Oak Mast Production and Animal Impacts on Acorn Survival in the Central Hardwood Forest

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Abstract

We measured the proportion of acorns infested with weevils (*Curculio spp.*), and the probability of acorn removal by seed predators from a system of semipermeable exclosures. The three years of the study included two years of high mast production in both species (2006-2007) and one year of mast crop failure (2008). Across all three years, 19% of acorns were infested. We found that the rate of weevil infestation was slightly higher in *Q. velutina* than for *Q. alba* in each individual year, but infestation peaked for both species during the year of mast failure (2008). Overall, 39% of acorns in the exclosures were removed by seed predators. The probability of acorn removal was lower when squirrels were excluded, providing support for additive effects of different seed predators. Removal probability was highest during the 2008 mast failure. In the future, these pre-harvest data will be compared to data obtained following timber harvests conducting in winter 2009.

Introduction

- Oak (*Quercus spp.*) is a dominant overstory species group in the Central Hardwood Region.
- Regeneration failure has occurred due to fire suppression and other factors[1].
- Researchers are attempting to use timber harvesting techniques to promote oak regeneration[2].
- Predation pressure by vertebrates (e.g. small mammals) and invertebrates (weevils) affects the ability of oak acorns to germinate successfully[3].

Figure 1. White oak (*Q. alba*; left) and black oak (*Q. velutina*, right) acorns

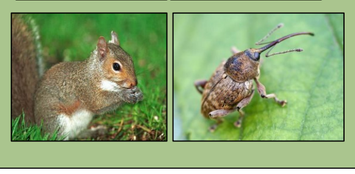

Figure 2. Common acorn predators: gray squirrel (*Sciurus carolinensis*, left) and the acorn weevil (*Curculio spp.*)

Objective

We measured mast production in two species of oak, *Quercus alba* and *Q. velutina*, and quantified the impacts of seed predators on acorn survival.

Hypotheses

1. Weevil infestation rates are higher for black oak than white oak[4].
2. Predators will preferentially remove sound acorns[5].
3. Acorn predation by deer, squirrels, and smaller mammals is additive (vs. compensatory).
4. Rates of infestation and predation are affected by overall mast availability.

Methods

- Study located at Morgan-Monroe and Yellowwood State forests in Southern Indiana
- Data collected at 112 trees over 3 years
- Trees divided among 3 future timber management regimes: even-aged, uneven-aged, and control
- A system of semipermeable exclosures restricting access to fallen acorns was installed at each tree (Figure 3)

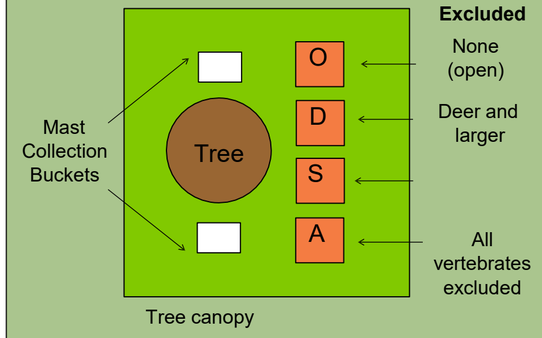

Figure 3. Arrangement of exclosures and collection buckets at each mast tree. All exclosures were under the canopy to allow acorns to fall in naturally. larger

Methods

- Buckets and exclosures were checked 5-8 times each fall at 2-week intervals
- Collected acorns were x-rayed to determine weevil infestation status
- GLMMs fit in a Bayesian framework were used to relate removal and infestation probabilities to explanatory variables

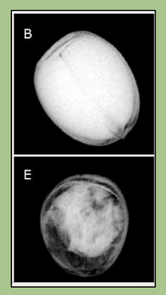

Figure 4. X-ray image of two acorns; the top acorn is intact but the bottom acorn shows discoloration indicative of weevil damage[6]

Results

Table 1. Sample sizes for the mast production, weevil infestation, and mast removal experiments in 2006-2008.

Quantity	2006	2007	2008	Total
Trees sampled	108	112	96	
Acorns Collected	355	670	115	1140
BO	235	414	9	658
WO	120	256	106	482
Acorns x-rayed	366	595	114	1075
BO	265	423	8	696
WO	101	172	106	379
Acorns in exclosures	1041	1827	240	3108
BO	468	1013	30	1511
WO	573	814	210	1597

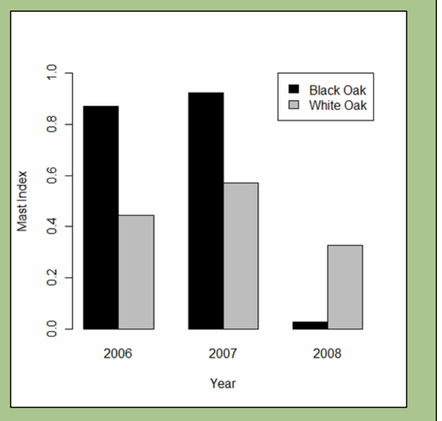

Figure 5. Index of mast production by black and white oaks, 2006-2008. Index was acorns/trap/sampling period.

- Overall, infestation probability was slightly higher for black oak than white oak (Table 2)
- Probability of infestation was highest in 2008, during the year of mast failure (Figure 6)

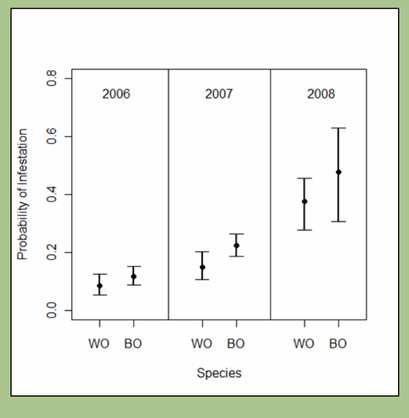

Figure 6. Posterior distributions for the mean probabilities of acorn infestation, Error bars represent 95% credible intervals

Parameter	Mean	SE	*f*
07 Year Effect	0.72	0.22	1.00
08 Year Effect	1.96	0.34	1.00
Acorn species (WO=1)	0.52	0.25	0.98
Sample day	0.18	0.094	0.98
Sample day^2	0.015	0.084	0.58

Table 2. Selected parameter values from logistic regression model of the probability of acorn infestation. Significant (i.e., 95% credible interval does not include 0) parameters are highlighted. The value *f* represents the proportion of the parameter's posterior distribution with the same sign as the mean.

Results

Parameter	Mean	SE	*f*
Sample day	-0.049	0.055	0.82
Acorn species (WO=1)	0.082	0.22	0.66
Acorn integrity (Broken=1)	0.48	0.15	1.00
Germination Status (Germ=1)	0.49	0.15	1.00
Weevil (Infested=1)	0.78	0.21	1.00
Exclosure (Relative to All (A) Exclosure)			
Open (O)	-3.91	0.24	1.00
Deer and larger (D)	-4.09	0.24	1.00
Squirrel and larger (S)	-3.39	0.24	1.00

Table 3. Selected parameter values from logistic regression model of acorn non-removal (i.e. 'survival'). Positive values indicate acorn was less likely to be removed.

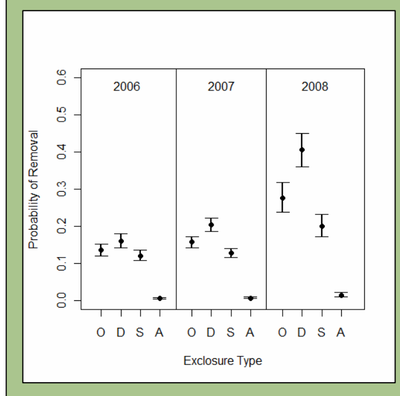

Figure 7. Mean removal probabilities from each exclosure type. See Table X for key to exclosure types.

- Germinated, broken, or infested acorns were less likely to be removed (Table 3)
- Acorns were less likely to be removed from squirrel exclosures (Figure 7), but 95% credible intervals overlapped
- Removal probabilities were highest in 2008 (Figure 7)

Discussion

- Higher rates of infestation in black oak (Table 2) support Hypothesis 1. Other studies indicate that generalist *Curculio spp*. preferred black oak to chestnut oak[4]. The literature indicates germination of infested acorns is greatly reduced[6].
- This study provided additional evidence that small mammal seed predators preferentially remove sound acorns (Hypothesis 2, Table 3).
- There was inconclusive evidence of additive effects of removal by the suite of acorn predators (Hypothesis 3). However, excluding squirrels reduced removal probability (Figure 7).
- Overall, 19% of collected acorns were weevil-infested and 39% were removed by predators; these potential sources of mortality are likely to be at least partially additive since seed predators avoided infested acorns.
- In the mast failure year (2008) the few acorns produced were devastated by predators (39% infested, 60% removed; Figures 6 and 7), evidence for Hypothesis 4.
- Future work will focus on the impacts of timber harvest treatments and tracking of removed acorns to determine their fate (cached or eaten) post-dispersal.

Acknowledgments

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Hardwood Ecosystem Experiment

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