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Shorebird avoidance of nearshore feeding and roosting areas at night correlates with presence of a nocturnal avian predator

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We here report two anecdotes about avian interactions relevant to the interpretation of differences in shorebird habitat use between day and night. Several studies have reported that shorebirds avoid feeding and roosting along nearshore areas at night yet commonly use these sites during daytime. This suggests that nighttime avoidance of nearshore places is a response to increased danger of predation. When mist-netting during autumn 2005 on nearshore intertidal habitats along South Spit, Egegik Bay (Alaska Peninsula), Alaska, we discovered that shorebirds that occurred there in large numbers during daytime low tides and roosted there during daytime high tides (especially Dunlin *Calidris alpina*, Rock Sandpipers *Calidris ptilocnemis*, Black-bellied Plover *Pluvialis squatarola*, and Surfbirds *Aphriza virgata*), were absent at night. Their avoidance of the area correlated with Short-eared Owls *Asio flammeus* concurrently hunting over the beach and adjacent intertidal habitats. Spotlighting over nearby expansive intertidal mudflats confirmed that the same suite of species continued to forage or roost nearby at night. To bring the story full circle, the morning following one mist-netting effort we found a Short-eared Owl on the beach that had been killed earlier by a Gyrfalcon *Falco rusticolus*. In the owl's stomach were remains of a freshly devoured Dunlin.

INTRODUCTION

The realisation that animals have specific requirements in terms of where and how much they feed has motivated most studies on distribution and abundance of birds and mammals. However, other factors are important, namely how animals avoid becoming food themselves. Indeed, the ways in which the "danger of predation" (i.e., the inherent probability of becoming a prey item in any particular situation if no anti-predation measures are taken, Lank & Ydenberg 2003) affects the distribution and behaviour of animals has been a focus of many recent ecological studies (e.g. Lima 2002, Caro 2005, Lind & Cresswell 2005). Although some studies on the distribution of shorebirds have considered explicitly the role of the danger of predation (e.g. Goss-Custard 1970, Piersma *et al*. 1993), studies of how predation danger affects behavioural strategies of shorebirds have only recently become more common (e.g., Cresswell 1993, 1994a,b, Ydenberg *et al.* 2002, Piersma *et al*. 2003, Quinn & Cresswell 2004).

During non-feeding periods of the day many shorebirds tend to congregate at communal roosts, whether during high tide in coastal, tidal environments or at night in inland wetlands. Considerations related to the danger of predation may well be one of the most important factors shaping the positioning of, and numerical abundance at, such roosts (e.g. Rogers 2003). Rogers (2003) and Rogers *et al*. (2006) showed that in Roebuck Bay, NW Australia, Great *Calidris tenuirostris* and Red Knots *C. canutus* roost farther from intertidal feeding grounds at night than during daytime. This difference is attributed to the nearest shoreline areas having dark (vegetated) backgrounds that enhance the danger of predation, possibly by owls, at night. Similarly, on the Yukon Delta in western Alaska, Handel & Gill (1992) felt that increased danger of predation by mammals explained their observations of Dunlin *Calidris alpina* avoiding onshore roost sites during nocturnal high tides that were used during the preceding or following daytime high tides. In terms of use of foraging areas, Sitters *et al*. (2001) attributed the absence at night of Red Knots at rich, relatively nearshore feeding areas in northern Patagonia, Argentina, to increased predation from predators such as owls. However, during none of these three studies was any nighttime predation event directly observed. In this light (or absence thereof), anecdotal observations that we made on feeding distributions of shorebirds

Fig. 1. Aerial view of the southwestern part of Egegik Bay at low tide with the Bering Sea in the background. The mouth of the bay is just to the right of the picture. Observations on 31 Aug 2005 were made on mudflats at the base of the spit; those on 20 Sept on the mussel bed, circled here in black to the right of centre of the picture and indicated by the arrow (photo: T. Piersma on 10 Sept 2005).

Fig. 2. The inside of South Spit at Egekik Bay showing the pebbled beach and the exposed mussel bed on which high densities of shorebirds foraged in Aug/Sept 2005 (photo: R.E. Gill).

Fig. 3. Dunlin roosting at high tide on mudflats at the base of South Spit, Egegik Bay. On 31 Aug 2005 mist nets were placed at this site roughly at the far edge of the flock shown here (photo: R.E. Gill).

Fig. 4. Fresh carcass of a Short-eared Owl killed by a Gyrfalcon on the upper (pebble) beach of South Spit, Egegik Bay, 20 Sept 2005 (photo: T. Piersma).

Fig. 5. The partially digested but feathery remains of a Dunlin (skull by finger) emptied from the gizzard of a Short-eared Owl, Egegik Bay, 20 Sept 2005 (photo: T. Piersma).

during day and night and the differential presence of a proven shorebird predator at an Alaska Peninsula estuary in September 2005 are illuminating. We describe how shorebirds at night avoid the use of a very rich feeding area and a traditional high tide roost during a time that one or more sandpiper-eating Short-eared Owls *Asio flammeus* hunted there.

STUDY SITE

From 25 Aug to 4 Oct 2005, shorebirds were studied at Egegik Bay, Alaska (58°11'N, 157°31'W), a large estuary near the base of the Alaska Peninsula that is protected from the Bering Sea by a long spit (Fig. 1). The edges of South Spit are predominantly vegetated with 0.3 to 0.8 m-tall beach rye grass *Elymus arenarius* that becomes mixed with slightly taller reed bent grass *Calamagrostris canadensis* at the base of the spit and along the southwest corner of the bay. The beach along the inside of the spit is composed of sand and fine gravel at the base, but changes in composition to more gravel and pebbles towards the distal end of the spit. In the southwest corner of the bay extensive intertidal mud flats remain exposed during all but the highest tides and were routinely used as a roosting site by Dunlin (tens of thousands) and waterfowl (thousands). Adjacent to the beach near the tip of the spit occurs a large (7–8 ha) mussel bed (Fig. 1) which was particularly attractive to foraging waterbirds. These included Rock Sandpipers *Calidris ptilocnemis* (up to several thousand), Dunlin (also several thousand), Black-bellied Plovers *Pluvialis squatarola* (a few hundreds), Surfbirds *Aphriza virgata* (up to 15 birds), Greater Yellowlegs *Tringa melanoleuca* (several tens) and sometimes Red Knots *C. canutus* and Bar-tailed Godwits *Limosa lapponica* (a few tens each), Glaucous-winged Gulls *Larus glaucescens* (few tens), and families of Emperor Geese (*Chen canagica*) (several tens).

Our observations took place on the evenings of 31 Aug and 20 Sept. On these dates, conditions (wind, tide, moonlight) were suitable for mist-netting shorebirds, either those roosting at night on flats at the base of the spit or feeding at night during low tide on the exposed mussel bed near the tip of the spit. On the evening of 31 Aug–1 Sept (21h30–00h45 Alaska Standard Time) two of us (DR and LT) set up mist nets at the base of the spit on exposed mud flats about 75–100 m from the vegetated shore, anticipating capturing birds that roosted in the area during previous day-time high tides. During our tenure there we occasionally used a strong spotlight to check the proximity of birds to the tide line and nets.

On the evening of 20 Sept, between 21h30 and midnight, under a quarter moon and occasionally clear sky, we tended a 50 m-long line of mist-nets erected across the mussel bed. On one occasion during this period one of us (REG) used a strong spotlight to search the mussel bed and nearby intertidal flats (up to one km offshore) for foraging shorebirds.

RESULTS AND DISCUSSION

To our big surprise we heard and saw no sandpipers or other shorebirds on the upper mudflats at the base of the spit during the nighttime high tide on 31 Aug or on the mussel bed during the nighttime low tide of 20 Sept. Both areas were always used by large numbers of shorebirds during daytime low and high tides throughout the entire study period between 25 Aug and 4 Oct (Figs 2 & 3). Spotlighting on the bare intertidal flats offshore of both areas nevertheless revealed the presence of large flocks of sandpipers (both Rocks Sandpipers and Dunlin and numerous Black-bellied Plovers), so their absence on the near shore did not reflect the absence of nocturnal foraging or roosting activity. Our observed absence of shorebirds on both areas soon began to make sense. On 31 Aug, we saw at least three different Short-eared Owls hunting at the edge of the mudflats and at times venturing well onto the mudflats proper – on one occasion even perching atop a mist net pole. On several occasions as the owls flew out over the flats they elicited a much higher-pitched alarm call from the plovers than given in daytime (DR).

On 20 Sept between 22h30 and 23h10, at least one Short-eared Owl was seen hunting along the beach and over the nearby mussel bed, occasionally swooping within a few meters of our heads as we sat in the dark on the upper edge of the beach. At dawn that next morning, in the same general area where we had been sitting seven hours earlier, one of us (MLS) flushed a juvenile Gyrfalcon *Falco rusticolus* off the beach. Upon returning to the site less than an hour later, we (REG and MLS) found the pectoral girdle, wings, tail, and gizzard of a Short-eared Owl (Fig. 4). The breast bone had been eaten clean and the abdominal organs except the gizzard were missing, the typical signs of predation by a falcon. Inside the owl's gizzard were the feathery remains of a freshly eaten Dunlin, with skull and bill fully recognisable (Fig. 5).

Short-eared Owls have been identified as a major predator of Dunlin during the non-breeding season (Page & Whitacre 1975) and occur commonly as breeding birds and fall migrants along the Alaska Peninsula with pronounced movements occurring between early Sept and mid-Oct (Murie 1959, Gill *et al.* 1981). During the six-week period that observers were present at Egegik Bay in fall 2005 we kept track of all observations (n = 140) of potential avian predators; Short-eared Owls represented 7% of these. Among the 16 owls seen, 8 were flushed from daytime roost sites, 5 were seen actively hunting in day over vegetated portions of the spit, and 3 were seen hunting at night over nearshore mudflats. We presume those hunting over vegetation were searching for voles which were commonly seen on the spit and which comprised the only prey remains identified from the half dozen or so regurgitated pellets we collected adjacent to owl roost sites.

The finding of a Dunlin in the gizzard of a Short-eared Owl killed by a Gyrfalcon was but one part of our anecdotal description of a tritrophic avian interaction. Equally important was our observation of nighttime hunting by Short-eared Owls over nearshore intertidal habitats that were used abundantly by shorebirds as low-tide feeding grounds and roosts during the day but not at night. Combined, they represent the "smoking gun" that helps explain the day–night shifts in roosting and foraging habitats observed during studies by Handel & Gill (1992), Sitters *et al.* (2001), and Rogers *et al.* (2006).

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