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STATUS OF ENDEMIC *SCAEVOLA PLUMIERI* AND INVASIVE *SCAEVOLA TACCADA* ON SAN SALVADOR ISLAND, BAHAMAS

Adam J. Finkle and Nancy B. Elliott
Biology Department
Siena College
515 Loudon Rd.
Loudonville, NY 12211

ABSTRACT

Island species are remarkably sensitive, making them particularly susceptible to the impact of non-native invaders. Without natural competitors, parasites, or predators present, invasive species can spread rapidly and out-compete endemic species, causing serious ecological problems. The relationship between two co-generic plant species *Scaevola plumieri* (L.) Vahl and *Scaevola taccada* (Gaertn.) Roxb. was examined on San Salvador Island, Bahamas. *Scaevola plumieri*, native to the Americas and southern Africa, has long been a fixture of dune vegetation in Florida, the West Indies, and the Bahamas. *Scaevola taccada* was recently introduced to the region from the Indo-Pacific and has encroached upon the habitat of *S. plumieri*.

INTRODUCTION

Research dating back to the mid 19th century has recognized *Scaevola plumieri* (inkberry) as a common constituent of the Bahamian beach strand community (Eshbaugh and Wilson, 1985). *Scaevola plumieri*, with its white half-flowers, dark, glossy, fleshy fruit, and medium-sized green leaves continues to be a prominent member of the Bahamian flora (Figure 1). In contrast, the larger beach strand shrub *Scaevola taccada* (beach naupaka, white inkberry) was absent according to the early literature and was likely introduced to the region as an ornamental species only in the mid-1970's (Eshbaugh and Wilson, 1985; Fried and Kerwin, 1998; Kass, 2005). In 1982, Correll and Correll noted the presence of *S. taccada* with white-fringed, purple-striped half-flowers, large, light green leaves, and white, corky fruit on the northern Bahamian islands of Grand Bahama, the Abacos, and Andros (Figure 2). While both species are similar and morphologically plastic, no hybridization between the two has been observed (Koontz et al 1996).

Since its introduction as an ornamental, *S. taccada* has spread extensively, becoming well established throughout the Bahamas. Nellis (1994) first noted the encroachment of *S. taccada* onto the beach strand in Florida and throughout the Caribbean in the mid-1990's. Shortly thereafter, Eshbaugh and Wilson (1996) documented the situation on Andros Island where *S. taccada* had altered the beach strand community by encroaching upon native flora. Once introduced, *S. taccada* continues to spread naturally due to the ability of its seeds to float, survive prolonged exposure to salt water, and remain viable after digestion by avian species (Eshbaugh and Wilson, 1985; Koontz et al 1996). These, among other observations, led members of the Bahamas Environmental and Technological Commission to list *S. taccada* as an invasive plant species in need of eradication in their 2003 publication, The National Invasive Species Strategy for the Bahamas.

Since Correll and Correll (1982) first observed *S. taccada* in the Bahamas, the species has spread southeast to the out-islands. In a letter to the Bahamas National Trust Scientific Advisory Committee, Dr. Lee Kass (2007) discussed the presence of the invasive plant on San Salvador Island. Kass (2007) and Eshbaugh and Wilson (1996) speculated that the species was introduced to San Salvador Island in 1992 when Club Mediterranean was established and countless exotics were introduced. Over the past eighteen years, it is likely that several ornamentals escaped from the resort, subsequently colonizing the island. Since

its introduction to San Salvador Island, *S. taccada* has become remarkably well-established as an ornamental, and has begun to encroach upon *S. plumieri* along several beach strands (Figure 3). The purpose of this research is to provide a preliminary report describing the distribution of *S. plumieri* and *S. taccada* on San Salvador Island with regard to commercial and residential development.

Figure 1- Scaevola plumieri with white half-flowers, small, immature fruit, and dark, fleshy, mature fruit. Photographed at The Thumb, San Salvador, Bahamas.

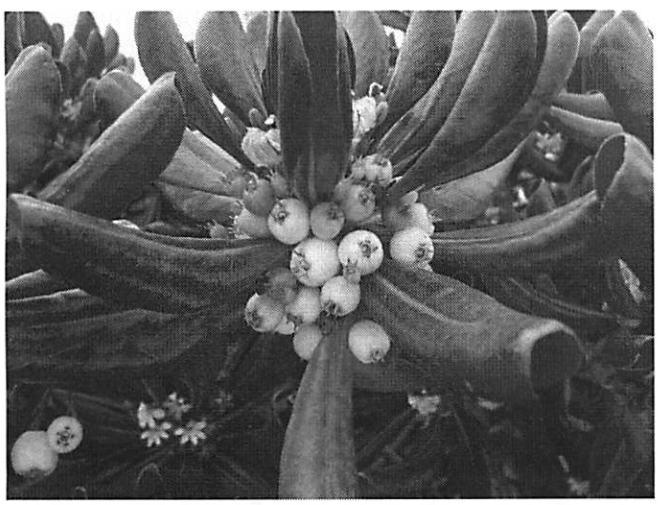

Figure 2- Scaevola taccada with purple striped white half-flowers and white, spongy fruit. Photographed at Lindsay Reef, San Salvador, Bahamas.

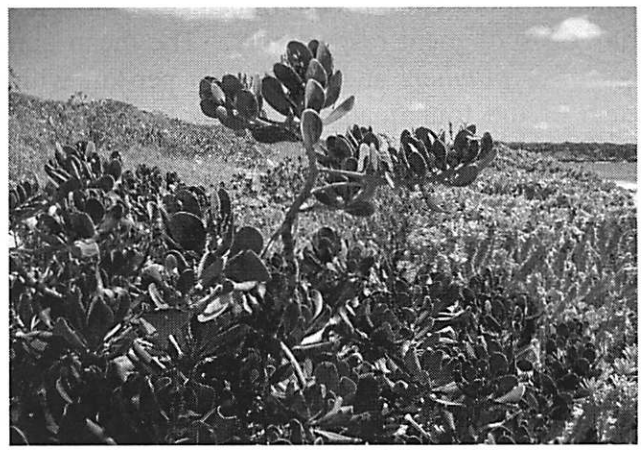

Figure 3- Scaevola plumieri projecting up out of large S. taccada illustrating interaction observed between the species where they co-occur. Photographed along East Beach, San Salvador, Bahamas.

METHODS

From July 24th-August 2nd, 2008 a preliminary survey of 10 beach strand and 24 residential-roadside transects was conducted on San Salvador Island. Within each transect, the number of *S. plumieri* and *S. taccada* specimens were recorded and the dimensions of each were measured using an electronic distance meter to ensure accuracy and consistency. Transects were completed at various intervals around the island and ranged in length from 0.1km-2.9km.

After completing the preliminary census, the number of *S. plumieri* and *S. taccada* specimens-per-km was determined within each transect. The island was then divided into four quadrants based on the level of development in each (Figure 4). The southeastern quadrant which stretched from Almgreen Cay south to the Bluff, was largely undeveloped (n = 1 transect). The southwestern quadrant was moderately developed and included the Columbus Landings development (n = 6 transects). The northeastern quadrant was also moderately developed and contained the United Estates and Brandy Hill settlements (n = 11 transects). The northwestern quadrant was highly developed, stretching from Sugarloaf north to the Gerace Research Centre (n = 16 transects). The northwestern quadrant contained Cockburntown, Riding Rock Marina, San Salvador Interna-

tional Airport, Club Mediterranean and the Victoria Hill settlement respectively. The mean number of *S. plumieri* and *S. taccada* per-km within each of the four quadrants was then determined for beach strand and residential roadside transects. P-values were generated to determine whether significant differences in distribution existed within any of the four quadrants.

RESULTS

Scaevola plumieri and *S. taccada* were both present on the beaches of San Salvador Island. Within the ten beach strands surveyed, the density of *S. plumieri*-per-km exceeded that of *S. taccada*-per-km by an order of magnitude ($p = 0.02$), (Table 1). However, within 24 residential and roadside transects, the mean number of *S. taccada*-per-km exceeded the mean number of *S. plumieri*-per-km by an approximate factor of eight ($p = 0.001$), (Table 1). The largest individual *S. plumieri* specimen was recorded in the South-central depression of Cut Cay, where an individual measuring 28.6m x 25.8m x 25.8m was observed. Some of the largest *S. taccada* specimens were planted as ornamental shrubs in Columbus Landings, measuring 21.1m x 5.44m x 5.38m and 22.5m x 3.67m x 7.85m.

The highest concentration of *S. plumieri* was observed along East Beach beginning at the Brandy Hill Junction and extending south 2.8km to the eastern Columbus Monument. Within this transect, an average of 338.6 *S. plumieri*-per-km were recorded, while no *S. taccada* were observed. Other notable populations of *S. plumieri* extended from the East Beach-Brandy Hill Junction northward 1.8km to the Hannah Bay Cliffs (244.4 *S. plumieri*-per-km v. (0) *S. taccada*) and from The Thumb north 2.9km to Almgreen Cay (207.6 *S. plumieri*-per-km v. 3.448 *S. taccada*-per-km). Along each of the transects where *S. plumieri* flourished, the beach was undisrupted, allowing the shrub to spread extensively, fully populating the beach strand between the high tide line and the *Coccoloba* groves bordering dune forest and coastal scrub.

A large population of *S. taccada* was observed along a 0.3km transect at the Riding Rock Inn, where numerous specimens had been planted as ornamentals. A large hedge was observed bordering the pool, several individual specimens were incorporated into the landscape, and large specimens were observed shielding the beachside patios of each ocean-view villa. At the Riding Rock Inn, 43.44 *S. taccada*-per-km were observed, while *S. plumieri* was absent from the transect. A second large population of *S. taccada* stretched from the Long Bay intersection south through the Olympic Monument grounds. Within this 0.3km transect, approximately 80.0 *S. taccada*-per-km were observed while again, no *S. plumieri* were recorded. Several other notable concentrations of *S. taccada* existed south of Grotto Beach in Columbus Landings where many homeowners planted ornamental *S. taccada* which had subsequently overgrown. In addition, many residential properties along the Prince's Highway contained ornamental populations of *S. taccada*. We suspect that a sizeable population of *S. taccada* also exists within the Club Mediterranean compound but were unable to confirm.

Within the undeveloped southeastern quadrant of the island, stretching from Almgreen Cay south to the Bluff, a single 2.8km transect was surveyed. The mean number of *S. plumieri*-per-km exceeded the number of *S. taccada*-per-km 207.6 to 3.448 within this quadrant (Figure 5a). The southwestern quadrant of the island had been moderately developed and stretched from the Gulf to Sugarloaf ($n = 6$ transects which ranged in length from 0.1km-0.3km). The mean number of *S. taccada*-per-km exceeded the number of *S. plumieri*-per-km 21.11 to 18.06 within the moderately developed southwestern quadrant (Figure 5b), but the difference was not significant ($p = 0.88$). The northeastern quadrant of the island had also been moderately developed and extended from the Gerace Research Centre to Crab Cay ($n = 11$ transects ranging from 0.1km-2.9km). The northeastern quadrant yielded an average of 70.59 *S. plumieri*-per-km and 16.11 *S. taccada*-per-km (Figure 5c), the difference was not statistically significant ($p = 0.14$). The highly developed northwestern quadrant ($n = 16$ transects ranging from 0.1km-12.0km) stretched from the Sugarloaf Settlement north to the Gerace Research Centre.

Within this quadrant, an average of 35 *S. taccada*-per-km were recorded, while an average of 5.3 *S. plumieri*-per-km were observed (Figure 5d), the difference was statistically significant ($p < 0.001$).

*Table 1- Mean S. plumieri-per-km and S. taccada-per-km along beach transects, roadways and within residential areas of San Salvador Island, Bahamas. (*Values = Mean number of individuals-per-km of transect +/- SD).*

Transect Type (# of transects)	*S. plumieri**	*S. taccada**
Beach (n = 10)	107.1 +/- 115.4	12.1 +/- 20.8
Residential-Roadside (n = 24)	4.4 +/- 21.4	31.1 +/- 28.6

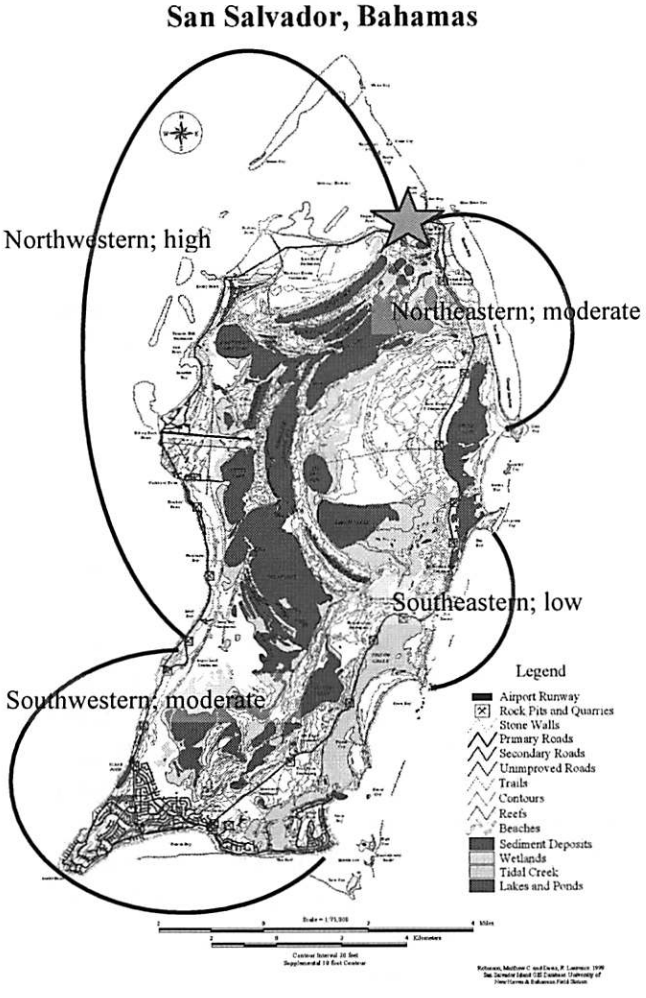

Figure 4- Map of San Salvador Island, Bahamas (Robinson and Davis, 1999) denoting quadrants surveyed for S. plumieri and S. taccada, approximate level of development in each, and the location of the Gerace Research Centre (star).

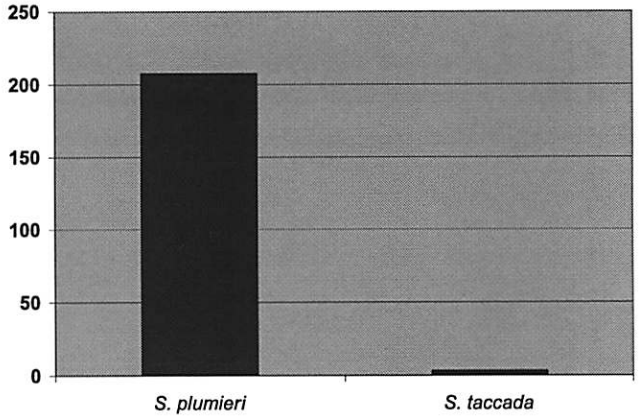

*Figure 5a- Mean number of S. plumieri and S. taccada specimens-per-km transect along the **undeveloped southeastern coastline** of San Salvador (n = 1).*

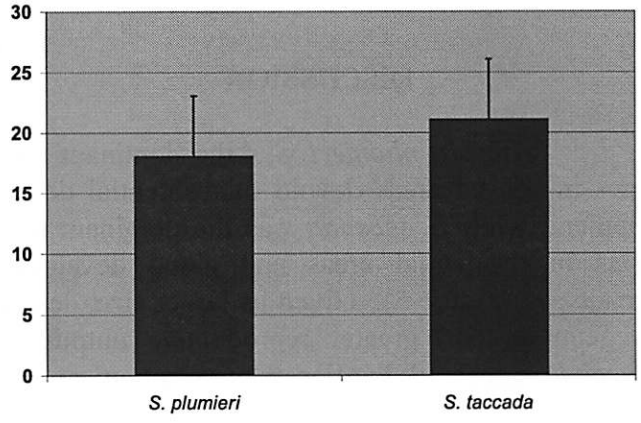

*Figure 5b- Mean number of S. plumieri and S. taccada specimen- per-km transect along the **moderately developed, southwestern coastline** of San Salvador (n = 6; p = 0.88).*

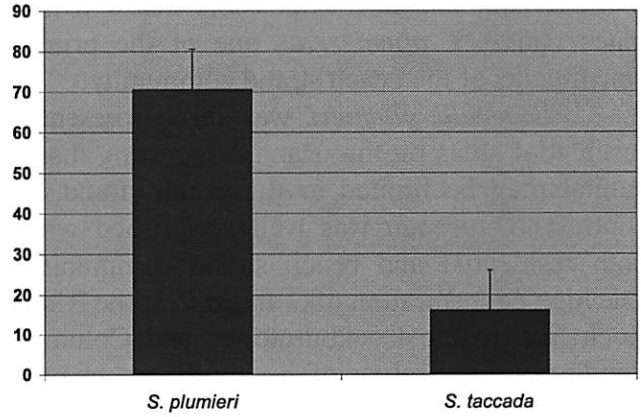

*Figure 5c- Mean number of S. plumieri and S. taccada specimens-per-km transect along the **moderately developed, northeastern coastline** of San Salvador (n = 11; p = 0.14).*

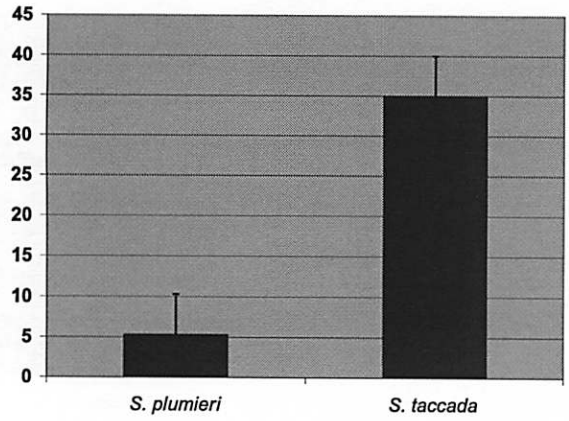

Figure 5d- Mean number of S. plumieri and S. taccada specimens-per-km transect along the ***highly developed northwestern coastline*** *of San Salvador (n = 16; p < 0.001).*

DISCUSSION

Scaevola plumieri was the dominant species in coastal areas devoid of residential development, while *S. taccada* was the dominant species in residential areas and along developed roadways (Figure 5). Given its larger size, denser vegetation, and greater reproductive output, *S. taccada* appeared hardier than *S. plumieri* and able to spread rapidly along the beach strand of San Salvador Island. In several instances, stalks of *S. plumieri* were observed projecting up out of large *S. taccada* shrubs (Figure 3). If *S. taccada* continues to establish itself along the beaches of San Salvador Island, it is possible that it will replace native *S. plumieri* as one of the primary constituents of the beach strand community.

Scaevola plumieri was rarely present in residential areas on the island, suggesting that its habitat may be limited to the beach strand. In contrast, *S. taccada* was well established within both residential and beach strand communities. The high concentration of *S. taccada* at the Riding Rock Inn, within Cockburntown, and Columbus Landings is indicative of its appeal as an ornamental shrub and suggests that the development of the beach strand and surrounding communities plays a pivotal role in the spread of invasive *S. taccada.* The preservation of the beach strand is therefore imperative to the preservation of *S. plumieri* and other native flora threatened by the encroachment of *S. taccada.*

In the United States, the Florida Exotic Pest Plant Council has listed *S. taccada* as a Category 1 pest plant, restricting its use as an ornamental due to its impact on *S. plumieri* and *Tournefortia gnaphalodes* (endangered bay lavender) (AFFN, 2004). Category 1 legislation designates *S. taccada* as one of many "invasive exotics that are altering native plant communities by displacing native species, changing community structures, or ecological functions, or hybridizing with natives" in Florida (FLEPPC, 2007). In addition, the Florida Department of Environmental Protection has identified *S. taccada* as a species which quickly displaces the natural habitat of *Tournefortia gnaphalodes*, *Okenia hypogaea* (beach peanut), *Jacquemontia reclinata* (beach clustervine), and *Scaevola plumieri*, all of which act as primary dune stabilizers (FDEP, 2008). Furthermore, on Andros Island, *S. taccada* has spread rapidly and encroached upon the beach strand, altering the entire community structure (Eshbaugh and Wilson, 1996). The interaction between *S. plumieri* and *S. taccada* on Andros, coupled with progressive legislation against *S. taccada* elsewhere in the region reinforces the decision of the Bahamas Environmental and Technological Commission to list *S. taccada* as a species in need of eradication.

The relationship between *S. plumieri* and *S. taccada* on San Salvador Island has the potential to mirror their unfortunate history elsewhere in the tropics (Nellis (1994); Eshbaugh and Wilson (1996); AFFN, (2004); Hickey (2007); FDEP, (2008); FLEPPC, (2008)). However, if *S. taccada* can be isolated to or extirpated in its present locations around the island, a situation similar to that on Andros may be avoided. The distribution patterns of *S. plumieri* and *S. taccada* on San Salvador Island must be closely monitored over the coming years in order to reach sound conclusions regarding the impact of commercial and residential development on the status of each species. Additional research is currently underway on San Salvador which will allow a complete statistical analysis to be conducted, yielding important in-

formation regarding the relationship between *S. plumieri* and *S. taccada*.

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