THE INSECT GUILD OF WHITE OAK ACORNS: ITS EFFECT ON MAST QUALITY IN THE OZARK AND OUACHITA NATIONAL FORESTS

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Abstract—Hardwood regeneration, especially of oaks, is an essential component of ecosystem management in the Ouachita and Ozark Mountains of Arkansas. In addition, oak mast is an important wildlife food. Several species of insects inhabit and consume acorns. Data on the insect guild inhabiting white oak (*Quercus alba* L.) acorns were collected from two undisturbed mature (control) and two single-tree selection stands in the Ouachita and Ozark National Forests from 1993-1998. Insects collected were: weevils of the genus *Curculio* and *Conotrachelus* spp. (Coleoptera: Curculionidae); filbertworm, *Melissopus latifereanus* (Walsingham) (Lepidoptera: Tortricidae); acorn moth, *Valentinia glandulella* Riley (Lepidoptera: Blastobasidae), cynipid gall wasps (stone galls) (Hymenoptera: Cynipidae) and midge larvae (Diptera). Over the 5 years of study, sound acorns averaged 31.9 percent. *Curculio* weevils, with an average infestation rate of 26.6 percent, were the most abundant acorn-infesting insect. Other insect species occurred in much smaller numbers.

INTRODUCTION

Oak regeneration is essential to the health and sustainability of hardwood and mixed pine-hardwood forests in the Ouachita and Ozark Mountains of Arkansas. Also, hard mast produced by oaks is an important food for wildlife in these ecosystems (e.g. Goodrum and others 1971, McShea and Schwede 1993, Nixon and others 1975). Estimates of the effect insects have on acorn quality can help managers assess regeneration potential and hard mast availability.

The insect guild that utilizes acorns includes species in the orders Coleoptera, Lepidoptera, Diptera, and Hymenoptera. Damage to the acorns in most cases results from larvae feeding on the nutritious endosperm of the acorn. Primary acorn-infesting insects are weevils in the genus *Curculio* (Coleoptera: Curculionidae) and the filbertworm, *Melissopus latiferreanus* (Walsingham) (Lepidoptera: Tortricidae). These primary insects infest developing acorns on the tree and are able to directly enter the acorn (Myers 1978). They can completely consume the endosperm, thus destroying the acorn (Gibson 1972). Additional, though less abundant, primary acorn insects include several species of cynipid gall wasps whose larvae inhabit galls on or in the acorn (Myers 1978).

Secondary insects include the acorn moth, *Valentinia glandulella* Riley (Lepidoptera: Blastobasidae), weevils of the genus *Conotrachelus* (Coleoptera: Curculionidae) and Diptera (midge larvae). These insects are scavengers that typically enter acorns which are damaged or have been infested by primary insects (Myers 1978), although Galford (1986) demonstrated that *V. glandulella* can be a primary invader of germinating acorns.

MATERIALS AND METHODS

Our study was part of the USDA Forest Service Ouachita Mountain Ecosystem Management Research Project (Phase II), located in the Ouachita and Ozark National Forests of Arkansas and Oklahoma. This long-term study examines the effects of different timber harvest methods on numerous aspects of forest biology (Baker 1994).

We sampled white oak (*Quercus alba* L.) acorns from four forest stands, yearly, from 1993 to 1998. However, an almost complete mast failure combined with extreme predation by wildlife resulted in few acorns collected in 1998. Therefore, we did not include 1998 data in our analyses.

We selected a single-tree selection (STS) stand and an undisturbed mature forest stand (control) in both the northern and southern portions of the Ouachita region. Pine-hardwood STS stands (C70 S10 and C1649 S13) were initially harvested the summer of 1993 with residual hardwood basal areas (BA) ranging from 2.8 to 5.1 m^2 per ha and total BA ranging from 15.4 to 16.1 m^2 per ha (Baker 1994). Control stands were approximately 80 years old, previously unmanaged, with approximate hardwood BA of 7.1 m^2 per ha and total BA of 29.9 m^2 per ha. In the north zone we used Phase II control stand C284 S11, however, a complete mast failure occurred in this stand in 1994 and we used an alternative stand (C406 S1) as a control that year. Because of low numbers of co-dominant white oaks in the south zone Phase II stand, we selected an alternative control stand (C1652 S58) for sampling in 1993. However, harvesting adjacent to this stand made it unsuitable in 1994. Therefore, from 1994-1998 we sampled an alternative south-zone control stand (C1637 S4).

In each stand, we selected 12-25 mast-producing white oaks and placed 1-6 traps under each tree. Traps were placed half-way between the trunk and canopy edge and in random orientation to the trunk. We used two types of traps: metal trash cans (37 cm tall with a 0.33 m diameter opening) and wooden peach baskets (30 cm tall with a 0.43 m opening). All traps had poultry wire covers to prevent wildlife from removing acorns. In 1993 and 1994 we also collected acorns from a single 1-m radius ground plot encircling each trap. All collections were made in 14-day intervals from late August until all acorns had fallen (late November).

Collected acorns were sorted by stage of development (Myers 1978). Stage 1 and 2 acorns were dead and hard-

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ened fruits aborted soon after pollination. Stage 3 acorns were either green acorns not yet fully developed or brown acorns, apparently mature, but dwarfed. Stage 4 acorns were fully developed but green. Stage 5 acorns were fully mature.

Each acorn was dissected, examined, and tallied as either sound or damaged. Acorn quality categories were: sound acorn, *Curculio*, *Conotrachelus*, filbertworm, acorn moth, Cynipidae, Diptera (midge), rancid, aborted, and wildlife damaged (Myers 1978). The "rancid" category included acorns soured by moisture and/or fungi. If more than one category or damage was present, the acorn was categorized by the primary invader or cause of damage.

For our developmental stage analysis, we pooled data from all four stands and averaged yearly percentages for the five years of data. We included both ground-and trap-collected acorns for 1993 and 1994. For our acorn quality measures, we included only stage 4 and 5 acorns; we excluded data from ground-collections in the analysis of acorn quality because corresponding data were not available for 1995 to 1997. We pooled data from single-tree selection and control stands and calculated yearly percent damage rates to compare damage among groups by year. For overall acorn quality measures, we averaged yearly damage rates for the five years data was collected.

RESULTS AND DISCUSSION

Stage of Development

Fully mature stage 5 acorns constituted the greatest portion of acorns collected (fig. 1). A great portion (34 percent) of the acorn crop was aborts (Stages 1-3). However, because traps were placed in mid-late August of each year, just prior to mature acorn fall, we probably underestimated percentages of aborted and immature.

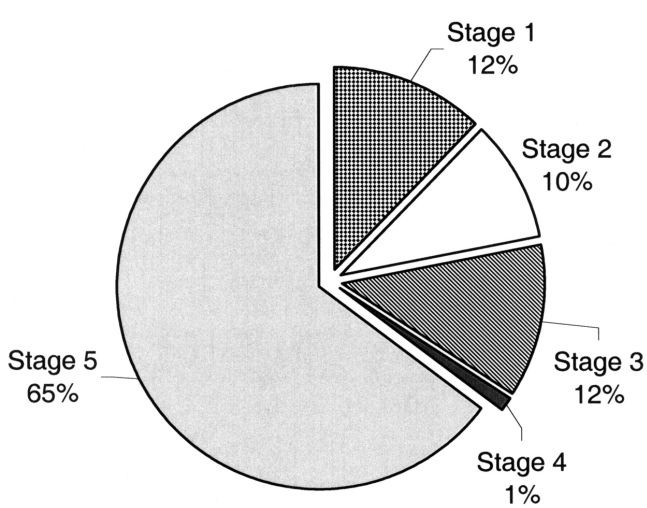

Figure 1—Average proportion of acorns by development stages collected from white oaks located in two single-tree selection and two unharvested mature forest stands in the Ouachita and Ozark National Forests, Arkansas. Percentages were averaged from yearly data from 1993 to 1997. Data for 1993 and 1994 include acorns collected from ground plots and traps; 1995-1997 data include only trap-collected acorns.

Acorn Quality by Year

The white oak acorn crop varied yearly (fig. 2); such variation is characteristic of oaks, with very large crops produced during "mast" years (e.g. Auchmoody and others 1993, Koenig and others 1994). Although more acorns were collected in 1995 than in 1996, the total number of sound acorns was greater in 1996. Total percent soundness was also greater in 1996 than in 1995 (fig. 3). This suggests 1996 may have been a "true" mast year because a greater amount of sound acorns were available for wildlife and regeneration.

Curculio weevils were the most abundant insect infesting white oak acorns, with a substantial presence each year. However, in 1995 and 1996, the *Curculio* infestation rate was lower than in 1994 despite the larger acorn crop of these latter years. This suggests that, in years of abundant mast, the reproductive capacity of this insect is overwhelmed. The other primary insect species, the filbertworm, maintained a smaller but more consistent percentage across years.

Secondary insect species were less abundant than the primary infestors. Percent of acorns damaged by Cynipidae was noticeably greater in 1993, 1995 and 1997 compared

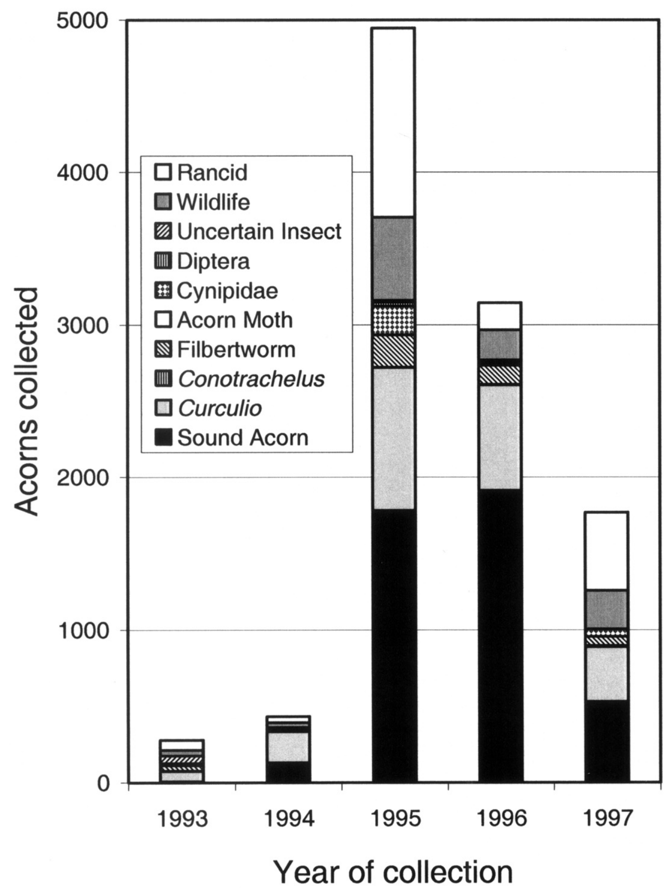

Figure 2—Numbers of white oak acorns, by damage category and year, collected from traps from 1993 to 1997 in the Ouachita and Ozark National Forests, Arkansas. Acorns from two single-tree selection and two unharvested mature forest stands were combined.

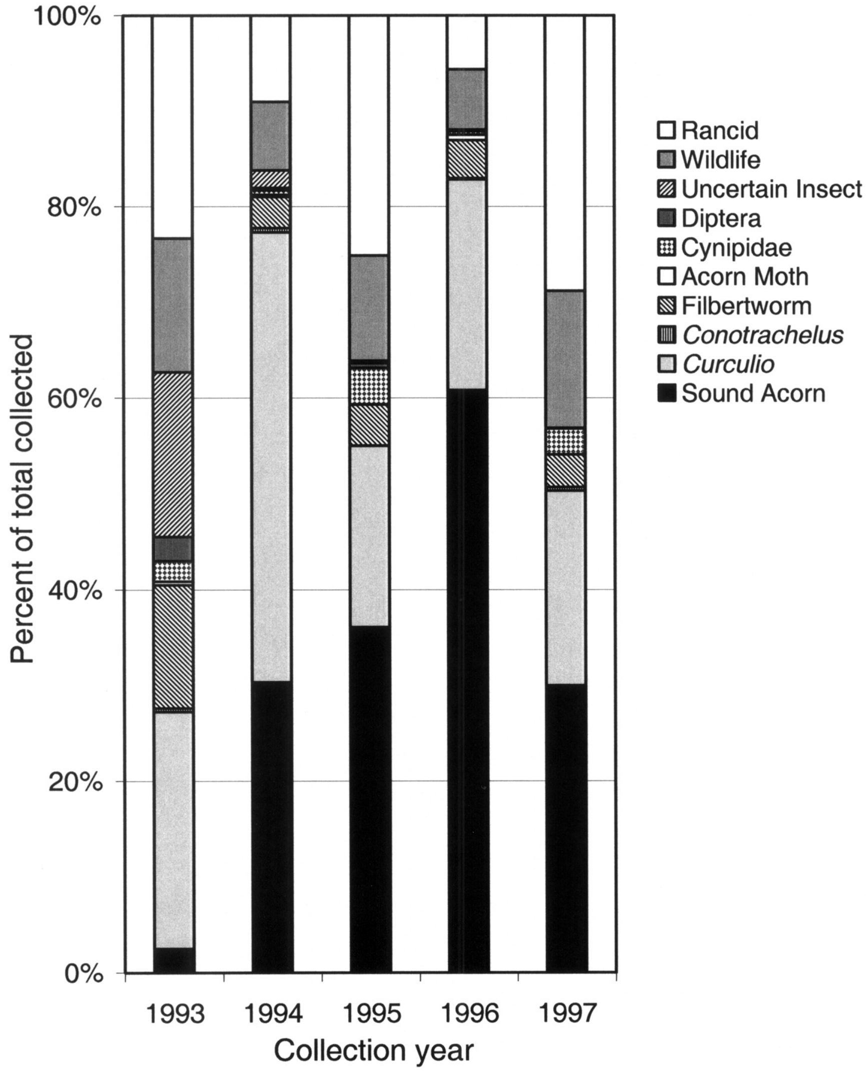

Figure 3—Percentage of white oak acorns in each quality category, by year, collected from traps from 1993 to 1997 in the Ouachita and Ozark National Forests, Arkansas. Acorns from two single-tree selection and two unharvested mature forest stands were combined.

with 1994 and 1996. This suggests a periodicity in Cynipid populations. Acorn destruction by wildlife was fairly consistent across years. However, the damage rate in 1996 was relatively lower than other years suggesting the mast production of 1996 was greater than the consumption rate of wildlife, furthermore suggesting 1996 was a mast year.

Overall Acorn Quality

When averaged over the five years of collection (fig. 4), sound acorns were the largest quality category. *Curculio* weevils were by far the most abundant insects infesting the acorns and surpassed wildlife in numbers of acorns destroyed. However, many *Curculio*-infested acorns had only a few small larvae and these acorns could still be consumed by wildlife and would probably still germinate.

Other insect species were present in much smaller numbers. The acorn moth and *Conotrachelus* weevils were relatively rare inhabitants in acorns. Galford (1986) indicated "secondary" insects such as the acorn moth may destroy significant numbers of acorns that have fallen to the ground and commenced germination. However, because we used acorns collected from traps rather than the ground, the damage rates for these secondary insects may be underrepresented. Perry and Mangini (1997) indicated differences in damage rate estimates for some secondary infestors between ground- and trap-collected acorns.

CONCLUSIONS

Insects feeding on white oak acorns had a significant impact on the quality of the acorn crop. *Curculio* weevils were responsible for the greatest amount of the damage. Curculio infestation, along with wildlife damage and fungi damaged 56 percent of the total mature acorn crop available for regeneration. In addition, a great portion of the overall acorn crop was aborted or fell prior to maturity.

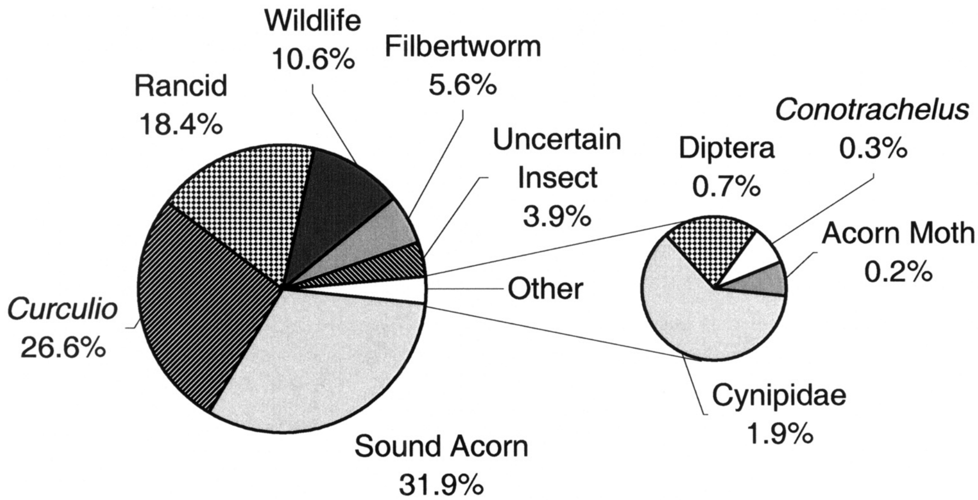

Figure 4—Average percent of white oak acorns for each quality category, collected from traps in the Ouachita and Ozark National Forests, Arkansas. Percentages were averaged from yearly data collected from 1993 to 1997 and represent acorns collected from two single-tree selection and two unharvested mature forest stands.

Our study involved acorns collected during the fall acorn drop. Consequently, our estimates of insect damage are likely to be conservative in regards to regeneration potential because additional infestation and rot could be expected as acorns lay for an extended period on the forest floor prior to sprouting. Furthermore, our overall damage rate estimates were probably reduced because we estimated acorn quality using only trap-collected acorns.

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LITERATURE CITED

Auchmoody, L.R.; Smith, H.C.; Walters, R.S. 1993. Acorn production in northern red oak stands in northwestern Pennsylvania. Research Paper NE-660. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Baker, J.B. 1994. An overview of stand-level ecosystem management research in the Ouachita/Ozark National Forests. In: Baker, J.B., comp. Proceedings of the symposium on ecosystem management research in the Ouachita Mountains: pretreatment conditions and preliminary findings. Gen. Tech. Rep. SO-112. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 18-28.

Galford, J.R. 1986. Primary infestation of sprouting chestnut, red and white oak acorns by *Valentinia glandulella* (Lepidoptera: Blastobasidae). Entomological News 97:109-112.

Gibson, L.P. 1972. Insects that damage white oak acorns. Research Paper NE-2, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Goodrum, P.D.; Reid, V.H.; Boyd, C.E. 1971. Acorn yields, characteristics, and management criteria of oaks for wildlife. Journal of Wildlife Management 35:520-532.

Koenig, W.D.; Mumme, R.L.; Carmen, W.J.; Stanback, M.T. 1994. Acorn production by oaks in central coastal California: variation within and among years. Ecology 75: 99-109.

McShea, W.J.; Schwede, G. 1993. Variable acorn crops: responses of white-tailed deer and other mast consumers. Journal of Mammalogy. 74: 999-1006.

Myers, S.A. 1978. Insect impact on acorn production in Missouri. Columbia, MO: University of Missouri. 246 p. Ph.D. dissertation.

Nixon, C.M.; McClain, W.M.; Donohoe, R.W. 1975. Effects of hunting and mast crops on a squirrel population. Journal of Wildlife Management 39: 1-25.

Perry, R.W.; Mangini, A. 1997. A comparison of trap versus ground collections of acorns to assess insect infestation. Journal of Entomological Science 32: 412-415.