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Millipede Damage to Germinating Acorns of Northern Red Oak

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Abstract

Millipedes have not been reported as pests of germinating acorns. Studies in Pennsylvania on the impact of insects on northern red oak (*Quercus rubra* L.) seedling establishment revealed that the millipede *Ptyoiulus impressus* (Say) damaged the radicles of germinating acorns. Up to 17 percent of the acorn radicles in areas with heavy acorn crops were damaged in 1991. Millipede feeding began in late March to early April, several days prior to feeding activity of insects that damage or destroy germinating acorns.

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Introduction

Since 1989, studies have been conducted in central Pennsylvania on the impact of insects in limiting northern red oak (*Quercus rubra* L.) seedling establishment. Three species of insects have been identified as the major destroyers of germinating red oak acorns: a weevil, *Conotrachelus posticatus* Boheman, a sap beetle, *Stelidota octomaculata* (Say), and a moth, *Valentinia glandulella* (Riley) (Galford et al. 1991). However, a new type of damage to the radicles of germinating red oak acorns was noted in Pennsylvania in late March and early April of 1990. The chewing damage on some of the radicles was unlike that caused by the insects mentioned, and only 50 percent of the acorns with radicle damage contained insect larvae. Preliminary investigations indicated that millipedes might be responsible for the damage. Although some species of millipedes have been reported as pests of plants, none has been reported feeding on germinating acorns (Richard Hoffman, Va. Mus. Nat. Hist., 1992, pers. commun.). Winston (1956) and Galford (1988) did not report the millipede as an arthropod affecting red oak acorns in Illinois and Ohio. However, an undetermined species of millipede occasionally was observed feeding on germinating white oak (*Q. alba* L.) and red oak acorns in central and southern Ohio (Galford, unpublished). It is not known whether millipede feeding on acorns in the Ohio studies occurred before or after damage to the acorns from other agents.

The species of millipede suspected of damaging germinating acorns in Pennsylvania was identified as *Ptyoiulus impressus* (Say) (Family: Parajulidae). A preliminary study demonstrated that it feeds on the radicles of germinating red oak acorns. Field and laboratory studies were conducted in 1991 to learn more about *P. impressus* as a pest of germinating acorns. This paper reports the results of those studies.

Methods

Field Studies

Observations of acorn samples collected in late March and April of 1990 indicated that arthropod damage to germinating acorns began soon after the radicles began to elongate and were still very small. Many of the 1990 acorns already had been damaged by more than one species of arthropod. To determine when arthropod feeding damage began and which species initiated damage, we began collecting acorns in 1991 in late winter soon after the acorns began to swell and open but before actual germination (radicle growth).

In 1991, samples of northern red oak acorns were collected in the Moshannon State Forest in Clearfield County in central Pennsylvania and in Warren County at the northwestern edge of the Allegheny National Forest. Acorns were collected from February 27 until April 22 on four sites in the two counties. As many as 100 acorns were collected at each site at 6- to 14-day intervals

depending on snow cover, radicle development, and arthropod activity. Germinating acorns or acorns that had opened for germination were collected randomly at each site; about equal numbers of acorns with or without leaf cover were collected. In the laboratory, the acorn samples were examined individually for damage under a binocular microscope. When possible, a determination of the arthropod species causing the damage was made. After examination, the acorns from a sample site were placed in a loosely covered jar to rear out any insects in them. Records were kept for 4 to 5 weeks of any insects that emerged from these acorns. The acorns were then removed from the jar and cut open with pruning shears. Any insect larvae inside the acorns were counted and the condition of acorn cotyledons recorded.

In late October 1991, 100 germinating chestnut oak (*Q. prinus* L.) acorns were collected randomly from under a tree with a heavy crop of acorns in a forest in Warren County. In the laboratory, each acorn radicle was examined for insect and/or millipede feeding damage. The acorns were placed in a jar for 3 weeks to rear out any insects. Then each acorn was cut open to determine the extent of internal damage.

Laboratory Studies

Northern red oak acorns used in the laboratory studies were collected in the autumn of 1990 and stored at 5° to 7°C in dry sand or peat moss in sealed plastic bags. Several small holes 2 to 3 mm in diameter were punched in the bags for aeration. Several days before use, the acorns were removed from the bags and soaked for 20 minutes in distilled water. Floating acorns were discarded. The acorns were then placed on moist paper towels in a lightly sealed container at room temperature to promote germination. Germination usually occurred within 3 weeks.

Acorns of white oak and chestnut oak were collected in late October 1991 and stored in dry sand in sealed plastic bags. Because it is difficult to store white and chestnut oak acorns for more than 1 or 2 months without the acorns either germinating or desiccating, tests of acorns of these species were conducted soon after they were collected. Viable acorns of white and chestnut oak germinated within 7 days when placed on moist paper towels at room temperature.

Adults of *P. impressus* were collected in Clearfield and Warren Counties in late September and October of 1991 using pitfall traps baited with red oak acorns cut into halves (Galford 1991). Some millipedes also were collected by searching under leaf litter.

In the laboratory, the millipedes were kept in glass culture dishes (100 by 80 mm) about one-third filled with a mixture of equal parts of moist peat moss, sand, and perlite. Two or three dead oak leaves were laid on top of the medium for the millipedes to hide under but no other potential food source was provided during acorn feeding tests. The contents of the jars were misted periodically with distilled water. No more than one pair (male plus

female) of millipedes was kept in each dish to prevent possible cannibalism and/or asphyxiation caused by secretions from the repugnatorial glands. *P. impressus* are easily sexed; the legs of the male on the seventh body ring are modified into sex organs (gonopods) and the first pair of legs are greatly enlarged. By contrast, females have legs on the seventh body ring and the first pair of legs are not enlarged.

Acorn feeding tests were conducted as follows: one germinating red oak acorn (radicle 2 to 10 mm long) was introduced into each of seven culture dishes containing a pair of millipedes. After 72 hours, the acorns were removed and inspected for feeding damage. Three replicates using only red oak acorns were conducted. In another feeding test involving choice, three germinating acorns (one each of red, white, and chestnut oak) were placed in each of seven culture dishes and exposed to the millipedes for 24, 48, 72, or 120 hours. The 120-hour test was conducted first. At the end of each test period, the acorns were removed and inspected for damage and new, undamaged acorns were placed in culture dishes for the next test period. The millipedes were not starved between test periods. All tests were conducted at 18° to 25°C under a 10/14 hour light/dark cycle under normal fluorescent laboratory lighting.

Results and Discussion

Field Study Results

Table 1 gives the results of the study of millipede damage

to germinating acorns in 1991 in Warren and Clearfield Counties. In both counties, millipede damage to acorn radicles began March 20 to 27. Damage increased weekly until April 22 when the last sample was collected (Fig. 1). Sampling was discontinued in late April when most of the acorn radicles had been damaged by more than one species of arthropod and it became impossible to determine which species initiated the primary damage. Once damaged, acorns become more attractive to some species of insects (Galford and Weiss-Cottrill 1991). It is common for two or more species to attack the same acorn simultaneously, and millipede-damaged acorns may be attacked by insects within a few days or even hours.

The single sampling of germinating chestnut oak acorns collected in October 1991 revealed that millipedes also damage acorn radicles in autumn (Table 1). Most of the radicles damaged by an undetermined species or species may have been damaged by millipedes because no *Conotrachelus* weevils were reared from the acorns. Also, several millipedes were found under the leaf litter when the acorn sample was collected. Most insect damage in the sample was light and caused by the 1st and 2nd instars of the moth *V. glandulella* (Galford 1986).

Laboratory Study Results

In the study in which only red oak acorns were offered to millipedes for feeding, the radicles of 18 of 21 acorns were fed upon to some extent. These studies revealed that feeding damage by *P. impressus* on the radicles of

Table 1.—Arthropod damage to germinating acorns in Warren and Clearfield Counties, Pennsylvania, in 1991

Sampling date	Acorns in Sample		Acorn radicles in sample damaged by:		
	Warren	Clearfield	Millipedes	Insects ^a	Undetermined ^b
-----Number-----					
2/27	25		0	0	0
2/27		25	0	0	0
3/3	25		0	0	0
3/3		25	0	0	0
3/20	25		0	1	0
3/20		25	0	0	0
3/26	25		2	0	0
3/27		25	3	0	0
4/8	50		7	8	0
4/9		50	8	18	0
4/15		100	17	29	11
4/22		100	16	26	41
10/30	100 ^c		15	22	60

^aPrimarily damage from adults of the weevil *Conotrachelus posticatus* and larvae of the moth *Valentinia glandulella*.

^bArthropod species initiating primary damage not known (multiple species involved).

^cChestnut oak acorns (earlier samples were acorns of northern red oak).

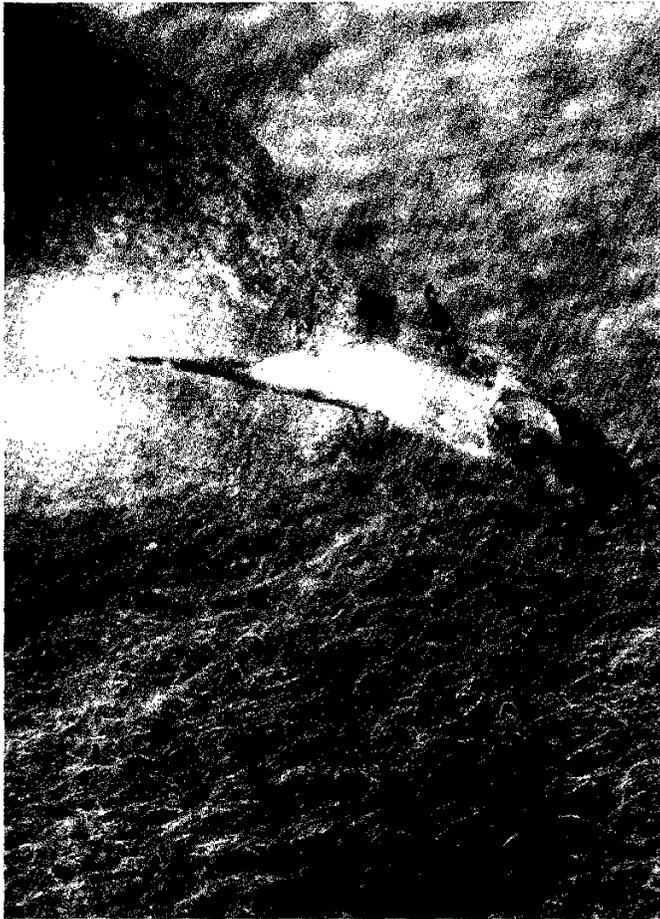


Figure 1.—Acorn radicle damaged by millipede feeding.

germinating acorns varied with the length of the radicles at the time when acorns were first exposed to millipedes. When the radicle was only 2 to 5 mm long and just emerging from the acorn, only the radicle tip was consumed. The millipedes rarely fed for a short distance into the acorn. If the acorn radicle was large in diameter, the millipede might eat the tip and then feed for a short

distance inside the radicle, hollowing it out. Damage to radicles longer than 5 mm occurred anywhere on the radicle but usually on the side. This damage ranged from a shallow-round hole chewed into the radicle to a deep hole extending nearly through it. Longitudinal feeding along the length of a radicle resulted in a short, shallow groove or a deep groove several millimeters long. The most common damage observed in the forest was radicle tips eaten just as they emerged from the acorn. Another type of radicle damage observed in the forest was small round holes chewed by immature millipedes; however, only adult millipedes were used in the laboratory studies. The weevil *C. posticatus* also eats holes in acorn radicles but these usually are smaller in diameter, more cylindrical, and deeper than those caused by immature millipedes. But damage from both arthropods is variable and can be confused.

In the laboratory, millipedes sometimes burrowed into the potting medium and fed on the tender, white roots of acorns that had rooted. However, the feeding damage was not extensive. Root damage in the field also has been observed, especially where acorns root in deep leaf litter, but it has not been established that millipedes caused the damage. Larvae of two species of noctuid moths, *Polia detracta* (Wlk.) and *Anorthodes tarda* (Gn.), can cause similar damage to roots (Galford et al., unpublished).

P. impressus preferred red oak acorns but fed on white and chestnut acorns (Table 2). The first choice test, conducted for 120 hours, did not reveal a clear preference for red oak. However, 24-, 48-, and 72-hour tests with the same millipedes used in the 120-hour test revealed a preference for red oak acorns. Thus, after the millipedes had a 5-day period to become conditioned to the three kinds of acorns, red oak acorns were preferred in subsequent choice tests.

In a given year in a particular location or site, the actual impact of *P. impressus* on red oak seedling establishment would be difficult to ascertain unless the same acorns were inspected daily in the forest beginning with the first sign of millipede feeding on acorns. In one sample collected in 1991, 17 percent of the acorn damage was attributed to

Table 2.—Number of radicles of germinating acorns damaged by millipedes, by test sequence/duration and acorn type^a

Acorn type	Acorn radicles damaged				Total
	120-hr	24-hr	48-hr	72-hr	
White	5	1	0	1	7 of 28
Red	7	4	4	5	20 of 28
Chestnut	5	2	1	2	10 of 28

^aOne germinating acorn each of white, red, and chestnut oak placed in each of seven culture dishes containing a pair of millipedes.

millipedes. Yet, the actual percentage probably was higher. Millipede activity begins just days before insect activity and, as mentioned earlier, once both kinds of arthropods are actively feeding on the same acorn, it is difficult to differentiate damage and determine which species was the primary attacker. However, it is clear that *P. impressus* by itself and in conjunction with insects adversely affects oak seedling establishment in Pennsylvania in some areas in some years. The impact of millipedes no doubt varies considerably due to site, climatic conditions, acorn crops, and other variables such as insect and rodent populations. Under ideal conditions, many, if not most, of the acorns damaged by *P. impressus* can resprout and root. But, under natural forest conditions, most of the damaged acorns succumb to desiccation, rodents, or insects.

Research on oak regeneration in Pennsylvania has revealed that red oak seedling establishment is adversely affected on some sites in some locations largely due to

destruction of the germinating acorns by a complex of arthropods including *P. impressus*. The 1991 acorn samples were collected in areas that had heavy crops of acorns in 1990. Thousands of acorns per hectare survived predation from rodents, bear, deer, and other animals to germinate in the spring. Thus, the impact of arthropod damage observed in spring of 1991, though significant, was diluted by the heavy acorn crop.

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Keywords: Diplopoda; Parajulidae; *Ptyoiulus impressus*; acorn pest; oak regeneration

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