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EXPERIMENTAL EVIDENCE THAT SCARE TACTICS AND EFFIGIES REDUCE CORVID OCCURRENCE

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ABSTRACT—Common Ravens (*Corvus corax*) and American Crows (*C. brachyrhynchos*) are important predators of eggs and chicks of the Snowy Plover (*Charadrius nivosus*), which compromises population recovery of this federally listed species. We used a before-after, control-impact experiment over a 4-d interval to examine changes in corvid occurrence within 1, 10, and 50 m of a feeding area in response to scare tactics and corvid effigies, a non-lethal predator control method. We conducted our study during September–February at Clam Beach, California, where corvids are abundant and plovers experience high reproductive failure compared with other sites in northern California. On Day 1, food and trash attracted corvids within 1–2 h after sunrise, suggesting that some individuals frequented beaches to scavenge for food left by humans. On Days 2 through 4, effigies significantly reduced average corvid abundance and incidence (percentage of observations with at least 1 corvid present), but the effect was only significant within the 50-m zone. In all cases, however, some, albeit fewer, corvids continued to occur on plots with effigies, suggesting that their effectiveness as a deterrent of corvids near plover nests during the breeding season is limited.

Key words: American Crow, Common Raven, corvids, effigy, non-lethal, predator management, Snowy Plover

Worldwide, corvids have had a long association with humans; they are both revered and persecuted in many cultures (Moore 2002; Marzluff and Angell 2005; Londei 2010). In North America, corvid populations have increased and ranges have expanded into formerly unoccupied habitats (Restani and others 2001; Kelly and others 2002; Kristan and Boarman 2003; Marzluff and Neatherlin 2006), primarily aided by increased food supplements made available to these intelligent omnivores by humans (Marzluff and Angell 2005). Increases in corvid abundance are often correlated with declines in their prey (Lauro and Tanacredi 2002; Kelly and others 2005; Webb and Marzluff 2007; Klausen and others 2010), especially threatened and endangered taxa such as the Desert Tortoise (*Gopherus agassizii*; Kristan and Boarman 2003), Marbled Murrelet (*Brachyramphus marmoratus*; Peery and Henry 2010), Greater Sage-Grouse (*Centrocercus urophasianus*; Coates and others 2008), and the California Least Tern (*Sterna antillarum browni*; Caffrey 1995). However, causal relationships between predator abundance and prey decline are difficult to establish because there are often multiple predators at work and the predator assemblage changes over time and space (Luginbuhl and others 2001). Corvids are adept predators of eggs and young of many bird species, and this predation is widely recognized as an important ecological factor that may limit population sizes in some species (Ricklefs 1969; Martin 1993). Therefore, understanding corvid behavior in response to potential deterrents may be useful for reducing predation and increasing productivity of threatened and endangered species.

A variety of non-lethal control methods have been used by wildlife managers to deter avian predators, including scare tactics, repellents, and nest exclosures. Each of these methods has shortcomings and may only provide short term benefits (Schmelzeisen and others 2004; Hardy and Colwell 2008; Pauliny and others 2008). Effigies, such as carcasses and taxadermic preparations, are a method of non-lethal predator control that mimics a dead model of the predator in an attempt to scare individuals and deter their use of an area. Effigies have been used to scare gulls (*Larus* spp.), Turkey Vultures (*Cathartes aura*), ravens, and crows and to deter them from roosting in undesirable locations such as airports and urban areas (Caffrey 1995; Seamans 2004; Avery and others 2008; Ball 2009). Anecdotal reports suggest that effigies are successful at deterring corvids near California Least Tern breeding colonies (Caffrey 1995).

Lethal predator control is often controversial and lacks public support (Messmer and others 1999). Moreover, lethal control may not be effective at minimizing negative impacts on reproductive success if control does not reduce predator population size or fails to remove individuals that cause losses of eggs and chicks. Removal of individuals may be a temporary solution if conspecifics fill vacant territories (Webb and others 2012). In either case, lethal control alone may not be sufficient to significantly increase reproductive success (Donehower and others 2007). Additionally, residual effects of removing predators are often unknown and, as with other predator control methods, killing may provide only a short term solution without the desired effect of ultimately increasing breeding bird population sizes (Côte and Sutherland 1997). Before a decision to kill predators is made, other management options should be explored (Boarman 2003; Marzluff and Angell 2005).

In 1993, the United States Fish and Wildlife Service (USFWS) listed the Pacific coast population of the Snowy Plover (*Charadrius nivosus*) as threatened under the Endangered Species Act (USFWS 1993). One of the principal factors limiting plover recovery is egg and chick predation (USFWS 2007), especially by Common Ravens (*Corvus corax*) and to a lesser degree American Crows (*C. brachyrhynchos*). To address the negative impacts of corvids on plovers, a variety of lethal and non-lethal methods have been used with varying degrees of success. Although lethal methods have been used in an effort to increase reproductive success of Snowy Plovers elsewhere along the Pacific coast (for example, Robinson-Nilsen and others 2009), results are mixed with regard to their effectiveness (Neuman and others 2004). To reduce nest predation rates, managers have: (1) exclosed nests from large mammal and avian predators (Hardy and Colwell 2008); (2) restored nesting habitat by removing invasive European Beach Grass (*Ammophila arenaria*) (Muir and Colwell 2010); (3) spread oyster shells to increase egg and chick crypsis (USBLM 2010); and (4) killed predators (Neuman and others 2004). Despite these efforts, Snowy Plover populations remain well below the region-wide recovery goal of 3000 breeding adults (USFWS 2007).

Over the past 12 y and across approximately 20 locations in Northern California, the leading cause of nest failure has been egg predation by corvids. Evidence for corvid predation in this region includes a negative correlation between raven activity and per capita reproductive success of plovers (Burrell and Colwell 2012), and in 2008 and 2009 video cameras showed that ravens depredated 70% of 20 failed plover nests at Clam Beach, California, one of the region's most important nesting sites (Burrell and Colwell 2012). Here, we present experimental evidence evaluating the effectiveness of raven carcasses or ''effigies'' in reducing Common Raven and American Crow presence and abundance at Clam Beach, a site where Snowy Plover egg and chick predation by corvids was especially high (Burrell and Colwell 2012; Hardy and Colwell 2012).

METHODS

Study Area

Clam Beach, Humboldt County, California (Fig. 1) fronts the Pacific Ocean and extends approximately 7 km between the mouths of Little River and Mad River. Invasive European Beach Grass, and native plants such as Searocket (*Cakile maritima*), Sand Verbena (*Ambronia umbellata*), and Dune Grass (*Leymus mollis*) dominate dune vegetation. Unvegetated substrates consist mostly of sand, littered with shells, woody debris, eel grass bundles, and brown algae (Colwell and others 2010; Hardy and Colwell 2012). Of all plover breeding sites in northern California, Clam Beach has the highest levels of human use (Burrell and Colwell 2012), such as jogging, clamming, dog walking, and horseback riding. As a result, the site has a comparatively large amount of anthropogenic garbage (MA Colwell, unpubl. data).

Effigies

We acquired raven carcasses from the Humboldt Wildlife Care Center where birds had either died or were euthanized because severe

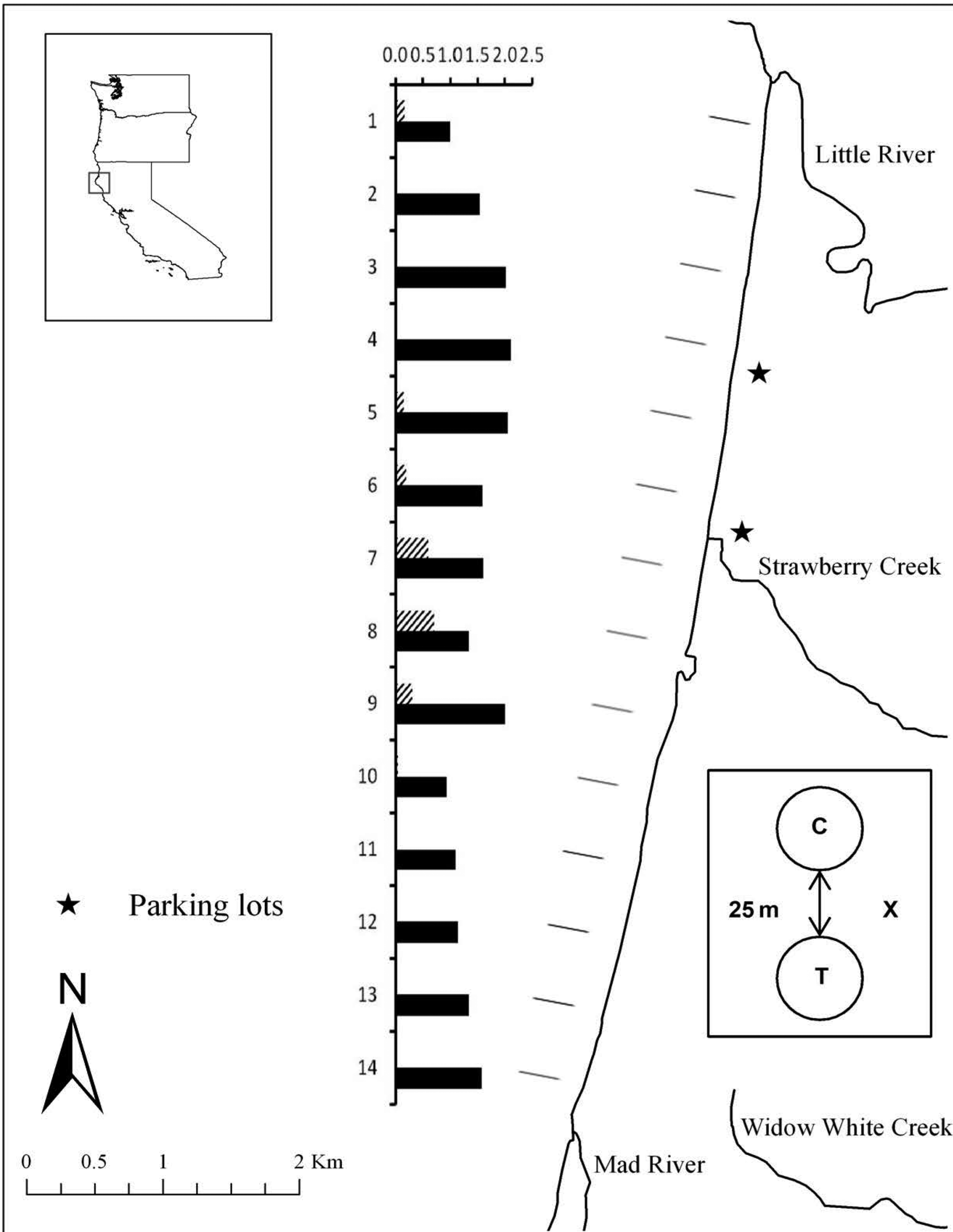

FIGURE 1. Location of experimental study of the use of effigies on corvid occurrence on Clam Beach, Humboldt County, CA, September 2011 through February 2012. Paired control (C) and treatment (T) plots separated from each other by 25 m were located at the midpoint of 500-m beach sections (horizontal dashes), with an observer located at the midpoint of plots (X). Horizontal bars associated with the measurement scale at the top of the figure shows average number of Common Raven (■) and American Crow (▨) along fourteen 500-m sections of beach during March–August, 2005–2011, coincident with the Snowy Plovers breeding season (see Colwell and others 2010 for methods).

trauma precluded rehabilitation. We prepared effigies with wings and tail feathers spread to portray an unnatural position of a dead bird.

Experimental Design and Data Collection

To avoid possible negative impacts to breeding plovers, we conducted our experiment from September 2011 through February 2012, when plovers do not breed (Colwell and others 2010). We used ArcGIS v.9.3 (ESRI, Redlands, CA) to subdivide the north-south length of the beach into fourteen 500-m segments (Fig. 1), and randomly assigned each segment to a trial date. At the start of each trial, we established paired 50-m radius control and treatment plots on the foredunes north and south of the midpoint of each 500-m section, with plot edges separated by 25 m. We placed small pieces of woody debris within plots at 1, 10, and 50 m from the center of each plot as plot markers to facilitate observations. Observations occurred from a blind at the midpoint between the plots (Fig. 1).

We used a before-after, control-impact design consisting of paired treatment (effigy and bait) and control (bait only) plots, which we determined randomly prior to each trial. During a 4-d interval (or trial), we observed corvids on paired plots for 4 h beginning at sunrise. Each trial consisted of Day 1 (before) when we baited both plots with food (a large container of French fries, a large soft drink cup, and a paper bag); Day 2 (after) when we used scare tactics and an effigy; and Days 3 and 4 (after) when we hung an effigy in the treatment plot. The effigy hung from a 0.5-m plastic pipe attached horizontally to a 2.5-m metal pole placed at the plot's center; we placed an identical pole (without the effigy) at the center of the control plot. Both plots had bait for Days 2, 3 and 4. To avoid vandalization and removal of our equipment, we removed all items from plots after each morning observation. Initially, we conducted 14 trials on each of the 14 beach sections; we repeated trials late in the study on 4 sections of beach, which resulted in a total of 18 trials.

Because birds may learn that an object is harmless and simply ignore it (Godin 1994; Schmelzeisen and others 2004), it is important to test if corvids continue to utilize an attractive area (such as an area with bait) when faced with a risk factor (J. Marzluff, pers. comm.). Effectiveness of scaring devices can be enhanced with loud noises, which reduce the potential for habituation (Godin 1994). Accordingly, we supplemented effigies with scare tactics. On the 1st treatment day (Day 2) before we hung the effigy, an assistant wearing a mask to eliminate facial recognition by corvids (Cornell and others 2011) acted out a theatrical death scene at the center of the treatment plot as corvids passed nearby. During this scene, the assistant yelled while shaking the effigy, threw the effigy on the ground, and pretended to shoot it while a speaker broadcasted loud gunshots. Immediately after the scene, the assistant hung the effigy and played a recording of raven distress calls (Cornell Lab of Ornithology, Macaulay Library), which played the duration of the 4-h observation. We placed informative signs requesting public cooperation in not disturbing the plots at access points to the beach and at plot boundaries during each observation. We refer to the collective effect of effigy and scare tactics (applied on Day 2 only) and the effigy (Days 3 and 4) as effigy throughout the paper to simplify reporting results. However, we acknowledge that the scare tactics are an integral factor influencing our results.

One of us (SAP) conducted all observations from a blind hidden amidst dune grass at a vantage point that maximized observation of both plots and minimized the likelihood that corvids were aware of the observer's presence. We used an instantaneous sampling method (see Martin and Bateson 2007) to record the total number of corvids present within 1, 10, and 50 m of the center of the paired plots at the beginning of each observation. We chose these distances to facilitate ease of data collection under sometimes fast-paced changes in the position and behavior of corvids. We alternated observations between control (bait only) and treatment (bait and effigy) plots every minute, which yielded a total of 120 observations for each plot during a 4-h observation period.

Data Summary and Analysis

We summarized the number of corvids present within 1, 10 and 50 m of each plot center based on 120 observations. This produced 2 response variables: abundance (average number of corvids) and incidence (percentage of 120 observations with at least 1 corvid). To

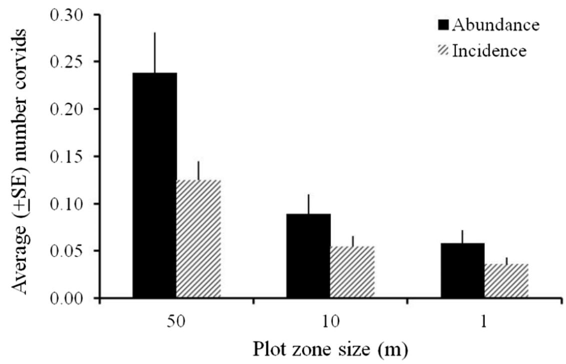

FIGURE 2. Average (± SE) abundance and incidence of corvids within 50, 10, and 1 m of bait on Day 1.

evaluate the effectiveness of bait as an attractant, we calculated the average time (min) required for the 1st corvid to approach within 50, 10, and 1 m of the plot center on Day 1 (bait but no effigy). We found no significant difference (at each spatial scale; all P-values > 0.38; Peterson 2013) in the time it took corvids to enter treatment and control plots on Day 1; therefore, we pooled data to increase sample size ($n = 36$).

Following methods of Tarr and others (2010), we gauged the effectiveness of effigies in reducing corvid abundance and incidence using the formula $D_i = (X_{IAi} - X_{IBi}) - (X_{CAi} - X_{CBi})$, where D_i denotes the treatment effect, X_{IA} and X_{IB} are mean responses after and before, respectively, on treatment plots, and X_{CA} and X_{CB} are mean responses after and before, respectively, on control plots. We calculated relative differences and effect sizes by comparing average corvid abundance and incidence on plots with effigies and control plots. In this comparison, we used means averaged across Days 2, 3, and 4 of each trial because there were no significant differences in D_i across these days (all $F < 0.93$, all $P > 0.40$).

We used paired t-tests to examine differences in response variables between plots. We used Spearman's rank correlation test to examine whether or not the effectiveness of the effigy diminished over time (18 trials conducted September–February). We combined data from the 3 d after the use of effigies (see above) and analyzed effigy effects within 1, 10, and 50 m of the plot center in a simple before (Day 1) and after (Days 2, 3 and 4) comparison. In summary statistics, we present mean ± standard error.

RESULTS

Although both ravens and crows were present on Clam Beach, in most trials (83%) only ravens frequented plots; both ravens and crows occurred in 17% of trials. Ravens occurred in similar numbers (similar incidence and abundance across the 18 trials) across the 7 km of beach, whereas crows were recorded on plots at the most northern stretch of beach and near the main public access points adjacent to parking lots and picnic areas. These distributions are similar to the observations of ravens and crows during the plover breeding season (see inset Fig. 1).

On Day 1, prior to scare tactics theatrical display and effigy placement, corvids responded readily to bait, with the highest numbers within 50 m of the plot center (Fig. 2). On average, the 1st corvid approached to within 50 m of bait approximately an hour (53 ± 2 min) after the start of observations; however, it took longer for corvids to approach within 10 m (111 ± 3 min) and 1 m (136 ± 4 min) of bait. On Day 1, significantly more corvids (Paired t-test $=$ 2.91, $P = 0.01$) frequented 50 m treatment (0.29 ± 0.07) than control plots (0.19 ± 0.05).

After we introduced scare tactics and effigy (Day 2) and effigies (Days 2, 3 and 4 combined), corvid abundance decreased on both plots (Fig. 3), although plots with effigies (Paired $t_{17} = 4.2$; $P = 0.001$) decreased to a greater extent than control plots (Paired $t_{17} = 2.1$; $P = 0.06$). Overall, relative differences between treatment and control plots (Table 1) indicated that effigies reduced corvid abundance 27 to 70% and corvid incidence 55 to 100%. The treatments, which included effigies with scare tactics, appeared to

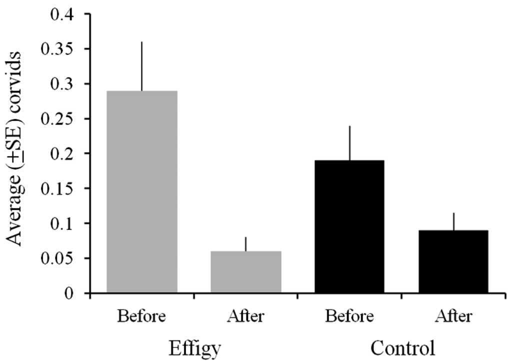

FIGURE 3. Comparison of average (± SE) corvid abundance within 50 m of bait on plots with effigies compared with control plots.

have their greatest effect within 1 and 10 m of the effigy, although the significance of results was minimized by the few corvids that approached bait this closely.

Corvid response to effigies appeared strongest in trials conducted early in the study (Fig. 4). However, average number (r_s = 0.27, P = 0.87) and incidence (r_s = 0.27, P = 0.86) of corvids was not correlated with trial sequence (trial 1 to 18). In January and February there was a noticeable treatment effect when the experiment occurred in the northern most section of the beach, a location with large numbers of crows. With crow activity removed from trials, there was still no significant treatment effect in average number (r_s = 0.27, P = 0.87) or incidence (r_s = 0.27, P = 0.86) of ravens with respect to trial sequence.

Finally, species other than corvids were attracted to the bait despite the early morning observations; non-corvids disturbed or consumed bait during most (97%) trials. Control and treatment plots were visited by dogs (78% and 78%, respectively), humans (78% and 83%), and gulls (83% and 67%). In some cases, bait was completely consumed or removed in control and treatment plots by dogs (44% and 17%, respectively), humans (6% and 6%), and gulls (72% and 67%). In all instances, however, trash remained as an attractant for corvids.

Discussion

Our experiment offers preliminary evidence that effigies may be effective at reducing corvid activity. This finding applied only to the 50-m zone within plots; results for the 10- and 1-m zones were similar but not statistically significant, probably owing to the large number of observations with no corvids. Interestingly, during the 3 d of treatment (effigies) corvid activity also decreased on control plots. We cautiously interpret this result as a treatment ''spillover effect'' onto adjacent control plots separated by 25 m. Overall, our findings corroborate reports that effigies deter corvid use of specific areas such as roosts (Avery and others 2008), as well as anecdotal evidence of their effectiveness near colonies of breeding birds (Caffrey 1995). We acknowledge that our findings are specific to the presence of an effigy coupled with a theatrical death scene and playing of distress calls, therefore our interpretation of corvid response to the presence of effigies includes all of these factors present together, not separately.

Although effigies alone may hold promise as a non-lethal method for reducing corvid impacts on Snowy Plovers, several unanswered questions remain regarding their utility in boosting productivity and aiding in the recovery of this listed species. First, we designed our study as a series of short trials to provide sufficient replication for statistical analyses. However, the 4-d trial represented a small percentage (approximately 12%) of the 32 d (encompassing egg-laying and incubation periods; Page and

TABLE 1. Summary of the effectiveness of scare tactics and a Common Raven effigy at reducing corvid abundance and incidence within varying distances of bait.

	Abundance treatment effect:					Incidence treatment effect:				
Distance	Average D_i[a]	SE	ts[b]	df	P	Average D_i	SE	ts	df	P
50 m	−0.134	0.042	−3.16	17	0.006	−0.112	0.043	−2.58	17	0.019
10 m	−0.031	0.028	−1.10	17	0.287	−0.073	0.038	−1.90	17	0.074
1 m	−0.016	0.021	−0.75	17	0.461	−0.029	0.018	−1.66	17	0.115

[a] $D_i=(X_{IAi} - X_{IBi}) - (X_{CAi} - X_{CBi})$, the difference between the change in corvid activity at the control plot and the treatment plot.
[b] ts = test statistic, the value obtained from the performed statistical test and used to reject or accept the null hypothesis.

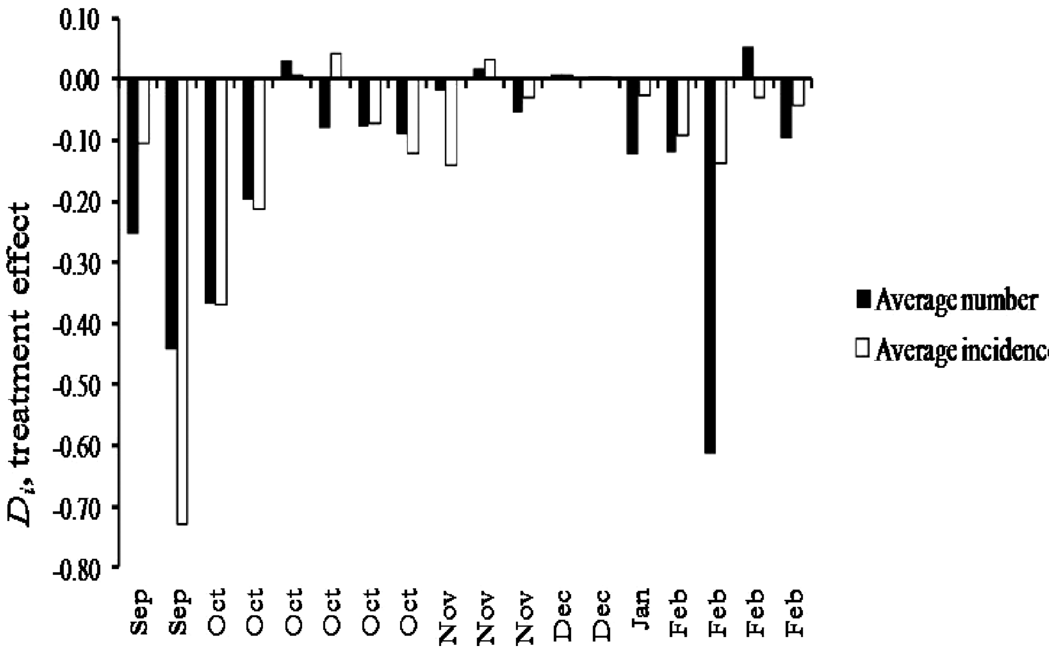

FIGURE 4. Seasonal variation (trial sequence 1–18) in the effect (D_i) of effigies on average number and incidence of corvids within 50 m of bait.

others 2009) during which plover eggs are exposed to predation. If effigies are used to enhance nest (and chick) survival, then their efficacy should be evaluated for longer intervals, ideally during the plover breeding season. The effectiveness of effigies will likely be site-dependent and vary with the abundance and behaviors of corvids as predators of plover nests and chicks.

Second, effigies could potentially negatively affect shorebird nest site selection (Colwell 2010), which may depend on when and where effigies are deployed. For example, a strategy of erecting multiple effigies in suitable habitat prior to the plover breeding season may adversely affect plover nest site selection behaviors if individuals perceive effigies as a danger (Lima 2009) and avoid these nesting areas. Alternatively, effigies erected after the start of breeding in areas of high nest density (for example, colonial seabirds; Caffrey 1995) may be successful, assuming that effigies do not cause nest abandonment. In either case, plover behavioral responses to effigies remain unknown and require further study.

A third issue concerning the effectiveness of effigies in boosting plover reproductive success concerns their utility in protecting nidifugous chicks. Specifically, while effigies near nests may be useful in protecting eggs, precocial chicks often wander widely under the care of adults (Wilson and Colwell 2010). Consequently, effigy effectiveness will diminish as broods roam into areas that lack them. Even if effigies prove effective in protecting eggs, they will not boost local productivity unless they diminish predation of chicks. This observation is true of another commonly used non-lethal method of predator control, nest exclosures, in which nests are able to hatch due to protection; however, most chicks are depredated once they leave this protected area (Hardy and Colwell 2008). Resolving these issues requires further study of effigies.

The inclusion of bait was a critical element of our study design because it showed that corvids avoided an area, such as with an effigy that was otherwise attractive to them. Although we informed the public of our study, we observed humans removing bait, and their dogs as well as gulls consumed bait. Our results withstood disruption of most trials by these events. Still, the presence of trash alone as an attractant resulted in a comparatively rapid response of corvids to bait on Day 1. This observation suggests that some corvids regularly patrolled the beach to scavenge food. Corvid abundance has been shown to be positively correlated with human settlements and campgrounds, presumably because food is readily available (Kristan and Boarman 2003; Marzluff and Neatherlin 2006; Withey and Marzluff 2009). Two additional lines of evidence suggest an association between corvids and humans in our study area: a positive correlation between tracks of corvids and humans (Colwell, unpubl. data), and the concentration of American Crows near parking lots and picnic areas (asterisks, Fig. 1). Collectively, these observations suggest that efforts to manage corvids must include reducing human use of plover nesting beaches when plovers are nesting, and removal of anthropogenic sources of food.

Corvids are intelligent (Emery 2006), highly social omnivores that transmit knowledge culturally via interactions with conspecifics (Cornell and others 2011). Several unforeseen problems may have influenced our results by altering corvid behaviors. First, the effectiveness of the bait may have been compromised if it was consumed, leading to lower corvid activity. There was, however, no detectable difference in bait loss from control and experimental plots (Peterson 2013). Ideally, it would be best to test effigies at sites where public interference was minimal. Second, using French fries as bait facilitated rapid consumption by gulls and dogs on both control (54%) and treatment plots (43%), leaving only trash as an attractant. Corvids may not have remained on plots or returned on subsequent days if there was no initial reward. Because single or paired ravens often recruit groups of ravens to food sources (Heinrich 1988; Wright and others 2003), the information of no reward may have been communicated to conspecifics. A better option may have been to use a large carcass, which would have persisted longer. A third limitation of this study was that we collected data from September through February. Corvid populations, distributions, and foraging behavior probably vary seasonally (Heinrich 1988; Kristan and Boarman 2003; Roth and others 2004; Preston 2005); therefore, responses may not represent those of corvids during the plover breeding season. Finally, although we detected no significant change in the response of corvids to effigies over 6 mon, we suspect that learning and habituation by corvids is possible. If so, then efforts to increase and sustain effigy effectiveness will require additional measures.

Acknowledgments

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