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Duncan S. Bell

Rancho Santa Ana Botanic Garden, Claremont, California

Tasya Herskovits

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A NEWLY DISCOVERED LARGE AND SIGNIFICANT POPULATION OF *CASTELA EMORYI* (EMORY'S CRUCIFIXION THORN, SIMAROUBACEAE) IN CALIFORNIA

DUNCAN S. BELL[1,3] AND TASYA HERSKOVITS[2]

[1]*Rancho Santa Ana Botanic Garden, 1500 North College Avenue, Claremont, California 91711;*
[2]*Joshua Tree, California 92252 (tasyaherskov@yahoo.com)*
[3]*Corresponding author (dbell@rsabg.org)*

ABSTRACT

Castela emoryi is an understudied species, and recent visits to populations across California have shed new light on its distribution and biology, including recruitment, natural history, and herbivory. Field exploration in Rice Valley in Riverside County revealed what is considered to be the largest population of *C. emoryi* in California. Possible threats and conservation needs of this species are discussed.

Key words: California, *Castela emoryi*, conservation, hermaphrodite, population dynamics, rare, Rice Valley, Simaroubaceae, species modeling.

INTRODUCTION

Castela emoryi occurs from northwest Mexico, where it is reportedly very uncommon, to central and western Arizona and into California's Mojave and Sonoran deserts, where most populations are small and scattered and very rarely exceed 100 individuals (SEInet 2013). The species is usually found in silty soils of dry lake beds and occasionally in wash bottoms or on rocky slopes. *Castela emoryi* has a California Native Plant Society Rare Plant Rank of 2.3, which states that it is ''rare, threatened, or endangered in California, but more common elsewhere''.

New insights into the distribution and biology of this species emerged from a population discovered in Rice Valley, Riverside County, California. The Rice Valley population was first documented by Michael Honer in March 2005 who reported a ''solitary tree 2.5 m tall'' (*Honer 2066*, RSA) (Consortium of California Herbaria [CCH] 2013). In October 2009 the first author (D.B.) found twelve scattered individuals in the same general location while doing floristic work in the area (*Bell 505*, RSA) (CCH 2013). On a return trip to Rice Valley in January 2012, D.B. found over 2500 individuals farther south from the previously documented populations (*Bell 3062*, RSA). Just a few weeks later, in February 2012, Tasya Herskovits (T.H.) visited this population as part of a modeling survey to determine the extent and range of *C. emoryi* in California, and also noted that this population had over 2000 individuals. She returned in June 2012 to set up two demographic study sites. These study plots serve to address some of the many questions about the overall success and reproductive output of this species.

NOTEWORTHY OBSERVATION

Castela emoryi (A.Gray) Moran & Felger (Simaroubaceae).—USA. California: Riverside County. Rice Valley, ca. 6 air miles SE of the ghost town of Rice at ca. 34.00633, −114.80672, ca. 663 ft (202 m), Duncan S. Bell & Tasya Herskovits. Observations made by D.B. on 28 Jan 2012 (*Duncan Bell & Amanda Bell 3062*, RSA) and by T.H. on 29 Feb 2012. Shrubs locally common on silty flats of valley bottom, at times between shifting sand dunes. Over 2500 individuals scattered over a large area. Individuals ranging from seedlings to fully grown adults up to 15 ft (4.6 m) tall. Seedlings uncommon, and most adult plants 4–8 ft (1.2–2.4 m) in height. Growing with *Ambrosia dumosa* (A.Gray) W.W.Payne, *Amsinckia tessellata* A.Gray, *Androstephium breviflorum* S.Watson, *Astragalus insularis* Kellogg var. *harwoodii* Munz & McBurney, *Brassica tournefortii* Gouan, *Chamaesyce abramsiana* (L.C.Wheeler) Koutnik, *Cryptantha angustifolia* (Torr.) Greene, *Datura discolor* Bernh., *Eriastrum harwoodii* (T.T.Craig) D.Gowen, *Geraea canescens* Torr. & A.Gray, *Larrea tridentata* (Sessé & Moc. ex DC.) Coville, *Lepidium lasiocarpum* Nutt. ex Torr. & A.Gray, *Nicotiana obtusifolia* M.Martens & Galeotti, *Palafoxia arida* B.L.Turner & M.I.Morris, *Proboscidea altheifolia* (Benth.) Decne., *Prosopis glandulosa* Torr., *Tamarix aphylla* (L.) H.Karst.

Significance.—These observations and collections represent the largest population of *C. emoryi* known to date. The largest previously known population is from the Crucifixion Thorn Natural Area in Imperial County, reportedly the largest population in California with over 1000 individuals (Sanders 1998: 2).

Biology and population dynamics.—*Castela emoryi* plants vary greatly in morphology, size, number, sex ratio, and reproductive success between sites. Two main environments have been observed while visiting all known *C. emoryi* populations: the edges of non-saline dry lake beds and the fine-textured soil of washes and lower bajadas. Always located in places where water collects, their preferred habitat appears to be near non-saline, dry lake beds.

So far, *C. emoryi* has not been found in relation to any surveyed alkaline, saline dry lakes. While saline dry lakes are large and numerous throughout the southern California desert, non-saline dry lakes are generally smaller and less frequent, thereby limiting the preferred habitat of *C. emoryi*. The sites harboring the largest, most healthy populations of California *C. emoryi* are, in order of decreasing population size: Rice Valley, the Crucifixion Thorn Natural Area, Sheephole Dry Lake (San Bernardino County), Hayfield Dry Lake (Riverside County), and a very small dry lake north of Afton Canyon

(San Bernardino County). Smaller populations occur in washes often containing fine particle silt and/or clay soil. The two largest of these populations are at Homer Wash (San Bernardino County) and a shallow wash east of Pisgah Crater (San Bernardino County).

In general, *C. emoryi* appears to take on one of two morphological habits, either short (<3 m) and robust or tall (≥3 m) and spreading. *Castela emoryi* may simply tend to grow taller where more water is available, since plants found in washes, with greater runoff and erosion, generally show the shorter habit, while those found near basins and dry lakes, where water collects, are generally taller. The amount of clay and silt content in the soil may also affect water absorption and hence size and morphology.

Rice Valley, home to the largest population of *C. emoryi*, demonstrates the plant's preferred habitat and microhabitat. The Rice Valley population appears to be one of the healthiest, showing numerous females with abundant fruit clusters (Fig. 1) and large, robust individuals with minimal dieback. This site also may have the highest concentration of seedlings and juveniles (Fig. 2, 3) of any site and may therefore be the most reproductively successful. The preferred soil type of *C. emoryi* in Rice Valley is a combination of fine sand mixed with clay where dry lake bed and sand dune habitats merge. Though the population is most dense near the dry lake bed, the individuals that are immediately adjacent to—or in—the dry lake are generally more stunted and less reproductive than the individuals towards the interior of the population. Towards the north end of the population, where sand dune habitat merges with dry lake habitat, the individuals are generally larger, more robust, more reproductive, and generally show more new growth. Within the boundaries of the population the ground is mostly flat or slightly undulating.

In very rare instances, *C. emoryi* occurs on rocky slopes of washes. According to Sanders (1998: 5), *C. emoryi* seed found in 9750-year-old pack rat middens (Van Devender 1990) on rocky slopes in the Kofa Mountains, Arizona, implies that *C. emoryi* formerly occurred on rocky hillsides. He postulates that climate change may have driven *C. emoryi* to a narrower range of habitats (Sanders 1998: 5). In support of his theory, active populations in California have since been found on rocky slopes. Two populations occur in the Eagle Mountains (Riverside County) and Coxcomb Mountains (Riverside and San Bernardino Counties) of Joshua Tree National Park. It is unclear how old these populations are, though differences in morphology, such as numerous branches that are blunt at the apex at the Coxcomb Mountains site (California Natural Diversity Database [CNDDB] Occurrence #50), imply that these populations could be genetically isolated. This site, located on the north-facing slope of a boulder-strewn wash in the southwest Coxcomb Mountains, contains only two individuals, one female and one that is a potential hermaphrodite.

The Eagle Mountains site is also unique as the seven plants growing on the very steep sides of a rocky wash are extremely stressed and skeletal in appearance. In contrast to the stout and robust individuals found in the Coxcombs, they appear to be just surviving, not thriving. Of six females and one male, the total seed count for the population was about 20 and the result of a single reproductive cycle over one year previous to the visit, implying that these plants do not produce seed every year. Most other sites show evidence of three to five separate reproductive cycles spanning up to five years. This site was also impacted heavily by packrat herbivory.

In general, the fewer the plants present at the site, the greater the pack rat damage per plant. Pack rats seem to prize the protective *C. emoryi* thorns for lining their nests, and individuals from smaller populations were more severely impacted. There are many questions as to the role of pack rats in *Castela* survival and reproduction. Initial observations of demographic sites show that numerous inflorescences tagged in 2012 were snipped off by pack rats, implying that they may eat the seeds or collect fruiting branches. It is possible that pack rats play a role in seed dispersal, a role that may have previously been filled by now-extinct Pleistocene megafauna (Sanders 1998: 3). However, in some populations, such as the Eagle Mountains site and a larger site near Pisgah Crater, the pack rat damage is so extensive that it impedes the plants' ability to thrive and produce viable seed.

Though other species in family Simaroubaceae are known to be hermaphroditic, the existence and significance of hermaphroditic *C. emoryi* individuals has been virtually unexplored. In 2012 hermaphrodites were found at six of twenty sites. All noted hermaphrodites are male dominant, with some presence of female flowers and developed or aborted fruits. It is possible that female-dominant individuals also produce male flowers, though this is much more difficult to determine with the naked eye. Sites vary in frequency of hermaphrodites, with CNDDB Occurrence #29, in a dry lake east of the Sheephole Mountains, showing the most documented hermaphrodites. Hermaphrodites may play an important role in fruit production in populations with little or no males.

Insect interactions and herbivory.—The relationship of *C. emoryi* with pollinators is also largely undocumented. In the summer of 2012 numerous species of bees and wasps were observed at four populations. It appeared that they were more attracted to the male flowers than the female flowers. The flowers also produce nectar which attracts ants (Fig. 4). Since few plants bloom during this hot mid-summer time, *C. emoryi* may be essential for some bee and wasp species (Fig. 5), and more study is needed to determine if other *C. emoryi*-dependent species exist other than *Atteva exquisita* (Lepidoptera) which appears to rely on *C. emoryi* as a larval host plant (Powell et al. 1973).

Insect herbivory was found to be prevalent and widespread across California's *C. emoryi* populations. At Rice Valley, extensive damage to fruit clusters by the moth larvae of *A. exquisita* was observed in September and November 2012. The outer coatings of the fruits were chewed, extensive webbing was present, and the fruits were prematurely dried and browned, which was also previously noted by Powell and Harbison at *C. emoryi* populations in Imperial County in the 1960s (Powell et al. 1973). In contrast to the previous year's fruits, 2012 showed an unusual "boom" of *A. exquisita*, perhaps due to heavy summer rains. *Atteva exquisita* is the only documented insect that is immune to the insecticidal properties of compounds present in the stems of *C. emoryi*.

In being restricted to—and therefore dependent on—plants of family Simaroubaceae (Powell et al. 1973), of which *C. emoryi* is the sole representative in the California deserts, *A. exquisita* is completely dependent on *C. emoryi* as its larval host plant. In the field, Powell et al. (1973) noted that, since *C.*

Fig. 1–5. *Castela emoryi*.—1. One of the thousands of mature individuals of Rice Valley, with first author for scale. This individual was approximately ten feet tall. Note the different color of fruit clusters: the green seeds are the newest in age, and the darker seed clusters are two- to five-years old. Photo by Amanda Bell.—2. Seedling growing out of the hard pan silty clay soils of Rice Valley. Photo by Duncan S. Bell.—.3. Leafy sapling in Rice Valley. Recruitment in the Rice Valley population is more abundant than in most other populations across California. Photo by Duncan S. Bell.—4. Close-up of flower with visiting ant species. Photo by Tasya Herskovits.—5. Flowers and developing fruit with a visiting wasp species. Photo by Tasya Herskovits.

emoryi is largely leafless, *A. exquisita* larvae fed primarily on flowers and developing seeds. Later in the season when flowers were gone larvae were found primarily in the seed clusters of *C. emoryi* where they fed on the seed covers of its fruits. Herbivory was also noted on the stems and branches of *C. emoryi* where, at times, sections were skeletonized and girdled by the larvae. Morgan and Felger (1968), while doing field studies in Baja California, also found larvae of *A. exquisita* eating leaves and bark of *C. emoryi*.

Population explosions of *A. exquisita* potentially could be detrimental to isolated populations of *C. emoryi* and may explain the case of the Skull Valley population in Imperial County (CNDDB Occurrence #1) observed in 2012 in which nearly all 100+ individuals were dead. However a local resident (Edie Harmond, pers. comm.) noted that this die-off was possibly due to a lengthy drought that occurred in the area in the 1970s that led to intense pack rat herbivory due to a shortage of pack rat resources. It has also been suggested that border patrol may have sprayed plants with herbicide or other chemicals in an attempt to kill the plants and prevent illegal immigrants from hiding in the large dense stands of *C. emoryi* in Imperial County (Steve Hartman, pers. comm.). Whatever the reason, this is currently the only known population of *C. emoryi* in California that is in serious decline. This population needs further observation as it is very uncommon to find dead individuals of this long-lived species.

Natural history, recruitment, and seed germination.—Another noteworthy discovery in 2012 was that of new leaf growth of *C. emoryi* on adults as well as juveniles. It was previously thought that fully developed leaves (in contrast to deciduous, scale-like leaves) never appear on mature plants once these have lost their first season's ephemeral leaves, even as new growth or sucker shoots (Sanders 1998: 3). However, sucker shoots as well as new, leafy branches were observed on plants at several sites, including Rice Valley and Homer Wash (San Bernardino County). At the Homer Wash population, new shoots were observed growing from the base on many individuals. The south end of the population was visited on 3 Jul 2012, and the north portion of the population was visited on 11 Sep 2012. While the northern individuals were healthy and reproductive, the southern individuals appeared to have suffered a massive vegetative die-off in the recent past. Most of these individuals, growing along the steep sandy banks of a wash, were resprouting from the base with leafy, spiny branches. This population warrants further exploration to compare the conditions of the northern and southern portions and discover the reason for massive dieback on the southern portion.

Very little is known about the germination of *C. emoryi* seeds. Sanders (1998: 3) proposed that seeds may need to be passed through the gut of an animal to germinate properly. *Castela emoryi* holds its seed clusters for an extended period of time, possibly for up to 5–7 years (Shreve 1964). Recent or newer seeds tend to be green or yellow in color and very full in size, whereas older seeds are dark yellow, red, or black and shriveled and withered in appearance. The branches of a single *C. emoryi* individual can hold seeds of a broad age range (Fig. 5). Observations of seedlings are very rare, and the Rice Valley population has been one of the only known locations where seedlings have been found in large numbers. A majority of the seedlings were observed growing at the skirt or near the understory of the adult individuals (for a sample of seedlings see *D. Bell 3062*, RSA). A common garden study is needed to explore germination further.

Threats and conservation needs.—Rice Valley was designated an open OHV [off-highway vehicle] recreational area but was closed in 2002 due to lack of use and visitation; however, OHVs are still a threat in the area, and motorcycle and dune buggy tracks were noted on several trips to Rice Valley. *Castela emoryi* is often a large, robust shrub, but seedlings are rare and juvenile plants are under threat from OHV activity.

Renewable energy projects are also a threat. A solar project has been approved for the north end of the valley, and it has been reported that the project will be tapping into the water table of Rice Valley in the form of wells to extract water needed to wash the project's parabolic mirrors. Tapping into the valley's water table could prove devastating for this population of *C. emoryi*.

Some possible conservation options would be to designate this population another "Crucifixion Thorn Natural Area" as has been done in Imperial County and to incorporate this area into the Rice Valley Wilderness which lies just to the south of this important population. An Area of Critical Environmental Concern (ACEC) would also be an option: there are other rare plant populations that co-occur with this *C. emoryi* population, as well as fauna that are endangered or of conservation concern, such as the desert tortoise and fringe-toed lizard. Moreover, there are a number of Native American cultural sites that are known from the area.

There are many renewable energy projects under construction in the southwestern deserts at this time, and these projects specifically look for open, flat basins on which to build, a habitat that *C. emoryi* also often prefers. In 2012 several individuals of *C. emoryi* were bulldozed for the Desert Sunlight solar project northwest of Desert Center in California. We would like to see all forms of development avoided in the greater Rice Valley area to protect its unique and diverse flora and fauna.

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