NOTE

A Comparison of Trap Versus Ground Collection of Acorns to Assess Insect Infestation1

Roger W. Perry and Alex Mangini[2]

USDA Forest Service
Southern Research Station
Hot Springs, AR 71902 U.S.4

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Oak (*Quercus* spp.) species are a significant portion of the forest in the eastern United States. Oaks provide valuable timber products and habitat for many wildlife species. Acorns are essential for oak regeneration and are a major food source for more than 186 species of birds and mammals (Van Dersal, 1940, J. Wildl. Manage. 38: 129-132). Great variation in annual acorn production causes dramatic fluctuations in seed availability for food and oak regeneration (Sharp, 1958. Penn State Univ. Agric. Exp. Sta. Bull. 635; Christisen and Kearby, 1984, Missouri Dept. Conserv. Terrestrial Series 13). Although total annual production may have the greatest effect on acorn abundance, availability can be dramatically reduced by insects. During years of high production, insect losses are usually low in proportion to abundance; however, insects can destroy most acorns during years of low production (Christisen, 1955, J. For. 53: 439-441). Loss of acorns to insects can vary from as low as 6% (Goodrum et al., 1971, J. Wildl. Manage. 35: 520-532) to more than 80% (Christisen, 1955, J. For. 53: 439-441). Thus, studies seeking information on oak regeneration and studies involving wildlife food availability may be biased when insect predation is not considered.

Many types of insects and fungus invade and damage acorns. The most important and numerous of these infesting insects are weevils of the genus *Curculio*. Other insects, including the filbertworm (*Cydia latiferreana* Walsingham), the acorn worm (*Valentinia glandulella* Riley), and cynipid

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[2] USDA Forest Service. Forest Health Protection. Pineville, LA 71360

gall wasps can cause major damage to acorn crops (Kearby et al., 1986, Missouri. Dept. Conserv. Terrestrial Series 16). The life cycles of these insect groups are similar; eggs are deposited in mature or immature acorns in the tree and the acorns are partially or completely consumed by the larvae.

To provide information on acorn abundance and loss to insects, most studies have used acorns collected from traps. Many types of traps have been designed to catch acorns falling from trees (Thompson and McGinnes, 1963, J. For. 61: 129-132). However, traps are costly to build and maintain, require many hours to install, and provide limited sampling areas and high variance. Collecting acorns from the ground is a quick and inexpensive method of obtaining large samples of acorns. Given the high costs associated with trapping acorns, we tested whether insect infestation level differed according to collection method to determine whether collecting acorns from the ground is a viable alternative to trapping.

Four late-rotation mixed pine-hardwood stands were selected for the study. A natural forest stand (unharvested) and a partially-harvested forest stand were selected in both the northern and southern regions of the Ouachita Mountains (Ozark and Ouachita National Forests), AR. Natural stands were approximately 80 years old, were previously unmanaged, and occupied about 15 ha on predominately southern aspects with slopes of 5 to 20%. Partially-harvested stands were similar in size, age, and aspect to natural stands but had some trees removed in 1993 using a pine-hardwood single tree selection method with overstory residual hardwood basal areas ranging from 2.8 to 5.1 m^2/ha (12 to 22 ft^2/acre) and total overstory basal areas ranging from 15.4 to 16.1 m^2/ha (67 to 70 ft^2/acre).

Twenty-five acorn traps were placed in each area between 9 September and 21 September in 1993 and between 10 August and 24 August in 1994. Traps were metal trash cans with 0.315 m diam openings covered with chicken-wire (2.6 cm X 3.7 cm hexagonal mesh) to prevent birds and mammals from removing acorns. One trap was placed under 25 individual seed-bearing white oaks (*Quercus alba* L.) in each area. If 25 seed-bearing oaks could not be located, multiple traps were placed under a single tree. Traps were placed under trees halfway between the trunk and canopy edge, at random azimuths around the trunk. For ground collecting, acorns were removed from plots with a l-m radius encircling each acorn trap. The l-m radius ground plots were centered on the acorn trap center with the area of the trap not included (total plot size $\approx$ 3.06 m^2). Acorns were removed from traps and ground plots every 14 days from the time traps were in place until all acorns had fallen from trees (late November). Mature acorns were cut open to determine acorn soundness (lack of insect or microorganism damage) and to determine which, if any, insect groups were represented. If individuals of several species were present, the acorn was categorized by the most prominent infesting species.

Data from all four stands and both sample years were combined because our purpose was to determine effects resulting from collection method only. An analysis was designed to detect significant differences in acorn predation between collection methods. Aborted, immature, and wildlife-damaged acorns were removed from the samples and the percentage of acorns infected by insects or damaged by disease was determined for each trap and its corresponding ground plot. The difference in acorn density (acorns/m") between acorn traps and ground plots was tested using a Wilcoxon matched-pairs sign rank test (SAS Institute Inc., 1988, SAS/STAT User's Guide, Cary, NC). Because the traps we used sampled a relatively small area, some acorn traps did not catch any acorns. Data from these traps were included in the estimates *of* acorn density but were excluded in the insect infestation comparisons. Insect infestation levei data could not be normalized by transformation, thus, differences in predation rate by damaging groups were tested using Wilcoxon matched-pairs sign-rank tests.

Fifty-seven trap and corresponding ground plot samples were compared. Numbers of acorns collected in traps were much lower than numbers collected from ground plots because of the smaller areas that traps sampled. The total number of acorns collected in traps in 1993 and 1994 combined was 759, with a mean number per sample (± SE) of 4.1 ± 0.5 (n = 184 samples). The total number of acorns collected from ground plots was 13,373, with a mean number per sample (± SE) of 72.7 ± 6.9 in = 184 samples). Acorn density in traps (48.1 ± 5.4 acorns/m2) was greater (S = 4742, P = 0.00011 than acorn density on ground plots (22.2 ± 2.1 acorns/m^2). Wildlife removing acorns from ground plots was the probable cause of these density differences. Wildlife had access to ground plots but not to traps which were protected by mesh tops.

Although acorn soundness (undamaged acorns) appeared to be much higher in trap samples. this difference was not significant. Differences in estimated infestation level by damaging groups were evident and differences were found in 5 of the 7 insect groups (Table 1). Weevils of the genus *Conotrachelus* were found in ground samples but not in trap samples. This difference may have been due to the rarity of these insects which were only represented when very large numbers of acorns were collected, as in the ground samples. Acorn worm larvae were more abundant in ground samples and filbertworm larvae were over 3 times as abundant in ground samples. Weevils of the genus *Curculio* and dipteran larvae were more abundant in trap samples.

The difference in acorn density between traps and ground plots suggested animals were removing substantial numbers of acorns from ground plots, and this removal may have affected infestation level estimates on ground plots. Van Dersal (1940, J. Wildl. Manage. 38: 129-132) listed over 50 species of birds and mammals indigenous to Arkansas that consume acorns and some of these species may have been selectively removing acorns from the ground plots. Wildlife studies have suggested that vertebrates prefer undamaged (not insect-infested) seeds (Korstain, 1927, Yale School For. Bull. 19; Duvendeck, 1962, J. Wildl. Manage. 26: 371-3'79; Sork, 1983, Ecology 64: 1949-1056). However, other studies have demonstrated no preference by mammals for damaged or undamaged acorns. An experiment with white-footed mice *(Peromyscus leucopus* Paradiso) suggested no preference for acorns infested with *Curculio* larvae (Semel and Anderson, 1988, Am. Midl. Nat. 385-394). Weckerly et al. (1989, Am. Midl. Nat. 122: 412-415) found no preference for damaged or undamaged acorns by gray squirrels *(Sciurus carolinensis* L.).

Our results suggest that these two methods of acorn sampling do not produce similar estimates of damage rates for many of the insect groups we identified. Significant differences in acorn density between traps and ground

Table 1. Mean percent (± SE) of mature acorns with damage, listed by damaging groups, for two acorn collection methods in 1993 and 1994. Values of S and $P > |S|$ are for Wilcoxon matched-pairs sign-rank tests on 57 matched samples.

Damaging group	Trap Collected	Ground collected	S	$P > \|S\|$
Weevils (*Curculio* spp.)	45.2 ± 3.5	40.4 ± 1.7	-281.5	0.0239
Weevils (*Conotrachelus* spp.)	0.0 ± 0.0	0.8 ± 0.2	126.5	0.0001
Filbertworm (*Cydia latiferreana*)	5.4 ± 1.3	17.5 ± 1.2	493.0	0.0001
Acorn worm (*Valentinia glandulella*)	0.5 ± 0.4	1.3 ± 0.2	109.0	0.0006
Cynipid gall wasps	1.0 ± 0.4	1.1 ± 0.2	42.5	0.1434
Dipteran larvae	1.7 ± 0.8	1.3 ± 0.2	85.5	0.0632
Other unidentified insects	9.4 ± 2.4	9.9 ± 0.9	96.0	0.3300
Fungi and bacteria	18.5 ± 3.0	17.8 ± 1.1	134.5	0.2892
Undamaged	18.4 ± 3.1	9.9 ± 1.2	-23.5	0.8179

plots suggested wildlife were removing acorns from the ground plots. Furthermore, wildlife preferences for acorn quality are not fully known. Thus, when studies are designed to solely determine levels of insect abundance, using trap collected acorns may reduce the biases caused by wildlife. If ground collection is used, the effects of wildlife removal may be minimized to some degree by more frequent collections (i.e., collecting every 7 instead of every 14 days). However. neither collection method reduces biases resulting from wildlife removing acorns directly from the tree canopies. We suggest that removing acorns directly from trees would minimize the effects of wildlife removal if the objective of the study is to determine levels of insect abundance only. For studies investigating availability of acorns for oak regeneration, collection of acorns from the ground would give a more accurate representation of the natural conditions and the levels of insect infestation occurring in acorns left for regeneration.

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