Notes

Post-dispersal Seed Predation in the Temperate Rainforest of Southeast Alaska

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Bermejo, Teresa, Anna Traveset, and Mary F. Willson. 1998. Post-dispersal seed predation in the temperate rainforest of southeast Alaska. Canadian Field-Naturalist 112(3): 510–512.

Post-dispersal predation on seeds of vertebrate-dispersed plants (*Rubus spectabilis*, *Oplopanax horridus*, and *Streptopus amplexifolius*) of the temperate rainforest of southeast Alaska was experimentally examined comparing "clean" seeds with seeds embedded in feces of bears, important dispersers in the area, and comparing also different microhabitats where seeds may be dropped or defecated. It was found that seed removal was significantly higher for clean seeds than for seeds within bear feces, and that levels of seed predation were similar for seeds under plants of the same species and for seeds under plants of other species. These results indicate that seed predators (presumably mostly rodents) use neither fecal material nor the presence of a conspecific plant as a clue to the location of seeds.

Key Words: Southeast Alaska, seed predation, seed dispersal, rainforest, bears, rodents.

The seeds of many species of plants with fleshy fruits are dispersed by vertebrates, commonly by passing through the digestive tract and being deposited on the ground in feces. Presence of fecal material may provide fertilizer for the seedlings, but large deposits of seeds may also attract seed predators (e.g., Janzen 1982, 1986; Willson 1989). Furthermore, proximity to a conspecific plant or density of dispersed seeds often increases the risk of predation (e.g., Janzen 1971; Willson and Whelan 1990; Schupp 1988a,b; Traveset 1990; Hulme 1994). We experimentally examined the effect of conspecific plants and bear feces on the risk of predation to seeds of three species of fleshy-fruited plants (Salmonberry, *Rubus spectabilis* [Rosaceae]; Devil's Club, *Oplopanax horridus* [Araliaceae]; and Clasping Twisted-stalk, *Streptopus amplexifolius* [Liliaceae]) which are relatively common in the temperate rainforests of southeast Alaska (Pojar and MacKinnon 1994). The main seed dispersers of these plants in this area are both bears and birds (Traveset and Willson 1997).

Methods

Field work took place within the area of Juneau, Alaska, during July and August of 1994 in four localities, separated by at least 6 km apart. Three of the sites [2-Mile (2M), Herbert River (HR), and Thane Road (TR)] are located within large expanses of mature temperate rainforest of Western Hemlock (*Tsuga heterophylla*) and Sitka Spruce (*Picea sitchensis*). The other site, Sheep Creek valley(SC), supports mostly deciduous vegetation, including Salmonberry (*Rubus*), Elderberry (*Sambucus*), High-bush Cranberry (*Viburnum*), Sitka Alder (*Alnus*), and Black Cottonwood (*Populus*).

Seeds of the three study species were gathered from fruits collected from several different individuals. Groups of 50 seeds of each species were used in the two treatments: (1) "cleaned" seeds, which were placed in 5 cm aluminum dishes, perforated to drain rain water away and (2) seeds embedded in what we called "pseudofeces", hand-made balls made with dung of Brown Bears (*Ursus arctos*). This dung was collected on Chichagof Island (Alexander Archipelago), was fresh when employed and contained vegetal material but no seeds. Both aluminum dishes and pseudofeces were separately placed on thin 15 × 15 cm wooden trays to avoid losing them in the forest.

In each locality, the experimental presentations were laid out on a transect parallel to an existing trail. Five plots, each separated by 75 m, were chosen along the transect. In each plot, we located three plants of each study species, separated by a distance of at least 3 m. Under each plant we placed a tray with seeds in an aluminum dish and a tray with seed-bearing feces. One plant of each species received trays with the same species of seed, and

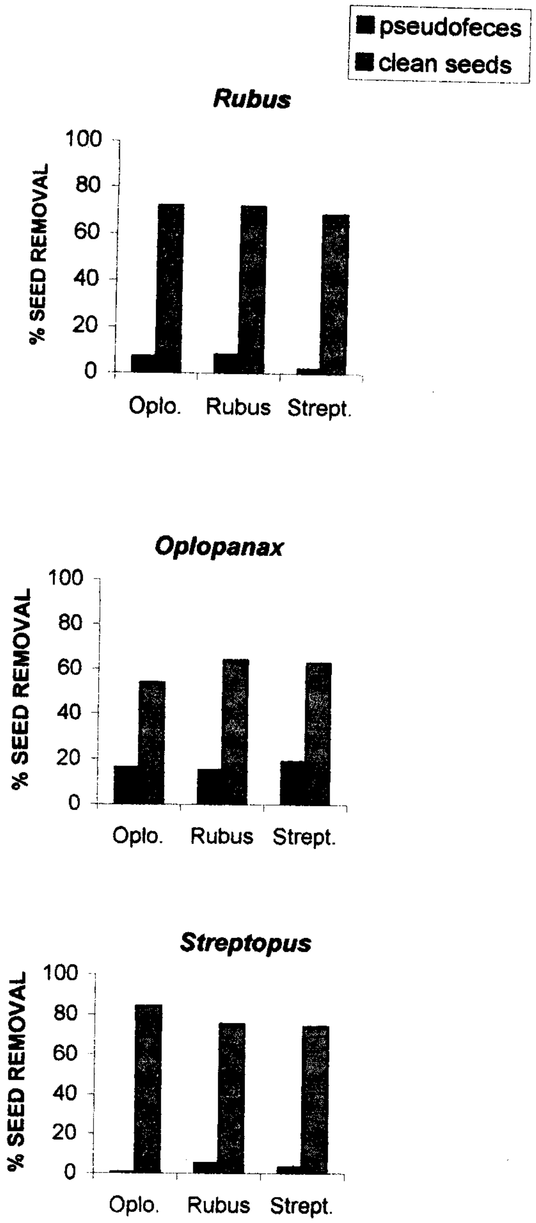

FIGURE 1. Mean percentage of seed removal, for each of the three species, observed in each treatment (clean seeds vs. seeds in pseudofeces) and in each microsite (under *Oplopanax*, *Rubus*, or *Streptopus* plants) during the fruiting season of 1994.

the other two received trays with the other species of seed. After 4-5 days, seed removal was checked in each plot (recording also the number of broken seeds present), and the experiment was repeated at the next set of consecutive plots along the transect, for a total of three trials per site. A total of 15 plots (replicates) were chosen in three localities (2M, TR and SC) whereas only 10 plots (two replicates) could be used in the other locality (HR). Experiments lasted about three weeks, from 18 July through 9 August.

Because in Sheep Creek we could not locate enough *Streptopus* individuals in each plot, we decided to use the closest area (TR) where this species is abundant to place the trays in order to have an orthogonal experimental design. Considering all areas together, a total of 120 trays, half with clean seeds and half with pseudofeces, were placed for each species.

Data were analysed by a fully crossed ANOVA with three fixed effects: species, microsite (plant species underneath which seeds were placed) and treatment (clean seeds and pseudofeces). Data from all sites were pooled after knowing that no differences existed among them. The proportion of seeds removed from each tray was the dependent variable, which was normalized with the angular transformation before doing the analyses. SYSTAT for Windows (1992) was the statistical package used for all analyses.

Results

Seeds were removed significantly more often from the dishes than from the pseudofeces (Table 1), and this was evident in all three species of seed (Figure 1). The effect of clean seeds was stronger for *Streptopus* than for the two other species (Figure 1; significant interaction term for species × treatment [Table 1]). Neither species nor microsite had a significant effect on overall seed removal (Table 1).

Seed coat fragments of the study species were often found on the trays. Such fragments were those typically left by rodents after these eat the endosperm. Red Squirrels (*Tamiasciurus hudsonicus*), several species of voles (*Microtus spp.*) and Deer Mouse (*Peromyscus maniculatus*) are com-

TABLE 1. ANOVA results of percentage of seed removal for the effect of species (*Rubus*, *Oplopanax*, and *Streptopus*), treatment ("cleaned" seeds, seeds in pseudofeces) and microsite (underneath plants of the three study species) after 4-5 days of placement. Data were arcsine-square root transformed. *** P=0.0001

Source of Variation	df	MS	F
Species	2	0.24	1.41
Treatment	1	154.27	882.87 ***
Microsite	2	0.02	0.14
Species × Treatment	2	3.93	22.52 ***
Species × Microsite	4	0.11	0.60
Treatment × Microsite	2	0.03	0.16
Species × Treatment × Microsite	4	0.15	0.87

mon in the area, and we strongly believe these animals were mainly responsible for the seed predation observed. Seed-eating birds such as Dark-eyed Juncos (*Junco hyemalis*) have sometimes been observed picking seeds from bear dung, and it might well be that they have contributed to some of the seed removal. No ants exist in the area, so they certainly cannot be responsible for any seed removal.

Discussion

Rodents commonly use olfaction in food detection (Hulme 1993), and it has been hypothesized that feces might act as an olfactory cue to the presence of numerous seeds. However, we found that clean seeds were removed significantly more often than seeds inside bear feces. One possible explanation for these results is that rodents search in bear feces when they do not find clean seeds in the area. Actually, in all cases where seeds were removed from pseudofeces, the majority of clean seeds had also been removed.

High concentrations of clean seeds on the forest ground are infrequent. Fruits dropped by the plant are rapidly detected by animals and eaten, whereas "almost clean" seeds that have been defecated or regurgitated by birds are regularly found scattered in an area. Future research is warranted in comparing the probability of survival of seeds from bear dung to that of seeds from the rapidly decomposing feces of fruit-eating birds, which typically contain few seeds.

Bears commonly deposit hundreds and thousands of seeds of each of the study species in a single defecation and, thus, are potentially important dispersers for these plants. However, the rich seed deposits are subject to potentially high risks of predation. On Chichagof Island, we have observed bear feces scattered by the seed-foraging of rodents, sometimes to a distance of over a meter from the original deposit, and with most seeds removed. These risks of predation most likely vary greatly with the dramatic fluctuations of rodent populations, and many dung deposits in the field are actually not depredated (MFW, personal observation).

The lack of association between microsite and seed predation suggests either that rodents are not more likely to consume seeds that are near a conspecific plant or that rodents were so ubiquitous that any kind of selection was masked.

Acknowledgments

We thank B. Cannon and M. Cannon for their valuable assistance in the field. We are also grateful to Philip Hulme and to three anonymous reviewers for their comments on a previous version of the manuscript.

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Received 24 April 1997
Accepted 23 December 1997