

Rapid Communication**First record of naturalization of *Scaevola taccada* (Gaertn.) Roxb. (Goodeniaceae) in southeastern Mexico**Gonzalo Castillo-Campos^{1,*}, José G. García-Franco² and M. Luisa Martínez²¹Red de Biodiversidad y Sistemática, Instituto de Ecología, A.C., Xalapa, Veracruz, 91073, México²Red de Ecología Funcional, Instituto de Ecología, A.C. Xalapa, Veracruz, 91073, MéxicoAuthor e-mails: gonzalo.castillo@inecol.mx (GCC), jose.garcia.franco@inecol.mx (JGGF), marisa.martinez@inecol.mx (MLM)

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OPEN ACCESS**Abstract**

Scaevola taccada (Gaertn.) Roxb. is native of Asia and eastern Africa but has been introduced into the Americas as an ornamental urban plant. This paper reports, for the first time, the presence of *Scaevola taccada* in natural environments from southeastern Mexico. Several populations of *S. taccada* were identified during a botanical survey of the coastal dunes of the Cozumel Island Biosphere Reserve (State of Quintana Roo, Mexico) aimed at recording the most common plant species. *Scaevola taccada* is considered as an invasive species of coastal areas in this region. Evidence of its invasiveness is suggested by the fact that populations consisting of individuals of different size classes are found distributed throughout the island. Furthermore, they appear to belong to different generations since we found individuals of different sizes and with and without flowers and fruits. Our observations suggest that the population of *Scaevola taccada* can be in a process of expansion. Further studies are necessary to understand the potential effect on the native flora.

Key words: Cozumel, coastal dunes, flora of Mexico, invasive species, Quintana Roo**Introduction**

The family Goodeniaceae R. Br. comprises 11–13 genera and some 329–440 species worldwide (Howarth et al. 2003; Avendaño-Reyes 2008; Grande and Nozawa 2010; Márquez-Llauger et al. 2013; The Plant List 2013). *Scaevola* L. is one of the most diverse genera, including 102–130 species (Jabaily et al. 2012; POWO 2019). *Scaevola* plants characteristically have flowers solitary or aggregated in terminal or axillary inflorescences, with or without involucral bracts, hermaphrodite, small to medium-sized, zygomorphic, pentamerous, with 2-whorled perianth; calyx usually small or reduced to a small ring, gamosepalous; ovary superior or inferior, with 1–2 (–4) locules, axillary placentation, style solitary, stigmas 1–3, papillate; fruit a drupe, capsule or nut, fleshy or non-fleshy, dehiscent or indehiscent (Avendaño-Reyes 2008).

Species from the genus *Scaevola* L. are commonly found in environments that are either arid or with prolonged dry periods (Grande and Nozawa

2010). Only three native species, *S. wrightii* M. Gómez, 1890; *S. plumieri* (L.) Vahl, 1791 and *S. rialagartensis* Cast.-Campos, 2019 are known from the American continent and the Caribbean, all of which mainly inhabit the beach and coastal dunes (Thieret and Brandenburg 1986; Howarth et al. 2003; Gutiérrez-Báez et al. 2013; Castillo-Campos et al. 2019). *Scaevola wrightii* is endemic to Cuba (Liogier 1962; Howarth et al. 2003), whereas the other two species are native to Mexico. *Scaevola plumieri* is found in some states of the Mexican Pacific coast, the Gulf of Mexico and the Yucatan Peninsula (Flores Guido 1983; Téllez Valdés and Cabrera Cano 1987; Avendaño-Reyes 2008; Gutiérrez-Báez et al. 2013; Parra-Tabla et al. 2018), although it is also distributed in other tropical and subtropical regions of the Northern and Southern hemispheres (Howarth et al. 2003). *Scaevola rialagartensis* is a recently described species, endemic to the northern part of the Yucatán Peninsula (Castillo-Campos et al. 2019). *Scaevola taccada* (Gaertn.) Roxb., 1814 is a species native to Asia that currently has a pantropical distribution (Emura et al. 2014). In the Americas, the distribution range of *S. taccada* covers from the USA to Venezuela, crossing the Caribbean basin (Grande and Nozawa 2010; Howarth et al. 2003). In Mexico it is often used as an ornamental plant in hotel and urban gardens in coastal locations (personal observations); however, to date, populations growing in natural conditions have not been recorded.

As part of a botanical survey of the coast of the Cozumel Island Biosphere Reserve, Quintana Roo, Mexico, we observed specimens of the genus *Scaevola* (Goodeniaceae), which we thought might belong to the recently described *S. rialagartensis* (Castillo-Campos et al. 2019). Under closer examination, we noticed that the specimens showed characteristics that were different from those of *S. rialagartensis*. A review of type specimens of *Scaevola* species available in the JSTOR Global Plants (JSTOR 2019) and Tropicos (Tropicos.org 2019) databases showed that the characteristics of our specimens corresponded to *Scaevola taccada*.

This paper reports, for the first time, the presence of *Scaevola taccada* in natural environments in the Cozumel Island Biosphere Reserve, municipality of Cozumel, State of Quintana Roo, Mexico. The species was found naturalizing on sand dunes and beaches where only *S. plumieri* had previously been recorded (Flores Guido 1983; Téllez Valdés and Cabrera Cano 1987; Collantes-Chávez-Costa et al. 2019).

Materials and methods

A wide literature search for floristic and vegetation studies carried out in the Yucatán Peninsula and/or the Island of Cozumel was conducted by surveying the major academic electronic databases (Journal of Citation Reports [JCR], SCOPUS, Google Scholar), aiming to locate records of *Scaevola taccada*.

Because the island is a Biosphere Reserve, the collection of specimens for herbaria is not permitted. Thus, in order to make an in-depth comparison of the characteristics of *Scaevola plumieri* and *S. taccada*, we examined voucher specimens of the genus *Scaevola* collected in Mexico and deposited in major Mexican herbaria (CHAPA, CICY, ENCB, MEXU, and XAL, see Index Herbariorum NYBG for more information about herbaria). The characteristics of the voucher specimens were compared to those recorded in at least 20 specimens in the field using a hand lens (20x Coddington, Bausch & Lomb, USA), measurements made with a calliper, and detailed photographs. Afterwards, scientific illustrations were drawn based on high-quality photos taken with a Canon SX270 HS 20x zoom lens and the characteristics recorded in the field. Species characteristics recorded in the field and those observed in the herbarium specimens were used to make the taxonomic description presented here.

Spatial distribution

To determine the distribution of this species throughout the island of Cozumel, in August and November 2019, and again in February 2020, we thoroughly explored the coasts of the island using all the available coastal roads and via boat where there were no roads available, on the north-eastern part of the island. Transects 1 to 2 km long, covering most of the coastline of the island, were walked to record as many plants as possible. Points were taken for each individual, using a Magellan GPS. The largest and smallest diameters of the individual were measured to estimate the plant's area using the ellipse formula. When it was not possible to distinguish between individuals, the cluster of individuals were recorded as one single plant. Geographical data were used to generate a distribution map, and with the individual plant cover records we built a frequency histogram with the different plants size classes.

Results

A literature search through the major academic electronic databases (JCR 2020; SCOPUS 2020; Google Scholar 2020) showed that *Scaevola plumieri* is found along the coast of the Mexican Pacific Gulf of Mexico, and Yucatan Peninsula (Flores Guido 1983; Téllez Valdés and Cabrera Cano 1987; Avendaño-Reyes 2008; Gutiérrez-Báez et al. 2013; Parra-Tabla et al. 2018), whereas *S. rialagartensis* is endemic to the Yucatan Peninsula (Castillo-Campos et al. 2019). No previous scientific records of the presence of *S. taccada* in Mexico were found.

Scaevola taccada is an invasive species that was introduced to the Caribbean islands and the American continent as an ornamental plant for hotel gardens from which it has spread and successfully adapted to the natural environment on dunes and beaches in coastal zones (Grande and

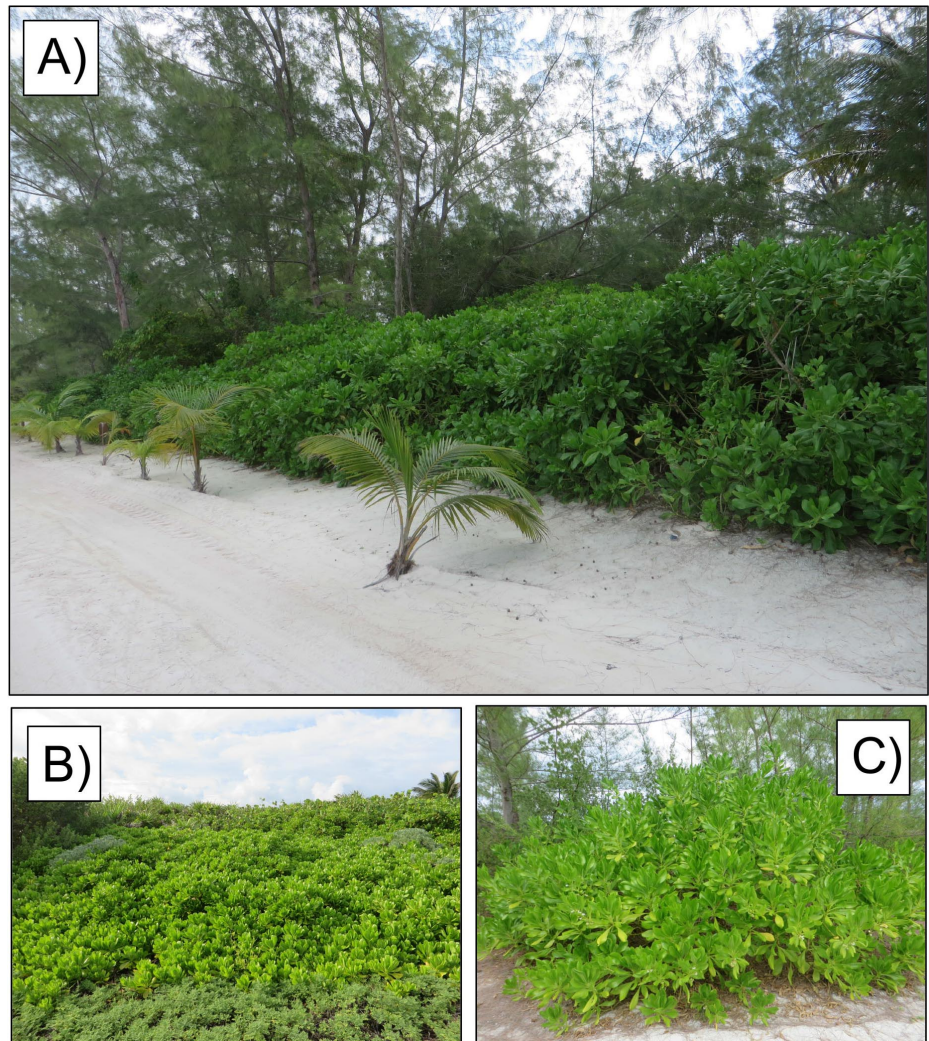


Figure 1. A) *Scaevola taccada* (Gaertn.) Roxb. in its habitat, shrubs on the sand dune. B) Large individual of *S. taccada* on the sand. C) Medium size individual of *S. taccada* (Photos G. Castillo-Campos).

Nozawa 2010). Based on the differences observed between our specimens and those of the species naturally occurring in the American continent, we can positively conclude that our sightings of *S. taccada* are a new record for the municipality of Cozumel, State of Quintana Roo, Mexico (Figure 1).

***Scaevola taccada* (Gaertn.) Roxb. Fl. Ind. (ed. Carey) 2: 146 (1824)**
(Figure 2).

Lobelia frutescens Mill., Gard. Dict. (ed. 8) 1768.

L. taccada Gaertn., Fruct. Sem. Pl. 1: 119–120, pl. 25, f. 5. 1788.

Scaevola billardieri Dieter., Syn. Pl. 786. 1839.

S. leschenaultii A. DC., Prodr. 7: 505 1839.

S. chlorantha de Vriese., Ned. Kruidk. Arch. 2: 137. 1851

S. koenigii Vahl., Sym. Bot. 3: 36. 1794.

S. lambertiana de Vriese., Ned. Kruidk. Arch. 2: 139. 1851.

S. latevaga Hance ex Walp., Ann. 2: 1054. 1852.

S. macrocalyx de Vriese., Ned. Kruidk. Arch. 2: 138. 1851.

S. piliplena Miq., Fl. Ned. Ind. 2: 581. 1856.

S. plumerioides Nutt., Trans. Amer. Philos. Soc. 2(8): 252. 1843.

S. sericea Vahl., Symb. Bot. 2: 37. 1791.

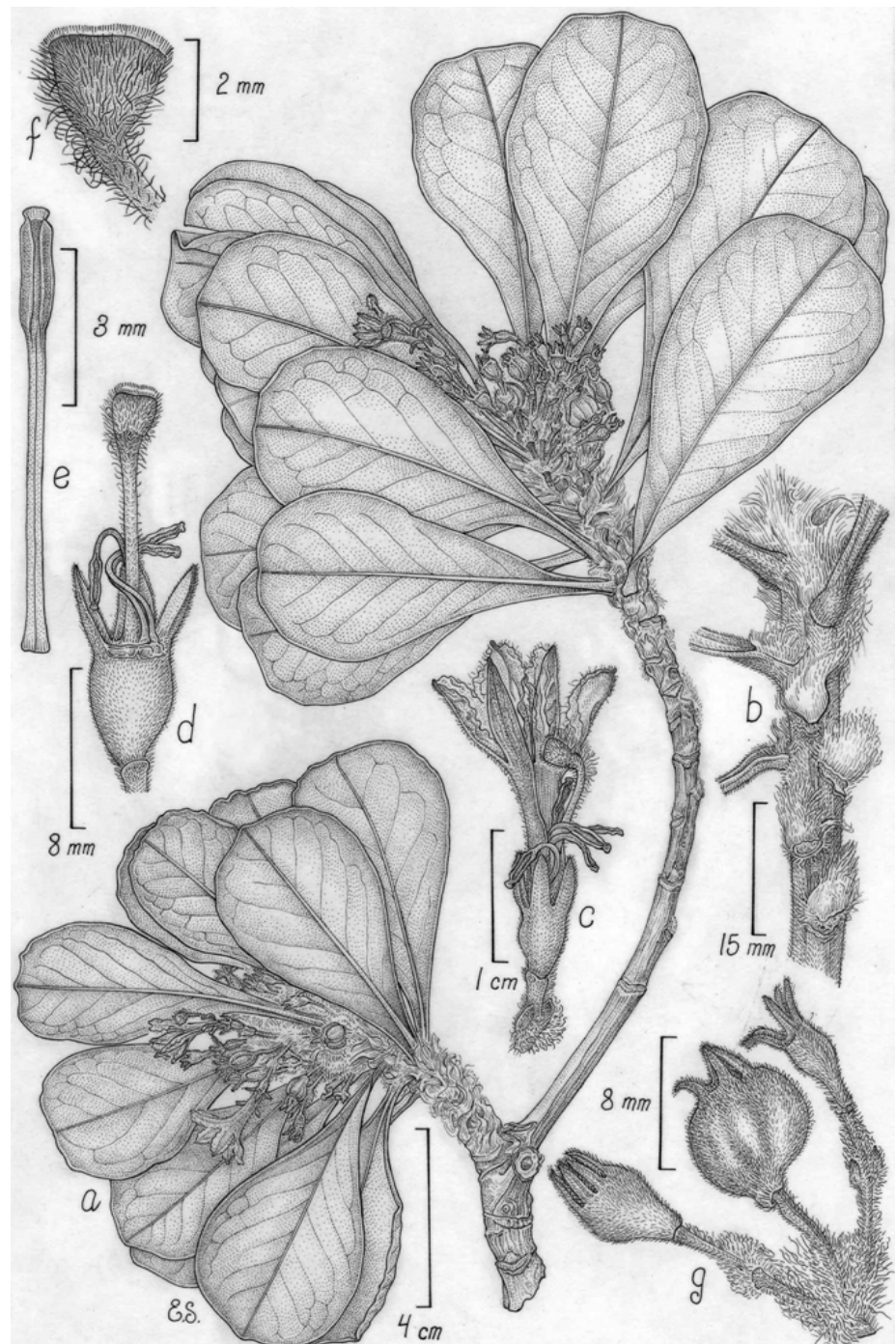


Figure 2. *Scaevola taccada* (Gaertn.) Roxb. a, branch with flowers and fruits; b, detail of the indument; c, flower; d, detail of the flower with the corolla, two sepals and two stamens removed; e, stamen; f, stigma; g, detail of the infructescence. Illustration by Edmundo Saavedra.

Shrubs 1–3 m high, erect or ascending, commonly deciduous, rarely prostrate. *Stem* cylindrical, slightly succulent, whitish, greenish or occasionally yellowish, with numerous leaf scars on younger branches. *Leaves* succulent, alternate, subsessile, arranged spirally along the stem, lower leaves deciduous, upper or terminal leaves mostly aggregated near the branch apex, oblanceolate, spatulate, 7.1–11 × 3.5–4.8 cm, margin entire, scarcely revolute, apex rounded, truncate, occasionally emarginate, base tapered, cuneate, axillary grey bearded, with glossy pubescence; upper surface

pubescent, lower surface densely pubescent (velvety to the touch), reticulate venation, central vein impressed above, prominent below, secondary venation visible above, prominent below, 5–7 pairs of lateral veins. *Inflorescence* paniculate, 2.5–5.3 cm long. *Involucral bracts*, triangular, 2.2–3 × 0.8–2 mm, pubescent. *Peduncles* axillary, 6–11 mm long, 1.6–2 mm thick, pubescent. *Flowers* bisexual, 3–5 per inflorescence, pedicels articulated at the apex, pubescent, 3–8 mm long, 0.6–1 mm thick. *Calyx* persistent, sepals 5, fused in more than half their length, 4–5 × 1.6–2.8 mm in the middle, subulate, 2.6–2.8 × 0.8–1 mm, pubescent. *Corolla* white, woolly internally, 1.5–1.9 cm long, lobes 5, brown when dry, half as long as the corolla tube, lanceolate, subacute, 7.6–11 × 1.4–4 mm, with three longitudinal veins, externally pubescent, internally pubescent towards the base, margin membranaceous, crenulate, tube 7.4–8.8 mm long, 1.4–1.8 mm thick, pubescent, laterally open to about half its length. *Stamens* 5, filaments 5.8–6.8 mm long, 0.2 mm thick. *Anthers* separate or connivant, basifixed, 1.8–2.6 × 0.4 mm. *Style* brown, 9.5 × 0.4 mm, pubescent, incurved, *Stigma* grey, villous, 2.2 mm diam., surrounded by a cup-shaped indusium. *Fruit* a drupe, ovoid-globose, 7–10 mm diam., white, brown when dry, pubescent, 8–10.8 × 4.8–9 mm, epicarp laminar, mesocarp succulent, endocarp woody, bilocular, 8-ribbed, 6.6 × 6 mm, calyx persistent, pubescent. *Seeds* one per locule.

Plant communities and spatial distribution

Scaevola taccada is usually found in the shrub stratum of coastal dune scrub vegetation, growing on white sandy soils, at elevations from 0 to 7 m above sea level, mainly on beaches in the northeast part of Cozumel Island (Figure 3). The prevailing climate type at Cozumel island is Am(f)(i), Köppen's classification, i.e., warm, humid with summer rains, mean temperature of 25.5 °C and mean annual rainfall of 1,570 mm (García 1988). The species commonly associated with *S. taccada* include: *Bidens pilosa* L. (Asteraceae), *Bravaisia tubiflora* Hemsl. (Acanthaceae), *Bursera simaruba* (L.) Sarg. (Burseraceae), *Canavalia rosea* (Sw.) DC. (Fabaceae), *Cassytha filiformis* L. (Lauraceae), *Chiococca alba* (L.) Hitchc. (Rubiaceae), *Coccoloba uvifera* (L.) L. (Polygonaceae), *Conocarpus erectus* L. (Combretaceae), *Ernodea littoralis* Sw. (Rubiaceae), *Hymenocallis littoralis* Salisb. L. *Pancratium littorale* (Jacq.) (Amaryllidaceae), *Ipomoea pes-caprae* (L.) R. Br. (Convolvulaceae), *Lantana incarnata* Raf. (Verbenaceae), *Metopium brownei* (Jacq.) Urb. (Anacardiaceae), *Sesuvium portulacastrum* (L.) L. (Aizoaceae), *Sporobolus virginicus* (L.) Kunth (Poaceae), *Suriana maritima* L. (Surianaceae), *Tournefortia gnaphalodes* (L.) R. Br. Ex Roem. & Schult. (Boraginaceae), *Thrinax radiata* Lood. ex Schult. & Schult. f. (Arecaceae), *Zygophyllum pterocarpum* Bunge (Zygophyllaceae) and *Waltheria indica* L. (Malvaceae) and *Zygophyllum pterocarpum* Bunge (Zygophyllaceae).

We recorded 1,565 plants and plant clumps throughout the Cozumel Island coastal area (Figure 3). Despite the fact that *S. taccada* is used as an

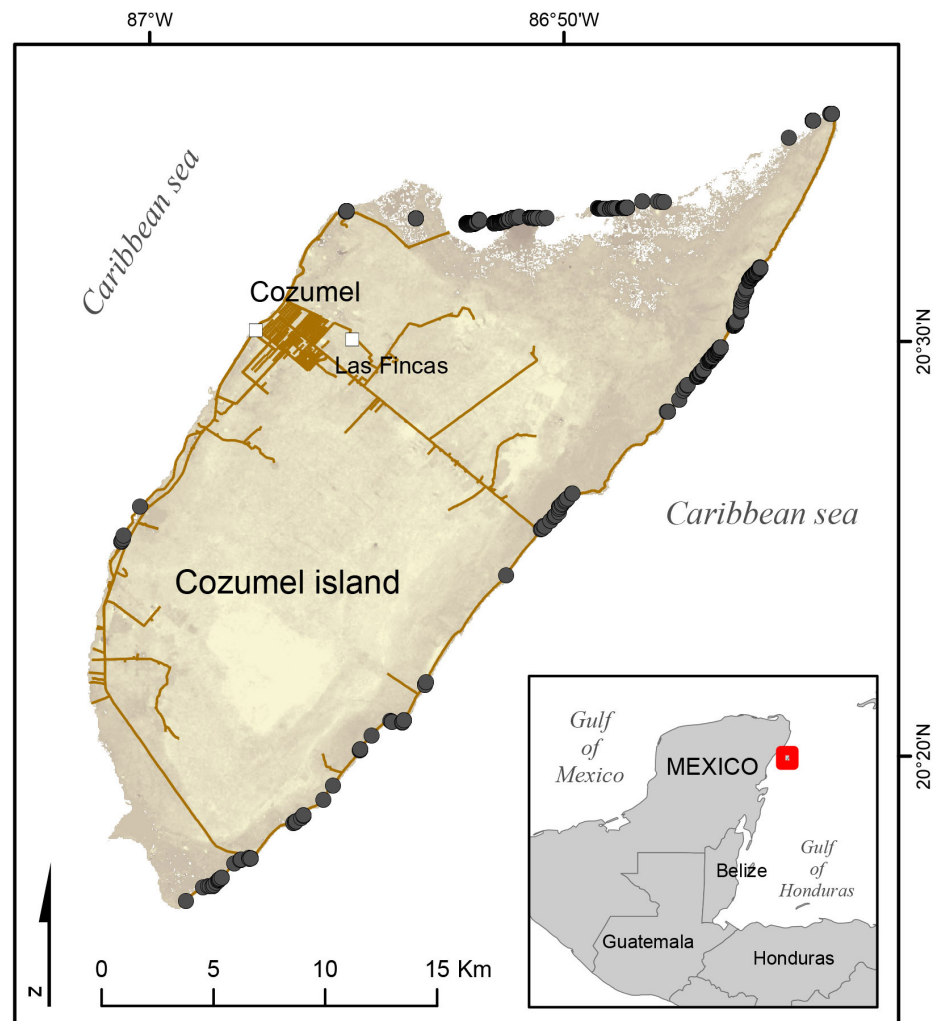


Figure 3. Map showing the register sites (black dots) of *Scaevola taccada* (Gaertn.) Roxb. at Cozumel Island, Quintana Roo, Mexico.

ornamental plant in urban and hotel gardens in the central western and south-western coastal areas, respectively, most individuals of this species are located in the areas specifically destined for the protection of terrestrial and maritime flora and fauna in the north and northeastern side of the island (DOF 2012; SEMARNAT 2016). We also observed different sizes of *S. taccada*, ranging from very small with only 0.10 m in diameter (0.008 m² of coverage), with the largest clumps reaching more than 15 m in diameter (> 200 m² of coverage) (Figure 4). Most individuals were found to be between 1 and 5 m in diameter (0.40 m² and < 20 m²), which are mature and reproductive plants. This suggests that the *S. taccada* population has been expanding in the coastal zone, the smaller plants being of a later generation from the larger, more established plants.

Discussion

Scaevola taccada was introduced to the Island of Cozumel as an ornamental plant for urban and hotel gardens. It blooms almost all year round; however, flowering peaks occur between May and November and produces

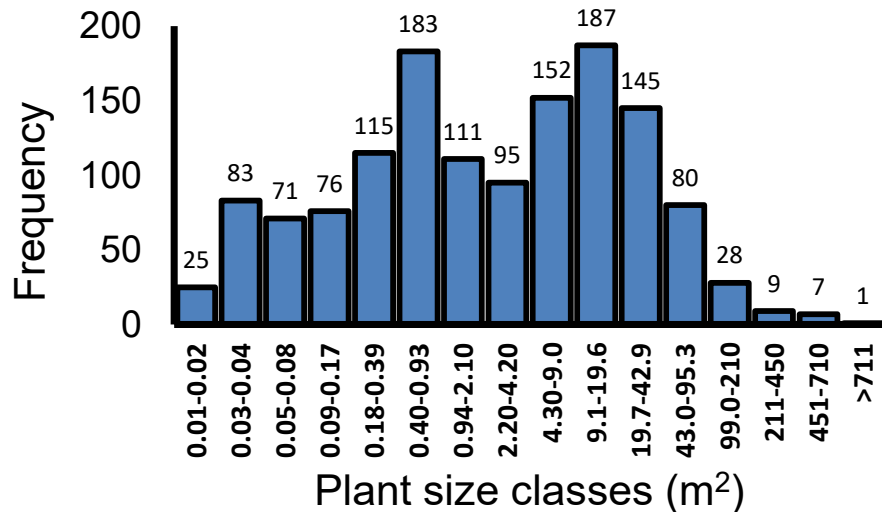


Figure 4. Frequency of *Scaevola taccada* (Gaertn.) Roxb. individuals in to the different size categories according to their coverage (m²) registered on the Island of Cozumel, Quintana Roo, Mexico.

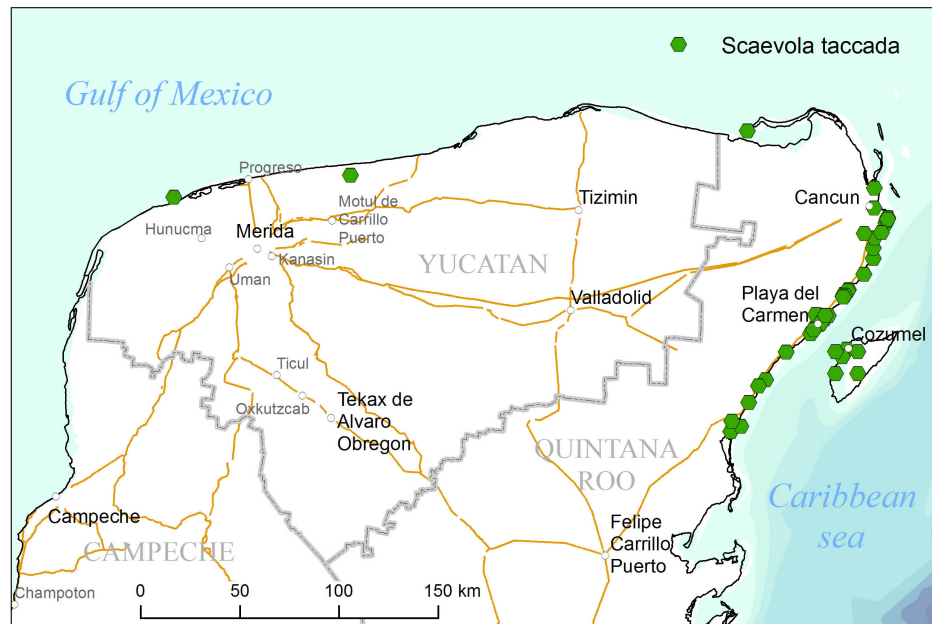


Figure 5. Occurrence records of *Scaevola taccada* found in the Global Biodiversity Information Facility (GBIF) along the coasts of the Yucatan Peninsula (map from GBIF.org).

fruits from July to December. The plant escaped from these sites and has spread widely to the entire coastal area of the island. The fact that we observed populations consisting of individuals of various size classes distributed throughout the island is evidence of this species' invasiveness. Furthermore, the species seems to have become naturalized along the Mexican coasts, but mostly concentrated along the Mexican Caribbean, as indicated by the occurrence information found in the database from the Global Biodiversity Information Facility (GBIF.org 2020). Here 26 records are reported along the Mexican Caribbean, with 4 additional occurrences on the Island of Cozumel, and three more in northern Yucatan Peninsula (Figure 5). As mentioned earlier, to our knowledge, these findings have not

been verified with field observations and are not reported in the published scientific literature. Thus, this is the first report on the invasion by *S. taccada* along the coasts of the Island of Cozumel, with field corroboration.

Apparently, the effective invasiveness of *S. taccada* is associated with the dispersal attributes of its fruits, rather than by the occurrence of a long-lasting seedbank. Although local studies in Mexico do not exist, studies elsewhere can help understand the dispersal modes of the species. In this sense, Emura et al. (2014) observed that fruits collected from the Okinawan islands in Japan had two morphs: one floats on seawater and thus can be dispersed by ocean currents, and the other is eaten and dispersed by birds. On the Island of Cozumel we observed seeds of *S. taccada* in small vertebrate droppings in the northeastern part of the island. It is also possible that birds are eating the fruits. However, we do not have information on which species might be acting as dispersers in Cozumel. Ocean currents are also likely to have promoted the local dispersal of the species, especially because sea water facilitates seed germination by breaking the hard-coat dormancy (Lesko and Walker 1969).

In contrast with the above, there is no evidence that a permanent long-lasting seed bank of *S. taccada* seeds is inducing its invasiveness, since fruits and seeds are predated in the soil and do not accumulate (Louda and Zedler 1985; O'Dowd and Lake 1991).

The broad expansion of *S. taccada* along the coasts of the Island of Cozumel is probably affecting the natural ecosystems of this Biosphere Reserve, especially those from the beach and coastal dunes. In fact, on-going studies in Cozumel are showing an impact in community composition and structure of beach and coastal dunes vegetation (Castillo-Campos et al. *unpublished*). In other tropical locations, such as Florida, Gordon (1998) found ecosystem effects of *S. taccada*, but did not observe a competitive advantage of this species over the native flora.

The potential impact of this broadly expanding invasive calls for more detailed studies on the local reproductive biology and dispersal forms of the species, as well as the effect that the expansion has had on the local flora. This information is highly relevant to help local authorities to implement control programs and tighter restrictions on using *S. taccada* as an ornamental plant.

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