SHORT COMMUNICATIONS

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INFLUENCE OF PREY DISTRIBUTION ON AGGRESSION IN RUDDY TURNSTONES[1]

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Individual foragers must often decide whether or not defense of a food resource is profitable (Brown 1964, 1969). Among shorebirds, both characteristics of the prey (type, size, spatial and temporal distribution, and availability) and competitor density appear to be major factors in determining the costs and benefits of aggression for food resources (Recher and Recher 1969, Myers 1984). One of the predictions generated from observations of foraging shorebirds is that individual aggression should be more frequent in areas with patchy food distributions than in areas with more even distributions (Recher and Recher 1969, Myers 1984). I tested this prediction in Ruddy Turnstones (*Arenaria interpres*) by presenting foraging turnstones with both irregularly and evenly distributed food resources.

During spring migration along the mid-Atlantic coast, several species of shorebirds forage extensively on buried clumps of horseshoe crab (*Limulus polythemus*) eggs (Wander and Dunne 1981). Ruddy Turnstones were chosen for this study because they were abundant, they were foraging on a single type of prey (horseshoe crab eggs) that could be manipulated, and altercations over food were frequent occurrences (Sullivan, unpubl.).

The spatial pattern of egg deposition, along with the action of the tide and other foraging shorebirds, results in clusters of 10 to 150,000 eggs buried 2 to 25 cm in the sand with little appreciable food between clusters (Sullivan, unpubl.). Turnstones locate patches of these small (0.0035 g) eggs by probing in depressions left from spawning crabs or other foraging turnstones. After finding a cluster of eggs, they excavate the eggs by flinging the sand to the side and enlarging the depression.

Only one turnstone occupies a patch at a time, and patches are often defended by a foraging turnstone when another approaches. Conspecifics generally approach by calling and running toward the patch with head lowered, tail depressed, scapulars raised, and wings dropped (Groves 1978), an apparently aggressive posture. Defense behaviors include calling, facing the intruder in an aggressive posture, pecking and jabbing at the intruder, grabbing the intruder by the wing or bill, and beating and kicking the intruder as the two birds fly into the air. If the patch is not defended, the turnstone walks away from the patch when approached and either walks to another patch or rests at the water's edge.

METHODS

I observed Ruddy Turnstones foraging on beaches along Great Bay Boulevard near Tuckerton, New Jersey, from 17 May to 6 June 1983. Turnstones foraged in restricted areas (<1 to 2.5 m^2) on these beaches. Randomly selected turnstones were observed from blinds for 1 to 15 min. I identified individual turnstones by their unique breast and back coloration (Ferns 1978). Few individuals were seen more than once. At this time of year thousands of turnstones pass through the study area (Wander and Dunne 1981), and observations were conducted at six beaches.

I made artificial patches of eggs by scooping out 120 ml of sand, placing 2 g of eggs in the hole and covering them with 1 to 2 cm of sand. Turnstones could see the depressions, but not whether the depressions contained eggs. The horseshoe crab eggs used in these tests were collected on another beach, rinsed in seawater, weighed, and stored in plastic bags. Previous observations indicated that the size of an egg cluster is an important factor in predicting whether a turnstone will defend a patch. In 1981 turnstones defended patches containing at least 2 g of eggs in 74% of the observed encounters (Sullivan, unpubl.). Therefore I used 2-g patches for these manipulations to ensure that turnstones would defend patches.

I arranged the patches in two patterns, even and irregular. The even distribution had patches arranged in a grid with a patch every 15 cm. The irregular distribution had patches scattered over the foraging area in a pattern approximating that of the natural patches. Between 25 and 80 patches were set out for a trial depending on the size of the foraging area so that there was a constant density of 36 patches/m^2 for each trial.

I used a small portable computer to record arrivals at patches, departures from patches, foraging events, aggression, and travel time between patches. Each event was coded as a letter followed by the time in hr, min, and sec. Data collection began 2 min after the first turnstone began foraging on the beach. I ceased watching a randomly selected individual either when the bird left the beach or when the computer memory was full. I performed a log transformation on patch times, foraging times, and travel times to equalize the variances among groups.

RESULTS

Turnstones foraging at the irregularly distributed patches defended them against conspecifics in 38 of the 80 times (47.5%) they were approached. In 32 cases (84.2%) in which defense occurred, the resident bird retained possession of the patch and in 6 cases (15.8%) the intruder acquired possession of the patch. In contrast, turnstones foraging at the evenly distributed patches did not defend their patches against conspecifics (0 of 16 cases). When approached, these birds simply left their patch and walked to another patch nearby. The probability of defense dif-

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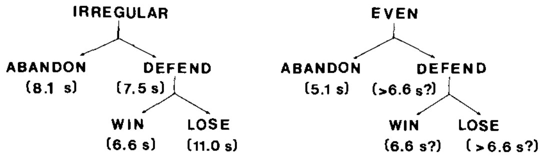

FIGURE 1. The choices available to a turnstone when approached by a conspecific, and the expected consequences in seconds not spent foraging.

fered significantly between the two patch distributions ($\chi^2 = 11.38$, $P < 0.01$).

Although patch density was the same under the two distributions, travel times were significantly longer for birds feeding at the irregularly distributed patches ($\bar{x} = 5.4$ sec, SE = 0.42, $n = 75$) than for birds feeding at the evenly distributed patches ($\bar{x} = 3.2$ sec, SE = 0.89, $n = 52$; Student's t-test, $t = 2.50$, $P < 0.05$). There was no significant difference in the density of foraging turnstones between the two distributions of egg clusters (even: $\bar{x} = 2.8$ birds/m^2; irregular: $\bar{x} = 3.0$ birds/m^2; $t = 0.91$, $P < 0.05$).

When approached by a conspecific, a turnstone must decide whether to abandon the patch or attempt to defend it. Each choice results in a loss of time from foraging (Fig. 1). Where patches were irregularly arranged, turnstones that abandoned their patches lost significantly more foraging time ($\bar{x} = 8.1$ sec, SE = 0.32) than those who successfully defended their patches ($\bar{x} = 6.6$ sec, SE = 0.29) but lost significantly less foraging time than birds who lost their patches to the intruder ($\bar{x} = 11.0$ sec, SE = 0.68; ANOVA $F = 73.35$, df = 3, 92, $P < 0.01$; Duncan's new multiple range test $P < 0.05$). Resident birds retained possession of their patch in 80% of the encounters observed in this manipulation and in other observations at the same study site. Therefore, the expected time spent on activities other than foraging was 7.5 sec (6.6 sec [0.8] + 11.0 sec [0.2]) for birds which chose to defend their patch. Turnstones that defended their patches lost significantly less foraging time regardless of the outcome, than birds that abandoned their patches ($t = 18.02$, $n = 80$, $P < 0.01$).

Where patches were placed in an even distribution, turnstones that abandoned patches spent less time traveling to a new patch ($\bar{x} = 5.1$ sec, SE = 0.51) than turnstones that successfully defended their patch under the irregular distribution (Duncan's new multiple range test $P < 0.05$).

DISCUSSION

My results indicate that the spatial distribution of clusters of horseshoe crab eggs influences Ruddy Turnstones' defense of these patches against conspecifics. As food resources become more evenly distributed, travel times decrease and the expected cost of moving to a new patch decreases relative to the cost of defending a patch. Turnstones are then less likely to defend their food supplies. When the patch distribution was altered from the naturally occurring irregularly spaced patches to a more even or spatially predictable arrangement, the results were dramatic. Within a 2-min sampling period, the turnstones altered their aggressive behavior.

Under the irregular distribution of patches, the expected cost in time of moving to a new patch is greater than the expected cost of defending the patch. Why then did half of the birds abandon their patches? In this analysis I used time rather than energy as the currency. I have no measure of the energetic costs of aggression or traveling between patches. Often defense consists of posturing and calling, behavioral acts which do not appear to use much energy. But some fights escalate to chasing, pecking, and flying which could be more energetically demanding than running to a new patch. Also, turnstones that defend a patch may risk injury during these fights and may increase their vulnerability to predation when they concentrate their attention on the intruding bird.

Since none of the turnstones feeding at the even distribution of patches defended their patches, I have no direct measure of the time spent on defense in this condition. Assuming that it would be equal to the time spent on defense at the irregularly spaced patches, the expected cost in time of moving to a new patch would be less than the cost in time of defending the current patch (Fig. 1).

The difference in travel times between the two prey distributions is small, only about 2 sec. This is statistically significant, but is it biologically significant? Turnstones spent on average only 2.5 sec at unsuccessful patches before moving to a new patch (Sullivan, unpubl.). This short sampling period suggests that turnstones may be making decisions about food resources based on small time intervals.

Prey type and size, patch density, and competitor density were all similar in the two treatments. Therefore, although all of these factors strongly influence aggression, the dramatic differences in aggression in this study appear to be due to the differences in the spatial distribution of prey, rather than to the differences in these other factors.

During migration, turnstones need to acquire energy for the rest of migration in addition to their daily energetic expenditures. The turnstones at my study site appeared to be constrained neither by a shortage of food nor by time to acquire enough food to survive. Horseshoe crab eggs were abundant, and turnstones spent long periods of time resting at the water's edge between foraging bouts.

Turnstones in other habitats without abundant horseshoe crab eggs may face more severe time constraints before and during migration. In England, migrating Ruddy Turnstones do appear to face time constraints. Adult Ruddy Turnstones spend proportionately less time on vigilance and more time on foraging before migration, while juveniles, who will not migrate, maintain relatively high vigilance levels (Metcalfe and Furness 1984). If turnstones in New Jersey are not under time constraints to acquire enough food for migration and survival, why do they appear to alter their behavior to avoid losing a few seconds of foraging time?

To avoid predation, these turnstones may be minimizing the time they are actively foraging on the beach. It is quite likely that turnstones are vulnerable to predation by raptors when they are feeding with their heads in depressions. I rarely saw birds resting on the beach near their foraging sites. Instead, they rested at the water's edge or in the *Spartina* at the edge of the beach. Peregrine Falcons (*Falco peregrinus*) were present at my study site, and turnstones responded to their presence by moving as a flock to the water's edge or flying away. While I never saw a peregrine kill a turnstone, I did see them kill Sanderlings (*Calidris alba*) and Semipalmated Sandpipers (*C. pusilla*).

My results support other observations on aggression among foraging shorebirds and manipulations of prey dispersion in White Wagtails (*Motacilla alba*) by Zahavi (1971). Aggressive interactions occur more frequently over prey with a patchy spatial distribution (corresponding to the irregular distribution used in this study) than over prey with a more even distribution (Recher and Recher 1969, Myers 1984). In particular, Fleischer (1983) showed that aggression increased among Ruddy Turnstones when they switched from foraging on relatively scattered small invertebrates to foraging on crabs with a more patchy spatial distribution.

Horseshoe crab eggs tend to be associated with aggressive encounters in Short-billed Dowitchers (*Limnodromus griseus*) as well as Ruddy Turnstones. Mallory and Schneider (1979) found that flocks of dowitchers foraging on horseshoe crab eggs had more aggressive encounters than similar flocks foraging on other prey items. My results indicate that the spatial distribution of horseshoe crab egg clusters is one factor influencing the amount of aggression observed among shorebirds foraging on this resource. Altering the distribution from the naturally occurring irregularly spaced clusters to evenly spaced clusters dramatically decreased the frequency of aggressive encounters among turnstones.

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CASSIN'S FINCH NESTING IN BIG SAGEBRUSH[1]

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Key words: Cassin's Finch; big sagebrush; nesting; Oregon; shrubsteppe.

Cassin's Finches (*Carpodacus cassinii*) nest primarily in conifers. Several authors (Bent 1968, Samson 1976, Harrison 1984) imply that nesting might occur in nonconiferous species. Ridgway (1877) and Jones and Baylor (1969) cite cases in which Cassin's Finches were found nesting in deciduous trees. In California, Ridgway located nests in quaking aspen (*Populus tremuloides*) and narrow-leaved cottonwood (*P. angustifolia*). In Idaho, Jones and Baylor found nests in black locust (*Robinia pseudo-acacia*), box elder (*Acer negundo*), and cottonwood (*Populus* sp.). We have been unable to locate specific references to Cassin's Finches nesting in shrubs.

While conducting breeding bird censuses in shrubsteppe habitats on Hart Mountain National Antelope Refuge in 1984, we found four Cassin's Finch nests in big sagebrush (*Artemesia tridentata*), one in western juniper (*Juniperus occidentalis*), and one in quaking aspen. All four nests in big sagebrush fledged young (Table 1), the nest in aspen failed, and the outcome of the juniper nest is unknown.

Hart Mountain lies in the Basin and Range province in southcentral Oregon (Hunt 1974). Vegetation is characteristic of the semi-arid high desert and is dominated by big sagebrush, low sagebrush (*A. arbuscula*), and bitterbrush (*Purshia tridentata*). Draws with springs support quaking aspen and willows (*Salix* spp.). Groves of western juniper and mountain mahogany (*Cercocarpus ledifolius*) occur in scattered locations. A 30-ha relict stand of ponderosa pine (*Pinus ponderosa*) is located on the southeast slope of the mountain.

All four nests in big sagebrush were within 350 m of Robinson Camp Spring (11 km south of refuge headquarters) and were 7 km from the relict stand of ponderosa pine. The next closest non-*Juniperus* conifer concentration greater than 30 ha occurs more than 30 km from Hart Mountain. The four sagebrush nests were located 155 m to 1.5 km from each other.

L. R. Mewaldt (pers. comm.) found that Cassin's Finches were common in the relict ponderosa pine stand. He estimated that from 63 to 91 pairs of Cassin's Finches nested in 5.4 ha of the pine stand in 1975 through 1979. From observations of cloacal protuberances and incubation patch development, he calculated that most nesting occurs in late May and early June, three weeks earlier than the dates we found nests in sagebrush in 1984.

The nesting in Big Sagebrush by Cassin's Finches is of particular interest because the potential nesting habitat of the species could be expanded significantly through the utilization of big sagebrush. Additional observations may reveal an even wider choice of nesting substrates for this seldom-studied species.

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