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Effect of Seed Damage on Germination in the Common Vetch (Vicia sativa L.)

Abstract.—Larvae of the tortricid moths *Cydia lunulana* and *C. nigricana* feed inside developing pods of *Vicia* spp. (Fabaceae: Papilionoideae) in North Yorkshire, England. In the common vetch *Vicia sativa,* larvae commonly consume or at least damage every single seed in the pod in which they develop. Seeds that are completely consumed cannot perpetuate the vetch species, but what about partially damaged seeds? Naturally damaged seeds were obtained from field-collected pods, and sorted into five categories: (1) no damage, (2) <10% damage (volume missing), (3) 10–25% damage, (4) 25–50% damage, and (5) 50–75% damage. Seeds were soaked and planted individually to monitor germination. While scarification of the seed coat of perfect seeds is beneficial to imbibition and germination, the percent of germination decreased with each successive damage category. That a substantial proportion of damaged seeds do germinate suggests that seed damage is not always a death sentence; but growing conditions in North Yorkshire are likely to favor the survival of seeds with seed coat intact to prevent germination in the autumn rains and plant death (before reproduction) in the winter frost.

Introduction

Seed predation takes different forms in plant/herbivore systems (Janzen, 1971). Large seed eaters, like parrots, may consume and kill entire seeds by eating many of them at a time; specialist insects, like bruchid weevils, complete their development by burrowing into and eating the vital parts of a single seed, each damaged seed yielding one adult weevil. Many insects, such as some tortricid moths, whose larvae develop by feeding on seeds inside developing fruit, devour some of the seeds, but only partially damage others (Koptur and Lawton, 1988).

Just how much damage a seed can sustain and still yield a viable seedling has not been the subject of many investigations (Janzen, 1976). If the embryo is not killed, many seeds can germinate and develop normally (Sonesson, 1994), though perhaps with fewer initial reserves. With reduced initial reserves, the seedling may be a poorer competitor than its better provisioned counterparts.

Many temperate herbs in the legume family have seeds that dry out and/or become physically dormant (Baskin and Baskin, 1989), and have a seed coat that is impermeable to water unless some force compromises the integrity of the seed coat (freezing, cracking, abrading, fire, etc.). For such species, a bite from a seed predator during the seed's development thwarts this seed coat integrity, and will render this physical seed dormancy nonfunctional even though the seed may be functional in all other ways. Baskin and Baskin (1989) argued that scarification by microbes, insects or physical factors is relatively unimportant in germination of legume seeds because many legumes have evolved a specific anatomical region of the seed coat that becomes permeable to water in response to certain temperature regimes. Such responses to temperature are adaptive mechanisms to permit seeds to respond to seasons, or to microclimatic changes such as gaps in the forest canopy. I have observed, however, that scarification by seed predators also takes place, and can compromise the adaptive response of seeds to the prevailing climate. This study addresses the effects of biotic scarification and seed damage.

Defoliation of the common vetch, *Vicia sativa,* significantly reduces the number of fruit and seeds, as well as total seed mass and individual seed mass (Koptur *et al.,* 1996). *Vicia sativa* enjoys some protection against surface-feeding herbivores from ants visiting its stipular nectaries in both alien (Koptur, 1979) and native (Koptur and Lawton, 1988) habitats. But the extrafloral nectaries also enhance predation by internally feeding pod predators by protecting these herbivores against their natural enemies in areas where both ants and these herbivores are abundant; the resulting damage to seeds is substantial (Koptur and Lawton, 1988).

In north Yorkshire, many developing seeds are wholly or partially consumed in the pods by internally feeding larvae of tortricid moths in the genus *Cydia.* Most are attacked by *Cydia dorsana* (Fab.) [= *Cydia lunulana* (D. & S.)]; late initiating pods are infrequently attacked by *Cydia nigricana* (Fab.), an agricultural pest known as the 'pea moth.' A third species of *Cydia* was found in some pods, but no adults were reared for identification. No other pod-feeding herbivores (seed predators) were found in our

TABLE 1.—Germination of *Vicia sativa* seeds that had experienced different amounts of natural damage, and days to germination (mean and standard error) for seeds that germinated in different damage categories. Means with different superscripts are significantly different (Tukey P < 0.05)

Damage category	Number germinated		Days to germination		
	Germinated	Not	Mean	SE	n
0%	79	20	13.4^{a}	0.9	79
<10%	54	46	9.2^{b}	1.1	54
10–25%	45	55	8.9^{b}	1.2	44
25–50%	23	76	10.1^{ab}	1.7	24
50–75%	10	90	10.6^{ab}	2.6	10
Total	211	287			

Yorkshire study sites (Koptur and Lawton, 1988), though weevil larvae are known to utilize this resource in more southerly parts of England (D. Jones, pers. comm.).

Consumption of seeds by specialists, especially insects, is usually totally destructive (Louda, 1989). It is obvious that seeds that are completely consumed by moth larvae will not produce seedlings, but what of the partially consumed seeds? How much damage can a seed sustain and still produce a seedling?

MATERIALS AND METHODS

Seeds were saved from pods collected in July and August 1984 from plants monitored in York in a study of natural damage to vegetative and reproductive parts of vetch plants at different sites (Koptur and Lawton, 1988). Seeds were put in paper envelopes, dried at room temperature, and kept until November 1985. In Miami, Florida, a subsample was visually inspected and sorted into 100 seeds each of the following damage categories: (1) no damage; (2) <10% damaged (volume of seed missing); (3) 10–25% damage; (4) 25–50% damage, and (5) 50–75% damage. The coats of the undamaged seeds were nicked with a razor blade (all others had broken seed coats by virtue of being damaged). I did not include a control group of undamaged seeds (not scarified) because the time to germination would have been substantially delayed compared with all the damage groups, and not informative. Seeds were soaked in water overnight, and then planted individually in labeled spaces in vermiculite-filled trays, which were watered lightly and evenly every day to maintain soil moisture, and kept in a greenhouse environment. Seeds were monitored daily for 28 days, at which time the experiment was terminated.

The number of seeds from each damage category that germinated and grew into seedlings was compared using contingency table analysis in the tables procedure of SYSTAT. The days-to-germination for all seeds that germinated was compared among damage categories with analysis of variance (ANOVA) in SYSTAT, with a Tukey posthoc test of difference between means.

RESULTS

Level of damage had a significant effect on probability of germination (Pearson chi-square = 120.38, df = 4, P < 0.0001), with the proportion of seeds germinating decreasing with level of damage (Table 1).

There was a significant effect of damage category on days-to-germination (F = 3.11, df = 4, P = 0.016). Seeds with smaller amounts of natural damage (groups 2 and 3, <10% and 10–25%) germinated significantly more quickly than did undamaged seeds (Tukey P < 0.05), but there were no other distinctions among the damage groups (Table 1).

DISCUSSION

A large proportion of common vetch seeds germinate and grow even after sustaining substantial damage. While the proportion of seeds germinating decreases significantly with damage level, even 10% (the proportion of the most heavily damaged seeds germinating) of a large seed crop can be a substantial number of seedlings. Damage from seed-feeding larvae does not always kill the embryo, if the embryo itself is not eaten. Although no field observations were made on seedlings from this experiment, observations on seedlings (of unknown seed damage history) shows that survival is independent of extrafloral nectaries and ant protection, depending rather on whether or not they are encountered by snail or vole seedling predators (Koptur, pers. observ.).

Without scarification, it is difficult to germinate seeds of *Vicia sativa* from North Yorkshire populations. This suggests some advantage to a seed being slightly eaten: that seed will more easily be able to imbibe water necessary to germinate. Benefits associated with dispersers of some plants include scarification of surviving seeds (Louda, 1989). The fact that undamaged seeds that were nicked before soaking and planting in this experiment germinated a bit more slowly than seeds with lower levels of natural damage suggests that the latter had greater imbibition through the larger open areas in the seed coats. If some biochemical difference provided speedier germination as a result of damage, I might have seen the same difference in seeds that experienced higher levels of damage, but this was not the case.

But does the apparent advantage of a small amount of damage improve survival to maturity in the natural environment of the common vetch? Overwintering in a N temperate climate, freezing temperatures and harsh weather may alter seed coat characteristics, and this can provide seasonal control to the pattern of vetch seed germination. I have observed flushes of seedlings appearing in late September and October, after the autumn rains, and have surmised that these seedlings are the products of damaged seeds. Very few, if any, of these plants will survive the winter's freezing temperatures and harsh conditions to produce seeds; so while a certain amount of damage does not necessarily kill a seed, it induces untimely germination which very likely results in its death. Field observations on marked seedlings reveal that most healthy plants that live to reproductive maturity in the field come from seeds germinating in the spring months (March–April) (Koptur, pers. observ.).

In *Vicia sativa,* partial predation of some seeds has a decided phenological effect, resulting in premature germination and death of damaged seeds and decreased input into the seed bank as a result of predispersal seed predation. Consumers throughout the life cycle of a plant affect seed dynamics (Louda, 1989); defoliation reduces seed production (number and weight) in *V. sativa,* and seed predators either consume seeds entirely or kill them by eating the embryo or indirectly by causing them to germinate out of season. The environment determines variation in the impact of predation (Louda, 1989), and certainly the climatic regime in which this species can occur may alter the impact of seed predators. In a similar climate that does not freeze in the winter, autumn-germinating seeds may be able to survive and reproduce. But in North Yorkshire, partial damage to vetch seeds will result in zero fitness under normal field conditions.

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