Tools and Technology Note

Diazacon Inhibits Reproduction in Invasive Monk Parakeet Populations

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ABSTRACT Throughout the United States, managers lack safe, effective methods to control expanding populations of the invasive monk parakeet (*Myiopsitta monachus*). Because the reproductive inhibitor diazacon (20,25 diazacholesterol) has been used effectively in captive monk parakeets, we provided diazacon-treated sunflower seeds to birds at electric utility substations inhabited by parakeets in south Florida, USA. Nest productivity (nestlings plus eggs with embryos) averaged 1.31 (SE = 0.45, $n = 100$ nests) at 6 treated sites compared to 4.15 (SE = 0.68, $n = 50$ nests) at 4 untreated sites, a 68.4% reduction. Exposure of native bird species to treated bait was infrequent. Diazacon is an effective means to reduce reproductive success of monk parakeets, and development of methods to limit exposure of nontarget birds will enable more widespread use of this useful population management technique. (JOURNAL OF WILDLIFE MANAGEMENT 72(6):1449–1452; 2008)

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Monk parakeets (*Myiopsitta monachus*), native to South America, were introduced to the United States in the 1960s via the pet trade and soon established feral populations following accidental and intentional releases (Spreyer and Bucher 1998). Because of the monk parakeet's reputation as a serious crop pest in South America, there was concern they would cause substantial damage to agricultural crops in the United States as well (Neidermyer and Hickey 1977). Major crop damage has yet to materialize, however, except for localized damage in south Florida (Tillman et al. 2001). Also, the monk parakeet has not been implicated in negative interactions with native species in the United States (Spreyer and Bucher 1998).

Monk parakeets build a bulky nest structure of sticks, often on electric utility substations and support structures of distribution and transmission lines. Nesting by monk parakeets on electric utility facilities in south Florida dates at least to the late 1980s, and the birds' nesting activity has become an important service reliability issue (Avery et al. 2006). In addition to Florida, utility companies in several other states (e.g., TX, NY, IL, CT, OR, WA) currently face similar monk parakeet management issues. Trapping and nest removal is an ongoing activity on distribution poles, at substations, and on transmission lines (Tillman et al. 2002). Since 2003, approximately 3,126 nests have been removed from utility structures in south Florida (J. R. Lindsay, Florida Power and Light Company, personal communication). Nest removal is estimated to cost \$415 to \$1,500 (United States currency) per nest (Hodges and Newman 2002). Thus, in the past 5 years, the cost of nest removal alone is estimated to be \$1.3 to \$4.7 million.

Exponential growth of monk parakeet populations nationwide and in Florida indicates that such problems will continue to increase unless population growth is checked (Pruett-Jones et al. 2005, 2007). Lethal control of these charismatic birds is an option that often elicits strong negative response by the public and is difficult to implement. Alternatively, reproductive inhibition can be used to slow the growth of wildlife populations (Bomford 1990). For birds, diazacon (20,25 diazacholesterol) has been used successfully to lower reproductive output in a number of species (Bomford 1990, Yoder et al. 2004). Yoder et al. (2007) demonstrated that diazacon applied to hulled sunflower seed eliminated production of nestlings among pairs of captive parakeets. Our objectives were to 1) document nest productivity in free-flying parakeet populations exposed to diazacon-treated bait at electric utility substations, and 2) document exposure of nontarget birds to diazacon-treated bait.

STUDY AREA

In consultation with utility company officials, we selected 9 substations in Miami-Dade County, Florida, USA with established parakeet nesting populations. Seven substations were in mixed residential and commercial areas and 2 were in suburban and agricultural areas. Within the gravel-covered fenced compound at each site was a small control building, in addition to the open structure of girders that supported transformers, and other electrical equipment upon which parakeets nested. Substations ranged in size from 0.10 ha to 3.02 ha ($\bar{x} = 0.60$ ha, SE = 0.31).

METHODS

At each substation, we erected a feeding station consisting of 1–3 open-platform feeders (42 cm × 33 cm). We generally fixed multiple feeders 20 cm apart and 1 m above

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the ground on a rack made of metal fence posts and wood. At one site, we placed the feeders directly on concrete structural support pads.

Timing of bait presentation differed between years, but the general sequence of events was consistent. On 6 March 2006 and 24 January 2007, we began prebaiting at each study site by providing a mixture of wild bird seed, hulled sunflower seeds, and fresh fruit. Later, when we noted regular visitation by parakeets, we provisioned feeders each morning with only hulled, untreated sunflower. Each day we collected uneaten food and replenished the bait stations with new seed. On 18 March 2006 and 17 February 2007, when we observed consistent consumption of hulled sunflower by parakeets, we began presenting diazacon-treated sunflower seed at designated treatment sites; untreated control sites continued to receive plain sunflower seed. In 2006, we had 2 treated sites and 2 untreated control sites. In 2007, we used 4 treated sites and 2 untreated control sites. One of the untreated control sites in 2006 served as a treated site in 2007. Bait presentation at each site continued for 10 days.

Based on previous findings with captive parakeets, we set the target daily diazacon treatment dose at 50 mg/kg/bird (Yoder et al. 2007). We dissolved the diazacon in water and mixed it with hulled sunflower seeds to achieve a treatment concentration of 500 ppm. We then presented approximately 15 g of treated seed per bird for 10 consecutive days. To achieve this treatment, we anticipated that each bird would consume 10–12 g of diazacon-treated seed daily (approx. 10% of a parakeet's body mass), which translates approximately to a daily diazacon dose of 50 mg/kg for each bird. To estimate daily bait consumption, we multiplied total bait removed at each site by the proportion of total bird visits represented by monk parakeets. We then divided by the number of adult birds at the site based on the number of active nests, assuming 2 parakeets per nest.

We monitored each bait station during daylight hours to determine acceptance of the bait by parakeets and to document the species and number of nontarget birds using the feeders. In 2006, we used surveillance video cameras and video cassette recorders powered by 12-V automobile batteries. To document bird activity in 2007, we installed a motion-activated digital camera (Cuddeback NoFlash®; Non Typical Engineering, Park Falls, WI) at each site approximately 2.5 m from the feeder. We set controls on the digital cameras so that there was a $\geq$1-minute time lag between images. Each year we experienced technical problems with camera systems, which resulted in incomplete coverage at the study sites.

We reviewed videotapes (2006) and still images (2007) to record all birds on or within the platform bait stations provisioned with diazacon-treated seed. To make the 2006 and 2007 data comparable, we sampled the videotapes by simulating operation of the motion-activated cameras. When the first birds arrived at the feeder, we paused the tape and recorded the number and species of birds. The tape resumed and we imposed a 1-minute delay before the next bird movement to or from the feeder was permitted to trigger the next pause. We repeated this procedure until the entire tape was reviewed. We then summed all of the birds recorded at each site during the 10-day treatment period and computed the proportional representation by each species.

During 1–4 May 2006 and 23 April–10 May 2007, utility company personnel removed all nests that could be safely accessed. At each site, we evaluated each nest and marked its location on a map of the substation. We considered a nest complete and active if it had an integrated structure, a well-defined opening, and fresh material lining the nest chamber. We carefully documented contents of each nest as utility company personnel removed it. We weighed and euthanized nestlings with carbon dioxide (Beaver 2001). We weighed and refrigerated eggs for later examination to determine viability (i.e., a developing embryo was visible). After we secured the nest contents, utility company personnel dismantled and removed each nest structure. We used one-way analysis of variance to assess differences in nest productivity between treated and untreated sites. We conducted our research following Good Laboratory Practices and animal care procedures as specified in National Wildlife Research Center approved study protocol QA-1346.

RESULTS

The diazacon-treated sunflower bait was readily accepted by parakeets, and estimates of daily parakeet bait consumption ranged from 6.79 g/bird to 11.08 g/bird (Table 1). At 3 study sites, monk parakeets constituted 98.8%, 98.9%, and 99.1%, respectively, of the birds that used bait stations during the treatment phase. At the other 3 treated sites, we frequently recorded Eurasian collared-doves (*Streptopelia decaocto*). At one site, we recorded rock pigeons (*Columba livia*) and white-winged doves (*Zenaida asiatica*). Exposure of native species to diazacon-treated bait was minimal and principally limited to one site where mourning doves (*Z. macroura*) accounted for 22.2% of the visits, and common grackles (*Quiscalus quiscula*) and boat-tailed grackles (*Q. major*) combined contributed 7.8% of the birds we recorded feeding on treated bait.

During the 2 field seasons, we documented the contents of 150 monk parakeet nests (Table 1). The remaining 54 nests at the study sites were too close to sensitive high-voltage equipment to be safely accessed. At treated sites, 32% of active, complete nests were empty, compared to 6% empty nests at untreated sites. Mean number of nestlings plus eggs with embryos in nests at substations exposed to diazacon-treated bait (1.31/nest, SE = 0.45, n = 100 nests) was reduced 68.4% ($F_{1,8} = 13.34$, $P = 0.006$) relative to the sites not exposed to diazacon (4.15/nest, SE = 0.68, n = 50 nests).

DISCUSSION

Our findings suggest that effects of diazacon on monk parakeet reproduction can be manifested in various ways. The number of empty nests (32%) indicates that in some cases, diazacon inhibits egg production altogether, possibly

Table 1. Numbers of monk parakeet nests, nest productivity, and amount of diazacon-treated bait removed at electric substation study sites in Miami-Dade County, Florida, USA, April and May, 2006 and 2007.

Yr	Site[a]	Complete nests		Productivity[b]		Diazacon bait removed (g/day)		
		Total	Removed	$\bar{x}$	SE	Total	SE	Per bird
2006	Davis (D)	37	13	2.08	0.80	552	26.3	7.46
	Galloway (D)	23	13	3.15	0.62	345	20.6	7.50
	Coral Reef (U)	29	23	4.78	0.42			
	Hainlin (U)	13	13	5.69	0.43			
2007	Arch Creek (D)	28	27	1.04	0.34	572	31.1	10.10
	Biscayne (D)	20	17	0.82	0.36	474	21.8	6.79
	Coral Reef (D)	21	17	0.29	0.24	663	36.4	11.08
	Suniland (D)	13	13	0.46	0.39	404	16.1	9.21
	Princeton (U)	8	7	2.57	0.69			
	Killian (U)	12	7	3.57	1.09			
Totals	Diazacon	142	100	1.31	0.45			
	Untreated	62	50	4.15	0.68			

[a] Sites where parakeets were exposed to diazacon-treated bait are indicated with (D). Sites where birds were not exposed to diazacon are indicated by (U).
[b] Nestlings plus eggs with embryos.

by preventing progesterone and estradiol production (Yoder et al. 2004). When parakeets exposed to diazacon did produce nestlings and eggs with embryos, their reproductive output was substantially reduced relative to untreated sites.

Numbers of nestlings were considerably lower in 2007 than in 2006 at both the untreated and treated sites. We attribute the decrease in nestling numbers at the treated sites to earlier bait presentation in 2007 that likely resulted in a greater proportion of pairs being affected than in 2006. At untreated sites, the reduction in nestling numbers between years is attributed to our inability to access one of the 2007 study sites until 8 May, 2 weeks after the intended nest removal date. Fecal material in some nests that we eventually removed indicated that nestlings had been present and fledged before we could access the site. Furthermore, 2–3 weeks before we arrived, utility company maintenance personnel at this same site removed several nests with young. Those untreated nests are not reflected in our results.

Results from our 2-year field study are consistent with those obtained in trials with captive monk parakeets (Yoder et al. 2007). Reduction of reproductive output through ingestion of diazacon is not limited to monk parakeets (Bomford 1990, Yoder et al. 2004). A potential constraint to using diazacon is its possible effect on nontarget native species. One option for mitigating impacts on target species is to use selective bait stations that allow parakeets access but exclude other birds. We are currently pursuing this approach and recommend that consideration be given to establishing permanent bait sites where parakeets can be conditioned to feed so that diazacon-treated bait can be efficiently presented. On the other hand, because effects of diazacon are not limited to monk parakeets, there is potential for expanding the use of diazacon for population control in other nonnative species, notably house sparrows (*Passer domesticus*), European starlings (*Sturnus vulgaris*), and rock pigeons. These species regularly nest in electric utility facilities where they contribute to major problems for which effective management methods are currently lacking (James et al. 1999).

Management Implications

Diazacon holds promise as a means for controlling population growth of monk parakeets. Refinement of bait presentation procedures will minimize potential exposure of nontarget species and will broaden the usefulness of this reproductive inhibitor. As reproductive inhibitors like diazacon become more available, wildlife managers will have increased options for long-term population management of overabundant problem species.

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