

Tradeoffs between food abundance and predation danger in spatial usage of a stopover site by western sandpipers, *Calidris mauri*

Andrea C. Pomeroy

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Foragers use a variety of anti-predator behaviours to increase their safety from predators. While foraging, animals should alter usage within or between sites to balance the benefits of feeding with the costs of predation. I tested how the distribution of food abundance and predation danger interacts to explain spatial usage (i.e. distance from shore) by migratory western sandpipers (*Calidris mauri*) at Boundary Bay, British Columbia, Canada, during northward and southward migrations. At Boundary Bay there are opposing spatial gradients in the distribution of food abundance and safety from predators. Predation danger for sandpipers is high near the shoreline where there is approach cover for falcons and decreases with distance from shore. Food abundance for sandpipers declines as distance from the shoreline increases. Food and danger attributes at Boundary Bay also differ temporally, such that food abundance is higher during southward migration, and predation danger is higher during northward migration. The spatial usage by western sandpipers balances the tradeoff between the opposing spatial gradients in food and safety. For both migratory periods spatial usage of the mudflat by sandpipers is highest at distances from the shoreline where food abundance and predation danger are intermediate. During the northward migration sandpiper usage is highest between 150 and 500 m from the shoreline, and during the southward migration sandpiper usage is highest between 100 and 600 m from the shoreline. Despite temporal differences in food and danger attributes, spatial usage of the site by sandpipers does not differ between migratory periods. Understanding how the distribution of food abundance and predation danger interact to affect the within site usage by shorebirds has important implications for assessments of site quality.

A. C. Pomeroy, Centre for Wildlife Ecology, Simon Fraser Univ., 8888 University Drive, Burnaby, British Columbia, Canada, V5A 1S6 (apomeroy@sfu.ca).

Tradeoffs between predation danger and energy intake affect the foraging behaviour of animals (Lima and Dill 1990). Foragers employ a suite of behaviours including increasing group size and vigilance levels (Elgar 1989, Bednekoff and Lima 1998, Downes and Hofer 2004) and altering habitat usage (Grubb and Greenwald 1982, Lindströ

Distribution of food

Western sandpipers are considered invertebrate generalists opportunistically feeding on a variety of benthic macro-invertebrates (Wilson 1994). To measure the distribution of shorebird food abundance I quantified benthic macro-invertebrate abundance in mud cores extracted at sample stations according to the methods described by (Sutherland et al. 2000). Each taxa sampled has been shown to be consumed intentionally (Wolf 2001) or unintentionally (Sutherland et al. 2000) by western sandpipers.

Briefly, samples weedic1

relationship between invertebrate density and distance

significantly greater during the southward migration (least squares mean = 159.6 invertebrates core⁻¹, $P < 0.0001$) than during the northward adult migration (least squares mean =

Overall the relationship between spatial usage of the

foraging at Boundary Bay spread out over the mudflat as the tide recedes.

The opposing gradients of food and safety at Boundary Bay provide a natural analogy to a giving-up density (GUD) experiment. GUDs offer an effective measure of the cost to an animal foraging under the danger of predation (Brown 1988, Altendorf et al. 2001, Kotler et al. 2004). The GUD of an animal in a controlled food patch measures the amount of food an animal is willing to give up for a certain level of safety (Brown 1988). The position of a sandpiper along the food and safety gradients serves as an index of how it evaluates these two things. For example, a bird observed feeding any

Spatial differences in food abundance and/or preda-

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