Rare outbreak of the Oak Eriococcid, *Eriococcus quercus* (Comstock), on Northern Red Oak, *Quercus rubra*, in eastern Tennessee

P Lambdin[1], J Grant[1] & S Schlarbaum[2]

[1]Department of Entomology & Plant Pathology, University of Tennessee, Knoxville, 37996; [2]Department of Forestry, Wildlife & Fisheries, University of Tennessee, Knoxville, 37996.

Abstract: A rare outbreak of the oak eriococcid, *Eriococcus quercus* (Comstock), was observed threatening northern red oak, *Quercus rubra* L., within the U.S. Forest Service seedling seed orchard in 1995. In April 1995, ca. 85% of the 787 northern red oak trees in the orchard was infested with the oak eriococcid. By July 1995, the infestation had decreased to ca. 51% of the trees, and by June 1996, it was rarely found. The life history and seasonality of *E. quercus* were assessed from specimens obtained weekly from branch samples on each of 20 trees representing 10 open-pollinated families. *Eriococcus quercus* has two overlapping generations, with females undergoing three developmental stages, while males have additional prepupal and pupal stages. Females have a relatively high fecundity rate [$\bar{x}$ =119 (0-300) eggs/female]. Greater numbers of eggs were observed within the felt-like test of females on tree families 701 and 6662, while fewer eggs were recorded on tree families 323 and 896. The eriococcid settles and feeds on the underside of branches of northern red oak, especially around forks, wounds, and leaf buds. These areas may provide the eriococcid protection from adverse weather conditions and predators. Newly-emerged first-instar nymphs often move to and settle on new tree growth. The eriococcid population was dispersed throughout the tree. Although no parasitoids were discovered in 1995 or 1996, a high population of the lady beetle, *Hyperaspis bigeminata* (Randall), was observed feeding on gravid eriococcids. Population numbers declined for the overwintering generation from 6.56 individuals/cm^2 in July to 0.14 individuals/cm^2 by November 1995, and specimens were rarely found by June 1996. Both *E. quercus* and *H. bigeminata* represent new state records.

Introduction

The diverse forests of Tennessee are an integral component of the State's economic base. Forested land provides materials and aesthetic areas utilized by consumptive and nonconsumptive industries within the State. The forests provide raw materials important to Tennessee's commercial forestry, nursery, and Christmas tree industries. Over 14 million tourists annually visit eastern Tennessee to enjoy the natural beauty and contribute more than $5.7 billion to the state's economy. Commercial harvest of Tennessee forests annually contributes 3.5 billion dollars (value added) to the State's economy and employs over 51,000 people.

Some of the largest remaining native stands of mature northern red oak, *Quercus rubra* L., east of the Mississippi River occur within eastern Tennessee and make up an integral component of the state's forest ecosystems. A unique 32-year-old northern red oak seedling orchard, which provides acorns for artificial regeneration throughout much of the southern Appalachian, was treated with the insecticide esfenvaterate to survey the insect fauna in the canopy over a three-year period from 1992 to 1994. These applications are believed to be responsible for a rare outbreak of the oak eriococcid, *Eriococcus quercus* (Comstock), in the fall of 1994. This scale insect is widespread throughout the United States, where it is found in the Atlantic Gulf Coast, mid-western and southeastern states as well as parts of Canada (Gill, 1993; Majka & McCorquodale, 2006; Miller & Miller, 1992; 1993). The oak eriococcid is recorded only from the branches and stems of several *Quercus* species (Miller & Miller, 1992; Kosztarab, 1996).

The application of insecticides often results in reducing the number of natural enemies at the target site as well as competition among scale insect individuals for suitable sites to settle and feed. McClure (1977) reported a reduction in four of five predator species evaluated after application of insecticides. This heavy infestation by the oak eriococcid represents a significant threat to the survivability of this unique seed orchard within eastern Tennessee. One potential result of massive defoliation by insect pests (native or exotic) to *Q. rubra* is the decline in the number of oak genotypes available as well as effecting the composition of native insect species within the area. A list of the species found on northern red oak in eastern Tennessee was provided by Trieff (2002). The invasion by this exotic species in forests has the potential to affect those species associated with this host tree, including those depending on the foliage and acorns produced as a food source (bears, birds, squirrels, etc.), including numerous native species.

Because the widespread infestation (>45% of the trees) posed a threat to development of the northern red oaks and because little information was known regarding the life history and control of this species, we initiated a two-year study in 1995 to: (1) determine the seasonal abundance and distribution of the oak eriococcid on ten northern red oak genotypes, and (2) assess the incidence of any natural enemies associated with the oak eriococcid.

Materials and Methods

A northern red oak seedling seed orchard, located in the Cherokee National Forest in Johnson Co., TN, proximal to Watauga Lake ca. 48.2 km from Elizabethton, TN, was developed from open-pollinated progeny test northern red oak (220 families), which was planted in 1973 by the U. S. Forest Service and the Tennessee Valley Authority. The families incorporated in the test originated from trees that exhibited superior phenotypic characteristics located throughout the Tennessee Valley region. The original field design was arranged in a randomized complete block containing eight replications and occupying 6.5 ha. The seedling seed orchard was created in 1987 by thinning undesirable families and trees within selected families in the progeny test. The remaining trees (787) varied in size from 3.1 - 9.1 m in height and 15.3 - 20.3 cm in diameter (at 1.4 m height).

A. Infestation Rating for Oak Eriococcid in Northern Red Oak Seedling Seed Orchard: Two red oak trees were selected and tagged from each of ten open-pollinated genetic families (323, 520, 555, 701, 880, 896, 2423, 2451, 6431, and 6662). The maternal parents of these genetic families originated from various locations throughout the Tennessee Valley region (data on file, University of Tennessee's Tree Improvement Program). The number of infested limbs, total number of limbs, and the infestation rating were recorded for each of the 20 trees. The level of infestation on each tree was rated in April and July in 1995 and May, August and October in 1996. The infestation rating [where 0=none, 1=light sporadic (1-5 limbs), 2= light encrusted (1-5 limbs), 3= moderate sporadic (6-10 limbs), 4= moderate encrusted (6-10 limbs), 5= heavy sporadic (11+ limbs), and 6= heavy encrusted (11+ limbs)] was made for each tree within the seed orchard.

B. Development of the Oak Eriococcid on Ten Oak Genotypes: Scale insect infested samples (10) were taken weekly from one of two trees representing each family. Samples (2.5 cm^2 of bark) were sequentially taken from the second tree the following week to avoid adversely reducing the population size. Insects were collected from April to December 1995. Each sample was placed into a cellophane bag, labeled (host tree number, date, number specimens, stage of development), and data recorded in Excel files. Specimens were viewed

under a Leitz stereoscope to determine the number and stage of the specimens collected. Egg counts were taken from ten gravid females from each genotype.

The live specimens were placed into a Syracuse disk (20 mm diam.) filled with Essigs Aphid Fluid to clear the specimens. Specimens were transferred to a clean dish containing lignin double stain (2 drops/dish), specimens were then placed into a dish containing 90% ethyl alcohol to remove any excess stain, and then transferred to a disk containing clove oil to soften specimens prior to mounting in Canada balsam (Wilkey, 1962). Slides were marked with a diamond point pen consisting of: date and tree number, and placed into a drying chamber for two weeks. Upon removal from the drying chamber, a label depicting species name, stage, collection location, date, host, and tree number were placed on each slide for proper identification. Slide specimens were then viewed under a Wild® microscope to determine and verify the number and stage of the specimens collected for a specific date.

C. Assessment of the Native Beneficial Population: A survey for predators was conducted weekly from one tree representing each of the ten families. Predators were collected by hand, placed into vials, taken to the lab, identified, and recorded. To survey for parasitoids, ten traps/week (one per oak family) were placed around oak eriococcid infestations in the lower canopy. Each trap was made from 3.2 cm PVC pipe cut into 15.2 cm lengths with ½ dr glass vial mounted in center. Upon emergence, parasitoids tend to fly into the glass vial for recovery. Vials were collected weekly and taken to the laboratory to observe for any parasitoids.

D. Analysis of Data: Data were entered into Excel files for analysis to assess distribution and degree of infestation within the orchard. The data incorporated included: species name, family name, collection date, site, host plant location, number of specimens/host, instar at the time collected, and number of generations per species. These data were processed using SAS Procedures (e.g., Analysis of variance, regression and correlations, trend analysis, and graphing) (SAS Institute, Inc. 1989).

Results

In April 1995, ca. 85% of the 787 northern red oak trees in the seedling seed orchard was infested with the oak eriococcid (Fig. 1). By July 1995, the infestation had decreased to ca. 51% of the trees. The eriococcid population was dispersed throughout the tree with highest numbers on the lower branches. In 1995, the population of the overwintering generation continued to decline from 6.56 live individuals/cm^2 in July to 0.14 individuals/cm^2 in November. By October 1996, the infestation had declined to about 28% on the trees evaluated.

Eriococcus quercus has two overlapping generations per year with females undergoing three developmental stages, while males have an additional prepupal and pupal stages (Fig. 2). Eggs began to hatch in late March. Upon hatching during the spring, crawlers migrate to the new growth and settle on the underside of the branches. This area of the branch may provide the eriococcid protection from adverse weather conditions and natural enemies. Most crawlers tend to settle close to one another in a circular fashion on the underside of branches around the nodes and leaf buds or in damaged areas on the branch. Males tend to settle around a cluster of females or aggregate in separate groups apart from the females. Once settled, individuals began to produce a whitish felt-like covering (test). Several second-instar males migrated to the underside of the leaves to settle and pupate. Several females were found wedged in or near the buds and on wounds. Females have a relatively high fecundity rate [$\bar{x}$ =119 (0-300) eggs/female]. Significantly greater numbers

of eggs (P<0.05) were observed within the felt-like test of females on the tree families 701 and 6662, while fewer eggs were recorded for females on hosts in tree families 323 and 896 (Fig. 3).

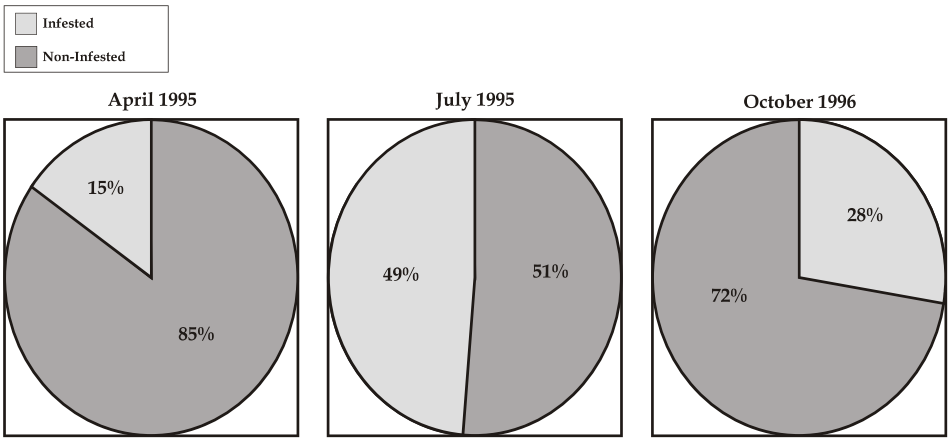

Figure 1. Percent infestation of northern red oak trees by the oak eriococcid in a seedling orchard in eastern Tennessee.

In the second generation, eggs began to hatch in mid-July through early-August. Second-instar males and females were present by mid-August through mid-September. Adult females were the dominant stage from mid-September through the winter months. The adult males began emerging in mid-September and were present to mid-October. Several of the overwintering adult females were observed laying eggs during the winter months, and the eggs were protected by the felt-like test until hatching.

Although no parasitoids were discovered in 1995 or 1996, a high population of the lady beetle, *Hyperaspis bigeminata* (Randall), was observed feeding on gravid eriococcids. This species is recorded as a predator of scale insects and mealybugs (Hodek & Honek, 1996). This predator is widespread throughout the eastern and midwestern United States and much of Canada (Majka & McCorquodale, 2006). Predator damage consisted of chewing a hole through the felt-like test and feeding on the eggs. The predator was not observe feeding on immatures or on adult males. The average number of beetles on each 15 cm sample of the infested trees was 0.2 (range 0-5), while the average number of eriococcids damaged was 3.9 (range 0-34).

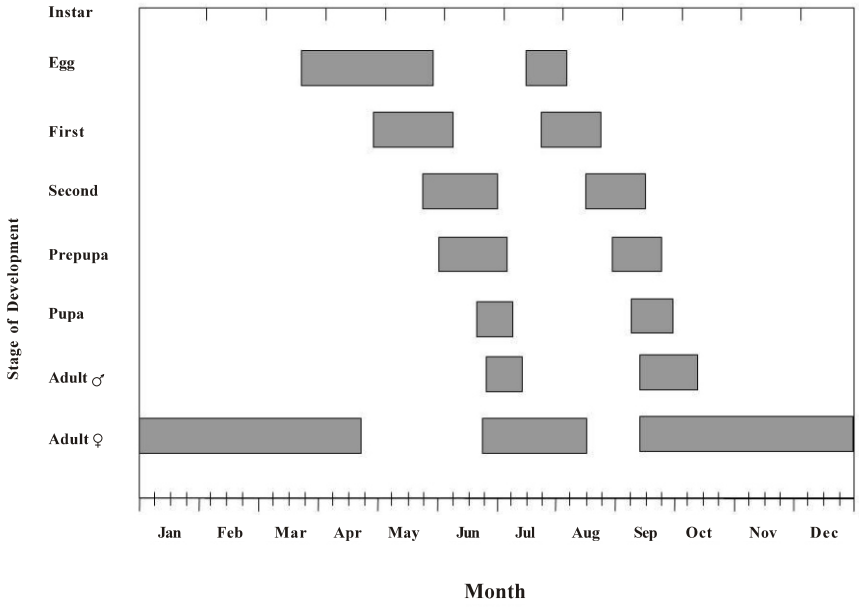

Figure 2. Seasonal development of *Eriococcus quercus* on northern red oak in eastern Tennessee.

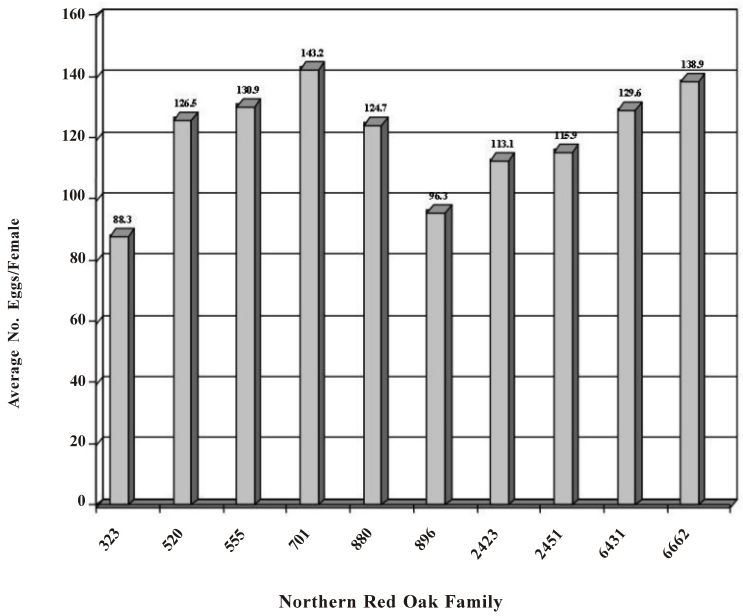

Figure 3. Mean number of eggs produced by oak eriococcid females on ten northern red oak genotypes.

Conclusions

The oak eriococcid has two overlapping generations with adult females producing an average of 119 eggs. Upon hatching, the crawlers migrate to the new growth to settle on the underside of the branches throughout the canopy of the tree. Because the scale settles on the underside of the branches, incomplete coverage by insecticide applications and their effect on established predators at the seed orchard may well be the reason for the rare, massive population build-up of the oak eriococcid. During this short period, the heavy infestations resulted in substantial limb die-back. Damage to the tree by this species is in the form of reduced photosynthesis due to limb die-back, damage to developing leaf buds, and interference with acorn production. The high numbers of the predator, *H. bigeminata*, may be responsible for the elimination of this eriococcid from the seed orchard. This predator has been documented as feeding specifically on Sternorrhyncha, primarily scale insects (Gordon, 1985). Both *E. quercus* and *H. bigeminata* represent new state records.

Acknowledgments

We wish to thank Dr. Joan Chapin (Louisana State University, Baton Rouge, LA) for her identification of the lady beetle, *Hyperaspis bigeminata*, Dr. Douglass Miller (USDA SEL-BARC, Beltsville, MD) for his identification of the eriococcid, and to M. Lambdin, D. Paulsen and D. Noon (University of Tennessee) for their assistance in collection of specimens for evaluation and development of this manuscript.

References

Gill, R.J. 1993. The Scale Insects of California: Part 2. The minor families (Homoptera: Coccoidea): Margarodidae, Ortheziidae, Kerriidae, Asterolecaniidae, Lecanodiaspididae, Cerococcidae, Aclerdidae, Kermesidae, Dactylopiidae, Eriococcidae, and Phoenicococcidae. Sacramento, CA: Calif. Dept. Food & Agric. 244 pp.

Gordon, R.D. 1985. The Coccinellidae (Coleoptera) of America North of Mexico. J. New York Entomol. Soc. 93:1-912.

Hodek, I. & Honek, A. 1996. Ecology of Coccinellidae. Kluwer Academic Press, Boston.

Kosztarab, M. 1996. Scale Insects of Northeastern North America: Identification, Biology, and Distribution. Martinsville, VA: VA. Mus. Nat. Hist.

Majka, C. & McCorquodale, D. 2006. The Coccinellidae (Coleoptera) of the Maritime provinces of Canada: new records, biogeographic notes, and conservation concerns. ZooTaxa. 1154:49.

McClure, M.S. 1977. Resurgence of the scale, *Fiorinia externa* (Homoptera:Diaspididae), on hemlock following insecticide application. Environ. Entomol. 6:480-484.

Miller, D.R. & Miller, G.L. 1992. Systematic analysis of *Acanthococcus* (Homoptera: Coccoidea: Eriococcidae) in the western United States. Trans. Amer. Entomol. Soc. 18:1-106.

Miller, D.R. & Miller, G.L. 1993. Eriococcidae of the eastern United States (Homoptera). Contrib. Amer. Entomol. Inst. 27(4):1-91.

SAS Institute. 1989. SAS/STAT users guide, v.6, 4th ed. Cary, North Carolina, SAS Institute.

Trieff, D. 2002. Composition of the Coleoptera and associated insects collected by canopy fogging of northern red oak (*Quercus rubra* L.) trees in the Great Smoky Mountains National Park and the University of Tennessee Arboretum. MS Thesis. University of Tennessee, Knoxville.

Wilkey, R.F. 1962. A simplified technique for clearing, staining and permanently mounting small arthropods. Ann. Entomol. Soc. Amer. 55:606.