

## PROTECTING RARE FLORIDA CACTI FROM ATTACK BY THE EXOTIC CACTUS MOTH, *CACTOBLASTIS CACTORUM* (LEPIDOPTERA: PYRALIDAE)

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### ABSTRACT

*Cactoblastis cactorum* (Berg) represents a threat to rare *Opuntia* cacti in the Florida Keys. Conservation of such species may depend upon successful outplantings of young cacti in places that minimize attack rates by *Cactoblastis*. This paper discusses how to maximize the success rates of such outplantings of the endangered semaphore cactus, *O. corallicola* Small. A 1998 outplanting of 180 cacti in the Lower Keys showed that planting close to *Opuntia stricta* (Haw.) Haworth infected with *Cactoblastis* results in heavy losses, as *Cactoblastis* bleed over from *O. stricta* to attack outplanted *O. corallicola*. Growth rates of outplanted *O. corallicola* are greatest in shade conditions, but attack rates by *Cactoblastis* are also greater in the shade. An outplanting of 240 *O. corallicola* cacti on six different Keys in 2000, all far away from *O. stricta*, had no *Cactoblastis* related mortality. The most successful conservation strategy for *O. corallicola* thus appears to be outplanting in the shade, possibly in tropical hammocks, far away from *Opuntia* cacti that might contain *Cactoblastis*.

Key Words: invasive pest, Florida Keys, *Opuntia corallicola*, rare cacti

### RESUMEN

La presencia de la especie *Cactoblastis cactorum* (Berg) representa una amenaza real para las especies de *Opuntia* que se encuentran en peligro de extinción y que ocurren en los Cayos de Florida (Florida Keys). La conservación y supervivencia de estas especies podría depender de la efectividad en establecer parcelas plantadas con estas especies en áreas donde el posible ataque de *Cactoblastis* sea mínimo. Este artículo discute algunas de las maneras en que se pueden maximizar las probabilidades de supervivencia de parcelas plantadas con *O. corallicola* Small. Por ejemplo, una parcela plantada en 1998 con 180 especímenes de *O. corallicola* en un área cercana a especímenes de *O. stricta* (Haw.) Haworth infestadas con *Cactoblastis* demostró que este insecto se dispersó hacia los especímenes *O. corallicola* causando grandes daños. La tasa de crecimiento en *O. corallicola* es máxima cuando las áreas en donde se encuentra son sombreadas; sin embargo, el daño causado por *Cactoblastis* también se maximiza en áreas sin sol. Al examinar 240 especímenes de una parcela plantada con *O. corallicola* en diferentes islas de los Cayos de Florida, en áreas sin *O. stricta*, no se encontró daño causado por *Cactoblastis*. Por lo tanto, la estrategia más prometedora en cuanto a la conservación de *O. corallicola* parece ser la localización de parcelas de esta especie en áreas sombreadas y libres de la presencia de *O. stricta* que puedan encontrarse infestadas con *Cactoblastis*.

The moth *Cactoblastis cactorum* (Berg) was recorded in Florida for the first time in 1989, in the Florida Keys. This moth, a native of South America that specializes on *Opuntia* cacti, had already been introduced around the world to control pestiferous *Opuntia* in such places as Australia, South Africa and Hawaii (Zimmermann et al. 2000). It was widely considered to be a dazzling success for biological control. In 1957 it was introduced into the Caribbean and a little over 30 years later was recorded in the Florida Keys, having island hopped via winged flight or been transported to Florida as larvae via the port of Miami in cacti imported from the Dominican Republic (Pemberton 1995). Regardless of its method of entry into the United States, fears are high that this moth will, either on its own or in movement associated with the ornamental cactus trade, invade the rest of the Southeastern and Gulf States, and

eventually the cactus-rich desert areas of Southwestern U.S. and Mexico (see other pages in this special issue).

Our research on *Cactoblastis* activity in Florida, at the University of South Florida, has focused on the rate of spread of *Cactoblastis*, its rate of attack on *Opuntia* cacti, and moth-related mortality levels. We are also determining whether natural enemies, especially parasitoids, have bled over from native hosts onto *Cactoblastis* and are reducing *Cactoblastis* density. Our research showed that in the first few years of invasion the moth spread rapidly, up to 160 miles per year, but in recent years the rate of spread has slowed to only 24 miles per year (Johnson & Stiling 1998), which is more comparable to rates of dispersal in other areas, like Australia (Dodd 1940). The rate of spread has been faster up the Florida east coast, than the west coast. In fact, in

1999 *Cactoblastis* was reported in Sapelo Island, GA, whereas in September 2000 it had only dispersed as far north as Cedar Key on Florida's west coast. If the moth can survive and thrive at Sapelo Island it can probably survive at most Gulf Coast latitudes and the threat of dispersal to the U.S. Southwest looms large. In addition, there is a very real possibility that dispersal will be accelerated by human activity. In July 2000 *Cactoblastis* was reported on cacti at a Wal-Mart in Pensacola, FL, having been transported from a nursery in Miami. Only diligence by field agents from Florida's Division of Plant Industry and swift action by Nancy Coile, curator FDACS, resulted in its detection and removal. Damage by *Cactoblastis* to native cacti may be considerable, with 90% of the common prickly pear cactus plants, *Opuntia stricta* (Haw.) Haworth, suffering damage (Johnson & Stiling 1998). Although only 15% of our monitored plants died, these were all small plants and we believe mortality to juveniles is probably high, which threatens the integrity of future cactus populations. So far, attack rates of *Cactoblastis* larvae by native parasitoids has been slight, <10%, and only one species of tachinid fly has been reared from pupae.

A more immediate concern for the State of Florida is the likely effect of *Cactoblastis* on native Florida cacti, many of which are rare and endangered. Florida has six species of native *Opuntia*, the common prickly pear, *O. stricta* (Haw.) Haworth and *O. humifusa* (Raf.) Rafinesque, which are frequently present in coastal habitats, *O. pusilla* (Haw.) Nutt., and the rare *O. corallicola* Small, *O. triacantha* (Willdenow) Sweet and *O. cubensis* Britton & Rose, the last three of which are found only in the Florida Keys. All six species are vulnerable to *Cactoblastis* and most are attacked by larvae in the field (Johnson & Stiling 1996). While concern is high that even the common *Opuntia* species could be decimated by *Cactoblastis*, concern is even higher for the rare Florida species that exist nowhere else in the U.S.

This paper focuses on a strategy to conserve the rarest of the Florida *Opuntia*, *O. corallicola* Small. Only 12 mature individuals of this species exist in the world, all on one small Key. Protecting the parent cacti from attack from *Cactoblastis* by the use of cages is problematic for two reasons. First, cages prevent cross-pollination and second, cages are susceptible to tropical storm or hurricane force winds and can knock down the cacti inside if they fall over. For this reason, cages initially erected to protect the cacti from *Cactoblastis*, in 1990, have been removed. Since cage removal, at least two of these cacti have subsequently been attacked by *Cactoblastis*, one of which has been killed. The preservation of *O. corallicola* in the Florida Keys may depend on successful outplantings of new cacti designed to

bolster the current population. This manuscript discusses our findings on the best strategies to use in outplantings that might minimize attack rates by *Cactoblastis* and maximize growth rates of cacti.

#### MATERIALS AND METHODS

During the summer of 1997 we collected about 150 young *O. corallicola* cacti from around the bases of several parent plants growing on private land in the lower Florida Keys. These young cacti were returned to the U.S.F. Botanical Garden in Tampa, Florida, where they were planted in trays. For the next year the cacti grew and pads from large individuals were broken off and replanted to create more new cacti. By the summer of 1998 we had nearly 250 young 10-30 cm cacti with one to three pads. These pads were then used in experimental outplantings.

In summer 1998 we outplanted 180 of our young cacti on Saddlebunch Key. There were six replicates of each of three treatments. The treatments represented different associations or neighborhoods of cacti. In the first treatment, 10 young cacti were planted within 3 m of *Opuntia stricta* plants attacked by *Cactoblastis* (= near attacked). The 10 cacti were planted in two rows of five, with 10 cm between the two rows and 10 cm between each plant. These distances were chosen to approximate the natural spacing between "volunteer" plants that grow up under the parents from fallen pads or from seed. In the second treatment, 10 young cacti were planted within 3 m of *Opuntia stricta* plants showing no evidence of attack by *Cactoblastis* (= near unattacked). In the third treatment, 10 young cacti were planted at least 20 m from any *Opuntia stricta* (= alone). Each replicate contained each of these three treatments for a total of 30 cacti per replicate. There were 6 replicates, with 100 m between each replicate, for a total of 180 cacti. Three replicates were planted in open, sunny conditions and three under the shade of buttonwood trees.

The cacti not used in the first outplanting continued to be maintained at U.S.F. and by the summer of 2000 we had built-up a collection of nearly 300 young rooted plants, again 10-30 cm tall with 1-3 pads. In the summer of 2000 we performed our second outplanting. Here, forty cacti were placed on each of six separate Keys: Sugarloaf, Little Torch, Ramrod, Cudjoe, No Name and Big Pine. The forty cacti were planted in four groups of ten. Two groups were planted in the shade of a tropical hammock and two in a light gap within a tropical hammock. On each Key care was taken to keep all cacti at least 500 m from any other *Opuntia* cacti.

At both outplantings all cacti were visited every three months and attack rates by *Cactoblastis* were scored, along with plant height and pad

TABLE 1. ANOVA ON ATTACK RATE OF *OPUNTIA CORALLICOLA* OUTPLANTINGS BY *CACTOBLASTIS CACTORUM* ON SADDLEBUNCH KEY, FL.

Source	SS	df	MS	F	P
Shade	1469.444	1	1469.444	9.404	0.01
Neighborhood	4116.667	2	2058.333	13.173	0.001
Shade × Neighborhood	1672.222	2	836.111	5.351	0.022
Error	1875.000	12	156.25		

number, as a measure of growth. *Cactoblastis* attack results in "green slime" exuding from fed-upon pads or, in the later stages of attack, a characteristic skeletal appearance of the cactus with all the tissue between the epidermal layers eaten. In the first outplanting, growth as measured by difference in height over two years, summer 1998 to summer 2000, was analyzed using the mean increase in height for each replicate group of 10 cacti in a two-way ANOVA with neighborhood and shade as the factors. Analysis of variance was also used to examine death of cacti from *Cactoblastis* from 1998 to 2000.

### RESULTS

In the first outplanting, *Cactoblastis* attacked and killed many outplanted *O. corallicola*. Deaths rates were significantly greater where cacti were placed adjacent to *O. stricta* already attacked by *Cactoblastis* and contained a reservoir of actively feeding larvae (Table 1, Fig. 1). The 3 m distance between the *O. corallicola* and the *O. stricta* was probably too great to be crossed by *Cactoblastis* larvae, so this suggests that adults that hatched from pupae under the attacked *O. stricta* proba-

bly laid eggs on neighboring *O. corallicola*. Attack rates of *O. corallicola* near unattacked *O. stricta* or on those planted away from any *O. stricta* (alone) were very low. The growth rates of cacti among these treatments were not significantly different (Table 2, Fig. 2), indicating that all neighborhoods where cacti were planted were equally good places for cacti to grow.

Outplanted cacti were attacked significantly more by *Cactoblastis* when planted in the shade than when they were planted in the sun (Table 1, Fig. 1). Growth rates of shade cacti were almost twice as high as sun cacti, indicating that growth conditions were better in the shade and that shade cacti were healthier. Higher plant quality in the shade may promote higher attack by *Cactoblastis*.

In the second outplanting, after one year, by summer 2001, none of the 240 cacti were attacked by *Cactoblastis* and growth occurred in all treatment groups, indicating cacti were planted in appropriate locations. In contrast, in the first outplanting, nearly two thirds of the total cacti killed by *Cactoblastis* had been killed by the end of year one, indicating that the difference in results between the two outplantings was not time-related.

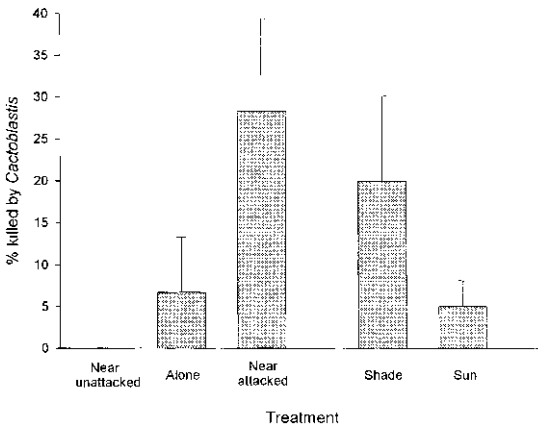


Fig. 1. Mortality of outplanted *Opuntia corallicola* cacti caused by *Cactoblastis* when placed near *Cactoblastis*-attacked *O. stricta*, when placed alone, and when placed near unattacked *O. stricta*. Also shown are levels of *Cactoblastis* mortality on *O. corallicola* when outplanted in shade or sun conditions.

### DISCUSSION

Our major conclusion is that any recovery plan for the rare cactus *O. corallicola* in the Florida Keys should locate outplanted cacti as far away as possible from *O. stricta* because this common species may act as a reservoir for *Cactoblastis*. None of the 240 cacti outplanted in 2000, far away from *O. stricta*, were attacked by *Cactoblastis*. In contrast, in the first outplanting, where cacti were placed in close proximity to *O. stricta* containing *Cactoblastis*, they were likely to be attacked and killed by *Cactoblastis*. In the first outplanting even some cacti placed more distant from attacked *O. stricta* were attacked and killed. This would suggest that only outplantings at least 500 m from attacked *O. stricta*, and perhaps in the seclusion of a tropical hammock, would be isolated enough to prevent detection by *Cactoblastis*, at least in the short term. Such short-term protection might be critical because larger cacti appear more likely to survive *Cactoblastis* attack than

TABLE 2. ANOVA ON HEIGHT OF *OPUNTIA CORALLICOLA* OUTPLANTINGS ON SADDLEBUNCH KEY, FL.

Source	SS	df	MS	F	P
Shade	294.981	1	294.981	6.516	0.025
Neighborhood	33.593	2	16.796	0.371	0.698
Shade $\times$ Neighborhood	11.716	2	5.858	0.124	0.880
Error	543.232	12	45.269		

smaller cacti (Johnson & Stiling 1998). Bevill et al. (1999) also showed how protection of juvenile rare native Pitcher's thistle, *Cirsium pitcheri* (Eaton) T. & G., from non-target effects of a weevil released to control exotic thistles increased growth rates. For the thistles, protection from weevils in the early growth stages resulted in a 50% increase in juvenile survival and a concomitant increase in flowering and seed production of mature plants.

*Opuntia corallicola* appears to grow better in the shade than in the full sun, a finding also reported by Stiling et al. (2000) from an earlier outplanting in 1996. However, here the conservationist faces somewhat of a dilemma because shade cacti are significantly more susceptible to attack by *Cactoblastis*, perhaps because they are of superior quality to small, relatively stunted sun plants. Other authors have noted higher attack rates of cacti by moths in shaded areas. For example, cladode mortality of *O. fragilis* (Nutt.) Haworth by the native moth *Melitara dentata* (Grote) (Lep.: Pyralidae) in Nebraska was higher in shaded sites than in open ones (Burger & Louda 1995). Perhaps the best conservation strategy for the rare *O. corallicola* would be to plant in shaded conditions but only well away from *O. stricta*, which acts as a reservoir for *Cac-*

*toblastis*. In this way rare cacti, both in the Florida Keys and elsewhere, might suffer less death by *Cactoblastis* yet have maximal growth rates.

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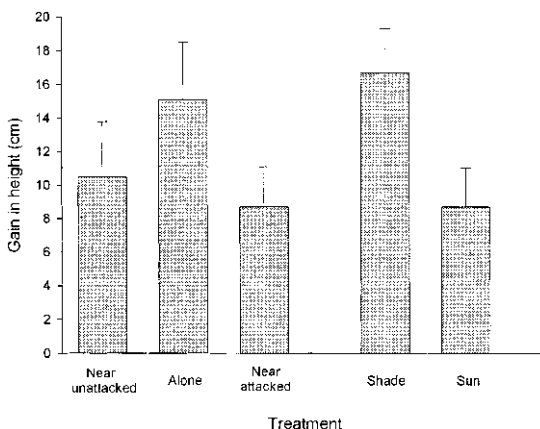


Fig. 2. Growth of outplanted *Opuntia corallicola*, as measured by gain in height, when placed near *Cactoblastis*-attacked *O. stricta*, alone, near unattacked *O. stricta*, and in sun or shade conditions.