diameter of the primary axis. Although the samples analyzed were up to 3 cm tall, Hoek (1982) reported that the thallus of *Cladophora brasiliana* could reach up to 30 cm.

Hoek (1982) considered *Cladophora brasiliana* to belong to the *Rupestres* section and compared it to other species in that section (*Cladophora albida* [Nees] Kutz., *Cladophora montagneana* Kutz., *Cladophora jongiorum* Hoek, and *Cladophora chlorocontracta* Hoek). *Cladophora brasiliana* is distinguishable from the other species in this section by having cylindrical cells, long apical cells, and sparse branching or rows of unilateral branches (which are sometimes curved) in the distal region of the thallus.

This species had previously been recorded only at Itaparica Island and on the Penha, Coroa, and Barra Grande beaches in Todos os Santos Bay (Santos, 2010; Alves *et al.*, 2012a).

Cladophora laetevirens (Dillwyn) Kütz., Phycol. General., p. 267. 1843. *Conferva laetevirens* Dillwyn, Brit. Conferv., pl. 48. 1805.

(Fig. 3 E-H)

Thallus dark green, slender, growing in small tufts up to 4 cm tall, attached to the substrate by branched rhizoids originating from the basal cell. Thallus growth through apical cell division, followed by cell thickening and elongation. Pseudo-dichotomous to unilateral branching; short unicellular branches present in the median-apical region of the thallus. Main axis with cells 580-(900)-1.300 µm long and 140-(180)-300 µm in diameter; cells in terminal branches 300-(380)-560 µm long and 80-(130)-160 µm in diameter; apical cells with rounded tips, 230-(365)-540 µm long and 100-(130)-150 µm in diameter; laminated cell wall 5-(12)-25 µm thick.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 21.VI.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 170478).

The species was found growing on bivalve shells or on rocky substrates in the study area in association with *Caulerpa fastigiata*, *Cladophoropsis membranacea* and *Centroceras* sp.; it was epiphytized by *Stylonema alsidii*.

The studied specimens agreed with the descriptions of Hoek (1963, 1982) and Hoek & Chihara (2000). Hoek & Chihara (2000) described specimens with cells along the main axis up to 250 µm in diameter – which are close to the dimensions observed in the present study.

The analyzed material agrees with the descriptions and illustrations provided by Alves *et al.* (2012a), but differed by having smaller cell diameters.

The presence of short, unicellular, lateral branches in the median region of the thallus is a useful characteristic for identifying *Cladophora laetevirens*. According to Hoek (1982), *C. laetevirens* is closely related to *Cladophora vagabunda* L. (Hoek) and *Cladophora dalmatica* Kütz. In addition to being the only species (among those three) to have short unicellular branches, *Cladophora laetevirens* also differs from *C. vagabunda* in having cylindrical apical cells with rounded, occasionally thin, apices; it differs from *C. dalmatica* in having short lateral branches and larger diameter apical cells.

Records of this species in Todos os Santos Bay were previously restricted to Itaparica Island (Alves *et al*., 2012a).

Cladophora socialis Kütz., Sp. Alg., p. 416. 1849.

(Fig. 3 I-O)

Thallus dark green to olive green, slender, growing entangled with the thalli of other macroalgae and forming mats of thin and highly interlaced filaments. Thallus growth by division of intercalated cells, forming short cells and/or apical cells followed by cell elongation and thickening. Branching dense, occasionally sparse, irregular to unilateral. Presence of unicellular rhizoids originating from the basal poles of their cells. Main axis with long cells 147-(355)-940 µm long and 40-(70)-132 µm in diameter; terminal branch cells 70-(135)-260 µm long and 17-(30)-45 µm in diameter; apical cells with a rounded tips 60-(82)-100 µm long and 15-(20)-27 µm in diameter; laminated cell wall 2-(7)-17 µm thick.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 27.IV.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 148706); 19.VIII.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 170352); 11.VII.2010, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 170354).

Additional material examined: BRAZIL, BAHIA, Vera Cruz, Itaparica Island, Penha Beach, 01.III.2006, *C.W.N. Moura et al. s/nº* (HUEFS 165455); Vera Cruz, Itaparica Island, Conceição Beach, 18.III.2007, *C.W.N. Moura et al. s/nº* (HUEFS 160465).

Cladophora socialis was found in association with *Chaetomorpha brachygona, Cladophoropsis membranacea*, *Halimeda opuntia,* and *Acanthophora spicifera* in the study area. The specimens identified as *Cladophora socialis* on the Bahia coast correspond to the material described by Hoek (1963, 1982), Hoek & Chihara (2000), Leliaert & Coppejans (2003), Leliaert (2004) and Dawes & Mathieson (2008). The limits for the diameters of the apical cells of the specimens analyzed were closer to those described in the latter two publications.

Cladophora socialis is morphologically close to *Cladophora coelothrix* Kütz.; characterized by cushion-like thalli composed of long cells with laterally inserted branches and unicellular rhizoids from the basal poles of their cells; based on these characteristics, they are placed in the *Cladophora* section *Repentes* (Leliaert *et al.*, 2007). *Cladophora coelothrix* differs from *C. socialis* by having more robust cells (Hoek, 1963, 1982 and Hoek & Chihara, 2000).

Molecular phylogenetic studies have indicated that *Cladophora socialis* is a member of the Siphonocladales clade, along with *Cladophora prolifera* (Roth) Kütz., *C. coelothrix*, *C. liebetruthii* Grunow, *C. catenata* (L.) Kütz., and *C. sibogae* Reinbold (Bakker *et al*., 1994; Leliaert *et al*., 2003, 2007; Gestinari *et al*., 2010). The relationship among these species would be expected morphologically, given that all can form rhizoids from cells in the distal portion of the thallus (Leliaert *et al.,* 2007).

Cladophora socialis forms thin films on rocks and encrusted coralline material in the sublittoral zone and on floating "pompons" in mangroves (Hoek & Chihara, 2000). The specimens in the study area were found in mats with delicate tufts in the sublittoral zone (1 m deep), in tidal pools, and on *Rhizophora* L. roots.

The geographic distribution *Cladophora socialis* is similar to that of *Cladophora coelothrix*; it reaches the tropical regions of the Northern Atlantic, Indian, and Pacific Oceans and the edges of subtropical regions (Hoek, 1982; Hoek & Chihara, 2000). The present data extends the distribution of this taxon to the Southern Atlantic. The species has a disjunct distribution on the Atlantic coast, and has been recorded in Panama (Wysor & Kooistra, 2003; Wysor, 2004) and Brazil (present study).

Rhizoclonium africanum Kütz., Tab. Phycol., p. 21, pl. 67, fig. II. 1853.

(Fig. 4 A-E)

Thallus dark green, rough, usually tangled, attached to the substrate by multicellular lateral rhizoids and basal cell. Presence of intercalated junctions at 90º angles along the entire length of the filaments. Apical cells with rounded tips 200-(300)-380 µm long and 80-(140)-160 µm in diameter; median cells 100-(220)-360 µm long and 80-(110)-170 µm in diameter; basal cells straight 90-(92)-100 µm in diameter; laminated cell wall 10-(20)-30 µm thick.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 27.II.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 155876); 19.VIII.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 155875); 03.XI.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 159273); 31.III.2010, *W.R. Almeida s/nº* (HUEFS 160515).

This species was found growing on mangrove tree trunks or entangled with pneumatophores in the study area and associated with *Bostrychia tenella* (J.V.Lamour.) J.Agardh, *Rhizoclonium riparium,* and *Cladophoropsis membranacea*.

The analyzed material had characteristics similar to those described and illustrated by Barata (2004) and Alves *et al*. (2009) for specimens collected on the coasts of the states of Espírito Santo, and Bahia respectively. Similar to the specimens in the present study, the material analyzed by Alves *et al*. (2009) contained frequent multicellular lateral rhizoids along the thallus. This characteristic was different in the material analyzed by Coto & Pupo (2009), who reported filaments lacking branching or only rare intercalated rhizoids.

Rhizoclonium africanum is distinct from *Rhizoclonium riparium* in having a rough thallus due to the larger cell diameters of its component cells and the presence of intercalated junctions, at 90º angles. The latter characteristic has been emphasized by many authors in identifying this species (Lawson & John, 1987; Sartoni, 1992; Coppejans *et al*., 2002; Alves *et al*., 2009).

This species is widely distributed in Todos os Santos Bay, being previously recorded at Itaparica Island, São Francisco do Conde, Salinas da Margarida, and Cajaíba Island (Alves *et al*., 2009).

Rhizoclonium riparium (Roth) Kütz. *ex* Harv., Phycol. Brit., pl. 238. 1849. *Conferva riparia* Roth Cat. Bot., p. 216-217. 1806.

(Fig. 4 F-J)

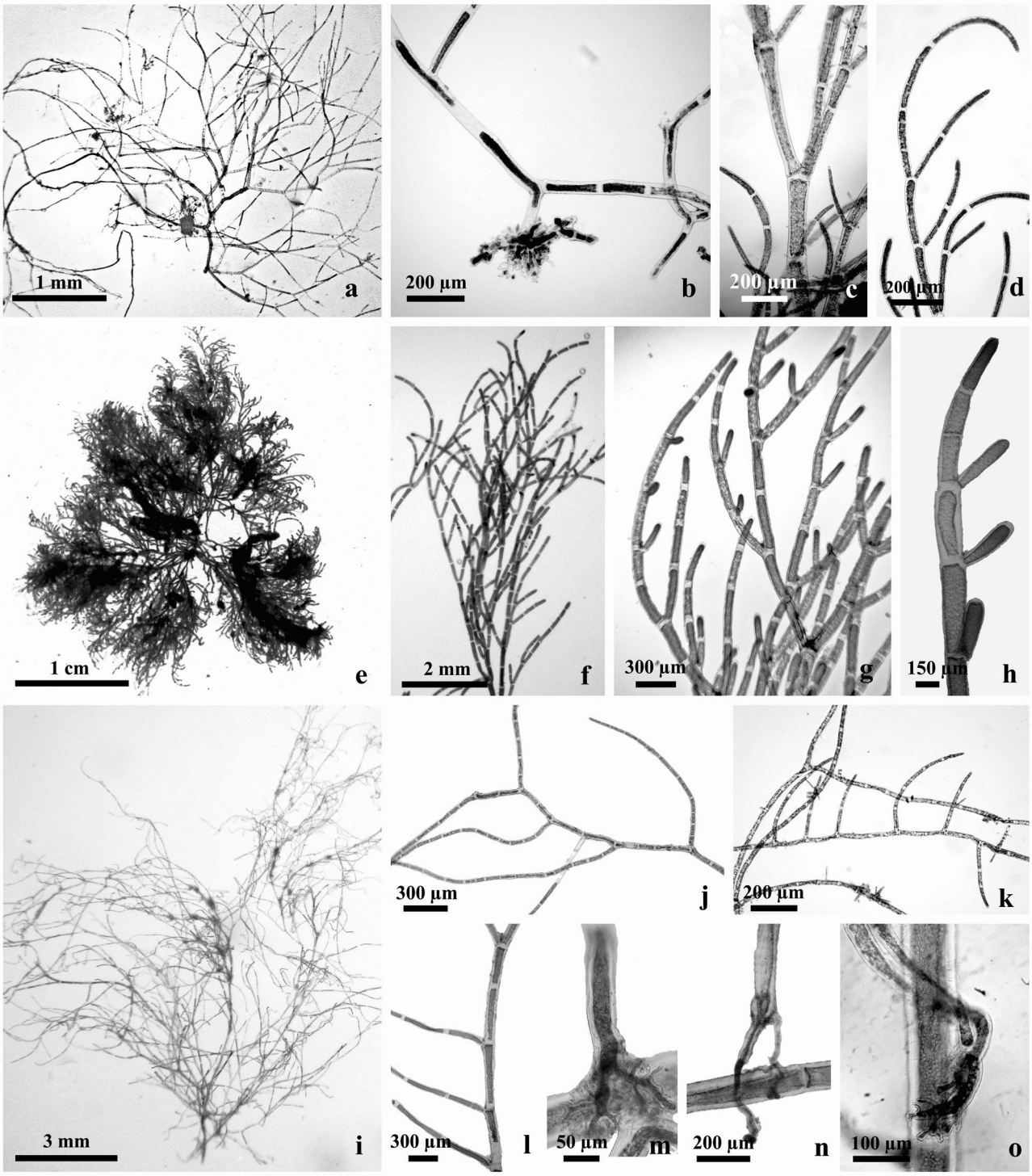

Fig. 3 A-D. *Cladophora brasiliana*. **A.** General aspect of the thallus; **B.** Detail of basal cells; **C.** Details of the main long axis cells; **D.** Terminal branch cells and apical cells with rounded to tapered tips; **E-H.** *Cladophora laetevirens*. **E.** General aspect of the thallus; **F.** Detail of pseudo-dichotomous to unilateral branching; **G.** Median region of the thallus with short unicellular branches; **H.** Detail of cells along the terminal axis; **I-O.** *Cladophora socialis*. **I.** General aspect of the thallus; **J-K.** Details of irregular to unilateral branching; **L.** Detail of cells along the main axis; **M-O.** Details of unicellular hapteroidal rhizoids originating from the lower filament cells.

Thallus light-green to brown, thin, densely entangled; filaments forming tufts without defined shapes, fixed to the substrate by unicellular lateral rhizoids and basal cell. Tapered or rounded apical cells 30-(51)-55 µm long and 25-(27)-32 µm in diameter; elongated to sub-quadratic median cells, longer than wide, 30-(45)-67 µm long and 22-(27)-36 µm in diameter; basal cells straight to curved, 30-(37)-40 µm in diameter; laminated cell wall 2-(5)-7 µm thick.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 27.II.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 15883); 03.XI.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 155884); 27.V.2010, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 170467); 22.I.2010, *C.W.N. Moura et al. s/nº* (HUEFS 170466).

This species was found in the study area growing on mangrove tree trunks or entangled with pneumatophores in association with *Bostrychia tenella*, *Rhizoclonium africanum,* and *Cladophoropis membranacea*.

The analyzed material agrees with the descriptions and illustrations provided by Taylor (1960), Kanagawa (1984), Schneider & Searles (1991), Leliaert & Boedeker (2007) and Alves *et al.* (2009).

The species is widely distributed in Todos os Santos Bay. It has been recorded at Itaparica Island, Matarandiba Island, Madre de Deus Island, Cajaíba Island, Santo Amaro, Acupe, and Saubara (Alves *et al*., 2009).

Shiphonocladales
Boodleaceae

Boodlea composita (Harv.) F.Brand, Beih. Bot. Centralbl., 18(Abt. 1): 187-190. 1904. *Conferva composita* Harv., J. Bot., 1: 157. 1834.

(Fig. 5 A-G)

Thallus light to dark green, prostrate or erect, forming small tufts composed of branched filaments; attached to substrate by branched rhizoids originating from the base of the thallus or by tenacular cells forming at any position along the thallus. Opposite or unilateral branching; lateral branches with delayed septum formation that maintains them connected to the parental cell; thallus with intensely interlaced branches anastomosed to the tenacular cells. Cylindrical main axis cells 250-(450)-1.140 µm long and 102-(190)-380 µm in diameter; apical cells with rounded or curved tips, 350-(660)-1.520 µm long and 100-(140)-220 µm in diameter; thin cell wall 2-(5)-12 µm thick. Thin, elongated, hexagonal crystals present in all thallus cells, except the tenacular cells.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 14.XII.2008, *C.W.N. Moura et al. s/nº* (HUEFS 146503); 27.II.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 146504); 27.IV.2009, C.*W.N. Moura & W.R. Almeida s/nº* (HUEFS 170474); 03.XI.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 159230); 27.V.2010, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 130387); 18.V.2011, *C.W.N. Moura et al. s/nº* (HUEFS 170388).

This species was found attached to rocky substrates and bivalve shells in the study area and was associated with the species *Caulerpa fastigiata*, *Cladophora brasiliana*, *Cladophoropsis membranacea*, *Acanthophora spicifera*, *Centroceras* sp., *Gelidiella acerosa* (Forssk.) Feldmann & Hamel, *Hypnea spinella,* and *Palisada perforata*; it was epiphytized by *Erythrotrichia carnea*.

Based on morphological variations of the thallus and the presence of long crystals in species of *Boodlea*, *Phyllodictyon* J.E.Gray, *Cladophoropsis* Børgesen, *Nereodictyon* Gerloff, and *Struveopsis* Rhyne & H.Rob., Leliaert & Coppejans (2007) considered *Boodlea composita* to be a part of the species complex *Boodlea composita-Phyllodictyon anastomosans.* These authors identified seven morphotypes (different growth forms of the same species) in this complex: *anastomosans*, *composita*, *delicatula*, *kenyensis*, *montagnei*, *siamensis,* and *struveopsis*, based on the branching pattern of the thallus, apical cell division, the types of tenacular cells responsible for the structural reinforcement of the thallus, and cellular dimensions. The material analyzed here displayed characteristics of the *siamensis* morphotype described by Leliaert & Coppejans (2007). According to these authors, several references to *Boodlea composita* in the literature [such as Taylor (1945); Egerod (1952) and Littler & Littler (2000)] correspond the *siamensis* morphotype.

The material analyzed here agrees with the descriptions and illustrations provided by Yoneshigue *et al.* (1986), and Alves *et al.* (2012b) for the Brazilian coast.

Molecular studies based on analyses of internal transcribed nrDNA spacer sequences allowed Leliaert *et al.* (2009) to demonstrate that the genera *Boodlea*, *Cladophoropsis*, *Phyllodictyon*, and *Struveopsis* were all part of the *Boodlea* complex that groups morphologically plastic species with long histories of taxonomic confusion. These authors recognized 13 phylogenetic taxa in this complex as morphologically

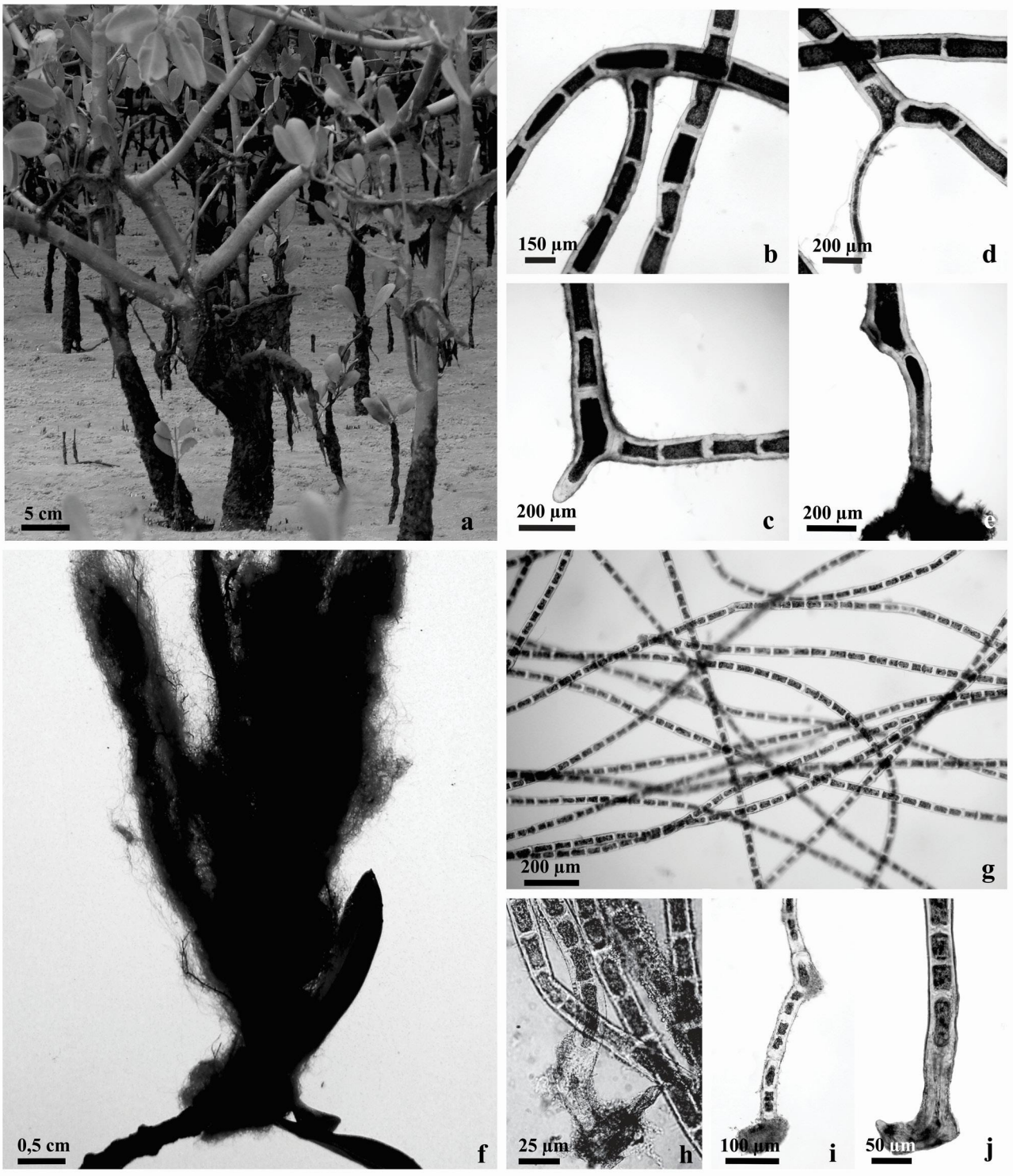

Fig. 4 A-E. *Rhizoclonium africanum*. **A.** Thalli growing on the trunks of mangrove trees; **B-C.** Detail of intercalated junctions, at 90º angles; **D.** Detail of multicellular lateral rhizoids; **E.** Detail of basal cell; **F-J.** *Rhizoclonium riparium*. **F.** General aspect of the thallus: **G.** Detail of entangled filaments; **H-J.** Details of basal cell.

identical forms distributed among the different clades, and most of the phylogenetically recognized species demonstrated a mixture of distinct morphologies. This demonstrates that most of the species included within the *Boodlea* complex are cryptic and demonstrate conflicts in their DNA sequences and, considerable intraspecific phenotypic plasticity.

Until recently, records of this taxon in Todos os Santos Bay were restricted to Itaparica Island (Alves *et al.*, 2012b).

Cladophoropsis membranacea (Bang *ex* C.Agardh) Børgesen, Overs. K. Danske Vid. Selsk. Forh., 3: 289. 1905. *Conferva membranacea* Bang *ex* C.Agardh, Syst. Alg., p. 120-121. 1824.

(Fig. 5 H-M)

Thallus light to dark green, filamentous, forms dense tufts and/or entangled mats 1,5 to 2,5 cm tall, attached to the substrate by multicellular rhizoids originating from the base of the basal cell and by tenacular cells originating at any position along the thallus. Thallus with unilateral to irregular branching to the third level; lateral branches with secondarily formed septa. Main axis cells 420-(1.382)-4.600 µm long and 100-(140)-310 µm in diameter; secondary axis cells 340-(1.410)-3.660 µm long and 80-(160)-280 µm in diameter; cylindrical, straight, or slightly curved apical cells 650-(1.620)-2.840 µm long and 100-(140)-280 µm in diameter; cell wall 2-(37)-40 µm thick. Segregative cell divisions and elongated hexagonal crystal inclusions visible in the cells.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 28.IX.2008, *C.W.N. Moura & W.R. Almeida s/n°* (HUEFS 146512); 14.XII.2008, *C.W.N. Moura et al. s/n°* (HUEFS 146516); 27.II.2009, *C.W.N. Moura & W.R. Almeida s/n°* (HUEFS 146518); 27.IV.2009, *C.W.N. Moura & W.R. Almeida s/n°* (HUEFS 170471); 21.VI.2009, *C.W.N. Moura & W.R. Almeida s/n°* (HUEFS 170477); 19.VIII.2009, *C.W.N. Moura & W.R. Almeida s/n°* (HUEFS 155828); 17.X.2009, *W.R. Almeida s/n°* (HUEFS 160511); 31.III.2010, *W.R. Almeida s/n°* (HUEFS 160512); 27.V.2010, *C.W.N. Moura & W.R. Almeida s/n°* (HUEFS 170381); 11.VII.2010, *C.W.N. Moura & W.R. Almeida s/n°* (HUEFS 170384); 11.VIII.2010, *C.W.N. Moura & W.R. Almeida s.n.* (HUEFS 170470); 22.I.2011, *C.W.N. Moura et al. s/n°* (HUEFS 170468); 18.V.2011, *C.W.N. Moura et al. s/n°* (HUEFS 170469); 03.VII.2011, *E.B.S. Neto & W.R. Almeida s/n°* (HUEFS 170390).

The species was found growing attached to rocky substrates in the study area and entangled with *Boodlea composita*, *Boodleopsis* sp., *Bryopsis hypnoides* J.V.Lamour., *Caulerpa fastigiata*, *Chaetomorpha brachygona*, *C. vieillardii*, *Dictyota* sp., *Acanthophora spicifera*, *Amphiroa fragilissima*, *Centroceras* sp., *Palisada perforata*, *Dasya* sp., *Gelidiella acerosa*, *Hypnea musciformis,* and *H. spinella*; it was epiphytized by *Erythrotrichia carnea*, *Herposiphonia* sp., and *Stylonema alsidii*.

The material studied agrees with the descriptions and drawings published by Joly (1957, 1965), Barata (2004), and Alves (2008); cell diameters and cell wall thicknesses were larger, however, in the specimens analyzed here.

Morphologically, the intermediate cell dimensions of *Cladophoropsis membranacea* often complicate its separation from *Cladophoropsis fasciculata* (Kjellm) Wille and from *Cladophoropsis macromeres* W.R.Taylor. According to Leliaert & Coppejans (2006), *Cladophoropsis fasciculata* differs from *Cladophoropsis membranacea* in having thinner filaments [apical cells (40-) 60-120 (-140) µm and basal cells (80-) 180-250 µm], whereas *Cladophoropsis macromeres* has thicker filaments [apical cells (140-) 280-360 (-400) µm, with cells along the main axis 280-510 µm].

The small needle or rod-shaped crystal inclusions seen in the material analyzed are reported here for the first time in Brazilian specimens. The elongated rectangular shapes of these crystal inclusions are consistent with the illustrations provided by Leliaert & Coppejans (2006).

Studies undertaken by Leliaert & Coppejjans (2006) and Leliaert *et al.* (2007) revealed that *Cladophoropsis* was intimately related to the genera *Boodlea*, *Phyllodictyon*, *Struveopsis*, *Struvea* Sond., and *Chamaedoris* Mont. More recently, Leliaert *et al*. (2009) working with internal transcribed nrDNA spacer sequences confirmed that this genus is part of the *Boodlea* complex, which comprises 13 phylogenetic taxa.

The taxon *Cladophoropsis membranacea* is widely distributed in Todos os Santos Bay and has been recorded on Itaparica Island, Cajaíba Island, Madre de Deus Island, Santo Amaro, Saubara, and Salinas da Margarida (Alves, 2008).

Siphonocladaceae

Dictyosphaeria versluysii Weber Bosse, Nuova Notarisia, 16: 144. 1905.

(Fig. 5 N-Q)

Thallus dark green, solid, rigid, globular to flattened, 0,3-1,2 cm long and 1,9-3,5 cm in diameter, growing isolated or in groups, attached to the

substrate by basal rhizoids. Polygonal medullary cells 540-(970)-1.560 µm in diameter joined by rounded tenacular cells with dilated and crenulated extremities, bi- or trifurcated. Simple, straight, spiniform projections growing from the cell walls toward the middle of the cell. Crystal inclusions and reproductive structures not observed.

Material examined: BRAZIL, BAHIA, São Francisco do Conde, Bimbarras Island, 14.XII.2008, *C.W.N. Moura et al. s/nº* (HUEFS 146502); 17.X.2009, *W.R. Almeida s/nº* (HUEFS 159225); 03.XI.2009, *C.W.N. Moura & W.R. Almeida s/nº* (HUEFS 159224); 03.VII.2011, *E.B.S. Neto & W.R. Almeida s/nº* (HUEFS 170392).

Dictyosphaeria versluysii was found to form small, sparse populations in the study area that grew

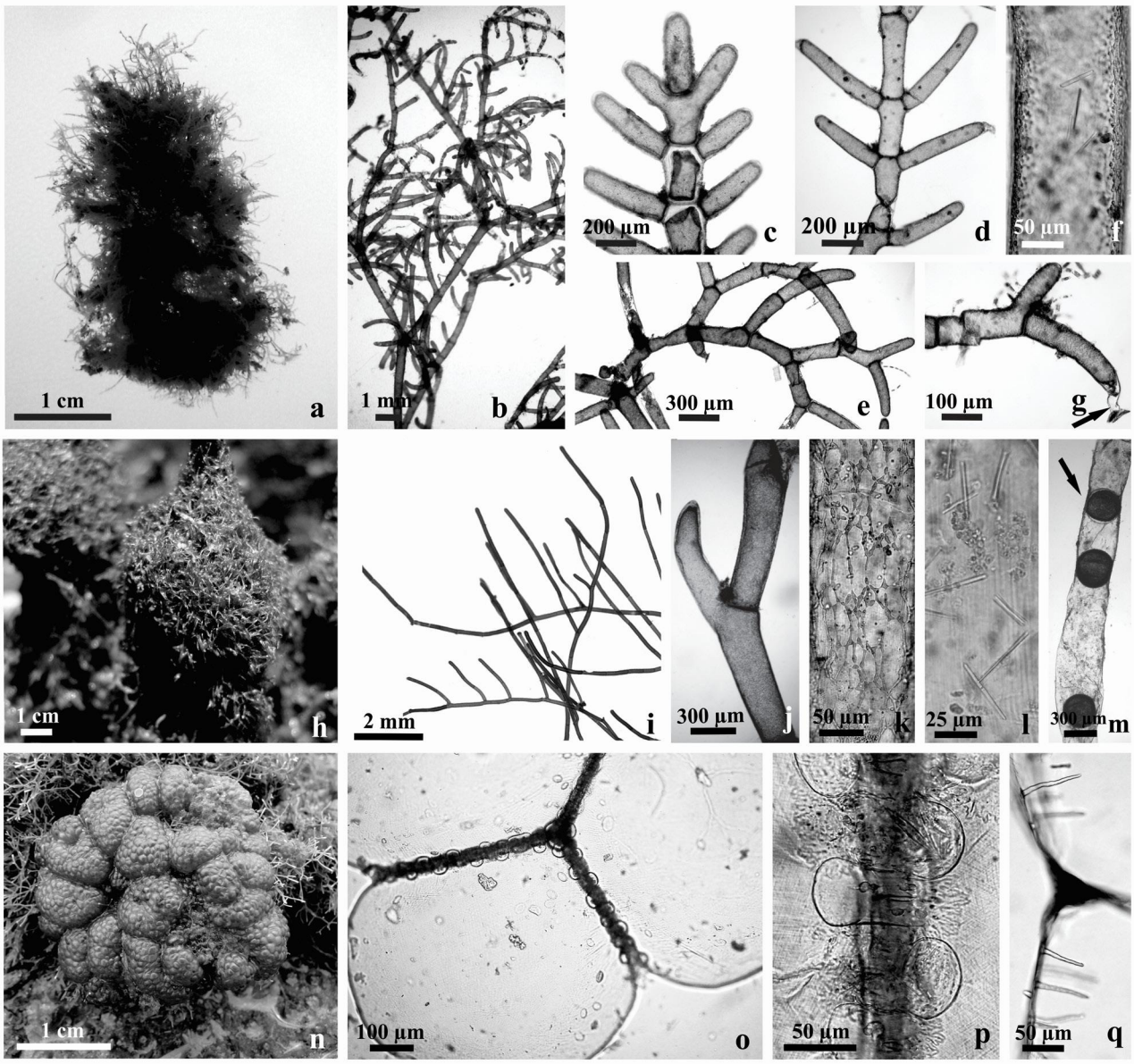

Fig. 5 A-G. *Boodlea composita*. **A.** General aspect of the thallus; **B.** Detail of branching; **C.** Apical cell with a rounded tip; **D.** Opposed branching; **E.** Unilateral branching; **F.** Elongated hexagonal crystals; **G**. Detail of tenacular cell (arrow); **H-M.** *Cladophoropsis membranacea*. **H**. General aspect of thalli growing on mangrove prop roots; **I.** Details of irregular to unilateral branching; **J.** Detail of lateral branch with secondarily formed septa; **K.** Detail of reticulate chloroplast with pyrenoids; **L.** Elongated hexagonal crystal inclusions; **M.** Segregative cell division (arrow); **N-Q.** *Dictyosphaeria versluysii*. **N.** General aspect of the thallus; **O.** Polygonal medullary cells; **P.** Detail of rounded tenacular cells; **Q.** Detail of spiniform projections.

on the edges of small sandstone pools along the beach front; it was epiphytized by *Caulerpa fastigiata*. The material analyzed agrees with the descriptions and illustrations published by Kanagawa (1984), Barata (2004), and Alves (2008) for specimens collected in the states of Paraíba, Espírito Santo, and Bahia respectively.

Two species of *Dictyosphaeria* Decne. have been reported for the Brazilian and Bahian coasts: *Dictyosphaeria cavernosa* (Forssk.) Børgesen and *Dictyosphaeria versluysii*. Although they have generally similar thalli morphologies, they can be differentiated by their internal anatomies. *Dictyosphaeria cavernosa* has a hollow thallus with a single layer of cells derived from the earliest stages of development, whereas *D. versluysii* has a solid, rigid thallus composed of several cell layers.

Dictyosphaeria versluysii differs from *Dictyosphaeria intermedia* Weber Bosse (which has a solid or rudimentary hollow thallus) in that the latter has a loose cellular organization and lacks spiniform projections in the cells (Kraft, 2007).

This species was previously recorded on the Islands Maré (Marins *et al.*, 2008), Itaparica, and dos Frades (Alves, 2008; Marins *et al*., 2008) in Todos os Santos Bay.

The present study was recorded 12 taxa. *Cladophorales* was represented by the single family, *Cladophoraceae*, while *Siphonocadales* was represented by two families, *Boodleaceae* and *Siphonocladaceae*. *Cladophoraceae* was the best represented family, with nine taxa (four of which belong to the genus *Chaetomorpha*). *Boodleaceae* was represented by *Boodlea composita* and *Cladophoropsis membranacea*, while the *Siphonocladaceae* family was represented by *Dictyosphaeria versluysii*. This study expanded the known geographic distribution of *Cladophora socialis* to the South American Atlantic Ocean, and *Chaetomorpha ligustica* was recorded for the first time on the coast of Bahia. *Cladophora laetevirens* was recorded here for the second time on the coast of northeastern Brazil.

Comparisons of the data obtained in the present study of the BTS with that available in the literature showed that Bimbarras Island had a great diversity of representatives of *Cladophorales* and *Siphonocladales*, although Itaparica Island had approximate 30 taxa representative of those orders (Marins *et al.*, 2008; Alves 2008; Alves *et al.*, 2009; Santos, 2010). In addition to Bimbarras, and Itaparica islands, taxa of *Cladophorales* and *Siphonocladales* occurred in other areas of the BTS, such as the Frades, Maré, Madre de Deus, Matarandiba, and Salvador (Humaitá Beach) islands, as well as at Saubara, São Francisco do Conde, and Salinas da Margarida, although less frequently, and restricted to the species *Chaetomorpha brachygona*, *C. vieillardii*, *Cladophora vagabunda*, *Cladophoropsis membranacea*, *Dictyosphaeria versluysii, Rhizoclonium africanum*, *R. riparium*, and *Valonia ventricosa* J.Agardh (Alves, 2008; Marins *et al*., 2008; Alves *et al*., 2009).

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