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Differences in Feeder Visitation by Invasive Rose-Ringed Parakeets (*Psittacula krameri*) Between Hawaiian Islands¹

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Abstract: Rose-ringed parakeets (*Psittacula krameri*; parakeets) are among the most invasive bird species worldwide. In their introduced range, populations of this species have caused negative effects on native species, natural environments, economies, and human safety. Lethal population management has been complicated by the intelligence of the birds, as they quickly alter behavior to avoid risks. Further, lethal control programs have been halted due to public opposition, as parakeets are considered to be charismatic by animal welfare advocates. The contraceptive DiazaCon has been demonstrated to effectively reduce fertility in captive parakeets. In field applications, any chemical control agents (e.g., toxicants or contraceptives) must be delivered in a manner that prohibits access by non-target species. Parakeets are known to feed from bird feeders throughout their native and introduced range, suggesting contraceptive-treated bait may be a useful management strategy. However, our 24-week trials with free-ranging parakeets using platform, hopper, and tube feeders on the island of Kaua'i did not result in any parakeet visitation and thus precluded further testing of using feeders to selectively deliver fertility control products. Nonetheless, multiple citizen science reports and other documentation indicate parakeets using feeders on the island of O'ahu over a period of >10 years, and recently on the island of Maui. Our findings suggest the chemical control of nonnative parakeet populations is a promising technique, but implementation success will likely vary by target population acceptance, location, local faunal diversity, and availability of alternative forage.

Keywords: citizen science, fertility control, Hawai'i, invasive species, *Psittacula krameri*, rose-ringed parakeet, toxicant delivery

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INVASIVE BIRD POPULATIONS have become problematic throughout the world but can be particularly detrimental to agriculture and native biota on islands (Brochier et al. 2010). An estimated 15% of the 400 species within the order Psittaciformes, commonly known as parrots, have established populations outside of their native range (Menchetti and Mori 2014). Rose-ringed parakeets (*Psittacula krameri*; hereafter parakeets) have established the largest nonnative range and arguably represent the most problematic invasive parrot species (Avery and Shiels 2018, Collar et al. 2020). This species possesses 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). Parakeets have been observed in >70 countries, with documented nonnative populations spanning every continent except Antarctica (Butler 2003, Strubbe 2009, Collar et al. 2020, Jackson 2021). Balmer et al. (2013) estimated the global parakeet breeding range increased by over 4,400% from the late 1960s to mid-2010s, representing one of the greatest geographic range expansions of any species. In the USA, parakeet populations are established in Florida, Hawai'i, and California (Avery and Shiels 2018).

Negative ecological effects by invasive populations of parakeets have been documented throughout their introduced range. Their diet includes a variety of plant parts, including seeds, nuts, dry and fleshy fruits, nectar, vegetables, and flower buds (Clergeau and Vergnes 2011, Klug et al. 2019a, 2019b, Collar et al. 2020). Parakeets potentially spread seeds of invasive plants (Shiels et al. 2018) and strip bark, resulting in death of trees (Fletcher and Askew 2007). In Europe, native birds reduced feeding rates and increased vigilance behavior in response to parakeet presence (Clergeau and Vergnes 2011, Peck et al. 2014). Parakeets are secondary cavity nesters, relying on cavities that naturally occur or are created by other species; multiple accounts of antagonistic behaviors between parakeets and other cavity-nesting species have been documented (Fletcher and Askew

2007, Orchan et al. 2013, Menchetti et al. 2016). In Spain, parakeets displaced greater noctule bats (*Nyctalus lasiopterus*) at nesting sites by attacking and killing them (Hernández-Brito et al. 2018).

Invasive populations of parakeets have negatively affected economic resources as well as human health and safety. Parakeets are considered crop pests within their native ranges (Alī and Ripley 1969, Khan and Ahmad 1983, Shivashankar and Subramanya 2008, Khan et al. 2011). Likewise, this species has caused substantial economic losses in its introduced range through crop depredation (Paton et al. 1982, Koopman and Pitt 2007, Mentil et al. 2018, Shiels and Kalodimos 2019). Parakeets on Kaua'i cost farming companies economic losses each year by feeding on the kernels of seed corn (*Zea mays*), one of Hawai'i's most valuable agricultural commodities (Gaudioso et al. 2012, Avery and Shiels 2018). At Heathrow Airport in London, UK, at least 3 parakeet aircraft strikes have been documented; response to bird strikes in this region cost an average of >US \$22,000 each (Fletcher and Askew 2007).

Relatively few methods are available to successfully manage invasive parakeet populations and their associated effects; however, parakeet populations are often managed through lethal control techniques such as shooting (Avery and Shiels 2018, Bunbury et al. 2019, Klug et al. 2019a, 2019b, Shiels and Kalodimos 2019, Anderson et al. 2023a, Klug et al. 2023). Avicides are used to control other pest bird species in the USA such as pigeons (*Columba livia*), European starlings (*Sturnus vulgaris*), magpies (*Pica* spp.), and gulls (*Larus* spp.). However, none are currently registered for use with parakeets (USDA 2001, Klug et al. 2023). Live trapping has been used to capture parakeets with varying success by location and trap type, but success may be dependent upon the attractant (Gaudioso et al. 2012, Avery and Shiels 2018, Bunbury et al. 2019, Saavedra and Medina 2020, Klug et al. 2023).

Attractants such as decoys, projected vocalization recordings, and feeders may provide important means to localize and

manage problematic wild birds (Strubbe and Matthysen 2011). While these techniques may be used in various combinations to achieve specific management objectives, feeders may be used to attract birds for trapping or to deliver chemical control agents such as vaccines (Wambura and Godfrey 2010, Klug et al. 2023), avicides, or contraceptives in treated foods (Anderson et al., 2023b). Feeders may be used to selectively deliver treatments, thereby avoiding unintended effects to non-target species. This is particularly important in introduced ranges where native, endemic, or imperiled species may have access to chemically treated bait.

Managers have used contraceptive-treated feeds to reduce populations of Canada geese (*Branta canadensis*; Bynum et al. 2005) and pigeons (Avery et al. 2008, Dobeic et al. 2011). Parakeets have been documented using bird feeders throughout much of their introduced range (Clergeau and Vergnes 2011, Shiels and Kalodimos 2019), suggesting contraceptive-treated seed may be a useful tool in reducing invasive populations. Further, parakeet movements are centralized between roosts and foraging areas (Khan 2003, Gaudioso et al. 2012), and breeding habits are seasonal, indicating contraceptives used to control this species would only need to be delivered short-term in targeted areas. The contraceptive known by the product name DiazaCon (20,25-diazacholesterol dihydrochloride) inhibits reproductive hormones (Miller and Fagerstone 2000). DiazaCon was found to effectively reduce reproduction in captive parakeets when administered orally (Lambert et al. 2010), suggesting it could be beneficial to control free-ranging populations. Chemically treated and selectively delivered fertility control agents may also lessen the need for lethal control techniques to reduce populations of overabundant invasive bird species (Massei and Cohan 2014). Such non-lethal techniques are becoming increasingly favored by the public (Verbrugge et al. 2013, Crowley et al. 2019).

We attempted to habituate nonnative parakeets to feeders on the island of Kaua'i to determine if a selective feeder might be a promising technique to deliver chemical

control agents as part of a strategy to reduce the island's invasive parakeet population. We also examined citizen science reports to determine feeder visitation by parakeets on other Hawaiian islands and the types of feeders and foods most commonly used to determine which types would be attractive to parakeets.

MATERIALS AND METHODS

Study Area

Kaua'i (~22.075° N, 159.500° W) is the northernmost of the main Hawaiian Islands. With an area of nearly 1,500 km², it is the fourth largest Hawaiian island. It has a tropical climate, with average daily temperatures of 26°C in February and 29°C in August. January–March is regarded as the wet season, although precipitation is high year-round; mean annual rainfall ranges from 440 mm in the lowlands to nearly 10,000 mm at the highest peak (Giambelluca et al. 2013). Elevation ranges from sea-level to 1,598 m. The lowlands surrounding the perimeter of the island are predominantly agricultural and periurban, and the higher elevations in the center of the island are predominately tropical forests. Agriculture includes large corn fields in the southwestern portion of the island (previously sugar cane) and tropical produce farms throughout the lowlands largely comprised of tropical fruit tree crops.

Large parakeet populations have been documented on the islands of O'ahu, and Kaua'i. The population on O'ahu is believed to have established first in the 1930s. The population was estimated to include 4,650 individuals in 2018 (Shiels and Kalodimos 2019). Parakeets were accidentally introduced to the island of Kaua'i in the 1960s by workers at a vacation rental near Lāwai (Pyle and Pyle 2017), and several other pet birds escaped and joined the wild population after Hurricane Iwa in 1982. While the population initially remained small, the abundance was estimated as >10,500 individuals on Kaua'i in 2020 (Anderson et al. 2023a). Parakeets were documented to be nesting on Hawai'i Island in the 1980s (Paton et al. 1982), although it is unknown if a breeding population has become

established. A few individual parakeets were observed on Maui in 2021–2023.

Parakeet Feeder Habituation Field Trials

We tested strategies to habituate wild parakeets to feeders. Although parakeets are regularly observed using bird feeders on the neighboring island O‘ahu (Shiels and Kalodimos 2019), we were not aware of any observations of parakeets using feeders on Kaua‘i. Thus, we aimed to acclimate parakeets on Kaua‘i to feeders to evaluate whether a parakeet-selective feeder may be incorporated into a viable management strategy. We conducted trials of two feeder heights and three feeder types. In the first trial, we placed platform feeders at five field sites: two small tropical fruit farms with documented parakeet crop depredation, one tropical fruit farm with documented parakeet presence but no documented crop depredation, one cattle pasture with known parakeet presence, and one

suburban backyard with documented parakeet consumption of java plums (*Eugenia cumini*; Figure 1). Each feeding station included three platform feeders constructed of pine wood frames with screened mesh bottoms; the center frame measured 46×30 cm and each end frame measured 46×46 cm. Platform height was approximately 1 m from the ground. Two feeding stations were placed at each field site, each baited daily with commercial bird seed (milo, millet, wheat, and sunflower seed) and whole peanuts. At each field site, 1 of the 2 feeding stations was also outfitted with artificial fruits and a decoy parakeet (Figure 2). Feeders were maintained for 12 weeks, February–May 2020. Feeders were checked daily to ensure adequate food was available.

Post-hoc observations indicated the feeders were used extensively by non-target species, but there was no use of platform feeders by parakeets. Thus, we trialed two additional feeder types at an elevated height.

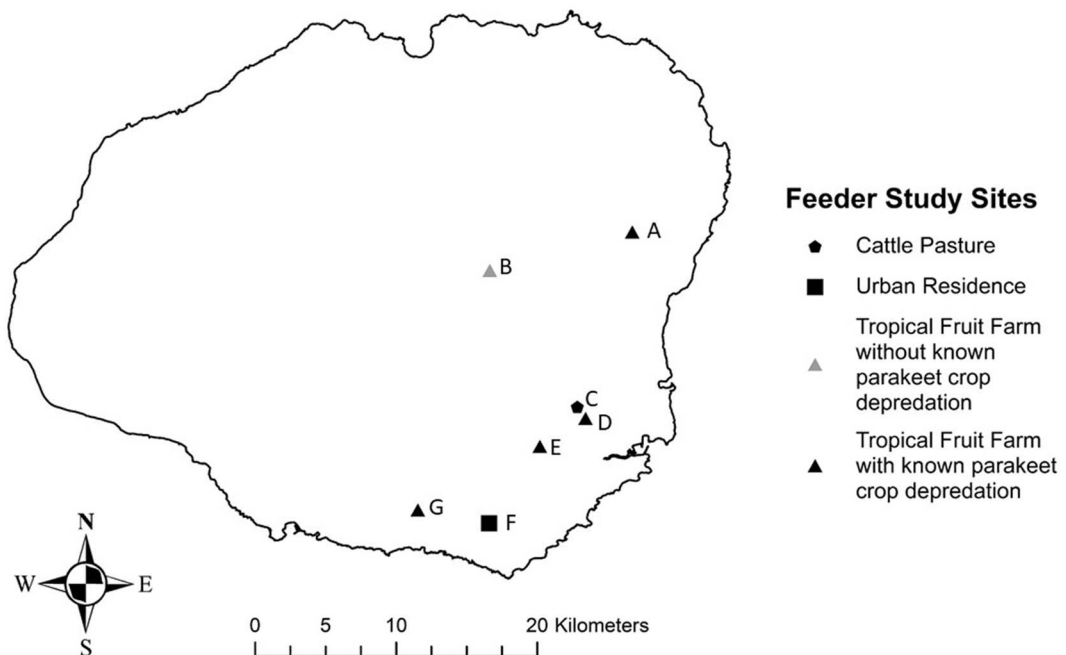


FIGURE 1. Study sites used to test rose-ringed parakeet (*Psittacula krameri*) feeder acclimation on Kaua‘i, Hawai‘i, USA 2020–2021 (Phase 4). Sites B, E, and G were used in all feeder studies, sites C and F in only the platform feeder study, and sites A and D in only the tube and hopper feeder study.



FIGURE 2. Feeders tested on Kaua'i. Platform feeders with decoy parakeet and fruits in cattle pasture, Kaua'i, Hawai'i, USA, February 2020 (top). Tube feeder with decoy fruits and commercial bird seed mix in tropical fruit farm (bottom left), and house-style hopper feeder with decoy parakeet and whole peanuts in tropical fruit farm, Kaua'i, Hawai'i, USA, October 2020 (bottom right).

A tube feeder (Stokes Select Jumbo Seed Songbird Tube Feeder, Classic Brands, Denver, CO, USA) was baited with the same commercial bird seed used in the platform feeder trial. A hopper feeder (Large Ranch Wild Bird 5lb Cedar Combo Seed & Suet Bird Feeder, National Audubon Society, Manhattan, NY, USA) was baited with whole peanuts. Both feeders were elevated to a height of ~3.3 m using metal electrical conduit. We painted the conduit brown and green to better replicate vegetation and

prevent glare. We attached two artificial papayas to the conduit used to elevate the tube feeder. On the conduit used to elevate the hopper feeder, we attached a decoy parakeet and a water-resistant MP3 player (Toilet Tree STORMp3) programmed to continuously play parakeet flight and feeding calls (Figure 2). We placed each feeder type at five field sites. Three sites were the same as used during the platform feeder trial (two tropical fruit farms with known parakeet crop depredation, and one tropical fruit farm with

known presence but no documented depredation). The additional two sites were also tropical fruit farms with known parakeet crop depredation (Figure 1). Feeders were maintained for 12 weeks, October 2020–January 2021. Feeders were checked daily to ensure adequate food was available.

In both the platform and elevated feeder trials, bird activity was monitored by motion-activated camera traps (Moultrie 880i). Cameras were programmed to take a single still photo when triggered. Camera operation and photo captures were checked once weekly during the platform feeder trial. During the elevated feeder trials, checks of the cameras and MP3 players were performed twice weekly. Using camera data, we documented species' use of each feeder. All research protocols were reviewed and approved by the US Department of Agriculture, Animal Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center (NWRC) Animal Care and Use Committee (QA-3187) and by the Texas A&M University – Kingsville Institutional Animal Care and Use Committee (IACUC protocol number 2019-12-03/1448).

Citizen Science

We examined all occurrence records of parakeets in the Hawaiian Islands from three citizen science databases from January of 2017 until June of 2022. Within these records, we aimed specifically to determine photographic evidence of parakeet feeder visitation. Two of these databases, eBird (Cornell Lab of Ornithology) and iNaturalist (California Academy of Sciences and the National Geographic Society), contained photographic records sorted by county, with attributes of date, unique observer, and location. Although locations were sometimes inexact, they identified county and municipality. Activity of birds in the photographs could be determined although the location surroundings and context may have been cropped out of some images. For example, the type of feeder and foods in feeders could be identified and were sometimes supported with associated notes. The third citizen science database, Project

Feeder Watch (Cornell Lab of Ornithology), provided data on the relative occurrence of all species observed at feeders combined for the entire State of Hawai'i for each annual season which spans November through April. Consequently, we inquired with database administrators concerning the specific locations of parakeets reported at feeders. We also conducted general internet searches to determine if there was any other evidence of parakeets using feeders in the Hawaiian Islands.

RESULTS

Parakeet Feeder Habituation Field Trials

Parakeets on Kaua'i were never pictured landing on or feeding from the platform, tube, or hopper feeders. Likewise, there were no photo captures of any native species using any feeder type. The platform feeders were consistently used by zebra doves (*Geopelia striata*), northern cardinals (*Cardinalis cardinalis*), red-crested cardinals (*Paroaria coronata*), northern mockingbirds (*Mimus polyglottos*), domestic chickens (*Gallus gallus*), house sparrows (*Passer domesticus*), and spotted doves (*Spilopelia chinensis*; Table 1). A total of 8 nonnative species were documented using the tube and hopper feeders: zebra doves, northern cardinals, northern mockingbirds, house sparrows, spotted doves, java sparrows (*Lonchura oryzivora*), common mynas (*Acridotheres tristis*), and house finches (*Haemorhous mexicanus*). Individual species use of the feeders varied by site and by feeder type (Table 2).

Citizen Science

The three citizen science databases contained more than 1,112 records of parakeets, of which >84% ($n = 938$) were from the island of O'ahu (Table 3). There were 15 records of parakeets photographed at feeders from January of 2017 to June of 2022, all from the island of O'ahu (Supplemental information available in the online version of this article). Most photographs were taken at hanging feeders of different configurations, although there was one photograph of parakeets at a food cup attached to a fence.

TABLE 1
Species Use of Platform Feeders in Kaua'i, Hawai'i, USA, February–May 2020

Species	Site B – Tropical Fruit Farm Without Known Parakeet Crop Depredation	Site C – Cattle Pasture	Site E – Tropical Fruit Farm With Known Parakeet Crop Depredation	Site F – Urban Residence	Site G – Tropical Fruit Farm With Known Parakeet Crop Depredation
Zebra dove					
Northern cardinal					
Red crested cardinal					
Northern mockingbird					
House sparrow					
Spotted dove					
Domestic chicken					

Shaded cells indicate use at the respective site (column) by the respective species (row).

TABLE 2
Use of Tube and Hopper Feeders by Non-Target Bird Species on Kaua'i, Hawai'i, USA, October 2020–January 2021

Species	Site A – Tropical Fruit Farm With Known Parakeet Crop Depredation	Site B – Tropical Fruit Farm Without Known Parakeet Crop Depredation	Site D – Tropical Fruit Farm With Known Parakeet Crop Depredation	Site E – Tropical Fruit Farm With Known Parakeet Crop Depredation	Site G – Tropical Fruit Farm With Known Parakeet Crop Depredation
Zebra dove	H	T, H	T	H	T, H
Northern cardinal	T, H	T, H	T, H	T, H	T, H
Northern mockingbird	T				T
House sparrow	T				
Spotted dove	T				T, H
Java sparrow	T, H	T, H	T, H	T, H	T, H
Common myna	T, H		T		
House finch	H	T	H		

Shaded cells indicate use at the respective site (column) by the respective species (row). T indicates use of tube feeder (baited with commercial bird seed). H indicates use of house hopper feeder (baited with whole peanuts).

TABLE 3
The Number of Citizen Science Reports of Rose-Ringed Parakeets (*Psittacula krameri*) and the Number of Reports Photographed at Feeders in the State of Hawai'i by Major County From January of 2017 Until June of 2022

	State of Hawai'i		Kaua'i County		Honolulu County		Maui County		Hawai'i County	
	Reports	At feeders	Reports	At feeders	Reports	At feeders	Reports	At feeders	Reports	At feeders
eBird	844	4	139	0	705	4	0	0	1	0
iNaturalist	267	10	33	0	233	10	1	0	0	0
Feeder Watch	1	1	0	0	1	1	0	0	0	0
	1,112	15	172	0	938	15	1	0	1	0

Common foods appeared to be commercial bird seed mix containing milo, millet, sunflower, and safflower seeds, although suet was noted in two photographs. The median group size of parakeets at feeders from citizen science databases eBird and iNaturalist was 1 and the maximum group size was 5. Project Feeder Watch confirmed that all observations of parakeets at feeders were from Honolulu County (O'ahu Island) from 2001 to 2022 (E. Grieg, Cornell Univ., pers. comm.) although there were participants from the island of Kaua'i in 3 reporting years (2001–2003 and 2017–2018), Maui County in 4 reporting years (2003–2004, 2008–2009, and 2019–2022), and the island of Hawai'i in 15 years (2005–2020). In addition to citizen science reports, a small number of parakeets on Maui were known to visit bird feeders and have become habituated to at least one feeder at Napili, enabling photographs of adult males (A. Knox, Maui Invasive Species Committee, pers. comm.). Moreover, a general internet search also provided a series of 12 photographs dated January 2012 of parakeets at food cups attached to a fence in Honolulu (R. Bernico, Hawaii Profiles), extending the amount of time parakeets have been known to use feeders in Hawai'i to >10 years and the maximum group size from 5 to 14. Although parakeets have been known to nest on Hawai'i Island (Paton et al. 1982), none of the citizen science databases contained photographic reports from Maui or Hawai'i counties.

DISCUSSION

Our study indicates chemical control implemented with a parakeet-selective feeder is not a feasible management strategy for parakeets on Kaua'i at present; however, it may be suitable for application on the island of O'ahu given the propensity of parakeets on the island to use feeders. Likewise, chemical control delivered via feeders may be an option in other locations where nonnative parakeet populations have been documented using feeders such as France (Clergeau and Vergnes 2011), the United Kingdom, Japan, and California, USA (Shiels and Kalodimos 2019). Given the consistent use of the platform and hopper

feeders on Kaua'i by non-target species and documented use of feeders by parakeets in other parts of their native and introduced range, it is unclear why the effort was unsuccessful on Kaua'i. It is possible that parakeets use feeders rarely on the island of Kaua'i, but this behavior has not been reported by citizen scientists. Citizen science data may provide a convenient way to not only verify population trends and range of invasive alien species over time and space (Frigerio et al. 2021), but also differences in behavior between locations, as our analysis indicates. There were ~5.5 times more citizen science reports of parakeets on O'ahu than Kaua'i, reflecting in part the fact that the human population of O'ahu is ~14 times larger than that of Kaua'i notwithstanding differences in parakeet abundance on each island, which was ~33% greater on the island of Kaua'i in 2018 (Shiels and Kalodimos 2019). Because citizen science data indicated that parakeets on O'ahu were attracted to similar commercial bird seed mixes that we used on Kaua'i, the attractiveness of these foods can be ruled out as a factor responsible for differences in behavior.

There are several non-exclusive possibilities why parakeets use feeders on the island of O'ahu but apparently do not use feeders on the island of Kaua'i. First, parakeets may prefer year-round abundant agricultural crops to any foods presented to them, precluding the need to search for supplementary sources (Le Louarn et al. 2016). This may be particularly true if they perceive some risk associated with an unnatural structure such as a feeder. Second, having been established and naturalized in the wild on Kaua'i since the 1960s, perhaps with little or no foods offered to them in feeders, they may have no cultural memory of this behavior. In contrast, parakeets may be more habituated to the highly urbanized environment of O'ahu, including close proximity to buildings and people, and there could have been semi-tame individuals that moved between captivity and the wild. Despite the lack of positive feeder response on Kaua'i, additional research is warranted to evaluate whether the selective delivery of chemical control agents may be effective for reducing invasive parakeet populations.

Although several other species of nonnative passerine birds were consistently attracted to our feeders on Kauaʻi, none of these species are responsible for the amount of agricultural damage that parakeets cause despite their high abundance. Doves and sparrows are known to consume milo and millet, which would explain these non-target occurrences and abundances in our study. If treated feed were openly accessible, these non-target species as well as native species such as nēnē (*Branta sandvicensis*) could potentially access and be affected by the treatment. All of these species could be effectively excluded by a parakeet selective feeder (Anderson et al. 2023b). Such selective delivery could reduce the movement of administered chemicals into the environment by other animals such as rodents which could be scavenged, as well as the risk of disease transmission between bird species at feeders, which is known to be a problem.

In addition to contraceptives, toxicants may be considered for selective administration to parakeets. While many mammal and avian species are controlled with toxicants (e.g., Dolbeer and Linz 2016, US EPA 2021), the registration of an additional use pattern for a toxicant in the US would require extensive supporting data on efficacy and specificity submitted to the US Environmental Protection Agency (Klug et al. 2023), including an evaluation of potential effects on non-target species, including scavengers (Nakayama et al. 2019). Although DiazaCon is currently not registered for use in the US, its efficacy with parakeets was promising in laboratory trials (Lambert et al. 2010). This or another type of contraceptive would be of interest to those opposed to toxicants or other means of lethal control. If management by way of contraceptives or toxicants for the other regularly encountered invasive birds becomes a priority on Kauaʻi, our visitation data could provide baseline information for subsequent requisite studies on specificity.

Lethal population control of invasive mammal and bird species may be opposed by the public more than that of other taxa (Verbrugge et al. 2013, Crowley et al. 2019), particularly if the target species is perceived as exotic or as a companion animal. Lethal

parakeet removal programs in Hawaiʻi have been opposed by residents and animal welfare proponents (KITV Island News 2023). Moreover, urban residents in Hawaiʻi may not value native and introduced bird species differently because few native bird species occur in urban environments of Hawaiʻi. Indeed, acclimatization societies in Hawaiʻi (Hui Manu) imported nonnative birds because of a perceived absence of birds in the environment (Lewis 2018). Lethal control may be viewed by the public as less humane than contraceptives to reduce wildlife conflicts (Fagerstone et al. 2006) and may therefore require outreach programs to gain acceptance. Further, while most pest parakeet population management efforts have used culling, lethal control alone is typically not sufficient to control crop damage by large continental populations of granivorous birds (Linz et al. 2015, Klug et al. 2023). Conversely, invasive populations are unlikely to be eradicated by contraceptives alone (e.g., Anderson et al. 2019). Therefore, some component of selectively administered fertility control may be useful to gain public support if conducted in conjunction with lethal control, which may also increase the overall efficacy of an integrated pest management program.

A possible remedy to the problem of feeder avoidance on Kauaʻi could involve captive habituation to feeders. Wild parakeets on Kauaʻi could be captured, held in aviaries, and provisioned with untreated foods in feeders of desired designs, in plain view of their flock mates, thus serving as live decoys (e.g., Saavedra and Medina 2020). Bashir (1979) found live, baited decoy traps to be attractive to parakeets in Pakistan, but the same traps were not attractive on Kauaʻi (Gaudioso et al. 2012). If their flock mates are attracted to the aviaries, feeders could then be placed outside of aviaries to further encourage this learned behavior in wild parakeets. Feeder-trained captive parakeets could then also be released into the wild, perhaps after surgical sterilization, and monitored with radio telemetry to determine if they continue to use feeders, but also if other wild conspecifics join them in using feeders. The number of habituated individuals released from captivity may need

to be large to affect behavior in a wild population of >10,000 birds and would require permission from regulatory agencies.

There would be a number of steps to consider before using a bird feeder to deliver chemical control in Hawai'i or elsewhere, including assessing the behavioral response of local target and non-target species with non-treated bait, as described, and registration of chemical control product(s) for the intended use pattern. Monitoring the fate of the chemical control product in scavengers and the environment would also be necessary. The burden of proof for safety and efficacy of such products would need to be demonstrated. Support from the community, local, state, and federal agencies and governments would also be essential to fulfill all the regulatory obligations.

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