

CRUCIFIXION THORN

Castela emoryi (Gray) Moran and Felger
[*Holacantha emoryi* Gray]

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Management Status: Federal: None
California: S2.2, G4 (CDFG, 1998)
CNPS: List 2, RED code 2-1-1 (Skinner and Pavlik, 1994)

General Distribution:

Crucifixion thorn is endemic to the Sonoran Desert and southern Mojave Desert, is widely scattered in southwestern Arizona (e.g., along Interstate 10) and reaches its western limits as a few populations in the deserts of southeastern California (Turner, et al, 1995). This species also occurs in northwestern Sonora, but is reported from only 4-5 sites there (Turner, et al., 1995), and in northern Baja California at one site immediately adjacent to the Crucifixion Thorn Natural Area (CTNA) population in Imperial County, California (Turner, et al., 1995). It is “nowhere abundant” (Wiggins, 1964), except , as we now know, at the CTNA. The Sonoran populations are so scarce that just 50 years ago the species was unknown from south of the United States border (e.g., Cronquist, 1944), though by 1951 it was known from a few localities (Shreve, 1964) as it still is today (Turner, et al., 1995). The plant occurs at so few locations in California that, as late as 1936, it was possible to report that only four locations were known in the state (Jepson, 1936) and in 1951 only six (Abrams, 1951). In California south of San Bernardino County there are still apparently only about five reported or documented populations. There are several populations in eastern San Bernardino County outside the WMPA, including sites along Chemehuevi wash; nearby in the Turtle Mountains; Ward Valley, 20 mi. (33 km) east of Essex; south of Needles and north of Goffs. The westernmost of these populations is just outside the WMPA at a point 5 mi. (8.3 km) east of Amboy (Munz and Johnston, 1922).

Distribution in the West Mojave Planning Area:

The crucifixion thorn barely reaches the WMPA as a few scattered populations and individuals: Amboy Crater quad. (Davidson, 1920; Skinner and Pavlik, 1994); Lavic, 8 miles (13 km) west of Ludlow, occurs for some distance along a sandy wash (Ferris, 1919; Munz and Johnston, 1922; Munz, 1974; Jepson, 1936; Tibor, 1997); east of Hector Mine Road in a wash, Sunshine Peak quad. (*Wear and Wade s.n.*, UCR, RSA; Skinner and Pavlik, 1994); lava beds 25 mi. (40 km) northeast of Daggett, Dunn quad. (*Greer s.n.*, SD; Jepson, 1936; Parish, 1921; Skinner and Pavlik, 1994); at the southeast edge of the area at Clark’s Pass east of Twentynine Palms (*Aulenbrock 127*, UCR), and at Dale Dry Lake (*D. Swinney s.n.*, UCR).

Natural History:

The type of this species was collected by George Thurber in July 1852 “on the desert between the Gila River and Tucson, Arizona” (Abrams, 1951; McMinn, 1939). The species is sufficiently common and conspicuous in Arizona that it was discovered and described very early in the exploration of that state (i.e., during the Mexican Boundary Survey of 1850-1854), rather than escaping detection into the 1980s, as several other rare plants of the WMPA did.

The plants are often 3-6 ft. (1-2 m) tall but are generally taller, to 12-19 ft. (4-6 m), in optimum frost-free areas (specifically, at the CTNA). Plants flower as early as April (Turner, et al., 1995) and late May (Jaeger, 1941), but apparently mainly in June and July (Munz, 1974). Fruits probably ripen at the arrival of the fall rains in about September, though fruit ripening has apparently never been studied. The fruits consist of about 7 (6-8) spreading carpels forming a wheel or star-like structure. Each individual carpel contains a single seed closely enclosed by the dried drupe-like carpel body. The plants are dioecious, that is, male and female flowers occur on separate plants. No indication is given of plant height on the labels of most specimens from the southern Mojave, but they are reported to be 3-4 ft. (1-1.3 m) tall (Munz and Johnston, 1922) in contrast to the 10-19 ft. (3-6 m) plants at the CTNA, where height is regularly noted by collectors. Stems are rigid and have rather stout spine-tipped twigs that are covered with a short dense pubescence. The branches are light green. The flowers are inconspicuous and greenish-yellow, but are produced in abundance and must produce copious nectar, based on the numerous insects that visit (J. Wear, pers. comm., 1998). This species is not easily confused with any other member of the California flora.

Crucifixion thorn is leafless shrub or small tree of washes and other sites where water accumulates. It is particularly characteristic of non-saline dry lakes. The plants are long-lived and thorny and thus not much subject to grazing damage. It is mostly restricted to outwash plains and reported not to occur on rocky slopes (Shreve, 1964; Turner, et al., 1995), but there is a recent (obs. in Nov. 1994) unconfirmed report of this from talus slopes in the Cady Mountains (CNPS, 1998). Plants occur as scattered colonies of fairly small size that never extend far across the landscape (Shreve, 1964). It has been suggested that these populations may be partially clonal in origin (Shreve, 1964), but this is unconfirmed and appears unlikely. In many areas there are large areas of unoccupied, but apparently suitable, habitat between colonies (Shreve, 1964), though in most of California this is less obviously the case. The largest known population (about 1000 individuals) is at the CTNA in the Imperial Valley just north of the Mexican border (Turner et al., 1995). Jaeger (1941) reports that it is “locally abundant” along washes east of the Chocolate Mountains, but no one else seems to have noticed this, though it has been collected (once only?) in the area described. Perhaps Jaeger knew the location of a population now lost.

In California, the fruits seem to persist on the plant for a long time, and this observation is supported by the literature where it is reported that the fruit typically remains on the plant for 5-7 years after it matures (Shreve, 1964) or at least “sometimes persisting several years” (McClintock, 1993). In addition to the long persistence on the plant, germination is further inhibited by a need for scarification of the thick carpel wall surrounding the seed (Shreve, 1964). Shreve also reports that seeds germinate readily in

cultivation after the hard seed coat has been opened by filing through it. It is claimed that there is “no mechanism for the release of the seeds” (Shreve, 1964) but this is probably not strictly true. Shreve seems to have thought that the fruits normally remain on the plant until the twigs break due to weathering or other causes and that there is no other dispersal mechanism. This idea makes little biological sense. It is true that the pedicels do eventually weaken due to weathering, thus permitting the seeds to fall to the ground, but it is not in the interest of the plant to hold its seeds in a position where they cannot germinate, and where they are exposed to extreme heat and potential desiccation, unless there is some evolutionary “reward” for doing so. The fact that the fruits are held for a long time in large clusters at the ends of branches suggests that they are being “presented” for dispersal by vertebrate herbivores. This supposition is supported by the thick seedcoat which would be necessary to assure that the seeds can pass undamaged through the gut of a large herbivore, such as a camel, horse or sloth. A seed, which is not normally subject to such abrasion, would not need such a seed coat. That this species is normally dispersed by large herbivores is supported by the observation that donkeys and goats readily eat the fruits, but do not touch the branches (Jaeger, 1941). Whether cattle consume the fruits is unknown. Seed dispersal mechanisms are not discussed in the literature, but it seems likely that the seeds are distributed (or were) by large herbivores. It may be that this plant was formerly dispersed by the now extinct Pleistocene megafauna, as has been demonstrated for some plant species in other regions (Janzen and Martin, 1982). It is noteworthy that the closely related *Castela polyandra*, perhaps similar to the ancestor of crucifixion thorn, has fleshy fruits (“drupes”) that are promptly deciduous (Moran and Felger, 1968). It appears that the persisting fruits of crucifixion thorn are a derived characteristic and are the result of some specific selective factor. Fruit dispersal by large herbivores appears the most likely candidate for such a factor. It would be interesting to test the fruits of this plant to see if germination is facilitated by scarification in passing through an herbivores gut. Fruits do eventually fall to the ground, and the seed coat eventually weathers away permitting germination, but this is probably not the historically normal seed release mechanism. Cultivated plants at Rancho Santa Ana Botanical Garden (RSABG) do have a moderate number of seedlings around them, which is evidence that the simple dropping and weathering of seeds can result in the production of new individuals (pers. obs., 1998). Wild populations at some sites (i.e., Hayfield Lake on the Colorado Desert) do contain plants of various sizes including leafy seedlings, young plants less than 1 m tall, and mature fruiting individuals (B. Pitzer, pers. comm.). Reproduction is thus definitely occurring under modern conditions.

The plants have no developed leaves, except in seedlings (Cronquist, 1944) and thus the stems are, of necessity, photosynthetic. The leaves on seedlings are reported to be both deeply divided (Shreve, 1964) and simple (Turner et al., 1995), so this point could use some clarification. Recent observations at RSABG revealed that seedling plants can have both simple leaves and leaves with two deep lateral lobes (pers. obs., 1998). Mature plants do sometimes produce small deciduous scale-like leaves (Moran and Felger, 1968), but developed leaves never appear on mature plants, even on new growth or “sucker” shoots. The plants are presumably leafless because this is an adaptation that results in reduced water loss due to the thin cuticle of leaves, versus the thicker cuticle of stems, and also avoids the problem of leaf wilt and resultant tissue damage. The cost of being

leafless, and thus reducing transpiration loss, is that the mature plants are not very fast growing (Turner et al, 1995) and hence are perhaps not very competitive with other large shrubs and trees. This could account for its scattered and apparently “refugee” distribution. The species may be restricted to a few unusual spots that have sufficient water, but are dry enough to reduce competition from larger and faster growing plants. The hard stems and spiny branch tips are doubtless responses to large herbivore attacks in the past, though such threats are not now apparent. This is the only native member of the tropical family Simaroubaceae that exists in California.

It may be that the dioecious habit works against this species in areas like the southern Mojave where populations are often small and scattered. Some individuals may not be sufficiently close to other plants for effective pollination. This supposition is supported by the fact that none of the four collections of this species at UCR from the southern Mojave Desert have fruit, whereas six of seven from the Colorado Desert, where populations are larger, are fruiting. Given that the fruits may persist for 5-7 years on the plant (Shreve, 1964) it is expected that fruits will be present whenever a collector gathers material of this species, if the population collected is producing fruit at all regularly. The frequent absence of fruits in the northern part of the range suggests a problem in fruit production. It is, of course, expected that 50% of any population in a dioecious species will never be able to bear fruit. In a sizable population, there will always be at least a few fruit-bearing females present for collection, whereas a solitary individual has a 50% chance of being fruitless even if the species were autogamous. There are, or were, some substantial populations on the southern Mojave Desert, based on herbarium specimens at Rancho Santa Ana and on field notes. The population 8 miles west of Ludlow [= near Lavic] was reported to occur “for several miles” along a sandy wash (Munz and Johnston, 1922). Specimens taken from this population bear fruit. This population, or part of it, was rediscovered in 1997 and was found to consist of 52 individuals scattered along about 1 mile of wash (Tibor, 1997).

Pollinators are unreported in the literature, but J. Wear (pers. comm., 1998) reports that the small population north of the Hector Mine was being heavily visited by numerous insects, especially various wasps, including the large tarantula hawks (*Pepsis*) and numerous small metallic-colored species. Since the plants are reported not to begin flowering until quite old (Turner et al, 1995) and frequently occur in small populations, as at Hector, the pollinators are presumably generalists.

Germination requirements are unknown, except that the species probably relies on summer rainfall for seedling establishment, based on its distribution and relationships. It is reported that the seedlings rapidly develop a deep tap root and that they grow relatively rapidly if sufficient moisture is available (Shreve, 1964). Many of the seedlings present near the cultivated plants at RSABG are growing in the shade of their parents or of other shrubs and trees. A single young seedling at Hayfield Lake was likewise growing in shade under mesquite (B. Pitzer, pers. comm.). Full sun is evidently not required for seedling establishment, and a possible preference for a “nurse plant” should be investigated.

The extent of insect predation on the plants is unknown, but insect damage is not extensive on available herbarium specimens. It is reported that moth larvae (*Atteva exquisita* Busck.) eat this species (presumably the flowers, bark and young twigs) in California, as well as the flowers, bark and leaves of the related *Castela polyandra* in Baja

California (Moran and Felger, 1968). This insect may attack young fruits as well. There are compounds in the stems that have insecticidal properties (Turner et al., 1995) and these may also contribute to the reported distaste for the foliage by goats and burros (Jaeger, 1941). However, it is obvious that the insecticidal compounds are not effective against the moth *Atteva*. In addition, one specimen examined had a number of twigs clipped off, apparently by a jack rabbit (*Lepus californicus*).

Habitat Requirements:

Crucifixion thorn occupies low, 350-2100 ft. (115-640 m), seasonally moist sites where water accumulates, but which are not saline. Plants occur along washes, at non-saline playas (e.g., Clark's Pass, Hayfield, CTNA) and often in drainage ways around basalt flows, at least in the southern Mojave. Crucifixion thorn occurs on fine-textured soil of plains and alluvial bottomlands (not even on upper alluvial slopes) and has been reported on dunes (Turner, et al., 1995). Basalt flows probably generate large amounts of water runoff into adjacent washes, and may hold heat due to their dark color. Washes among basalt flows may thus be both relatively warm and moist sites. This species occurs entirely in low hot areas (e.g., Jaeger, 1941; Turner et al., 1995), perhaps because of a lack of tolerance for severe frost, or a need to escape certain competitors. Examination of a range map of the species (e.g., Elias, 1980; Turner, et al., 1995) reveals that it is distributed through the hottest and driest parts of the southwestern deserts, but examination of the microsites occupied reveals that within the larger habitat it is specialized to relatively moist sites. The species is most common in areas where summer rainfall is common or predominant, but extends sparsely into areas of the western Mojave where winter rainfall is the dominant mode (Turner et al., 1995) and summer rainfall is infrequent. Areas occupied are characterized by high summer temperatures and rare frost (Turner et al., 1995).

It may be that climatic change has driven this species into a narrower range of habitat types than it formerly occupied. In the Kofa Mountains of Arizona, a seed of this plant was found in a 9750 year old packrat midden on rocky slopes (Van Devender, 1990). Since packrats gather the material for their nests/middens over relatively small areas around the sites occupied, this implies that crucifixion thorn formerly occurred on rocky hillsides. In addition, there is a recent unconfirmed report that this species occurs on a talus slope in the Cady Mountains.

Population Status:

Populations in the WMPA are often small and hence precarious, and the species is only very locally common anywhere in California. Populations are few and highly scattered. There appear to have been few attempts to count individuals of this species. Most records are based on specimens where the locality is recorded, and often nothing more. At Clark's Pass the species is recorded on a specimen label as "scarce", and near Hector Mine there were four individuals (J. Wear, pers. comm., 1998). Only the report from near Lavic seems to represent a substantial population, but recent survey work in exactly that area for *Penstemon albomarginatus* did not reveal crucifixion thorn. The plant is certainly not common anywhere in the WMPA, and it may be that most records are based on single individuals or very small populations. It appears that the southern

Mojave Desert populations are having trouble reproducing due to lack of opportunity for cross pollination, poor seed dispersal or marginal environmental conditions.

Threats Analysis:

Currently, no significant human threats are known to exist, and the few threats that have impacted the species in the past have not significantly reduced its populations, except perhaps at Hayfield Dry Lake. Some populations are, or were, somewhat impacted by off highway vehicle (OHV) recreation, but the mature plants are large and stout enough that they are generally avoided. Seedlings could be damaged or destroyed by OHV activity.

Jaeger reported a “large aggregation” at Hayfield Dry Lake (outside the WMPA), but implied that this was largely destroyed when the pumping plant for the Colorado River aqueduct was constructed, though he actually says that the plants occupied an area “now covered by the waters of the Hayfields Reservoir” (Jaeger, 1941). Since there is no such reservoir today, this is puzzling. Perhaps there was a temporary reservoir that has since been eliminated. This is the only population in California reported to have been heavily damaged by human activity, but even here plants persisted and these still appear healthy and numerous. Besides Jaeger, other authors say that in the 1920s this population consisted of “hundreds” of plants (Munz and Keck, 1922) or that they were “numerous” (Parish, 1921). If this population was damaged, it has since substantially recovered because today there are at least 300 individuals present (B. Pitzer, pers. comm.). Many of the plants present today are tall 6-10 ft. (2-3 m) and mature and in places they form thickets so dense that they are difficult to walk through (B. Pitzer, pers. comm.).

As noted above, there may be a problem with pollination and hence seed set in some populations. Populations that consist only of a few large old individuals that are not setting seed are subject to elimination as those plants age and die. There may also be problems with seed dispersal and germination, if this species requires, or is greatly aided by, large herbivores that consume the fruits.

The largest population in California and the world, that at the CTNA, is protected by the BLM.

Biological Standards:

The few populations (or scattered individuals) in the WMPA are probably not crucial to the species’ survival, even just within California. However, it would be highly desirable to conduct extensive surveys of likely habitat areas to confirm that there are no large populations in the area. In particular, the population eight miles west of Ludlow that was collected by Munz and associates in 1920 should be located and monitored. This is the only significant population ever reported in the WMPA.

The possible requirement for seed scarification should be investigated. It is possible that the fencing of the CTNA stand to protect it from OHVs also has the effect of keeping out livestock, and other large animals such as deer or bighorn sheep, that could serve to enhance germination. It may be that allowing cattle to roam in the fenced population at the CTNA at certain times of the year (perhaps late summer/fall in years when higher than normal summer rainfall is expected) would aid population recruitment. At least, this potential management tool should be investigated.

Once the biology of this species is better understood, rational measures can be taken to protect the most important populations.

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