Potential Pollination of Non-native Coconut Palms, *Cocos nucifera* (Arecales: Arecaceae), by Non-native Madagascar Giant Day Geckos, *Phelsuma madagascariensis grandis* (Sauria: Gekkonidae), in the Florida Keys

Fig. 1. Adult male Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) on buttonwood tree (*Conocarpus erectus*), 14 December 2004, Little Torch Key, Monroe County, Florida.

Kenneth L. Krysko[1] and A. Nichole Hooper[2]

1 Florida Museum of Natural History, Division of Herpetology, P.O. Box 117800, University of Florida, Gainesville, FL 32611

2 College of Veterinary Medicine, Campus Box 100125, University of Florida, Gainesville, FL 32610

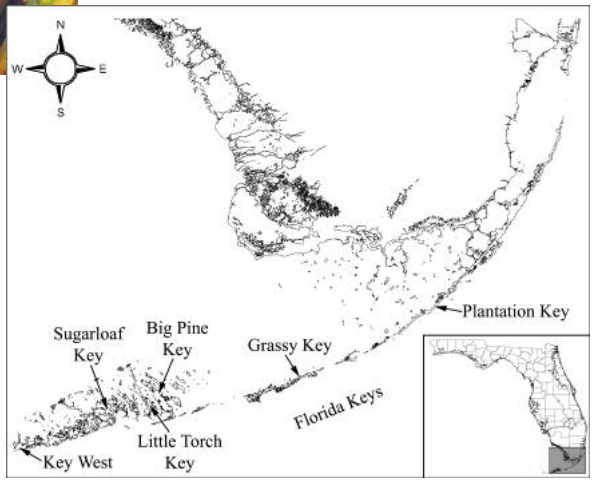

Fig. 2. Study sites in the Florida Keys, Monroe County.

Background

There are numerous reasons for the proliferation of non-native species in Florida, including subtropical climate, diverse human-altered habitats, large ports of entry, thriving trades, and escapees and illegal releases (Wilson and Porras, 1983; Simberloff, 1997; Krysko et al., 2003). Florida presently has about 1340 non-native plants (Hansen, pers. comm.), as well as the largest number of non-native herpetofaunal species (Enge et al., 2004; Meshaka et al., 2004) and second largest number of non-native fishes in the United States (Fuller et al., 1999). It is often difficult to document negative effects of non-native species, especially when considering that most of Florida's non-native herpetofauna are relatively small-sized lizards and their

Fig. 3. Adult Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) on strangler fig (*Ficus aurea*), 2 January 2003, Little Torch Key, Monroe County, Florida.

interactions with other species and subsequent effects on the environment frequently go unnoticed. It has been relatively easier, however, to detect environmental effects caused by many of Florida's non-native plants. Because many of these plants are quite invasive, in 2002 alone the Florida Department of Environmental Protection spent more than 20 million U.S. dollars on exotic vegetation removal (Bureau of Invasive Plant Management, 2003). Herein, we report nectar consumption along with potential pollination of non-native coconut palms, *Cocos nucifera* Linnaeus 1753, by non-native Madagascar giant day geckos, *Phelsuma madagascariensis grandis* Gray 1870, in the Florida Keys, possibly resulting in a synergistic relationship.

Non-native Introductions

Although somewhat controversial, *Cocos nucifera* is believed to be native to the southwestern Pacific (Uhl and Dransfield, 1987; Ohler, 1999) and because of its many uses, including oil, food, and tropical landscape effects (Small, 1929; Perera et al., 1998; Gilman and Watson, 2003; Meléndez-Ramírez et al., 2004), it has been introduced to many parts of the world. The first known introduction of *Cocos nucifera* in Florida was ca. 1807, resulting in a small grove about 6.5 km (4 miles) north of Jupiter Inlet, Martin County (Austin, 1978). Thereafter, *C. nucifera* was introduced to other areas in southern Florida creating relatively small standing groves. However, it was not until February 1878, when a substantial introduction of this species took place. The Spanish brig "Providencia," loaded with coconuts from Trinidad, wrecked off the Atlantic coast near Lake Worth (Pierce, 1970). Thousands of these nuts were taken and intentionally planted around homesteads, creating the most impressive palm forests in Florida to date (Small, 1929; Pierce, 1970). It was these introductions that put "the word 'Palm' in Palm Beach" County (Pierce, 1970:117).

Phelsuma madagascariensis grandis is native to northern Madagascar (Henkel and Schmidt, 1991, 2000; McKeown, 1993; Glaw and Vences, 1994) and has been introduced into the United States in Hawaii (Kraus, 2002) and Florida (Krysko et al., 2003). *Phelsuma m. grandis* was first introduced into Florida in the late 1990s–early 2000s on five separate islands in the Florida Keys, Monroe County (Krysko et al., 2003; Krysko and Daniels, 2005; Krysko and Sheehy, 2005), where it is known to be reproducing. This species occurs on Big Pine, Grassy, Little Torch, Sugarloaf, and Plantation keys (Fig. 2). *Phelsuma m. grandis* is sometimes confused with other lizards in Florida; but it can reach 280 mm total length, is relatively thick-bodied, bright green with a red stripe from the snout to

Fig. 4. Subadult Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) on oak tree (*Quercus* sp.), 29 May 2003, Grassy Key, Monroe County, Florida.

Fig. 5. Senior author noosing adult female Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) on coconut palm (*Cocos nucifera*), 14 December 2004, Little Torch Key, Monroe County, Florida. Inset photograph is close up of same gecko.

the eye, and has reddish-orange spots over the dorsum and a white venter (Glaw and Vences, 1994; Henkel and Schmidt, 2000; Krysko and Daniels, 2005). *Phelsuma madagascariensis* is diurnal and arboreal, and feeds primarily on nectar and arthropods (Demeter, 1976; Tytle, 1992; Krysko et al., 2003), but adults occasionally eat hatchling *Phelsuma* (Krysko et al., 2003) and *Hemidactylus* geckos (pers. obs.; García and Vences, 2002). *Phelsuma m. grandis* is extremely wary and fast, and in the Florida Keys it is mostly diurnal and can be observed on gumbo limbo (*Bursera simaruba*), buttonwood (*Conocarpus erectus*)(Fig. 1), strangler fig (*Ficus aurea*) (Fig. 3), slash pine (*Pinus elliottii*), umbrella (*Schefflera actinophylla*), white bird of paradise (*Strelitzia nicolai*), oaks (*Quercus* sp.)(Fig. 4), and palm trees (Fig. 5), other vegetation, buildings (Fig. 6), wooden fences (Fig. 7), and utility poles (Fig. 8) (Krysko et al., 2003). Some residents enjoy the look of unusual wildlife so much that that they have hired artists to portray these animals on utility poles (Fig. 9).

Fig. 6. Adult Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) on side of house, 3 January 2003, Plantation Key, Monroe County, Florida.

Observations

While studying *Phelsuma madagascariensis grandis* on Little Torch Key (24°40.39'N, 81°23.262'W), we observed a single adult on 6 July 2003 at 1000 h that had climbed far out onto the flower spikes of a *Cocos nucifera* (Fig. 10). This individual licked nectar from the male flowers for about 20 min before

Fig. 7. Adult male Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) on wooden fence, 3 March 2002, Little Torch Key, Monroe County, Florida.

Fig. 8. Neonate Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) on utility pole, 9 July 2003, Little Torch Key, Monroe County, Florida.

Fig. 9. Utility pole depicting non-native Madagascar giant day geckos (*Phelsuma madagascariensis grandis*), Little Torch Key, Monroe County, Florida.

climbing to a more secluded position on the tree. On 9 July 2003 at 0900 h, we observed three adult *P. m. grandis* exhibiting this same foraging behavior for ca. 30 min on another single *C. nucifera* (Fig. 11). These geckos were also observed snapping at hymenopterans as the insects approached flowers. That same day at 0910 h, we observed a neonate *P. m. grandis* licking nectar from male flowers on a nearby *C. nucifera* (Fig. 12). We found it quite interesting that this small gecko was so focused on feeding that it allowed us to approach within ca. 25 cm and photograph it. Since these dates, we have observed this foraging behavior on numerous occasions suggesting that they are not isolated events.

Palms are mainly insect pollinated (although some may be wind pollinated), and pollen and nectar are used as rewards to their pollinators (Henderson, 1986; Meléndez-Ramírez et al., 2004). *Cocos nucifera* is normally allogamous, but autogamy (i.e., self-pollination) may occur (Patel, 1938; Ohler, 1999; Meléndez-Ramírez et al., 2004). Day geckos (*Phelsuma* spp.) are reported to be important

Fig. 10. Adult Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) licking male flowers of a coconut palm (*Cocos nucifera*), 6 July 2003, Little Torch Key, Monroe County, Florida.

Fig. 11. Adult Madagascar giant day geckos (*Phelsuma madagascariensis grandis*) foraging on a single coconut palm (*Cocos nucifera*), 9 July 2003, Little Torch Key, Monroe County, Florida. Note that the third adult is just outside of the photograph and not represented.

pollinators by providing plant outcrossings in their native and introduced range on Hawaii (Nyhagen et al., 2001; Calviño-Cancela, 2005). *Phelsuma m. grandis* climbing on flowers and licking nectar, followed by contacting both stamens and stigmas of the same palm could result in autogamy, whereas if geckos climbed onto a nearby palm outcrossings might occur. *Phelsuma* are known to transport pollen over substantial distances (Nyhagen et al., 2001).

Fig. 12. Neonate Madagascar giant day gecko (*Phelsuma madagascariensis grandis*) licking male flowers of a coconut palm (*Cocos nucifera*), 9 July 2003, Little Torch Key, Monroe County, Florida.

Successfully pollinated female flowers leads to fruit set, thus interactions between these two non-native species may lead to both of them flourishing in southern Florida.

Acknowledgments

We thank Andrew P. Borgia, Sean W. Morey, Kevin M. Enge, Coleman M. Sheehy III, Kenyatta K. Nichols, and Brian J. Camposano for assistance in the field; Frank and Susan Morey, and Andrew P. Borgia for accommodations; Kevin M. Enge for photograph in Fig. 4; Walter S. Judd for plant ID and botanical information; Bruce F. Hansen for non-native plant information and Max A. Nickerson for comments on this paper.

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