

Scientific Note

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Invasive Chinese tallow tree serves as a new host for four scale insect species

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Abstract: Chinese tallow tree (*Triadica sebifera* [L.] Small) (Malpighiales: Euphorbiaceae) is one of the most invasive plants in the southeastern United States and is designated as a noxious weed in the state of Florida. Current management strategies for Chinese tallow are expensive and ineffective at the landscape scale, allowing for further spread. Here, we document the first records of four scale insect species, *Ceroplastes rusci* (Linnaeus) (Hemiptera: Coccidae), *Coccus hesperidum* Linnaeus (Hemiptera: Coccidae), *Rhizoecus floridanus* Hambleton (Hemiptera: Rhizoecidae), and *Aonidiella orientalis* (Newstead) (Hemiptera: Diaspididae), feeding on a small population of cultivated Chinese tallow and discuss the implications of invasive species interactions.

Keywords: Coccoomorpha; fig wax scale; brown soft scale; Florida ground mealybug; oriental scale; invasional meltdown

Resumen: El sebo chino (*Triadica sebifera* [L.] Small) (Malpighiales: Euphorbiaceae) es una de las plantas más invasoras del sureste de Estados Unidos y está designado, en el estado de Florida, como una maleza nociva. Las estrategias actuales de gestión del sebo chino son costosas e ineficaces a escala de paisaje, lo que fomenta una mayor propagación. Aquí documentamos los primeros registros de cuatro especies de insectos escamosos, *Ceroplastes rusci* (Linnaeus) (Hemiptera: Coccidae), *Coccus hesperidum* Linnaeus (Hemiptera:

Coccidae), *Rhizoecus floridanus* Hambleton (Hemiptera: Rhizoecidae) y *Aonidiella orientalis* (Newstead) (Hemiptera: Diaspididae), que se alimentan de una población pequeña de sebo chino cultivado y además discutimos las implicaciones de interacciones entre especies invasoras.

Palabras Clave: Coccoomorpha; escala de cera de higo; escama blanda marrón; cochinita molida de Florida; escala oriental; crisis invasiva

Chinese tallow tree (*Triadica sebifera* [L.] Small) (Malpighiales: Euphorbiaceae) is one of the most invasive and widespread weeds in the southern United States (Gan et al. 2009; Oswalt 2010; Pile et al. 2017). Native to East Asia, Chinese tallow was first introduced to the US in 1772, with the first recorded shipment of seeds to Georgia by Benjamin Franklin (Bell 1966). Chinese tallow was originally grown both as a seed oil crop and ornamental (Howes 1949; McComick 2005). In recent decades, Chinese tallow populations have increased rapidly, and are now found throughout most of the southern US including Texas, Louisiana, Mississippi, Alabama, and Florida (Oswalt 2010; Pile et al. 2017). In Florida, Chinese tallow is designated as a noxious weed and classified as a Florida Invasive Species Council (FISC) Category I invasive plant (McCormick 2005).

Chinese tallow is a monoecious, deciduous woody perennial capable of growing up to 18 m tall and producing up to 100,000 seeds per year (APHIS 2020; Vanheuveln 2016). Chinese tallow grows and spreads rapidly, outcompeting native plants and consequently causes reductions in arthropod biodiversity (Hartley et al. 2004). Current control methods, including costly herbicide applications, controlled burns, and mechanical removal, have shown to be ineffective at the landscape scale, with tallow continuing to expand its range (McCormick 2005; Vanheuveln 2016). In 2012, a study projected the economic impact of Chinese tallow from 2003 to 2023 to exceed \$200 million USD (Wang et al. 2012).

Besides direct economic losses and ecological impacts, an invasive plant can also facilitate the establishment and spread of invasive generalist herbivores, contributing to their invasion success, highlighting the importance of documenting interactions among invasive species (Engelkes and

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Mills 2013). Here, we document the first records of four scale insect species feeding on Chinese tallow in Florida.

From October 2022 to April 2024, *Ceroplastes rusci* (Linnaeus) (Hemiptera: Coccoomorpha: Coccidae), *Coccus hesperidum* Linnaeus (Hemiptera: Coccoomorpha: Coccidae), *Rhizoecus floridanus* Hambleton (Hemiptera: Coccoomorpha: Rhizoecidae), and *Aonidiella orientalis* (Newstead) (Hemiptera: Coccoomorpha: Diaspididae) were found feeding and reproducing on young cultivated Chinese tallow plants at the Florida Department of Agriculture and Consumer Services, Division of Plant Industry in Gainesville, Florida. All four scale insect populations had multiple life stages, including adult females and first-instar crawlers, present on the host with heavy infestations of *C. hesperidum* and *R. floridanus* persisting throughout the two-year period of observation. All Chinese tallow plants were grown from seeds collected in the southeastern US and were kept in greenhouse and screen-house conditions year-round. Again, in October 2023, *C. rusci* was found feeding on a Chinese tallow tree in the landscape in a residential area of Indian River County, Florida. Slide-mounted specimens are vouchered in the Florida State Collection of Arthropods (FSCA) in Gainesville, Florida. Prior to this study, 12 species of Coccoomorpha were known to feed on Chinese tallow worldwide (Table 1). Chinese tallow is a previously unrecorded host plant for each of these four scale insect species.

The fig wax scale, *C. rusci*, is a soft scale insect covered in a hemispherical thick pink wax test (Hodgson and Peronti 2012) (Figure 1a). This species first arrived in Florida in the mid-1990's, becoming established in the landscape after repeated introductions on nursery stock (FDACS-DPI Database 2024). First described from Italy, its native distribution is likely Palearctic, but present-day distribution is cosmopolitan, spanning 63 countries (García Morales et al. 2016). Of the 12 species of *Ceroplastes* wax scales in Florida, *C. rusci* was the most submitted species by plant inspectors over the last five years (FDACS-DPI Database 2024). *Ceroplastes rusci* is a polyphagous species recorded on 95 plant genera in 53 families (García Morales et al. 2016).

The brown soft scale, *C. hesperidum*, is a dorsoventrally flattened brown soft scale with a thin transparent wax test (Gill 1988; Hamon and Williams 1984) (Figure 1b). This common and widespread scale insect pest feeds on a recorded 417 plant genera across 138 families spanning 177 countries (García Morales et al. 2016). First described from Europe in the mid-18th century (Linnaeus 1758) and believed to be native to either the Afro-Ethiopian, Oriental, and/or Austro-Oriental regions (Kozár and Ben-Dov 1997), the oldest record in the United States National Museum (USNM) slide collection from Florida is from Cedar Key in 1880.

Table 1: All scale insects known to feed on *Triadica sebifera* from the published literature and the present study. Presence in Florida (FL) reported.

Family	Species	Present in FL	Source
Coccidae	<i>Ceronema koebeli</i> Green	No	Green (1909, 1937); Sasscer (1911); Ali (1971)
	<i>Ceroplastes rusci</i> (Linnaeus)	Yes	Present study
	<i>Coccus formicarii</i> (Green)	No	Ferris (1936); Ali (1971); Tao et al. (1983)
	<i>Coccus hesperidum</i> Linnaeus	Yes	Present study
	<i>Parasaissetia nigra</i> (Nietner)	Yes	Ali (1968, 1971); Tao et al. (1983)
	<i>Aonidiella orientalis</i> (Newstead)	Yes	Present study
Diaspididae	<i>Aspidiotus destructor</i> Signoret	Yes	Takahashi (1934)
	<i>Aulacaspis mischocarpis</i> (Cockerell & Robinson)	No	Ali (1969)
	<i>Aulacaspis yabunikkei</i> Kuwana	No	Hua (2000)
	<i>Hemiberlesia lataniae</i> Signoret	Yes	Beshear et al. (1973)
	<i>Lepidosaphes cycadicola</i> Kuwana	No	Hua (2000)
	<i>Lepidosaphes tubulorum</i> Ferris	No	Ferris (1921)
	<i>Lepidosaphes ulmi</i> (Linnaeus)	No	Quaintance and Sasscer (1916)
	<i>Pseudaulacaspis cockerelli</i> (Cooley)	Yes	Dekle (1965b)
<i>Pseudaulacaspis pentagona</i> (Targioni Tozzetti)	Yes	Beshear et al. (1973)	
Rhizoecidae	<i>Rhizoecus floridanus</i> Hambleton	Yes	Present study

The Florida ground mealybug, *R. floridanus*, is less than 2 mm in length and covered in powdery white wax (Hambleton 1973) (Figure 1c). It lacks marginal filaments and has geniculate (elbowed) antennae, set close to the apex of the head, which may be visible with a hand lens (McKenzie 1967). Root mealybugs are subterranean and produce loose wax ovisacs that can cover roots and surrounding soil (Kozár and Benedicty 2007; Miller et al. 2014; Williams 2004). Infestations are often inconspicuous until reaching severe levels, as with the heavy infestations in greenhouse-grown Chinese tallow. *Rhizoecus floridanus* has been named among the most damaging species of the Rhizoecidae in the US (Hambleton 1976) and is reported to feed on 41 host plant

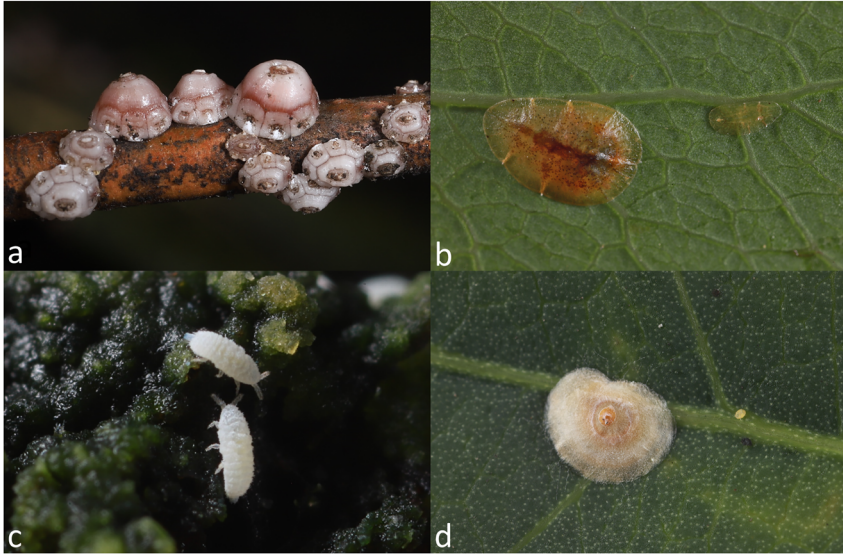


Figure 1: *In situ* photos of the four scale insect species found in the present study. (a) *Ceroplastes rusci* (Linnaeus) (Coccidae), fig wax scale, (b) *Coccus hesperidum* Linnaeus (Coccidae), brown soft scale, (c) *Rhizoecus floridanus* Hambleton (Rhizoecidae), Florida ground mealybug, and (d) *Aonidiella orientalis* (Newstead) (Diaspididae), oriental scale. Note that all species were photographed on *Triadica sebifera* (L.). Small except (a) which is pictured on *Platanus occidentalis* L.

genera across 27 families (García Morales et al. 2016). *Rhizoecus floridanus* was once considered endemic to Florida, although there are no records in Florida before 1959 (Hambleton 1973, 1976). Though its native origin is unclear, it appears to be limited to the US where its range is now known to include Florida, Georgia, Indiana, and Maryland (García Morales et al. 2016; Kosztarab 1996).

The oriental scale, *A. orientalis*, is an armored scale pest with a flat, yellow-brown, circular test with the first and second instar exuviae incorporated at its center (Dekle 1965a) (Figure 1d). Below the test, or cover, is where the yellow reniform adult female is found. Like all armored scales, the adult females lack legs and feed on individual plant cells with four long stylets (Foldi 1990). *Aonidiella orientalis* is a widespread polyphagous pest, known to feed on 187 plant genera in 77 families across 70 countries (García Morales et al. 2016). This species was first described from India in 1894 (Newstead 1894) and its native region is likely Asia (Miller et al. 2005). Records of *A. orientalis* in Florida date back to 1908 (Miller et al. 2005).

The polyphagous and pestiferous nature of these four scale insect species found feeding and reproducing on Chinese tallow in Florida eliminates them as promising biological control candidates. Formal host competency experiments should be done in the future to determine whether Chinese tallow is a preferred reproductive host of these scale insect species. Nevertheless, documenting the herbivore species feeding on invasive plants informs us of their ability to adapt to established nonindigenous species. Polyphagous insect herbivores may readily jump between their native hosts and nonindigenous hosts where ranges overlap, causing disruptions in community structure and overall ecosystem function (Crous et al. 2017; Rodriguez et al.

2019; Schwarz et al. 2005). For polyphagous exotic herbivores, invasive plants can contribute to their spread and geographic range expansion thereby complicating the management strategies for these herbivores (Engelkes and Mills 2013).

Invasive plants can have lower defenses in their invasive range due to decreased natural enemy pressure and high resource availability, thus allowing a shift in resource allocation to favor faster growth and reproduction (Blossey and Notzold 1995; Blumenthal 2006; Elton 1958; Orians and Ward 2010). These reduced defenses allow for higher herbivore loads over time (Siemann et al. 2006). Chinese tallow specifically has reduced defensive compounds in its invasive range, making it more susceptible to herbivory (Huang et al. 2010).

In addition to endemic species, invasive insects have been found to feed on invasive plants in their invasive range. For example, the invasive brown marmorated stink bug, *Halyomorpha halys* Stål (Hemiptera: Pentatomidae), is heavily associated with the invasive plants tree-of-heaven [*Ailanthus altissima* (Mill.) Swingle; Simaroubaceae] and empress tree [*Paulownia tomentosa* (Thunb.) Steud.; Paulowniaceae] in its invasive range in the US (Bakken et al. 2015; Hadden et al. 2023). Similarly, the invasive spotted lanternfly, *Lycorma delicatula* (White) (Hemiptera: Fulgoridae), is frequently observed on its preferred host, *A. altissima*, in the US (Dara et al. 2015; Wakie et al. 2020). The same holds true for scales, such as the newly invasive Asian armored scale, *Lepidosaphes laterochitinosus* Green (Hemiptera: Diaspididae), that prefers the Old-World *Epipremnum pinnatum* (L.) Engl. (Araceae) in Florida (Powell et al. 2023, 2024) or *Fiorinia phantasma* Cockerell & Robinson (Hemiptera: Diaspididae) frequently found on nonindigenous

palms like *Phoenix roebelenii* O'Brien (Arecales: Arecaceae) and *Cocos nucifera* L. (Arecaceae) (Ahmed et al. 2021). The process by which a group of nonindigenous species contributes to one another's invasion resulting in increased survival and greater ecological impact is known as invasional meltdown (Green et al. 2011; Simberloff and Van Holle 1999).

The four scale insect species discussed in this paper, three of which are known to be invasive in Florida, have now been found feeding and reproducing on Chinese tallow in Florida. These species using Chinese tallow as an alternative host may provide evidence of an invasional meltdown, potentially aiding in their invasive success. This observation of nonindigenous herbivores hosting on an invasive plant speaks to the long-term ecological impacts of invasive species and highlights the need for further research on this topic.

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