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Susceptibility of *Ilex* Species, Hybrids and Cultivars to Florida Wax Scale (*Ceroplastes floridensis* Comstock)[1]

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Abstract

Susceptibility of 231 holly species, hybrids and cultivars to Florida wax scale (*Ceroplastes floridensis* Comstock) were evaluated on field grown plants in Tifton, Georgia. Florida wax scale have two generations/year in this region. Population ratings on different parental lines were grouped as either low populations (<10 scales/60 second count), moderate populations (11–20 scales/60 second count), high populations (21–40 scales/60 second count) and very high populations (>40 scales/60 second count). Taxa from the study rated as being least preferred (low populations) by the Florida wax scale included those with *I. crenata*, *I. buergeri*, *I. glabra*, *I. myrtifolia*, *I. verticillata* and *I. vomitoria* within parental lines. Those prone to heavy infestations were *I. aquifolium*, *I.* x *attenuata*, *I. cassine*, *I. ciliospinosa*, *I. cornuta*, *I.* x *koehneana*, *I. latifolia*, *I.* x *meserveae*, *I. opaca*, *I. purpurea*, *I. rugosa* and *I. serrata*. Other scale insects noted on the hollies included: Barnacle wax scale (*Ceroplastes cirripediformis* Comstock), Indian wax scale (*Ceroplastes ceriferus* (Fabricius)), European fruit lecanium (*Parthenolecanium corni* Bouche), Brown soft scale (*Coccus hesperidum* Linneaus), Tea scale (*Fiornia theae* Green), Latania scale (*Hemiberlesia lataniae* (Sign.)), and a pit scale (*Asterolecanium puteanum* Russell).

Index words: Florida wax scale (*Ceroplastes floridensis*), *Ilex*, integrated pest management, holly, pest-resistant plants.

Significance to the Nursery Industry

Use of pest-resistant plants can reduce the need for insecticide applications in the landscape and nursery. Identification of pest-resistant material also provides an opportunity for incorporation of pest-resistant plants in breeding programs. The knowledge of pest resistance status of available cultivars can enhance the recommendations concerning their use in landscapes. The 231 *Ilex spp*. selections in this study ranged from highly susceptible to resistant in regards to establishment of Florida wax scale populations. Florida wax scale populations may have two generations/year in the Southeastern United States. Having two generations/year makes predicting optimal timing for control measures more difficult. This can also increase the likelihood for spreading of the pest. Planting pest-resistant plants can help suppress populations of this pest. Species generally resistant to the Florida wax scale included: *I. buergeri*, *I. crenata*, *I. glabra*, *I. integra*, *I. myrtifolia*, *I. verticillata* and *Ilex vomitoria*. This information can assist nurserymen and landscapers to make alternative selections or take appropriate control measures. Plants rating moderate to very high for Florida wax scale would require control measures in nursery or landscape settings.

Introduction

The Florida wax scale (FWS), *Ceroplastes floridensis* Comstock, is a common scale species in the southern parts of North America. The origin of this insect is thought to be from the Neotropical region even though it now spans the following regions: Austro-Oriental region, Ethiopian region, Madagasian region, Neotropical region, New Zealand and Pacific region, Neartic region, Oriental region and the Paleartic region (1). Within the Neartic region the FWS ranges from Maryland to Florida and has been reported as far west as New Mexico. Although it occurs in the Northeastern United States, it is not considered a pest due to its inability to survive the winter (5). In the Southeastern United States, the FWS can become a serious pests of citrus and many landscape plants such as hollies (4, 5). The damage caused by the FWS includes both direct and indirect damage. Direct damage is caused by the insertion of stylets (for the purpose of feeding) by the insect. This can cause premature leaf drop,

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twig die-back and possibly death of the host if populations reach high numbers. Indirect damage can best be seen with the production of large amounts of honeydew which provides a good media for sooty mold growth. Sooty mold growth can cause a decrease in photosynthesis for the host as well as a decrease in the overall aesthetic value of the plant (7).

One generation per year of the FWS has previously been shown to occur in North America. However, a second generation has been shown to occur in areas with a sandy-loam soil such as Israel (5, 7). Eggs typically overwinter underneath the adult female which remains attached to the host plant foliage. Eggs that overwinter will hatch in early to late spring and the nymphs will search for a suitable feeding site. Once the nymphs settle, they start producing a characteristic wax covering that protects them while they are feeding. The FWS progresses through three nymphal stages before reaching its adult stage. Adult males are not known for this species. Our objective for this study was to determine the range of susceptibility among holly selections to the FWS.

Materials and Methods

Evaluation of FWS populations were conducted on the Holly collection field site at the University of Georgia Coastal Plain Experiment Station in Tifton, GA, on July 29–31 of 1998 and February 11–12 of 1999. A total of 231 selections representing species, hybrids and cultivars of *Ilex* were evaluated. The taxa were distributed randomly throughout the field site. Plant age ranged from two to seven years in the field. The field plot is approximately 0.6 ha (1.5 A) with rows being 3.8 m (12.5 ft) apart and individual plants spaced 3.05 m (10 ft) apart within rows. Population counts of FWS individuals, from all life stages, were made (using a hand-held counter) in 60 second intervals for each selection. Each count started on the western side of the plant and progressed counter-clockwise. Holly taxa were identified according to their parentage. Data were subjected to ANOVA using the GLM procedure, and mean separation was accomplished using a Waller-Duncan multiple range test. Populations of FWS on different parental lines were grouped in the following manner: low populations (<10 scales/60 sec); moderate populations (10–20 scales/60 sec); high populations (21–40) scales/60 sec) and very high populations (>40 scales/60 sec) (Tables 2 and 3). Population ratings were made for each of the individual selections (Table 4) by averaging the two counts and basing the rating on the mean of those counts. Data were also subjected to analysis of covariance with plant size as a covariate to determine whether plant size affected susceptibility ratings.

Results and Discussion

At the *Ilex* field collection in Tifton, GA, two generations of FWS were observed in 1998. The first generation emerged in the spring (May–June) and the second generation emerged in the fall of the year (November). Previous literature (1) only made one note of the FWS having two or more generations (Israel on citrus). All stages of the FWS feed on landscape plants such as hollies. Feeding sites of the FWS included both leaves and stems of *Ilex* selections. Average number of scale per 60 second count ranged from 1.2 to 38.9 in 1998 and 0.1 to 69.3 in 1999 (Table 1). The results from covariate analysis indicated that there was no influence of plant size on FWS populations. Hollies in the collection ranged from highly susceptible to resistant at the site (Table 4). Those supporting the fewest scale during 1998 and 1999 included: *Ilex buergeri*, *I. crenata*, *I. glabra*, *I. integra*, *I. myrtifolia*, *I. verticillata*, and *I. vomitoria* (Tables 2 and 3). In addition to the above mentioned parents, variegated plants regardless of parentage had low ratings. This held true even

Table 1. Florida Wax Scale counts based on parentage of different *Ilex* taxa in 1998 and 1999.

Species	(N)	Mean (1998 count)	Mean (1999 count)
aquifolium	28	24.7abc[z]	47.4abc
x *altaclarensis*	5	15.6bc	42.0abc
x *aquipernyi*	7	19.0bc	6.2c
x *attenuata*	16	20.5bc	29.8bc
buergeri	8	2.8c	8.4c
cassine	25	23.6abc	33.8bc
ciliospinosa	7	21.9abc	20.6bc
cornuta	65	21.8bc	47.7abc
crenata	9	2.4c	0.2c
decidua	9	11.8cde	14.6cde
glabra	6	1.7c	1.0c
integra	13	7.9c	12.2c
x *koehneana*	8	38.9ab	91.4ab
latifolia	24	27.5abc	71.3abc
x *meserveae*	4	26.0abc	69.3abc
myrtifolia	4	7.0c	3.8c
opaca	26	15.6bc	24.0bc
purpurea	3	16.7bc	37.0bc
pernyi	20	10.4c	17.9c
rugosa	5	51.2a	111.6a
serrata	6	16.0bc	34.0bc
verticillata	22	8.4c	3.2c
vomitoria	14	1.2c	0.1c

[z]Means within columns followed by the same letter or letters are not significantly different by Waller-Duncan.

Table 2. Ratings of *Ilex* spp. for FWS reported as population density per 60 second counts (July 1998).

Low (<10 scales)	Moderate (10–20 scales)	High (21–40 scales)	Very high (>40 scales)
buergeri	x *altaclarensis*	*aquifolium*	*rugosa*
crenata	*decidua*	x *attenuata*	
glabra	*opaca*	*cassine*	
integra	*pernyi*	*ciliospinosa*	
myrtifolia	*purpurea*	*cornuta*	
verticillata	*serrata*	x *koehneana*	
vomitoria	x *aquipernyi*	*latifolia*	
		x *meserveae*	

Table 3. Ratings of *Ilex* spp. for FWS reported as population density per 60 second counts (February 1999).

Low (<10 scales)	Moderate (10–20 scales)	High (21–40 scales)	Very high (>40 scales)
x *aquipernyi*	*decidua*	x *attenuata*	x *altaclarensis*
buergeri	*integra*	*cassine*	*aquifolium*
crenata	*pernyi*	*ciliospinosa*	*cornuta*
myrtifolia		*opaca*	x *koehneana*
glabra		*purpurea*	*latifolia*
verticillata		*serrata*	x *meserveae*
vomitoria			*rugosa*

Table 4. Relative resistance among holly taxa to Florida wax scale (FWS) in field evaluations.

Plant taxa	FWS preference	Plant taxa	FWS preference
Ilex x *altaclarensis* (Dallim.) Rehd.		'Avery Island'	L
'Emerald Elegance'	L	'Claredon Bat Wing'	VH
'Escort'	L	'Berries Jubilee'	H
'W.J. Bean'	H	'Burfordii'	H
'Wight Selection'	VH	'Dwarf Burford'	VH
'Wilsonii'	L	'RPV Special'	VH
Ilex aquifolium (L.)		'Cajun Gold'	L
'Angustifolia'	H	'Carissa'	L
'Golden Milkmaid'	L	'Cartwright Compact'	M
Ilex (*aquifolium* x *attenuata*)	L	'Casey'	VH
Ilex (*aquifoilium* x *cornuta*)		'D'Or'	M
'Hollowell'	M	'Dazzler'	VH
'Edward J. Stevens'	L	'Femina Spreading'	VH
NA 28279	L	'Fineline'	VH
'Nellie R. Stevens'	VH	'Hume'	M
Ilex [(*aquifolium* x *cornuta*) x *latifolia*]		'Lottie Moon'	VH
'Venus'	L	'Anicet Delcambre'	VH
Ilex [(*aquifolium* x *cornuta*) 'Nellie R. Stevens' x *integra*]		'O'Spring'	H
NA 28297	L	'Rotunda'	L
Ilex [(*aquifolium* x *cornuta*) 'Nellie R. Stevens' x *leucoclada*]		Accession S13-8	L
'Clusterberry'	L	'Sam Souder'	L
Ilex [(*aquifolium* x *cornuta*) x *pernyi*]		Accession N4-4	VH
'Miniature'	L	'Shangri La'	H
Ilex [(*aquifolium* x *cornuta*) x (*ciliospinosa* x (x *aquipernyi*))]		'Shui-Ying'	L
'Coronet'	VH	'Sizzler'	M
Ilex x *aquipernyi*		'Slack'	VH
Accession S14-1	L	'Stoutmeyer'	VH
'Dorothy Lawton'	L	'Sunrise'	L
'Dragon Lady'	L	*Ilex* (*cornuta* x *ciliospinosa*)	
'San Jose'	H	'Harry Gunning'	L
'Dragon Lady' (grafted on Nellie R. Stevens)	L	'Washington'	M
Ilex x *attenuata* Ashe		'William Cowgill'	VH
'Alagold'	H	*Ilex* (*cornuta* x *latifolia*)	
'Bienville Gold'	L	'Emily Bruner'	VH
'Blazer'	H	'Ginny Bruner'	VH
'Eagleson'	VH	'James Swan'	VH
'East Patalaka'	H	*Ilex* (*cornuta* x *pernyi*)	
'Foster No. 2'	L	'Brighter Shines'	M
'Gold'	M	'Dr. Kassab'	H
'Greenleaf'	M	'Gable #76'	M
'Hume'	L	'Hohman's Weeping'	M
'Marylin'	L	NA 28337	L
'Nasa'	M	*Ilex* [(*cornuta* x *pernyi*) x *aquifolium*]	
'Rocket'	L	'Doctor Bissonette'	L
'Savannah'	H	'Pernella'	L
'Sea Island'	L	*Ilex* [(*cornuta* x *pernyi*) x *latifolia*]	
'Sunny Foster'	M	'Mary Nell'	VH
Ilex buergeri Miq.		'Professor Joe'	M
Accession N3-7	M	*Ilex* [(*cornuta* x *pernyi*) x *latifolia*] x ?	
Accession N9-20	L	'Conal'	L
Accession S15-4	L	'Convive'	L
Accession S15-5	L	'Coned'	L
Ilex buergeri x *integra*	L	'Conaf'	L
Ilex cassine L.		'Conin'	M
Accession N5-11	VH	*Ilex cornuta* x ?	
Accession N5-10	VH	'Carolina Sentinel'	M
'Lowei'	H	Ilex crenata *Thunb.*	
Accession N5-13	L	'Convexa'	L
Accession S15-11	L	'Glass'	L
Accession N7-7	L	'Helleri'	L
Ilex (*cassine* var. *myrtifolia* x *opaca*)		'Jersey Pinnacle'	L
'Oriole'	L	'Repandens'	L
Ilex (*cassine* var. *angustifolia* x *vomitoria*)		'Snow Flake'	L
Accession N4-12	L	'Sky Pencil'	L
Ilex (*ciliospinosa* x *aquipernyi*)		'Soft Touch'	L
'September Gem'	L	'Variegata'	L
Ilex (*ciliospinosa* x *cornuta*)		Ilex decidua *Walt.*	
'Brilliant'	L	'Council Fire'	M
'Doctor Hu'	L	'Finches Golden'	L
Ilex colchica *Franch.*		Accession N7-10	H
Accession N3-6	L	'Pendula'	L
Ilex cornuta *Lindl.* & *Paxt.*		'Piedmont'	L

Table 4. Relative resistance among holly taxa to Florida wax scale (FWS) in field evaluations (continued).

Plant taxa	FWS preference	Plant taxa	FWS preference
'Pocohontas'	VH	*Ilex* (*opaca* var. *arenicola* x *cassine*)	
'Warren's Red'	H	'580 Lady'	L
Accession N7-9	L	Ilex pernyi *Franch.*	
var. curtissii	L	Accession S14-4	L
Ilex dimorphophylla Koidizumi	L	Accession S14-3	L
Ilex dipyrena Wallach	L	*Ilex* (*pernyi* x *latifolia*)	
Ilex glabra (*L.*) *Gray*		NA 28211	L
'Compacta'	L	Ilex purpurea *Hassk.*	
'Georgia Wine'	L	Accession N3-3	L
'Ivory Queen'	L	Accession N3-4	M
'Chamzin'	L	Accession N4-6	VH
Accession S1-3	L	*Ilex rubra* Watson	
'Shamrock'	L	Accession S14-8	L
Ilex integra *Thunb.*		Accession S14-7	L
Accession N5-18	L	*Ilex* (*rugosa* x *cornuta*)	
Accession N9-19	L	'China Boy'	VH
Ilex [*integra* x (x *altaclarensis* 'Hodginsii')]		'China Girl'	VH
'Scepter'	L	Ilex serrata *Thunberg ex. J.A. Murray*	
Ilex (*integra* x *pernyi*)		'Sundrops'	L
'Elegance'	L	*Ilex* (*serrata* x *verticillata*)	
Ilex (*integra* x *rugosa*)	L	'Autumn Glow'	VH
Ilex x *koehneana* = (*aquifolium* x *latifolia*)		'Carolina Cardinal'	L
'Agena'	L	'Harvest Red'	L
'Hohman'	VH	'Raritan Chief'	VH
'Jade'	VH	'Sparkleberry'	L
'Lassie'	VH	*Ilex shennongjiansis* T.R. Dudley and S.C. Sum	L
'Loch Raven'	L	*Ilex spinigera* (Loesener) Loesner	L
'Martha Berry'	L	Ilex verticillata *(L.) Gray*	
'Wetumpka'	L	'Afterglow'	M
'Wirt L. Winn'	VH	'Aurantica'	L
Ilex x *kuisiana*	VH	'Cacapon'	L
Ilex latifolia	M	'Chrysocarpa'	L
Ilex x *latifolia*		'Earlibright'	L
Accession N8-7	H	'Fairfax'	L
'Kurly Koe'	L	'Jim Dandy'	L
Accession N9-11	M	'Le Have'	L
Ilex latifolia x *cornuta*		'Maryland Beauty'	L
'Lib's Favorite'	L	'Peter's Fireworks'	L
Ilex longipes Chapman ex. Trelease f. *longipipes*	VH	'Port Joli'	L
Ilex macrocarpa Oliver	L	'Red Sprite'	L
Ilex x *meserveae* = (*aquifolium* x *rugosa*)		'Shaver'	L
Blue Maid® (grafted on Nellie R. Stevens)	M	'Southern Gentleman'	L
Blue Princess® (grafted on Nellie R. Stevens)	L	'Stoplight'	L
Blue Prince®	VH	'Winter Gold'	L
Blue Princes®	L	'Winter Red'	L
Ilex cassine var. mexicana (Turzinaow) Loesener	L	Ilex vomitoria *Ait.*	
Ilex maximowicziana var. kanehirae (Yamamota) Yamakazi		'Roundleaf'	L
Accession S10-8	L	'Condeaux'	L
Accession S10-7	L	'Dare County'	L
Ilex myrtifolia Walter		'Folsom's Weeping'	L
Orange fruit	L	'Gold Top'	L
Yellow fruit	L	'Kathy Ann'	L
Red Fruit	M	'Lynn Lowrey'	L
Ilex opaca *Ait.*		'Pendula'	L
'Canary'	L	'Saratoga Gold'	L
'Carolina No. 2'	VH	'Stokes Dwarf'	L
'Dan Fenton'	L	'Will Fleming'	L
'George Hart'	L	Accession N7-14	L
'Jersey Knight'	L	'Wiggin Yellow'	L
'Jersey Princess'	L	*Ilex* x *wandoensis* C.F. Miller	
'Maurice River'	L	Accession S12-5	M
'Red Velvet'	L	Accession S15-8	H
'William Hawkins'	L		

for *I. cornuta* which was shown to have high populations of FWS. A previous study (9) did show that two phloem feeding homopterans (*Unaspis euonymi* and *Aphis fabae*) preferred variegated selections of *Euonymous* over non-variegated selections. The authors noted that the performance of these two insects was enhanced on variegated plants due to an increased nitrogen flux. This study also suggested that the variegation mutation could increase the suitability of host plants to phloem feeding insects. It is not known why the FWS do not prefer variegated plants but the results of our study do reflect that variegated selections were less preferred than non-variegated selections.

Selections supporting the most scale insects during 1998 and 1999 had as parents: *I. aquifolium*, *I.* x *aquipernyi*, *I.* x *attenuata*, *I. cassine*, *I. ciliospinosa*, *I. cornuta*, *I.* x *koehneana*, *I. latifolia*, *I.* x *meserveae*, *I. purpurea*, and *I. rugosa*. One of the more popular varieties that is often used in landscapes is 'Savannah' from *I.* x *attenuata*. This variety rates as very high as do most of the varieties within *I.* x *attenuata*. There was one variety within *I.* x *attenuata* which rated as low ('Foster No. 2') which could be recommended to growers for use in place of 'Savannah'. Plants that were a cross between a susceptible host such as 'Nellie R. Stevens' and a resistant host such as *I. integra* yielded a hybrid that also rated low. Therefore, parents such as *I. integra*, which rated low and where crosses with *I. integra* also rated low, maybe useful for breeding purposes to develop selections resistant to FWS.

Deciduous selections included those plants with the following parents: *I. decidua*, *I. serrata* and *I. verticillata*. It was expected that deciduous plants would not be preferred with most of the scales being present on the leaves which would be shed in the fall of each year. Results indicated that *I. decidua*, *I. serrata* and *I. serrata* x *verticillata* rated as high to very high in FWS populations with substantial population numbers overwintering on the stem of the plants. Varieties within the *I. verticillata* group rated low (only 'Afterglow' rated moderate) in numbers of FWS present. Plants that had moderate to very high ratings would require treatment for scale.

Previous work (2) investigated the susceptibility of holly selections to another pest species, the two lined spittlebug (TLS) (*Prosapia bicincta* (Say)). The results from that study indicated that the following selections supported low or no levels of TLS: *I. buergeri*, *I. cornuta*, *I. crenata*, *I. decidua*, *I. glabra*, *I. integra*, *I. latifolia*, *I. verticillata* and *I. vomitoria*. Those selections that maintained high levels of TLS included: *I.* x *attenuata*, *I. cassine*, and *I. opaca*. Selections from both studies that support low levels of both pests include: *I. buergeri*, *I. crenata*, *I. glabra*, *I. integra* and *I. vomitoria*.

Additional insects were observed on the hollies at the field site. These included spittlebugs, sharpshooters and other scale insects. None of these other occasional pests were in high enough numbers to warrant the implementation of control measures. Other scale insects noted on the hollies included: barnacle wax scale (*Ceroplastes cirripediformis* Comstock), Indian wax scale (*Ceroplastes ceriferus* (Fabricius)), brown soft scale (*Coccus hesperidum* Linneaus), European fruit lecanium (*Parthenolecanium corni* Bouche), tea scale (*Fiornia theae* Green), Latania scale (*Hemiberlesia lataniae* (Sign.)), and a pit scale (*Asterolecanium puteanum* Russell). All of the above mentioned scale insects have been noted to occur on hollies and to be occasional pests reported in Georgia (6, 7, 8) except for the brown soft scale and the European fruit lecanium. The brown soft scale has been reported to infest hollies in Florida. A literature search revealed that this scale was reported to occur on *Ilex glabra* in the far eastern regions of Russia (3). This is the only other report to support that the European fruit lecanium can occur on this host.

These experiments evaluated the susceptibility of holly taxa to the Florida wax scale. The selections that were not observed to have infestations under these conditions may prove suitable for the FWS under no choice conditions. Cultural management practices such as irrigation and fertilization practices may also influence the degree of susceptibility of plant taxa to their insect and mite pests (10). Overall, 5 species were determined to have low susceptibility. The rest of the taxa investigated housed moderate to very high populations of the FWS and would require control measures to reduce populations of FWS.

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