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IDENTIFYING NEST PREDATORS OF AMERICAN AVOCETS (*RECURVIROSTRA AMERICANA*) AND BLACK-NECKED STILTS (*HIMANTOPUS MEXICANUS*) IN SAN FRANCISCO BAY, CALIFORNIA

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ABSTRACT—We evaluated predation on nests and methods to detect predators using a combination of infrared cameras and plasticine eggs at nests of American avocets (*Recurvirostra americana*) and black-necked stilts (*Himantopus mexicanus*) in Don Edwards San Francisco Bay National Wildlife Refuge, San Mateo and Santa Clara counties, California. Each technique indicated that predation was prevalent; 59% of monitored nests were depredated. Most identifiable predation (n = 49) was caused by mammals (71%) and rates of predation were similar on avocets and stilts. Raccoons (*Procyon lotor*) and striped skunks (*Mephitis mephitis*) each accounted for 16% of predations, whereas gray foxes (*Urocyon cinereoargenteus*) and avian predators each accounted for 14%. Mammalian predation was mainly nocturnal (mean time, 0051 h ± 5 h 36 min), whereas most avian predation was in late afternoon (mean time, 1800 h ± 1 h 26 min). Nests with cameras and plasticine eggs were 1.6 times more likely to be predated than nests where only cameras were used in monitoring. Cameras were associated with lower abandonment of nests and provided definitive identification of predators.

RESUMEN—Evaluamos la depredación de nidos y métodos de detección de depredadores usando una combinación de cámaras con luz infraroja y huevos de plasticina colocados en nidos del piquicurvo (*Recurvirostra americana*) y del candelero mexicano *(Himantopus mexicanus)* en Don Edwards San Francisco Bay National Wildlife Refuge, condados de San Mateo y Santa Clara, California. Cada técnica indicó que la depredación de nidos era común; 59% de los nidos estudiados fueron depredados. La depredación más identificable (n = 49) fue causada por mamíferos (71%) y las tasas de depredación fueron similares entre las dos especies de playeros. Los mapaches (*Procyon lotor*) y los zorrillos (*Mephitis mephitis*) se adjudicaron por separado 16% de la depredación, mientras que los zorros grises (*Urocyon cinereoargenteus*) y aves depredadoras fueron responsables por 14%, cada uno. La depredación de mamíferos fue mayormente nocturna (hora media = 0051 h ± 5 h 36 min), mientras que aves depredaban mayormente tarde por la tarde (hora media = 1800 h ± 1 h 26 min). Nidos con cámaras y huevos de plasticina fueron 1.6 veces más propensos a ser depredados que los con cámaras solamente. Cámaras fueron asociadas con nidos menos abandonados y proveyeron identificación definitiva de los depredadores.

Predation on nests plays a critical role in nesting success of shorebirds (Grant et al., 1999; Neuman et al., 2004; Liebezeit et al., 2009). Identifying predators that influence nesting success may be important in understanding trends in populations, particularly when restoration practices may impact distribution of predators. However, different methods for identifying predators of nests can produce different results and each is subject to inherent biases (Major and Kendall, 1996; Thompson and Burhans, 2004; Richardson et al., 2009). For example, cameras have been used to identify predators at nests, but some investigators have reported lower rates of predation at nests with cameras than at nests without cameras because some predators are

wary of cameras (Hernandez et al., 1997; Richardson et al., 2009). In contrast, other studies have not detected an effect by cameras on survivorship of nests (Pietz and Granfors, 2000; Liebezeit and Zack, 2008). Artificial eggs placed in artificial nests also have been used to identify predators (via tooth or beak marks left on wax or plasticine eggs; Pasitschniak-Arts and Messier, 1995; Major and Kendall, 1996). The artificial-egg technique has experienced variable success, partly because investigators have not always matched size, color, patterning, or number of eggs (Major and Kendall, 1996). In addition, differences in rates of predation between artificial and natural nests suggest that artificial nests may produce biased results, and direction of the bias may not be consistent (Major and Kendall, 1996). However, these methods remain useful in identification of predators if inherent biases can be addressed (Major and Kendall, 1996; Larivière and Messier, 2001).

The estuary of San Francisco Bay is a site of hemispheric importance for migratory, wintering, and breeding shorebirds (Harrington and Perry, 1995) and is surrounded by highly developed urban areas. The two most-abundant breeding shorebirds in San Francisco Bay are American avocets (*Recurvirostra americana*; hereafter avocets) and black-necked stilts (*Himantopus mexicanus*; hereafter stilts; Stenzel et al., 2002; Rintoul et al., 2003). Currently, 50–90% of existing salt-evaporation ponds are being restored into tidal-marsh habitats (Goals Project, in litt.; J. Steere and T. N. Schaefer, in litt.). Some of these restoration efforts will entail removing or breaching existing levees around salt ponds to restore tidal marshes, which will result in loss of potential breeding habitat for island-nesting shorebirds. Removal of levees also will result in direct loss of nesting habitat and force relocation of the largest colony of California gulls (*Larus californicus*) in San Francisco Bay, which may displace up to 19,000 gulls into adjacent habitat used for nesting by shorebirds (J. T. Ackerman, in litt.). Further, the population of California gulls is rapidly expanding (Strong et al., 2004; J. T. Ackerman, in litt.) and they could become an increasingly important predator of eggs and chicks of waterbirds in wetlands of San Francisco Bay. It is expected that restoration efforts will force avocets and stilts to nest in greater densities within remaining salt ponds, and density-dependent predation on nests may occur if predators increase use of these areas as they encounter more densely clustered nests (Larivière and Messier, 1998, 2001).

Consequently, identifying predators of shorebird nests has important management implications because it will provide essential baseline estimates of the degree of predation and an inventory of species of predators. This research will lead to a better understanding of effects of local predators on nesting shorebirds if their populations or distributions change as a result of restoration efforts. Our objectives were to identify predators and temporal patterns of predation on nests of avocets and stilts in southern San Francisco Bay, and to assess differences among techniques used to detect predators.

Materials and Methods—Our study was conducted in the estuary of San Francisco Bay (37°26′N, 121°58′W), on levees and islands in former salt-evaporation ponds and wetlands within the Don Edwards San Francisco Bay National Wildlife Refuge, San Mateo and Santa Clara counties, California, including Ponds A8, A16, Coyote Creek Marsh, and New Chicago Marsh. Both avocets and stilts are semi-colonial nesters and incubate eggs for ca. 24 days (Robinson et al., 1997, 1999). Sites at salt ponds (A8, A16) largely were devoid of vegetation, with the exception of edges of ponds and marshes (New Chicago Marsh and Coyote Creek Marsh) that were dominated by pickleweed (*Sarcocornia pacifica*). The United States Department of Agriculture has an active mammalian-predator management program on and adjacent to the refuge to protect endangered species. Based on data from 2000–2002, primary predators that were removed included striped skunks (*Mephitis mephitis*; 84% of predators removed), domestic cats (*Felis catus*; 9% of predators removed), and non-native red foxes (*Vulpes vulpes*; 5% of predators removed; Meckstroth and Miles, 2005).

We located nests of avocets and stilts during weekly surveys within wetlands during 13 April–29 June 2006 and 3 April–9 July 2007. Each nest was marked with a colored pin flag placed 2 m north of the nest and a uniquely numbered metal tag at the edge of the nest. We randomly selected nests to be monitored by cameras (2006 and 2007) or deployment of plasticine eggs (2006) from those that were active (i.e., no evidence of predation or abandonment), contained ≥3 eggs, and incubated for ≤6 days (determined via flotation of eggs; Sandercock, 1998; Mabee et al., 2006; Liebezeit et al., 2007; Ackerman and Eagles-Smith, 2010).

We used Bushnell Trailscout Pro (Bushnell, Overland Park, Kansas) passive-infrared-sensor, digital, trip cameras to monitor selected nests (2006, $n = 74$; 2007, $n = 33$). Cameras were 7.6 by 17.8 by 26.1 cm, brown, and were powered by four internal D-cell batteries. Cameras were mounted on metal stakes placed ca. 30–50 cm above the ground, 1–1.5 m from nests, and recorded 15 s (preset time) of video footage upon

TABLE 1—Number of nests monitored by three treatments used to detect predators and frequency of predation on nests of American avocets (*Recurvirostra americana*) and black-necked stilts (*Himantopus mexicanus*) in Don Edwards San Francisco Bay National Wildlife Refuge, San Mateo and Santa Clara counties, California, 2006–2007.

	Monitored		Hatched		Flooded		Discontinued		Abandoned		Depredated		Predations detected	
Treatment	Avocet	Stilt	Avocet	Stilt	Avocet	Stilt	Avocet	Stilt	Avocet	Stilt	Avocet	Stilt	Avocet	Stilt
Camera	60	12	17	1	2	0	4	0	2	1	35	10	15	4
Plasticine egg	19	21	2	2	1	0	0	0	6	3	10	16	8	10
Camera and plasticine egg	23	12	3	6	2	0	0	0	7	2	11	4	9	3

activation of motion sensor. Speed of trigger for the Bushnell Trailscout Pro was <1 s. Cameras monitored nests 24 h/day and we checked cameras, including those with plasticine eggs, 1–2 times/week. Nests with cameras were visited more regularly than those monitored with plasticine eggs because of the necessity to check batteries and memory cards. We wore rubber boots to minimize scent of humans at nests. At each visit to nests, we recorded status of each egg (e.g., presence, damage, stage of incubation), checked status of memory cards and batteries, and replaced batteries and memory cards in cameras until fate of nest was determined. We defined successful nests as those with clean fragments of egg shells present (Maybee, 1997). We reviewed all photographs and identified predators and time of day when a predator was first observed at the nest. When multiple predators were observed, we used the first predator associated with the first predation at the nest for analyses; we assumed the first predator was responsible for the predation.

In 2006, plasticine eggs were deployed at nests with cameras (n = 35) and at randomly selected nests without cameras (n = 40) to identify predators via marks from teeth and beaks (Pasitschniak-Arts and Messier, 1995). We randomly replaced one egg in each nest with a plasticine egg (n = 75 eggs). Mean size of clutch for avocets and stilts was 3.83 ± 0.02 *SE* and 3.85 ± 0.04 *SE*, respectively. We only used active nests for plasticine eggs to minimize potential bias associated with artificial nests (Major and Kendall, 1996; Thompson and Burhans, 2004). We matched size, shape, and color pattern of replacement plasticine egg to real eggs of the host by modeling them from real eggs collected previously. We recorded pond and number of the nest on the bottom of each plasticine egg so that we could determine where the egg was placed initially. We revisited nests containing plasticine eggs every 7 days until fate of the nest was determined. We wore rubber gloves and boots to minimize scent at nests during all checks. We identified predators by comparing bite marks with reference eggs from a prior study of predation (Meckstroth and Miles, 2005) and from a reference collection of skulls at the Museum of Wildlife and Fish Biology, University of California, Davis.

To examine diurnal patterns of predation using data from cameras, we first tested for a uniform distribution of predation events throughout the day for all predators using Rayleigh's *Z*-test (Zar, 1996). We then used circular statistics (Watson-Williams *F*-test; Zar, 1996) to test for differences in time of day between mammalian and avian predators.

Using data from detection treatments, we tested whether avian or mammalian predators were responsible for observed predations. We used logistic regression (JMP, 2001), where predator (avian or mammalian) was the nominal dependent variable and where species (avocet or stilt), detection treatment (camera, plasticine egg, camera and plasticine egg), and their interaction were independent variables. Because we collected data for plasticine eggs only during the first year, we constructed a preliminary logistic-regression model to determine if year was a significant factor in predation when using data from only cameras at nests (where we had 2 years of data). Year was not significant in this model (χ^2_1 = 1.97, P = 0.16, n = 19), so we pooled data across years in subsequent models.

We tested whether fate of nests differed among the three treatments used to detect predators. We did so using an iterative process where we first examined whether status of nest (abandoned or non-abandoned) differed among detection treatments (camera, plasticine egg, or both). For those nests that were not abandoned, we tested whether fate of nest (hatch or depredated) differed among detection treatments. We first used logistic regression where status (abandoned or active) was the dependent variable and detection treatment, species, and their interaction were independent variables. Of those nests that were not abandoned, we used logistic regression where fate of nest (hatched or depredated) was the dependent variable and detection treatment, species, and their interaction were independent variables. We constructed separate logistic models for each nesting species because the species-by-treatment interaction in the global model was significant. For all logistic-regression analyses, we dropped interaction terms from the final model if they were not significant ($P > 0.10$).

RESULTS—Of 72 nests monitored exclusively with cameras, 45 were depredated (Table 1). Only 19 of 45 (42%) predations were recorded on cameras at nests monitored exclusively with cameras. We identified eight species of predators from videos; three avian and five mammalian (Table 2). Avian predators accounted for 7 and mammalian predators accounted for 12 of the 19

TABLE 2—Predators and frequency of predation on nests of American avocets (*Recurvirostra americana*) and black-necked stilts (*Himantopus mexicanus*) for each treatment used to assess predation in Don Edwards San Francisco Bay National Wildlife Refuge, San Mateo and Santa Clara counties, California, 2006–2007.

	Camera		Plasticine egg		Camera and plasticine egg		
Predators	Avocet	Stilt	Avocet	Stilt	Avocet	Stilt	Total
Mammals							
Gray fox	3				1	3	7
Raccoon	1	2	1		4		8
Rat	2		1	1	1		5
Striped skunk	1	2	3	2	1		9
Virginia opossum	1			2			3
Unknown			1		2		3
Total mammals	8	4	6	5	9	3	35
Birds							
California gull	2						2
Common raven	1						1
Red-tailed hawk	4						4
Unknown			2	5			7
Total birds	7		2	5			14
Total	15	4	8	10	9	3	49

observed predations (Table 2). Avian predators were the California gull, common raven (*Corvus corax*), and red-tailed hawk (*Buteo jamaicensis*), and mammalian predators were the gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), rat (*Rattus*), striped skunk, and Virginia opossum (*Didelphis virginiana*; Table 2).

For all nests where predations were captured by cameras (includes both camera at nest and camera and plasticine egg at nest; $n = 21$), predation was not uniformly distributed throughout the day (Rayleigh's test of uniformity $R_{21} = 4.99$, $P = 0.006$; Fig. 1). Mean time of predation differed between mammalian and avian predators ($F_{1,19} = 24.9$, $P = 0.001$). Predation by mammals was mainly nocturnal (mean, 0051 h PDT ± 5 h 36 min). In contrast, predation by birds occurred in afternoon (mean, 1800 h PDT ± 1 h 26 min), with 43% before 1800 h PDT, 43% occurred between 1800 h and sunset, and 14% occurred within 1 h of sunset (Fig. 1).

Of the 40 nests monitored exclusively with plasticine eggs, 26 were depredated (Table 1). Of the 26 depredated nests, we identified the predator in 18 cases (69%). Of the 18 plasticine eggs that had identifiable marks from predators, 11 were mammalian and 7 were avian (Table 2). Avian predators could not be identified to species using plasticine eggs, but mammalian predators were identified as raccoons, rats, striped skunks, and unknowns (Table 2).

Of 35 nests monitored with both cameras and plasticine eggs, 15 were depredated (Table 1). Of the 15 depredated nests, only one provided detection of a predator using both methods; camera and plasticine egg identified the same predator (raccoon). On 10 occasions, bite marks were present to identify predators but cameras did not record the event. One time the camera recorded a predation event while the plasticine egg was left unmarked. Mammalian predators accounted for all identifiable predation events on nests with both cameras and plasticine eggs ($n = 12$; Table 2). Mammalian predators included gray foxes, raccoons, rats, striped skunks, and unknown mammals (Table 2). For the remaining three predation events, neither cameras nor plasticine eggs provided information on identity of the predator.

To determine why cameras missed some predation events, we pooled data for the two treatments that used cameras. Cameras failed to detect a predator 39 times (Table 1), but 22 of these times were attributed to full memory cards and dead batteries because of recordings of moving vegetation. For 17 times, we could not determine why the camera failed to record the

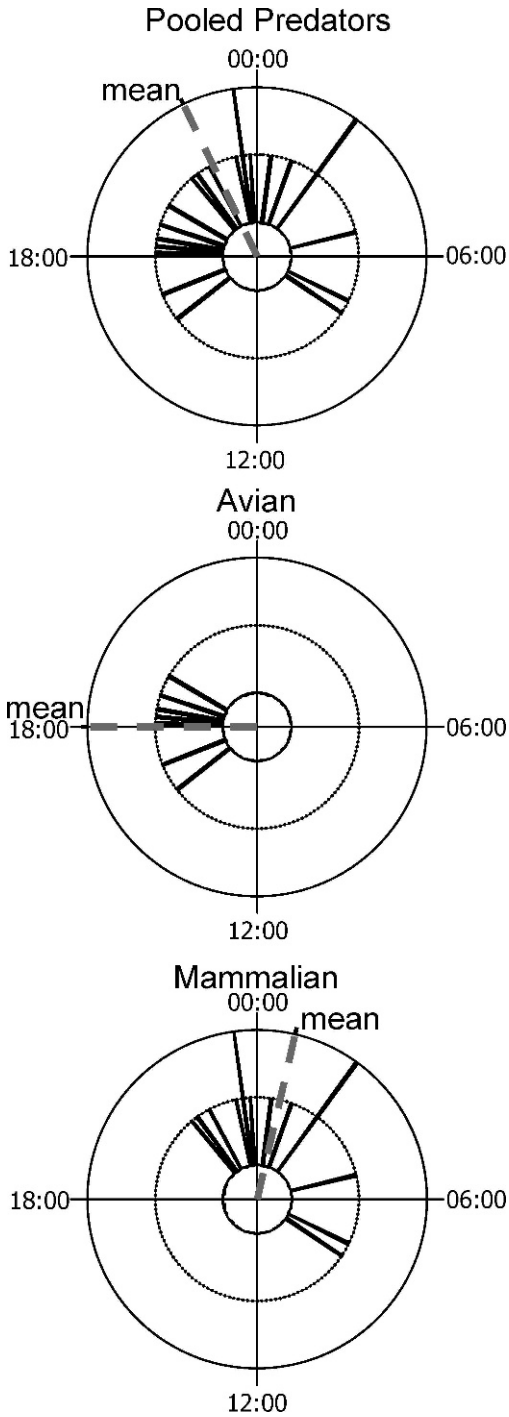

FIG. 1—Time of day when nests of American avocets (*Recurvirostra americana*) and black-necked stilts (*Himantopus mexicanus*) were depredated in wetlands of Don Edwards San Francisco Bay National Wildlife Refuge, San Mateo and Santa Clara counties, California, 2006–2007. Each solid line extending to the dotted circle represents one predation of a nest and solid lines extending to the solid circle represent two predations of nests.

predator, although the predator may have triggered the camera and moved out of the field of view during the trigger delay.

There was a significant effect of detection treatment, but not nesting species, on probability of a nest being depredated by an avian or mammalian predator in our global model (treatment, $\chi^2_2 = 9.8$, $P = 0.007$; species, $\chi^2_1 = 0.3$, $P = 0.560$, $n = 49$). Using only data for camera or plasticine egg alone resulted in detection of both avian and mammalian predators (63 and 37% for camera and 61 and 39% for plasticine, respectively), whereas the combination of cameras and plasticine eggs detected only mammalian predators (Table 2).

There was a significant effect of detection treatment on likelihood of a nest being abandoned or remaining active (treatment, $\chi^2_2 = 14.6$, $P = 0.001$; species, $\chi^2_1 = 1.5$, $P = 0.210$, $n = 136$). Nests with only cameras had lower abandonment (5%, $n = 72$) than nests with plasticine eggs (23%, $n = 40$) or nests with cameras and plasticine eggs (29%, $n = 35$).

For hatched versus depredated nests, there was a significant interaction between nesting species and detection treatment (species, $\chi^2_1 = 0.03$, $P = 0.840$; treatment, $\chi^2_2 = 4.46$, $P = 0.100$; species by treatment, $\chi^2_2 = 6.9$, $P = 0.030$, $n = 117$). Therefore, we evaluated separate logistic-regression models for each nesting species to test effect of detection treatments on likelihood of a nest being hatched or depredated. For avocets, the likelihood of a nest hatching or being depredated was not related to detection treatment ($\chi^2_2 = 1.71$, $P = 0.420$, $n = 78$). In contrast, likelihood of a nest of a stilt being hatched or depredated was related to detection treatment ($\chi^2_2 = 9.41$, $P = 0.009$, $n = 39$). Nests of stilts with camera and plasticine eggs together had the highest number of hatching nests (40%), compared to cameras alone (9%) or plasticine eggs alone (11%).

DISCUSSION—Predators had an important influence on survival of nests of avocets and stilts in wetlands of San Francisco Bay, with >50% of

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nests depredated. No particular predator was dominant, although raccoons, striped skunks, and gray foxes were common mammalian predators. Red-tailed hawks and California gulls were responsible for most of the identified avian predation. Recent research using simulated, artificial nests also detected that striped skunks were one of the most common predators of nests in wetlands of San Francisco Bay (Meckstroth and Miles, 2005). Previous studies of nesting avocets and stilts discovered that mammals (wild boars *Sus scrofa* and coyotes *Canis latrans*) accounted for 100% of predation on nests in Texas (Conway et al., 2005), 64% by coyotes and 36% by ring-billed gulls (*Larus delawarensis*) in Oklahoma (Winton et al., 1997), and 69% by California gulls and ring-billed gulls and 31% by red foxes, striped skunks, and long-tailed weasels (*Mustela frenata*) in Utah (Sordahl, 1996). These studies are consistent with ours in that both mammalian and avian species are common predators of nests.

Frequency of predation in our study (59%) was within the range for avocets and stilts breeding elsewhere. Conway et al. (2005) observed that the proportion of nests depredated for avocets and stilts averaged 45 and 50%, respectively, in playa lakes of Texas. Similarly, Sordahl (1996) estimated that predation of nests of avocets and stilts in northern Utah averaged 57%. In a constructed wetland with an electric fence to exclude predators, predation occurred in <1% of nests for each species (Davis et al., 2008), demonstrating the potential for large increases in success of nesting if mammalian predators are excluded. In the study of exclusion of predators by Davis et al. (2008), avian predators were not significant. However, in the estuary of San Francisco Bay, avian predators were important with ≥29% of all predation caused by birds.

Differences in time of day when predation occurred appeared to be largely related to periods of peak activity of predators, to visual cues typically used by avian predators (Picozzi, 1975; Yahner and Cypher, 1987), and to olfactory cues mainly used by mammalian predators (Whelan et al., 1994; Rangen et al., 2000). Larivière and Messier (2001) also observed that timing of predation was not random; mammalian predation occurring mostly nocturnally at 0100–0200 h. Avian predators in our study depredated nests most often near dusk, which may be a function of increased hunting efficiency in the case of red-tailed hawks (Elliot et al., 2006; Rutz, 2006) and coincides with the general timing when California gulls leave local landfills at the end of the day and return to roost sites and breeding colonies (J. T. Ackerman, in litt.).

Cameras recorded no avian predator at nests of stilts, but cameras indicated that avian predators were responsible for 47% of depredated nests of avocets. Stilts typically nested in more vegetation than avocets, which may have reduced predation by visual avian predators; however, the difference in composition of predator faunas between nests of avocets and stilts was likely an artifact of size of sample. Fewer cameras were placed at nests of stilts during this study, and results from nests with only plasticine eggs demonstrated that avian predators accounted for one-half of all nests of stilts lost to predators. Overall, avian predators appeared to play an important role in predation of nests of avocets and stilts, but predation by mammals was most common, especially for avocets.

Recent meta-analysis of effects of cameras on success of avian nests suggests that studies that use these predator-detection technologies may underestimate rates of predation. Richardson et al. (2009) synthesized results across 21 studies and observed that surveillance by cameras sometimes reduced frequency of predation and biased estimates of survival of nests high. Within detection treatments, we observed that a larger proportion of nests monitored with both cameras and plasticine eggs hatched, suggesting that the combination of treatments may have decreased likelihood of a predator depredating a nest in accordance with the report by Richardson et al. (2009).

Our results also demonstrated that the proportion of nests that were abandoned was lower at nests monitored with only cameras than when plasticine eggs or cameras and plasticine eggs were used. Cameras at nests also provided definitive identification of predators, suggesting that the most suitable approach for future monitoring might be cameras alone. However, cameras were less effective at detecting predators during a predation event; thus, a trade-off exists between effectiveness of identification methods and likelihood of documenting the predation event.

We attribute most failures of cameras to full memory cards and dead batteries due to vegeta-

tion triggering the camera too often. Had nests been visited more regularly, many of these predation events would have been recorded. However, excessive visits might have biased estimates of failures due to increased disturbance and associated abandonment, and potentially increased activity of predators associated with increased time spent at nests by researchers (Götmark et al., 1990; Whelan et al., 1994). Bolton et al. (2007) assessed using a digital camera to identify predators of lapwings (*Vanellus vanellus*) and spotted flycatchers (*Muscicapa striata*). They determined that dead batteries and full memory cards (from inadvertent triggering) were common problems with infrared cameras. For unknown reasons, we missed 17 additional predation events. We speculate that the 1-s trigger time (delay between the infrared sensor detecting motion and the camera beginning to record) may have been too slow to capture fast-moving predators such as gray foxes and California gulls. Swann et al. (2004) tested six infrared-triggered cameras and noted that, on average, 52% of simulated predation events were captured on camera and the probability of capturing a predator on camera decreased with decreasing size. Future studies of predators might use cameras at nests with faster trigger times and check cameras more frequently with the caveat that increased disturbance may influence the outcome. Alternatively, researchers might use time-lapse, continuous-monitoring, video cameras to avoid issues with slow triggers (Keedwell and Sanders, 2002; Sanders and Maloney, 2002; Liebezeit and Zack, 2008). Benefits of continuous, time-lapse, video cameras should be tempered by their high cost and subsequent reduction in number of nests that can be monitored relative to using passive-infrared-sensor, digital, trip cameras (Thompson et al., 1999; Sanders and Maloney, 2002).

We discontinued use of plasticine eggs at the end of the first field season when we observed two instances where a plasticine egg was stuck to the incubating bird upon analysis of data from cameras; once to the foot of an avocet and another time to the brood patch of a stilt. In both instances, the nest was later abandoned. Ours is one of the first studies to use plasticine eggs in actively incubated nests to examine predation. We speculate that eggs stuck to incubating adults were warmed and made slightly adhesive in high humidity associated with wetland nesting sites. Although we cannot confirm that these events were related to abandonment, we suggest that researchers avoid using plasticine eggs in active nests.

The use of plasticine eggs did provide a means to assess bias of cameras in identifying predators of nests. It has been suspected that predators may avoid novel objects, such as cameras, at nests (Hernandez et al., 1997; Thompson et al., 1999; Pietz and Gransfors, 2000; Herranz et al., 2002; Richardson et al., 2009), although predators have been attracted to novel objects (Liebezeit and Zack, 2008). Had we only used cameras at nests, we would have underestimated avian predation on nests of stilts. Further, when nests were monitored with a camera and plasticine egg, only mammalian predators were detected at nests of both avocets and stilts, suggesting that local avian predators may have been wary of the double detection treatment.

Future large-scale restoration of salt ponds at San Francisco Bay into tidal marshes may decrease nesting habitat for avocets and stilts (Rintoul et al., 2003), resulting in more concentrated densities of nests at the remaining salt ponds. If nesting by avocets and stilts becomes more concentrated, likelihood of density-dependent predation on nests may increase as predators potentially increase use of these areas (Larivière and Messier, 1998, 2001). The rapidly increasing population of California gulls (Strong et al., 2004; J. T. Ackerman, in litt.) could lead to an increase in already high rates of predation. Whereas, current programs to remove predators in wetlands of San Francisco Bay do not appear to reduce overall rates of predation (Meckstroth and Miles, 2005), future efforts to maintain nesting avocets and stilts and minimize predation may require alternatives such as creating additional island habitats that could limit mammalian predation. Because creation of nesting islands will not mitigate avian predation, an important consideration for future research will be to develop effective techniques to manage avian predators.

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