Biological Notes on the Mealybug *Dysmicoccus obesus* (Homoptera: Pseudococcidae) on Loblolly Pine in Southern Arkansas[1]

L. C. Thompson and R. J. Colvin[2]

Department of Forest Resources, University of Arkansas at Monticello
Monticello, AR 71655

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ABSTRACT *Dysmicoccus obesus* (Lobdell) was first found in Arkansas in 1983 living in crevices, under bark scales of loblolly pines (*Pinus taeda* L.). Most mealybugs (77%) were found on the bole between 0-90 cm of the ground, and they showed slight preferences for the northern and southern bole exposures. *Crematogaster* ants were observed tending the mealybugs. Three broods per year were detected, with adults produced in May, July and September. *Dysmicoccus obesus* probably overwinter off the tree as immatures. Cytogenetic observations showed *D. obesus* was sexual and the sex ratio of eggs was 1:1. Males were never found. Mean fecundity was 300 ± 15 (SE). The documented occurrence of *D. obesus* from 10 southern and southeastern states suggests its distribution is probably throughout the range of its loblolly pine host. Records from Maryland indicate the mealybug also feeds on Virginia pine (*P. virginiana* Mill.).

KEY WORDS Loblolly pine, mealybug, life history, fecundity, distribution, *Crematogaster* ants.

A mealybug was found in 1983 feeding on loblolly pine, *Pinus taeda* L. Trees were located in a 4-year-old plantation on the experimental forest at the Southwest Research and Extension Center near Hope, AR. Several years previously some trees in the plantation had exhibited atypical growth. These trees were stunted, had a leaning leader with crooked upper branches and stem and had considerable butt swell with rapid bole taper. Trees were examined, and mealybugs were found living on the bole, under bark scales, near the base of trees. The insect was subsequently identified as *Dysmicoccus obesus* (Lobdell).

Published records on *D. obesus* are few and scattered; therefore, the following review consolidates this information. Most records on *D. obesus* are taxonomic (Lobdell 1930; Ferris 1950, 1953; McKenzie 1962, 1964, 1967; Miller and McKenzie 1971, 1973). Baker (1972) and Westcott (1973) summarized biological information about an infestation in ornamental loblolly pines published by Milliron (1958). Published distribution records for *D. obesus* include China (Wang 1982) and, in the U.S., Delaware (Milliron 1958) and Mississippi (Lobdell 1930).

Milliron (1958) included a photo of a *D. obesus*-infested tree showing typical symptoms, which were "spindly appearance, sparser foliage, shorter height and off-color" as compared to non-infested trees. Additionally, the most severely infested

[1] Accepted for publication 31 August 1989.

[2] University of Arkansas, Southwest Research and Extension Center, Hope, AR 71801.

tree had butt swell with rapid bole taper. Milliron also reported the mealybugs were found only on the trunk of the trees and a white powder was conspicuous in the cracks and crevices of the bark.

The purpose of this paper is to report new biological information and unpublished distribution records gathered on this mealybug.

Methods

The insect has been relatively abundant in an 8-ha plantation of genetically improved loblolly pine planted in March of 1979 near Hope, AR. The site was previously a mature stand of mixed loblolly and shortleaf, *P. echinata* Mill., pine. The plantation was established as part of a nutrient cycling study. Part of the plantation was divided into 16 0.2-ha study blocks. Prior to planting, half of the blocks received maximum site preparation (chop, burn and disc), and half received minimum site preparation (chop only). Half the blocks in each site preparation treatment received a total of 75 kg/ha of nitrogen in March, half as ammonium nitrate in 1982 and half as urea in 1983. The experimental design was a completely randomized 2 × 2 factorial.

To determine the distribution of mealybugs on the bole, 12 trees were cut in early July 1983 and brought to the laboratory. Six of these trees exhibited symptoms typical of mealybug infestation, and 6 did not. The bole of each tree was divided into 8 cardinal directions and successive 10-cm height divisions. The trees were thoroughly searched to a height of 180 cm, with mealybug numbers recorded by direction and height on the bole. Sampling was terminated at 180 cm because most trees had forked by then, rendering the main stem indistinguishable from branches. In early September, 14 more trees, all showing symptoms, were cut and their boles searched as described above. Because inhabitable surface area decreased with increasing height on the bole, mealybug counts were adjusted to the number of insects per centimeter of bark surface area, transformed (square-root of counts + 0.5) and then analyzed using the analysis of variance (ANOVA) (SAS Institute 1985).

The trees collected in July and September were also used to evaluate any relationship between the apparent symptom of butt swell with rapid bole taper and the number of mealybugs present. A bole taper index for each tree was calculated by dividing its inside-bark diameter at 10 cm by that at 80 cm. An upper limit of 80 cm was selected because forking and branching above this point on numerous trees produced irregular bole cross sections. This index was selected because greater taper produced larger index values. The index was then compared to the total number of mealybugs present to 80-cm height.

Mealybug life stages were determined from information supplied by D. R. Miller (pers. comm.). First-instar females have 6-segmented antennae and few bristles; 2nd-instars have 6-segmented antennae and many bristles; 3rd-instars have 7-segmented antennae; and adult females have 8-segmented antennae with a vulva and multilocular pores.

Infested trees were periodically sampled in 1984 and 1985 to determine seasonal occurrence of life stages. The sampling procedure of removing bark scales effectively destroyed the mealybug habitat; therefore, the number of trees sampled was minimized. In 1984, the lower 1 m of bole was searched on 4 different trees each month from March through November. Monthly observations proved inadequate to clearly distinguish broods, so in 1985 sampling occurred twice monthly from March through November. Also, if mealybug populations on a tree were considered adequate, only a portion of the bole was sampled, and these trees were resampled one month later.

Fecundity was estimated by dissecting 5 of the largest gravid females removed from each of 12 trees cut in early September 1983. The effects of taper index and total mealybugs per tree on fecundity were determined with an ANOVA and linear correlation (SAS Institute 1985).

The mealybug-affected trees in the plantation appeared to be clumped in certain site preparation and fertilizer blocks. This relationship was tested by counting the number of trees in each block in mid-July of 1983 that showed typical mealybug symptoms and expressing this count as a percentage of the total living pines in that block. An ANOVA (SAS Institute 1985), using the arcsine transformation, tested for relationships.

Inquiries were made to various public insect collections to delimit the occurrence of *D. obesus* among states and to investigate additional hosts. Variation for all descriptive statistics is expressed in terms of the standard error.

Results and Discussion

Life History and Biology. Results of periodic sampling estimated seasonal occurrence (Fig. 1). Three broods can be distinguished using seasonal occurrence of the various stages. Smaller instars (1 and 2) were detected in 1984 in mid April, in late June, in late July and again in mid October and in 1985 in late March, in mid June, in early August and in early October. Adults were detected in 1984 in late May, in late July, in late September and in mid October and in 1985 in early May, in late July and early August, in late September and early October.

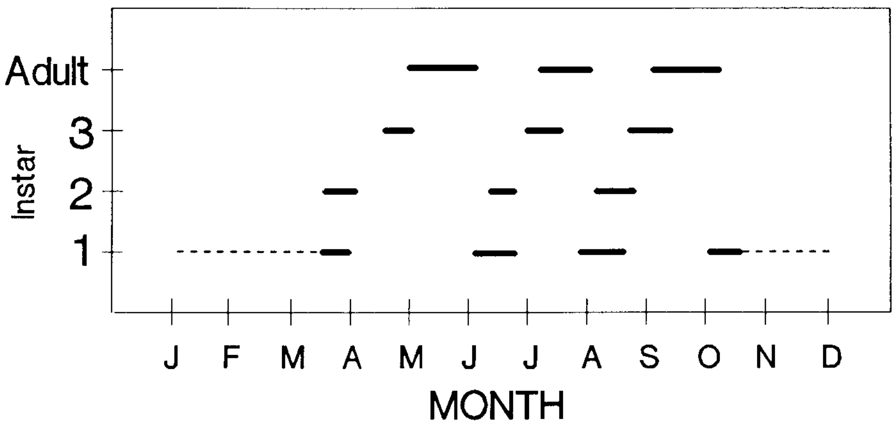

Fig. 1. Approximate seasonal occurrence (bold lines) of the three larval instars and the adults of *Dysmicoccus obesus* (Lobdell) in southeastern Arkansas. Dashed line represents overwintering early instars off the tree.

We hypothesize that *D. obesus* overwinter as smaller immatures off the tree, perhaps in ant burrows, although the supporting evidence is circumstantial. First, sampling in early spring (March and April) revealed only immatures. Second, sampling in November revealed only a few adult cadavers, where 1st-instars occurred several weeks previously. Third, McKenzie (1967) commented on ants caring for mealybugs in their burrows during the winter. And lastly, on those occasions when ants were observed carrying mealybugs, they had only immatures or early adults. Milliron (1958) speculated that *D. obesus* overwintered as immatures or eggs because he could not locate life stages when he made collections in mid-March.

Adult females increased substantially in size as their eggs matured. Recently molted adult females were much smaller than those with mature eggs (mean length 2.1 ± 0.05 mm vs. 4.8 ± 0.08 mm, N = 20). Mean mealybug fecundity was 300 ± 15 eggs with a maximum of 570 and a minimum of 130 eggs. The ANOVA showed fecundity varied among host trees ($F_{11,48} = 4.95$, $P < 0.001$). However, the linear correlation analysis showed only weak relationships among mean mealybug fecundity per tree and two related tree factors, total mealybug counts and the taper index (Fig. 2). If mealybugs are affected by tree physiology, then the bole taper index and the number of mealybugs per tree are not good predictors of fecundity.

Neither eggs nor males were observed on trees, so initially *D. obesus* was thought to be parthenogenetic. To elucidate the sexual status, gravid females were sent to Dr. Uzi Nur, an insect cytogeneticist, for examination. These gravid females had sperm and spermbundles in the reproductive tract. Also, the sex ratio of cytologically examined eggs was approximately 1:1. This evidence shows the insect is sexual.[1] Additionally, eggs inside gravid females had fully formed legs and antennae, indicating that they likely would hatch soon after being laid. Also, the diploid (2n) chromosome number was 16, which is uncommon for mealybugs, where 10 is usually the norm, and is different from 4 other *Dysmicoccus* species [*boninsis* (Kuana) = 12, and *brevipes* (Cockerell), *cuspidatae* (Rao) and *neobrevipes* (Beardsley) = 10]. Dr. D. R. Miller (pers. comm.) indicated males may live in an entirely different place on the host, on the foliage perhaps.

Mealybugs were observed crawling on various occasions; sometimes they did so in response to our prodding. Crawling was usually observed in bark crevices, and it was infrequently observed on the bark surface.

Acrobat ants, *Crematogaster lineolata* (Say) or *C. laeviuscula* Mayr, were constantly found in association with the mealybugs. Other reported ant-*D. obesus* associations include the cornfield ant, *Lasius alienus* (Foerster), (Milliron 1958) and the Argentine ant, *Iridomyrmex humilis* (Mayr), (Lobdell 1930). The acrobat ants aided detection of crevices that contained mealybugs because tree disturbances (such as pounding on the bole) usually sent the ants temporarily scurrying to the bark surface. On 3 occasions ants were observed carrying smaller-sized mealybugs. Also, when a mealybug colony was disturbed, ants attempted to dislodge attached mealybugs with their mandibles. They were seldom successful, except for one observation made in late fall; perhaps the mealybugs were not so firmly attached then.

From their position in bark crevices, the mealybug's stylet appeared to be long enough for them to feed either in inner bark phloem or in the xylem of the outer

[1] Letter of 26 September 1986 from Dr. Uzi Nur.

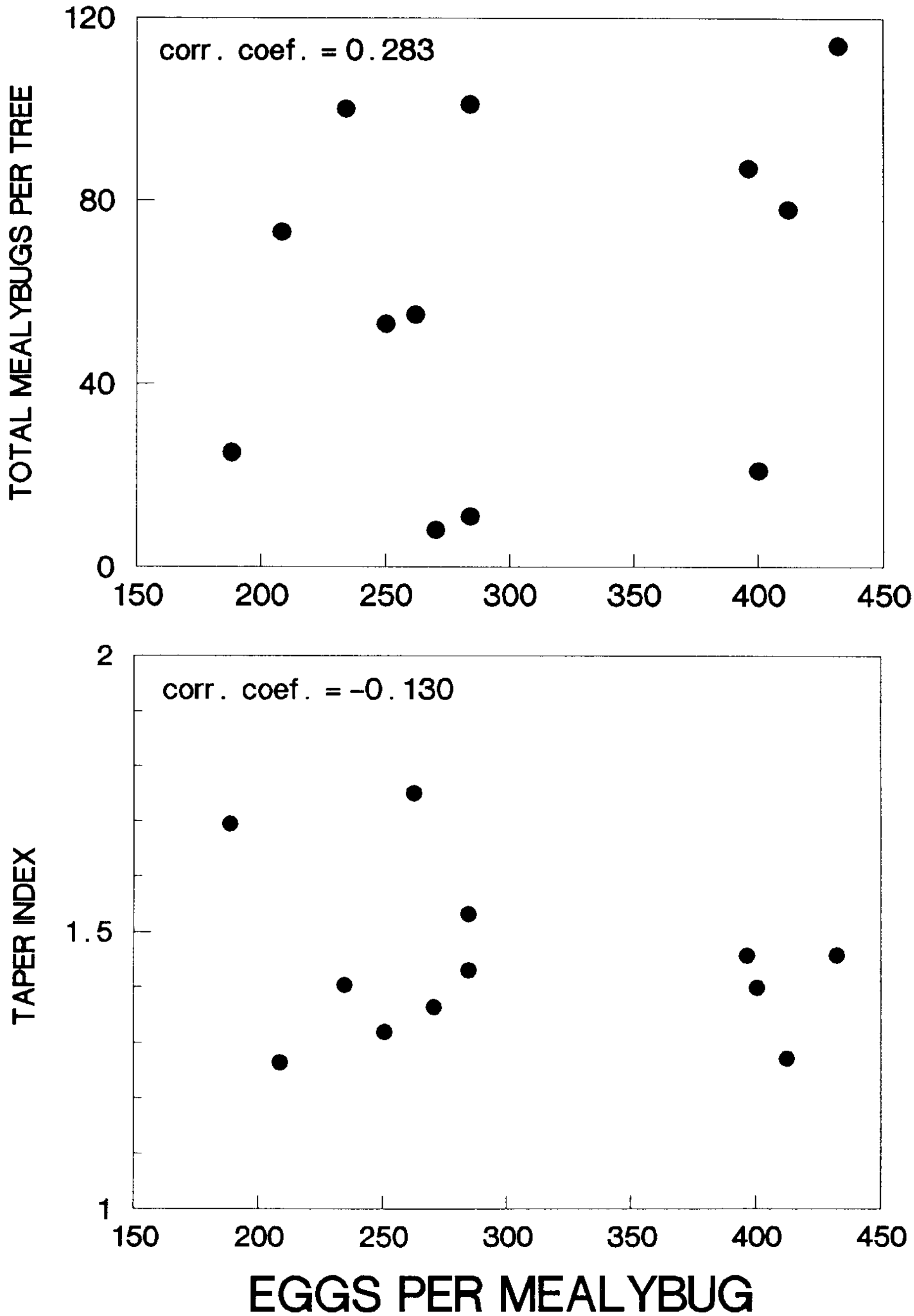

Fig. 2. Relationship between mean *Dysmicoccus obesus* fecundity per tree and two tree factors, total mealybug counts and the taper index (N = 12 trees).

sapwood. It was difficult to estimate the stylet's exact length because the collecting procedure probably broke the stylet. However, for a subset of gravid females that had part of their stylet intact, the stylet was at least as long as the body ($\bar{x}$ = 4.8 mm ± 0.08, N=20).

Within-tree Distribution. Mealybugs were found living in bark crevices under bark scales. Most (77.1%) were found on the bole below a height of 90 cm, probably reflecting the availability of suitable bark crevices. Of the mealybugs found above 90 cm, only 6.2% were located on major branches, and all of these were situated within 30 cm of the bole.

Location of mealybugs on the bole is influenced by multiple factors. The ANOVA of mealybug location (bugs per unit area) on the bole using tree, direction and height as the main effects revealed significant differences among tree ($F_{25, 1400}$ = 7.35, $P < 0.01$), direction ($F_{7,1400}$ = 2.33, $P < 0.02$), tree X height ($F_{200,1400}$ = 1.73, $P < .01$) and tree X direction ($F_{175, 1400}$ = 1.21, $P < 0.04$) interactions, but not among height ($F_{8, 1400}$ = 1.03, $P > 0.4$) or the height X direction interaction ($F_{56, 1400}$ = 1.08, $P > 0.3$). Differences were expected among trees because the total number of mealybugs per tree ranged from 1 to 170. The nonsignificance among heights was unexpected since more mealybugs appeared to be located lower on the bole where bark crevices were more numerous.

To test for directional differences, tree and height main effects were absorbed in the ANOVA. Based on 8 cardinal directions, the mealybugs showed slight preferences for northern and southern bole exposures (Table 1). To determine if any other directional preferences were apparent, the eight directions were pooled into several combinations for comparison (Table 1). Still, the mealybugs showed preferences only for northern and southern bole aspects.

Table 1. Mean number of *Dysmicoccus obesus* per square centimeter of bark surface recorded by height and direction on the bole of loblolly pine saplings (N = 26 trees).

Height		Cardinal Direction	
cm	Mean	Compass*	Mean No./cm²
0 to 10	0.031 ± 0.0050 a	NNW	0.050 ± 0.0079 a
10 to 20	0.043 ± 0.0073 a	NNE	0.049 ± 0.0067 a
20 to 30	0.042 ± 0.0104 a	SSW	0.047 ± 0.0104 ab
30 to 40	0.029 ± 0.0045 a	SSE	0.038 ± 0.0068 ab
40 to 50	0.026 ± 0.0052 a	ENE	0.036 ± 0.0100 ab
50 to 60	0.052 ± 0.0124 a	WNW	0.034 ± 0.0064 ab
60 to 70	0.040 ± 0.0083 a	ESE	0.031 ± 0.0057 ab
70 to 80	0.042 ± 0.0083 a	WSW	0.022 ± 0.0056 b
80 to 90	0.041 ± 0.0084 a	NE	0.042 ± 0.0060 a
		NW	0.042 ± 0.0051 a
		SE	0.035 ± 0.0044 a
		SW	0.035 ± 0.0059 a
		N	0.049 ± 0.0052 a
		S	0.043 ± 0.0062 ab
		E	0.034 ± 0.0057 b
		W	0.028 ± 0.0043 b
		N + S	0.046 ± 0.0040 a
		E + W	0.031 ± 0.0036 a

* For the first group, directions are based on the 8 cardinal directions. These 8 directions were pooled into various combinations to present progressively more course comparisons. Each directional grouping was analyzed separately.

Means with the same letter within a grouping are not significantly different at the 0.05 level; Tukey's Studentized Range Test.

Tree Symptoms. Initially, abnormal butt swell with rapid bole taper appeared to be one of the more severe results of mealybug infestation. However, comparing the calculated bole taper-index with total mealybugs demonstrated this relationship did not hold (Fig. 3). Mean taper-index for the 26 trees used in the analysis was 1.417 ± 0.0358. This mean is significantly different ($p < 0.05$) from published loblolly pine stem taper functions that produced corresponding bole taper-indices of 1.316 for natural stands (Farrar and Murphy 1988) and 1.237 for unthinned plantations (Feduccia et al. 1979). Evidently, our sample trees have a greater taper index than typical forest-run trees. The discrepancies between bole taper and number of mealybugs may reflect several factors. First, inconsistencies may exist between current and past infestation levels; second, some trees may be more recently infested than others, and abnormal growth is not yet evident; third, some trees may be more sensitive to mealybug feeding than others; or possibly all three factors are involved. Perhaps the effect this mealybug has on tree growth is similar to that of the balsam woolly adelgid, *Adelges piceae* (Ratzeburg), where saliva produces abnormal multiplication of cells and excessive growth, producing, among other effects, excessive bole taper (Drooz 1985).

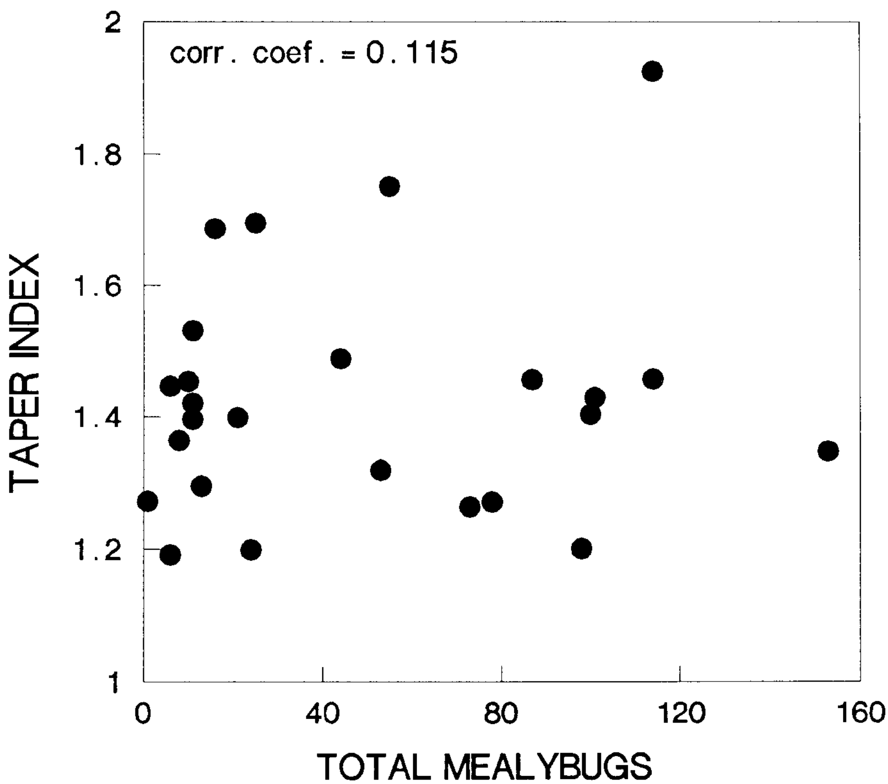

Fig. 3. Relationship between bole taper index (diameter at 10cm/80cm) of loblolly pine saplings (N = 25) and total number of *Dysmicoccus obesus* collected from 0 to 80 cm on each tree.

High application rates of single element fertilizers have been known to increase susceptiblity of trees to sucking insects (Foster 1968). However, the ANOVA showed the percentage of trees in each block with typical mealybug symptoms did not differ significantly (Table 2) by site preparation ($F_{1,13}$ = 2.76, P = 0.121) or fertilizer treatment ($F_{1,13}$, = 4.25, P = 0.060).

Table 2. Mean percentage of trees showing typical symptoms of *Dysmicoccus obesus* infestion by site preparation and fertilzer treatments.*

Site Preparation	Mean (%)	Fertilizer	Mean (%)
Maximum	2.96 ± 1.592 a	Nitrogen†	4.52 ± 3.028 a
		None	1.40 ± 1.014 a
Minimum	13.74 ± 6.941 a	Nitrogen	25.95 ± 11.186 a
		None	1.52 ± 0.519 a

* Completely randomized 2 × 2 factorial with 2 replicates.
† Total of 75 kg/ha of nitrogen; half applied in 1982 and half in 1983.
Means with the same letter for site preparation and fertilizer are not significantly different at the 0.05 level; Tukey's Studentized Range Test and the arcsine transformation.

Regional Distribution and Hosts. Although a comprehensive survey for mealybugs was not conducted in Arkansas, the insect is probably distributed on loblolly pine throughout the state. This conclusion is based on inspections of trees in 8 loblolly pine plantations in Hempstead County (southwestern Arkansas) and 5 in Drew County (southeastern Arkansas) in 1983. Although not always abundant, mealybugs were found in all plantations inspected. Indeed, because the mealybug has been found in 9 other states (Table 3), the insect is probably distributed throughout the range of its loblolly pine host in the southern United States. Additionally, the *D. obesus* collected in Maryland were from Virginia pine, *P. virginiana* Mill., establishing that the mealybug infests other species.

Table 3. State records for *Dysmicoccus obesus* (Lobdell).

State	County	Host	Date	Collector
Alabama*	Choctaw	Loblolly pine	20 Nov. 1958	L. L. Hyche
Arkansas	Hempstead	Loblolly pine	12 May 1983	V. L. Ford
Delaware†	New Castle	Loblolly pine	9 Sep. 1956	H. E. Milliron
Georgia*	Spalding	Loblolly pine	13 Oct. 1970	H. H. Tippins
Louisiana‡	Webster	Loblolly pine	31 Aug. 1966	B. H. Ebel
	Webster	Loblolly pine	19 Apr. 1968	H. O. Yates
Maryland*	Prince George	Virginia pine	8 Oct. 1946	H. S. McConnell
	Prince George	Virginia pine	4 Jun. 1948	H. S. McConnell
Mississippi§	Lauderdale	Pine	14 Nov. 1927	M. R. Smith
North Carolina¶	Chatham	Loblolly pine	25 Sep. 1987	R. H. Bradley
South Carolina**	Georgetown	Loblolly pine	10 Apr. 1989	R. L. Hedden
Virginia*	Albemarle	Pine	12 Jun. 1946	D. W. Clancy

* Personal communication with Dr. S. Nakahara.
† Milliron (1958)
‡ Personal communication with Dr. A. B. Hamon.
§ Lobdell (1930)
¶ Personal communication with Dr. L. L. Dietz.
**Personal communication with Dr. R. L. Hedden.

This mealybug's lack of notoriety may be due to several factors. First, inhabitation of bark crevices under bark scales can make the insect difficult to locate without some effort, and second, tree symptoms may be attributed to other factors or overlooked. These situations could easily occur in the weed-infested (Japanese honeysuckle, *Lonicera japonica* Thunberg, muscadine grape, *Vitis* spp., greenbrier, *Smilax* spp., and blackberry, *Rubus* spp.) young pine plantations where the mealybugs have been found.

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