Taxonomic study of two species of *Sargassum*: *Sargassum fluitans* (Børgesen) Børgesen and *Sargassum natans* (Linnaneus) Gaillon (brown algae) collected in Côte d'Ivoire coasts, West Africa.

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Abstract: Seaweeds, new for the coastal area of Côte d'Ivoire. The authors describe two seaweeds that have not been collected previously from Côte d'Ivoire coasts: the Phaeophyceae *Sargassum fluitans* and *Sargassum natans*. Ecological data are added to the morphological description.
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1. Introduction

The widespread tropical to temperate marine algal genus *Sargassum* Agardh (Fucales, Phaeophyceae) is one of the most taxonomically difficult and species-rich genera in the brown algae, accounting for 336 currently recognized species (Guiry and Guiry, 2014).

Sargassum Agardh is a taxonomically difficult genus distributed worldwide and reported as the most species-rich genus of the Fucales. When on land, *Sargassum* creates complicated problems for residents along the shoreline. In 2011, *Sargassum fluitans* was added to the Global Invasive Species Database (ISSG, 2011). During June 2011, pelagic *Sargassum* began washing ashore along Gulf of guinea West African and Brazilian coastlines in unprecedented quantities. Tourist beaches were covered by more than a meter of seaweed. Economic impacts of this Atlantic basin-scale inundation event drew international media attention (Higgins, 2011).

Significant works on the taxonomy and ecology of genus *Sargassum* have been carried out in many countries like: Africa sub-region (John *et al*., 2003); U. S. A (Dawes and Mathieson, 2008); French Polynesia (Mattio *et al*., 2008); New Caledonia (Mattio and Payri 2009). In Cote d'Ivoire, there have been few studies on macroalgues taxonomy, species composition and distribution including the Phaeophyceae genus *Sargassum* Agardh, (Lawson and John, 1987; John *et al*., 2001; John *et al*., 2003). According to John *et al.,* 2003, three species were previously reported in marine waters of Côte d'Ivoire namely *Sargassum cymosum, Sargassum filipendula* and *Sargassum vulgare* var. *foliosissimum.*

Unfortunately no thorough systematic studies have been carried out along the Cote d'Ivoire seaboard. Taking into account the above lack of information, the following work was carried out on the Atlantic

Ocean. The main objective of this study is to provide a taxonomic and floristic account of species from genus *sargassum* occurring in the Atlantic Ocean. Detailed morphological descriptions and illustrations are provided, as well as an identification key.

2. Materials and Methods

Specimens examined were collected from nine stations in sea water during the two visits, 4 May 2016 and 12 -17 June 2016 along the Côte d'Ivoire coastline (Figure 1). The collected samples were examined for identification and laboratory analyses were carried out to determine nutritional and mineral constituents. Specimens fixed in 10% formalin/seawater were used for microscopic observations. The identification and distribution of the species were based on the research done by Lawson and John (1987); John *et al*. (2001); Moreira and Suárez (2002) ; John *et al.* (2003); Dawes and Mathieson (2008); Széchy *et al*. (2012); Guiry and Guiry (2013); Oxenford (2015); Oyesiku and Egunyomi (2015); Schell *et al.* (2015).

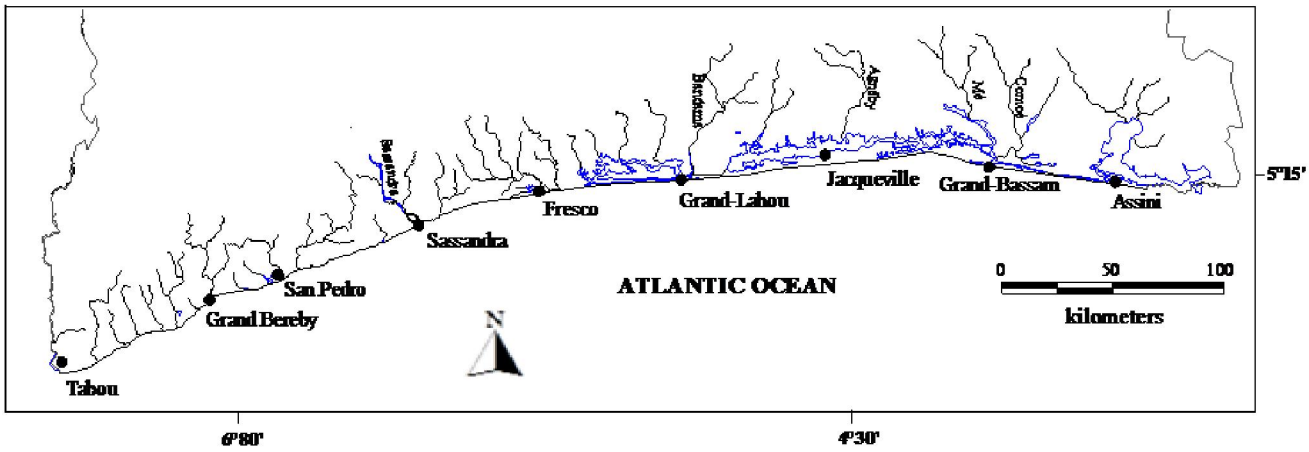


Figure 1: Map of the study area, showing the sampling stations along the coast of Côte d'Ivoire, 4 May 2016 to 14-17 June 2016.

Table 1. Sampling sites in Côte d'Ivoire coastline, 4 May 2016 to 14-17 June 2016.

Stations	Location	Geographic coordinates
St1	Asinine	5°06 N, 3°55 W
St2	Grand-Bassam	5°11 N, 3°45W
St3	Jacqueville	5°14 N, 4°25 W
St4	Grand-Lahou	5°08 N, 5°00W
St5	Fresco	5°04 N, 5° 34W
St6	Sassandra	4°57 N, 6°04W
St7	San Pedro	4°45 N, 6°36W
St8	Grand Bereby	4°39 N, 6°55W
St9	Tabou	4°24 N, 7°31W

3. Results

The pH values varied between 7.24 and 8.73; surface temperature varied between 27.2 and 27.96 °C and the conductivity between 3747 µS Cm^{-1} and 43, 76 mS cm^{-1}. The surface salinity varied between 1, 97 and 28, 14 psu. Nitrates and phosphates values varied from 25, 49 to 52, 89 mg L^{-1} and from 5.28 mg L^{-1} to 10, 20 mg L^{-1}, respectively.

Genus *Sargassum* Agardh

The key was built based on rigorous morphological examination of newly collected samples, of specimens.

1a. Plants floating, without holdfast; cryptostomata and receptacles absent 2

1b. Plants attached by a solid or a rhizomatous holdfast; cryptostomata and receptacles present 3

2a. Leaves linear, 1-4 mm wide; vesicles with an apical spine-like projection or a reduced leaf..... *Sargassum natans*

2b. Leaves lanceolate, 3-8 mm wide; vesicles usually smooth *Sargassum fluitans*

Description of the species

Class: Phaeophyceae

Order: Fucales

Family: Sargassaceae

Genus: *Sargassum*

***Sargassum fluitans* (Børgesen) Børgesen**

Taylor, 1960; Schneider and Searles, 1991; Littler and Littler, 2000; Dawes and Mathieson, 2008; Oyesiku and Egunyomi, 2015.

Morphology: pelagic Plants (Figure 2), without a holdfast or a distinct main axis. Branches smooth or with few spiny projections, terete or sometimes compressed, 1-1.8 mm diam., ramified several times. Leaves simple, flat, lanceolate or linear (Figure 5A), 20-50 (60) mm long and 3-8 mm wide; serrate margins (Figure 5A), symmetrical or asymmetrical bases, acute apices and per current midrib. Vesicles 10-55 per short branch; elliptical or spherical, reaching up to 6 mm long and 5 mm diam., usually smooth (Figure 5A); stipe of vesicles up to 8 mm long, terete (no spines) or compressed. Cryptostomata and receptacles not observed.

Distribution: Colombia: San Andres and Providence Islands. Western Atlantic: Massachusetts, North Carolina, Bermuda, Gulf of Mexico (Mexico, Texas, Louisiana, Mississippi, Alabama, Florida), Florida, Bahamas, Greater Antilles (Cuba, Hispaniola, Jamaica), Lesser Antilles (Virgin Islands, Guadeloupe), Western Caribbean (British Honduras, Costa Rica, Mexico), and Southern Caribbean (Panama) and Africa sub-region (Benin, Cameroun, Côte d'Ivoire, Gabon, Gambia, Ghana, Liberia, Nigeria, São Tomé Príncipe, Senegal, Sierra Leone and Togo). Habitat. Pelagic.

***Sargassum natans* (Linnaneus) Gaillon**

Taylor, 1960; Schneider and Searles, 1991; Littler and Littler, 2000; Dawes and Mathieson, 2008; Oyesiku and Egunyomi, 2015.

Morphology: Thallus up to 25 cm long, erect, widely branching, tangled, pelagic, without a dominant axis. Annual branches up to 20 cm long with smooth axis, linear, apex acute or obtuse, margins serrate, 1-4 cm long, 1-3 mm wide. Cryptostomata scattered. Vesicles subspherical to elliptical, 2-5 mm long, 1-3 mm broad, stalked, stalk up to 5 mm long, typically mucronate, tipped with a long spine. Cryptostomata and receptacles not observed (Figure, 5B).

Distribution: Colombia: Bolivar (Cartagena), San Andres and Providence Islands. Western Atlantic: Canada (Newfoundland), Massachusetts, North Carolina, Bermuda, Gulf of Mexico (Mexico, Texas, Louisiana, Alabama), Florida, Bahamas, Caicos Is., Greater Antilles (Cuba, Hispaniola, Jamaica), Lesser Antilles (Guadeloupe, Barbados, Granada), Western Caribbean (British Honduras), Southern Caribbean (Colombia, Panama), Brazil and Africa sub-region (Benin, Cameroun, Côte d'Ivoire, Gabon, Gambia, Ghana, Liberia, Nigeria, São Tomé Príncipe, Senegal, Sierra Leone and Togo). Habitat. Pelagic.

Figure 2: *Sargassum* mass *(Sargassum natans and S. fluitans)* found at Asinine beach, Atlantic Ocean, Côte d'Ivoire, 4 May 2016 to 14-17 June 2016.

Figure 3: Gas bladders (pneumatocysts) of *Sargassum fluitans,* spines absent

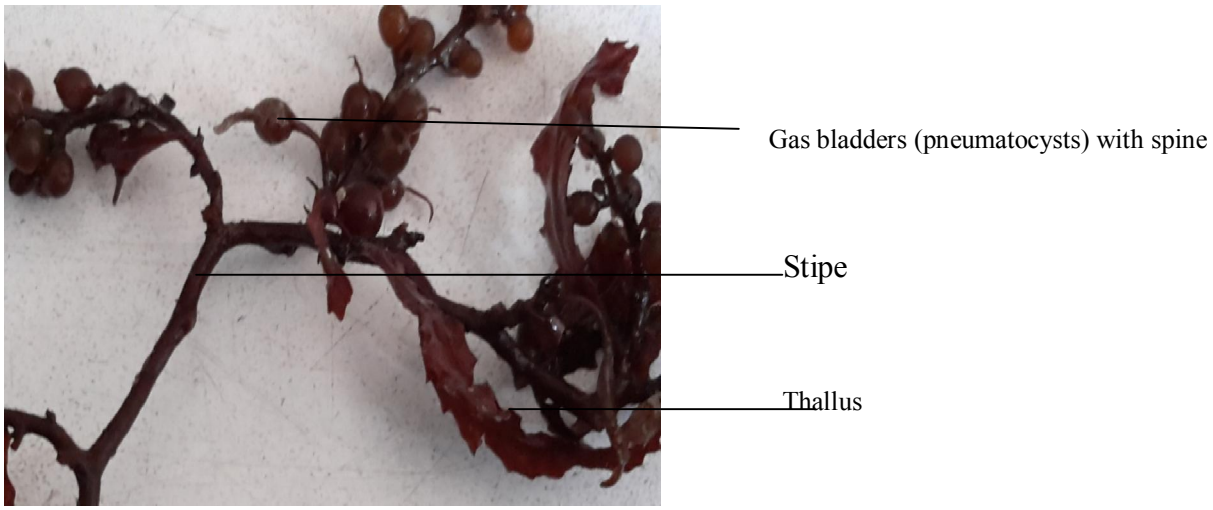
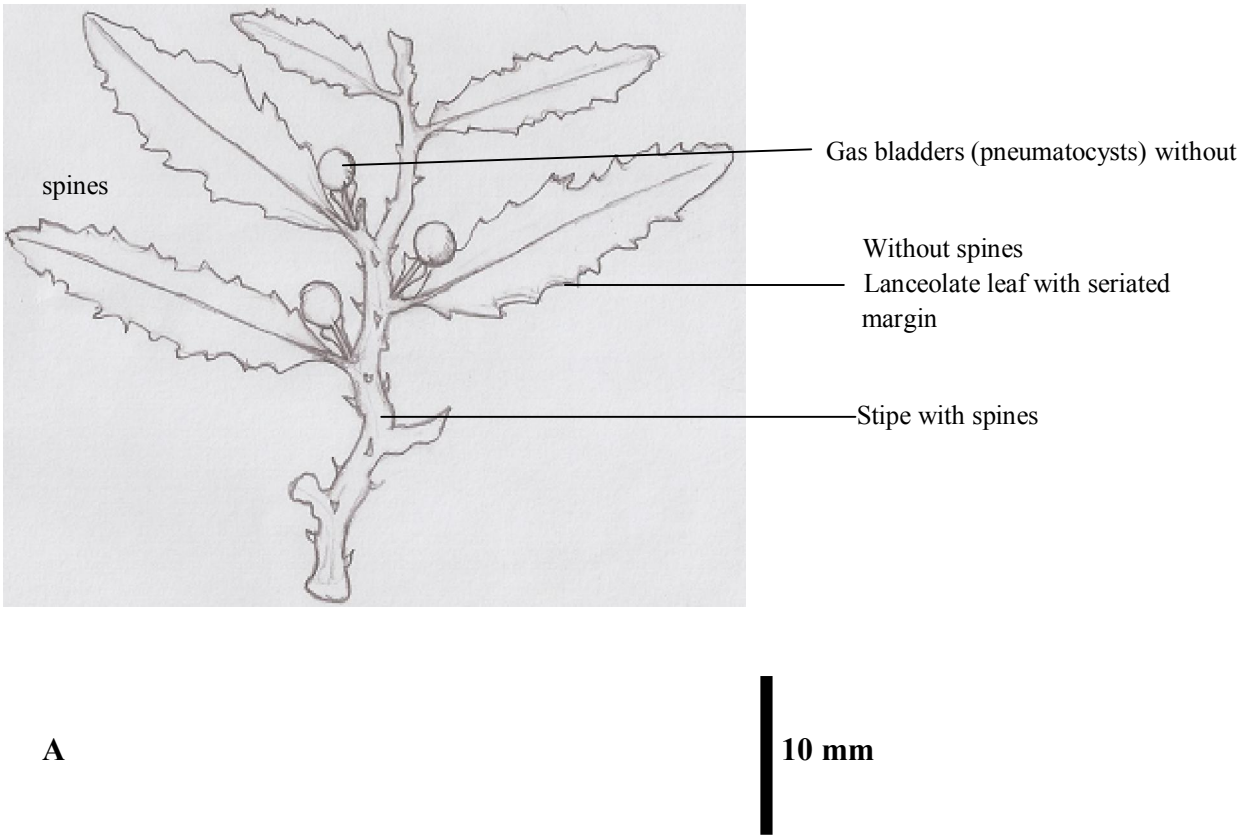
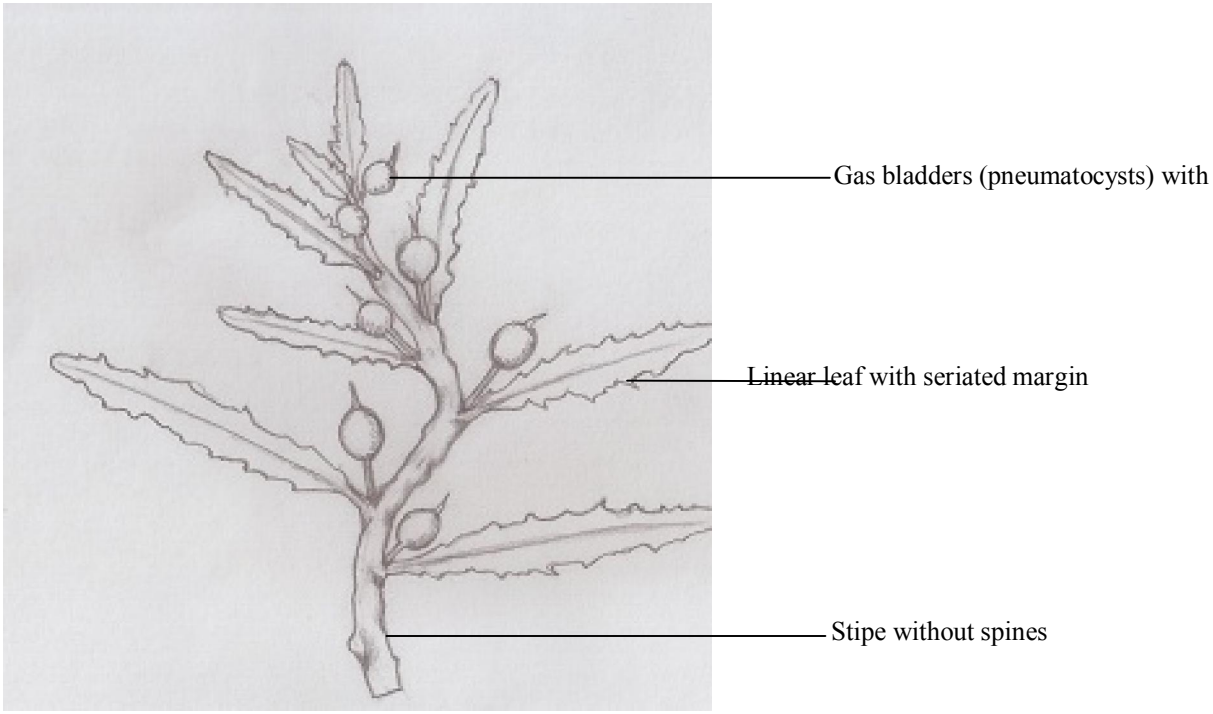


Figure 4: Gas bladders (pneumatocysts) of *Sargassum natans*, spines present





B

Figure 5: Characteristics of two pelagic *Sargassum* (A: *Sargassum fluitans* showing floats without spines; B: *Sargassum natans* showing floats with spines)

4. Discussion

The two species of the genus *Sargassum* that dominate the floating algal communities of the Sargasso Sea are *S. fluitans* (Boergesen) Boergesen, and *S. natans* (Linnaeus) Gaillon. *Sargassum fluitans* and *S. natans* are taxonomically valid species (Guiry and Guiry, 2011), and both occur in the western Atlantic Ocean (Wynne 2011). These species are similar in the following characteristics: their populations reproduce by vegetative fragmentation and both species float freely on the sea.

Sargassum species can be identified by their lateral, branch-like morphology. One or two leaf-like structures form at the base of the organism. The thallus and branch structure of the algae grows from this organ (or 1 of them, if 2 are present) (Fritsch, 1965). The thallus and blades are generally brown, yellow or gold in color. *Sargassum fluitans* and *Sargassum natans* are marked by tiny, circular bladders (pneumatocysts) that are filled with gas (Conti 2008, Rogers 2011). These bladders keep them afloat allowing their blades to photosynthesize. *Sargassum fluitans* can be distinguished from *Sargassum natans* by the presence of winged tissue around the bladder stalk and the lack of spines on bladders (Conti 2008, Shapiro 2004). The 2 species are highly difficult to distinguish from one another once they have arrived on the shoreline (Shapiro 2004).

Vegetative Propagation Free-floating species of *Sargassum*, which include *Sargassum fluitans* and *Sargassum natans*, reproduce asexually by fragmentation (Awasthi, 2005; Rogers, 2011). Fragmentation occurs when parts of the thallus grow old, decay and separate from the younger parts. Fragmentation can also occur via physical injury to any part of the plant. Younger parts of the plant then break off and mature into fully-formed organisms. Neither asexual reproduction via spores nor sexual reproductions via seeds are methods of multiplication employed by *Sargassum fluitans* and *Sargassum natans* (Rogers 2011, Weis 1968). Viability *Sargassum fluitans* and *Sargassum natans*, like the majority of their pelagic algae counterparts, require a

variety of physical and chemical properties in their environment to survive. These include: the circulation of water for continual exposure to nutrients and waste removal, a growth medium consisting of a dynamic system of water, organic components, dissolved gases and dissolved salts and access to light (Fritsch, 1965; Round, 1981).

According to some authors, these species come from the small sea of *Sargassum* located the side of Brazil. The presence of species in the Gulf of Guinea is due to the fact of sea currents (North Equatorial Current, North Equatorial Counter current, Canary Current and Guinea current). Indeed, strong currents occasioned by several storms in May or June bump into the edges of the Sargasso Sea breaking off segments of the ecosystem (Grower and King, 2008). In the process, the sea currents and winds carry the *Sargassum* fragments along, eventually sweeping it into countries of West African coastal regions of countries (Colombini and Chelazzi, 2003). *Sargassum*, being highly tolerant of variations in environmental parameters like desiccation, sunlight, salinity and temperature occupies a broad range of habitats (Abbott and Dawson, 1978).

5. Conclusion

Sargassum natans and *sargassum fluitans* are reported for the first time in the Côte d'Ivoire coastal marine waters and on the beaches. Since 2011, *Sargasum* species have been reported on the Ivorian coast and from day to day, *Sargassum* pose serious problems for the whole community, both for fishermen, tourists and local residents from beaches. Studies showed occurrence of two species *S. natans and S. fluitans* and those results are important for future researches such as nutritional, mineral values, etc. Thus, faced with an environment favorable to the proliferation of those aquatic plants, it would be interesting to think about their valuation to control them.

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