

Response of Predators to Western Sandpiper Nest Exclosures

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into the sides and top of the enclosure as they attempted to leave the enclosure. 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 enclosures 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 enclosures 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 enclosures were removed from the study site.

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

Although two post-enclosure 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 enclosed 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 enclosures were in position, the daily survival rate of enclosed nests was significantly higher than that of controls. However, the daily survival rate of post-enclosure 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 enclosures with a food source, in-

fluenced 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-enclosure treatment showed a lasting influence of the enclosures 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 enclosures 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 enclosures. The practice of marking nests can increase predation rates of eggs or adults if predators learn to as-

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