Response of Predators to Western Sandpiper Nest Exclosures

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Abstract.—In 2001, predator exclosures were used to protect nests of the Western Sandpiper (*Calidris mauri*) in western Alaska. During the exclosure experiment, nest contents in exclosures had significantly higher daily survival rates than control nests, however, late in the study predators began to cue in on exclosures and predate the nest contents. An Arctic Fox (*Alopex lagopus*) dug under one exclosure and took the newly hatched chicks, and Long-tailed Jaegers (*Stercorarius longicaudus*) learned to associate exclosures with active nests and repeatedly visited them. The jaegers attempted to gain access to exclosed nests and pursued adult sandpipers as they emerged from the exclosures. The exclosures were removed to reduce potential mortality to adult and young sandpipers, but subsequently, post-exclosure nests had lower daily survival rates than controls during the same time period. Predation of post-exclosure eggs and chicks highlighted the lasting influence of the exclosure treatment on offspring survival because predators probably remembered nest locations. Researchers are urged to use caution when considering use of predator exclosures in areas where jaegers occur. *Received 18 May 2003, accepted 20 September 2003.*

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Egg predation is the primary cause of nest failure for tundra-nesting shorebirds such as the Western Sandpiper (*Calidris mauri*) (Holmes 1972). Predation on eggs of the Western Sandpiper at study sites in western Alaska range from 40% to nearly 90% (Sandercock 1997; Ruthrauff 2002; B. J. McCaffery, unpublished data), and other breeding shorebirds have experienced similar rates of egg predation (Rimmer and Deblinger 1990; Melvin *et al.* 1992; see Estelle *et al.* 1996).

To reduce egg predation, researchers have used exclosures to protect the nests of small breeding birds (Rimmer and Deblinger 1990; Melvin *et al.* 1992; Johnson and Oring 2002). Exclosures are typically large wire structures that completely surround the nest, thus reducing or eliminating access to the nest by mammalian or avian predators. In some studies, exclosures have been shown to significantly increase nesting success compared with unexclosed nests (Vaske *et al.* 1994; Estelle *et al.* 1996; Johnson and Oring 2002; Murphy *et al.* 2003a).

Possible negative effects of predator exclosures have been closely monitored when used on threatened species (review in Mabee and Estelle 2000). Mustelids have been known to take eggs or incubating adults from within exclosures (Nol and Brooks 1982; Johnson and Oring 2002). For the most part, however, exclosures are effective at preventing egg predation by avian and large mammalian predators. Here, we evaluate the effectiveness of nest exclosures in reducing egg predation and describe predator attraction to exclosures at Western Sandpiper nests.

METHODS

Treatments

Fieldwork occurred at the Kanaryarmiut Field Station on the Yukon Delta National Wildlife Refuge in western Alaska (61°21.801'N, 165°07.534'W). Between 6 and 19 June 2001, sixteen Western Sandpiper nests were assigned to the exclosure treatment, using a non-random selection process to maximize spatial distribution across the study area. All nests selected for experimental or control groups had clutches of four eggs. Controls were all unexclosed nests in use during the exclosure experiment (N = 107), and exclosures remained over nests until removed on 25 or 26 June. Post-exclosure controls were those active after the exclosure experiment (N = 32).

Nests were checked every one to five days to determine status and to identify signs of attempted or actual egg predation. Egg predation was defined as the removal of one or more eggs from a nest by a predator and attempted egg predation by digging at the exclosure, fur at or near the exclosure, or signs of damage to the nest or eggs. Western Sandpiper chicks remain in the nest

post-hatching for up to 18 hours (Holmes 1972), and chicks taken from nests within hours of hatch were included in egg predation estimates.

Exclosure Design and Construction

Exclosures were modeled on designs used successfully by other shorebird researchers (Estelle *et al.* 1996; D. Schamel, pers. comm.). Exclosures were large wire cylinders about 1 m in height and 1 m in diameter, and Western Sandpipers were able to walk freely to and from the nest through the 5 × 10 cm mesh wire sides. The exclosures were completely covered at the top with chicken wire to prevent entrance by avian predators. Exclosures were taller than those used by Estelle *et al.* (1996), to reduce the likelihood that Arctic Foxes (*Alopex lagopus*) would knock over the structures in an attempt to gain access to the nest. To steady the structures, sharp tines along the bottom edge of the exclosure were pressed into the ground, and the exclosure was affixed to three 46-cm-long rebar stakes that were driven into the permafrost beneath the tundra surface. Exclosures were fabricated prior to approaching nests, and installation at nests took less than five minutes.

Statistical Tests

Daily survival rates (DSR) were estimated as 1- (the number of mortalities/total exposure days) (Mayfield 1961), and standard errors were calculated as recommended by Johnson (1979): $\sqrt{[(\text{exposure days-mortalities})*(\text{mortalities})/\text{exposure days}^3]}$ (Young and Young 1998). This method is appropriate for data where some nests are not followed from initiation, or in this case, where DSR were calculated only after the initiation of the experiment. Daily survival rates are reported with 95% confidence intervals (CI), calculated from the standard errors of the samples (Zar 1996). Days prior to installation of the first exclosures were excluded from analyses, and DSR were assumed to be constant throughout the study period. Exposure days were the number of days during which the nest was active during each treatment, i.e. during the exclosure experiment or after removal of the exclosures. When exclosures were removed prior to hatching of young, the nests were followed until hatch or until eggs were predated. If unknown, mortalities were assigned to the day between the penultimate and ultimate nest checks.

RESULTS

During the exclosure experiment, nests in exclosures had significantly higher DSR (±95% CI) (0.99 ± 0.01; N = 15) than control nests (0.96 ± 0.01; N = 107) ($t_{121} = 4.9$, $P < 0.001$). After removal of the exclosures, post-exclosure nests had significantly lower DSR (0.79 ± 0.16; N = 9) than post-exclosure controls (0.96 ± 0.02; N = 32) ($t_{40} = 2.4$, $P < 0.05$). The lower survival of post-exclosure nests likely resulted from predators (see below).

At 15 of 16 exclosed nests, the attending parent resumed incubation within seven minutes of disturbance, i.e. set-up of exclosure or subsequent flushing. At one exclosed nest, the male consistently failed to resume incubation within 30 minutes of disturbance, and after three days the exclosure was removed from around this nest. This nest was excluded from analyses.

The principal nest predators at Kanaryarmiut were the Arctic Fox and the Long-tailed Jaeger (*Stercorarius longicaudus*), which hunted on the site throughout the season. No Arctic Fox activity was observed at any exclosure until 19 days into the study, when a fox dug underneath one exclosure and removed young chicks from a nest cup. The fox also killed the attending female, and her remains were found adjacent to the nest.

Long-tailed Jaegers were frequently seen near predator exclosures late in the study. On the seventeenth day of the study, two jaegers chased an adult sandpiper as it emerged from an exclosure. The sandpiper evaded capture and returned to its nest, and no further incidents of this nature were observed until two days later, when a Long-tailed Jaeger was seen looking through the mesh of an exclosure at a nest cup containing four newly hatched chicks, while the parent sandpiper scolded nearby. The approach of humans startled the jaeger, and it did not immediately return. Later the same day, however, a pair of Long-tailed Jaegers began methodically visiting and harassing Western Sandpipers at predator exclosures. The pair visited all seven exclosures in one area of the study site, including two empty exclosures: one that was depredated by a fox and another from which the chicks had already departed. No control nests were visited by the jaegers during this time. At this time, the jaegers clearly associated the exclosures with nests and used these cues to find and attempt predation of eggs, chicks and adults.

During these nest visits, the jaegers looked through the wire sides of the exclosures, less than 0.5 m from nests, and perched on the exclosure tops, typically causing the adult sandpipers to flush from the nest and leave the exclosure to scold or perform distraction displays nearby. Under these conditions, sandpipers flew forcefully

into the sides and top of the exclosure as they attempted to leave the exclosure. Upon emergence, at least two sandpipers were chased by the jaegers for up to 400 m. In the presence of the jaegers, sandpipers at nests in exclosures did not incubate eggs or brood recently hatched chicks, and one chick died from cold exposure during this time.

Because of the risks to adult and young sandpipers caused by the jaegers' visits, the exclosures were removed. Three hours after the jaegers were first observed methodically visiting experimental nests, all nest markings associated with these nests were removed, and within twelve hours all exclosures were removed from the study site.

At the time when all exclosures were removed, nine Western Sandpiper nests were active in the exclosure treatment group. Of these, three broods had hatched on the day that the jaegers began to visit exclosures; soon after the exclosures were removed, these broods were predated while still in the nest. Minutes after the removal of one exclosure, the jaegers flew directly to a nest and consumed the chicks. On the following day, a brood hatched at a post-exclosure nest, and the chicks were also consumed at the nest. Three of the remaining post-exclosure clutches were predated within five days.

Although two post-exclosure clutches did successfully hatch and the young departed from the nest, these broods probably did not fledge. In contrast, four of five broods that hatched from exclosed nests successfully fledged at least one chick. In previous years, at least one chick fledged from approximately 70% of all nesting attempts at this site (Ruthrauff 2002).

DISCUSSION

During the period when exclosures were in position, the daily survival rate of exclosed nests was significantly higher than that of controls. However, the daily survival rate of post-exclosure nests was lower than that of controls active during the same time, reflecting the learning by the predators that occurred during the study. Long-tailed Jaegers associated exclosures with a food source, influenced the behavior of adult sandpipers, and clearly affected the survival of the sandpipers' offspring at these nests. Predation of eggs and young chicks in the post-exclosure treatment showed a lasting influence of the exclosures on egg and chick mortality, as the jaegers apparently remembered the nest locations. This behavior has not been previously reported for Long-tailed Jaegers.

Avian predators have been known to develop strong search images for nests (Salathe 1987), and in a few cases, corvids and raptors have used exclosures as cues to nest locations (references in Liebezeit and George 2001; Murphy *et al.* 2003b). Recent studies have reported high mortality rates of adult shorebirds as a result of small mammal (Johnson and Oring 2002) or raptor (Murphy *et al.* 2003b) predation at exclosures. The practice of marking nests can increase predation rates of eggs or adults if predators learn to associate markers with food sources (Picozzi 1975; Reynolds 1985; B. Sandercock, pers. comm.). The effects of exclosures on predator attraction should receive more consideration in future studies, particularly in cases where exclosures are used to "protect" the nests of threatened or endangered species.

In addition, Western Sandpipers in this and other studies (J. Bart, pers. comm.) sometimes had difficulty leaving the exclosures, "bouncing around" within them or becoming entrapped in the wire sides. The birds appeared unharmed when this behavior was observed in the course of monitoring nest status, however, the forceful attempts to escape observed during the jaeger visits indicate that predator-induced stress may reduce escape ability from exclosures. Reduced escape ability probably contributed to the predation of one female by an Arctic Fox at an exclosure. The escape behavior of birds at exclosed nests should be monitored carefully.

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LITERATURE CITED

Estelle, V. B., T. J. Mabee and A. H. Farmer. 1996. Effectiveness of predator exclosures for Pectoral Sandpiper nests in Alaska. Journal of Field Ornithology 67: 447-452.

Holmes, R. T. 1972. Ecological factors influencing the breeding season schedule of Western Sandpipers (*Calidris mauri*) in subarctic Alaska. American Midland Naturalist 87: 472-491.

Johnson, D. H. 1979. Estimating nest success: The Mayfield method and an alternative. Auk 96: 651-661.

Johnson, M. and L. W. Oring. 2002. Are nest exclosures an effective tool in plover conservation? Waterbirds 25: 184-190.

Liebezeit, J. R. and T. L. George. 2001. A summary of predation by corvids on threatened and endangered species in California and management recommendations to reduce corvid predation. Department of Wildlife, Humboldt State University, Arcata, CA.

Mabee, T. J., and V. B. Estelle. 2000. Assessing the effectiveness of predator exclosures for plovers. Wilson Bulletin 112: 14-20.

Mayfield, H. F. 1961. Nesting success calculated from exposure. Wilson Bulletin 73: 255-261.

Melvin, S. M., L. H. MacIvor and C. R. Griffin. 1992. Predator exclosures: A technique to reduce predation at Piping Plover nests. Wildlife Society Bulletin 20: 143-148.

Murphy, R. K., R. J. Greenwood, J. S. Ivan and K. A. Smith. 2003a. Predator exclusion methods for managing endangered shorebirds: Are two barriers better than one? Waterbirds 26: 156-159.

Murphy, R. K., I. M. G. Michaud, D. R. C. Prescott, J. S. Ivan, B. J. Anderson and M. L. French-Pombier. 2003b. Predation on adult Piping Plovers at predator exclosure cages. Waterbirds 26: 150-155.

Nol, E. and R. J. Brooks. 1982. Effects of predator exclosures on nesting success of Killdeer. Journal of Field Ornithology 53: 263-268.

Picozzi, N. 1975. Crow predation on marked nests. Journal of Wildlife Management 39: 151-155.

Reynolds, J. D. 1985. Sandhill Crane use of nest markers as cues for predation. Wilson Bulletin 97: 106-108.

Rimmer, D. W. and R. D. Deblinger. 1990. Use of predator exclosures to protect Piping Plover nests. Journal of Field Ornithology 61: 217-223.

Ruthrauff. D. R. 2002. Seasonal and age-related trends in the reproductive output of Western Sandpipers (*Calidris mauri*) at Kanaryarmiut, Alaska. Unpublished M.Sc. Thesis. Department of Wildlife, Humboldt State University, Arcata, CA.

Salathe, T. 1987. Crow predation on Coot eggs: Effects of investigator disturbance, nest cover, and predator learning. Ardea 75: 221-230.

Sandercock, B. K. 1997. Factors affecting the breeding demography of Western Sandpipers (*Calidris mauri*) and Semipalmated Sandpipers (*C. pusilla*) at Nome, Alaska. Unpublished Ph.D. Thesis. Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia.

Vaske, J. J., D. W. Rimmer and R. D. Deblinger. 1994. The impact of different predator exclosures on Piping Plover nest abandonment. Journal of Field Ornithology 65: 201-209.

Young, L. A. and J. H. Young. 1998. Statistical Ecology: A Population Perspective. Kluwer Academic Press, Boston, MA.

Zar, J. H. 1996. Biostatistical Analysis. 3rd ed. Prentice-Hall, Inc., Englewood Cliffs, NJ.