Restoration of Native Baboon-plant Mutualisms Following Biocontrol of the Invasive Prickly Pear Cactus (Opuntia stricta) in Kenya

Marissa A. Dyck
University of Wyoming, mdyck@uwyo.edu

Follow this and additional works at: http://repository.uwyo.edu/honors_theses_16-17

Part of the Evolution Commons, and the Other Ecology and Evolutionary Biology Commons

Recommended Citation
http://repository.uwyo.edu/honors_theses_16-17/44
Restoration of Native Baboon-plant Mutualisms
Following Biocontrol of the Invasive Prickly Pear Cactus
(Opuntia stricta) in Kenya

Marissa A. Dyck
University of Wyoming Honors Program
Advisor: Anne-Marie Hodge
Background

The genus *Opuntia* comprises prickly pear cacti that are native to western North America, Central America, the Caribbean, and South America. Several *Opuntia* species—predominately *Opuntia ficus-indica, Opuntia engelmannii, and Opuntia stricta*—have become invasive across the Old World (Monteiro et al., 2009). *Opuntia stricta* was introduced to central Kenya in the 1940s as an ornamental plant at the colonial district commissioner’s office in the village of Doldol (Strum et al., 2015). Since its introduction in Kenya, *O. stricta* has spread southward and westward across the high altitude semi-arid savanna on the Laikipia plateau, a region comprised of valuable commercial rangelands and conservation areas (Kunyaga et al., 2009).

One of the reasons that *O. stricta* is such a highly successful invasive species is because it has two modes of reproduction (Padrón, 2011). Thus, *O. stricta* can reproduce sexually and spread through a dispersal agent, such as a mammal or bird. The animal eats its fruits and then disperses seeds through its feces (Strum et al. 2015). *Opuntia stricta* can also reproduce asexually if the plant’s paddles drop to the ground, as they can root and establish new plants (Strum et al., 2015; Fig. 1).

Invasive species, although often viewed as threats to biodiversity, sometimes serve as localized resource subsidies for native fauna (Rand et al., 2006; Rodriguez, 2006; Van Riel et al., 2000). For example, a census of bird species in the Sabah Softwoods Plantation in Sabah, East Malaysia revealed that native bird species were able to utilize non-native plantation trees, and the plantation forests had impressive diversity that was not significantly different from the primary native forest (Mitra and Sheldon, 1993). However, subsidizing local fauna means that invasive species can disrupt native mutualisms in the area they’re introduced (Traveset and Richardson, 2014). *Opuntia stricta* produces fleshy fruits that native frugivores eat and aid in the plant’s dispersal and establishment success. If native frugivores are selecting for *O. stricta* over the native plants in the region, this could disrupt native mutualisms and ecological stability of the area (Traveset and Richardson, 2014).
Although *O. stricta*’s effects on mammal species richness may be positive in the short-term, long-term interactions between introduced plants and native wildlife can cause loss of biodiversity, especially if native mutualism networks are disrupted (Traveset & Richardson, 2014). Therefore, understanding factors that facilitate the establishment and spread of problem species such as *O. stricta* is essential for the restoration of native species interactions. Laikipia’s economy centers on livestock production (Denney, 1972), which is also disrupted when *O. stricta* replaces native forage. Thus, encroachment of *O. stricta* across the landscape has had enormous implications for both wildlife and humans in Laikipia (Foxcroft & Rejmánek, 2007).

*Opuntia stricta* has two primary natural enemies, the cactus moth (*Cactoblastis cactorum*) and the cochineal insect (*Dactylopius opuntiae*) (Hosking et al., 1994). *Dactylopius opuntiae* is specifically adapted to feed solely on *O. stricta* (Githure et al., 1999). The cochineal insect has been successful as a biocontrol in other areas where *O. stricta* is invasive (Hosking et al., 1994). Therefore, the Kenya Plant Health Inspectorate Service (KEPHIS) and the National Environment Management Authority (NEMA) approved the insect’s introduction as a biocontrol agent in 2015 as an attempt to eradicate the cactus from Laikipia (pers. comm. Merinyi). The insect helps reduce *O. stricta* density by targeting the soft parts of the cactus plants, including the fruits of adult cactus plants and the paddles of the juvenile cactus plants (Fig. 2). This insect also stops production of fruits by adult cactus plants, hindering the dispersal of *O. stricta* seeds by frugivores.

So far, no one has quantified the effects of this biocontrol effort in relation to the reduction of *O. stricta* density across Laikipia’s wildlife conservancies, or the effects this is having on restoration of mutualisms between native plants and their seed dispersers. Laikipia represents one of Kenya’s last remaining strongholds for several globally endangered animals (Kinnaird & O’Brien, 2012). Assessing the effects of this invasive cactus and the biocontrol effort are essential for our understanding of the most efficient ways to conserve native fauna and stabilize the agricultural economy in this region.
Olive baboon (*Papio anubis*; hereafter, “baboons”) feces often contain hundreds of *O. stricta* seeds, apparent by their pink color (Fig. 3). This evidence suggests that the baboons prefer *O. stricta* fruits over the fruits of native plants. Olive baboons are opportunistic omnivores (Barrett and Henzi, 2008); therefore they often adjust their diet to conditions within a specific region, season, or sometimes time of day. However with the expansion of *O. stricta*’s range and increasing density of the cactus, baboons have been found to consume large amounts of the fleshy fruits of *O. stricta* (Van Riel et al., 2000), and serve as significant long-distance seed dispersers for *O. stricta* and other fruiting plants (Foxcroft & Rejmánek, 2007; Hodge & Goheen, 2014; Strum et al., 2015). Due to the recent reduction of *O. stricta* density following the introduction of *D. opuntiae*, I hypothesized that I would find a decrease in the number of *O. stricta* seeds in baboon scats compared to 2014 data, and that seeds from native plants would be present in 2016 scats, despite their absence in previous years. These results would support the hypothesis that the introduction of *D. opuntiae* will contribute to restoring mutualisms between native plants and frugivores. I worked with a University of Wyoming doctoral candidate, Anne-Marie Hodge, who collected data on seeds found within baboon feces collected over five and a half months per year in both 2014 and 2015.

**Hypothesis and Questions**

To gain more insight into the role that *O. stricta* has played in disrupting native mutualisms and whether or not those mutualisms are being restored with the introduction of *D. opuntiae*, I investigated two hypotheses: first, that the release of *D. opuntiae* has resulted in the significant reduction of *O. stricta* populations, and that due to the extreme reduction in *O. stricta* density baboons must be supplementing their diets with other plant species in order to meet energy demands. Therefore, I sought to answer the following questions:

1. Do baboons select for the *O. stricta* fruits over native plant species?

2. To what extent has the reduction in *Opuntia* population density changed the concentration of *Opuntia* fruits in the baboon’s diet?
3. What native plant species are baboons consuming after the decline in availability of *Opuntia* fruits?

**Methods**

I conducted my study at the Mpala Research Centre (MRC) in Laikipia, Kenya. The MRC is approximately 40 kilometers southwest of the site at which *O. stricta* was first introduced in the 1950s (Strum et al., 2015). *Opuntia stricta* has spread predominantly westward of the origin near Doldol (Strum et al., 2015), and subsequent research has quantified the density of the invasion on four properties between Doldol and the MRC. Hodge used this location for her prior samples, which provided my statistical analyses with greater certainty and true replication. Mpala Research Centre is a prime location to conduct this research, because it is far enough from the original introduction site that there is heterogeneity of *O. stricta* on the landscape. Additionally, there are naturally occurring sites at Mpala with and without the cactus to which I can compare to quantify how the cactus is spreading. Furthermore, the baboon roosts and troops had already been identified here, which eased the logistical work involved in planning my project.

Laikipia receives 350 to 800 mm of rainfall annually, and Central Kenya has two rainy seasons and two dry seasons annually (Strum et al., 2015). I collected baboon fecal samples from eight baboon roosts of five different baboon troops during the dry season. Baboons establish roost sites habitually over time (Harding, 1976; Hamilton, 1982), and roost locations have already been located on MRC land, as well as sampled and monitored, by Hodge over the previous two years. Baboons prefer to roost on top of large rock outcrops (“kopjes”) (Hamilton, 1982), and the rocky substrate facilitates easy sample detection and collection. Baboons commute to water sources during the day (Hill and Dunbar, 2002), which created ample opportunity to collect feces during their absence from the late morning to the early afternoon.

I sampled troops roosting along the 45 km north-south expanse of the MRC. I collected 166 scats over a three-month period during the dry season on MRC. Fecal samples were dried, weighed on an analytical balance scale (precision = 0.1 mg), and dissected to remove all plant matter. After
dissection in the lab, dry fecal material was weighed again. Seeds found in the scats were then separated by species, counted, and weighed again. I used these data to calculate ratio of dry feces to seed mass for each sample. I identified plants found in baboon feces to species level using MRC’s reference collection of local plants and seeds. I used ANOVA (analysis of variance) models to quantify differences in quantities of *O. stricta* seeds found in feces between 2014 and 2016 for each troop, as well as to test for differences between troops in quantities of native seeds from 2016 samples.

Additionally, I conducted a survey of each of the roost sites, assessing cactus density, fruit production, and proportion of cacti infected with the cochineal insect. The survey conducted used the methods from Hodge’s prior surveys (Hodge & Goheen, *in prep*). I sampled 100-meter sections along each roost site with 6 meters on each side for a total of 1,200 square meters of coverage. Within each 1,200 square meters section, I counted all the cacti and fruits per cactus, and noted whether or not they were infected with the biocontrol. The information gathered from these surveys combined with the data from the scats allowed me to assess whether baboons are consuming proportionally more *O. stricta* fruits than are available, as well as correlating any decrease or increase in cactus density or fruits with the biocontrol infection rate. I completed all analyses in Program R.

Finally, I completed a census on one and two-year old *O. stricta* plants at each roost site (number of paddles is an indicator of the age of *O. stricta* individuals; Nobel & Barrera, 2003), and integrated that data with the previous year’s fecal seed load data in order to determine the relationship between fecal seed load and *O. stricta* cohort size. For the census, I counted all the *O. stricta* plants along a 100 meter transect and within six meters along either side of the transect. I counted the number of fruits each plant had produced. Using a Welch two-sample t-test, we compared cactus fruit production, cactus density, and the proportion of *O. stricta* seed mass in baboon scats between 2014 and 2016.

**Results**

Our results from cactus fruit production census show that there were significantly fewer
numbers of fruits produced by cacti in 2016 (mean=15) compared to 2014 (mean=68, t=2.49, df=113.29, p < 0.014; Fig. 4). Additionally, there was no significant difference in the proportion of *O. stricta* seed mass in the baboon scats between years, although there is a trend of decreasing seed mass between 2014 and 2016 (t=1.79, df=204.46, p=0.07; Fig. 5).

**Discussion**

Our data suggest that the olive baboons at select *O. stricta* fruits over native fruits. Based on the scat analysis and the fruit production quantified from the roost site surveys I determined that the baboons’ consumption of *O. stricta* fruits was disproportional to their availability (Figs. 4 & 5). If olive baboons are selecting for *O. stricta* fruits then this gives us insight into the ecology and relationships between the baboons and the flora on the Laikipia Plateau. The knowledge that baboons select for the fruits of *O. stricta* is important for management decisions regarding this invasive cactus, and also has implications for the health of native flora populations.

Changes in the availability of *O. stricta* fruits over time may have important implications for the restoration of native mutualisms. As the abundance of *O. stricta* cacti and their fruits decreases, olive baboons may be forced to revert back to their historical food sources. Consuming the native flora may reestablish the mutualisms between the olive baboons and the native flora; the baboons will return to acting as seed dispersers for the native plants rather than the invasive cactus. In turn, this could create a positive feedback loop for the decrease in cactus density, whereby their population numbers are declining due to the cochineal insect and with less cactus and fruits the baboons eat less of them which decreases the extent to which they are spread and thereby further decreases the population numbers.
Figure 1: Young *Opuntia stricta* plant from asexual reproduction; far right cladode fell off another plant and has rooted and begun to sprout a new plant.
Figure 2: An *Opuntia stricta* seedling infected by the biocontrol (*Dactylopius opuntiae*); the fluffy white substance in the photo is a coating the insect makes around itself.
Figure 3: An Olive baboon (*Papio Anubis*) scat died pink from the fruits of *Opuntia stricta*
Figure 4: *Opuntia stricta* fruit production decreased significantly between 2014 and 2016.
Figure 5: There was no significant difference in *Opuntia stricta* fruit consumption by Olive baboons between the 2014 and 2016.
References


Hosking, J. R., P. R. Sullivan, S. M. Welsby. 1994. Biological control of Opuntia stricta (Haw.) Haw. var. stricta using Dactylopius opuntiae (Cockerell) in an area of New South Wales, Australia, where Cactoblastis cactorum (Berg) is not a successful biological control agent. Agriculture, Ecosystems and Environment 48: 241-255


Rodríguez, L. F. 2006. Can invasive species facilitate native species? Evidence of how, when, and why these impacts occur. Biological Invasions 8:927-939

