UNIQUENESS OF THE ENDANGERED FLORIDA SEMAPHORE CACTUS (*OPUNTIA CORALLICOLA*)

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ABSTRACT

Morphological analysis led to the conclusion that Florida Semaphore Cactus is a distinct species. That conclusion is congruent with genetic studies reported elsewhere. Our plants are properly called *Opuntia corallicola* (Small) Werdermann (*O.* subgenus *Consolea*). The Florida plants are not *O. spinosissima*, as recorded in recent literature. Indeed, the Florida plants are probably more closely related to *O. rubescens* and *O. millspaughii* than to *O. spinosissima*. Details of the Florida species, and a key to similar and confusing Caribbean relatives are provided. Because of the limited number of individuals remaining in the wild, the threat from the alien pest moth *Cactoblastis cactorum*, the low genetic diversity within Florida, and recent damage by Hurricane Georges, the Semaphore Cactus may be the most endangered plant in the United States.

RESUMEN

El estudio morfológico nos lleva a la conclusión de que el cactus semáforo de Florida es una especie distinta. Esta conclusión está de acuerdo con los estudios genéticos publicados en otros lugares. Las plantas son propiamente llamadas *Opuntia corallicola* (Small) Werdermann (*O.* subgénero *Consolea*). Las plantas de Florida no son *O. spinosissima*, tal como fue publicado en la literatura reciente. Es mas, las plantas de Florida probablemente son más cercanas a *O. rubescens* y *O. millspaughii* que a *O. spinosissima*. Se ofrecen detalles de la especie de Florida y una clave taxonómica de las especies emparentadas y confusas del área del Caribe. Dado el número limitado de individuos que quedan en estado salvaje, la amenaza de la polilla alóctona *Cactoblastis cactorum*, la poca diversidad genética dentro de Florida, y el reciente impacto del huracán Georges, el cactus semáforo puede que sea la planta más amenazada de los Estados Unidos de Norte América (EEUU).

In 1930, John K. Small described a cactus from the Florida Keys as a new species that he called *Consolea corallicola*. Very little was known about the species in the 1930s and in the subsequent decades until it became a candidate for endangerment in the 1970s under the name *O. spinosissima*.

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Cactus hobbyists were thought to have eliminated the species from the state in the late 1970s. Even George Avery, a student of the Keys flora for 25 years at the time, could not locate the plants because they no longer grew where he had known them (Austin et al. 1980; Avery 1981). Somewhat later Ann Williams (in litt. 1986) found plants in the lower Keys and brought them to everyone's attention. Eventually the land on which the Semaphore Cactus grew was purchased by The Nature Conservancy and it is now managed as a preserve (Gordon & Kubisiak 1998; Negrón-Ortiz 1998).

Although the Florida Semaphore Cactus rarely appears in the literature, there has been a raging controversy behind the scenes about what species it really is. Long and Lakela (1971) seem to be responsible for first calling the plants *Opuntia spinosissima* Miller, and they recorded it as endemic to Florida even though that name was given originally to Jamaican plants (Britton & Rose 1937). *Opuntia spinosissima* was picked up by those compiling the "Smithsonian List" of endangered species from the 1970s and that name continued to be used in subsequent publications (e.g., Benson 1982; Palmer 1984; Wunderlin 1998; Negrón-Ortiz 1998).

In the early 1980s, unpublished letters were being exchanged by Richard Howard of Harvard University and George Avery of Miami. Swayed by Howard and Touw's (1982) comments on the Lesser Antilles plants, Avery decided that the Florida Keys plants must be *Opuntia rubescens* Salm-Dyck. ex DC. (G. N. Avery, in litt.).

This was the state of affairs in 1990 when Doria Gordon (The Nature Conservancy, Gainesville), who was concerned about their plants on the preserve, brought the problem to our attention. We present here the first results of our studies. Other studies examine the genetic relationships of these endangered plants and their relatives (Dougherty 1996; Gordon & Kubisiak 1998).

To discover the evolutionary and nomenclatural status of the Florida plants, it was first necessary to determine what taxa have been considered related to those plants. Various authors have considered this alliance at different ranks. Some consider *Consolea* Lemaire a distinct genus (Areces 1996). We consider it a subgenus, e.g., *Opuntia* subg. *Consolea* (Lemaire) A. Burger.

Methods. Survey of the literature revealed nine nominate species. Areces (1996) has excluded *O. bahamana* from them and we concur (Fig. 1). We were able to obtain live specimens of six of the taxa. Live material of these six remains in the collections at Fairchild Tropical Garden. Duplicates have been sent to the University of Arizona and Desert Botanical Garden, Tempe. From the living material available, and the literature records of the other species, we created a data matrix of morphological traits that may be used for recognizing these various plants. We present here only those six species most likely to be confused with the Florida plants (Table 1).

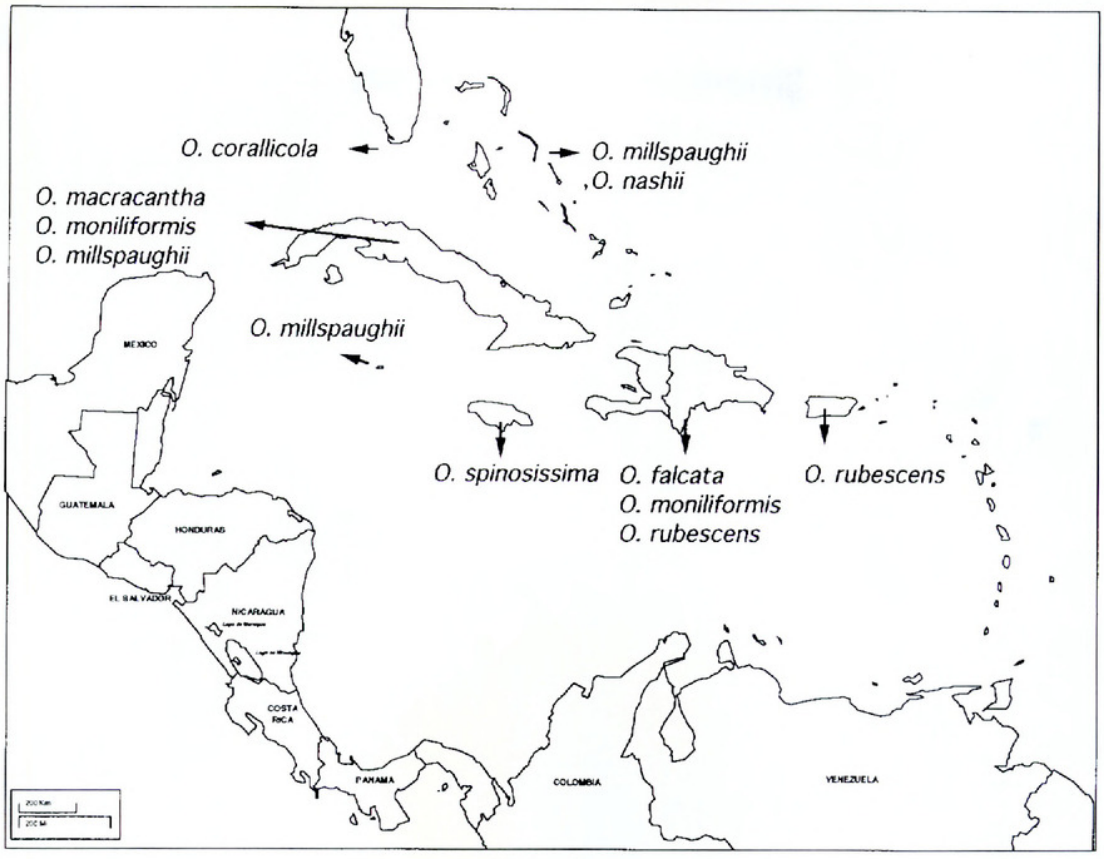

FIG. 1. Distribution of the species in *Opuntia* subgenus *Consolea*. This subgenus is confined to the Caribbean.

Results and Conclusions. Confusion of *O. corallicola* with *O. spinosissima* apparently resulted from previous studies not having examined living plants (Austin and Pinkava 1991). Although names are not fixed by typification in *O. spinosissima* and *O. rubescens*, we are applying them consistently with historical usage. Moreover, the morphotypes have distinct ranges (Table 1) consistent with historical name application, and with the usage by Areces (1996).

As stated by Britton and Rose (1937), *O. spinosissima* is endemic to Jamaica. Although *O. rubescens* is widespread in the upper Antilles (Fig. 1), it too is distinct from the Florida plants. In addition to morphological traits, *O. rubescens* has $2n=132$ chromosomes in the living material we examined. Previous reports have given *Opuntia rubescens* as $2n=22$ and 132 (Spencer 1955; Katagiri 1952; Yuasa et al. 1973). We do not know if these reports represent different chromosome races or misidentifications. At least the numbers are consistent with polyploid series known within the genus (Pinkava et al. 1985).

Analysis of morphology indicates that the Florida population of Semaphore Cactus, *O. corallicola*, is related to *O. millspaughii*, *O. rubescens*, and

TABLE 1. Comparative morphology of Caribbean species confused with *O. corallicola*.

Traits	*corallicola*	*spinosissima*	*rubescens*	*millspaughii*	*nashii*	*moniliformis*
Distribution	Florida Keys	Jamaica	Hispaniola & Puerto Rico to Guadelupe	Cuba and the Bahamas to Caymans	Bahamas	Cuba
Habitat	mesic	xeric	xeric	xeric	xeric	xeric
Height	1–3.5 m	1–3.5 m	5–10 m	±4 m	1–3.5 m	≤5 m
Areoles	not reticulate	reticulate	not reticulate	reticulate	not reticulate	reticulate
Areole distance	1–1.5 cm	1–1.5 cm	1–1.5 cm	1–1.5 cm	1.5–3 cm	1–1.5 cm
Areole level	sunken	raised	raised	raised & pitted	raised & pitted	raised
Pad shape	elliptic	oblong-linear to oblong	oblong-linear to oblong	lanceolate to lanceolate-oblong	oblong-linear to oblong	oblong-linear to oblong
Joint length	1–3 dm	3–5 dm	1–3 dm	3–5 dm	≤10 dm	1–3 dm
Spine color	gray or white	straw	straw	gray or white	gray or white	gray or white
Spine location	entire surface	entire surface	entire surface	marginal	entire surface	marginal
Maximum spine number	1–5	1–5	5–9	1–5	1–5	1–5
Spine shape	acicular	acicular	subulate	acicular	acicular	subulate
Spine length	7–12 cm	7–12 cm	7–12 cm	>12 cm	3–5 cm	7–12 cm
Spine direction	deflexed	deflexed	spreading	deflexed	deflexed	spreading
Petal apex	acute	rounded	acute	acute	acute	rounded
Petal length	10–15 mm	10–15 mm	10–15 mm	≤5 mm	10–15 mm	10–15 mm
Maximum pericarpel length	5–6 cm	7–8 cm	5–6 cm	3–4 cm	3–4 cm	5–6 cm
Fruits	proliferous	non-proliferous	proliferous	non-proliferous	proliferous	non-proliferous
Chromosomes	2n=66	2n=?	2n=22, 132	2n=66	2n=?	2n = 22

the Jamaican endemic *O. spinosissima* (Austin and Pinkava 1991). Chloroplast DNA study (Dougherty 1996) supports that conclusion. The morphological data (Table 1) indicates more similarities between *O. millspaughii* and *O. corallicola* than between the others. RAPD data (Gordon & Kubisiak 1998) also indicate that *O. corallicola* is more closely related to *O. millspaughii* (Cayman Brac plants of Gordon & Kubisiak 1998) than to *O. spinosissima*.

As the Cayman Brac plants are a species (*O. millspaughii*) that ranges geographically closer to Florida than Jamaica, the morphological and genetic results are consistent with biogeographic predictions (Brown 1998). More exact relationships among the various species within *Opuntia* subg. *Consolea*, and between those species and the remainder of the genus will be reported by Areces (New York Botanical Garden).

We conclude that Small (1930) was correct when he proposed the Florida Semaphore cacti as distinct. While this uniqueness was confused by use of the name *O. spinosissima* in recent literature, available data indicate that the Florida and Jamaica plants are markedly different species. The Jamaica plants are morphologically unique (Table 1) and endemic to that island, as originally recorded by Britton and Rose (1937).

TAXONOMY

The complete taxonomy of the group *Consolea* is being revised by Areces (1996). Here, only the Florida taxon will be addressed.

Opuntia corallicola (Small) Bakeberg, Neue Kakteen, Jagden, Arten, Kultur. Gartenbau-Verlag Trowitzsch and Shon, Frankfurt (Oder)-Berlin. 1931.
Consolea corallicola Small, Addisonia 15:25–26, pl. 493. 1930. TYPE: FLORIDA. Monroe Co.: Big Pine Key, 1919, *Small* (SYNTYPE: NY!); Key Largo, *Small* (SYNTYPE: NY!). No lectotype is chosen in deference to Areces (in prep.).

Opuntia spinosissima sensu authors, non Miller (1768).

Description: Shrub or small tree 1–3.5 m tall. Trunk nearly cylindrical, 0.5–2.5 m long, reaching 3–4 cm in diameter. Larger terminal joints light green, standing mostly ascending, all flattened, ca. 1 cm thick, mostly elliptic, but ranging to elongate or asymmetrical, 1–3 dm long. Areoles elliptic, typically 1–1.5 cm apart. Spines numerous, in all areoles or some joints nearly spineless, gray or white, turning brown with age, 2–3(–4) per areole, spreading and deflexed, the longer 7–12 cm, basally 0.25–0.5 mm in diameter, acicular, nearly circular in cross section, twisted, somewhat barbed. Glochids yellow, abundant, 1–1.5 mm long. Leaves rudimentary, small, deciduous, scale-like. Flowers 1.2–2.5 cm in diameter. Sepals green, ovate-deltoid, 3–6 mm long, mostly acute. Petals orange-yellow, turning red shortly after opening, broadly ovate-acute, mucronate, entire. Filaments yellow, 6 mm long; anthers yellow, 0.5 mm long. Styles 6–7.5 mm long, ca 0.5 mm in diameter; stigmas 5, thick, mostly 1.5 mm long. Ovary in anthesis spiny,

flattened. Fruits when produced turning yellow, 5–6 cm long, proliferous; seeds few, circular and flattened, irregular, the edges cristate, the sides puberulent, 6–8 mm in diameter.

Range.—Known from 12 plants with vegetative seedlings on The Nature Conservancy preserve in the Florida Keys; also a few individuals that have been brought into cultivation from sites in the keys, both known and unknown. Formerly known from Key Largo and Big Pine Key.

Illustrations.—A color plate 493 was published by Small (1930).

Comments.—Britton and Rose (1937) provided a black and white plate of *O. spinosissima* with a longitudinal section of the flower and ovary showing the nectar chamber typical of subgenus *Consolea*. That chamber is also found in *Nopalea*. Areces (1996:230) has given superlative diagnostic sketches of the flowers of four other species in subgenus *Consolea*: *O. macracantha, O. moniliformis, O. nashii*, and *O. millspaughii*. The flowers of *O. corallicola* are most similar to those of *O. millspaughii*, but these two differ in several other traits (Table 1).

The nectary chamber, the unjointed central woody axis, and distinctive pollen (Leuenberger 1976), are among traits that make *Consolea* distinctive, regardless of the rank it is given (Areces 1996).

KEY TO SOME CONFUSING CARIBBEAN *OPUNTIA*

1. Spines straw-colored.
   2. Plants 1–3.5 m tall. Areoles reticulate. Joints 3–5 dm long. Spines 1–5, acicular, deflexed. Petal apex rounded. Pericarpel 7–8 cm long. Fruits not proliferous ..... **O. spinosissima**
   2. Plants 5–10 m tall. Areoles not reticulate. Joints 1–3 dm long. Spines 5–9, subulate, spreading. Petal apex acute. Pericarpel 5–6 cm long. Fruits proliferous ..... **O. rubescens**
1. Spines gray or white (brownish with age).
   3. Areoles reticulate. Spines >12 cm long, mostly marginal. Fruits non-proliferous. ..... **O. millspaughii**
   3. Areoles not reticulate. Spines 3–12 cm long, over entire surface. Fruits proliferous.
      4. Areoles sunken, 1–1.5 cm apart. Joints 1–3 dm long. Pericarpels 5–6 cm long ..... **O. corallicola**
      4. Areoles raised and pitted, 1.5–3 cm apart. Joints ≥ 10 dm long. Pericarpels 3–4 cm long. ..... **O. nashii**

The future. Current findings indicate that the Florida plants are an exceptionally rare and endangered endemic species. Presently *O. corallicola* is known from 12 plants on one small land parcel that is owned and protected by The Nature Conservancy. That organization has formulated and implemented an informal recovery plan for this endangered species, but that procedure is complicated by recent events.

The presence of the exotic moth *Cactoblastis cactorum* has initiated a series of problems with those plants (Pemberton 1995). This moth has substan-

tially reduced the abundance of *Opuntia* in the Keys and attacked the Semaphore cacti in the past. Those attacks resulted in most of the remaining plants being placed within screened "cages" in 1990. Although the cacti grow in partial shade conditions, the exclosures may have altered the light quality reaching the plants and caused growth anomalies such as etiolation. No data are available on these characters. Moreover, the cages exclude any potential pollinators of the cacti, precluding potential allogamous sexual reproduction. Future survival with this insect pest is problematical for the Florida plants in spite of the dubious declining infestation trends predicted by Johnson and Stiling (1998). That short-term study, terminated in 1993, did not include the Florida Atlantic University (FAU) campus (Pierce 1995), nor did it address the more recent (1996–1998) upswing in infestation in southern Florida. Cultivated plants on the FAU campus were destroyed during 1997 by *Cactoblastis*, after the native population of *O. stricta* was decimated.

A second more recent event has led to another problem for the plants. Hurricane Georges swept through the Florida Keys in September of 1998. The exclosures were removed when the Hurricane was approaching and have not been replaced. With that event, storm surge swept over the low limestone keys and deposited ocean water. That salty deposit was not immediately diluted by subsequent rainfall, and its long-term impact on the plants is unknown. Also, the main stems on two of the individuals were broken. On others the stems remained erect, but the pads were removed (D. Gordon, pers. comm., 13 Oct 1998). Smaller propagules at the bases of the cacti remain. The full impact of the hurricane on these plants is still being evaluated.

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