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RESEARCH ARTICLE

WILDLIFE SOCIETY BULLETIN

A novel parakeet-selective feeder for control of invasive psittacines

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Abstract

Over 40 species of parrots, members of order Psittaciformes, have established nonnative populations globally. Monk parakeets (*Myiopsitta monachus*) are among the most invasive bird species worldwide. In their introduced range, populations of monk parakeets have caused negative impacts on native species, habitats, economies, and human safety. Lethal population management has been complicated by the intelligence of monk parakeets, as they quickly alter behavior to avoid risks. Further, lethal control programs have been halted due to public controversy, as parakeets are highly charismatic. The contraceptive DiazaCon has been demonstrated to effectively reduce fertility in monk parakeets and other psittacines. In field applications, chemical control agents (e.g., toxicants and contraceptives) must be delivered in a manner that prohibits access by nontarget species. We developed and tested a parakeet-selective feeder. The feeder allows access by parakeets and limits access by nontarget bird species by lowering a wire exclusion curtain around the feeder, requiring a zygodactyl toe arrangement to access food. We tested the parakeet-selective feeder in trials with captive and free-ranging monk parakeets and nontarget species in Florida, USA. Monk parakeets successfully accessed food from the parakeet-selective feeder throughout the study. The mean

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number of daily feeder uses by nontarget species decreased from a high of nearly 16 uses per day when the exclusion curtain was not implemented to <1 use per day when implemented. Our findings suggest the parakeet-selective feeder is a promising tool for delivery of bait treated with chemical control agents to manage monk parakeets and other nonnative parakeet populations, but implementation success will likely vary by target species, location, local faunal diversity, and availability of alternative forage.

Invasive parrot populations have become a difficult wildlife management challenge globally. There are nearly 400 species within the order Psittaciformes. While approximately 28% of parrot species are classified as threatened or endangered (Olah et al. 2016), an estimated 15% of parrot species have established populations outside of their native range (Menchetti and Mori 2014). Largely facilitated by transport through the pet trade, nonnative parrot populations are now established on every continent outside of Antarctica. Nonnative parrot populations have been documented altering habitats (Fletcher and Askew 2007) and threatening native species through resource competition (Hernández-Brito et al. 2018). Economic impacts of nonnative parrot populations have included crop depredation and property damage (Klug et al. 2019, Anderson et al. 2023). Despite the documented negative impacts, few viable management options exist for invasive parrot populations (Avery and Shiels 2018, Bunbury et al. 2019, Klug et al. 2023). As particularly intelligent avian species, parrots are capable of quickly learning to avoid management efforts (Bunbury et al. 2019, Anderson et al. 2023). Further, given the highly charismatic nature of these species, lethal control has been challenged by local public sentiment (Crowley et al. 2019, Crowley 2021).

Monk parakeets (*Myiopsitta monachus*) are native to southeastern South America in the lowlands east of the Andes Mountains (CABI 2010, Burgio et al. 2020). Nonnative monk parakeet populations have been introduced in over 20 countries in North America, Europe, Africa, Asia, and at least 4 Caribbean islands (CABI 2010, Avery 2020, Burgio et al. 2020), representing one of the largest nonnative ranges of any parrot species (Calzada Preston et al. 2021). Monk parakeets possess attributes considered favorable in facilitating nonnative range expansion, including a wide ecological tolerance, high transport numbers through the pet trade, and highly synanthropic behavior (Menchetti et al. 2016). Of the 25 parrot species believed to be reproducing in the USA, monk parakeets are most abundant and have the widest distribution (Uehling et al. 2019, Burgio et al. 2020), with breeding populations in at least 7 states (Avery 2020).

Populations of invasive monk parakeets have demonstrated negative ecological, economic, and human welfare impacts. Monk parakeets have displayed agonistic behaviors toward native species when foraging and nesting in introduced habitats (DiSanto et al. 2016, Briceño et al. 2019). Monk parakeets are considered crop pests within their native range (Neidermyer and Hickey 1977, Bucher 1992, Preston et al. 2021), and likewise have caused economic losses in their introduced ranges through crop depredation (Tillman et al. 2001, Senar et al. 2016, Preston et al. 2021). Perhaps the most substantial human impact of nonnative monk parakeets results from their unique nesting behavior. Monk parakeets construct bulky colony nests from sticks and branches, ranging in size from ~0.7 to >3 m in height (Newman et al. 2008). In urban areas, nests are most frequently built on electrical utility structures, where they contact energized components (Newman et al. 2008, Reed et al. 2014, Avery and Shiels 2018). When nest materials become wet, a short circuit is created, resulting in power outages

and fires (Burgio et al. 2014, Avery and Shiels 2018) and, in turn, posing safety concerns for local communities as well as a substantial financial burden and liability risk for utility companies (Avery et al. 2002).

Managers of nonnative monk parakeet populations around the world have employed lethal and nonlethal management strategies to suppress parakeet populations and mitigate impacts. Live trapping and netting have been used with varying success by location and trap type (Martella et al. 1987, Tillman et al. 2004, Avery and Shiels 2018, Klug et al. 2023). In the USA, monk parakeet nests are removed from power poles and substations; however, this is typically ineffective, as the nest sites are reoccupied almost immediately (Avery and Shiels 2018). Populations of other nonnative psittacines such as rose-ringed parakeets (*Psittacula krameri*) have been controlled by culling using firearms (Bunbury et al. 2019, Anderson et al. 2023), but shooting cannot be safely implemented near electrical infrastructure. Lethal control via toxicants is the primary method of controlling monk parakeet crop damage in their native range (Linz et al. 2015). While avicides are used to control other pest bird species in the USA (e.g., pigeons, starlings, magpies, and gulls [U.S. Department of Agriculture {USDA} 2001]), none are currently registered for use with parakeets (Klug et al. 2023).

Fertility control is an option to reduce pest bird populations through targeted feeding with contraceptive-treated baits. Successful field applications have been documented with Canada geese (*Branta canadensis*; Bynum et al. 2005) and pigeons (*Columba livia*; Dobeic et al. 2011, Klug et al. 2023). Monk parakeets are an ideal species for control via contraception, as their limited dispersal and seasonal breeding habits would require contraceptives to only be delivered on a short-term basis in targeted areas (Yoder et al. 2007). Further, monk parakeets readily use bird feeders (Yoder et al. 2007), suggesting they could be habituated to feeding stations where contraceptive-treated bait is delivered. The contraceptive 20,25-diazacholesterol dihydrochloride, commonly referred to as DiazaCon (CAS No. 1249-84-9), appears to be a promising option for the control of pest parakeet populations (Yoder et al. 2007, Avery et al. 2008, Lambert et al. 2010). DiazaCon inhibits the formation of pregnenolone, the parent compound of steroid hormones; in turn, this prevents reproduction by inhibiting the synthesis of progesterone or testosterone (Miller and Fagerstone 2000). DiazaCon was found to effectively reduce reproduction in captive monk parakeets through treated seed (Yoder et al. 2007) and rose-ringed parakeets when orally administered (Lambert et al. 2010). Evidence of field efficacy was provided in south Florida, where monk parakeet productivity (nestlings plus eggs with embryos) was 1.3/nest at 6 sites provided with DiazaCon-treated seed verses 4.1/nest at 4 sites given untreated seed (Avery et al. 2008). However, because the contraceptive is not species specific, application for management of wild populations must be delivered in a manner that limits access by nontarget species. Prohibiting access to contraceptive-treated bait is particularly critical in introduced ranges where native, endemic, or imperiled species occur.

We developed a novel parakeet-selective feeder, designed to allow feed access to parakeets and exclude nontarget species. We evaluated performance of the parakeet-selective feeder through trials with both captive monk parakeets and a free-ranging, nonnative monk parakeet population. We further evaluated the efficacy of the feeder in nontarget exclusion through trials with free-ranging, nontarget species.

STUDY AREA

Captive monk parakeet trials were conducted indoors at the United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (USDA APHIS WS), National Wildlife Research Center Invasive Species Research Building (ISRB) in Fort Collins, Colorado, USA. Captive monk parakeet trials were also conducted in an outdoor aviary at the USDA APHIS WS National Wildlife Research Center Florida Field Station (FFS) in Gainesville, Florida, USA.

Trials with free-ranging monk parakeets were conducted in areas with documented monk parakeet presence in Miami-Dade County (~26.65°N, −80.35°W). Monk parakeets were first documented breeding in south Florida in 1969 and have been established in the region since the 1970s (Avery and Shiels 2018). While monk parakeets have been reported throughout Florida, at the time of our study populations had only been documented in the southern

portion of the state (Early Detection and Distribution Mapping System 2022). South Florida is characterized as a humid, tropical environment (Chen and Chen 2013). The climate consists of a 5-month wet season from late spring into fall, followed by a 7-month dry season. Mean daily temperatures range from 17 to 25°C, and maximum daily temperatures consistently exceed 27°C in the summer months. Dominant landcover classes include freshwater and brackish wetlands, rangeland, agriculture, and urban development. Landscape cover includes a heterogeneous mixture of upland, wetland, estuarine, and marine ecosystems (Obeysekera et al. 1999). Topography is low, with a maximum elevation of approximately 60 m (National Aeronautics and Space Agency 2020). Agriculture in the area includes citrus, tropical fruits, and vegetables. The largest urban development is the Miami-Dade metropolitan area, spanning >6,000 km^2 with a population of >2.5 million people.

Trials with free-ranging, nontarget species outside of the monk parakeet range were conducted at the FFS. North central Florida is characterized as a humid, subtropical environment (Chen and Chen 2013). Mean daily temperatures range from 12 to 28°C (US Climate Data 2021). June–October is hot and humid, with thunderstorms nearly daily (Hubbard and Judd 2013). Landscape cover at the FFS includes pine flatwoods and mixed hardwood forests interspersed with urban development.

METHODS

Feeder design

We developed a prototype using a cylindrical hopper-style feeder with a 360-degree feeding tray (Mandarin Sky Café AR360, Arundale, St. Louis, MO, USA) mounted atop a metal pole. Around the hopper, we affixed a wire mesh exclusion curtain, which served as an exclusionary tactic for nontarget species (Figure 1). Parrots have zygodactyl feet, wherein the second and third digits face forward and the first and fourth face backward. Zygodactyly is considered an adaptation for climbing, perching, and manipulation (Botelho et al. 2014), as it allows birds to climb vertical surfaces and hang inverted. By placing the cage wire curtain around the hopper, feed access was limited to zygodactyl species capable of climbing under the curtain. The curtain was constructed of PVC-coated welded wire mesh (2.54 cm^2 opening size) and affixed with plastic cable ties to U-shaped metal supports (Advanced Pole System$^®$ stabilizers, Wild Birds Unlimited, Inc., Carmel, IN, USA) attached beneath the feeder, allowing it to be raised or lowered over the hopper. Post-hoc observations indicated additional modifications were needed to prevent access by nontarget species flying under the exclusion curtain to access the feed hopper (Figure 2; described in Phase 3 below). We attached a seed-catching device (SeedSaucer™, Backyard Birding Solutions, Concorde, ON, Canada) below the feeder to capture spilled seed, preventing access by ground-foraging nontarget species, and we drilled a hole in the center of the SeedSaucer™ to allow it to slide over the pole (Figure 1).

We tested application of the parakeet-selective feeder in 3 phases. In Phase 1, we tested feeder use by captive monk parakeets by measuring weight of feed consumed. In Phase 2, we tested feeder use by wild monk parakeets and the feeder's ability to exclude nontarget species by weight of feed consumed and mean number of daily feeder uses observed via cameras. In Phase 3, we tested modifications to the feeder to improve nontarget exclusion, both in controlled trials with captive monk parakeets (by weight of feed consumed) and in the field with nontarget bird species (by mean number of daily feeder uses).

Phase 1: monk parakeet captive trials

We conducted 3 trials of the parakeet-selective feeder with captive–monk parakeets, each spanning 10 days. Two trials were conducted indoors at the ISRB in Fort Collins, Colorado, USA, in January 2008. The third was conducted in an outdoor aviary at the FFS in Gainesville, Florida, USA in January and February 2008.

FIGURE 1 Parakeet-selective feeder schematic (top left), platform feeder in front of parakeet-selective feeder at electrical utility substation (top right), use by invasive monk parakeets (*Myiopsitta monachus*) and nontarget bird species with exclusion curtain fully raised (bottom left), and use by monk parakeets with exclusion curtain fully lowered (bottom right). Photos were taken at an electrical substation in south Florida, USA, June–July 2008.

For each captive trial, a group of 4 birds was housed in a visually-isolated test enclosure (ISRB = 3 × 1.5 × 1.8 m; FFS = 9.1 × 3 × 1.8 m). In the center of the enclosure, we provided a water bowl and food bowl containing the birds' maintenance diet (1:2:1 parts by weight of striped sunflower seeds, white proso millet, and whole horse oats with hulls). Birds were acclimated for a minimum of one week. On the morning of test day 1, we permanently removed the bowl containing the maintenance diet and installed the parakeet-selective feeder containing a measured amount of the same diet (100 g at ISRB, 250 g at FFS). The parakeet-selective feeder was positioned so that the feeder contents were visible from adjacent perching areas (food tray ~1.2 m high). For the first 3 days, the exclusion curtain was in the fully raised position, allowing free movement to and from the food tray. Thereafter, every 2 days the exclusion curtain was lowered 1/3 of the distance to the fully lowered position. Thus, the exclusion curtain was lowered 1/3 on the fourth day, 2/3 on sixth day, and fully lowered on the eighth day. The exclusion curtain remained in this position until the end of the trial (day 10).

We used cameras to continuously monitor parakeet activity (video surveillance cameras attached to a DVR at ISRB; motion-activated Cuddeback No Flash Non Typical Inc, De Pere, WI, USA camera traps at FFS). We reviewed recordings to ensure all 4 birds within each enclosure were able to access feed and water at will. Because the aim of the parakeet-selective feeder was to deliver chemical control to parakeets, it was important to evaluate how consumption amount varied throughout the study. We evaluated monk parakeet use of the feeders at the 4 curtain

FIGURE 2 Modifications to the parakeet-selective feeder designed to reduce access by nontarget species: stiff wires not deployed (top left), stiff wires deployed (top right), and dangling wires (bottom).

positions by comparing the weight of seeds consumed each day; we considered the first day an acclimation day and thus evaluated consumption beginning on day 2. Every morning, food remaining in the feeder was removed, weighed, and a new measured amount added; spilled and uneaten food was weighed after collections from the spill tray. For the outdoor trial at the FFS, any seed exposed to rain was dried in an oven (Isotemp Oven Model 655F, Fisher Scientific, Hampton, NH, USA) for 24 hours prior to being weighed. We measured seed consumption by subtracting the weight of the uneaten and spilled seed from the weight of the total provided seed.

Phase 2: monk parakeet and nontarget species field trials

We selected 3 electrical substations in south Florida (Miami-Dade County) with documented monk parakeet presence—Killian, Marion, and Suniland. Within the fenced compound at each substation, we mounted an open platform feeder (33.6 × 41.9 × 6.4 cm; Hang, Pole Mount or Ground Platform Feeder, Woodlink, Mount Ayr, IA, USA) and a parakeet-selective feeder (Figure 1). The platform feeder was mounted at a height of 1.2 m and the parakeet-selective feeder at a height of 1.8 m with the exclusion curtain fully raised (allowing complete access). Both feeders were provisioned with a mixture of wild bird seed (2:1:1 parts by weight of Higgins Pigeon Grain Supreme, black-oil sunflower, and safflower). When we observed reliable and adequate visitation by both monk parakeets and nontarget bird species to a feeding station (in-person or via camera), we reduced the amount of bird seed in the platform feeder over the course of 2 to 3 days (dependent on how quickly the birds acclimated to the feeders) to none. Thereafter, seed was only placed in the parakeet-selective feeder. We continued to operate the parakeet-selective feeder in a fully raised position for 2 to 5 days to ensure consistent visitation. Following the captive feeder trial methodology of Phase 1, we lowered the exclusion curtain by 1/3 every 2 days until fully

lowered. Trials at all 3 stations were conducted from June to July 2008. Trial duration, including prebaiting, was 25 days at Killian, 29 days at Marion, and 32 days at Suniland; differences in trial duration were due to longer bird acclimation times in Marion and Suniland and because we extended the fully lowered portion of the study in Suniland to ensure we collected adequate data.

We monitored use of the parakeet-selective feeders using motion-activated cameras (Cuddeback No Flash, Non Typical Inc, De Pere, WI, USA) programmed to capture one still photo and a 1-minute video when motion was detected. We experienced camera malfunctions on multiple days at each site, resulting in a total number of days of observation of 22 at Killian, 24 at Marion, and 18 at Suniland. Using camera data, we evaluated the number of daily feeder uses as the number of times the feeder was used by birds each day (perched on the feeding tray or inside the feeder); because we were unable to identify and distinguish individual birds, the number of daily feeder uses may have included repeat use by individuals. Using the video data, we documented interactions between birds and eastern grey squirrels (*Sciurus carolinensis*) and used the observations for design improvement. We visited each feeder daily to remove and measure remaining seed and replace it with new seed. Seed consumption was calculated following the protocols of Phase 1. Seed that was exposed to rain was dried in a low humidity, air-conditioned environment until dry to the touch (≥24 hours, dependent on wetness and seed amount) prior to being weighed.

Phase 3: modified feeder design trials

Post-hoc evaluation of the field trials (Phase 2) indicated modification to further restrict access by nontarget species was merited. The aim of all modifications was to ensure climbing around the curtain, rather than simply flying up to the feeding tray, was requisite for feed access. Each modification was tested to evaluate whether monk parakeets were able to access feed despite the modification and whether the modification impeded feed access by nontarget bird and mammal species.

Captive monk parakeet response to modifications

The first tested modification introduced rigid, downward-pointing sharp, stiff wires from the exclusion curtain into the space where birds gained access to the feeder tray. Stiff wires were attached to the bottom of the curtain and their position secured with cable ties, such that they could be disarmed (flush with the outside of the curtain) during the pre-baiting and curtain lowering stages and deployed downward and inward when the curtain was fully lowered (Figure 2). To evaluate whether monk parakeets were able to access feed with the stiff wire modification, we conducted 2 trials, each with 4 wild-caught, captive monk parakeets with no prior exposure to the parakeet-selective feeder. Trials were conducted in an outdoor aviary at the FFS. Like Phase 1, the curtain was lowered to 1/3 height on day 4, 2/3 height on day 6, and fully lowered on day 8. We added stiff wires on days 10 and 11 (the third and fourth days the curtain was in the fully lowered position). The first trial was conducted in May–June 2010 and the second in June–July 2010. Seed consumption was calculated following the protocols of Phase 1. Bird activity was monitored using motion activated cameras (Moultrie GameSpy I-65 Infrared, Birmingham, AL, USA).

The second set of captive trials tested the addition of dangling wires beneath the feeding tray and exclusion curtain. For this modification, a wire loop was attached beneath the perimeter edge of the feeding tray and dangling wires suspended from it (Figure 2). Additional dangling wires were hung from the bottom edge of the exclusion curtain when it was in the fully lowered position (not when in the accessible positions). Like the stiff wires, the dangling wires were constructed of metal. Because these wires were affixed in a non-rigid manner, they moved in response to birds landing on the feeder. We conducted 2 trials with the dangling wire modification, each with 4 wild-caught, captive monk parakeets with no prior exposure to the parakeet-selective feeder. Each trial was conducted at the FFS following the protocols used for the stiff wires. The first trial was conducted April–May 2013

and the second May–June 2013. Seed consumption was calculated following the protocols of Phase 1. Bird activity was monitored using motion activated video surveillance cameras (Supercircuits PC 165-DNR Mini box camera, Austin, TX, USA) connected to high resolution DVRs (Supercircuits MDVR25HR).

Nontarget species response to modifications

We evaluated whether nontarget species were able to access feed in the parakeet-selective feeder using 4 modifications. Modifications were tested iteratively with 5 combinations. We conducted the trial on the property of the FFS, which was outside of the Florida monk parakeet range and therefore only accessible to nontarget species. Prior to the study, a hopper-style feeder had been maintained on the property for >2 years, with regular observations of bird use. We removed the hopper-style feeder and replaced it with an elevated parakeet-selective feeder. The trial lasted 56 days from June to August 2010. In the first 9 days of prebaiting, the exclusion curtain was in the fully raised position. Over the following 10 days, we lowered the curtain by 1/3 position every 2 days and measured daily seed consumption. Thereafter, we tested modifications. On day 20, we added 12 stiff wires (described above), and on day 21 we increased the number of stiff wires to 16. On days 22–24, we maintained 16 stiff wires but positioned the exclusion curtain to 2/3 lowered; this brought the wires closer to the feeding tray, thereby constricting the open space through which nontarget birds may gain access. On days 25–36, we returned the curtain to the fully lowered position and added a wire ring around the feeding tray in the space between the stiff wires and tray. On day 37, we added dangling wires to the wire ring, which we maintained for 2 days. Days 42–48, the study was halted due to personnel limitations, and the feeder was not maintained. Observations of camera data during this time indicated birds were using the spill tray as a launching point to fly to the feeding tray. Therefore, during days 49–55, we maintained the aforementioned modifications and removed the spill tray.

Bird activity was continuously monitored via a motion-activated camera trap (Moultrie® GameSpy I-65 Infrared, Moultrie Feeders LLC, Birmingham, AL, USA); when triggered, the camera documented one still photo and a 30 second video. To evaluate variation in use at exclusion curtain positions and modifications, we documented the number of feeder uses per species per day. We further used the video clips to evaluate bird and squirrel interactions with the wire curtain to guide future modification development.

RESULTS

Phase 1: monk parakeet captive trials

In all 3 captive trials of Phase 1, monk parakeets were able to access feed in all 4 exclusion curtain positions (fully raised, 1/3 lowered, 2/3 lowered, fully lowered). Daily seed consumption was relatively stable at all curtain levels in the 2 indoor trials (~30 g/day). Daily feed consumption was more variable at the FFS trial, with the highest consumption occurring while the curtain was 1/3 lowered (81.3 g/day; Figure 3).

Phase 2: monk parakeet and nontarget species field trials

Monk parakeets were documented using the parakeet-selective feeder at all 4 exclusion curtain positions, except for 2/3 lowered at Suniland (due to camera malfunction, we only had data for one day at this position). There were 360 documented events of 11 nontarget bird species using the parakeet-selective feeder at accessible exclusion curtain positions (fully raised, 1/3 lowered, and 2/3 lowered) and 9 documented events of 3 nontarget bird species using the parakeet-selective feeder when the exclusion curtain was fully lowered: house sparrows (*Passer domesticus*; Killian), blue
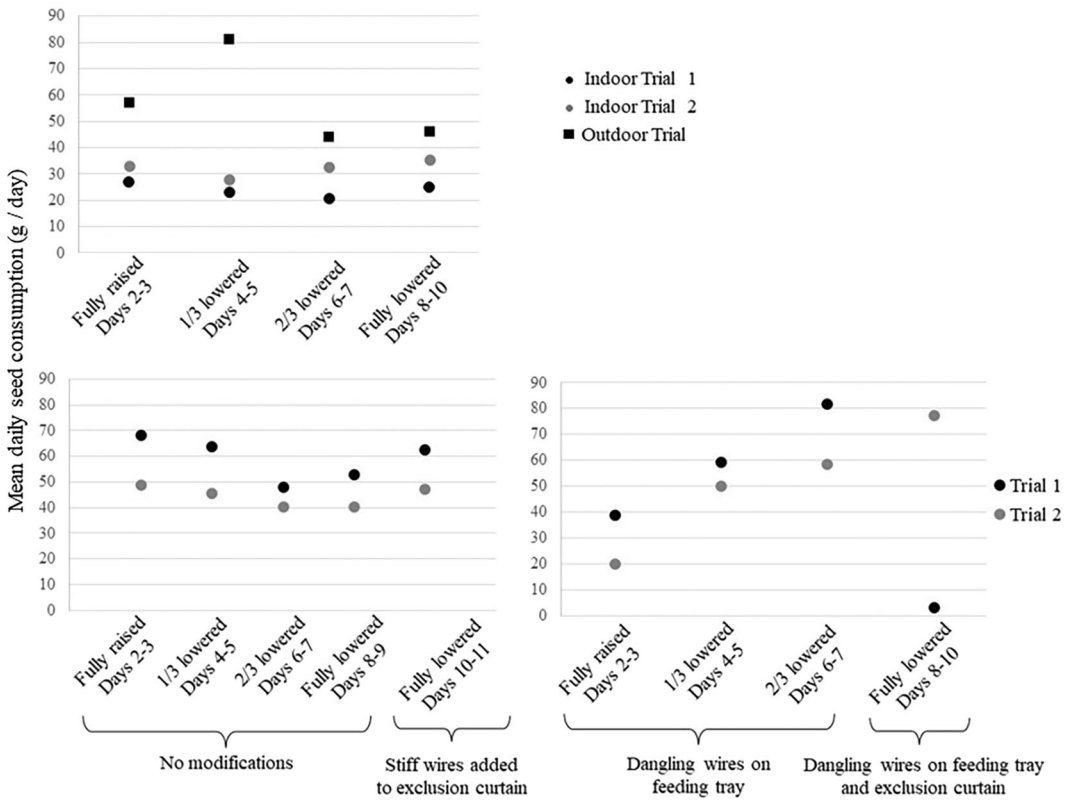
FIGURE 3 Mean daily seed consumption during trials of parakeet-selective feeder using captive monk parakeets (*Myiopsitta monachus*). Consumption measured with no modifications to the parakeet-selective feeders in an indoor aviary in Fort Collins, CO, USA, in January 2008 and an outdoor aviary in Gainesville FL, USA, in January–February 2008 (top; Phase 1). Consumption measured with the modification of stiff wires in an outdoor aviary in Gainesville FL, USA, May–July 2010 (bottom left, Phase 3). Consumption measured with the modification of dangling wires in an outdoor aviary in Gainesville FL, USA, April–May 2013 (bottom right, Phase 3). Variance was not calculated due to small sample sizes.

jays (*Cyanocitta cristata*; Marion), and mourning doves (*Zenaida macroura*; Suniland). Averaged among the 3 sites, the number of daily feeder uses by nontarget species was 15.5 with the exclusion curtain 1/3 lowered and <1 with the exclusion curtain 2/3 lowered and fully lowered (Figure 4). Eastern grey squirrels consumed feed from the parakeet-selective feeder at all curtain phases at Killian; there were no documented uses by eastern grey squirrels at the other 2 sites. At all 3 sites, mean daily feed consumption decreased as the exclusion curtain was lowered. Among the 3 sites, average daily seed consumption was 306 g/day with the curtain fully open, 346.5 g/day 1/3 lowered, 194.7 g/day 2/3 lowered, and 131.2 g/day fully lowered (Figure 5).

Phase 3: modified feeder design trials

Captive monk parakeet response to modifications

The monk parakeets were able to access feed at all exclusion curtain levels with the stiff wires. Daily seed consumption decreased as the exclusion curtain was lowered (average between the 2 trials was 58.6 g/day with the
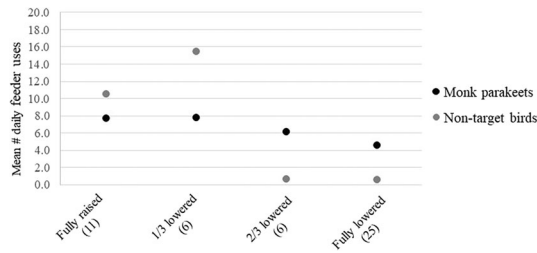
FIGURE 4 Mean number of monk parakeet (*Myiopsitta monachus*) and nontarget bird daily feeder uses per exclusion curtain level during trials in 3 study sites in south Florida, USA, June–July 2008 (Phase 2). X-axis denotes exclusion curtain level and, in parentheses, number of days per exclusion curtain level among the 3 study sites. Eleven nontarget bird species were documented utilizing the feeders, including American crow (*Corvus brachyrhynchos*), blue jay (*Cyanocitta cristata*), boat-tailed grackle (*Quiscalus major*), common grackle (*Quiscalus quiscula*), Eurasian collared dove (*Streptopelia decaocto*), house sparrow (*Passer domesticus*), mourning dove (*Zenaida macroura*), northern cardinal (*Cardinalis cardinalis*), northern mockingbird (*Mimus polyglottos*), red-winged blackbird (*Agelaius phoeniceus*), and white-winged dove (*Zenaida asiatica*). Variance was not calculated due to small sample sizes.
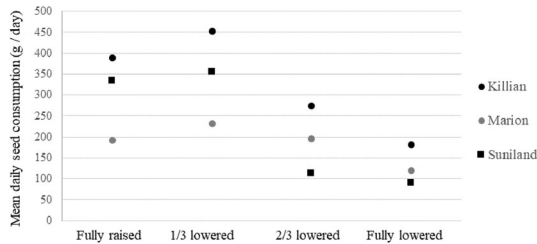
FIGURE 5 Seed consumption in parakeet-selective feeder trials with nonnative monk parakeets (*Myiopsitta monachus*) and nontarget species at 3 study sites, Killian, Marion, and Suniland, in south Florida, USA, June–July 2008 (Phase 2). The study was conducted with the curtain in the fully raised position for 2, 5, and 4 days at Killian, Marion, and Suniland, respectively, 1/3 lowered for 2 days at each site, 2/3 lowered for 2 days at each site, and fully lowered for 10, 6, and 9 days at Killian, Marion, and Suniland, respectively. Variance was not calculated due to small sample sizes.

curtain fully raised and 46.7 g/day with the curtain fully lowered), however consumption increased after the stiff wires were deployed (average 55 g/day; Figure 3). Response of captive monk parakeets to the dangling wires varied between the 2 trials. In the first trial, the monk parakeets displayed a negative reaction when the second set of dangling wires was added to the exclusion curtain (3.3 g/day daily seed consumption when curtain in the fully lowered position). In the second trial, the monk parakeets were able to efficiently navigate this addition (77.6 g daily seed consumption when curtain in the fully lowered position; Figure 3).

Nontarget species response to modifications

We documented eastern gray squirrels and 5 bird species using the parakeet-selective feeder: Carolina chickadee (*Poecile carolinensis*), eastern towhee (*Pipilo erythrophthalmus*), mourning dove, northern cardinal (*Cardinalis cardinalis*), and tufted titmouse (*Baeolophus bicolor*). Only the northern cardinal utilized the feeder with the exclusion curtain fully lowered. After the addition of stiff wires, eastern grey squirrels and 3 bird species accessed the feeder

TABLE 1 Mean number of daily feeder uses by species in a trial to evaluate efficacy of modifications to the parakeet-selective feeder in excluding nontarget species, Gainesville, Florida, USA, June–August 2010 (Phase 3). Modifications included stiff wires (SW), wire ring (WR), dangling wires (DW), and spill tray removal (SR). An additional four stiff wires were added on day 21. The study was halted on days 42–48 during which no data were collected.

Study phase	Pre-baiting	Trial without modifications				Trial with modifications				
Study day	1–9	10–13	14–15	16–17	18–19	20–21	22–24	25–36	37–41	49–56
Exclusion curtain position	Fully raised	Fully raised	1/3	2/3	Fully lowered	Fully lowered	2/3	Fully lowered	Fully lowered	2/3
Modifications implemented						SW	SW	SWWR	SWWRDW	SWWRDWSR
Mourning dove	0	0.3	0	0	0	0	0	0	0	0
Northern cardinal	8	12	4.5	0.5	3	2.5	0.7	1	1.2	0.1
Tufted titmouse	1.5	1	1	0.5	0	0.5	0.3	0.2	0	0.6
Eastern towhee	1	0	0	0	0	0.5	0	0	0	0
Carolina chickadee	0	0	0.5	0	0	0	0	0	0	0
Eastern grey squirrel	0	0	0	0	0	1	0	0.6	0.6	0

in the fully lowered position: northern cardinal, tufted titmouse, and eastern towhee. Lifting the exclusion curtain to the 2/3 lowered level decreased access to one daily feeder use. Thereafter, daily feeder uses were consistently around one with the addition of the wire ring, dangling wires, and removal of the spill tray. Only 2 species were documented feeding with all modifications with the exclusion curtain lowered to the 2/3 level, 1 use by a northern cardinal and 5 by tufted titmice (Table 1; Figure 6).

DISCUSSION

The parakeet-selective feeder is a promising tool for the delivery of contraceptive-treated bait to invasive monk parakeet populations as well as other invasive parakeet species. The exclusion curtain, coupled with modifications, appears to successfully allow feed access to avian species with zygodactyl feet and prevent use by those without. The parakeet-selective feeder may also prove useful for the delivery of other types of treated baits (i.e., oral vaccines, toxicants) to parakeet populations, should they become available. In this study, both captive and free-living populations of monk parakeets readily used the feeder despite exclusion curtain level or added modifications. Further, nontarget bird species use of the feeder was almost completely prohibited via the exclusion curtain and modifications. Our nontarget species finding is key for the use of contraceptives in the wild being approved by regulatory agencies as a management tool.

The efficacy of the parakeet-selective feeder as a tool to aid in the control of invasive parakeet populations is likely dependent on a myriad of factors including target species, location, and nontarget species in the area. Managers should thoroughly pretest the parakeet-selective feeder in their respective study areas with non-treated bait before using it for chemical management programs, both to ensure the target species will utilize the
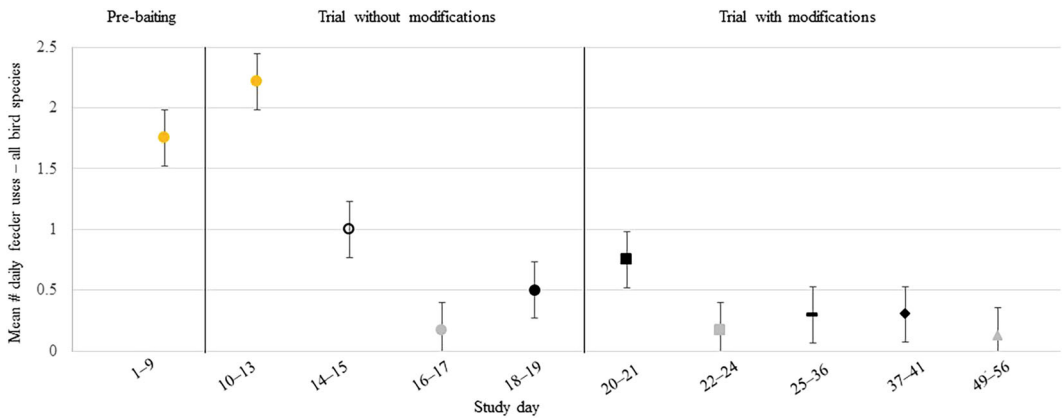
FIGURE 6 Mean number of daily feeder uses in a trial to evaluate efficacy of modifications to the parakeet-selective feeder in excluding nontarget species, Gainesville, Florida, USA, June–August 2010 (Phase 3). Exclusion curtain height was tested fully raised (yellow markers; days 1–9 and 10–13), one-third lowered (black marker with white center; days 14–15), two-thirds lowered (grey markers; days 16–17, 22–24, and 49–56), and fully lowered (black markers; days 18–19, 20–21, 25–36, and 37–41). There were no added modifications during the pre-baiting phase (circle markers; days 1–9) or during days 10–19 (circle markers). Modifications included stiff wires (square markers; days 20–21 and 22–24); stiff wires with a wire ring (flat rectangle marker; days 25–36); stiff wires, wire ring, and dangling wires (diamond marker; days 37–41); and stiff wires, wire ring, dangling wires, and spill tray removal (triangle marker; days 49–56). An additional four stiff wires were added on day 21. The study was halted on days 42–48 during which no data were collected. Bars represent standard error.

feeder and ensure the feeder is inaccessible to nontarget species. For example, rose-ringed parakeets have been documented utilizing bird feeders throughout their native and introduced ranges (Clergeau and Vergnes 2011, Shiels and Kalodimos 2019), but a 24-week trial of platform and hopper bird feeders on Kaua'i, Hawai'i, USA, documented no use by this species (Hess et al. in press). The apparent lack of rose-ringed parakeet feeder use on Kaua'i indicates that parakeet behavior can vary spatially, and chemically-treated bait may only prove a viable management strategy with some populations. Likewise, the ability or propensity of nontarget species to use the parakeet-selective feeder may vary spatially or seasonally. Because the parakeet-selective feeder is designed to allow access to species with zygodactyl feet, it may not be appropriate for use in locations with native parrot populations or other native granivorous or frugivorous birds with zygodactyl feet. In addition to psittacines, zygodactyly is found in 2 other existent clades, Cuculidae (cuckoos) and Piciformes (woodpeckers and allies; Bothelo et al. 2014). Should managers choose to trial the parakeet-selective feeder in areas where these species may be present, bait and feeder position should be tailored in a way to avoid attraction of nontarget zygodactyl species.

Avery et al. (2008) found daily consumption of 6.79 to 11.08 g of DiazaCon-treated seed per bird was sufficient to decrease wild monk parakeet nest productivity. Further research evaluating the amount of seed consumed per individual per day via the parakeet-selective feeder in field trials is merited. Further, our field trials indicated additional research to improve monk parakeet feeder fidelity is warranted. The use of the parakeet-selective feeder by wild monk parakeets decreased as nontarget species' use decreased. It is possible the monk parakeets became wary of the feeder as use by other species decreased. Extending the prebaiting phase may allow parakeets to become better habituated to the feeder. Alternatively, transitioning the feed to one that is preferred by parrots (e.g., increasing sunflower content or adding whole peanuts) may maintain or increase feeder fidelity. The use of live decoy parakeets placed near feeders may act as an attractant (Saavedra and Medina 2020)

and may be worth testing in areas where avian and mammalian predation risk and public concern for decoy parakeets can be mitigated.

Exclusion of nontarget species varied by exclusion curtain level, study site, and modification. When fully lowered, the exclusion curtain alone reduced nontarget use at a high rate in our field trials; however, nontarget use was greater in our north Florida field trials than in our south Florida field trials. The discrepancy in nontarget use between the 2 Florida sites was likely due to differences in habitat and species composition. Thus, site selection, including surrounding habitat and the diversity of nontarget species present, can be an important consideration when implementing the parakeet-selective feeder. When additional modifications to control nontarget use are warranted, we recommend the inclusion of stiff wires, as this modification improved nontarget species exclusion but did not deter monk parakeet use. Because the addition of the wire ring did not appear to alter use by nontarget species or by monk parakeets, we recommend its use if it proves useful with nontarget exclusion elsewhere. Given that the dangling wires did not appear successful in excluding nontarget species but did deter monk parakeets in one of our captive trials, we recommend against this modification. Our finding that the removal of the spill tray further reduced nontarget access to the feeder suggests modifications to this component (i.e., height beneath the feeder, addition of perching deterrents, alternative design) may further prohibit use by nontarget bird species. It should be noted, however, that some sort of spill collection component (e.g., a gridded tray lid and tray that is too deep for birds to reach the seed, or a concave tray that funnels into a bag) will be necessary when used operationally with chemically-treated bait to prevent consumption of spilled bait by nontarget terrestrial species. Eastern grey squirrels proved problematic in both south Florida and north central Florida. In areas with squirrel populations, feeders should be placed far enough from trees or other structures to prevent squirrels from jumping onto the feeder, and a squirrel exclusion device should be added to the parakeet-selective feeder; however, caution is warranted to ensure the squirrel exclusion device does not serve as a launching point for nontarget birds to access the feeder tray, as they did in this study using the spill tray. Squirrel exclusion devices should perhaps include the addition of bird perching deterrents.

In addition to contraceptives, toxicants may be an alternative application of the parakeet-selective feeder. However, before a toxicant could be approved for use with wild parrots in the U.S., species-specific acute toxicity tests and evaluations of parrot sensitivity to taste would be required. Further, while many mammal and avian species are controlled with toxicants (e.g., Dolbeer and Linz 2016, U.S. Environmental Protection Agency [USEPA] 2021), considerable research would be warranted to evaluate the potential impacts to nontarget species, including scavengers (Nakayama et al. 2019). In the U.S., both toxicants and contraceptives must undergo a robust registration process through the USEPA before use can be authorized for a particular species and locality. Given the amount of necessary regulatory measures, as well as noteworthy biological concerns, more research is needed for invasive parrot control with toxicants.

Population control of invasive species is challenging, particularly when the target species is charismatic. Public support of lethal control programs varies by species, and programs involving mammals and birds are less likely to receive support than other taxa (Verbrugge et al. 2013). Invasive parakeet lethal management programs have been halted in the U.S., U.K., and Spain due to protest by animal welfare activists (Crowley et al. 2019, Crowley 2021, M. Sabaté, Departmento Téchnico, personal communication). Further, while most pest parakeet population management efforts have used culling, lethal control alone is typically not sufficient to control crop damage by granivorous birds (Linz et al. 2015). Contraceptives for wildlife control are often perceived by the public to be more humane and acceptable than culling (Fagerstone et al. 2006). However, invasive populations are unlikely to be eradicated by contraceptives alone (Bomford and O'Brien 1992, Anderson et al. 2019). Therefore, the use of contraceptives via the parakeet-selective feeder likely offers an important component to an integrated pest management program.

MANAGEMENT IMPLICATIONS

The parakeet-selective feeder appears to provide a viable strategy to deliver contraceptives for control of invasive parakeet populations. Contraceptive use outside of a research setting must undergo a robust registration process before it can be used by managers. If approved for use, managers should test the parakeet-selective feeder using nontreated bait to determine daily seed consumption by target species and ensure the feeder adequately prohibits access by nontarget species. Considerable time should be allocated to prebaiting, wherein the exclusion curtain is not implemented, to allow both target and nontarget species to acclimate to the feeding site. Recommended modifications include stiff wires, a wire ring, and alternative methods or devices to collect spilled seed. Modifications will likely need to be tailored to respective field sites and the suite of nontarget species.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

Our research protocol was reviewed and approved by the U.S. Department of Agriculture, Animal Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center (NWRC) Animal Care and Use Committee (QA-1488). The parakeet-select feeder is in review for a U.S. patent led by E. Tillman, USDA APHIS Wildlife Services National Wildlife Research Center (Patent pending 63/305,288).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

Anderson, C. J., L. A. Brennan, W. P. Bukoski, S. C. Hess, A. B. Shiels, S. R. Siers, B. M. Kluever, and P. E. Klug. 2023. Evaluation of roost culling as a management strategy for reducing invasive rose-ringed parakeet (*Psittacula krameri*) populations. Biological Invasions. 25:1403–1419.

Anderson, C. J., M. van de Kerk, W. E. Pine, M. E. Hostetler, D. J. Heard, and S. A. Johnson. 2019. Population estimate and management options for introduced rhesus macaques. Journal of Wildlife Management 83:295–303.

Avery, M. L. 2020. Monk parakeet (*Myiopsitta monachus*) Boddaert, 1783. Pages 76–84 *in* C. T. Downs and L. Hart, editors. Invasive birds: global trends and impacts. CAB International, Wallingford, UK.

Avery, M. L., and A. B. Shiels. 2018. Monk and rose-ringed parakeets. Pages 333–357 in W. C. Pitt, J. C. Beasley, and G. W. Witmer, editors. Ecology and management of terrestrial vertebrate invasive species in the United States. CRC Press, Taylor and Francis Group, Boca Raton, Florida, USA.

Avery, M. L., C. A. Yoder, and E. A. Tillman. 2008. Diazacon inhibits reproduction in invasive monk parakeet populations. Journal of Wildlife Management 72:1449–1452.

Avery, M. L., E. C. Greiner, J. R. Lindsay, J. R. Newman, and S. Pruett-Jones. 2002. Monk parakeet management at electric utility facilities in south Florida. Pages 140–145 in R. M. Timm and R. H. Schmidt, editors. Proceedings of the 20th Vertebrate Pest Conference, 4–7 March 2002, Reno, Nevada, USA.

Bomford, M., and P. O'Brien. 1992. A role for fertility control wildlife management in Australia. Pages 344–347 in Proceedings of the 15th Vertebrate Pest Conference, 3–5 March 1992, Newport Beach, California, USA.

Botelho, J. F., D. Smith-Paredes, D. Nuñez-Leon, S. Soto-Acuña, and A. O. Vargas. 2014. The developmental origin of zygodactyl feet and its possible loss in the evolution of passeriformes. Proceedings of the Royal Society B: Biological Sciences 281:1–11.

Briceño, C., A. Sandoval-Rodríguez, K. Yévenes, M. Larraechea, A. Morgado, C. Chappuzeau, V. Muñoz, P. Dufflocq, and F. Olivares. 2019. Interactions between invasive monk parakeets (Myiopsitta monachus) and other bird species during nesting seasons in Santiago, Chile. Animals 9:1–13.

Bucher, E. H. 1992. Neotropical parrots as agricultural pests. Pages 201–219 in S. Beissinger and N. F. Snyder, editors. New world parrots in crisis. Solutions from conservation biology. Smithsonian Institution Press, Washington, D.C., USA.

Bunbury, N., P. Haverson, N. Page, J. Agricole, G. Angell, P. Banville, A. Constance, J. Friedlander, L. Leite, T. Mahoune, et al. 2019. Five eradications, 3 species, 3 islands: overview, insights and recommendations from invasive bird eradications in the Seychelles. Pages 282–288 in C. R. Veitch, M. N. Clout, A. R. Martin, J. C. Russell, and C. J. West, editors. Proceedings of the International Conference on Island Invasives 2017. Occasional Paper of the IUCN Species Survival Commission, University of Dundee, Scotland, UK.

Burgio, K. R., C. B. van Rees, K. E. Block, P. Pyle, M. A. Patten, M. F. Spreyer, and E. H. Bucher. 2020. Monk Parakeet (Myiopsitta monachus), version 1.0. in P. G. Rodewald, editor. Birds of the World. Cornell Lab of Ornithology, Ithaca, NY, USA.

Burgio, K. R., M. A. Rubega, and D. Sustaita. 2014. Nest-building behavior of Monk Parakeets and insights into potential mechanisms for reducing damage to utility poles. PeerJ 2:e601.

Bynum, K. S., C. Yoder, J. D. Eisemann, J. J. Johnston, and L. A. Miller. 2005. Development of nicarbazin as a reproductive inhibitor for resident canada geese. Pages 179–189 in D. L. Nolte and K. A. Fagerston, editors. Proceedings of the 11th Wildlife Damage Management Conference, 16–19 May, Traverse City, Michigan, USA.

Commonwealth Agricultural Bureaux International [CABI]. 2010. Myiopsitta monachus (monk parakeet). <https://www.cabi.org/isc/datasheet/74616>. Accessed 10 Jan 2021.

Calzada Preston, C. E., S. Pruett-Jones, and J. R. Eberhard. 2021. Monk parakeets as a globally naturalized species. Pages 173–192 in S. Pruett-Jones, editor. Naturalized parrots of the world. Princeton University Press, New Jersey, USA.

Chen, D., and H. W. Chen. 2013. Using the Köppen classification to quantify climate variation and change: an example for 1901–2010. Environmental Development 6:69–79.

Clergeau, P., and A. Vergnes. 2011. Bird feeders may sustain feral rose-ringed parakeets Psittacula krameri in temperate Europe. Wildlife Biology 17:248–252.

Crowley, S. L. 2021. Parrots and people: human dimensions of naturalized parrots. Pages 41–53 in S. Pruett-Jones, editor. Naturalized parrots of the world: distribution, ecology, and impacts of the world's most colorful colonizers. Princeton University Press, New Jersey, USA.

Crowley, S. L., S. Hinchliffe, and R. A. McDonald. 2019. The parakeet protectors: understanding opposition to introduced species management. Journal of Environmental Management 229:120–132.

Di Santo, M., C. Battisi, and M. A. Bologna. 2016. Interspecific interactions in nesting and feeding urban sites among introduced monk parakeet (Myiopsitta monachus) and syntopic bird species. Ethology Ecology & Evolution 29: 138–148.

Dobeic, M., K. Vlahović, and A. Dovc. 2011. Feral pigeon (Columba livia) population management in Ljubljana. Veterinary Archives 81:285–298.

Dolbeer, R. A., and G. M. Linz. 2016. Blackbirds. Wildlife Damage Management Technical Series, Ft. Collins, Colorado, USA.

Early Detection and Distribution Mapping System. 2022. Monk parakeet (Myiopsitta monachus). <https://www.eddmaps.org/distribution/viewmap.cfm?sub=18364>. Accessed 8 Dec 2022.

Fagerstone, K. A., L. A. Miller, K. S. Bynum, J. D. Eisemann, and C. A. Yoder. 2006. When, where and for what wildlife species will contraception be a useful management approach? In Proceedings of the 22nd Vertebrate Pest Conference. 6–9 May 2006, Berkleley, California, USA.

Fletcher, M., and N. Askew. 2007. Reivew of the status, ecology and likely future spread of parakeets in England. Central Science Laboratory, York, UK.

Hernández-Brito, D., M. Carrete, C. Ibáñez, J. Juste, and J. L. Tella. 2018. Nest-site competition and killing by invasive parakeets cause the decline of a threatened bat population. Royal Society Open Science 5:172477.

Hess, S. C., C. J. Anderson, E. A. Tillman, W. P. Bukoski, A. B. Shiels, P. E. Klug, S. R. Siers, and B. M. Kluever. 2023. Differences in feeder visitation by invasive rose-ringed parakeets (*Psittacula krameri*) between Hawaiian islands. Pacific Science 77(1):111–123.

Hubbard, J. R., and W. S. Judd. 2013. Floristics of Silver River State Park, Marion County, Florida. Rhodora 115:250–280.

Klug, P. E., W. P. Bukoski, A. B. Shiels, B. M. Kluever, and S. R. Siers. 2019. Critical review of candidate tools for invasive rose-ringed parakeet (*Psittacula krameri*) control in the Hawaiian Islands. Unpublished Final Report QA No. 2836. United States Department of Agriculture-Wildlife Services National Wildlife Research Center, Hilo, Hawai'i, USA.

Klug, P. E., A. B. Shiels, B. M. Kluever, C. J. Anderson, S. C. Hess, E. W. Ruell, W. P. Bukoski, and S. R. Siers. 2023. A review of lethal and nonlethal control tools for managing the damage of invasive birds to human assets and economic activities. Management of Biological Invasions 14:1–44.

Lambert, M. S., G. Massei, C. A. Yoder, and D. P. Cowan. 2010. An evaluation of Diazacon as a potential contraceptive in non-native rose-ringed parakeets. Journal of Wildlife Management 74:573–581.

Linz, G. M., E. H. Bucher, S. B. Canavelli, E. Rodríguez, and M. L. Avery. 2015. Limitations of population suppression for protecting crops from bird depredation: a review. Crop Protection 76:46–52.

Martella, M., J. Navarro, and E. Bucher. 1987. Método para la captura de cotorras (*Myiopsitta monachus*) en sus nidos. Vida Silvestre Neotropical 1:52–53.

Menchetti, M., and E. Mori. 2014. Worldwide impact of alien parrots (Aves Psittaciformes) on native biodiversity and environment: a review. Ethology Ecology & Evolution 26:172–194.

Menchetti, M., E. Mori, and F. M. Angelici. 2016. Effects of the recent world invasion by ring-necked parakeets Psittacula krameri. Pages 253–266 *in* F. M. Angelici, editor. Problematic Wildlife: A Cross-Disciplinary Approach. Springer International Publishing Switzerland, Cham, Switzerland.

Miller, L. A., and K. A. Fagerstone. 2000. Induced fertility as a wildlife management tool. Pages 160–168 *in* Proceedings of the 19th Vertebrate Pest Conference, San Diego, California, USA.

Nakayama, S. M. M., A. Morita, Y. Ikenaka, H. Mizukawa, and M. Ishizuka. 2019. A review: poisoning in non-target animals globally. Journal of Veterinary Medical Science 81:298–313.

National Aeronautics and Space Agency. 2020. Elevation of southern Florida. <https://earthobservatory.nasa.gov/images/4818/elevation-of-southern-florida>. Accessed 29 Nov 2021.

Neidermyer, W. J., and J. J. Hickey. 1977. The monk parakeet in the United States, 1970–75. American Birds 31:273–278.

Newman, J., C. Newman, J. Lindsay, B. Merchant, M. Avery, and S. Pruett-Jones. 2008. Monk parakeets: an expanding problem on power lines and other electrical utility structures. Pages 355–363 *in* Environmental Concerns in Right-of-Way Management: 8th International Symposium, 12–16 September, Saratoga Springs, New York, USA.

Obeysekera, J., J. Browder, L. Hornung, and M. Harwell. 1999. The natural south Florida system I: climate, geology, and hydrology. Urban Ecosystems 3:223–244.

Olah, G., S. H. M. Butchart, A. Symes, I. M. Guzmán, R. Cunningham, D. J. Brightsmith, and R. Heinsohn. 2016. Ecological and socio-economic factors affecting extinction risk in parrots. Biodiversity and Conservation 25:205–223.

Preston, C. E. C., S. Pruett-Jones, and J. R. Eberhard. 2021. Monk parakeets as globally naturalized species. Pages 173–192 *in* S. Pruett-Jones, editor. Naturalized parrots of the world. Princeton University Press, Princeton, New Jersey, USA.

Reed, J. E., R. A. McCleery, N. J. Silvy, F. E. Smeins, and D. J. Brightsmith. 2014. Monk parakeet nest-site selection of electric utility structures in Texas. Landscape and Urban Planning 129:65–72.

Saavedra, S., and F. M. Medina. 2020. Control of invasive ring-necked parakeet (*Psittacula krameri*) in an island Biosphere Reserve (La Palma, Canary Islands): combining methods and social engagement. Biological Invasions 22:3653–3667.

Senar, J. C., J. Domènech, and L. Arroyo. 2016. An evaluation of monk parakeet damage to crops in the metropolitan area of Barcelona. Animal Biodiversity and Conservation 39:141–145.

Shiels, A. B., and N. P. Kalodimos. 2019. Biology and impacts of Pacific Island invasive species. 15. *Psittacula krameri*, the rose-ringed parakeet (Psittaciformes: Psittacidae). Pacific Science 73:421–449.

Tillman, E. A., A. C. Genchi, J. R. Lindsay, J. R. Newman, and M. L. Avery. 2004. Evaluation of trapping to reduce monk parakeet populations at electric utility facitlities. Pages 126–129 *in* Proceedings of the 21st Vertebrate Pest Conference, Visalia, California, USA.

Tillman, E. A., A. van Doorn, and M. L. Avery. 2001. Bird damage to tropical fruit in south Florida. Pages 47–59 *in* Proceedings of the 9th Wildlife Damage Management Conference, 5–8 October 2001, State College, Pennsylvania, USA.

Uehling, J. J., J. Tallant, and S. Pruett-Jones. 2019. Status of naturalized parrots in the United States. Journal of Ornithology 160:907–921.

United States Environmental Protection Agency [USEPA]. 2021. Pesticide product and label system. <https://iaspub.epa.gov/apex/pesticides/f?p=113:1::::RP,17,1>. Accessed 29 Nov 2021.

United States Department of Agriculture [USDA] 2001. USDA Animal Plant and Health Inspection Service Wildlife Services Tech Note: DRC-1339 (Starlicide). <https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1735%26context=icwdm_usdanwrc>. Accessed 29 Nov 2021.

US Climate Data. 2021. Climate Gainesville – Florida. <https://www.usclimatedata.com/climate/gainesville/florida/united-states/usfl0163>. Accessed 29 Nov 2021.

Verbrugge, L. N. H., R. J. G. Van Den Born, and H. J. R. Lenders. 2013. Exploring public perception of non-native species from a visions of nature perspective. Environmental Management 52:1562–1573.

Yoder, C. A., M. L. Avery, K. L. Keacher, and E. A. Tillman. 2007. Use of DiazaconTM as a reproductive inhibitor for monk parakeets (*Myiopsitta monachus*). Wildlife Research 34:8–13.

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