BioInvasions Records (2015) Volume 4, Issue 1: 17–21
doi: http://dx.doi.org/10.3391/bir.2015.4.1.03

Open Access

Rapid Communication

Occurrence of the introduced alga *Caulerpa ollivieri* Dostál, 1929 (Caulerpaceae, Chlorophyta) in the Southern Gulf of Mexico

Ileana Ortegón-Aznar[1]*, Luis A. Rosado-Espinosa[2] and Alfonso Aguilar-Perera[1]

[1]*Departamento de Recursos Marinos Tropicales, Universidad Autónoma de Yucatán, Campus de Ciencias Biológicas y Agropecuarias, Mérida, Yucatán, A.P. 4-116. C.P. 97000, México*
[2]*Departamento de Botánica, Universidad Autónoma de Yucatán, Campus de Ciencias Biológicas y Agropecuarias, Mérida, Yucatán, A.P. 4-116. C.P. 97000, México*

**Corresponding author*
E-mail: oaznar@uady.mx

Received: 9 June 2014 / Accepted: 28 November 2014 / Published online: 11 December 2014

Handling editor: Melisa Wong

Abstract

This work reports the occurrence of the introduced alga *Caulerpa ollivieri* Dostál, 1929 in the Southern Gulf of Mexico off the northern coast of the Yucatan Peninsula, Mexico. In 2010, a specimen was collected off the Dzilam de Bravo, and additional specimens were detected in at least four localities along the coast. These records extend the distribution of *C. ollivieri* 800 km to the south; it was first recorded off the Tampa Bay in Florida (USA) in 1968 and subsequently in The Bahamas. Further work is now needed to determine the impact this introduced alga may have on the native benthic community.

Key words: macroalgae, exotic, Yucatan Peninsula, Mexico

Introduction

Species of the genus *Caulerpa* J.V. Lamouroux, 1809 (Caulerpaceae, Chlorophyta) are well-known macroalgae invaders in marine benthic environments. *Caulerpa taxifolia* (M. Vahl) C. Agardh, 1817 has been reported in the Mediterranean Sea since the 1980s (Jousson et al. 1998) as determined to be an invasive species (Meinesz et al. 1991, 2001; Piazzi et al. 1994) along with *C. cylindracea* Sonder, 1845 (Verlaque et al. 2003; Infantes et al. 2011). However, *C. taxifolia* has also been reported in California (Jousson et al. 2000, Anderson 2001, 2005), Japan (Komatsu et al. 2003), Australia (Creese et al. 2004, Davis et al. 2005), and Turkey (Cevik et al. 2007). Other *Caulerpa* species are also invasive, such as *C. filiformis* (Suhr) Hering, 1841 and *C. scalpelliformis* (R. Brown ex Turner) C. Agardh, 1817 in Australia (Davis et al. 2005) and *C. brachypus* Harvey, 1860 in Florida (Lapointe and Bedford 2010; Guiry and Guiry 2014).

Caulerpa ollivieri Dostál, 1929 is an alga native to the Mediterranean Sea that was found in the northern Gulf of Mexico, but treated as a form of *C. prolifera* (Forsskål) J.V. Lamouroux, 1809 (Dawes and van Breedveld 1969). However, Hine and Humm (1971) recorded *C. ollivieri* as a valid species for the first time in the Gulf of Mexico, close to the mouth of Tampa Bay in Florida where it was detected at a depth of 30 m. Recently, Lapointe et al. (2005) recognized *C. ollivieri* as an invasive alga in the harbors of The Bahamas.

In the Southern Gulf of Mexico, off the Yucatan Peninsula, at least 32 taxa (14 species, 10 varieties and 8 forms) of the genus *Caulerpa* have been recorded (Taylor 1935, 1941; Humm 1952; Huerta and Garza-Barrientos 1966; Huerta et al. 1987; Dreckmann 1998; Ortega et al. 2001; Garduno-Solorzano et al. 2005; Callejas-Jimenez et al. 2005; Robledo and Freile 2005; Sanchez-Molina et

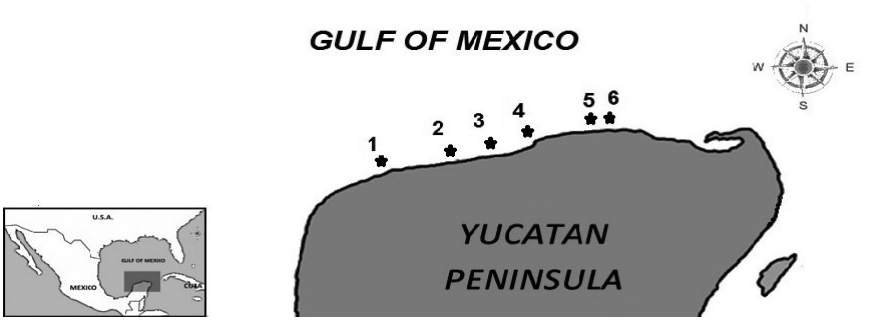

Figure 1. Map of study area in the Southern Gulf of Mexico along the northern Yucatan Peninsula, Mexico, showing sites where *Caulerpa ollivieri* was detected.

al. 2007; Pacheco-Cervera et al. 2010; Ortegón-Aznar et al. 2001; Ortegón-Aznar et al. 2009; Federicq et al. 2009; Ortegón-Aznar et al. 2010; Mateo-Cid et al. 2013). However, none of these studies detected *C. ollivieri*.

This work reports the occurrence of the introduced alga *C. ollivieri* in the southern Gulf of Mexico off the northern Yucatan Peninsula, Mexico. This represented a range extension of *C. ollivieri* of about 800 km from the closest previously recorded site in Florida.

Methods

The study area extends from Las Coloradas (21°38'55.29"N; 88°04'0.83"W) to Sisal (21°12' 35.3"N; 90°04'04.65"W) (Figure 1) off the northern coast of the Yucatan Peninsula. From 2010 to 2013, six sampling locations (3 to 10 m deep) in total were surveyed using SCUBA. *Caulerpa ollivieri* was detected during benthic surveys that targeted other macroalgae groups in the area. About five to six specimens of *C. ollivieri* were collected opportunistically directly from the bottom in each locality; however, no data on cover or density were recorded. Specimens were fixed in a solution of 4% formalin in seawater. In the laboratory, they were measured in millimeters and identified following Dawes and Mathieson (2008). Morphological characters measured included: fronds (width and length), stolon (length and diameter), rhizoidal pillars (diameter), secondary rhizoidal pillars (diameter), rhizoidal (diameter), and rhizoidal bouquets (diameter) (Kluser et al. 2004). Specimens were pressed dry and deposited in the Herbarium "Alfredo Barrera Marin" from the Universidad Autónoma de Yucatán (UADY), in Mérida Yucatán, México.

Results and discussion

During the summer in 2010, *Caulerpa ollivierii* was detected off the Dzilam de Bravo coast of the Yucatan Peninsula (21°29'50.37"N; 88°44' 17.96"W) in a low visibility area in water 10 m deep. Three specimens were collected, preserved, and brought to the laboratory where it was identified and deposited in the herbarium (UADY 1037). More specimens were collected off the north coast of the Yucatan Peninsula in 2013, as well as in other locations (Las Coloradas, Rio Lagartos, Telchac, Progreso and Sisal), at depths of 3 to 10 m (Figure 1, Appendix 1). All collected specimens were stoloniferous, with stolons 50 mm long (0.34–0.38 mm wide), and erect fronds up to 70–78 mm high (3.9–4.2 mm wide) (Table 1). Thalli grew over a sandy bottom with poorly developed rhizoids (0.26–0.28 mm diameter) that were infrequently branched. Blade proliferations emerged from the lower midlines of the blades (Figure 2).

Specimens of *C. ollivieri* were part of an algal mat (turf) that mainly consisted of other species of *Caulerpa* (e.g., *C. microphysa* Weber-van Bosse) Feldman, 1855 and *C. paspaloides* (Bory de Saint-Vincent) Greville, 1830), but with *C. ollivieri* as the primary species. In the turf there were also red algae, such as: *Jania adhaerens* J.V. Lamouroux, 1816; *Amphiroa fragilissima* (Linnaeus) J.V. Lamouroux, 1816; *Hypnea musciformis* (Wulfen) J.V. Lamouroux, 1813; and *H. spinella* (C. Agardh) Kützing, 1847. The turf was 5 and 10 cm high and growing on a thin layer of sand (< 5 cm thick) with patches of bare rock colonized by calcareous and stoloniferous species (Figure 3).

The specimens of *C. ollivieri* from the Yucatan Peninsula were, morphologically, slightly different from those described from Florida (Hine and Humm

Table 1. Morphological characters of *Caulerpa ollivieri* from the northern Yucatan Peninsula, Mexico.

Character	Mean (mm)	SD +/-
Fronds (Width)	4.05	0.13
Fronds (Length)	7.5	0.42
Stolon (Diameter)	0.36	0.03
Rhizoidal pillars (Diameter)	0.27	0.01
Secundary Rhizoidal pillars (Diameter)	0.175	0.02
Rhizoidal (used as anchorage) (Diameter)	0.11	0.01
Rhizoidal bouquets (used as anchorage) (Diameter)	0.04	0.05

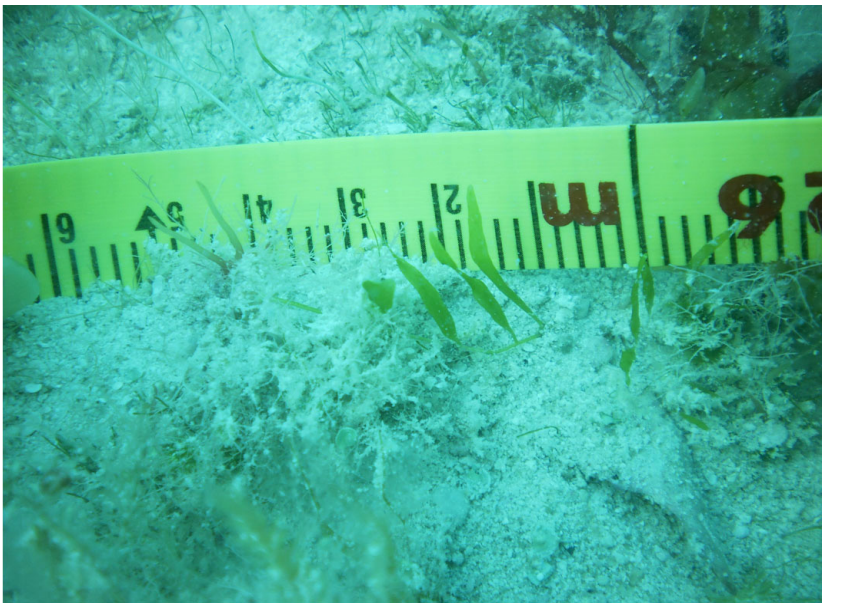

Figure 2. *Caulerpa ollivieri* from the southern Gulf of Mexico off the northern Yucatan Peninsula in Mexico. Photo by I. Ortegon-Aznar.

Figure 3. Algal mat associations (turf), mainly consisting of *Caulerpa* species (e.g., *Jania* sp, *Spyridia* sp) but with *C. ollivieri* as the primary species. Photo by I. Ortegon-Aznar.

1971). The Yucatan specimens had a lower density of rhizoids and grew obliquely upwards from a small attachment area where the stolons develop fibrous holdfasts, which is a characteristic of *Caulerpa*. In contrast, the specimen from Florida had proliferations of erect branches developing from the apices, apparently in response to low light intensity (Hine and Humm 1971).

We think *C. ollivieri* is widely distributed on the north coast of the Yucatan Peninsula, and assume that it has established permanent populations in the area. Our account extends the *C. ollivieri* distribution about 800 km south to the Gulf of Mexico from where it was first recorded off the Tampa Bay in Florida, USA. In addition, this is the first record for Mexico of *C. ollivieri*. In general, *Caulerpa* species are capable of spreading rapidly over large areas and creating turfs (Williams 2007). In The Bahamas, for instance, *C. ollivieri* can replace the seagrass *Thalassia testudinum* Banks ex König, 1805 in eutrophic coastal waters (Lapointe et al. 2005). Any stress directly or indirectly reducing seagrass density may contribute to increasing seagrass susceptibility to replacement by introduced macroalgae species (Williams 2007).

How *C. ollivieri* was introduced to the waters of the Yucatan Peninsula is unknow; however, it could have been introduced via ballast water of cruise ships coming from the USA to Progreso port. However, there is no evidence to support this hypothesis. In the Yucatan, *C. ollivieri* was detected in relatively small patches in seagrass. Environmental parameters were not recorded, but there are no urban developments in the area where the specimens were detected; consequently, sewage input to the area is minimal. We currently do not know how *C. ollivieri* is affecting the native benthic community, especially the seagrass beds, but further work is warranted to track population trends and the consequences of spread of this non-native species to this coastal ecosystem.

Acknowledgements

We thank David González, Adrian Morales, Elsy Rodríguez and Gustavo Guerrero for their assistance in this study, and also reviewers Melisa Wong and David Garbary. This work was funded under the project "Biodiversidad Acuática en la Zona Costera del Sureste de México: Fase 1. Primera Lista Regional de Especies en el Sur del Golfo de México" of the Secretary of Education of México (PROMEP Redes Temáticas de Colaboración Convocatoria 2011.UADY-CA-95 Recursos Marinos Tropicales).

References

Anderson LWJ (2001) *Caulerpa taxifolia*: new marine algal invader in US Waters. *Aquatic Invaders* 12: 1–6

Anderson LWJ (2005) California's reaction to *Caulerpa taxifolia*: a model for invasive species rapid response. *Biological Invasions* 7: 1003–1016, http://dx.doi.org/10.1007/s10530-004-3123-z

Callejas-Jiménez ME, Sentíes A, Dreckmann KM (2005) Macroalgas de Puerto Real, Faro Santa Rosalía y Playa Preciosa, Campeche, México, con algunas consideraciones florísticas y ecológicas para el estado. *Hidrobiológica* 15: 89–96

Cevik C, Yokes MB, Cavas L, Erkol LI, Derici OB, Verlaque M (2007) First report of *Caulerpa taxifolia* (Bryopsidales, Chlorophyta) on the Levantine coast (Turkey, Eastern Mediterranean) *Estuarine, Coastal and Shelf Science* 74: 549–556, http://dx.doi.org/10.1016/j.ecss.2007.05.031

Creese RG, Davis AR, Glasby TM (2004) Eradicating and preventing the spread of the invasive alga *Caulerpa taxifolia* in NSW. Final report to the Natural Heritage Trust's coast and clean seas introduced marine pests program, project no. 35593. NSW Fisheries Final Report no. 64

Davis AR, Benkendorff K, Ward DW (2005) Responses of common SE Australian herbivores to three suspected invasive *Caulerpa* spp. *Marine Biology* 146: 859–868, http://dx.doi.org/10.1007/s00227-004-1499-z

Dawes CJ, Van Breedveld J (1969) Benthic marine algae. Memoirs of the Hourglass Cruises. Vol 1 (Part 2). Marine Research Laboratory, Florida Board of Conservation, St. Petersburg, Florida, pp 1–47

Dawes CJ, Mathieson AC (2008) The seaweeds of Florida. University Press of Florida, USA, 591 pp

Fredericq S, Cho TO, Earle SA, Gurgel CF, Krayesky DM, Mateo-Cid LE, Mendoza- Gonzalez CA, Norris JN, Suárez AM (2009) Seaweeds of the Gulf of Mexico. In: Felder DL, Camp DK (eds), Gulf of Mexico: its Origins, Waters, and Biota. Vol. I. Biodiversity, Texas A & M University Press, College Station, pp 187–259

Garduño-Solórzano M, Godínez JL, Ortega MM (2005) Distribución geográfica y afinidad por el sustrato de las algas verdes (Chlorophyceae) bénticas de las costas mexicanas del Golfo de México y Mar Caribe. *Boletín de la Sociedad Botánica de México* 76: 61–78

Guiry MD, Guiry GM (2014) Algaebase versión 4.2. World-wide electronic Publication. National University of Ireland. Galway, Ireland. http:/www.algaebase.org

Hine AE, Humm HJ (1971) *Caulerpa ollivieri* in the Gulf of Mexico. *Bulletin of Marine Science* 21: 552–555

Huerta-Múzquiz L, Garza-Barrientos AM (1966) Algas marinas del litoral del estado de Campeche. *Ciencia (México)* 24: 193–200

Huerta-Múzquiz L, Mendoza-González AC, Mateo-Cid LE (1987) Avance de un estudio de las algas marinas de la península de Yucatán. *Phytologia* 62(1): 23–53

Infantes E, Terrados J, Orfila A (2011) Assessment of substratum effect on the distribution of two invasive *Caulerpa* (Chlorophyta) species. *Estuarine, Coastal and Shelf Science* 91: 434–441, http://dx.doi.org/10.1016/j.ecss.2010.11.005

Jousson O, Pawlowski J, Zaninetti L, Meinesz A, Boudouresque CF (1998) Molecular evidence for the aquarium origin of the green alga *Caulerpa taxifolia* introduced to the Mediterranean Sea. *Marine Ecology Progress Series* 172: 275–280, http://dx.doi.org/10.3354/meps172275

Jousson O, Pawlowski J, Zaninetti L, Zechman FW, Dini F, Di Guiseppe G, Woodfield R, Millar A, Meinesz A (2000) Invasive alga reaches California. *Nature* 408: 157, http://dx.doi.org/10.1038/35041623

Kluser S, Giuliani G, De Bono A, Peduzzi P (2004) *Caulerpa taxifolia*, a growing menace for the temperate marine environment. UNEP. Environment Alert Bulletin, pp 1–4, http://www.grid.unep.ch/products/3_Reports/ew_caulerpa.en.pdf

Komatsu T, Ishikawa T, Yamaguchi N, Hori Y, Ohba H (2003) But next time? Unsuccessful establishment of the Mediterranean strain of the green seaweed *Caulerpa taxifolia* in the Sea of Japan. *Biological Invasions* 5: 275–278, http://dx.doi.org/10.1023/A:1026164902868

Lapointe BE, Barile PJ, Wynne MJ, Yentsch CS (2005) Reciprocal *Caulerpa* invasion: Mediterranean native *Caulerpa ollivieri* in the Bahamas supported by human nitrogen enrichment. *Aquatic Invaders* 16: 2–5

Lapointe BE, Bradford BJ (2010) Ecology and nutrition of invasive *Caulerpa brachypus f. parfolia* blooms on coral reefs off southeast Florida, U.S.A. *Harmful Algae* 9: 1–12, http://dx.doi.org/10.1016/j.hal.2009.06.001

Mateo-Cid LE, Mendoza-González AC, Ávila-Ortiz AG, Díaz Martínez S (2013) Algas marinas bentónicas del litoral de Campeche, México. *Acta Botanica Mexicana* 104: 53–92

Meinesz A, Hesse B (1991) Introduction of the tropical alga *Caulerpa taxifolia* and its invasion of the Northwestern Mediterranean. *Oceanologica* Acta 14: 415–426

Meinesz A, Belsher T, Thibaut T, Antolic et al. (2001) The introduced green alga *Caulerpa taxifolia* continues to spread in the Mediterranean. *Biological Invasions* 3: 201–210, http://dx.doi.org/10.1023/A:1014549500678

Ortega MM, Godínez JL Garduño Solórzano G (2001) Catálogo de algas bénticas de las costas mexicanas del Golfo de México y Mar Caribe. Comisión Nacional para el Estudio de la Biodiversidad y Universidad Nacional Autónoma de México. México, D.F., México, 594 pp

Ortegón-Aznar I, González-González J, Sentíes A (2001) Estudio ficoflorístico de la laguna de Río Lagartos, Yucatán, México. *Hidrobiológica* 11: 97–104

Ortegón-Aznar I, Sánchez-Molina I, Casanova-Cetz RA (2009) The distribution of marine algae in a coastal lagoon, northern Yucatan Peninsula, Mexico. *Neotropical Biology and Conservation* 4: 99–105, http://dx.doi.org/10.4013/nbc.2009.42.05

Ortegón-Aznar I, Freile-Peregrin Y, Robledo D (2010) Diversidad vegetal: Algas. In: Durán R, Méndez M (eds), Biodiversidad y Desarrollo Humano en Yucatán. CICY, PPD-FMAM, CONABIO, SEDUMA, pp 162–164

Pacheco-Cervera MC, Pacheco-Ruiz I, Ramos-Miranda J, Cetz-Navarro NP, Soto Ávila JL (2010) Presencia del género *Caulerpa* en la Bahía de Campeche, Camp. *Hidrobiológica* 20: 57–69

Robledo D, Freile-Pelegrin Y (2005) Seasonal variation in photosynthesis and biochemical composition of *Caulerpa* spp. (Bryopsidales, Chlorophyta) from the Gulf of Mexico. *Phycologia* 44: 312–319, http://dx.doi.org/10.2216/0031-8884(2005)44[312:SVIPAB]2.0.CO;2

Sánchez-Molina I, González-Ceballos J, Zetina-Moguel C, Casanova-Cetz R (2007) Análisis de la biodiversidad de algas marinas situadas entre Uaymitún y Chuburná, Yucatán. *Ingeniería* 11: 43–51

Taylor RW (1935) Marine algae from the Yucatan Peninsula. Paper from the herbarium and the dept. of botany of the University of Michigan. No. 542, pp 117–124

Taylor RW (1941) Tropical marine algae of the Arthur Schott herbarium. *Botanical series. Field Museum of Natural History* 20: 87–103

Williams SL (2007) Introduced species in seagrass ecosystems: Status and concerns. *Journal of Experimental Marine Biology and Ecology* 350: 89–110, http://dx.doi.org/10.1016/j.jembe.2007.05.032

Appendix 1. Records of *Caulerpa ollivieri* from the Southern Gulf of Mexico. Numbers refer to sites shown in Figure 1.

Record No. (map ref.)	Location	Record coordinates		Record date	Reference
		Latitude	Longitude		
1	Sisal	21°12'35.30" N	90°04'04.65"W	03 December 2013	Present study
2	Progreso	21°17'55.60"N	89°39'52.59"W	11 Novembaer2013	Present study
3	Dzilam de Bravo	21°29'50.37"N	88°44'17.96"W	10 July 2010	UADY 1037
4	Telchac	21°20'46.90"N	89°15'47.35"W	6 June 2013	Present study
5	Río Lagartos	21°38'18.90"N	88°11'30.03"W	4 April 2013	Present study
6	Las Coloradas	21°38'55.29"N	88°04'00.83"W	3 April 2013	Present study