

Rapid Communication

The exotic invasive candle bush *Senna alata* (L.) Roxb. in Baja California Peninsula, México, a new threat for relictual oasis

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Abstract

We recorded the invasive candle bush (*Senna alata*) for the first time in oases of southern Baja California peninsula in October 2013 and February 2015. Candle bush is likely an escape from residential plantings in this region. Data on density, plant cover, number of pods per plant, and seeds per pod are presented. In the oasis of Santiago, candle bush plant density was low and contained mainly mature plants, which made up 90% of the total population. In the oasis of San José del Cabo, population density was higher, but individuals were mostly shorter than 10 centimeters in height, and 60% of the population consisted of seedlings and young plants. Mature plants were seen mainly in full bloom and early fruiting stages. Candle Bush is invading very dry climates in oasis systems, this is the first documented record of the species invading this kind of wetlands and even starting to invade tropical deciduous forest around arroyos. The introduction pathways and time since the introduction of candle bush into the peninsula are unknown, but no records existed before 2013 when we found the population. We strongly recommend eradicating this invasive species from Baja California oases now, while it is in the early stages of invasion.

Key words: ornamental invasive plant, invasion, mesic habitat, dry climate, Santiago, San José del Cabo, Baja California tip

Introduction

The Candle Bush (*Senna alata* (L.) Roxb = *Cassia alata* L.) is a shrub native to South America, from the Amazonian rainforests of Peru, Brazil, French Guiana, Guyana, Suriname, Venezuela and Colombia (Irwin and Barneby 1982; Chatterjee et al. 2012). It is a medicinal and ornamental species that has been introduced and has naturalized in tropical countries of Africa, Asia, Oceania, and North America, where it is widespread. The invaded range of this species includes Cuba, the Caribbean islands, Florida and Hawaii, and Mexico (Irwin and Barneby 1982; USDA 2012). The yellow flowers are attractive and visited by different insects and pollinated by bees and wasps. Candle bush produces several winged pods containing up to 60 seeds each (Dezhao et al. 2010). Seeds are compressed, deltoid or

rhomboid in shape, and have a prolonged dormancy (Arowosegbe 2016). Germination occurs mainly during the wet season and has a fast seedling root growth (Swarbrick and Skarrat 1994; Arowosegbe 2016; Ni et al. 2018). Candle bush is an invasive plant (Richardson and Rejmánek 2011; Sandilyan and Van't Klooster 2016; Ni et al. 2018) that can form dense thickets up to 3–4 m tall, displacing native shrub species in areas with permanent water and in wet temporal open areas displacing native bushes (Smith 1957; Dezhao et al. 2010). Candle bush can impede access to waterways and could be poisonous to stock animals (Guézou et al. 2007). In Australia, Candle bush is included on a list of 15 species of high priority weeds that can have significant impacts (Storrs 1996; Parsons and Cuthberston 2001) and a control program has been developed in Australia for eradication of this species. However, little information exists on the autoecology of candle bush (Richardson and Rejmánek 2011). Humans have moved this species to new areas because of its use as an ornamental and medicinal plant (California Invasive Plant Council 2008; Sandilyan and Van't Klooster 2016). For example, candle bush was introduced in Hawaii in 1871 as an ornamental plant (Motooka et al. 2003). Escapes originate mainly in residential areas (Guézou et al. 2007).

Candle bush appears to have been introduced to Mexico in Veracruz, Sinaloa, Morelos, Michoacán, Tamaulipas, Nayarit, Jalisco, Colima, Puebla, Guerrero, Oaxaca, Tabasco, Chiapas, Campeche, Yucatán and Quintana Roo (Villaseñor and Espinosa-García 2004; GBIF 2018; SEINET 2018; Tropicos.org 2018); the earliest records are from the 1890's and 1930's from Guerrero and Oaxaca (GBIF 2018; SEINET 2018; Tropicos.org 2018). Thus, the introduction to México dates back from more than 100 years ago.

In this note, we present our records of candle bush in the southern tip of the Baja California peninsula, in the Cape region. Candle bush has not been previously reported in the wild in Baja California peninsula, either in the literature or in herbarium records (Garcillán et al. 2013; Rebman et al. 2016). Additionally, until 2018 we have not found candle bush plants in any of our study sites along the 1800 km length of the peninsula. It is unknown when candle bush was introduced to this area.

Materials and methods

We first recorded the presence of candle bush in the Santiago oasis in October 2013. The plant was first noticed in home yards, along arroyos, and in tropical deciduous forest vegetation along waterways (23.443249°N; –109.774997°W) in as well the rural towns of Santiago and Agua Caliente. Candle bush was also recorded in San José del Cabo oasis (23.054710°N; –109.690770°W), Los Barriles (23.671728°N; –109.698761°W) and Santa Anita (23.235351°N; –109.699610°W) arroyos surrounded by xerophytic scrub vegetation. The study site was located in a 21-hectare area of the

Table 1. Candle bush data in the Santiago and San José del Cabo oases, southern Baja California peninsula, in 2013–2015.

	Santiago	San José del Cabo
Sampled area (ha)	21	2
Plant (n)	71	223
Average plant height (m)	1.78 ($\pm$ 0.69)	1.06 ($\pm$ 1.09)
Range plant height (m)	0.17–3.3	< 0.05–5.0
Plant crown cover (average $\pm$ standard deviation) (m ²)	5.09 ($\pm$ 4.53)	1.43 ($\pm$ 2.60)
Density (plants/ha)	3.38	111.50



Figure 1. Candle bush in the Santiago oasis. See a typical habitat in southern Baja California peninsula where the plant was found. A zoom of flowering and fruiting plant is shown in the upper right. Photo composition by authors: habitat RRE, upper corner JJPN.

Santiago arroyo (23.45106°N; –109.75398°W to 23.453639°N; –109.749205°W), and in 2 hectares along the edge vegetation of the estuary of San José del Cabo (23.05162°N; –109.68961°W to 23.05799°N; –109.69116°W).

We measured plant crown cover (m²), number of pods per plant, and estimated plant density (individuals/ha) at each site. We also collected a sample of 50 pods, 5 pods taken randomly from 10 plants. We measured the length and width and counted the number of seeds for each pod. The crown cover was estimated according to the ellipse formula: $C = \pi \cdot 0.25 \cdot d_1 \cdot d_2$; where d_1 is the largest crown diameter and d_2 the diameter perpendicular to d_1 .

Results

A total of 294 plants were recorded in both the Santiago and San José del Cabo oases. In the oasis of Santiago, populations of candle bush were scattered, and consisted mainly (90%) of mature plants. In the oasis of San José del Cabo, density was higher, but individuals were shorter than 10 centimeters in height. 60% of the population consisted of seedlings and young plants (Table 1). Mature plants were mostly in full bloom and early fruiting stages (Figure 1). In Los Barriles and Santa Anita, few plants were recorded, some of which were found in home yards.

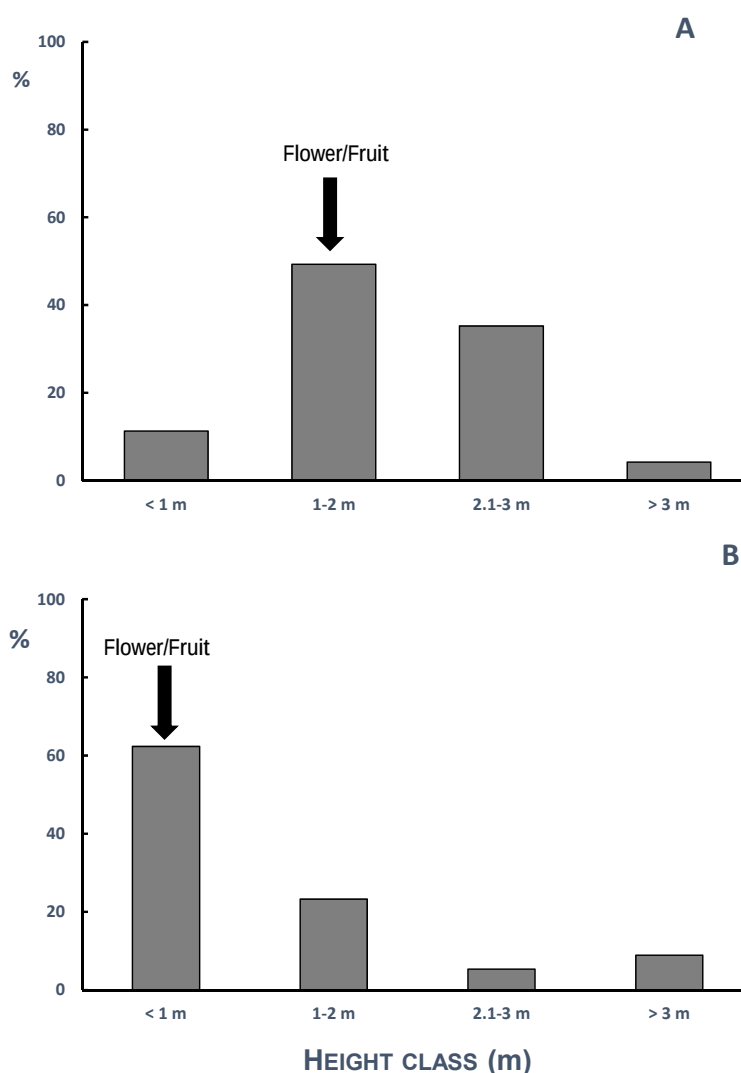


Figure 2. Height categories of candle bush in the Santiago oasis in 2013 (A), and San José del Cabo in 2015 (B), southern Baja California peninsula. The arrow indicates the plant height category where reproductive stages were recorded.

Candle Bush seems to have been introduced by people to each oasis as an ornamental as several home yards contained plants. Subsequently, seeds are likely to have been dispersed through temporal arroyos during flood events. The pathway of invasion appears to have started in home yards inside oases, with the plant dispersing outside the oasis via arroyos. Some plants were 100 m from the edge of the arroyo in the tropical mountainous deciduous forest, indicating that candle bush can escape outside moist areas. In Santiago, most plants had already reached 2 meters in height and were sparsely distributed, forming small patches; no dense candle bush thickets were observed. In San José del Cabo, a wider range of developmental stages were represented in the population, from seedlings to individuals up to 5 m in height (Figure 2).

From the 50 fruits collected, each pod contained an average of 35 seeds (range 27–55 seeds). Higher, mature plants produced more fruits and seeds than lower, younger plants; one mature plant (3 m or taller) may produce 16,000 seeds annually (Figure 3).

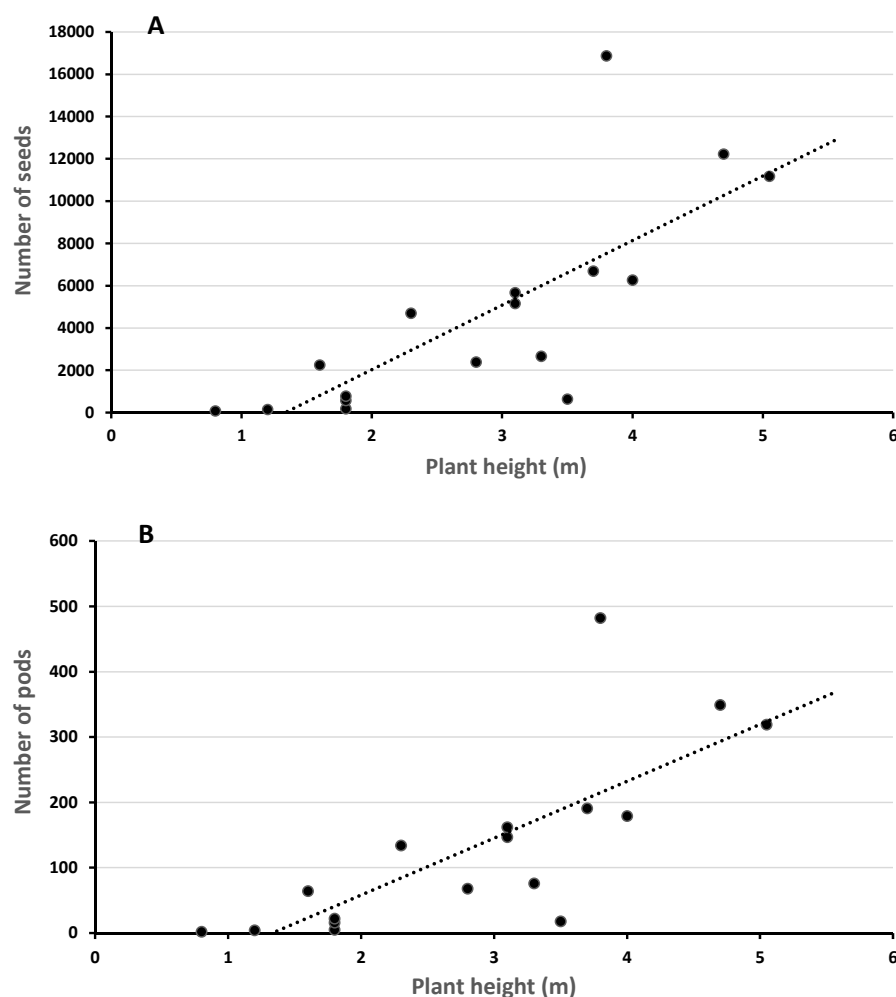


Figure 3. The relationship of candle bush plant height and the production of number of pods (A) and number of seeds (B) in Baja California peninsula populations.

Discussion

Candle bush could become a significant invasive species in Baja California peninsula if it is not controlled and eradicated from the areas in this early stage of the invasion process. Data presented here indicate that *Senna alata* could currently be in an expansion phase (following Williamson and Fitter 1996). In contrast to annual species, invasion of woody plants takes a longer time period. Some of the traits related to the invasiveness of candle bush are: a short life cycle, ability to coppice, a long-distance dispersal via waterways (Irwin and Barneby 1982; Csurhes and Edwards 1998; USDA 2012), and a prolific seed production. The history of introduction of this species in oases of southern Baja California peninsula is unknown, but our records show an association of this plant with riparian areas, which has facilitated its dispersal within the past 10 years. Similar to other introduced ornamental plants that produce copious amounts of seeds (Richardson 2011), candle bush has quickly naturalized and spread in Baja California peninsula oases and arroyos. Of concern is the recent record of candle bush in Loreto town, within the urbanized area not in the wild. This record in the middle of the peninsula is not an escape (GBIF 2018).

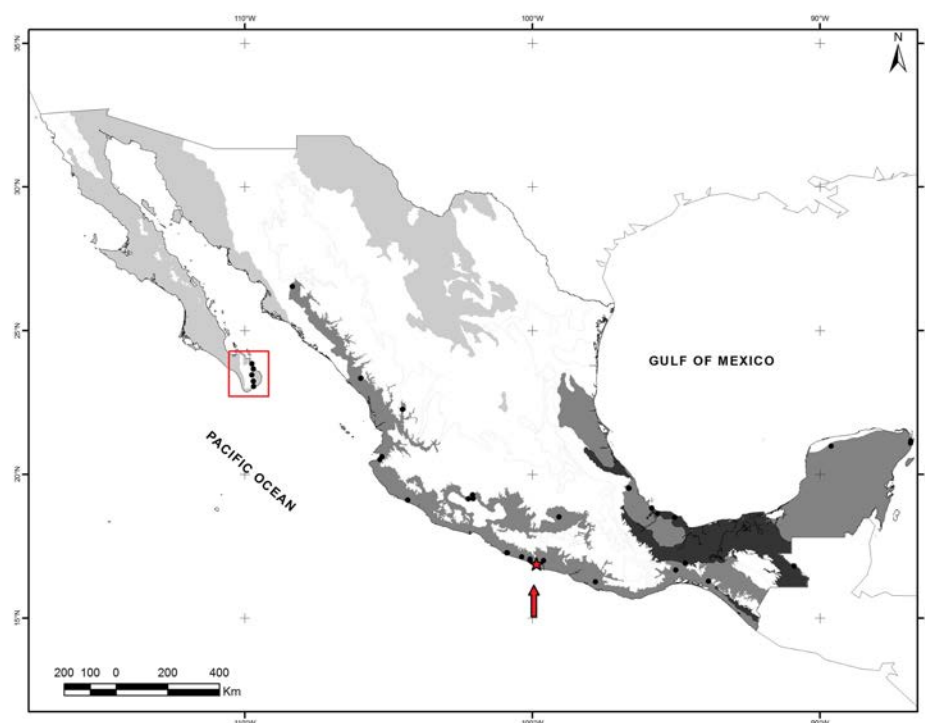


Figure 4. Current distribution map of candle bush in México. Candle bush plant locations reported in this study in southern Baja California peninsula are in the red box. Records from the mainland are in warm, humid (dark gray) and sub-humid (intermediate gray) climates; in our Baja California peninsula study sites, the climate is very dry (light gray). The classification of climates is based on INEGI (2010) data. First herbarium record for México was collected in Acapulco, Guerrero in 1894 (see arrow; SEINet 2018).

Herbarium records of candle bush collected in Mexico indicate that this plant generally occurs in warm humid and sub-humid climates (Figure 4; Table S1); however, our records in the Baja California peninsula are located in very dry climate in oasis habitats. Candle bush can tolerate arid climates but preference for humid, sub-humid or seasonally humid tropical climates have been reported (Invasive Species Compendium 2018, Irwin and Barneby 1982). Our records in Baja California peninsula show candle bush can tolerate very dry climates although invasion occurs mainly in the moist oasis system. Oases are small, fragile relict mesic habitats in the arid desert ecosystem of the Baja California peninsula that contain a significant number of endemic and water-dependent species from all taxon groups (Rodríguez-Estrella et al. 2010). Oases have been invaded by exotic species such as rubber vine (*Cryptostegia grandiflora*), giant reed (*Arundo donax*), bamboo (*Bambusa vulgaris*), and salt cedar (*Tamarix aphylla*), and also by bullfrogs (*Lithobates catesbeianus*) and tilapia (*Coptodon zillii*, *Oreochromis niloticus*) (Luja and Rodríguez-Estrella 2010; Rodríguez-Estrella et al. 2010; Pérez Navarro et al. 2019). The invasion of Candle bush adds to the threats that native species of relict oases are currently facing in Baja California peninsula and that put their existence at risk, which in turn affects the function and structure of these systems. Monitoring of candle bush populations in Baja California peninsula should continue. However, an

eradication program of invasive species, candle bush in particular, from fragile oases has been proposed and should be implemented soon as funding is now available. Catching this species early in the invasion process will ensure that resources are saved in conserving oases of the Baja California peninsula.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Records of candle bush in México.

This material is available as part of online article from:

http://www.reabic.net/journals/bir/2020/Supplements/BIR_2020_Navarro_Rodriguez-Estrella_Table_S1.xlsx