

NEW RECORDS OF SARGASSUM SPECIES (SARGASSACEAE, PHAEOPHYTA) FROM THE PERSIAN GULF AND OMAN SEA IN IRAN

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The genus *Sargassum* C. Agardh (Sargassaceae, Fucales), despite considerable research efforts, is still one of the most systematically complex and problematic genera of Phaeophyta. The marine algal flora of Iran received little attention than other marine water bodies. This paper describe 7 species as *Sargassum* new records along the Iranian coasts including *Sargassum baccularia* (Mertens) C. A. Agardh, *S. binderi* Sonder, *S. gemmiphorum* Tseng et Lu, *S. longifructum* Tseng et Lu, *S. henslowianum* C. Agardh, *S. boveanum* J. Agardh var. *atterrimum* Grunow and *S. spinuligerum* Sonder. The more consistent morphological characters for each species were recognized and these characters include: Holdfast shape, length/width leaves, leaves margin and apex, vesicles and receptacles shape. The most common species were *S. spinuligerum*, *S. baccularia*, *S. henslowianum* and *S. longifructum* distributed widely in Sistan va Baluchestan province and *S. binderi*, *S. boveanum* var *atterrimum* restricted to Bandar Lengeh and Bushehr province, respectively.

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گزارش‌های جدید گونه‌های سارگاسوم (سارگاسه- فتوفایتها) از سواحل خلیج فارس و دریای عمان در ایران

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جنس *Sargassum* C. Agardh متعلق به جلبک‌های قهوه‌ای بوده که علیرغم مطالعات متعدد، یکی از مهمترین جنس‌های پیچیده از نظر سیستماتیک محسوب می‌شود. فلور جلبک‌های ایران نسبت به سایر آبزیان کمتر مورد بررسی قرار گرفته است. در این مقاله، 7 گزارش جدید گونه‌های سارگاسوم شامل *S. baccularia* (Mertens) C. A. Agardh, *S. binderi* Sonder, *S. gemmiphorum* Tseng et Lu, *S. longifructum* Tseng et Lu, *S. henslowianum* C. Agardh, *S. boveanum* J. Agardh var. *atterrimum* Grunow, *S. spinuligerum* Sonder گزارش شده است که صفات مهم در شناسایی این گونه‌ها شامل، شکل هولدفست، طول و عرض و حاشیه و راس برگ‌ها، شکل وزیکول‌ها و رسپتاکل‌ها می‌باشند. بیشترین گونه‌ها در استان سیستان و بلوچستان شامل *S. longifructum*, *S. spinuligerum*, *S. baccularia*, *S. henslowianum* و کمترین گونه‌ها شامل *S. binderi*, *S. boveanum* var *atterrimum* در بندر لنگه و بوشهر پراکنش داشتند.

INTRODUCTION

Sargassum C. Agardh (*Sargassaceae*) is a very large brown seaweed genus including nearly 500 species. It is an ecologically dominant genus in shallow waters throughout subtropics and tropics of both hemispheres, especially in the Indo-west Pacific region and Australia (Nizamuddin & Gessner 1970; Tseng & al. 1985; Yoshida 1988). Iran is a temperate country in Asia with a coastline of approximately 1260 kilometers along the Persian Gulf and Oman Sea. There have been some systematic studies about *Sargassum* in the Persian Gulf and Oman Sea. Previous phycological studies in Persian Gulf were compiled by Endlicher and Diesing (1845), Børgessen (1939), Nizamuddin & Gessner (1970) and Basson (1992), and more ecologically oriented research was conducted by Sheppard & al. (1992). In addition, Sohrabipour and Rabii (1999) have identified 6 *Sargassum* species in this area, while Gharanjik (2005) reported five *Sargassum* species in Sistan va Baluchestan coasts (Oman sea) in southeast of Iran. Recently, Shams & al. (2013) reported 19 *Sargassum* species in Persian Gulf and Oman Sea. In the south of Iran, *Sargassum* species with more than 40 tons annual biomass production have been considered as economically important phaeophyta. *Sargassum* spp. is a potential source of alginate, which used as food (soup and salad), liquid fertilizer and animal feed sand for the control of heavy metal pollution, grain crops enhances their production, as source of vitamins. *Sargassum* spp. are sources for many metabolites such as alginic acid, alginates, sulfated fucoidans, pigments, oils, sterols and mannitols (Wong & al. 2004). In addition, fucoidans from *Sargassum* were discovered to have antitumor (Yamamoto & al. 1984) and cytotoxic activities (Stevan 2001). Members of the genus *Sargassum* exhibit a high degree of age-dependent morphological variations (Ang & Trono 1987; Kilar & al. 1992). In general, there is limited information about *Sargassum* populations and the studies performed mainly concern the identification of species by using morphological characters. This paper describe 7 species as *Sargassum* new records along Persian Gulf and Oman Sea coast of Iran including of *Sargassum baccularia* (Mertens) C. A. Agardh, *S. binderi* Sonder, *S. gemmiphorum* Tseng et Lu, *S. longifructum* Tseng et Lu, *S. henslowianum* C. Agardh, *S. boveanum* J. Agardh var. *aterrimum* Grunow and *S. spinuligerum* Sonder.

MATERIAL AND METHODS

The specimens were collected from 15 stations along the Persian Gulf and Oman Sea including: Sistan va Baluchestan province; Bandar Lengeh area; Qeshm Island, Hormoz Island, Bushehr province (Fig. 1) from November 2010 to July 2012 (especially in winter and

autumn). Whole thalli (usually with holdfast) were collected on reef flats at low tide or by SCUBA from a variety of habitats to 4 m depth. At each site, 20 individuals were selected randomly with a minimum distance of at least 3 m. *Sargassum* specimens were kept in separate plastic bags from each site without seawater and transported to the laboratory on ice (Lobban et al., 1988; APHA 2005). All of the species collected during this study belonged to subgenus *Sargassum*. According to available identification keys and taxonomic references, we examined the morphological features (aspect of holdfasts, axes, leaves, vesicles and receptacles) of samples. The morphological characters used for analysis were thallus length, stem, primary and secondary branch, leaf length, width, shape in apex and base, vesicle length, width, pedicle and receptacle shape and length. Some of the collected samples were fixed in %4 formaldehyde, and the reminder was dried on herbarium sheets. Important parts of the thallus were drawn, and sections of receptacles were prepared and stained with %1 aniline blue. Identification of samples were based on the following taxonomic references: C. A. Agardh (1820); J. G. Agardh (1848, 1889); Grunow (1915); Setchell (1935); Børgessen (1939); Tseng (1983, 1985, 2000); Yoshida (1988, 2004, 2005); Basson (1992); Tseng & Lu (1992); Noro & al. (1994); De Clerck & Coppejans (1996); Ajisaka & al. (1999), Noiraksar & al. (2006); Noiraksar & Ajisaka (2008), Abdel-Kareem (2009). Specimens were studied using a Stemi 2000-C Zeiss stereomicroscope and photographed with a Canon Power shot G6 camera. In addition, in this study, the species were checked with available specimens of Belgium, Mexico, Australia, Indian Ocean and Japan in Ghent herbarium. Iranian *Sargassum* species are deposited at the Herbarium of the University of Isfahan (HUI).

RESULTS

All of the *Sargassum* species commonly grow on rocks and dead corals in littoral and sub-littoral sites. *Sargassum* species were made from different sites along the Persian Gulf coast, identified as presented in the literatures, checked for synonymy-accepted names with www.algaebase.org site, referred to its systematic groups. *Sargassum* density is much higher in Sistan va Baluchestan and Hormozgan provinces than the other sites. An identification key to the *Sargassum* species of Iran is presented here.

The identification key for the new records of the Iranian *Sargassum* species

- 1- Thalli with rhizoidal to discoid holdfast, primary branches warty 1. *S. spinuligerum*
- Thalli with discoid to conical holdfast, primary



Fig. 1. Study area and localities of collection for *Sargassum* along the Persian Gulf and Oman Sea seashore of Iran. Sistan va Baluchestan province (61° 30' N, 25° 14' E); Bandar Lengeh (54° 52' N, 26° 32' E); Qeshm Island (55° 23' N, 26° 34' E); Hormoz Island (56° 29' N, 27° 22' E); Bushehr province (50° 44' N, 28° 55' E).

- branches smooth and without spines 2
 2- Receptacles triquetrous, verrucose sometimes twisted 3
 Receptacles simple and cylindrical 4
 Receptacles less than 2 cm long 2. *S. baccularia*
 Receptacles more than 2 cm long 3. *S. longifeructum*
 Basal leaves simple or divided, larger than of upper leaves, warty stem 4. *S. gemmiphorum*
 Basal leaves simple or divided, larger than of upper leaves, smooth stem 5
 Vesicles spherical to ellipsoidal, rounded at apex, simple and cylindrical stalk, vesicle surface bearing cryptostomata 5. *S. henslowianum*
 Vesicles spherical, entire, sometimes mucronate the apex, stalk terete and cylindrical, vesicle surface lacking of cryptostomata 6
 Vesicles pointed, often crowned with mucronate at the apices, flattened stalk, receptacles flattened, often twisted 6. *S. binderi*
 Vesicles spindle-shaped, bearing of leaflet, mucronate pointed, terete, cylindrical stalk, receptacles cylindrical, not twisted
 . 7. *S. boveanum* var *aterrimum*

Description of the species

Order: **Fucales**

Class: **Phaeophyceae**

Family: **Sargassaceae**

Genus: ***Sargassum***

**Sargassum baccularia* (Mertens) C. A. Agardh

C. A. Agardh (1820); Setchell (1935); Tseng & Lu (1992); Ajisaka & al. (1999); Gavino & Trono (1999), Noiraksar & al. (2006); Noiraksar & Ajisaka (2008).

Fucus baccularia Mertens Basionym:

Heterotypic synonyms : *Fucus baccularia* Mertens

Holdfast discoid, up to 15 mm in diameter. Stem terete, warty, up to 2.5 mm in diameter and 1 cm long. Primary branches terete, smooth, up to 100 cm long and 1.5 mm in diameter; leaves large, lanceolate, simple, with asymmetrical bases, up to 4 cm long and 1 cm wide, with rounded to acute apices, margins dentate with small teeth, midribs distinct near apices, cryptostomata small and scattered in rows on both sides of the midrib. Secondary branches spirally arranged, terete, smooth, up to 30 cm long. Leaves lanceolate to linear, simple with asymmetrical bases, up to 4 cm long and 1 cm wide, with rounded apices, margins dentate with small teeth. Vesicles spherical, sometimes elliptical, up to 40 mm long, to 3 mm wide, entire at the apices, sometimes mucronate, stalks terete, usually shorter than the vesicles (Fig. 2). Plants dioecious. Male receptacles long, terete, up to 1 cm long and 2 mm wide, with smooth surface, simple to once to twice furcate. Female receptacles triquetrous, up to 10 mm long and 2 mm wide, with a warty surface, sometimes bearing spines near the apex, simple to furcate. Female and male receptacles arranged in a raceme, pseudozygocarpic, vesiculate.

Habitat: Reef flats and subtidal zone.

Ecology: This species usually grows in the lower

portions of the intertidal zone on rocky substrates or shallow subtidal zones. It has been found only in Sistan va Baluchestan province (Chabahar, Passabandar, Gowatr).

****Sargassum binderi* Sonder**

J. G. Agardh (1848, 1889), Setchell (1935); Yoshida (1988); Tseng & Lu (1992); Ajisaka & al. (1999); Gavino & Trono (1999), Noiraksar & al. (2006); Noiraksar & Ajisaka (2008).

Holdfast discoid, up to 10 mm in diameter. Stem terete, smooth or warty, up to 2.5 mm in diameter and 1 cm long. Primary branches flattened to compressed, smooth, up to 40 cm long and 3 mm in diameter; leaves large, lanceolate, simple, with asymmetrical bases, up to 5.5 cm long and 1.5 cm wide, with rounded to acute apices, margins entire to dentate with small teeth, midribs distinct near apices or vanishing midway, small cryptostomata and scattered to in rows on both sides of the midrib. Secondary branches spirally arranged, compressed, smooth, up to 40 cm long. Leaves lanceolate to linear, simple with asymmetrical bases, up to 5.5 cm long and 1.5 cm wide, with rounded apices, margins dentate with sharp teeth. Vesicles spherical, sometimes elliptical, up to 20 mm long, to 4 mm wide, often mucronate at the apices, sometimes entire, stalks flattened, usually longer than the vesicles (Fig. 3).

Plants monoecious. Receptacles androgynous, flattened, often twisted, up to 1.6 cm long and 2 mm wide, sharply dentate at the margin, simple to once to twice furcate. Receptacles arranged racemosely and acantho-zygocarpic.

Habitat: Coral flats and subtidal zone.

Ecology: This species grows in the lower portions of the intertidal zone on rock substrates or shallow subtidal zones. It has been found only in Hormoz and Qeshm Islands and Bandar Lengeh area.

****Sargassum boveanum* J. Agardh var. *aterrimum* Grunow**

J. G. Agardh (1848, 1889); Børgesen (1939); Basson (1992); De Clerck & Coppejans (1996).

Thallus up to 25 cm long, erect, attached to the substratum by a small perennial holdfast, up to 5 mm in diameter. Branching of the main axis, alternating. Side branchlets alternate or opposite, may obscuring the axis of the branch. Leaves lanceolate to linear, simple with asymmetrical bases, up to 5-12 mm long and 0.3-0.5 mm wide, thin, with rounded apices, margins entire, midribs distinct near apices, cryptostomata small and scattered on both sides of the midrib. Vesicles subspherical up to 2 mm wide and 2-4 mm long, some with terminal mucronate up to 4 mm long, stalks terete, usually to 2 mm long (Fig. 4). Receptacles in axillary

clusters, simple, cylindrical, 2-3 mm long and zygocarpic.

Habitat: Reef flats and subtidal zone.

Ecology: This species grows in the lower portions of the intertidal zone on rocky substrates or shallow subtidal zones. It has been found Bandar Lengeh area, Bushehr province.

****Sargassum gemmiphorum* Tseng et Lu**

Tseng & Lu (1992)

Holdfast conical, up to 1 cm in diameter. Thallus yellow brown, more than 35 cm in high. Axes cylindrical to 2 cm long, 1.5 mm in diameter, verrucose on the surface, several primary branches arising from the upper parts of the axes, with leaves dropped. Primary branches flattened below, compressed above, up to 45 cm long and 1.5 mm in diameter; the primary branches, some subspherical, other oblong, verrucose. Secondary branches arising from axils of the primary branches, compressed, short to 12 cm long, 1 mm wide. Basal leaves long-lanceolate, thin and membranous, usually 2-3 pinnately forked, up to 6 cm long and 4 mm wide, with acute apices, more regularly cuneate at the base, with percurrent midrib, slightly raised margins; cryptostomata small and scattered in rows on both sides of the midrib, denticulate at the margins. Upper leaves slender, linear, sometimes once or twice pinnately divided, to 4 cm long, 3 mm wide. Vesicles small, subspherical, sometimes ovate, up to 3 mm long, to 2-3 mm wide, rounded at the apex, with 2-3 cryptostomata on the surface; stalks terete, slender and cylindrical usually 5 mm long, 1 mm in diameter (Fig. 5).

Plants dioecious. Male receptacles long, terete, up to 10 mm long and 1 mm wide, with smooth surface, simple to once to twice furcate. Femal receptacles conical, smooth or verrucose on the surface, up to 3 mm long and 1 mm wide, simple or forked. Female and male receptacles arranged racemosley.

This species is mainly characterized by its conical holdfast, cylindrical axes, often 1-2 divided, verrucose on the surface, thin and narrow leaves, often 1-2 pinnately divided, denticulate at margins.

Habitat: Reef and coral flats and subtidal zone.

Ecology: This species has been found only in Sistan va Baluchestan province (Chabahar, Gowatr, Kacho).

****Sargassum henslowianum* C. Agardh**

C. A. Agardh (1820); Setchell (1935); Tseng (1983, 1985).

Thalli about 60 cm in high, arising from discoid holdfast, growing on lower intertidal to subtidal rocks. Main axes short, cylindrical, 1.5 cm long, bearing primary branches from their portions. Primary branches compressed, bearing many secondary branches at their

axils. Basal leaves simple or divided, about 5 cm long, 5 mm broad. Upper leaves narrow-lanceolate, about 5 cm long, 2 mm wide, sometimes dentate at the margins, midrib percurrent, cryptostomata scattered on both sides of the midribs, rounded to acute in apex. Vesicles spherical or ovate rounded at apices with long and terete stalks (Fig. 6).

Plants dioecious. Male receptacles long, cylindrical, simple or slightly forked, wart-like on the surface, 6 mm long, 1 mm wide. Female receptacles fusiform, 4-6 mm long, 1 mm wide. Female and male receptacles arranged in a raceme and malacocarpic.

Habitat: Reef flats and subtidal zone.

Ecology: This species grows in the lower portions of the intertidal zone on rocky substrates or shallow subtidal zones. It has been found only in Sistan va Baluchestan province (Tang, Passabandar, Gowatr).

****Sargassum longifructum* Tseng et Lu**

Tseng & Lu (1992); Ajisaka & al. (1999); Noiraksar & Ajisaka (2008).

Holdfast discoid, up to 15 mm in diameter. Stem terete, smooth, up to 2.5 mm in diameter and 3 cm long. Primary branches terete to subterete, smooth, up to 50 cm long and 2 mm in diameter; leaves linear-lanceolate to linear-elliptical, simple, with asymmetrical to cuneate bases, up to 3 cm long and 9 mm wide, with rounded to acute apices, margins entire to dentate with small teeth, midribs distinct near apices, small cryptostomata and scattered to in rows on both sides of the midrib. Secondary branches spirally arranged, terete, smooth, up to 2.5 cm long. Leaves linear-lanceolate to linear-elliptical, simple with asymmetrical bases, up to 3 cm long and 6 mm wide, with acute to rounded apices, margins entire to dentate with small teeth. Vesicles spherical, sometimes obovoid or elliptical, up to 40 mm long, to 2.8 mm wide, entire at the apices, sometimes provided with appendages, stalks terete to flattend, usually shorter than the vesicles (Fig. 7).

Plants dioecious. Male receptacles long, terete to slightly compressed and with a few spines at the apex, up to 2 cm long and 1.3 mm wide, simple to once to twice furcated. Female receptacles flattened and sometimes triquetrous, up to 1.8 cm long and 3 mm wide, margins dentate with spines, sometimes twisted, simple to once to twice furcate. Female and male receptacles arranged in a raceme, pseudozygocarpic, vesiculate and leaf.

Habitat: Reef flats and subtidal zone.

Ecology: This species usually grows in the lower portions of the intertidal zone on rocky substrates or shallow subtidal zones. It has been found only in Sistan va Baluchestan province (Chabahar, Gowatr and Tang).

***Sargassum spinuligerum* Sonder**

C. A. Agardh (1820); Tseng (1983); Ajisaka & al. (1999); Gavino & Trono (1999); Noiraksar & al. (2006); Noiraksar & Ajisaka (2008)

Heterotypic Synonyms: *Sargassum spinuligerum* var. *crispata* f. *angustifolia* Grunow, *Sargassum spinuligerum* var. *crispata* f. *asperrima* Grunow, *Sargassum spinuligerum* var. *stenophylla* Grunow, *Sargassum spinuligerum* var. *stenophylla* f. *intermedia* Grunow

Thalli yellow brown with a rhizoidal to discoid holdfast, up to 1 cm in diameter. Stem terete, warty, up to 2 mm in diameter and 3 mm long bearing 6-8 spirally arranged primary branches. Primary branches usually muricate with prolifically branched spines, up to 100 cm long and 2 mm in diameter; leaves elliptical, lanceolate to linear, simple, with asymmetrical to cuneate bases, up to 0.5 cm long and 1.2 cm wide, usually with rounded to acute apices, margins dentate with coarse teeth, midribs vanishing to distinct near apices, cryptostomata small and scattered to in rows on both sides of the midrib. Secondary branches spirally arranged, terete, crowded with spines, up to 50 cm long. Leaves linear-lanceolate, simple with asymmetrical bases, up to 2.5 cm long and 6 mm wide, with rounded to acute apices, margins dentate with coarse teeth. Vesicles spherical, sometimes obovoid to obovoid, up to 6 mm long, to 5 mm wide, entire at the apices or crowned with a leaflet or mucronate. Stalk terete, usually shorter than the vesicles (Fig. 8).

Plants dioecious. Male receptacles long, terete, up to 1.2 mm long, 1 mm wide, with a warty surface, simple to once furcate. Female receptacles terete to slightly compressed, up to 3 mm long, 1 mm wide, with a warty surface, simple to once furcate. Female and male receptacles arranged in a raceme. Holozygocarpic, vesiculate.

Habitat: Coral flats and subtidal zone.

Ecology: This species grows in the lower portions of the intertidal zone on rocky substrates or shallow subtidal zones. It has been found Sistan va Baluchestan (Chabahar, Drak, Gowatr) province.

DISCUSSION

In this study, 7 species of *Sargassum* are reported which are new records for Iran. *S. spinuligerum*, *S. baccularia* and *S. longifructum* were found only in Sistan va Baluchestan province and *S. boveanum* var. *atterrimum* and *S. binderi* were found in Bandar Lengeh area and Bushehr (Heleyleh site and Lian Park). *S. binderi* was differentiated from others by compress branches and monoecious receptacles, but we can easily identify them from shape of vesicles. *S. binderi* has been characterized by the receptacles with sharply

spinous margin. Womersley & Bailey (1970) suggested that *S. binderi* was a synonym of *S. oligocystum*. However, we retain *S. binderi* on the basis of its character receptacles with a clear spinous margin. *S. binderi* from Iran closely similar to specimens reported from Thailand and China (Noiriskadar & al. 2006; Tseng & Lu, 1992) in the morphology of its vesicles and receptacles. *S. baccularia* and *S. spinuligerum* are often misidentified as they share some morphological characters especially in young plant. Both species have spines on the branches. *S. baccularia* and *S. spinuligerum* are dioecious and share a few characteristics such as presence of spines on branches and spherical vesicles. In the present study, according to the results, we understand that *S. spinuligerum* is similar to *S. baccularia*. In this survey, *S. henslowianum* and *S. gemmiphorum* had furcated leaves bearing dispersed thinner cryptostomata, but *S. binderi* had large cryptostomata on the leaves (Gavino & Trono 1999; Noraksar & Ajisaka 2008). *S. longifeructum* identified according to twised receptacles than others. Also, *S. boveanum* var *aterrimum* observed only on Bushehr province. In general, *S. longifeructum* belongs to *Zygocapicae* section and *S. baccularia* and *S. henslowianum* belong to *Malacocarpicae* section. In summary, *S. spinuligerum* and *S. binderi* belong to *Sargassum* and *Binderianae* sections, respectively. Accordingly, our taxa is constituted Subgenus *Sargassum* with four sections.

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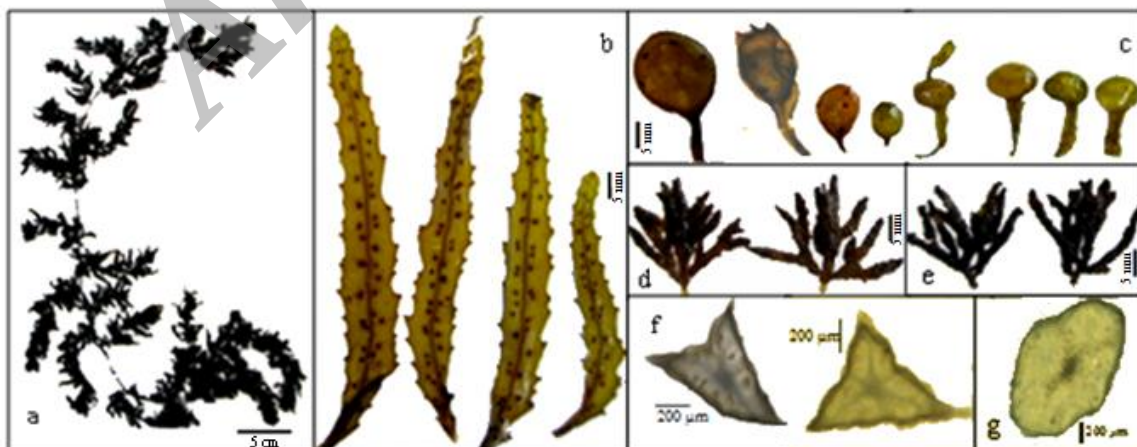


Fig. 2. *Sargassum baccularia* (Mertens) C. Agardh. a) Habit, b) leaves, c) vesicles, d) Female receptacles, e) Male receptacle f) transverse section of female receptacle, g) transverse section of male receptacle.



Fig. 3. *Sargassum binderi* Sonder. a) Habit, b) leaves, c) vesicles, d) receptacles, e) transverse section of receptacle.

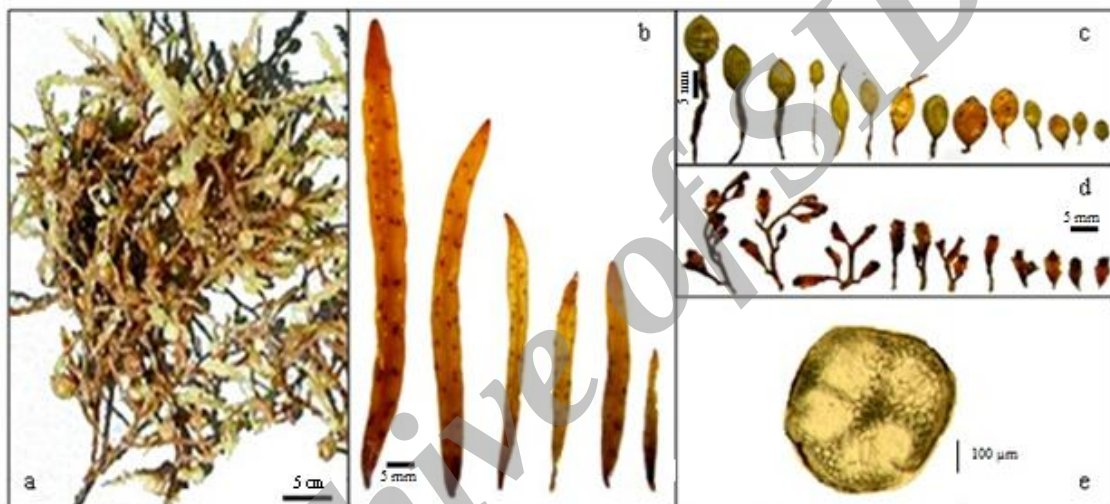


Fig. 4. *Sargassum boveanum* var. *aterrimum* J. Agardh. a) Habit, b) leaves, c) vesicles, d) receptacles, e) transverse section of receptacle.

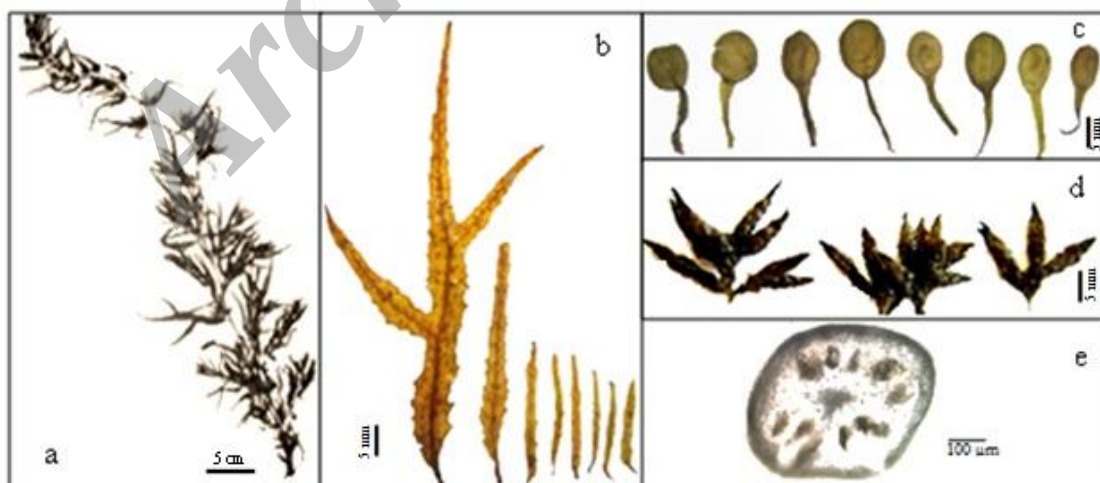


Fig. 5. *Sargassum gemmiphorum* Tseng and Lu a) Habit, b) leaves, c) vesicles, d) receptacles, e) transverse section of receptacle.

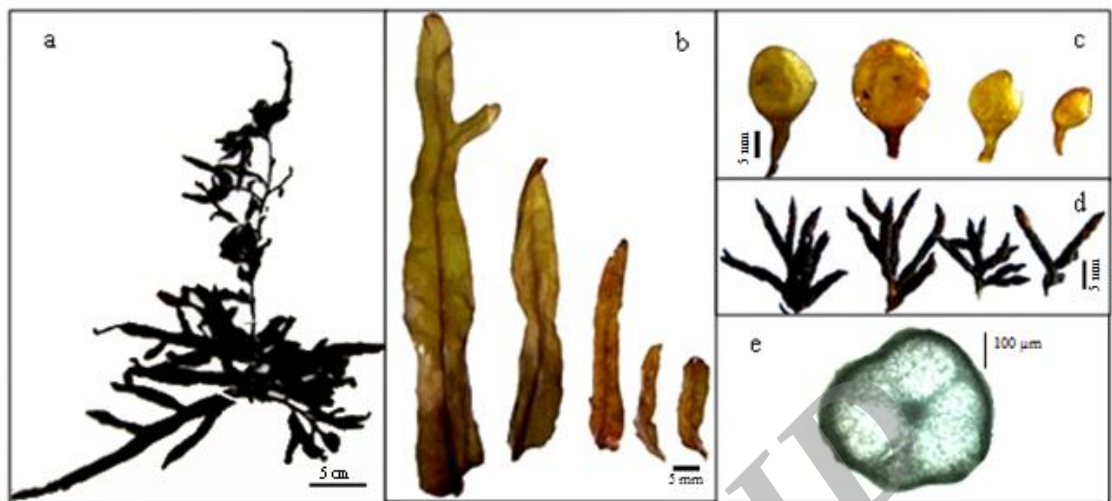


Fig. 6. *Sargassum henslowianum* C. Agardh. a) Habit, b) leaves, c) vesicles, d) receptacles, e) transverse section of receptacle.

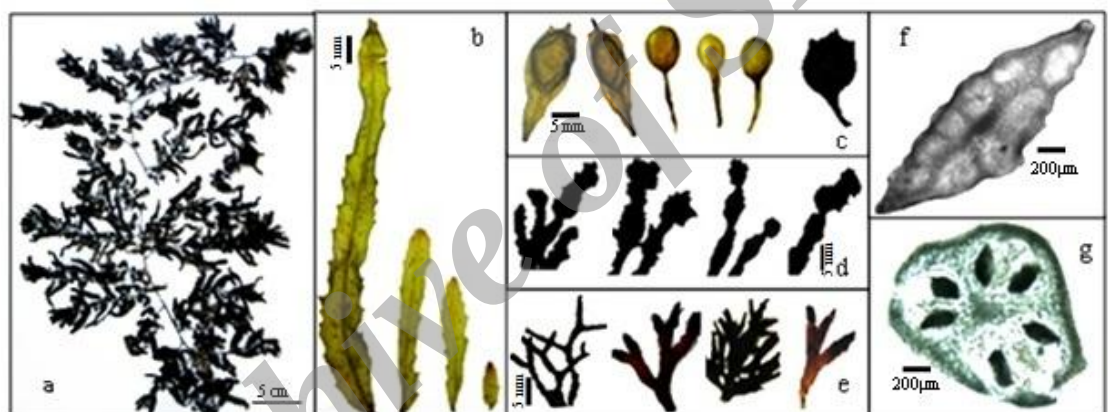


Fig. 7. *Sargassum longifructum* Tseng et Lu. a) Habit, b) leaves, c) vesicles, d) Female receptacles, e) Male receptacles, f) transverse section of female receptacle, g) transverse section of male receptacle.

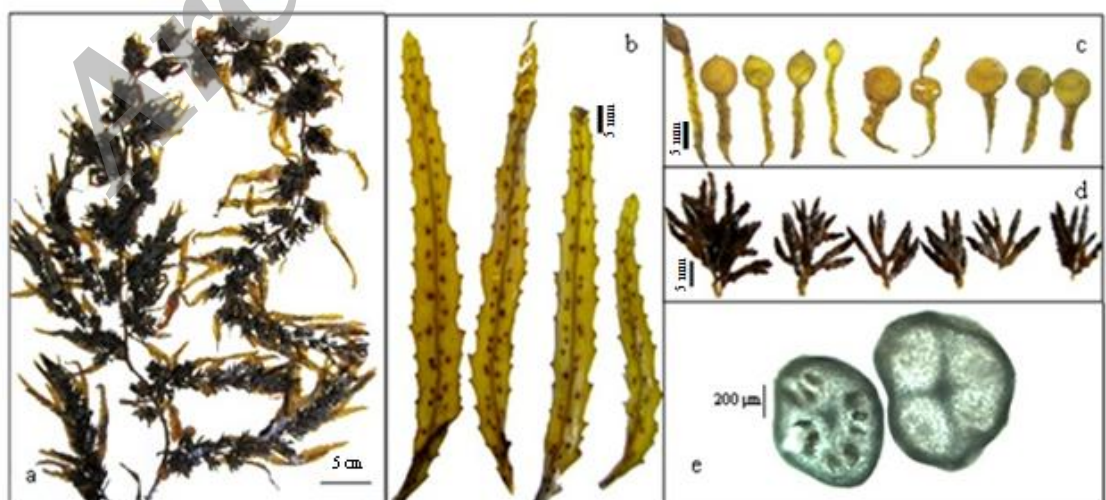


Fig. 8. *Sargassum spinuligerum* Sonder. a) Habit, b) leaves, c) vesicles, d) receptacles, e) transverse section of receptacle.