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Armored scale (Hemiptera: Diaspididae) pests on *Abies fraseri* (Pinaceae) Christmas trees imported into Florida

Ian C. Stocks*

In preparation for the Christmas holiday season, various conifer tree species are imported by retailers into Florida during Nov and Dec for sale as cut Christmas trees. All commercial agricultural products, including imported Christmas trees, are subject both to border inspection and follow-up import inspection at the store or tree lot by the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (FDACS-DPI). Not surprisingly, some insect, spider, and mite species are collected from trees during inspection. Many are incidental, widespread, and present no risk, but several intercepted species are not known to occur in Florida and when found elicit a regulatory response, such as quarantine, treatment, or destruction. The most commonly imported Christmas tree species are *Abies* species ("firs"), in particular *Abies fraseri* (Pursh) Poir (Pinaceae). Although firs do not occur naturally in Florida, some species may rarely be grown as ornamentals, and many related conifer species occur in Florida either as part of native plant communities or as economically important commodities (e.g., pines, *Pinus* spp.) or landscape species.

Since 2012, DPI inspectors surveying imported Christmas trees have collected elongate hemlock scale, *Fiorinia externa* Ferris (Hemiptera: Diaspididae), a scale species not present in Florida. In Dec 2015, specimens of *Hemiberlesia ithacae* (Ferris) (Hemiptera: Diaspididae), the hemlock scale, were collected from *A. fraseri* Christmas trees grown in North Carolina. Hemlock scale has not previously been collected in Florida from imported Christmas trees, and like elongate hemlock scale, has potential host overlap with species that occur in Florida and is therefore a quarantinable pest. Import records indicate that most cut trees are imported from North Carolina, but also in lesser numbers from other eastern US states such as Virginia and Pennsylvania.

Fiorinia externa was described in 1912 from specimens collected in Maryland from hemlock (*Tsuga* spp.; Pinaceae), but almost certainly is native to Asia (Ferris 1942). The scale now occurs throughout hemlock forests in the temperate eastern United States. *Hemiberlesia ithacae* was described in 1883 from specimens collected in New York, also from hemlock, and is now widely distributed throughout the United States (García et al. 2015a,b). Hemlock scale was described in the genus *Aspidiotus* but transferred to *Abgrallaspis*, the combination under which most literature was published, and recently moved to *Hemiberlesia* (Normark et al. 2014); it is unclear to what region of the world hemlock scale is native.

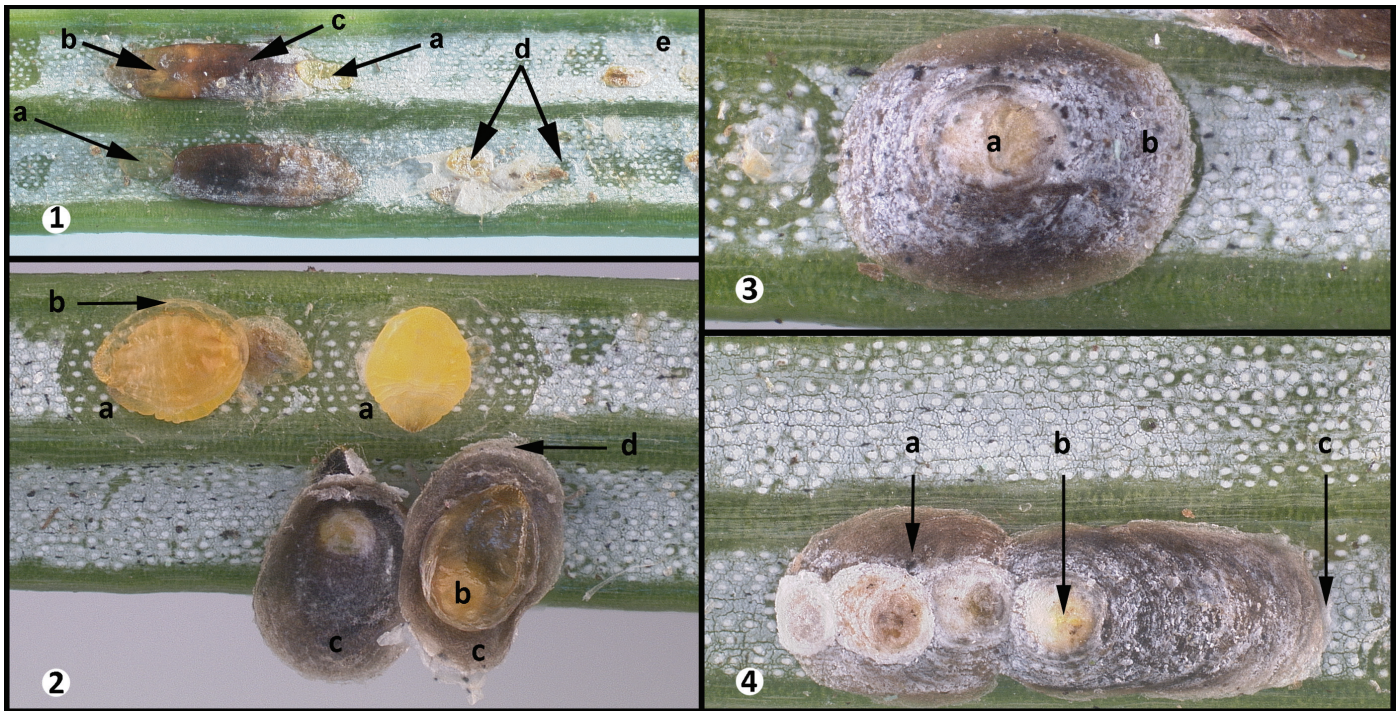
Both species develop on the underside, or abaxial surface, of the needle, but the shape of the cover of each species is distinct, a distinc-

tion in part reflected in the common name of *F. externa*, the elongate hemlock scale. Like the several related species of *Fiorinia* known in Florida, such as *F. theae* Green (tea scale) and *F. fioriniae* (Targioni Tozzetti) (many common names, camellia scale), elongate hemlock scale is longer than wide, whereas the scale cover of *H. ithacae*, like that of the common species *H. lataniae* (Signoret) (latania scale), is roughly circular in outline. Scale cover formation in armored scales was summarized by Stoetzel (1976). *Fiorinia proboscidea* Green (no common name), a potential pest of citrus, was recorded as a new continental record in 2013 (Stocks 2015) and should be consulted for additional images for comparison with *F. externa*. *Fiorinia* species differ significantly from most armored scale species in that the adult female remains contained within the exuviae, or cuticle, of the preceding stage, a condition termed "pupillarial." The habitus descriptions below pertain only to specimens on *Abies*, because specimens from other hosts have not been intercepted.

The adult female of *F. externa* (Fig. 1) is pupillarial, with the 2nd-stage exuviae dark brown, ~3 times longer than wide, and glossy. The exuviae of the crawler, or 1st-stage nymph, is attached terminally to the exuviae of the 2nd stage. Covers of other stages, such as developing males, with small amounts of attached wax may also occur on the needle (Fig. 1d), and yellow crawlers occur under or near the adult females, or are active on the leaf prior to settling. The pupillarial condition of the female makes it difficult to determine if it is still alive, but when observed with a 10–20× hand lens, living females or crawlers often are evident if the cover is opened. Submitted samples have varied from low levels of infestation with few living specimens to heavily infested ones with a high percentage of living scales of all stages. In some specimens, the cover varies along its length from an opaque light brown to dark brown; crawlers, embryonic cuticles, or crawler egg-shells can be seen beneath the exuviae in the opaque region, whereas the body of the female is shriveled toward the opposite end (Fig. 1a and c). The contours of the fir needle, as seen in cross section, create submarginal abaxial (ventral) "troughs" on each side of the mid-line in which the crawlers settle and develop. Each trough is covered by a white, waxy material (epicuticular wax; Fig. 1e) that protects the needle and the lines of respiratory stomata on the needle surface (Trimble et al. 1982).

The scale cover of adult females of *H. ithacae* (Figs. 2–4) is subcircular and varies in color from light brown to dirty gray. In general, the cover resembles that of *H. lataniae* and other aspidiotine scale insects, in which the scale cover of the adult female is composed of the cen-

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Figs. 1–4. Two intercepted scale species from imported Christmas trees in Florida. **1.** Female of *Fiorinia externa*; a) terminally attached crawler exuviae; b) hardened 2nd-stage female exuviae covering enclosed adult female, note enclosed embryonic cuticles; c) location of shriveled adult female; d) remains of males, with evidence of parasitism; e) plant stomatal bands and epicuticular wax. The adult females settled and developed in opposite orientations. **2–4.** Female of *Hemiberlesia ithacae*; **2.** a) body of adult female after scale cover removed; b) dorsal half of 2nd-stage exuviae; c) ventral surface of reflexed covers of early adult female; **3.** scale cover of early adult female; a) crawler exuviae; b) cover formation in early wax-deposition stages of development of adult female; **4.** commingled exuviae and scale covers of several females; a) cover formation in early wax-deposition stages of development of adult female. b) crawler exuviae and 2nd-stage wax; c) fully developed crawler flap for crawler emergence. Photograph credit: Ian Stocks.

trally or subcentrally located exuviae of the crawler (yellow to gold in color) and concentric layers of waxy material secreted by the female during growth. In this species, the exuviae of the 2nd stage is not integrated into the waxy material and is therefore not visible unless the cover is lifted and the female below is exposed. As noted above for elongate hemlock scale, this species also may become partly covered by the epicuticular wax, and in some instances the scale may appear to be striped (Figs. 3b and 4).

Multiple ages and remains of dead specimens are commingled on the needle (Fig. 4), but adult females can be located if the scale cover is gently lifted from the needle surface; adult females are golden-yellow and subcircular in outline (Fig. 2). For both species, identification is based on micro-anatomical structures observed in slide-mounted adult females.

Neither species has been reported on trees in the wild in Florida, but both are known as far south as Georgia, at least where appropriate hosts and conditions are present (García et al. 2015a, b), and *F. externa* is recorded throughout the temperate and boreal regions of Asia (China, Japan; García et al. 2015a, b). Both species are restricted to conifers, but the host range of elongate hemlock scale is wider and includes, in addition to Pinaceae, hosts in the families Cupressaceae and Taxaceae (García et al. 2015a,b).

Hemiberlesia ithacae hosts: *Abies* spp. (firs); *Picea* spp. (spruces); *Pseudotsuga menziesii* (Douglas fir); *Tsuga* spp. (hemlocks).

Fiorinia externa hosts: In addition to those listed for hemlock scale, hosts include Cupressaceae (*Juniperus* spp.), Taxaceae (*Taxus* sp.), and the genera *Cedrus* and *Pinus* (Pinaceae).

In Florida, hemlock, spruce, and fir do not occur naturally, and generally do not perform well under cultivation; thus, hemlock scale may not thrive in Florida. Conversely, many pine species (*Pinus* spp.) are

either native to Florida or commercially cultivated, and *Cedrus deodara* (Roxb.) G. Don f. (deodar) and *C. libani* A. Rich (Lebanon cedar), and many *Juniperus* species (Cupressaceae) are common landscape ornamental plants.

As documented hosts occur in the families Pinaceae and Cupressaceae, an expanded risk analysis based on potentially suitable hosts suggests that species in the families Taxaceae, Araucariaceae, and Podocarpaceae be evaluated as alternate hosts (e.g., Christenhusz et al. 2011). In Florida, Taxaceae include the critically endangered Florida torrey (Torrey *taxifolia* Arn.) and Florida yew (*Taxus floridana* Nutt. ex Chapman) as potentially suitable hosts. However, Jill Sidebottom, extension forestry integrated pest management specialist for North Carolina State University, who has extensive experience with both scale species and their economic and ecological impacts, did not find the scale during surveys of cultivated Florida torrey at the Biltmore Estate in Asheville, North Carolina, or of naturally growing stands in Torreya State Park, Florida (pers. comm.). No native species of Araucariaceae or Podocarpaceae occur in Florida, but both families include commercial ornamental species, such as the Norfolk Island pine (*Araucaria heterophylla* [Salisb.] Franco) and several species or varieties of podocarpus (*Podocarpus* spp., *Afrocarpus* sp.). Although both scale species may be economic pests under certain circumstances, biological controls (parasitoids and predators) are effective in suppression when part of an integrated pest management program (Jill Sidebottom, pers. comm.).

The phenomenon by which developing scale covers may acquire attributes of the substrate, such as by “burrowing” under the upper dermal layer, is well documented (e.g., mining scale, *Howardia biclavis* [Comstock], Miller & Davison 2005; *Diaspis gilloglyi* McKenzie, McKenzie 1963) and presumably confers additional environmental protection

to the scale or enhances crypsis. If the scale is transferring by some mechanism the epicuticular wax to the cover, it is likely to have a detrimental effect on the needle beyond that due to feeding. Epicuticular wax prevents condensation from blocking the stomata, thereby reducing gas exchange, and as such is integral to the proper physiological function of the needle (Jenks & Ashworth 1999).

The author extends his thanks to the many dedicated plant inspectors whose efforts help protect Florida's agriculture and native plants, and especially Lisa Hassell. Marc Frank, botanists at FDACS-DPI, provided information on the occurrence and cultivation of conifers in Florida and on epicuticular wax. Thanks are extended to Ben Normark, Dug Miller, John Davidson, and referees for their reviews. Voucher specimens are deposited with the Florida State Collection of Arthropods (FSCA), Coccoidea Slide Collection. This is contribution no. 1294 from the Bureau of Entomology, Nematology and Plant Pathology-Entomology Section.

Summary

Adventive and potentially pestiferous species are a constant threat to the agriculture of Florida. *Fiorinia externa* Ferris (Hemiptera: Diaspididae), the elongate hemlock scale, is a recent but persistently intercepted pest of Fraser fir and related species grown out-of-state and imported annually into Florida as cut Christmas trees. Although this and a second species, *Hemiberlesia ithacae* (Ferris) (Hemiptera: Diaspididae), the hemlock scale, may not become established in Florida on native or cultivated hosts, the risk remains and illustrates the importance of continued vigilance against pest species incursion.

Key Words: new record; Coccoidea; adventive species; economic entomology

Sumario

Especies que son plagas potenciales y que son adventivas son una amenaza constante para la agricultura de la Florida. *Fiorinia externa* Ferris (Hemiptera: Diaspididae) es una plaga reciente e interceptada repetidamente en abeto de Fraser y especies afines crecidas fuera del estado e importadas anualmente como árboles de Navidad. Aunque

es poco probable que esta especie, y una segunda, *Hemiberlesia ithacae* (Ferris) (Hemiptera: Diaspididae), se establezcan en la Florida en hospederos nativos o cultivados, el riesgo sigue existiendo e ilustra la importancia de mantener la vigilancia contra la incursión de plagas.

Palabras Clave: nuevo registro; Coccoidea; especies adventivas; entomología económica

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