Biol Invasions (2026) 28:85
https://doi.org/10.1007/s10530-026-03784-9

ORIGINAL PAPER

Non-native scale insects (Hemiptera: Coccomorpha) of the United States and their impact on U.S. agriculture

Scott A. Schneider · Erin C. Powell

Received: 6 August 2025 / Accepted: 2 February 2026

Abstract Scale insects are ubiquitous herbivores that are frequently transported on plants through horticultural trade and are encountered at ports of entry worldwide. We provide an update on the non-native species of scale insects that have been introduced to the continental United States including: the species involved, their host associations, pest status, introduction rates, invasion pathways, and we estimate their economic impact on U.S. agriculture. There are 1099 species of scale insects recorded in the continental U.S., 297 are non-native species (27%). Introduced species belong to 16 families, the most common of which are Diaspididae (150), Pseudococcidae (63), and Coccidae (44). These species are often pests; 216 species (73%) are minor to major horticultural pests or are recently introduced and have the potential to become pests. Over half (56%) of introduced scale insects are polyphagous, able to survive and reproduce on many host plant families, and the most impacted commodities include deciduous and tropical fruiting trees (e.g., apple, banana, citrus, grapevine, stone fruits), landscape and ornamental plants (e.g., exotic trees, shrubs, palms, roses), grasses (e.g., ornamentals including bamboos, cereal grain crops, sugarcane), houseplants (e.g., cacti, orchids, snake plants, succulents), trees (e.g., conifers and hardwoods), and miscellaneous other commodities (e.g., cut flowers, cotton, coffee). Scale insects are estimated to cost U.S. agriculture and consumers between $4–8 billion USD annually in production losses and management costs. We discuss the impact of plant quarantine measures and expectations about future species introductions.

Keywords Agriculture · Coccoidea · Economic · Horticulture · Invasive · Polyphagy · Systematics

Handling editor: Laura Meyerson.

We have deposited all supplementary files in the Ag Data Commons repository. The DOI for our supplementary data, which we prefer to use is https://doi.org/10.15482/USDA.ADC/29318378.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.15482/USDA.ADC/29318378.

S. A. Schneider (✉)
USDA, Agricultural Research Service, Systematic Entomology Laboratory, c/o National Museum of Natural History, 1000 Constitution Ave NW, Washington, DC, USA
e-mail: scott.schneider3@usda.gov

E. C. Powell
Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Florida State Collection of Arthropods, 1911 SW 34th St., Gainesville, FL 32608, USA
e-mail: erin.powell@fdacs.gov

Published online: 30 March 2026

Introduction

Scale insects (Hemiptera: Coccomorpha) are ubiquitous herbivores that can be serious pests of agriculture, horticulture, and forestry. Scale insects, like other hemipterans, adhere to plants by their mouthparts and remain attached in this way for most of their life. Collectively they can feed on most plant parts, including the roots, stems, bark, leaves, and fruits. Many species are highly polyphagous and able to survive on a multitude of hosts. They have evolved an array of reproductive strategies (Ross et al. 2010), including thelytoky, which can facilitate establishment when species are introduced to new environments (Liebhold et al. 2024). And in general, scale insects tend to be tiny, cryptic, unusual in appearance, and less easily recognizable as insects to non-experts. As a result, scale insects are frequently and inadvertently transported by people through horticultural trade, in the mail, and even in passenger cargo on commercial flights (Lichtenberg and Olson 2018; Pace et al. 2022; Turbelin et al. 2022). They rank among the most encountered insects in plant quarantine at ports of entry worldwide (Liebhold et al. 2024; Suh et al. 2013; Turner et al. 2021) and many non-native species have become established in the United States.

Certain invasive scale insects have great historical significance. For example, the cottony cushion scale, *Icerya purchasi* Maskell, is notable for necessitating the earliest biological control efforts (Van Driesche and Bellows 1996) and damage caused by the San José scale, *Comstockaspis perniciosa* (Comstock), helped motivate Congress to pass the Plant Quarantine Act of 1912 as a check on new plant pest invasions (Marlatt 1920). Many additional non-native species have become established over time and their impact on U.S. agriculture, horticulture, and forestry ranges from minimal to severe (Gill and Kosztarab 1997; Kosztarab 1990; Miller and Davidson 1990, 2005). On average, one new scale insect species is introduced to the country each year (Miller et al. 2005).

Miller et al. (2005) published the first full account of the non-native scale insect species introduced to the continental United States. They found that 255 species are adventive or invasive in the U.S., which comprised over 25% of the nation's scale insect fauna at the time. Twenty years later, we provide an update to Miller et al. (2005), compiling information on all non-native scale insects now recorded in the continental U.S. Building on their foundation, this study aims to report on (1) the species involved, (2) their earliest record by state, (3) their host associations, (4) pest status, (5) world region of origin, and (6) associated references. We use these data to assess historical rates of introduction, invasion pathways, and we estimate the economic impact of invasive scale insects on U.S. agriculture. We note 14 species that were introduced prior to 2005 but were excluded from the original list. Since 2005, 28 more species (1.4 species/year) have been introduced to the continental U.S. for a total of 297 non-native scale insects out of 1099 species overall, comprising 27% of the U.S. scale insect fauna. These figures likely represent most of the non-native species introduced to the U.S. However, it should be noted that two additional putative introductions of undescribed cryptic species have been discussed in the literature (Ahmed and Miller 2018b; von Ellenrieder et al. 2022); beyond these records, it is unclear at present to what extent any additional cryptic species may be established in the U.S.

Some recently introduced species raise concerns for U.S. agriculture and the economy. *Nipponaclerda biwakoensis* (Kuwana) is invasive in the Mississippi River Delta and has contributed, along with other stressors (Cronin et al. 2020; Knight et al. 2020), to extensive die-off in *Phragmites*-dominated marshlands. Mississippi River Delta ecosystems provide \$12–47 billion in economic benefits each year (Batker et al. 2010). Negative economic impacts of marsh die-offs that may be attributable to *N. biwakoensis* are difficult to separate from other stressors such as soil erosion, salinity, and pollution. This species is an interesting example, as the consequences for its introduction extend beyond agriculture and include risks to critical infrastructure (i.e., via increased hurricane damage). The Florida invasive *Fiorinia phantasma* Cockerell & Robinson has become a major pest of key commodities, primarily attacking palms along with many other valuable ornamentals and tropical fruit trees in Florida's multi-billion-dollar horticultural industry (Ahmed et al. 2021). In 2010, palms alone made up 10% of Florida's nursery and greenhouse sales, totaling \$404 million (Khachatryan and Hodges 2014). *Lepidosaphes laterochitinosa* Green is also now invasive in Florida, where it is increasingly found on common ornamental plants and appears to be spreading rapidly through southern Florida (Powell et al. 2024c). *Lepidosaphes laterochitinosa* has been taken in U.S. plant quarantine frequently in recent years and is known to feed on 29 host plant families including major commodities in the U.S., like citrus and grapevine. Both of these industries are valuable to U.S. agriculture; citrus production in the U.S. in 2024 was valued at $2.98 billion (Anonymous 2024) and in 2023 California's grape industry was valued at $6.52 billion (Anonymous 2023a). The potential for *L. laterochitinosa* to spread rapidly coupled with its broad host range raises concern for several U.S. commodities. In recent years, *Nipaecoccus viridis* (Newstead) has also become established in Florida, and *Citrus* spp. are among its preferred hosts (Olabiyi et al. 2023; Stocks 2013). It feeds on 53 host plant families and has been recorded as a pest on commodities that are important in other regions of the U.S., like cotton, grapevine, potatoes, soybean, and tomatoes in addition to many ornamentals (Maxwell-Lefroy 1908; Misra 1920; Sharaf and Meyerdirk 1987; Williams 2004).

This article evaluates information about non-native scale insect species in the U.S. to address the following questions. (1) Where have non-native species in the United States originated from and have trends in the region of origin changed over time? (2) Where are new species entering and establishing in the United States? (3) Are scale insect introduction rates tied to the volume of horticultural imports? (4) What are the major hosts and commodity groups impacted or at risk? And (5) what is the economic impact of invasive scale insects on U.S. agriculture?

Methods

Species introduction data

We reviewed publication records compiled in ScaleNet (García Morales et al. 2016) and updated the existing list to include species introduced to the United States since 2005 (Table 1). Species are treated as introduced when they are established in outside environments, excluding species known only from greenhouses, nurseries, or quarantine inspections. A full list of U.S. species with justification for any exclusions is provided in Table S1. Earliest records come from the literature and specimens in the collections of the National Museum of Natural History, Washington D.C. (USNM); The Florida State Collection of Arthropods, Gainesville, Florida (FSCA); and The Bohart Museum, Davis, California (UCD). Miller et al. (2005) noted that some of the earliest species records date back to when specimens were first deposited in museums and the actual date of introduction to the U.S. may have preceded these records by decades. For lack of better records, these are considered close to the actual date of introduction. Comments on pest status and region of origin are drawn primarily from the literature and these determinations are often subjective. Some cosmopolitan species were already widespread by the 1700–1800s and their origins may only be determined by relationships to other species that have limited geographical distribution. The principal hosts are grouped by categories and the term polyphagous is defined as any species known from 10 or more families of hosts following Miller et al. (2005). Some extremely polyphagous species, such as *Coccus hesperidum* Linnaeus, feed on at least 140 host plant families. ScaleNet compiles detailed information regarding host associations for further reference. We aim to give enough context here to convey commodity groups at risk.

Invasion pathways

Where have non-native species in the United States originated from and have trends in the region of origin changed over time? To address these questions, we plotted the number of species introduced from each region of origin over time. Observations were filtered to exclude species for which the origin is unknown but included observations with a best estimate. Species with more than one earliest state record occurring in the same year were treated as one introduction event, for a total of 247 observations. To assess differences among regions of origin we conducted a Kruskal–Wallis test and post-hoc comparisons of regions using the Dunn test with the R package ggstatsplot (Patil 2021). Introduction data available as of August 2025 were used for this and subsequent analyses.

Where are new species entering and establishing in the United States? We summed species introduction records for the continental U.S. overall and by regional groups of states, as defined by the U.S. Bureau of Economic Analysis, but we parsed out

Table 1 List of non-native U.S. species of scale insects

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Aclerdidae	*Aclerda takahashii* Kuwana **	established	FL, 2016	Stocks (2016a)	not a pest	Mottern et al. (2021)	grasses	1	AUS or ORI	
Aclerdidae	*Aclerda tokionis* (Cockerell)	established	CA, 1900	Kuwana (1902b)	not a pest	Gill (1993)	grasses	1	PAL	Gill (1993)
Aclerdidae	*Nipponaclerda biwakoensis* (Kuwana) **	established	LA, 2016	Knight et al. (2018)	pest	Knight et al. (2018)	grasses	2	ORI	Schneider et al. (2022)
Asterolecaniidae	*Asterodiaspis luteola* (Russell)	uncertain	PA, 1915	Russell (1941)	not a pest		trees	1	PAL	Stumpf and Lambdin (2006)
Asterolecaniidae	*Asterodiaspis minor* (Russell) *	established	PA, 1908	Russell (1941)	serious pest	Gill (1993)	trees	1	PAL	Stumpf and Lambdin (2006)
Asterolecaniidae	*Asterodiaspis quercicola* (Bouche) *	established	NY, 1898	Russell (1941)	pest	Gill (1993)	trees	1	PAL	Stumpf and Lambdin (2006)
Asterolecaniidae	*Asterodiaspis variabilis* (Russell)	uncertain	NY, 1903	Russell (1941)	not a pest		trees	1	PAL	Stumpf and Lambdin (2006)
Asterolecaniidae	*Asterodiaspis variolosa* (Ratzeburg)	established	DC, 1879	Russell (1941)	serious pest	Russell (1941)	trees	2	PAL	Stumpf and Lambdin (2006)
Asterolecaniidae	*Asterolecanium epidendri* (Bouché)	established	FL, 1941	USNM	not a pest		polyphagous	14	NEO	Stumpf and Lambdin (2006)
Asterolecaniidae	*Bambusaspis bambusae* (Boisduval)	established	FL, 1908	USNM	pest	Hamon (1980a)	grasses	8	PAL or ORI	Gill (1993)
Asterolecaniidae	*Bambusaspis bambusicola* (Kuwana) *	established	LA, 1919	Russell (1941)	not a pest		grasses	1	ORI	
Asterolecaniidae	*Bambusaspis miliaris* (Boisduval)	established	FL, 1919	USNM	pest	Stumpf and Lambdin (2006)	grasses	1	uncertain	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Asterolecaniidae	*Bambusaspis minuta* (Takahashi) **	established	FL, 2024	FSCA	pest	Powell et al. (2024a)	grasses	1	ORI	Takahashi (1930), Russell (1941)
Asterolecaniidae	*Planchonia arabidis* (Signoret)	established	CT, 1925	USNM	pest	Gill (1993)	polyphagous	22	PAL	Gill (1993)
Asterolecaniidae	*Planchonia stentae* (Brain)	established	CA, 1980	USNM	pest	Stumpf and Lambdin (2006)	polyphagous	16	AFR	Stumpf and Lambdin (2006)
Asterolecaniidae	*Pollinia pollini* (Costa)	established	CA, 1944	Armitage and McKenzie (1952)	pest	Gill (1993)	fruit	2	PAL	Gill (1993)
Asterolecaniidae	*Russellaspis pustulans* (Cockerell)	established	FL, 1882	USNM	pest	Stumpf and Lambdin (2006)	polyphagous	69	NEO	Stumpf and Lambdin (2006)
Cerococcidae	*Cerococcus deklei* Kosztarab, Vest	established	TX, 1927	Kosztarab and Vest (1966)	pest	Lambdin and Kosztarab (1977)	polyphagous	11	NEO	
Coccidae	*Ceroplastes ceriferus* (Fabricius)	established	CA, 1907	Carnes (1907)	pest	Gimpel et al. (1974)	polyphagous	62	NEO	Qin et al. (1998)
Coccidae	*Ceroplastes cirripediformis* Comstock	established	FL, 1880	Gimpel et al. (1974)	pest	Gimpel et al. (1974)	polyphagous	67	NEO	Qin et al. (1998)
Coccidae	*Ceroplastes dugesii* Lichtenstein	established	FL, 1908	Gimpel et al. (1974)	pest	Hamon and Williams (1984)	polyphagous	13	NEO	Gimpel et al. (1974)
Coccidae	*Ceroplastes floridensis* Comstock	established	FL, 1828	Gimpel et al. (1974)	pest	Gimpel et al. (1974)	polyphagous	70	uncertain	Qin et al. (1998)
Coccidae	*Ceroplastes rubens* Maskell	established	FL, 1955	Gimpel et al. (1974)	pest	Gimpel et al. (1974)	polyphagous	84	AFR	Qin et al. 1994
Coccidae	*Ceroplastes rusci* (Linnaeus)	established	FL, 1994	Hamon and Mason (1997)	pest	Ben-Dov (1988a)	polyphagous	52	AFR	Qin et al. (1994)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Coccidae	*Ceroplastes sinensis* Del Guercio	established	NC, 1920	Gimpel et al. (1974)	pest	Gimpel et al. (1974)	polyphagous	58	NEO	Qin et al. (1994)
Coccidae	*Ceroplastes stellifer* (Westwood)	established	FL, 1953	Dekle (1969)	pest	Dekle (1969)	polyphagous	22	ORI ?	
Coccidae	*Coccus capparidis* (Green)	established	FL, 1974	FSCA	minor pest	Gill et al. (1977)	polyphagous	21	ORI	
Coccidae	*Coccus hesperidum* Linnaeus	established	CA, 1880	USNM	pest	Ebeling (1959)	polyphagous	133	ORI	
Coccidae	*Coccus longulus* (Douglas)	established	FL, 1907	USNM	not a pest in US	Hamon and Williams (1984)	polyphagous	56	ORI(?)	
Coccidae	*Coccus pseudhesperidum* (Cockerell)	established	FL, 1923	Merrill and Chaffin (1923)	minor pest	Gill (1988)	houseplants	3	NEO	Gill et al. (1977)
Coccidae	*Coccus pseudomagnoliarum* (Kuwana)	established	CA, 1910	USNM	serious pest	Ebeling (1959)	polyphagous	16	PAL	Gill et al. (1977)
Coccidae	*Coccus viridis* (Green)	established	FL, 1921	FSCA	serious pest	Gill et al. (1977)	polyphagous	65	AFR	Gill et al. (1977)
Coccidae	*Eriopeltis festucae* (Boyer de Fonscolombe)	established	NY, 1899	USNM	minor pest	Williams and Kosztarab (1972)	grasses	2	PAL	
Coccidae	*Eucalymnatus tessellatus* (Signoret)	established	CA, 1897	UCD	serious pest	Dekle (1973)	polyphagous	57	NEO	Gill (1988)
Coccidae	*Eulecanium cerasorum* (Cockerell)	established	CA, 1909	USNM	serious pest	Gill and Kosztarab (1997)	trees	9	PAL	Gill (1988)
Coccidae	*Eulecanium kunoense* (Kuwana)	established	CA, 1896	USNM	serious pest	McKenzie (1951)	fruit	7	PAL	Gill (1988)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Coccidae	*Eulecanium tiliae* (Linnaeus)	established	CA, 1908	USNM	serious pest	Kosztarab (1996)	polyphagous	17	PAL	Bartlett (1978)
Coccidae	*Kilifia acuminata* (Signoret)	established	FL, 1912	USNM	pest	Nada et al. (1990)	polyphagous	36	ORI	
Coccidae	*Milviscutulus mangiferae* (Green)	established	FL, 1917	Wilson 1917	serious pest	Avidov and Harpaz (1969)	polyphagous	43	ORI	
Coccidae	*Parasaissetia nigra* (Nietner)	established	FL, 1920	FSCA	serious pest	Gill (1988)	polyphagous	101	AFR or ORI	Gill (1988)
Coccidae	*Parthenolecanium corni* (Bouché)	established	KS, 1874	USNM	serious pest	Hamon and Williams (1984)	polyphagous	51	PAL	
Coccidae	*Parthenolecanium fletcheri* (Cockerell)	established	IN, 1889	USNM	pest	Stimmel (1978)	trees	2	PAL	
Coccidae	*Parthenolecanium persicae* (Fabricius)	established	CA, 1897	USNM	serious pest	Williams and Kosztarab (1972)	polyphagous	34	PAL	
Coccidae	*Phalacrococcus howertoni* Hodges and Hodgson**	established	FL, 2008	FSCA	pest	Hodges and Hodgson(2010)	polyphagous	35	NEO uncertain	Hodges and Hodgson(2010)
Coccidae	*Physokermes hemicryphus* (Dalman)	established	CA, 1958	USNM	pest	Santas (1988)	trees	2	PAL	Gill (1988)
Coccidae	*Protococcus acutissimus* (Green)	established	FL, 1956	Gill et al. (1977)	not a pest	Gill et al. (1977)	polyphagous	29	ORI	
Coccidae	*Protopulvinaria pyriformis* (Cockerell)	established	FL, 1906	USNM	serious pest	Del Rivero (1966)	polyphagous	36	NEO(?)	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Coccidae	*Pseudokermes vitreus* (Cockerell) *	reestablished FL (previously eradicated from FL, Dekle 1969)	FL, 1917	USNM	not a pest	Hamon and Williams (1984)	polyphagous	10	NEO	Hamon and Williams (1984)
Coccidae	*Pulvinaria citricola* Kuwana	established	CA, 1939	Gill (1988)	serious pest	Gill and Kosztarab (1997)	polyphagous	15	PAL	
Coccidae	*Pulvinaria delottoi* Gill	established	CA, 1973	Gill (1979)	serious pest	Gill and Kosztarab (1997)	houseplants	2	AFR	Gill (1979)
Coccidae	*Pulvinaria elongata* Newstead	established	FL, 1927	USNM	minor pest	Carnegie (1997)	grasses	3	AFR	Williams and Watson (1990)
Coccidae	*Pulvinaria floccifera* (Westwood)	established	GA, 1892	USNM	pest	Gill and Kosztarab (1997)	polyphagous	32	PAL	Steinweden (1946)
Coccidae	*Pulvinaria mesembryanthemi* (Vallot)	established	CA, 1971	Gill (1979)	pest	Donaldson et al. (1978)	houseplants	2	AFR	Washburn and Frankie (1985)
Coccidae	*Pulvinaria phaiae* Lull	uncertain (eradicated CA, Gill (1988)	CA, 1906	UCD	minor pest	Gill (1988)	houseplants	1	PAL	Gill (1988)
Coccidae	*Pulvinaria psidii* Maskell	established	FL, 1909	USNM	pest	Nada et al. (1990)	polyphagous	71	ORI(?)	
Coccidae	*Pulvinaria urbicola* Cockerell	established	FL, 1923	Merrill and Chaffin (1923)	serious pest	Gill and Kosztarab (1997)	polyphagous	44	NEO	
Coccidae	*Pulvinaria vitis* (Linnaeus)	established	NY, 1880	USNM	pest	Kosztarab and Kozár (1988)	polyphagous	15	PAL	Hodgson (1994)
Coccidae	*Saissetia coffeae* (Walker)	established	CA, 1914	USNM	pest	Hamon and Williams (1984)	polyphagous	112	AFR	Gill (1988)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Coccidae	*Saissetia miranda* (Cockerell, Parrott)	established	FL, 1918	USNM	pest	Stauffer and Rose (1997)	polyphagous	27	AFR?	
Coccidae	*Saissetia neglecta* De Lotto	established	FL, 1921	USNM	pest	Stauffer and Rose (1997)	polyphagous	34	AFR?	
Coccidae	*Saissetia oleae* (Olivier)	established	CA, 1880	Bartlett (1978)	pest	Bartlett (1978)	polyphagous	81	AFR	Bartlett (1978)
Coccidae	*Sphaerolecanium prunastri* (Boyer de Fonscolombe)	established	PA, 1895	USNM	serious pest	Gill and Kosztarab (1997)	fruit	5	PAL	Hodgson (1994)
Conchaspididae	*Conchaspis angraeci* Cockerell	established	FL, 1905	USNM	pest	Hamon (1979)	polyphagous	25	NEA	Cockerell (1893)
Cryptococcidae	*Cryptococcus fagisuga* Lindinger	established	MA, 1919	Miller (1985)	pest	Kosztarab (1996)	trees	3	PAL	Ehrlich (1932)
Diaspididae	*Acutaspis aliena* (Newstead)	established	FL, 1919	FSCA	not a pest	Dekle (1976)	polyphagous	12	NEO	
Diaspididae	*Andaspis hawaiiensis* (Maskell)	established	FL, 1922	FSCA	not a pest	Dekle (1976)	polyphagous	23	AUS or ORI	Williams and Watson (1988a)
Diaspididae	*Aonidia lauri* (Bouché)	established but eradicated from CA Gill (1997)	NY, 1907	USNM	not a pest		trees	2	PAL	
Diaspididae	*Aonidiella aurantii* (Maskell)	established	CA, 1875	Rosen and DeBach (1978)	serious pest	Rosen and DeBach (1978)	polyphagous	87	ORI	McKenzie (1938)
Diaspididae	*Aonidiella citrina* (Coquillett)	established	CA, 1872	Rosen and DeBach (1978)	pest	Rosen and DeBach (1978)	polyphagous	28	ORI	McKenzie (1938)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Aonidiella inornata* McKenzie	established?	TX, 1968	McDaniel (1968)	not a pest		polyphagous	29	ORI	McKenzie (1938)
Diaspididae	*Aonidiella orientalis* (Newstead)	established	FL, 1908	USNM	pest	Dekle (1976)	polyphagous	73	ORI	McKenzie (1938)
Diaspididae	*Aonidiella taxus* Leonardi	established but eradicated from CA Gill (1997)	LA, 1921	Howard and Oliver (1985)	pest	Johnson and Lyon (1988)	trees	3	ORI	McKenzie (1938)
Diaspididae	*Aonidomytilus albus* (Cockerell)	established	FL, 1918	FSCA	not a pest in US	Dekle(1976)	polyphagous	12	NEO or NEA	
Diaspididae	*Aspidiella sacchari* (Cockerell)	established	FL, 1914	USNM	minor pest	Dekle (1976)	grasses	6	ORI?	
Diaspididae	*Aspidiotus cryptomeriae* Kuwana	established	NY, 1937	USNM	pest	Stimmel 1986	trees	4	PAL	
Diaspididae	*Aspidiotus destructor* Signoret	established but eradicated from CA Gill (1997)	FL, 1920	FSCA	serious pest	Taylor (1935), Balachowsky (1948)	polyphagous	72	AUS?	Balachowsky (1948)
Diaspididae	*Aspidiotus excisus* Green	established	FL, 1964	Dekle (1966)	pest	Dekle (1976)	polyphagous	26	ORI	
Diaspididae	*Aspidiotus nerii* Bouché	established	FL, CA, 1880	USNM	serious pest	Gill (1997)	polyphagous	121	AUS	Ferris (1941), Schneider et al. (2018)
Diaspididae	*Aulacaspis rosae* (Bouché)	established	CA, FL, NY, 1880	USNM	pest	Gill (1997)	polyphagous	11	PAL	Balachowsky (1954)
Diaspididae	*Aulacaspis tubercularis* Newstead	established	FL, 2002	Miller and Davidson (2005)	pest	Labuschagne et al. 1995	polyphagous	22	ORI	Normark et al. (2019)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Aulacaspis yasumatsui* Takagi	established	FL, 1996	Howard et al. (1999)	serious pest	Howard et al. (1999)	landscape	3	ORI	Howard et al. (1999)
Diaspididae	*Carulaspis juniperi* (Bouché)	established	MA, 1900	USNM	pest	Gill (1997)	trees	3	PAL	Balachowsky (1954)
Diaspididae	*Carulaspis minima* (Signoret)	established	CA, 1932	McKenzie (1956)	pest	Gill (1997)	trees	4	PAL	Gill (1997)
Diaspididae	*Chionaspis etrusca* Leonardi	established	AZ, 1917	Liu et al. (1989)	not a pest	Gill (1997)	trees	3	PAL	Gill (1997)
Diaspididae	*Chionaspis gilli* Liu, Kosztarab	established	AZ, 1933	Liu et al. (1989)	not a pest	Gill (1997)	trees	1	PAL	Gill (1997)
Diaspididae	*Chionaspis salicis* (Linnaeus)	established	MN, 1898	Liu et al. (1989)	minor pest	Lambdin 1990	polyphagous	27	PAL	
Diaspididae	*Chionaspis wistariae* Cooley	established	CA, 1926	Liu et al. (1989)	not a pest	Gill (1997)	landscape	3	PAL	Gill (1997)
Diaspididae	*Chrysomphalus aonidum* (Linnaeus)	established	FL, 1880	USNM	serious pest	Dekle (1976)	polyphagous	74	ORI	Rosen and DeBach (1978)
Diaspididae	*Chrysomphalus bifasciculatus* Ferris	established	CA, 1930	UCD	minor pest	Morrison (1946)	polyphagous	33	ORI or AUS	McKenzie (1939)
Diaspididae	*Chrysomphalus dictyospermi* (Morgan)	established	FL, 1903	USNM	pest	Gill (1997)	polyphagous	81	ORI or AUS	McKenzie (1939)
Diaspididae	*Chrysomphalus diversicolor* (Green) *	uncertain; only US records date back to 1920s	AL, 1921	Waltman et al. (2016)	not a pest		polyphagous	23	AFR	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Clavaspis herculeana* (Cockerell, Hadden)	established	FL, 1910	USNM	minor pest	Miller and Davidson (1990)	polyphagous	25	NEO	
Diaspididae	*Comstockaspis perniciosa* (Comstock)	established	CA, 1870	Rosen and DeBach (1978)	serious pest	Gonzalez (1981)	polyphagous	42	PAL	Rosen and DeBach (1978)
Diaspididae	*Diaspidiotus braunschvigi* (Rungs)	eradicated from US, Gill (1997)	CA, 1935	McKenzie (1956)	not a pest	Balachowsky (1950)	landscape	2	PAL	Gill (1997)
Diaspididae	*Diaspidiotus degeneratus* (Leonardi)	established	CA, 1931	McKenzie (1956)	minor pest	Gill (1997)	landscape	9	PAL	
Diaspididae	*Diaspidiotus gigas* (Thiem, Gerneck)	established	NY, OH, PA, 1902	USNM	pest	Baker 1972	trees	6	PAL	Balachowsky (1950)
Diaspididae	*Diaspidiotus ostreaeformis* (Curtis)	established	OH, 1895	USNM	pest	Richards 1962	polyphagous	20	PAL	Balachowsky (1950)
Diaspididae	*Diaspis boisduvalii* Signoret	established	FL, 1896	USNM	serious pest	Dekle (1976)	polyphagous	39	NEO	Balachowsky (1954)
Diaspididae	*Diaspis bromeliae* (Kerner)	established	FL, 1899	USNM	not a pest in US	Dekle (1976), Gill (1997)	polyphagous	11	NEO or NEA	Ferris (1937)
Diaspididae	*Diaspis coccois* Lichtenstein	established	CA, 1919	UCD	not a pest	Gill (1997)	landscape	4	NEO or NEA	
Diaspididae	*Diaspis echinocacti* (Bouché)	established	TX, 1893	USNM	pest		polyphagous	10	NEO or NEA	Ferris (1937)
Diaspididae	*Diaspis townsendi* Cockerell **	uncertain	AL, 2016	Waltman et al. (2016)	not a pest		trees	2	NEO or NEA	Cockerell (1899)
Diaspididae	*Duplachionaspis divergens* (Green)	established	FL, 2001	USNM	not a pest		grasses	1	ORI or PAL	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Duplaspidiotus claviger* (Cockerell) *	established	FL, 1962	Dekle (1976)	minor pest	Miller and Davidson (1990)	polyphagous	13	AUS or ORI	
Diaspididae	*Duplaspidiotus tesseratus* (D'Emmerez de Charmoy) *	established	FL, 1919?	Merrill and Chaffin (1923)	minor pest	Miller and Davidson (1990)	polyphagous	14	uncertain	
Diaspididae	*Dynaspidiotus abietis* (Schrank)	established	OR, 1923	USNM	not a pest		trees	7	PAL	Balachowsky (1948)
Diaspididae	*Dynaspidiotus britannicus* (Newstead)	established	OR, 1898	USNM	minor pest	Miller and Davidson (1990)	polyphagous	22	PAL	Balachowsky (1954)
Diaspididae	*Dynaspidiotus pseudomeyeri* (Kuwana)	established	NY, 1953	USNM	minor pest		trees	3	PAL	
Diaspididae	*Dynaspidiotus tsugae* (Marlatt)	established	NY, 1900	McClure (1988)	pest	McClure and Fergione (1977)	trees	2	PAL	Takagi (1961)
Diaspididae	*Epidiaspis leperii* (Signoret)	established	CA, 1882	Gill (1997)	pest	Gill (1997)	polyphagous	12	PAL	Gill (1997)
Diaspididae	*Fiorinia externa* Ferris	established	NY, 1908	McClure (1977)	serious pest	McClure (1977)	trees	3	PAL	Murakami (1970)
Diaspididae	*Fiorinia fioriniae* (Targioni Tozzetti)	established	FL, 1906	USNM	minor pest	Dekle (1976)	polyphagous	53	ORI	Balachowsky (1954)
Diaspididae	*Fiorinia japonica* Kuwana	established	CA, 1910	Essig (1910)	not a pest		polyphagous	13	PAL	Kuwana (1902a)
Diaspididae	*Fiorinia phantasma* Cockerell & Robinson **	established	FL, 2018	Ahmed and Miller (2018a)	pest	Ahmed et al. (2021)	polyphagous	25	AUS?	
Diaspididae	*Fiorinia pinicola* Maskell	established	CA, 1939	McKenzie (1956)	not a pest		polyphagous	15	PAL	Balachowsky (1954)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Fiorinia proboscidaria* Green **	established	FL, 2013	Stocks (2015)	potential pest	Ahmed and Stocks (2020)	polyphagous	13	ORI	
Diaspididae	*Fiorinia theae* Green	established	FL, 1898	USNM	serious pest	Munir and Sailer (1985)	polyphagous	19	ORI	Munir and Sailer (1985)
Diaspididae	*Froggattiella gigantochloae* Aono **	established	FL, 2011	FSCA	pest	Skelley et al. (2025)	grasses	1	ORI	Aono (2009)
Diaspididae	*Froggattiella penicillata* (Green)	established	LA, 1910	USNM	minor pest	Gill (1997)	grasses	1	ORI	Balachowsky (1953)
Diaspididae	*Furcaspis biformis* (Cockerell)	established	FL, 1953	Merrill (1953)	minor pest	Zimmerman (1948)	polyphagous	13	NEO, NEA	
Diaspididae	*Furchadaspis zamiae* (Morgan)	established	CA, 1906	UCD	pest	Gill (1997)	polyphagous	10	uncertain	
Diaspididae	*Genaparlatoria pseudaspidiotus* (Lindinger)	established	FL, 1908	USNM	not a pest	Dekle (1976)	houseplants	6	ORI?	
Diaspididae	*Gymnaspis aechmeae* Newstead	established	FL, 1917	USNM	serious pest	Dekle (1976)	houseplants	6	ORI	Ferris (1937)
Diaspididae	*Hemiberlesia cyanophylli* (Signoret)	established	AL, FL, 1921	USNM	minor pest	Dekle (1976)	polyphagous	72	NEAor NEO	
Diaspididae	*Hemiberlesia lataniae* (Signoret)	established	GA, NC, 1899	USNM	serious pest	Gill (1997)	polyphagous	115	NEO	Schneider et al. (2018)
Diaspididae	*Hemiberlesia palmae* (Cockerell)	established but eradicated from CA, Gill (1997)	FL, 1921	USNM	not a pest	Dekle (1976)	polyphagous	57	uncertain	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Hemiberlesia rapax* (Comstock)	established	CA, FL, 1880	USNM	serious pest	Gill (1997)	polyphagous	83	PAL	Gill (1997)
Diaspididae	*Howardia biclavis* (Comstock)	established but eradicated from CA, Gill (1997)	CA, 1912	USNM	pest	Dekle (1976)	polyphagous	76	AFR?	Williams and Watson 1988a
Diaspididae	*Ischnaspis longirostris* (Signoret)	established but eradicated from CA, Gill (1997)	FL, 1908	USNM	pest	Dekle (1976)	polyphagous	54	AFR	Ben-Dov 1974
Diaspididae	*Kuwanaspis bambusicola* (Cockerell) **	established	FL, 2005	Ahmed et al. 2020	potential pest	Ahmed et al. 2020	grasses	3	AFR?	
Diaspididae	*Kuwanaspis hikosani* (Kuwana)	established	SC, 1960	USNM	not a pest		grasses	1	PAL or ORI	
Diaspididae	*Kuwanaspis howardi* Cooley	established	TX, 1918	USNM	not a pest	Dekle (1976)	grasses	1	PAL or ORI	
Diaspididae	*Kuwanaspis pseudoleucaspis* (Kuwana)	established	FL, 1916	USNM	not a pest	Dekle (1976)	grasses	2	PAL	Balachowsky (1953)
Diaspididae	*Kuwanaspis vermiformis* (Takahashi)	uncertain	FL, 1998	FSCA	not a pest		grasses	1	ORI	
Diaspididae	*Lepidosaphes beckii* (Newman)	established	FL, 1859	Gill (1997)	serious pest	Ebeling 1959	polyphagous	44	ORI	Gill (1997)
Diaspididae	*Lepidosaphes camelliae* Hoke	established	GA, 1881	USNM	pest	Cooper and Oetting (1989)	landscape	9	PAL	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Lepidosaphes chinensis* Chamberlin	established	CA, 1927	UCD	not a pest		houseplants	9	PAL	Chamberlin (1925)
Diaspididae	*Lepidosaphes conchiformis* (Gmelin)	established	CA, 1905	Gill (1997)	pest	Stafford and Barnes (1948)	polyphagous	23	PAL	Rosen and DeBach 1978
Diaspididae	*Lepidosaphes flava* (Signoret)	established	CA, 1952	McKenzie (1956)	not a pest	Gill (1997)	fruit	3	PAL	Gill (1997)
Diaspididae	*Lepidosaphes gloverii* (Packard)	established	FL, 1838	Gill (1997)	minor pest	Rosen and DeBach (1978)	polyphagous	28	ORI	Rosen and DeBach (1978)
Diaspididae	*Lepidosaphes laterochitinosa* Green **	established	FL, 2022	Powell et al. (2023, 2024c)	pest	Stocks (2016b), Powell et al. (2023, 2024c)	polyphagous	29	ORI	Normark et al. (2019)
Diaspididae	*Lepidosaphes mackieana* McKenzie	established but eradicated from CA Gill (1997)	CA, 1942	McKenzie (1943)	not a pest	Dekle (1976)	houseplants	1	ORI	Williams (1963)
Diaspididae	*Lepidosaphes newsteadi* (Sulc)	Although this species has been reported in the U.S. several times, most reports are misidentifications of *L. pallida*. It may not be present in the U.S						5		
Diaspididae	*Lepidosaphes noxia* McKenzie	eradicated from U.S., Gill (1997)	CA, 1944	McKenzie (1956)	minor pest	Miller and Davidson (1990)	houseplants	1	ORI?	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Lepidosaphes pallida* (Maskell)	established	CA, 1890	USNM	pest	Dekle (1976)	polyphagous	15	PAL?	
Diaspididae	*Lepidosaphes pini* (Maskell)	established	MD, 1952	USNM	minor pest	Stimmel (1994)	trees	5	ORI or PAL	Stimmel (1994)
Diaspididae	*Lepidosaphes pinnaeformis* (Bouché)	established	FL, 1932	Dekle (1976)	minor pest	Gill (1997)	polyphagous	21	ORI?	
Diaspididae	*Lepidosaphes punicae* Laing	established	FL, 1995	Halbert (1995)	pest		polyphagous	15	AFR or ORI	
Diaspididae	*Lepidosaphes sciadopitysi* McKenzie	established but eradicated from CA, Gill (1997)	CT, DC, 1908	McKenzie (1955)	not a pest		trees	2	PAL	
Diaspididae	*Lepidosaphes tokionis* (Kuwana)	established but eradicated from CA, Gill (1997)	MS, 1921	UCD	not a pest		landscape	7	ORI or PAL	
Diaspididae	*Lepidosaphes ulmi* (Linnaeus)	established	ME, 1794	Howard (1894)	serious pest	Miller and Davidson (1990)	polyphagous	74	PAL	Balachowsky (1953)
Diaspididae	*Lepidosaphes yanagicola* Kuwana	established	MA, 1925	USNM	minor pest	Kosztarab 1996	polyphagous	14	PAL	
Diaspididae	*Leucaspis portaeaureae* Ferris	established	CA, 1938	McKenzie (1956)	not a pest	Gill (1997)	trees	1	AUS	McKenzie (1956)
Diaspididae	*Lindingaspis floridana* Ferris	established	FL, 1921	FSCA	not a pest	Dekle (1976)	fruit	5	ORI?	
Diaspididae	*Lindingaspis rossi* (Maskell)	established	CA, 1892	USNM	serious pest	Gill (1997)	polyphagous	58	AUS	Gill (1997)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Lopholeucaspis cockerelli* (Grandpre & Charmoy)	established but eradicated from CA, Gill (1997)	FL, 1946	Dekle (1976)	not a pest	Dekle (1976)	polyphagous	34	Old World	Balachowsky (1958)
Diaspididae	*Lopholeucaspis japonica* (Cockerell)	established	CT, 1914	USNM	minor pest	Miller and Davidson 1990	polyphagous	39	PAL	Tabatadze and Yasnosh (2001)
Diaspididae	*Melanaspis bromiliae* (Leonardi)	established	FL, 1923	FSCA	not a pest in US	Dekle (1976)	fruit	3	NEO	
Diaspididae	*Melanaspis leivasi* (Costa Lima) **	established	FL, 2017	Ahmed and Miller (2017)	potential pest	Ahmed and Miller (2017)	fruit	4	NEO	Ahmed and Miller (2017)
Diaspididae	*Melanaspis odontoglossi* (Cockerell)	established	FL, 1975	USNM	not a pest		polyphagous	22	NEA, NEO	Deitz and Davidson (1986)
Diaspididae	*Mercetaspis halli* (Green)	eradicated from US, Gill (1997)	CA, 1934	Fosen et al. (1953)	serious pest	Fosen et al. (1953)	fruit	5	PAL	
Diaspididae	*Morganella longispina* (Morgan)	established	FL, 1980	Hamon (1981)	minor pest	Talhouk (1975)	polyphagous	31	uncertain	Balachowsky (1948)
Diaspididae	*Mycetaspis apicata* (Newstead)	established	TX, 1962	USNM	not a pest		landscape	8	NEA, NEO	
Diaspididae	*Mycetaspis personata* (Comstock)	established	FL, 1932	FSCA	not a pest	Dekle (1976)	polyphagous	19	NEO	Ferris (1941)
Diaspididae	*Mycetaspis sphaerioides* (Cockerell)	established	LA, 1895	Howard and Oliver 1985	not a pest		landscape	4	NEA, NEO	Ferris (1941)
Diaspididae	*Neopinnaspis harperi* McKenzie	established	FL, 1946	Dekle (1976)	minor pest	Miller and Davidson (1990)	polyphagous	33	PAL or ORI	Gill (1997)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Oceanaspidiotus araucariae* (Adachi, Fullaway)	established	FL, 1985	FSCA	pest	Williams and Watson (1988a)	trees	1	AUS	Williams and Watson (1988a)
Diaspididae	*Oceanaspidiotus spinosus* (Comstock)	established	FL, 1919	USNM	minor pest	Wysoki (1997)	polyphagous	41	AUS	Schneider et al. (2018)
Diaspididae	*Odonaspis greenii* Cockerell *	established	CA, 1973; FL, 1998	Ben-Dov (1988b); USNM	not a pest		grasses	2	ORI?	Ben-Dov (1988b)
Diaspididae	*Odonaspis ruthae* Kotinsky	established	LA, 1910	USNM	pest	Potter (1998)	grasses	6	uncertain	
Diaspididae	*Odonaspis saccharicaulis* (Zehntner)	established	FL, 1920	Ben-Dov (1988a)	not a pest	Dekle (1976)	grasses	4	ORI?	
Diaspididae	*Odonaspis secreta* (Cockerell)	established	LA, 1910	Howard and Oliver (1985)	not a pest		grasses	1	PAL	
Diaspididae	*Opuntiaspis carinata* (Cockerell)	established	FL, 1978; TX, 1978	Hamon (1978); USNM	not a pest	Hamon (1978)	houseplants	9	NEA or NEO	
Diaspididae	*Opuntiaspis javanensis* Green	established	FL, 1979	USNM	not a pest		houseplants	3	NEA	
Diaspididae	*Parlatoreopsis chinensis* (Marlatt)	established	MO, 1940	USNM	minor pest	Miller and Davidson (1990)	polyphagous	25	PAL	McKenzie (1945)
Diaspididae	*Parlatoreopsis pyri* (Marlatt)	established	DC, 1960	USNM	not a pest		fruit	6	PAL	McKenzie (1945)
Diaspididae	*Parlatoria blanchardi* (Targioni Tozzetti)	eradicated from US, Boyden 1941	CA, 1905	Gill (1997)	serious pest	Boyden (1941)	landscape	5	PAL	Rosen and DeBach (1978)
Diaspididae	*Parlatoria camelliae* Comstock	established	CA, 1886	USNM	pest	Morrison (1946)	polyphagous	27	ORI or PAL	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Parlatoria cinerea* Hadden	Known only from limited infestations in greenhouses in DC, MD; thus not considered established in the U.S					polyphagous	13		
Diaspididae	*Parlatoria crotonis* Douglas	established but eradicated from CA, Gill (1997)	CA, 1901	USNM	not a pest	Dekle (1976)	polyphagous	14	ORI?	
Diaspididae	*Parlatoria oleae* (Colvée)	established	CA, 1931	Rosen and DeBach (1978)	serious pest	McKenzie (1945)	polyphagous	62	ORI	Rosen and DeBach (1978)
Diaspididae	*Parlatoria pergandii* Comstock	established	FL, 1880	Comstock (1881)	pest	Ebeling (1959)	polyphagous	36	ORI of PAL	
Diaspididae	*Parlatoria pittospori* Maskell	established	CA, 1935	McKenzie (1956)	minor pest	Gill (1997)	polyphagous	27	AUS	McKenzie (1945)
Diaspididae	*Parlatoria proteus* (Curtis)	established	LA, 1906	USNM	pest		polyphagous	54	Old World	McKenzie (1945)
Diaspididae	*Parlatoria theae* Cockerell	established but eradicated from CA, Gill (1997)	DC, 1899	USNM	pest	Westcott (1973)	polyphagous	34	PAL	Kuwana (1925)
Diaspididae	*Parlatoria vandae* McKenzie	eradicated from US	CA, 1960	McKenzie (1960a)	not a pest		houseplants	1	ORI?	
Diaspididae	*Parlatoria ziziphi* (Lucas)	established	FL, 1985	FSCA	serious pest	Blackburn and Miller (1984)	polyphagous	13	ORI?	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Pinnaspis aspidistrae* (Signoret)	established	CA, 1896	USNM	serious pest	Dekle (1976)	polyphagous	71	ORI	Ferris and Rao 1947
Diaspididae	*Pinnaspis buxi* (Bouché)	established but eradicated from CA, Gill (1997)	FL, 1922	FSCA	not a pest	Dekle (1976)	polyphagous	49	ORI	Ferris and Rao 1947
Diaspididae	*Pinnaspis strachani* (Cooley)	established	FL, 1911	USNM	serious pest	Dekle (1976)	polyphagous	78	ORI	Ferris and Rao (1947)
Diaspididae	*Poliaspis media* Maskell	established	CA, 1993	Gill (1997)	not a pest	Gill (1997)	polyphagous	23	ORI?	
Diaspididae	*Poliaspoides formosana* (Takahashi) **	established?	FL, 2011	Stocks (2014)	not a pest	Stocks (2014)	grasses	1	AUS or ORI	
Diaspididae	*Pseudaonidia duplex* (Cockerell)	established	LA, 1921	UCD	pest	Ebeling (1959)	polyphagous	24	PAL	
Diaspididae	*Pseudaonidia paeoniae* (Cockerell)	established	DC, 1909	USNM	pest	Dekle (1976)	polyphagous	14	PAL	
Diaspididae	*Pseudaonidia trilobitiformis* (Green)	established	FL, 1979	Hamon (1980b)	not a pest in US	Hamon (1980b)	polyphagous	50	PAL	
Diaspididae	*Pseudaulacaspis cockerelli* (Cooley)	established but eradicated from CA, Gill (1997)	FL, 1942	Dekle (1965a)	serious pest	Dekle (1976)	polyphagous	89	PAL or ORI	
Diaspididae	*Pseudaulacaspis pentagona* (Targioni Tozzetti)	established but eradicated from CA, Gill (1997)	DC, 1892	Howard (1895)	serious pest	Kosztarab (1996)	polyphagous	89	PAL or ORI	Rosen and DeBach (1978)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Pseudaulacaspis prunicola* (Maskell)	established	DC, 1901	USNM	pest	Kosztarab (1996)	polyphagous	18	PAL	
Diaspididae	*Pseudaulacaspis rubra* (Green) **	established	FL, 2025	Powell and Miller (2024)	???		fruit	3	ORI	
Diaspididae	*Pseudischnaspis bowreyi* (Cockerell)	established	FL, 1890	Miller et al. (1984)	not a pest	Dekle (1976)	polyphagous	29	NEO?	
Diaspididae	*Pseudoparlatoria ostreata* Cockerell	established	FL, 1920	FSCA	minor pest	Dekle (1976)	polyphagous	34	NEO	
Diaspididae	*Pseudoparlatoria parlatorioides* (Comstock)	established but eradicated from CA, Gill (1997)	FL, 1880	Comstock (1883)	minor pest	Miller and Davidson (1990)	polyphagous	60	NEO	
Diaspididae	*Radionaspis indica* (Marlatt)	established	FL, 1907	Marlatt (1908)	not a pest	Dekle (1976)	fruit	2	ORI	Marlatt (1908)
Diaspididae	*Rhizaspidiotus donacis* (Leonardi) **	established	CA, 2018	Braman et al. (2021)	not a pest; biocontrol agent	Braman et al. (2021)	grasses	1	PAL	
Diaspididae	*Rutherfordia major* (Cockerell)	established	FL, 1955	FSCA	minor pest	Dekle (1976)	polyphagous	15	ORI?	
Diaspididae	*Selenaspidus albus* McKenzie	established	CA, 1934	McKenzie (1953)	minor pest	Gill (1997)	landscape	1	AFR	McKenzie (1953)
Diaspididae	*Selenaspidus articulatus* (Morgan)	established but eradicated from CA, Gill (1997)	FL, 1887	USNM	minor pest	Ebeling (1959)	polyphagous	55	AFR	McKenzie (1953)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Diaspididae	*Selenaspidus rubidus* McKenzie	established but eradicated from CA?, Gill (1997)	CA, 1936	McKenzie (1953)	minor pest	Gill (1997)	landscape	4	AFR	McKenzie (1953)
Diaspididae	*Thysanaspis dennorum* Normark, Okusu **	established	FL, 2014	Normark et al. (2019)	not a pest		other hosts	1	ORI	Normark et al. (2019)
Diaspididae	*Thysanofiorinia leei* Williams **	uncertain?	FL, 2019; possibly 2004	Ahmed and Miller (2019b)	potential pest	Ahmed and Miller (2019b)	fruit	1	ORI	
Diaspididae	*Thysanofiorinia nephelii* (Maskell)	established	FL, 1996	FSCA	not a pest		fruit	7	ORI	
Diaspididae	*Unachionaspis tenuis* (Maskell)	established	TN, 1999	USNM	not a pest		grasses	1	PAL	
Diaspididae	*Unaspis citri* (Comstock)	established	LA, 1880	Comstock (1883)	serious pest	Dekle (1976)	polyphagous	14	ORI	Ferris (1937)
Diaspididae	*Unaspis euonymi* (Comstock)	established	VA, 1879	Gill et al. (1982)	serious pest		polyphagous	22	PAL	Ferris (1937)
Eriococcidae	*Acanthococcus lagerstroemiae* (Kuwana) **	established	TX, 2004	Wang et al. (2015)	pest	Cai et al. (2016)	polyphagous	15	ORI	
Eriococcidae	*Acanthococcus pittospori* (Ferris)	established	CA, 1954	Miller and Miller (1992)	minor pest		landscape	2	AUS	Miller and Miller (1992)
Eriococcidae	*Anophococcus insignis* (Newstead)	established	ID, 1924	Miller and Miller (1992)	minor pest		polyphagous	16	PAL	Miller and Miller (1992)
Eriococcidae	*Gossyparia spuria* (Modeer)	established	NY, 1884	USNM	pest		trees	7	PAL	Kosztarab (1996)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Eriococcidae	*Uhleria araucariae* (Maskell)	established	CA, 1880	Comstock (1881)	minor pest	Gill (1993)	trees	6	AUS	Hoy (1962)
Kuwaniidae	*Kuwania raygilli* Wu & Gullan	established	CA, 1965	USNM	not a pest	Gill (1993)	trees	1	PAL	Gill (1993)
Matsucoccidae	*Matsucoccus matsumurae* (Kuwana)	established	CT, 1946	Bean and Godwin (1955)	serious pest	McClure (1983)	trees	1	PAL	Bean and Godwin (1955)
Monophlebidae	*Crypticerya genistae* (Hempel) **	established	FL, 2005	Hodges et al. (2008)	pest	Hodges et al. (2008)	polyphagous	22	NEO	
Monophlebidae	*Icerya purchasi* Maskell	established	CA, 1868	Gill (1993)	serious pest	Gill (1993)	polyphagous	85	AUS	Gill (1993)
Ortheziidae	*Insignorthezia insignis* (Browne)	established	CA, 1911	UCD	serious pest		polyphagous	51	NEO	Bartlett (1978)
Phoenicococcidae	*Phoenicococcus marlatti* Cockerell	established	CA, AZ, 1905	USNM	minor pest	Gill (1993)	landscape	3	PAL	Gill (1993)
Pseudococcidae	*Antonina crawi* Cockerell	established	CA, 1900	Williams and Miller (2002)	minor pest	Sasscer (1918)	grasses	2	PAL	Williams and Miller (2002)
Pseudococcidae	*Antonina graminis* (Maskell)	established	TX, 1942	USNM	pest	Ben-Dov (1994)	grasses	4	ORI	Chada and Wood (1960)
Pseudococcidae	*Antonina nakaharai* Williams, Miller	established	SC, 1911	Williams and Miller (2002)	not a pest		grasses	2	ORI	Williams and Miller (2002)
Pseudococcidae	*Antonina pretiosa* Ferris	established	CA, 1915	Hendricks and Kosztarab (1999)	minor pest	Ferris (1953)	grasses	2	PAL	Ferris (1953)
Pseudococcidae	*Brevennia rehi* (Lindinger)	established	CA, AZ, 1967	USNM	pest	Ben-Dov (1994)	grasses	3	ORI	Miller (1975)
Pseudococcidae	*Chaetococcus bambusae* (Maskell)	established	FL, 1956	Hendricks and Kosztarab (1999)	not a pest		grasses	1	PAL	Hendricks and Kosztarab (1999)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Pseudococcidae	*Chaetococcus phragmitis* (Marchal)	established	NJ, 1975	USNM	not a pest		grasses	1	PAL	Kosztarab (1996)
Pseudococcidae	*Crisicoccus azaleae* (Tinsley)	established	CA, 1898	USNM	pest	Fox-Wilson (1939)	polpyhagous	12	PAL	Ferris (1953)
Pseudococcidae	*Crisicoccus pini* (Kuwana)	established	CA, 1918	USNM	not a pest		trees	1	PAL	Ferris(1950)
Pseudococcidae	*Delottococcus confusus* (De Lotto) **	established	CA, 2003	Miller and Giliomee (2011), von Ellenrieder (2025)	not a pest		polyphagous	10	AFR	Miller and Giliomee (2011)
Pseudococcidae	*Dysmicoccus angustus* (Ezzat, McConnell)	uncertain	NJ, 1912	USNM	not a pest		grasses	1	PAL or ORI	Ezzat and McConnell (1956)
Pseudococcidae	*Dysmicoccus boninsis* (Kuwana)	established	FL, 1895	USNM	minor pest	Ben-Dov (1994)	polyphagous	12	PAL	
Pseudococcidae	*Dysmicoccus brevipes* (Cockerell)	established	FL, 1880	USNM	minor pest	Ben-Dov (1994)	polyphagous	67	NEO	Carter (1935)
Pseudococcidae	*Dysmicoccus grassii* (Leonardi)	established	FL, 1966	USNM	pest	Williams and Granara de Willink (1992)	polyphagous	30	NEO	
Pseudococcidae	*Dysmicoccus neobrevipes* Beardsley *	established	FL, 1978	Miller and Miller (2002b)	threat	Miller and Miller (2002b)	polyphagous	40	NEO	Miller et al. (2002)
Pseudococcidae	*Dysmicoccus wistariae* (Green)	established	NJ, 1915	USNM	pest	Hamilton (1942)	trees	9	PAL	Kosztarab 1996
Pseudococcidae	*Ferrisia malvastra* (McDaniel)	established	FL, 1918	USNM	pest	Williams (1996c)	polyphagous	33	NEO(?)	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Pseudococcidae	*Ferrisia virgata* (Cockerell)	established	NM, 1896	USNM	pest	Ben-Dov (1994)	polyphagous	79	NEO(?)	Williams and Granara de Willink (1992)
Pseudococcidae	*Heliococcus summervillei* Brookes **	established, excluded from analyses	TX, 2025	Biles et al. (2025)	pest	Biles et al. (2025)	grasses	2	ORI(?)	
Pseudococcidae	*Heterococcus nudus* (Green)	established	NH, 1921	USNM	pest	McKenzie (1967)	grasses	3	PAL	
Pseudococcidae	*Hypogeococcus pungens* Granara de Willink	eradicated from FL?	FL, 1984	FSCA	serious pest	Hamon (1984)	houseplants	5	NEO	Williams and Granara de Willink (1992)
Pseudococcidae	*Hypogeococcus spinosus* Ferris	established	CA, 1951	McKenzie (1967)	minor pest	Ben-Dov (1994)	houseplants	2	NEA	McKenzie (1967)
Pseudococcidae	*Idiococcus bambusae* Takahashi, Kanda	uncertain	NJ, 1916	USNM	not a pest		grasses	1	PAL	Hendricks and Kosztarab (1999)
Pseudococcidae	*Maconellicoccus hirsutus* (Green)	established	CA, 1999	Miller (1999)	serious pest	Ben-Dov (1994)	polyphagous	82	ORI	Williams (1996a)
Pseudococcidae	*Miscanthicoccus miscanthi* (Takahashi)	established	MD, VA, 1989	USNM	minor pest	Stimmel (1996)	grasses	1	ORI or PAL	Stimmel (1996)
Pseudococcidae	*Nipaecoccus aurilanatus* (Maskell)	established	CA, 1912	McKenzie (1967)	minor pest	Brown and Eads (1967)	trees	1	AUS	
Pseudococcidae	*Nipaecoccus nipae* (Maskell)	established	CA, 1897	USNM	pest	Ben-Dov (1994)	polyphagous	51	NEO	
Pseudococcidae	*Nipaecoccus viridis* (Newstead) **	established	FL, 2009	Stocks and Hodges (2010)	threat	Stocks (2013)	polyphagous	51	ORI or AUS?	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Pseudococcidae	*Palmicultor browni* (Williams)	uncertain	FL, 1995	FSCA	not a pest		landscape	3	uncertain	
Pseudococcidae	*Palmicultor lumpurensis* (Takahashi)	established	FL, 2002	FSCA	minor pest?		grasses	1	ORI(?)	Williams (2003)
Pseudococcidae	*Palmicultor palmarum* (Ehrhorn) (complex)	established	FL, 1999	Hara et al. (1996)	minor pest	Hara et al. (1996)	landscape	7	uncertain	
Pseudococcidae	*Paracoccus gillianae* von Ellenrieder & Stocks **	uncertain, in nurseries	CA/FL, 2010	von Ellenrieder and Stocks(2014)	pest	von Ellenrieder and Stocks(2014)	houseplants	1	NEO	von Ellenrieder and Stocks(2014)
Pseudococcidae	*Paracoccus hakeae* (Williams) **	established	CA, 2016	von Ellenrieder et al. (2016)	not a pest		other hosts	1	AUS	
Pseudococcidae	*Paracoccus marginatus* Williams, Granara de Willink	established	FL, 1998	Miller and Miller (2002a)	pest	Williams and Granara de Willink (1992)	polyphagous	54	NEA	Miller and Miller (2002a)
Pseudococcidae	*Phenacoccus aceris* (Signoret)	established	ME, 1910	Bartlett (1978)	pest	Ben-Dov (1994)	polyphagous	34	PAL	Bartlett (1978)
Pseudococcidae	*Phenacoccus dearnessi* King	established	IL, 1894	USNM	pest	Cranshaw et al. (1998)	fruit	2	PAL ?	
Pseudococcidae	*Phenacoccus graminicola* Leonardi	established	CA, 1953	McKenzie (1967)	pest	Ward (1966)	fruit	7	PAL ?	
Pseudococcidae	*Phenacoccus miruku* Tanaka & Choi **	established	FL, 2019	Ahmed and Miller (2019a), Powell et al. (2024b)	pest	Ahmed and Miller (2019a); Powell et al. (2024b)	polyphagous	10	NEO	Powell et al. (2024b)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Pseudococcidae	*Phenacoccus multicerarii* Granara de Willink **	uncertain	FL, 2011	Stocks (2012a)	pest		polyphagous	14	NEO	Granara de Willink and Szumik (2007)
Pseudococcidae	*Phenacoccus parvus* Morrison	uncertain	FL, 1983	Williams and Hamon (1994)	pest	Williams and Watson (1988b)	polyphagous	27	NEO	Williams and Hamon (1994)
Pseudococcidae	*Phenacoccus peruvianus* Granara de Willink **	established	CA, 2020	von Ellenrieder et al. (2020)	not a pest		polyphagous	38	NEO	
Pseudococcidae	*Planococcus citri* (Risso)	established	FL, 1880	USNM	pest	Ben-Dov (1994)	polyphagous	91	ORI	Bartlett (1978)
Pseudococcidae	*Planococcus ficus* (Signoret)	established	LA, 1924; CA, 1994	USNM	pest	Ben-Dov (1994)	polyphagous	24	PAL	
Pseudococcidae	*Planococcus japonicus* Cox	established	MD, 1978	Cox (1989)	pest	Cox (1989)	polyphagous	12	PAL	Cox (1989)
Pseudococcidae	*Planococcus kraunhiae* (Kuwana)	uncertain	CA, 1915	McKenzie (1967)	pest	Park and Hong (1992)	polyphagous	25	PAL	Cox (1989)
Pseudococcidae	*Planococcus minor* (Maskell) *	established	FL, 2002	Stocks (2013)	pest	Watson and Kondo (2022)	polyphagous	86	AUS	Watson and Kondo (2022)
Pseudococcidae	*Pseudococcus calceolariae* (Maskell)	established	CA, 1913	Bartlett (1978)	pest	Ben-Dov (1994)	polyphagous	46	AUS	Bartlett (1978)
Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	established	DC, 1906	USNM	pest	Ben-Dov (1994)	polyphagous	47	PAL	Bartlett (1978)
Pseudococcidae	*Pseudococcus dendrobiorum* Williams **	uncertain	FL, 2009	Hodges and Buss (2009)	not a pest		houseplants	1	AUS	
Pseudococcidae	*Pseudococcus elisae* Borchsenius	established	FL, 1995	Gimpel and Miller (1996)	pest	Gimpel and Miller (1996)	polyphagous	13	NEO	Gimpel and Miller (1996)

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Pseudococcidae	*Pseudococcus importatus* McKenzie	established	CA, 1949	McKenzie (1960b)	minor pest	Johnston (1964)	houseplants	3	NEO	Gimpel and Miller (1996)
Pseudococcidae	*Pseudococcus jackbeardsleyi* Gimpel, Miller	established	FL, 1921	Gimpel and Miller (1996)	pest	Gimpel and Miller (1996)	polyphagous	54	NEO	Gimpel and Miller (1996)
Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti)	established	DC, 1881	USNM	serious pest	Ben-Dov (1994)	polyphagous	99	AUS	
Pseudococcidae	*Pseudococcus microcirculus* McKenzie	established	CA, 1954	McKenzie (1967)	minor pest		houseplants	6	NEO	Gimpel and Miller (1996)
Pseudococcidae	*Pseudococcus nakaharai* Gimpel and Miller	uncertain	CA, 1973	Gimpel and Miller (1996)	not a pest		houseplants	9	NEA	Gimpel and Miller (1996)
Pseudococcidae	*Pseudococcus odermatti* Miller, Williams	established	FL, 1973	Miller and Williams (1997)	pest	Miller and Williams (1997)	polyphagous	11	ORI	
Pseudococcidae	*Saccharicoccus sacchari* (Cockerell)	established	FL, 1944	USNM	minor pest	Ben-Dov (1994)	grasses	4	ORI ?	
Pseudococcidae	*Spilococcus mamillariae* (Bouché)	established	CA, 1938	McKenzie (1967)	pest	Manichote and Middlekauff (1967)	houseplants	5	NEA	Williams and Granara de Willink (1992)
Pseudococcidae	*Trionymus bambusae* (Green) **	established	WA, 2023	FSCA/USNM	pest		grasses	1	ORI	Jansen and Alferink (2023)
Pseudococcidae	*Trionymus diminutus* (Leonardi)	established	CA, 1906	USNM	pest	Saakyan-Baranova (1954)	landscape	1	AUS	Williams (1985)
Pseudococcidae	*Vryburgia amaryllidis* (Bouché)	uncertain	CA, 1925	McKenzie (1967)	minor pest	Ben-Dov (1994)	houseplants	8	AFR	

Table 1 (continued)

Family	Species	Eradication status	Earliest U.S. record, State	Earliest record reference	Pest status in U.S	Pest status reference	Host category	# Host families	Origin	Origin reference
Pseudococcidae	*Vryburgia brevicruris* (McKenzie)	uncertain	CA, 1935	McKenzie (1967)	pest	McKenzie (1967)	polyphagous	11	AFR	
Pseudococcidae	*Vryburgia trionymoides* (De Lotto)	established	CA, 1994	USNM	minor pest	Stocks (2012b)	houseplants	5	AFR	
Rhizoecidae	*Geococcus coffeae* Green *	uncertain	FL, 1958	Dekle (1965b)	not a pest		polyphagous	32	ORI	Williams (1969)
Rhizoecidae	*Rhizoecus americanus* (Hambleton)	established	FL, 1959	Hambleton (1973)	pest	Hambleton (1976)	polyphagous	29	NEO	Hambleton (1973)
Rhizoecidae	*Rhizoecus arabicus* Hambleton *	uncertain; FL greenhouse only	FL, 1982; CA 1996	FSCA; Dowell et al. (2016)	not a pest	von Ellenrieder (2025)	other hosts	3	NEO	Dowell et al. (2016)
Rhizoecidae	*Rhizoecus cacticans* (Hambleton) *	established	CA, 1948	McKenzie (1967)	pest	von Ellenrieder (2025)	polyphagous	28	NEO	Dowell et al. (2016)
Rhizoecidae	*Rhizoecus dianthi* Green	established	CA, 1954	McKenzie (1967)	pest	Snetsinger (1966)	polyphagous	15	uncertain	Williams and Nakahara (1980)
Rhizoecidae	*Rhizoecus falcifer* Kunckel d'Herculais	established	CA, 1917	McKenzie (1967)	pest	Cox (1987)	polyphagous	39	PAL	Hambleton (1976)
Rhizoecidae	*Ripersiella hibisci* (Kawai, Takagi)	established	FL, 1978	USNM	pest	Kawai and Takagi (1971)	polyphagous	15	PAL or ORI	Williams (1996b)
Rhizoecidae	*Ripersiella kondonis* (Kuwana)	established	CA, 1921	McKenzie (1967)	pest	Godfrey and Pickel (1998)	polyphagous	15	PAL	Hambleton (1976)
Tachardiidae (=Kerriidae)	*Paratachardina pseudolobata* Kondo & Gullan *	established	FL, 1999	FSCA	serious pest	Hamon and Hodges (2000)	polyphagous	67	ORI	Howard and Pemberton (2003)

Species marked with ** are new since 2005; species marked with * were introduced prior to 2005 but excluded from the previous list

AFR Afrotropical, *AUS* Australasian, *NEA* Nearctic, *NEO* Neotropical, *ORI* Oriental, *PAL* Palearctic counts for California and Florida because they are disproportionate contributors. We plotted the number of species introduced by state/region and national total over time. We performed trend analysis on species introduction records (the number of species first detected by state and by decade) using the peak period of introductions to the U.S. in 1900–09 for comparison. We calculated the percent change in number of species introduced per decade for major agricultural centers (i.e., California and Florida) and for the continental United States overall. We also performed changepoint analysis on the curve of total introduced species records by year to determine which years showed significant changes in the mean value of introductions and plotted the results, using the R packages changepoint (Killick et al. 2014) and ggplot2 (Wickham 2016). Changepoint analysis detects points in time where the underlying properties of a data sequence, such as mean or variance, change significantly.

Horticultural imports

Are scale insect introduction rates tied to the volume of horticultural imports? To address this question, we compiled a time-series dataset for regression analysis comprising quantity of horticultural imports and number of introduced species to the U.S. for the period of 1967–2024. Data on the quantity of horticultural imports was drawn from the USDA, Foreign Agricultural Service, Global Agricultural Trade System (FAS GATS) for all years with data reported (as FAS standardized quantity units per commodity group). The number of species introduced per year used the date of earliest published record as a proxy for date of introduction, acknowledging that time of publication lags the unknown true date of introduction. Assumptions for linear regression of time-series data were evaluated and tested. Data on the quantity of horticultural products were detrended and then tested for stationarity ($KPSS = 0.324$, truncation $lag = 3$, $p = 0.1$). The regression model was tested for autocorrelation (LM $test = 9.62$, $df = 10$, $p = 0.474$) and heteroscedastic variance (BP $test = 0.88$, $df = 2$, $p = 0.644$). Analyses using linear regression and dynamic regression models were run for comparison, but results of the models were the same. Dynamic regression models account for lag in response variables in relation to predictor variables.

Major hosts/commodities

What are the major hosts and commodity groups impacted or at risk? We defined polyphagous as species reported to feed on 10 or more host plant families, typically including a broad range of horticultural commodities. We looked at host patterns across 296 introduced scale insect species in the U.S. over time and then focused on the 27 species introduced from 2005 to August 2025. For scale insect species that were not considered polyphagous, we grouped hosts in the following ways: grasses (e.g., ornamentals including bamboos, cereal grain crops, sugarcane, etc.), tropical and deciduous fruit trees (e.g., apple, banana, citrus, grapevine, stone fruits), landscape and ornamental plants (e.g., exotic trees, shrubs, palms, roses), houseplants (e.g., cacti, orchids, snake plants, succulents), trees (e.g., conifers and hardwoods), and miscellaneous 'other hosts' (e.g., cut flowers, coffee, cotton). Results were plotted using the R package ggplot2 (Wickham 2016).

Economic impact

What is the economic impact of invasive scale insects on U.S. agriculture? We reviewed primary literature and online resources, gathering data about monetary costs incurred due to damage and control of scale insects domestically and globally. Examples are scarce and are limited in scope regarding the geographical distributions and commodity groups considered, which significantly limits what can be done to formulate estimates without more input data. We took a multi-pronged approach to estimate the economic impact of scale insects on U.S. agriculture and considered a few scenarios to identify a range of values that likely represent minimal costs attributable to scale insects. The first scenario relies on prior estimates provided by Kosztarab (1977, 1990) and simply adjusts for inflation. We similarly adjusted an estimate of costs due to armored scales offered by Miller and Davidson (2005) and assumed that the percent contribution of costs from armored scale pests is equal to their species richness. Thus, for the second scenario we extrapolated a range of costs attributable to scale insects overall using high and low-end values from the original estimate that considered armored scales alone. Our third scenario used a dataset of costs to ornamental plant trade in Georgia that were attributed to scale insects (Oetting et al. 2007), estimated an expected average cost per severe pest, and estimated overall costs for the continental U.S. using distribution data for species drawn from ScaleNet. Finally, we compiled information from references that assigned costs to scale insects, including information from any country. The data are too limited to form a meaningful estimate, but they help illustrate how under-reported these figures are and how costly scale insects are to agriculture worldwide. Several references were summarized and evaluated by Bradshaw et al. (2016) (supplementary data) and by Naranjo et al. (2019). We had to make broad assumptions about parameters involved in cost estimation, but we describe those assumptions so that their influence on estimates is apparent.

We also attempted to gather cost data from national and state agricultural resources. We sought data from the Cooperative Agricultural Pest Survey (CAPS), the National Agricultural Statistics Service (NASS), the USDA Economic Research Service (ERS), and multiple state departments of agriculture. We were unable to locate resources where monetary costs were attributed to a fine enough resolution to be useful for our purposes. We also tried using the INVACOST database (Leroy et al. 2022) but found that information on scale insects was too scarce to make an estimate.

Results

Species introductions

Table 1 summarizes a list of the non-native species of scale insects in the continental United States and information about their establishment, earliest record of detection, origin, pest status, host associations, and supporting citations. There are 1099 species of scale insects present in the continental U.S., 297 of which are non-native species (27%). Non-native scale insects in the U.S. belong to 16 families, the most common of which are Diaspididae (150), Pseudococcidae (63), and Coccidae (44) (Fig. 1). Most introduced species are pests of agriculture and horticulture; 210 species are minor to major pests and an additional six species that were introduced in recent years are considered likely to become pests considering their location and host range. Only 78 (27%) non-native scale insects in the U.S. are considered innocuous. Assuming that pests are more likely to receive attention for conspicuous damage, it is possible the number of innocuous non-native species in the U.S. is underreported.

Invasion pathways

The distribution of introductions originating from the Palearctic region over time differs significantly from

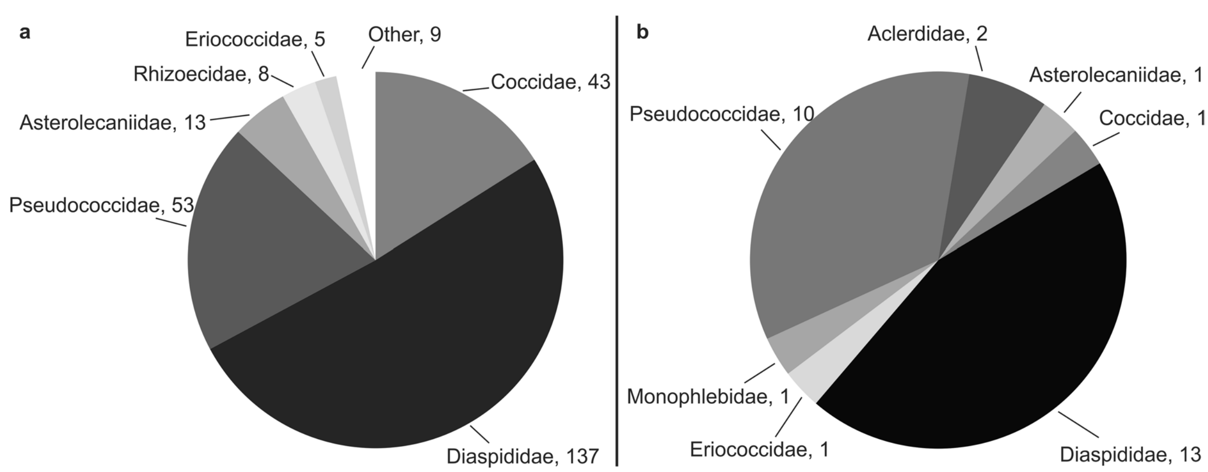

Fig. 1 Scale insect introductions by family. Pie charts depicting the number of non-native scale insects introduced to the continental United States proportionally by family (**A**) prior to 2005 and (**B**) in the ensuing 20 years (2005–2025). Recent introductions are illustrated separately to visualize changing trends. Armored scales (Diaspididae) consistently represent about half of introduced species, mealybug (Pseudococcidae) introductions have been more prevalent by proportion in the past 20 years compared with earlier periods, and soft scales (Coccidae) have been less prevalent

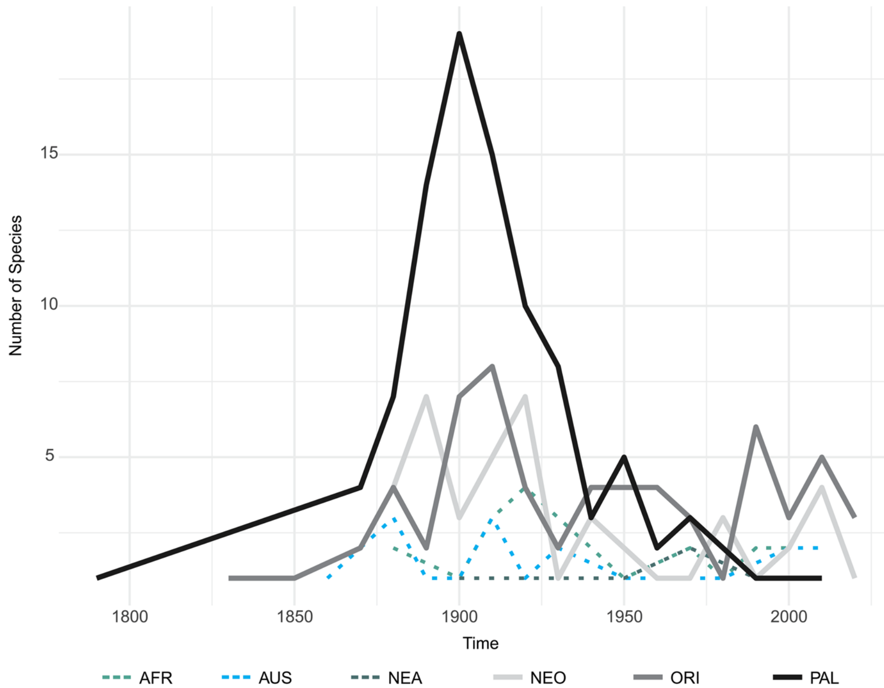

Fig. 2 Scale insect introductions by region of origin. The number of introduced non-native species, broken into world region of origin (AFR Afrotropical, AUS Australasian, NEA Nearctic, NEO Neotropical, ORI Oriental, PAL Palearctic), are plotted over time to assess how region of origin has changed. Introductions from the Palearctic dominated in the early 1900s and tapered off at the end of the century. Most recent introductions are from the Neotropical and Oriental regions

others ($\chi^2_{(df=5)} = 23.01$, $p < 0.001$); it skews heavily toward the early 1900s and tapers off toward 2020. This pattern is apparent in Fig. 2. Introductions from other world regions do not differ significantly in distribution over time despite fluctuations (Fig. S1). Most scale introductions in recent decades have originated from the Oriental and Neotropical regions (Fig. 2).

Records of new scale insect introductions peaked in the late 1800s to early 1900s but sharply declined in the 1920s, coinciding with passage of the Plant Quarantine Act of 1912 and its amended version in 1928 (Fig. 3). Significant changepoints on the curve of total introduced species reported per year occurred in 1878, 1880, 1894, and 1925 (Fig. S2); the first three dates correspond to an increase in slope and the fourth a decline. The mean number of species introduced prior to 1925 differs significantly from the mean value for 1925–2025 (one-tailed $t = 3.26$, $df = 68.44$, $p < 0.001$, mean of x and y = 2.78, 1.35).

California and Florida comprise most of the first records for non-native scale insects introduced to the United States. During the period of 2000–2019, relative to the peak period of introductions recorded in the United States (1900–09), the average number of new species introduced to California has seen a decline of 83%. During this same period, the United States overall has experienced an average 66% decline in new species introductions. Contrast these figures with Florida, which averaged a 17% decline during this 20-year period relative to peak and accounted for most new non-native species detected in the country (Fig. 3).

Volume of horticultural imports

Relative to 1967, the earliest year in which data on import quantities are reported, horticultural imports to the United States in 2024 increased by 1,005% (Table S2) but there was no significant relationship between the volume of imports and the number of new species introduced to the United States over this period ($F = 0.04$, df = 2 and 55, $p = 0.96$). Despite this dramatic increase in import trade, the U.S. has not experienced a proportionate increase in new species establishments.

Major hosts/commodities

Of 296 non-native species in the U.S., 166 (56%) are considered polyphagous (Fig. 4a). In total, 39 of the 296 (13%) introduced scale insect species in the U.S. are grass specialists. Trees, including coniferous and hardwood trees, were the next most common host

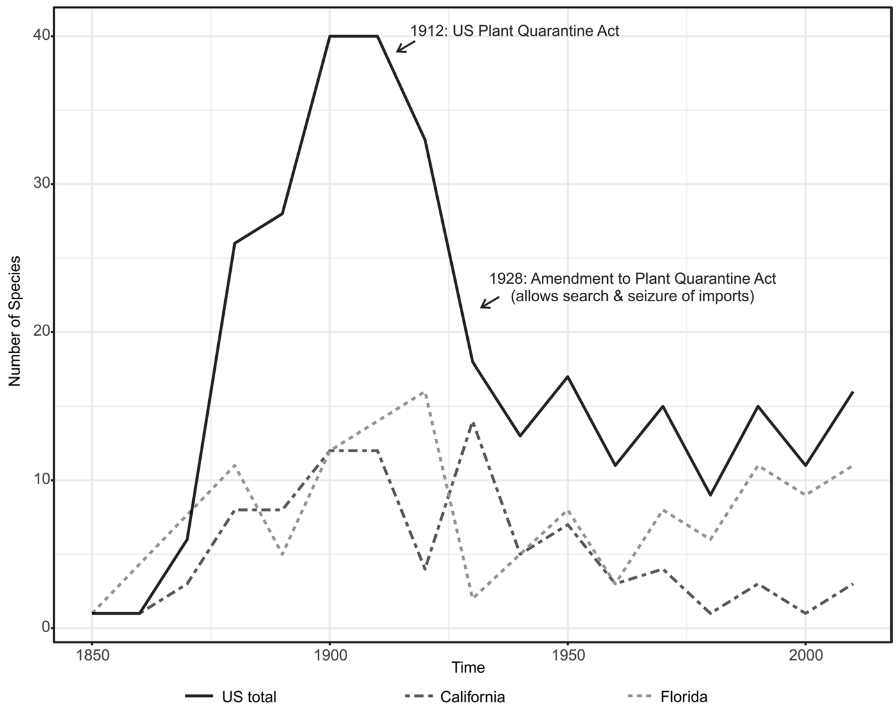

Fig. 3 Scale insect introductions by earliest U.S. record. Earliest records by state, from Table 1, were categorized regionally to assess where non-native species are most often introduced into the United States and how this has changed over time. California and Florida were by far the greatest contributors of earliest records for new non-native species. Thus, earliest records were plotted for California, Florida, and the U.S. overall to assess patterns of introductions over time. Introductions declined sharply between 1910–1930, corresponding with passage of the U.S. Plant Quarantine Acts of 1912 and 1928 and the enforcement of phytosanitary practices (i.e., search, seizure, and treatment) at ports of entry to the country. Rates of introduction have remained relatively steady since the 1930s. Most modern introductions are first reported from Florida

type (11%) followed by houseplants (7%), landscape and ornamentals (6%), fruit-producing plants (5%), and 'other' hosts (1%). Forty-four of the 296 (15%) species are extreme specialists, only reported on one family of host plants. Of the 27 species introduced since 2005, 11 (41%) are polyphagous, eight (30%) specialize on grasses and six of those are bamboo specialists. The remainder represent fruits (11%), houseplants (7%), 'other' miscellaneous plants (7%), and trees (4%) (Fig. 4b).

Economic impact

Kosztarab (1977, 1990) compiled cost information from a set of state and national government reports and primary literature sources. He estimated that scale insects cost U.S. agriculture a minimum of $500 million annually (in 1977 USD) and estimated that scale insects are responsible for global costs of about $5 billion annually (in 1990 USD). Adjusting for inflation (2025 USD), his estimates translate to $2.6 billion in minimal annual losses to U.S. agriculture and $12.3 billion in agricultural losses that can be attributed to scale insects globally. This estimate assumes that all factors beyond inflation of USD are fixed values, such as the costs of agricultural production, pest detection, and pest control. Realistically, technological advancements, changes in efficiencies, regulations, and behaviors of global markets have changed over time. Such impacts have not been considered in this and subsequent estimates.

Miller and Davidson (2005) suggested that armored scale insects cost U.S. agriculture at least $1–2 billion annually (in 2005 USD) for all commodity groups—crops, ornamentals, etc. This translates to $1.64–3.27 billion in 2025 USD. Armored scales comprise 39% of scale species that are considered domestic pests. If we assume they also account for

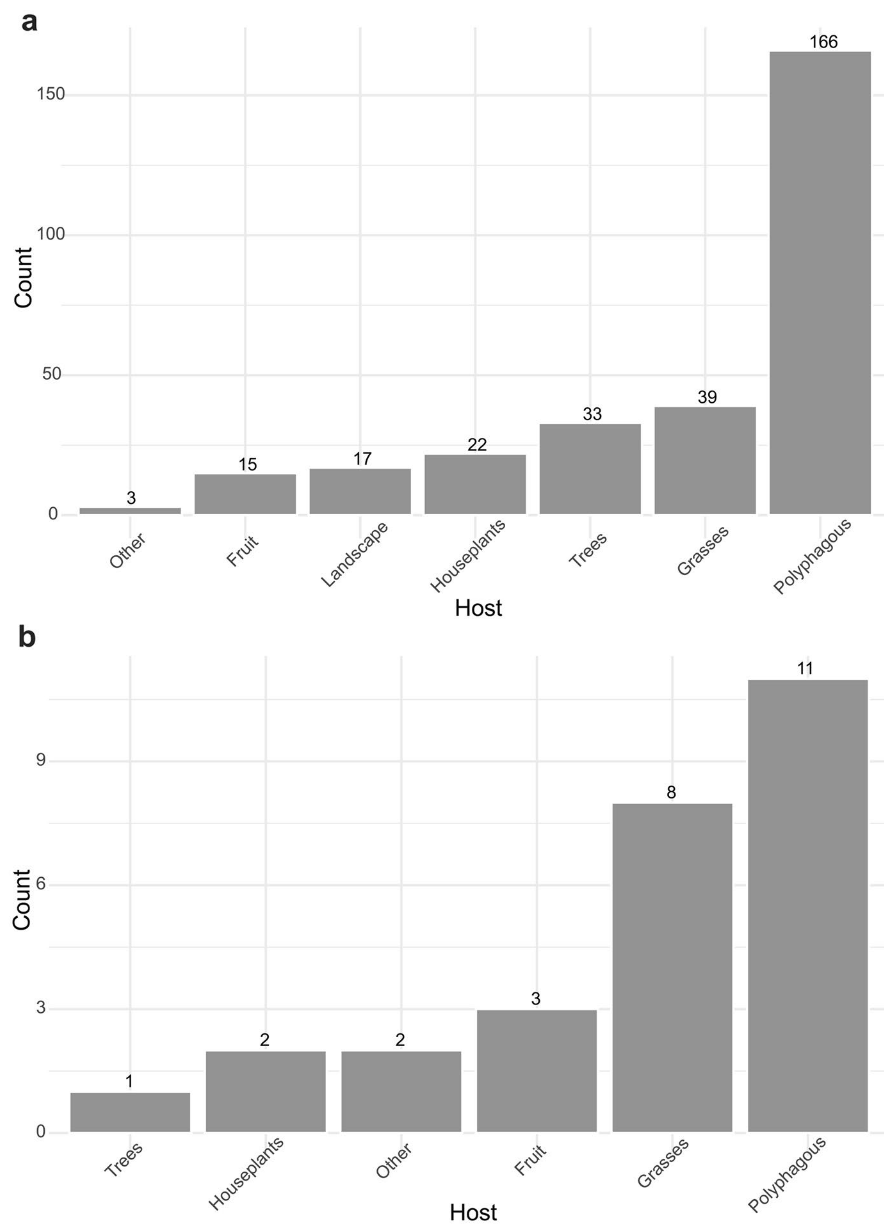

Fig. 4 Host plants of non-native scale insects in the U.S. (**a**) overall and (**b**) those introduced since 2005. Hosts are categorized as grasses (e.g., bamboos, cereal grain crops, sugarcane, etc.), tropical and deciduous fruit trees (e.g., apple, banana, citrus, grapevine, stone fruits), landscape and ornamental plants (e.g., exotic trees, shrubs, palms, roses), houseplants (e.g., cacti, orchids, snake plants, succulents), trees (e.g., conifers and hardwoods), and miscellaneous 'other hosts' (e.g., cut flowers, coffee, cotton). Species feeding on 10 or more host plant families, in various combinations of host categories, are considered polyphagous

39% of pest damage, then the minimum estimated cost of scale insects to U.S. agriculture would fall between $4.2–8.4 billion annually.

A survey in Georgia (Oetting et al. 2007) found that the annual cost incurred from damage and control of scale insects on ornamental plants amounted to $106,960,830 (adjusted to 2025 USD) annually for the state's businesses and consumers. Of the 212 species known to occur in Georgia (García Morales et al. 2016), 47 are considered severe or serious pests, from Table 1 and according to Klingeman et al. (2020). To estimate an average expected cost for a severe pest, we assumed these 47 species were responsible for all damage to ornamentals reported, with an average cost of $2,275,762 per severe pest. If we treat this figure as an average expected cost applied to every scale insect in the U.S. that is considered a severe pest, multiply each species by the number of states in which they occur (excluding Alaska and Hawaii), and sum across all species (Table S3.1) we estimate that scale insects generate about $2.6 billion dollars in damage and control costs annually for growers, sellers, and consumers of ornamentals in the continental U.S. The assumptions underlying this hypothesis are that costs are reported only for severe pests, that these pests will generate about the same costs on average, and that the value of ornamentals per state will be the same on average even if the ornamental plants in question vary by state. Realistically, some pests will cause much more, and others far less, than the average monetary costs. For example, according to Ranjan (2006) the management of *Maconellicoccus hirsutus* was estimated to cost the U.S. economy $700 million annually at the time, which translates to over $1.1 billion in 2025 USD. Furthermore, damage caused by pests will vary by locality and commodity, and the value of ornamental industries will vary by state. Many states contribute data on the value of ornamental commodities to USDA NASS (see Anonymous 2019), but incomplete reporting prevented us from determining proportional value of ornamental commodities by state to further refine estimates. The Oetting et al. (2007) survey was unique in that it considered costs to consumers of ornamental goods (i.e., for treating or replacing ornamentals due to scale insect damage), when most reports mainly consider costs to production.

A non-exhaustive search for references in which monetary costs were attributed to scale insects resulted in a list of 40 entries (Table S3.2). Geographic representation included Africa (broadly), Australia, Benin, Brazil, Grenada, India, Kenya, Kiribati, the Marshall Islands, Micronesia, Palau, Peru, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, São Tomé and Príncipe, Tanzania, Togo, Trinidad and Tobago and the United States (8 states) (Anonymous 1978, 1996, 1999, 2023b; Bokonon-Ganta et al. 2002; Bradshaw et al. 2016; Dean et al. 1979; Dutt 2007; Ellis and Howell 1982; Francis 1999; Francois 1996; Gill and Kosztarab 1997; Gutierrez et al. 1999; Hawthorne 1975; Hill and Greathead 2000; Huffaker et al. 1976; Kosztarab 1990; Lopes et al. 2009; Luck and Hoddle 2025; Mead 1975; Moffitt 1999; Myrick et al. 2014; Nagrare et al. 2009; Naranjo et al. 2019; Norgaard 1988; Oetting et al. 2007; Oliveira et al. 2013; Peters 1999; Ranjan 2006; Wang et al. 2010; Zeddies et al. 2001). Twenty-two species were mentioned specifically and five reports referred to unspecified groups of species. The commodities discussed included apple, breadfruit, cassava, citrus, coconut, coffee, cotton, eggplant, grapevine, grasses, mango, mulberry, olive, palm, papaya, peach, ornamentals, sugarcane, and tomato. Considering that hundreds of scale insects are considered pests throughout the world on many commodities, and that few localities are captured in these reports, the sum total is certainly only a fraction of the actual agricultural losses and control costs that scale insects are responsible for annually. Still, this global figure amounts to $4.2 billion USD.

Discussion

Over the past 20 years, non-native species of scale insects have been introduced to the United States at a similar rate to what Miller et al. found in 2005, about one new species per year. While we have not eliminated new introductions through plant quarantine measures, evidence and logic suggest that they are an effective preventative barrier and useful mechanism for delaying the introduction of new species (Aukema et al. 2010; Liebhold and Griffin 2016; Canelles et al. 2025). New introductions sharply declined following the Plant Quarantine Act of 1912 and have held stable since about the 1930s (Fig. 3, Fig. S2). Relative to 1967, the volume of horticultural imports to the U.S., on which scale insects are transmitted, dramatically increased by 1005% in 2024. And propagule pressure of scale insects remains high (Liebhold et al. 2024); for example, they accounted for 12% of all insects intercepted at U.S. ports of entry from 2021–2023, including many species likely capable of establishing in the United States (data from USDA APHIS, Plant Protection and Quarantine, Table S4). Yet despite increasing trade and high propagule pressure, the annual rate of establishment of non-native scales has remained steady over the past century, likely a success story for quarantine practices. Leung et al. (2014) found that even delaying new arrivals of invasive species through phytosanitary practices translates into billions of dollars in cumulative net benefit to the national economy, and that was just considering the benefit from treating wood packing materials to prevent beetle invasions. Prevention and delay of new invasions both benefit the U.S. economy and agriculture.

Historically, California and Florida are the states where most non-native scale insects have been first detected, and the number of earliest records were comparable for the two states in the early 1900s. They are both large populous states with booming agricultural industries, favorable environmental conditions, and many ports of entry, leading to high propagule pressure (Lockwood et al. 2005; Colunga-Garcia et al. 2013; Skelley et al. 2025). Both states lead the country, along with Hawaii, in having the most non-native insect species overall (Simpson et al. 2022). California and Florida are rich in native plant diversity (Brusati et al. 2014; Wunderlin et al. 2025), a factor posited to drive insect invasions (Liebhold et al. 2018). Moreover, both states also have high numbers of non-native plants (Gordon 1998; Brusati et al. 2014; Wunderlin et al. 2025), promoting invasional meltdown where non-native species facilitate one another's invasion (Simberloff and von Holle 1999; Bertelsmeier et al. 2024).

In recent decades, however, most new scale insect introductions have been detected in Florida alone (Fig. 3). Considering that the number of non-native species first detected in California and Florida during 1900–09 was 12 species each, it seems California has employed relatively successful strategies for preventing new introductions that originate from outside of the U.S., an 83% average decline compared to the U.S. overall (66% decline) and Florida (17% decline). So why are most non-native scale insect species currently entering the U.S. through Florida? Florida and California employ similar strategies for proactive detection and interception of non-native species with highway interdiction stations utilizing natural and artificial bottlenecks (Stirling 2012; Nance et al. 2024). But California has been operating such stations since 1921, whereas Florida's program began in 2009 (Stirling 2012; Nance et al. 2024). Thus, the current trend may change given more time. The rate of first detections in Florida may be artificially inflated if scale insects are less rapidly detected or reported in other states without the same infrastructure in place to inspect and identify plant pests. Interception data often provide early insights into distributions and introductions. There may be substantial lags in detection and reporting. For instance, the aphid, *Myzus cymbalariae* (Stroyan), has been intercepted repeatedly in Florida on plant material originating from California but it has not yet been reported from California (Skvarla et al. 2017; Nance et al. 2024). The brown anole, *Anolis sagrei* Duméril and Bibron, was first suspected to be present in Arizona because it was intercepted in Florida on Arizona cantaloupes (Leimroth et al. 2022). The armored scale *L. laterochitinosa* was intercepted from Costa Rica by APHIS for many years before it was formally reported from the country (Normark et al. 2019; Powell et al. 2024c). Similarly, *Lepidosaphes serrifrons* (Leonardi) is only formally reported from Italy in the literature but has been repeatedly intercepted on *Codiaeum* nursery stock from Costa Rica since the 1980's by both APHIS and Florida Department of Agriculture and Consumer Services (Powell et al. 2024c).

Most non-native scale insects in the United States (56%) are polyphagous (Fig. 4). When polyphagous species are introduced, the opportunity for establishment and spread is likely greater because these insects can colonize many different hosts. As such, scale insects not only have high propagule pressure, but the species introduced also tend to have a broad host range and the potential to impact many important commodities. For instance, 115 non-native scale insect species in the United States are reported to feed on citrus; 111 of those species are considered polyphagous. Host specialists include notable and impactful invaders too (e.g., roseau cane scale on *Phragmites australis*). The ornamental bamboo trade may warrant greater focus during inspections considering that a disproportionate number of recently introduced scale insects are grass specialists, particularly on bamboo.

Which species are most likely to be introduced to the United States in the coming years? Deng et al. (2023) took a novel approach to answering this question by deriving predictions from a neural network analysis of ScaleNet data via self-organizing map (SOM). Their prediction of the top ten species likely to establish in the United States considered climatic factors and species assemblages. It is almost prophetic that two of the species ranked most likely to become established in the U.S. by artificial intelligence analysis, *Nipaecoccus viridis* and *Planococcus minor* (Table 2), were in fact already established in Florida at the time of publication. The dataset they analyzed apparently pre-dated the capture of these records in ScaleNet. Further predictions could be made by consulting interception records for frequently encountered species that are not in the country at present. In

Table 2 List of likely future invaders

Rank	Species	No. countries	No. host families	Potential hosts
1	*Nipaecoccus viridis* *	68	53	Major pest of many commodities (e.g., citrus, coffee)
2	*Icerya seychellarum*	73	63	Major pest of orchard trees and ornamentals (e.g., apple, citrus, grapevine)
3	*Planococcus minor* *	70	86	Major pest of many commodities (e.g., cacao, cotton)
4	*Pseudococcus cryptus*	45	52	Major pest of many commodities (e.g., citrus, palms)
5	*Pulvinaria polygonata*	17	8	Citrus
6	*Pseudaulacaspis eugeniae*	10	13	Myrtles, palm, *Prunus*
7	*Discochiton expansum*	13	13	Ornamentals (e.g., laurels, *Ficus)*
8	*Fiorinia turpiniae*	8	3	Citrus
9	*Icerya aegyptiaca*	49	65	Pest on many commodities (e.g., breadfruit, citrus, ornamental flowers)
10	*Aulacaspis madiunensis*	22	5	Sugarcane, cycads

This table is based on predictions presented by Deng et al. (2023), derived from a neural network analysis of ScaleNet data by self-organizing map. Their prediction of top ten species likely to establish in the United States was based on relative establishment risk scores. Species marked with * were already established in Florida at the time of publication. Deng J, Li J, Zhang X, et al. (2023) Potential global invasion risk of scale insect pests based on a self-organizing map. Insects 14:1–11. https://doi.org/10.3390/insects14070572

this case, potential species may include *Phenacoccus franseriae* Ferris (on ornamentals), *Phenacoccus stelli* (Brain) (on ornamentals), and *Davidsonaspis aguacatae* (Evans, Watson, & Miller) (on avocado). Recent and historical trends indicate mealybugs (Pseudococcidae) and armored scales (Diaspididae) are the greatest invasion risks (Fig. 1). Some undescribed cryptic species may already be established in the U.S. as well; Table 1 excludes two records, *Pulvinaria* nr. *bambusicola* (Ahmed and Miller 2018b) and *Palmicultor* cf. *palmarum* (von Ellenrieder et al. 2022). Both have been detected in Florida and are likely non-native in origin. However, additional work is needed to determine whether specimens of the *Palmicultor palmarum* species-complex present in Florida include both *P. palmarum* and *P*. cf. *palmarum* or only the latter, as suggested by von Ellenrieder et al. (2022).

Despite the enormous economic impact of insects, especially those that are non-native (Pimentel et al. 2005), appraisals of their cost to agriculture remain grossly underestimated (Bradshaw et al. 2016) and information on monetary costs is exceedingly difficult to find. Kosztarab (1977) advocated for improved reporting on the costs to agriculture that are incurred due to scale insects. Methods for compiling and reporting this information are still sorely needed today. The Crop Protection Network offers a model that is currently limited to a few field crops (Mueller et al. 2024) but perhaps could be expanded or adapted to include other agricultural and horticultural commodities and drastically improve economic reporting. Based on the information available, scale insects may be responsible for $2.6 billion dollars in damage and control costs annually for ornamentals in the U.S. alone and considering all agricultural production they may cost the U.S. economy between $4–8 billion USD annually. If the limited records for global costs reported here account for just 25% of all costs attributable to scale insects, a conservative guess, then their global impact would be over $16 billion USD annually. Better data-driven estimates are needed for this economically important insect group to determine their true cost to agriculture.

Acknowledgements We thank Douglass R. Miller for providing helpful information while compiling the list of species included in this study and for providing feedback on an earlier version of the manuscript. We also thank Susan Halbert, Natalia von Ellenrieder, Nathan Harms, and an anonymous reviewer for their suggestions. This research was supported by the U.S. Department of Agriculture, Agricultural Research Service. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture; USDA is an equal opportunity provider and employer. The Florida Department of

Agriculture and Consumer Services, Division of Plant Industry is also thanked for supporting this work.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Scott Schneider. The first draft of the manuscript was written principally by Scott Schneider but with segments contributed by Erin Powell. All authors read, edited, and approved the final manuscript.

Funding The authors declare that no external funds, grants, or other support were received during the preparation of this manuscript.

Declarations

Competing interest The authors have no relevant financial or non-financial interests to disclose.

References

Ahmed MZ, Miller DR (2017) First continental record of *Melanaspis leivasi* Costa Lima, (Hemiptera: Diaspididae), a Leivasi armored scale (Suggested Common Name). Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 437, pp 1–4

Ahmed MZ, Miller DR (2018a) First U.S. continental record of *Fiorinia phantasma* Cockerell & Robinson (Hemiptera: Diaspididae), Phantasma Scale, potential pest of palms and ornamentals plants. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-01880:1–3

Ahmed MZ, Miller DR (2018b) A *Pulvinaria* sp. with morphological similarities to *P. bambusicola* (Tang), (Hemiptera: Coccomorpha: Coccidae): A potential pest of Florida sugarcane. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-01804:1–2

Ahmed MZ, Miller DR (2019a) *Phenacoccus sisymbriifolium* Granara de Willink (Pseudococcidae: Coccomorpha: Hemiptera), a new U.S. continental record in Florida and potential pest. Entomology Circular, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, vol 442, pp 1–4

Ahmed MZ, Miller DR (2019b) *Thysanofiorinia leei* (Diaspididae: Coccomorpha: Hemiptera), lychee leei scale, a new U.S. continental record in Florida and potential pest of Florida lychee. In: Entomology Circular, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, vol 441, pp 1–5

Ahmed MZ, Stocks IC (2020) *Fiorinia proboscidaria* Green (Hemiptera: Diaspididae), snout scale, a potential pest of *Citrus* in Florida. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-01929:1–7

Ahmed MZ, Miller DR, Hodges GS (2020) *Kuwanaspis bambusicola* (Cockerell) (Diaspididae: Hemiptera), a bamboo thread scale: a potential pest of Florida bamboo. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-02156:1–2

Ahmed MZ, Miller DR, Rohrig EA et al (2021) Field report and survey of *Fiorinia phantasma* (Hemiptera: Diaspididae), potential pest of palms, and ornamental plants in the United States. J Integr Pest Manag 12:1–10. https://doi.org/10.1093/jipm/pmab032

Anonymous (1978) Estimated losses and production costs attributed to insects and related arthropods-1976. Coop Plant Pest Rep 3:110

Anonymous (1996) Regional action programme for the control of pink mealybug, *Maconellicoccus hirsutus* (Green) in the Caribbean. Main report. (Programme Management Committee). In: Meeting of the Programme Coordinating Committee, St. Kitts and Nevis, 26 February 1996

Anonymous (1999) Summary of activities associated with *Maconellicoccus hirsutus* in St. Lucia. In: Evaluation workshop on biological control of Hibiscus Mealybug, *Maconellicoccus hirsutus* in the Caribbean Sub Region, Trinidad and Tobago, 11–12 March 1999

Anonymous (2019) Census of Horticultural Specialties. In: United States Department of Agriculture, National Agricultural Statistics Service. https://www.nass.usda.gov/Publications/Highlights/2020/census-horticulture.pdf Accessed January 14 2026

Anonymous (2023a) California's Top 10 Agricultural Commodities. In: California Department of Food and Agriculture. https://www.cdfa.ca.gov/Statistics/ Accessed April 22 2025

Anonymous (2023b) FY 2023 Technology Transfer Annual Report. United States Department of Agriculture, USA, pp 1–244

Anonymous (2024) All Citrus Value of Production United States. In: USDA NASS. https://data.nass.usda.gov/Charts_and_Maps/Citrus_Fruits/citrusvl.php Accessed April 22 2025

Aono M (2009) Taxonomic study on Odonaspidini, with particular reference to sexual dimorphism in the second instar (Sternorrhyncha: Coccoidea: Diaspididae). Insecta Matsumurana 65:1–92

Armitage HM, McKenzie HL (1952) Present status of the olive pollinia scale *Pollinia pollini* (Costa) in California (Homoptera; Coccoidea; Asterolecanidae). Bull Calif Dep Agric 41:115–121

Aukema JE, McCullough DG, Von Holle B et al (2010) Historical accumulation of nonindigenous forest pests in the continental United States. Bioscience 60:886–897. https://doi.org/10.1525/bio.2010.60.11.5

Avidov Z, Harpaz I (1969) Plant Pests of Israel. Israel Universities Press, Jerusalem

Baker WL (1972) Eastern forest insects. United States Department of Agriculture, Forest Service, Miscellaneous Publications, USA, pp 1–642

Balachowsky AS (1948) Les cochenilles de France, d'Europe, du nord de l'Afrique et du bassin Méditerranéen. Monographie des Coccoidea, classification-Diaspidinae

(Premiere partie). Entomologie Appliquée Actualités Scientifiques Et Industrielles 1054:243–394
Balachowsky AS (1950) Les cochenilles de France, d'Europe, du Nord de l'Afrique et du Bassin Méditerranéen. V.-Monographie des Coccoidea; Diaspidinae (deuxième partie) Aspidiotini. Entomologie Appliquée Actualités Scientifiques Et Industrielles 1087:397–557
Balachowsky AS (1953) Les cochenilles de France d'Europe, du Nord de l'Afrique, et du bassin Méditerranéen. VII.-Monographie des Coccoidea; Diaspidinae-IV, Odonaspidini Parlatorini. Entomologie Appliquée Actualités Scientifiques Et Industrielles 1202:725–929
Balachowsky AS (1954) Les cochenilles Paléarctiques de la tribu des Diaspidini. Memmoires Scientifiques de l'Institut Pasteur, Paris
Balachowsky AS (1958) Les cochenilles du continent Africain Noir. Vol. 2 Aspidiotini (2me partie), Odonaspidini and Parlatorini. Annales du Musée Royal du Congo Belge, N.S. vol 4, pp 145–356
Bartlett BR (1978) Introduced parasites and predators of arthropod pests and weeds: a world review. Agricultural Research Service, United States Department of Agriculture, Washington DC
Batker D, de la Torre I, Costanza R et al (2010) Gaining ground: wetlands, hurricanes, and the economy: the value of restoring the Mississippi River Delta. Environ Law Rep News Anal 40:11106–11110. https://doi.org/10.3411/col.08230102
Bean JL, Godwin PA (1955) Description and bionomics of a new red pine scale *Matsucoccus resinosae*. For Sci 1:164–176. https://doi.org/10.1093/forestscience/1.2.164
Ben-Dov Y (1974) A revision of *Ischnaspis* Douglas with a description of a new allied genus (Homoptera: Diaspididae). J Entomol (b) 43:19–32. https://doi.org/10.1111/j.1365-3113.1974.tb00081.x
Ben-Dov Y (1994) A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance. Intercept Limited, Andover, UK
Ben-Dov Y (1988a) The scale insects (Homoptera: Coccoidea) of citrus in Israel: Diversity and pest status. In: Proceedings of the Sixth International Citrus Congress, Tel Aviv, Israel, March 6–11, 1988
Ben-Dov Y (1988b) A taxonomic analysis of the armored scale tribe Odonaspidini of the world (Homoptera: Coccoidea: Diaspididae). In: United States Department of Agriculture Technical Bulletin 1723, pp 1–142
Bertelsmeier C, Bonnamour A, Brockerhoff EG, Pyšek P, Skuhrovec J, Richardson DM, Liebhold AM (2024) Global proliferation of nonnative plants is a major driver of insect invasions. Bioscience 74:770–781. https://doi.org/10.1093/biosci/biae088
Biles S, Sekula D, Santiago-Gonzáles J, Xiong C, Kerns D (2025) The pasture mealybug: A new invasive pest of pastures and hayfield in Texas. In: Texas A&M AgriLife Extension ENTO-PU_248:1–9
Blackburn VL, Miller DR (1984) Pests not known to occur in the United States or of limited distribution, No. 45: arrowhead scale. In: United States Department of Agriculture, Plant Protection & Quarantine, Animal and Plant Health Inspection Service, vol 81–45, pp 1–14
Bokonon-Ganta AH, de Groote H, Neuenschwander P (2002) Socio-economic impact of biological control of mango mealybug in Benin. Agric Ecosyst Environ 93:367–378. https://doi.org/10.1016/S0167-8809(01)00337-1
Boyden BL (1941) Eradication of the parlatoria date scale in the United States. Miscellaneous Publications United States Department of Agriculture, USA, pp 1–62
Bradshaw CJA, Leroy B, Bellard C et al (2016) Massive yet grossly underestimated global costs of invasive insects. Nat Commun 7:12986. https://doi.org/10.1038/ncomms12986
Braman CA, Lambert AM, Özsoy AZ et al (2021) Biology of an adventive population of the armored scale *Rhizaspidiotus donacis*, a biological control agent of *Arundo donax* in California. Insects 12:1–19. https://doi.org/10.3390/insects12070588
Brown LR, Eads CO (1967) Insects affecting ornamental conifers in southern California. Bull Calif Agric Exp Stn 834:1–72. https://doi.org/10.5962/bhl.title.59456
Brusati ED, Johnson DW, DiTomaso J (2014) Predicting invasive plants in California. Calif Agric 68:89–95. https://doi.org/10.3733/ca.v068n03p89
Cai X, Dou H, Gu M et al (2016) Update on crapemyrtle bark scale. Acta Hortic 1140:415–418. https://doi.org/10.17660/ActaHortic.2016.1140.94
Canelles Q, Pérez-Granados C, Roura-Pascual N, Biancolini D, Blackburn TM, Capinha C, Dawson W, Essl F, Golivets M, Guénard B, Hui C, Jeschke JM, Kühn I, Latombe G, Lenzner B, Seebens H, Leung B (2025) Policies slow biological invasions in Europe, but legacies still matter. One Earth. https://doi.org/10.1016/j.oneear.2025.101355
Carnegie AJM (1997) Sugarcane and bamboo. In: Ben-Dov Y, Hodgson CJ (eds) Soft Scale Insects: Their Biology, Natural Enemies, and Control, vol 7B. Elsevier, Amsterdam and New York, p 442. https://doi.org/10.1016/S1572-4379(97)80093-0
Carnes EK (1907) The Coccidae of California. In: Second Biennial Report of the Commissioner of Horticulture of the State of California (1905–1906), pp 155–222
Carter W (1935) Studies on biological control of *Pseudococcus brevipes* (Ckl.) in Jamaica and Central America. J Econ Entomol 28:1037–1041. https://doi.org/10.1093/jee/28.6.1037
Chada HL, Wood EA (1960) Biology and control of the rhodes-grass scale. In: United States Department of Agriculture Technical Bulletin, vol 1221, pp 1–21
Chamberlin JC (1925) A new species of *Lepidosaphes* from China. Pan-Pac Entomol 2:85–87
Cockerell TDA (1893) Coccidae, or scale insects. - II. Bull Bot Dep Jamaica 40:7–9
Cockerell TDA (1899) Rhynchota, Hemiptera - Homoptera. Biol Cent-Amer 2:1–37
Colunga-Garcia M, Haack R, Magarey R, Borchert D (2013) Understanding trade pathways to target biosecurity surveillance. NeoBiota 18:103–118. https://doi.org/10.3897/neobiota.18.4019
Comstock JH (1881) Report of the entomologist. In: Report of the Commissioner of Agriculture, United States Department of Agriculture 1880/1881:276–349

Comstock JH (1883) Second report on scale insects, including a monograph of the sub-family Diaspinae of the family Coccidae and a list, with notes of the other species of scale insects found in North America. Department of Entomology Report Cornell University Agricultural Experiment Station, New York, pp 47–142

Cooper RM, Oetting RD (1989) Life history and field development of the camellia scale (Homoptera: Diaspididae). Ann Entomol Soc Am 82:730–736. https://doi.org/10.1093/aesa/82.6.730

Cox JM (1987) Pseudococcidae (Insecta: Hemiptera). In: Duval CT (ed) Fauna of New Zealand, 11. DSIR Science Information Publishing Centre, Wellington, New Zealand, p 229

Cox JM (1989) The mealybug genus *Planococcus* (Homoptera: Pseudococcidae). Bull Br Mus Nat Hist Entomol 58:1–78

Cranshaw W, Gerace D, Demirel N (1998) Control of hawthorn mealybug, 1997. Arthropod Manag Tests 23:359–360. https://doi.org/10.1093/amt/23.1.359b

Cronin JT, Johnston J, Diaz R (2020) Multiple potential stressors and dieback of *Phragmites australis* in the Mississippi River Delta, USA: implications for restoration. Wetlands 40:2247–2261. https://doi.org/10.1007/s13157-020-01356-8

Dean HA, Schuster MF, Boling JC et al (1979) Complete biological control of *Antonina graminis* in Texas with *Neodusmetia sangwani* (a classic example). Bull Entomol Soc Am 25:262–267. https://doi.org/10.1093/besa/25.4.262

Deitz LL, Davidson JA (1986) Synopsis of the armored scale genus *Melanaspis* in North America (Homoptera: Diaspididae). Tech Bull N C Agric Res Serv 279:1–91

Dekle GW (1965a) Oleander scale (*Phenacaspis cockerelli* (Cooley)) (Homoptera: Coccidae). Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 32, pp 1–2

Dekle GW (1965b) A root mealybug (*Geococcus coffeae* Green) (Homoptera: Pseudococcidae). Department of Agriculture and Consumer Services Division of Plant Industry, vol 43, pp 1–2

Dekle GW (1966) *Aglaonema* scale (*Temnaspidiotus excisus* (Green)) (Homoptera: Diaspididae). Entomol Circ Fla Dep Agric Consum Serv Div Plant Ind 49:1–2

Dekle GW (1969) Stellate scale *Vinsonia stellifera* (Westw.) (Homoptera-Coccidae). Entomol Circ Fla Dep Agric Consum Serv Div Plant Ind 80:1–2

Dekle GW (1973) Tessellated scale, *Eulcalymnatus tessellatus* (Signoret) (Homoptera; Coccidae). Entomol Circ Fla Dep Agric Consum Serv Div Plant Ind 138:1–2

Dekle GW (1976) Florida armored scale insects (Revised). In: Arthropods of Florida and neighboring land areas. Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 3, pp 345

Del Rivero JM (1966) Nota sobre una plaga de agrios y aguacates. Boletín de Patología Vegetal y Entomología Agrícola. Madrid 29:59–62

Deng J, Li J, Zhang X et al (2023) Potential global invasion risk of scale insect pests based on a self-organizing map. Insects 14:1–11. https://doi.org/10.3390/insects14070572

Donaldson DR, Moore WS, Koehler CS et al (1978) Scales threaten iceplant in Bay area. Calif Agric 32:4–7

Dowell RV, Gill RJ, Jeske DR, Hoddle MS (2016) Exotic terrestrial macro-invertebrate invaders in California from 1700 to 2015: an analysis of records. In: Proceedings of the California Academy of Sciences Series 4, vol 63(3), pp 63–157

Dutt U (2007) Mealy bug infestation in Punjab: Bt. cotton falls flat. In: http://www.countercurrents.org/dutt210807.htm Accessed May 15 2025

Ebeling W (1959) Subtropical Fruit Pests. University of California, Division of Agricultural Sciences

Ehrlich J (1932) The occurrence in the United States of *Cryptococcus fagi* (Baer.). Dougl., the insect factor in a menacing disease of beech. J Arnold Arbor 13:75–80. https://doi.org/10.5962/p.185247

Ellis HC, Howell JO (1982) Peach insects. In: Suber EF (ed) Summary of economic losses due to insect damage and costs of control in Georgia 1980. University of Georgia College of Agriculture Experiment Stations Special Publications, Georgia, pp 3–27

Essig EO (1910) Notes on California Coccidae, V. Pomona Coll J Entomol 2:209–222

Ezzat YM, McConnell HS (1956) A classification of the mealybug tribe Planococcini (Pseudococcidae: Homoptera). In: Bulletin of the Maryland Agriculture Experiment Station A-e84:1–108

Ferris GF (1937) Atlas of the Scale Insects of North America. Series I. Stanford University Press, Palo Alto, California

Ferris GF (1941) The genus *Aspidiotus* (Homoptera; Coccoidea; Diaspididae). Microentomology 6:33–70

Ferris GF (1950) Atlas of the Scale Insects of North America. Series V. The Pseudococcidae (Part I). Stanford University Press, Palo Alto California

Ferris GF (1953) Atlas of the Scale Insects of North America. Series VI. The Pseudococcidae (Part II). Stanford University Press, Palo Alto California

Ferris GF, Rao VP (1947) The genus *Pinnaspis* Cockerell (Homoptera: Coccoidea: Diaspididae). (Contribution No. 54). Microentomol 12:25–58

Fosen EH, Cressman AW, Armitage HM (1953) The Hall scale eradication project. Circular (US Dep Agric) 920:1–16. https://doi.org/10.5962/bhl.title.64565

Fox-Wilson G (1939) Insect pests of the genus *Rhododendron*. Internationaler Kongress Entomologische, Berlin, pp 2296–2323

Francis A (1999) Report on biological control activities (pink hibiscus mealybug), St. Kitts. In: Evaluation Workshop on Biological Control of Hibiscus Mealybug, *Maconellicoccus hirsutus* in the Caribbean Sub Region, Trinidad and Tobago, 11–12 March 1999

Francois B (1996) Measuring the impact of mealybug infestation. In: Proceedings of the First Symposium on the Hibiscus Mealybug in the Caribbean, Grenada, 24–27 June 1996

García Morales M, Denno BD, Miller DR et al (2016) ScaleNet: a literature-based model of scale insect biology and systematics. Database 2016:bav118. https://doi.org/10.1093/database/bav118

Gill RJ (1979) A new species of *Pulvinaria* Targioni Tozzetti (Homoptera: Coccidae) attacking ice plant in California. Pan-Pac Entomol 55:241–250

Gill RJ (1988) The Scale Insects of California: Part 1. The Soft Scales (Homoptera: Coccoidea: Coccidae). California Department of Food & Agriculture, Sacramento CA

Gill RJ (1993) The Scale Insects of California: Part 2. The Minor Families (Homoptera: Coccoidea). California Department of Food & Agriculture, Sacramento CA

Gill RJ (1997) The Scale Insects of California: Part 3. The Armored Scales (Homoptera: Diaspididae). California Department of Food & Agriculture, Sacramento CA

Gill RJ, Kosztarab MP (1997) Economic importance. In: Ben-Dov Y, Hodgson CJ (eds) Soft Scale Insects: Their Biology, Natural Enemies, and Control, vol 7B. Elsevier, Amsterdam, pp 161–163. https://doi.org/10.1016/S1572-4379(97)80081-4

Gill SA, Miller DR, Davidson JA (1982) Bionomics and taxonomy of the Euonymus scale, *Unaspis euonymi* (Comstock), and detailed biological information on the scale in Maryland (Homoptera: Diaspididae). University of Maryland, Agricultural Experiment Station, Miscellaneous Publication, Maryland, pp 1–36

Gill RJ, Nakahara S, Williams ML (1977) A review of the genus *Coccus* Linnaeus in America north of Panama (Homoptera: Coccoidea: Coccidae). In: Occasional Papers in Entomology, State of California, Department of Food and Agriculture, vol 24, pp 1–44

Gimpel WF, Miller DR (1996) Systematic analysis of the mealybugs in the *Pseudococcus maritimus* complex (Homoptera: Pseudococcidae). Contributions on Entomology, International 2:1–163

Gimpel WF, Miller DR, Davidson JA (1974) A systematic revision of the wax scales, genus *Ceroplastes*, in the United States (Homoptera; Coccoidea; Coccidae). University of Maryland, Agricultural Experiment Station, Miscellaneous Publication, Maryland, pp 1–85

Godfrey LD, Pickel C (1998) Seasonal dynamics and management schemes for a subterranean mealybug, *Rhizoecus kondonis* Kuwana, pest of alfalfa. Southwest Entomol 23:343–350

González RH (1981) Biología, ecología y control de la escama de San José en Chile, *Quadraspidiotus perniciosus* (Comst.). Publicaciones En Ciencia Agricultura, Universidad De Chile, Facultad Ciencia Agrarias, Veterinarias, y Forestales 9:1–64

Gordon DR (1998) Effects of invasive, non-indigenous plant species on ecosystem processes: lessons from Florida. Ecol Appl 8:975–989. https://doi.org/10.1890/1051-0761(1998)008[0975:EOINIP]2.0.CO;2

Granara de Willink MC, Szumik C (2007) Phenacoccinae de Centro y Sudamérica (Hemiptera: Coccoidea: Pseudococcidae): Sistemática y filogenia. Rev Soc Entomol Argent 66:29–129

Gutierrez AP, Caltagirone LE, Meikle W (1999) Evaluation of results: economics of biological control. In: Bellows TS, Fisher TW (eds) Handbook of Biological Control. Academic Press, San Diego CA, pp 243–252. https://doi.org/10.1016/B978-012257305-7/50057-6

Halbert SE (1995) *Lepidosaphes punicae*. Tri-Ology 34:1

Hambleton EJ (1973) Florida mealybugs of the genus *Rhizoecus* with description of a new species (Homoptera: Pseudococcidae). Proc Entomol Soc Wash 75:62–71

Hambleton EJ (1976) A revision of the new world mealybugs of the genus *Rhizoecus* (Homoptera: Pseudococcidae). In: United States Department of Agriculture Technical Bulletin, vol 1522, pp 1–88

Hamilton CC (1942) The taxus mealybug, *Pseudococcus cuspidatae* Rau. J Econ Entomol 35:173–175. https://doi.org/10.1093/jee/35.2.173

Hamon AB, Hodges G (2000) Lobate lac scale, *Paratachardina pseudolobata* Kondo & Gullan (Hemiptera: Kerriidae). In: Pest Alert (Florida Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-01686:1–2

Hamon AB, Mason GJ (1997) Fig wax scale, *Ceroplastes rusci* (L.) (Homoptera: Coccoidea). Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 380, pp 1–2

Hamon AB, Williams ML (1984) The soft scale insects of Florida (Homoptera: Coccoidea: Coccidae). In: Arthropods of Florida and Neighboring Land Areas, vol 11, pp 1–194. https://doi.org/10.64338/fsca.af.11.qllbb

Hamon AB (1978) *Opuntiaspis carinata* (Cockerell) (Homoptera: Coccoidea: Diaspididae). Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 196, pp 1

Hamon AB (1979) Angreaceum scale, *Conchaspis angraeci* Cockerell (Homoptera: Coccoidea: Conchaspididae). Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 201, pp 1–2

Hamon AB (1980a) Bamboo pit scale, *Asterolecanium bambusae* (Boisduval) (Homoptera: Coccoidea: Asterolecaniidae). Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 220, pp 1–2

Hamon AB (1980b) *Pseudaonidia trilobitiformis* (Green) (Homoptera: Diaspididae). In: FDACS-P-01784 33rd Biennial Report, p 38–39

Hamon AB (1981) Plumose scale, *Morganella longispina* (Morgan) (Homoptera: Coccoidea: Diaspididae). In: Entomology Circular, Florida Department of Agriculture and Consumer Sevices Division of Plant Industry, vol 226, pp 1–2

Hamon AB (1984) A cactus mealybug, *Hypogeococcus festerianus* (Lizer Y Trelles), in Florida (Homoptera: Coccoidea: Pseudococcidae). Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 263, pp 1–2

Hara AH, Hata TY, Hu BKS (1996) Control of the palm mealybug with insecticides, Hawaii 1995. In: Burditt AK (ed) Arthropod Management Tests, vol 21. Entomological Society of America, Lanham Maryland, p 462. https://doi.org/10.1093/amt/21.1.381a

Hawthorne RM (1975) Estimated damage and crop loss caused by insect/mite pests 1974. In: California Department of Food and Agriculture E-82–14, pp 7–8

Hendricks H, Kosztarab M (1999) Revision of the Tribe Serrolecaniini (Homoptera: Pseudococcidae). de Gruyter, Berlin London. https://doi.org/10.1515/9783110804140

Hill G, Greathead DJ (2000) Economic evaluations in classical biological control. In: Williamson CPM, Dalmazzone S (eds) The Economics of Biological Invasions. Edward

Elgar, Cheltenham UK, pp 208–223. https://doi.org/10.4337/9781781008645.00020
Hodges GS, Hodges AC, Unruh CM (2008) A new exotic pest for Florida's natural areas: *Crypticerya genistae* (Hemiptera: Monophlebidae). Fla Entomol 91:335–337. https://doi.org/10.1653/0015-4040(2008)91[335:ANEPFF]2.0.CO;2
Hodges G, Buss L (2009) An orchid mealybug, *Pseudococcus dendrobiorum* Williams (Hemiptera: Pseudococcidae). In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry), vol 01653, pp 1–3
Hodges GS, Hodgson CJ (2010) *Phalacrococcus howertoni,* a new genus and species of soft scale (Hemiptera: Coccidae) from Florida. Fla Entomol 93:8–23. https://doi.org/10.1653/024.093.0102
Hodgson CJ (1994) The scale insect family Coccidae: an identification manual to genera. CAB International, Wallingford, Oxon, UK
Howard FW, Oliver AD (1985) Armored scale insects (Homoptera: Diaspididae) of Louisiana. Bull La Agric Exp Stn 767:1–125
Howard LO (1894) On the geographical distribution of some common scale insects. Can Entomol 26:353–356. https://doi.org/10.4039/Ent26353-12
Howard FW, Pemberton RW (2003) The lobate lac scale, a new pest of trees and shrubs in Florida: implications for the Caribbean region. Proc Caribb Food Crops Soc 39:91–94
Howard FW, Hamon AB, McLaughlin M et al (1999) *Aulacaspis yasumatsui* (Hemiptera: Sternorrhyncha: Diaspididae), a scale insect pest of cycads recently introduced into Florida. Fla Entomol 82:14–26. https://doi.org/10.2307/3495833
Howard LO (1895) Some scale insects of the orchard. In: United States Department of Agriculture Yearbook, 1894, pp 249–276
Hoy JM (1962) Eriococcidae (Homoptera: Coccoidea) of New Zealand, vol 146. Department of Scientific and Industrial Research Bulletin, New Zealand, pp 1–219
Huffaker CB, Simmonds FJ, Laing JE (1976) The theoretical and empirical basis of biological control. In: Huffaker C, Messenger PE (eds) Theory and Practice of Biological Control. Academic Press, London, pp 41–78. https://doi.org/10.1016/B978-0-12-360350-0.50009-X
Jansen MGM, Alferink LP (2023) An updated list of scale insects (Hemiptera, Coccomorpha) from import interceptions and greenhouses in the Netherlands. J Insect Biodivers 44:021–040. https://doi.org/10.12976/jib/2023.44.2.1
Johnson WT, Lyon HH (1988) Insects that feed on trees and shrubs, 2nd edn. Cornell University Press, Ithaca, New York
Johnston LC (1964) Two new orchid pests. Orchid Dig 28:122–124
Kawai S, Takagi K (1971) Descriptions of three economically important species of root-feeding mealybugs in Japan (Homoptera: Pseudococcidae). Appl Entomol Zool 6:175–182. https://doi.org/10.1303/aez.6.175
Khachatryan H, Hodges AW (2014) Florida nursery crops and landscaping industry economic impacts, situation, and Outlook: FE946/FE946, 9/2014. EDIS, 2014(7). https://doi.org/10.32473/edis-fe946-2014
Killick R, Haynes K, Eckley IA (2014) changepoint: An R package for changepoint analysis. J Stat Softw 58:1–19. https://doi.org/10.18637/jss.v058.i03
Klingeman WE, Chong J-H, Harmon C et al (2020) Scale insect records from ornamental plants help to prioritize plant health resource development. Plant Health Prog 21:278–287. https://doi.org/10.1094/PHP-05-20-0045-S
Knight IA, Wilson BE, Gill M et al (2018) Invasion of *Nipponaclerda biwakoensis* (Hemiptera: Aclerdidae) and *Phragmites australis* die-back in southern Louisiana, USA. Biol Invasions 20:2739–2744. https://doi.org/10.1007/s10530-018-1749-5
Knight IA, Cronin JT, Gill M et al (2020) Investigating plant phenotype, salinity, and infestation by the roseau cane scale as factors in the die-back of *Phragmites australis* in the Mississippi River Delta, USA. Wetlands 40:1327–1337. https://doi.org/10.1007/s13157-020-01307-3
Kosztarab MP (1977) The current state of coccoid systematics. Bull Va Polytech Inst State Univ Res Div 127:1–4
Kosztarab MP (1990) Economic importance. In: Rosen D (ed) Armoured Scale Insects: Their Biology, Natural Enemies and Control [Series title: World Crop Pests, Vol 4B]. Elsevier, Amsterdam, pp 307–311
Kosztarab MP (1996) Scale Insects of Northeastern North America: Identification, Biology, and Distribution. Virginia Museum of Natural History, Martinsburg, Virginia
Kosztarab MP, Kozár F (1988) Scale Insects of Central Europe. Boletín Del Museo De Entomología De La Universidad Del Valle Akademiai Kiado, BudaPest. https://doi.org/10.1007/978-94-009-4045-1
Kosztarab MP, Vest DF (1966) Two new *Cerococcus* species, with a revised key to the genus in North America (Homoptera: Coccoidea: Asterolecaniidae). Ann Entomol Soc Am 59:369–376. https://doi.org/10.1093/aesa/59.2.369
Kuwana SI (1902a) Coccidae (scale insects) of Japan. Proc Calif Acad Sci 3:43–98
Kuwana SI (1902b) A new coccid from California. Entomol News 13:134–136
Kuwana SI (1925) The diaspine Coccidae of Japan. I. Genera *Poliaspis*, *Ischnaspis*, and *Parlatoria*. Tech Bull Dep Financ Imp Plant Quar Serv Jpn 1:1–18
Labuschagne TI, van Hamburg H, Froneman IJ (1995) Population dynamics of the mango scale, *Aulacaspis tubercularis* (Newstead) (Coccoidea: Diaspididae), in South Africa. Isr J Entomol 29:207–217
Lambdin PL (1990) Development of the black willow scale, *Chionaspis salicisnigrae* (Homoptera: Diaspididae), in Tennessee. Entomol News 101:288–292
Lambdin PL, Kosztarab MP (1977) Morphology and systematics of the adult females of the genus *Cerococcus* (Homoptera: Coccoidea: Cerococcidae). Res Div Bull Va Polytech Inst State Univ Blacksbg 128:1–252
Leimroth A, Somma LA, Russell DN, Cutts LP, Ryan M, Babb RD, Hajek KE, Holycross AT (2022) Geographic distribution: *Anolis sagrei* (brown anole). USA: Arizona. Herpetol Rev 53:628–629
Leroy B, Kramer AM, Vaissière A-C et al (2022) Analysing economic costs of invasive alien species with the

INVACOST R package. Methods Ecol Evol 13:1930–1937. https://doi.org/10.1111/2041-210X.13929
Leung B, Springborn MR, Turner JA et al (2014) Pathway-level risk analysis: the net present value of an invasive species policy in the US. Front Ecol Environ 12:273–279. https://doi.org/10.1890/130311
Lichtenberg E, Olson LJ (2018) The fruit and vegetable import pathway for potential invasive pest arrivals. PLoS ONE 13:e0192280. https://doi.org/10.1371/journal.pone.0192280
Liebhold AM, Griffin RL (2016) The legacy of Charles Marlatt and efforts to limit plant pest invasions. Am Entomol 62:218–227. https://doi.org/10.1093/ae/tmw072
Liebhold AM, Yamanaka T, Roques A, Augustin S, Chown SL, Brockerhoff EG, Pyšek P (2018) Plant diversity drives global patterns of insect invasions. Sci Rep 8:12095. https://doi.org/10.1038/s41598-018-30605-4
Liebhold AM, Turner RM, Bartlett CR et al (2024) Why so many Hemiptera invasions? Divers Distrib 00:e13911. https://doi.org/10.1111/ddi.13911
Liu T-X, Kosztarab MP, Rhoades M (1989) Biosystematics of the adult females of the genus *Chionaspis* (Homoptera: Coccoidea: Diaspididae) of North America, with emphasis on polymorphism. In: Studies on the morphology and systematics of scale insects—No. 15 (Contribution No. 2 to a National Biological Survey). VAES Bulletin 88–2. Virginia Agricultural Experiment Station, Blacksburg, VA
Lockwood JL, Cassey P, Blackburn T (2005) The role of propagule pressure in explaining species invasions. Trends Ecol Evol 20:223–228. https://doi.org/10.1016/j.tree.2005.02.004
Lopes EB, de Brito CH, de Albuquerque IC et al (2009) Desempenho do óleo de laranja no controle da cochonilha-do-carmim em palma gigante. Engenharia Ambiental 6:252–258
Luck R, Hoddle M (2025) California Red Scale. In: Center for Invasive Species Research, University of California Riverside. https://cisr.ucr.edu/invasive-species/california-red-scale#:~:text=Economic%20Impact%3A%20California%20red%20scale,to%20three%20times%20per%20year. Accessed 25 April 2025
Manichote P, Middlekauff WW (1967) Life history studies of the cactus mealybug *Spilococcus cactearum* McKenzie (Homoptera: Coccoidea: Pseudococcidae). Hilgardia 37:639–660. https://doi.org/10.3733/hilg.v37n17p639
Marlatt CL (1908) New species of diaspine scale insects. US Dep Agric Bur Entomol Tech Ser 16:11–32
Marlatt CL (1920) Federal plant quarantine work and cooperation with state officials. J Econ Entomol 13:179–180
Maxwell-Lefroy H (1908) Notes on Indian scale insects (Coccidae). Mem Dep Agric India 2:109–137
McClure MS (1977) Resurgence of the scale, *Fiorinia externa* (Homoptera: Diaspididae), on hemlock following insecticide application. Environ Entomol 6:480–484. https://doi.org/10.1093/ee/6.3.480
McClure MS (1983) Population dynamics of a pernicious parasite: density dependent vitality of red pine scale. Ecology 64:710–718. https://doi.org/10.2307/1937193
McClure MS (1988) The armored scales of hemlock. In: Berryman AA (ed) Dynamics of Forest Insect Populations. Springer, Boston MA, pp 45–65. https://doi.org/10.1007/978-1-4899-0789-9_3
McClure MS, Fergione MB (1977) *Fiorinia externa* and *Tsugaspidiotus tsugae* (Homoptera: Diaspididae): distribution, abundance, and new hosts of two destructive scale insects of eastern hemlock in Connecticut. Environ Entomol 6:807–811. https://doi.org/10.1093/ee/6.6.807
McDaniel B (1968) The armored scale insects of Texas (Homoptera: Coccoidea: Diaspididae). Southwest Nat 13:201–242. https://doi.org/10.2307/3668932
McKenzie HL (1938) The genus *Aonidiella* (Homoptera; Coccoidea: Diaspididae). Microentomol 3:1–36
McKenzie HL (1939) A revision of the genus *Chrysomphalus* and supplementary notes on the genus *Aonidiella* (Homoptera: Coccoidea: Diaspididae). Microentomol 4:51–77
McKenzie HL (1943) Miscellaneous diaspid studies including notes on *Chrysomphalus* (Homoptera; Coccoidea; Diaspididae). Bull Calif Dep Agric 32:148–162
McKenzie HL (1945) A revision of *Parlatoria* and closely allied genera. (Homoptera: Coccoidea: Diaspididae). Microentomol 10:47–121
McKenzie HL (1951) Present status of the kuno scale, *Lecanium kunoensis* Kuwana, in California (Homoptera; Coccoidea; Coccidae). Bull Dep Agric State Calif 40:105–109
McKenzie HL (1953) Two new *Selenaspidus* scales infesting *Euphorbia* in California. (Homoptera; Coccoidea; Diaspididae). Scale studies-Part XII. Bull Calif Dep Agric 42:53–58
McKenzie HL (1955) A new species of *Lepidosaphes* scale infesting umbrella pine in California. (Homoptera; Coccoidea; Diaspididae). Pan-Pac Entomol 31:187–190
McKenzie HL (1956) The armored scale insects of California. Bull Calif Insect Surv 5:1–209. https://doi.org/10.1525/9780520345775
McKenzie HL (1960a) Taxonomic position of *Parlatoria virescens* Maskell, and descriptions of related species (Homoptera: Coccoidea: Diaspididae). Scale studies pt. 14. Bull Calif Dep Agric 49:204–211
McKenzie HL (1960b) Taxonomic study of California mealybugs with descriptions of new species (Homoptera: Coccoidea: Pseudococcidae). Hilgardia 29:681–770. https://doi.org/10.3733/hilg.v29n15p681
McKenzie HL (1967) Mealybugs of California with Taxonomy, Biology, and Control of North American Species (Homoptera: Coccoidea: Pseudococcidae). University of California Press, Berkeley. https://doi.org/10.1525/9780520338227
Mead FW (1975) Estimates of losses and cost of control for insects in the Southeastern United States (1974 crop-year). Florida Department of Agriculture, Florida, p 2
Merrill GB (1953) A revision of the scale insects of Florida. Bull Fla State Plant Board 1:1–143
Merrill GB, Chaffin J (1923) Scale insects of Florida. Q Bull Fla State Plant Board 7:177–298
Miller DR (1975) A revision of the genus *Heterococcus* Ferris with a diagnosis of *Brevennia* Goux (Homoptera: Coccoidea: Pseudococcidae). US Dep Agric Tech Bull 1497:1–61

Miller DR (1985) Superfamily Coccoidea. Scale Insects. In: Drooz AT (ed) Insects of Eastern Forests. Miscellaneous Publications United States Department of Agriculture, USA, pp 87–123

Miller DR (1999) Identification of the Pink Hibiscus Mealybug, *Maconellicoccus hirsutus* (Green) (Hemiptera: Sternorrhyncha: Pseudococcidae). Insecta Mundi 13:189–203

Miller DR, Davidson JA (1990) A list of the armored scale insect Pests. In: Rosen D (ed) Armoured Scale Insects: Their Biology, Natural Enemies and Control. Elsevier, Amsterdam, pp 299–306

Miller DR, Davidson JA (2005) Armored Scale Insect Pests of Trees and Shrubs (Hemiptera: Diaspididae). Cornell University Press, Ithaca, NY

Miller DR, Giliomee JH (2011) Systematic revision of the mealybug genus *Delottococcus* Cox & Ben-Dov (Hemiptera: Pseudococcidae). Afr Entomol 19:614–640. https://doi.org/10.4001/003.019.0306

Miller DR, Miller GL (1992) Systematic analysis of *Acanthococcus* (Homoptera: Coccoidea: Eriococcidae) in the western United States. Trans Am Entomol Soc 118:1–106

Miller DR, Miller GL (2002a) Redescription of *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Coccoidea: Pseudococcidae), including descriptions of the immature stages and adult male. Proc Entomol Soc Wash 104:1–23

Miller DR, Williams DJ (1997) A new species of mealybug in the genus *Pseudococcus* (Homoptera: Pseudococcidae) of quarantine importance. Proc Entomol Soc Wash 99:305–311

Miller DR, Davidson JA, Stoetzel MB (1984) A taxonomic study of the armored scale *Pseudischnaspis* Hempel (Homoptera: Coccoidea: Diaspididae). Proc Entomol Soc Wash 86:94–109

Miller DR, Miller GL, Watson GW (2002) Invasive species of mealybugs (Hemiptera: Pseudococcidae) and their threat to U.S. agriculture. Proc Entomol Soc Wash 104:825–836

Miller DR, Miller GL, Hodges GS et al (2005) Introduced scale insects (Hemiptera: Coccoidea) of the United States and their impact on US agriculture. Proc Entomol Soc Wash 107:123–158

Miller GL, Miller DR (2002b) *Dysmicoccus* Ferris and similar genera (Hemiptera: Coccoidea: Pseudococcidae) of the Gulf State region including a description of a new species and new United States records. Proc Entomol Soc Wash 104:968–979

Misra CS (1920) Some pests of cotton in North Bihar. In: Proceedings of the Third Entomological Meeting, Pusa, India, 3–15 February, 1919

Moffitt LJ (1999) Economic risk to United Status agriculture of pink hibiscus mealybug invasion. In: Report to the Animal and Plant Health Inspection Service, United States Department of Agriculture, Washington, DC

Morrison AE (1946) Insects infesting camellias. Bull Calif Dep Agric 35:131–135

Mottern J, Stocks IC, Gates MW (2021) A new species of *Comones* Noyes and Woolley (Hymenoptera: Encyrtidae), a parasitoid of flat grass scale, *Aclerda takahashii* Kuwana (Hemiptera: Aclerdidae), a new pest on sugarcane in Florida. Proc Entomol Soc Wash 123:136–146. https://doi.org/10.4289/0013-8797.123.1.136

Mueller DS, Sisson AJ, Eide B et al (2024) Field crop yield loss calculator for disease and invertebrate pests: an online tool from the Crop Protection Network. PhytoFrontiers 4:255–258. https://doi.org/10.1094/PHYTOFR-08-23-0109-A

Munir B, Sailer RI (1985) Population dynamics of the tea scale, *Fiorinia theae* (Homoptera: Diaspididae), with biology and life tables. Environ Entomol 14:742–748. https://doi.org/10.1093/ee/14.6.742

Murakami Y (1970) A review of biology and ecology of Diaspine scales in Japan (Homoptera, Coccoidea). Mushi 43:65–114

Myrick S, Norton G, Selvaraj K et al (2014) Economic impact of classical biological control of papaya mealybug in India. Crop Protect 56:82–86. https://doi.org/10.1016/j.cropro.2013.10.023

Nada S, Abd-Rabou S, Hussein GED (1990) Scale insects infesting mango trees in Egypt (Homoptera: Coccoidea). In: Proceedings of the Sixth International Symposium of Scale Insects Studies, Cracow, Poland

Nagrare VS, Kranthi S, Biradar VK et al (2009) Widespread infestation of the exotic mealybug species, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae), on cotton in India. Bull Entomol Res 99:537–541. https://doi.org/10.1017/S0007485308006573

Nance CE, Powell EC, Russell D, Halbert SE (2024) Florida's agricultural inspection stations: focus on intercepting invasive Hemiptera in interstate truck shipments. Fla Entomol 107:20240019. https://doi.org/10.1515/flaent-2024-0019

Naranjo SE, Frisvold GB, Ellsworth PC (2019) Economic value of arthropod biological control. In: Onstad DW, Crain PR (eds) The economics of integrated pest management of insects. CAB International, Wallingford Oxon UK, pp 49–85

Norgaard RB (1988) The biological control of cassava mealybug in Africa. Am J Agric Econ 70:366–371. https://doi.org/10.2307/1242077

Normark BB, Okusu A, Morse GE et al (2019) Phylogeny and classification of armored scale insects (Hemiptera: Coccomorpha: Diaspididae). Zootaxa 4616:001–098. https://doi.org/10.11646/zootaxa.4616.1.1

Oetting RD, Hudson W, Braman SK (2007) Ornamentals, lawn and turf insects. In: Guillebeau P, Hinkle N, Roberts P (eds) Summary of losses from insect damage and cost of control in Georgia 2004. University of Georgia Cooperative Extension Service, Athens GA, pp 20–22

Olabiyi D, Stelinski LL, Diepenbrock LM (2023) Laboratory evaluation of the life history of hibiscus mealybug, *Nipaecoccus viridis* (Hemiptera: Pseudococcidae), on selected citrus and potential non-citrus hosts in Florida. J Econ Entomol 116:891–898. https://doi.org/10.1093/jee/toad055

Oliveira CM, Auad AM, Mendes SM et al (2013) Economic impact of exotic insect pests in Brazilian agriculture. J Appl Entomol 137:1–15. https://doi.org/10.1111/jen.12018

Pace R, Ascolese R, Miele F et al (2022) The bugs in the bags: the risk associated with the introduction of small quantities of fruit and plants by airline passengers. Insects 13:617. https://doi.org/10.3390/insects13070617

Park JD, Hong KH (1992) Species, damage and population density of Pseudococcidae injuring pear fruits. Korean J Appl Entomol 31:133–138

Patil I (2021) Visualizations with statistical details: the 'ggstatsplot' approach. J Open Source Softw 6:3167. https://doi.org/10.21105/joss.03167

Peters T (1999) The pink mealybug (*Maconellicoccus hirsutus*) in Grenada. In: Evaluation Workshop on Biological Control of Hibiscus Mealybug, *Maconellicoccus hirsutus* in the Caribbean Sub Region, Trinidad and Tobago, 11–12 March 1999

Pimentel D, Zuniga R, Morrison D (2005) Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecol Econ 52:273–288. https://doi.org/10.1016/j.ecolecon.2004.10.002

Potter DA (1998) Destructive turfgrass insects: biology, diagnosis and control. Ann Arbor Press, Chelsea, Michigan

Powell EC, Deeter LA, Miller DR (2024a) *Bambusaspis minuta* (Takahashi), a bamboo pit scale detected in central Florida. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P02226. https://doi.org/10.13140/RG.2.2.27797.74724

Powell EC, Deeter LA, Moore MR et al (2024b) Taxonomy, hosts, and distribution of an emerging invasive mealybug, *Phenacoccus miruku* (Hemiptera: Coccomorpha: Pseudococcidae), in Florida. Fla Entomol 107:20240024. https://doi.org/10.1515/flaent-2024-0024

Powell EC, Zenoble M, Miller DR et al (2024c) A new invasive *Lepidosaphes* armored scale (Hemiptera: Coccomorpha: Diaspididae) for Florida: first records, natural enemies, and an identification key. Insecta Mundi 1073:1–24

Powell EC, Miller DR (2024) *Pseudaulacaspis rubra* (Maskell), an armored scale insect detected in South Florida. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-02256. https://doi.org/10.13140/RG.2.2.11682.54720

Powell EC, Moore MR, Stocks IC (2023) *Lepidosaphes laterochitinosa* (Green), an adventive mussel scale in South Florida. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-01527. https://doi.org/10.13140/RG.2.2.30766.89926

Qin TK, Gullan PJ, Beattie GAC et al (1994) The current distribution and geographical origin of the scale insect pest *Ceroplastes sinensis* (Hemiptera: Coccidae). Bull Entomol Res 84:541–549. https://doi.org/10.1017/S000748530003279X

Qin TK, Gullan PJ, Beattie AC (1998) Biogeography of the wax scales (Insecta: Hemiptera: Coccidae: Ceroplastinae). J Biogeogr 25:37–45. https://doi.org/10.1046/j.1365-2699.1998.251178.x

Ranjan R (2006) Economic impacts of pink hibiscus mealybug in Florida and the United States. Stoch Environ Res Risk Assess 20:353–362. https://doi.org/10.1007/s00477-005-0027-0

Richards AM (1962) The oyster-shell scale *Quadraspidiotus ostreaeformis* (Curtis), in the Christchurch district of New Zealand. NZ J Agric Res 5:95–100. https://doi.org/10.1080/00288233.1962.10419979

Rosen D, DeBach P (1978) Diaspididae. In: Clausen CP (ed) Introduced Parasites and Predators of Arthropod Pests and Weeds: A World Review. Agricultural Research Service, United States Department of Agriculture, Washington DC, pp 78–128

Ross L, Pen I, Shuker DM (2010) Genomic conflict in scale insects: the causes and consequences of bizarre genetic systems. Biol Rev 85:807–828. https://doi.org/10.1111/j.1469-185X.2010.00127.x

Russell LM (1941) A classification of the scale insect genus *Asterolecanium*. United States Department of Agriculture Miscellaneous Publications, vol 424, pp 1–319. https://doi.org/10.5962/bhl.title.65621

Saakyan-Baranova AA (1954) Pests of greenhouse plants. Akademii Nauk SSSR Glavnogo Botanicheskii Sada Trudy 4:7–41

Santas LA (1988) *Physokermes hemicryphus* (Dalman) a first scale insect used to apiculture in Greece. Entomol Hell 6:11–22. https://doi.org/10.12681/eh.13954

Sasscer ER (1918) Important foreign insect pests collected on imported nursery stock in 1917. J Econ Entomol 11:125–129. https://doi.org/10.1093/jee/11.1.125

Schneider SA, Okusu A, Normark BB (2018) Molecular phylogenetics of Aspidiotini armored scale insects (Hemiptera: Diaspididae) reveals rampant paraphyly, curious species radiations, and multiple origins of association with *Melissotarsus* ants (Hymenoptera: Formicidae). Mol Phylogenet Evol 129:291–303. https://doi.org/10.1016/j.ympev.2018.09.003

Schneider SA, Broadley HJ, Andersen JC et al (2022) An invasive population of roseau cane scale in the Mississippi River Delta, USA originated from northeastern China. Biol Invasions 24:2735–2755. https://doi.org/10.1007/s10530-022-02809-3

Sharaf NS, Meyerdirk DE (1987) A review on the biology, ecology and control of *Nipaecoccus viridis* (Homoptera: Pseudococcidae). Misc Publ Entomol Soc Am 66:1–18. https://doi.org/10.4182/VICJ7911.66.1

Simberloff D, von Holle B (1999) Positive interactions of nonindigenous species. Biol Invasions 1:21–32. https://doi.org/10.1023/A:1010086329619

Simpson A, Fuller P, Faccenda K, Evenhuis N, Matsunaga J, Bowser M (2022) United States register of introduced and invasive species (US-RIIS) (ver. 2.0, November 2022). U.S. Geological Survey data release. https://doi.org/10.5066/P9KFFTOD Accessed 19 March 2025

Skelley PE, Buss EA, Allen JS, Bolton SJ, Deeter LA, Fulton JC, Greer DJ, Halbert SE, Hayden JE, Moore MR, Nance CE, Powell EC, Rodriguez EJ, Roeder EE, Schnepp KE, Soto-Adames FN, Steck GJ, Talamas EJ, Smith TR (2025) Adventive arthropods in Florida as reported by the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, 1990–2023. Fla Entomol 108:20240027. https://doi.org/10.1515/flaent-2024-0027

Skvarla MJ, Halbert SE, Foottit RG, Jensen AS, Maw E, Miller GL (2017) An update to the adventive aphids

(Hemiptera: Aphidoidea) of America North of Mexico, with notes on intercepted species. Proc Entomol Soc Wash 119:90–111. https://doi.org/10.4289/0013-8797.119.1.90

Snetsinger R (1966) Biology and control of a root-feeding mealybug on *Saintpaulia*. J Econ Entomol 59:1077–1078. https://doi.org/10.1093/jee/59.5.1077

Stafford EM, Barnes DF (1948) Biology of the fig scale in California. Hilgardia 18:567–598. https://doi.org/10.3733/hilg.v18n16p567

Stauffer S, Rose M (1997) Biological control of soft scale insects in interior plantscapes in the USA. In: Ben-Dov Y, Hodgson CJ (eds) Soft Scale Insects: Their Biology, Natural Enemies, and Control, vol 7B. Elsevier, Amsterdam, pp 183–203. https://doi.org/10.1016/S1572-4379(97)80083-8

Steinweden JB (1946) The identity of certain common American species of *Pulvinaria* (Homoptera: Coccoidea: Coccidae) (Contribution No. 49). Microentomol 11:1–28

Stimmel JF (1978) Fletcher scale, *Lecanium fletcheri* Cockerell (Homoptera: Coccidae). Pa Dept Agric Reg Hort Ent Circ 4:15–16

Stimmel JF (1986) *Aspidiotus cryptomeriae* Kuwana, an armored scale pest of conifers. Pa Dept Agric Reg Hort Ent Circ 12:21–22

Stimmel JF (1994) *Lepidosaphes pini*, an armored scale on pines (Homoptera: Diaspididae). Pa Dept Agric Reg Hort Ent Circ 20:19–20

Stimmel JF (1996) Miscanthus mealybug, *Miscanthicoccus miscanthi* (Takahashi). Pa Dept Agric Reg Hort Ent Circ 22:21–23

Stirling M (2012) California's program to protect against pests entering the state at the borders. Outlooks Pest Manag 23:144–147. https://doi.org/10.1564/23jun14

Stocks IC, Hodges GS (2010) *Nipaecoccus viridis* (Newstead), a new exotic mealybug in South Florida (Coccoidea: Pseudococcidae). In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry), vol 01716, pp 1–3

Stocks IC (2012a) The mealybug *Phenacoccus multicerarii* Granara de Willink (Hemiptera: Pseudococcidae) in Florida. Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 422, pp 1–2

Stocks IC (2012b) *Vryburgia trionymoides* (DeLotto) (Pseudococcidae), a pest of succulents. Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 422, pp 1–2

Stocks IC (2013) Recent adventive scale insects (Hemiptera: Coccoidea) and whiteflies (Hemiptera: Aleyrodidae) in Florida and the Caribbean region. In: CABI INVASIVES series: Potential Invasive Pests of Agricultural Crops, CABI Boston: MA, pp 342–362 https://doi.org/10.1079/9781845938291.0342

Stocks IC (2014) *Poliaspoides formosana* (Takahashi) (Hemiptera: Diaspididae), an adventive armored scale on bamboo in Florida, USA. Entomology Circular, Florida Department of Agriculture and Consumer Services Division of Plant Industry, vol 429, pp 1–2

Stocks IC (2015) *Fiorinia proboscidaria* Green (Hemiptera: Diaspididae), a new armored scale pest of citrus in Florida. In Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-02033:1–3

Stocks IC (2016a) The flat grass scale, *Aclerda takahashii* Kuwana (Hemiptera: Aclerdidae), a new pest of sugarcane in Florida. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-01817:1–2

Stocks IC (2016b) *Lepidosaphes laterochitinosa* (Green), a new mussel scale intercepted in a Florida nursery. In: Pest Alert (Florida Department of Agriculture and Consumer Services Division of Plant Industry) FDACS-P-01527:1–2

Stumpf CF, Lambdin PL (2006) Pit scales (Sternorrhyncha: Coccoidea) of North and South America. Tennessee Agricultural Experiment Station, Knoxville Tennessee

Suh SJ, Yu HM, Hong KJ (2013) List of intercepted scale insects at Korean ports of entry and potential invasive species of scale insects to Korea (Hemiptera: Coccoidea). Korean J Appl Entomol 52:141–160. https://doi.org/10.5656/KSAE.2013.03.0.007

Tabatadze ES, Yasnosh VA (2001) Population dynamics and biocontrol of the Japanese scale, *Lopholeucaspis japonica* (Cockerell) in Georgia. Entomol 33:429–434

Takagi S (1961) A contribution to the knowledge of the Diaspidini of Japan (Homoptera: Coccoidea) part II. Insecta Matsumurana 24:4–42

Takahashi R (1930) Observations on the Coccidae of Formosa, Part II Report. Department of Agriculture Government Research Institute, Formosa, pp 1–45

Talhouk AMS (1975) Citrus pests throughout the world. Ciba-Geigy Agrochem Tech Monogr 4:21–23

Taylor THC (1935) The campaign against *Aspidiotus destructor,* Sign., in Fiji. Bull Entomol Res 26:1–102. https://doi.org/10.1017/S0007485300024925

Turbelin AJ, Diagne C, Hudgins EJ et al (2022) Introduction pathways of economically costly invasive alien species. Biol Invasions 24:2061–2079. https://doi.org/10.1007/s10530-022-02796-5

Turner RM, Brockerhoff EG, Bertelsmeier C, Blake RE, Caton B, James MacLeod AA, Nahrung HF, Pawson SM, Plank MJ, Pureswaran DS, Seebens H, Yamanaka T, Liebhold AM (2021) Worldwide border interceptions provide a window into human-mediated global insect movement. Ecol Appl 31(7):e02412. https://doi.org/10.1002/eap.2412

Van Driesche RG, Bellows TS (1996) Biological control. Chapman and Hall, New York. https://doi.org/10.1007/978-1-4613-1157-7

von Ellenrieder N (2025) New records of scale insects (Hemiptera: Sternorrhyncha: Coccomorpha) from California with an updated checklist for the state. Pan-Pac Entomol 101:15–50. https://doi.org/10.3956/2024-101.1.15

von Ellenrieder N, Stocks IC (2014) A new species of mealybug in the genus *Paracoccus* Ezzat & McConnell from North America (Insecta: Coccoidea: Pseudococcidae). Zootaxa 3873:025–036. https://doi.org/10.11646/zootaxa.3873.1.2

von Ellenrieder N, Watson GW, Kinnee SA et al (2016) *Paracoccus leucadendri* Mazzeo & Franco in Mazzeo, Franco & Russo, 2009, a junior synonym of *Paracoccus hakeae* (Williams, 1985) comb. nov. (Coccomorpha: Pseudococcidae). Zootaxa 4093:552–558. https://doi.org/10.11646/zootaxa.4093.4.6

von Ellenrieder N, Kinnee SA, Watson GW (2020) The bougainvillea mealybug, *Phenacoccus peruvianus* Granara de Willink, in Granara de Willink & Szumik, 2007 (Hemiptera: Pseudococcidae), an invasive species new to North America, with a description of the adult male and new host records. Pan-Pac Entomol 96:59–72. https://doi.org/10.3956/2020-96.2.59

von Ellenrieder N, Kinnee SA, Watson GW (2022) Review of the genus *Palmicultor* Williams, 1963 (Hemiptera: Coccomorpha: Pseudococcidae), with evidence of a cryptic species. Pan-Pac Entomol 97:240–260. https://doi.org/10.3956/2021-97.4.240

Waltman KG, Ray CH, Williams ML (2016) The armored scale insects (Hemiptera Diaspididae) of Alabama, USA. Redia XCIX:229–231. https://doi.org/10.19263/REDIA-99.16.31

Wang Y, Watson GW, Zhang R (2010) The potential distribution of an invasive mealybug *Phenacoccus solenopsis* and its threat to cotton in Asia. Agric for Entomol 12:403–416. https://doi.org/10.1111/j.1461-9563.2010.00490.x

Wang Z, Chen Y, Knox GW, Ring D, Diaz R (2015) Crape myrtle bark scale. Bug Biz 3440:1–4

Ward A (1966) Mealybugs (Hemiptera: Pseudococcidae) in Hawke's Bay orchards. NZ J Agric Res 9:452–454. https://doi.org/10.1080/00288233.1966.10420797

Washburn JO, Frankie GW (1985) Biological studies of iceplant scale, *Pulvinariella mesembryanthemi* and *Pulvinaria delottoi* (Homoptera: Coccidae) in California. Hilgardia 53:1–27. https://doi.org/10.3733/hilg.v53n02p027

Watson GW, Kondo T (2022) *Planococcus* spp. In: Kondo T, Watson GW (eds) Encyclopedia of Scale Insect Pests. CAB International, Boston MA, pp 177–192. https://doi.org/10.1079/9781800620643.0000

Westcott C (1973) The gardener's bug book. Doubleday and Co., Garden City New York

Wickham H (2016) ggplot2: Elegant graphics for data analysis. Springer-Verlag, New York. https://doi.org/10.1007/978-3-319-24277-4_9

Williams DJ (1963) Synoptic revisions of I. *Lindingaspis* and II. *Andaspis* with two new allied genera (Hemiptera: Coccoidea). Bull Br Mus (Nat Hist) Entomol 15:1–31. https://doi.org/10.5962/bhl.part.20532

Williams DJ (1969) A revision of the genus *Geococcus* Green (Homoptera, Coccoidea, Pseudococcidae). Bull Entomol Res 59:505–517. https://doi.org/10.1017/S0007485300003485

Williams DJ (1985) Australian Mealybugs. British Museum (Natural History), London

Williams DJ (1996a) A brief account of the hibiscus mealybug *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae), a pest of agriculture and horticulture, with descriptions of two related species from southern Asia. Bull Entomol Res 86:617–628. https://doi.org/10.1017/S0007485300039420

Williams DJ (1996b) Four related species of root mealybugs of the genus *Rhizoecus* from East and Southeast Asia of importance at quarantine inspection (Hemiptera: Coccoidea: Pseudococcidae). J Nat Hist 30:1391–1403. https://doi.org/10.1080/00222939600771291

Williams DJ (1996c) A synoptic account of the mealybug genus *Ferrisia*. Entomol Mon Mag 132:1–10

Williams DJ (2003) A mealybug (Hem., Pseudococcidae) increasing its range on bamboo. Entomol Mon Mag 139:68

Williams DJ (2004) Mealybugs of Southern Asia. Natural History Museum, London

Williams DJ, Granara de Willink MC (1992) Mealybugs of Central and South America. CAB International, Wallingford, UK

Williams DJ, Hamon AB (1994) *Phenacoccus parvus* Morrison, a possible injurious mealybug recorded for the first time from Florida (Homoptera: Coccoidea: Pseudococcidae). Insecta Mundi 8:16

Williams ML, Kosztarab MP (1972) Morphology and systematics of the Coccidae of Virginia with notes on their biology (Homoptera: Coccoidea). Res Div Bull Va Polytech Inst State Univ 74:1–215

Williams DJ, Miller DR (2002) Systematic studies on the *Antonina crawi* Cockerell (Hemiptera: Coccoidea: Pseudococcidae) complex of pest mealybugs. Proc Entomol Soc Wash 104:896–911

Williams DJ, Nakahara S (1980) *Rhizoecus pritchardi* McKenzie, a junior synonym of *R. dianthi* Green (Homoptera: Pseudococcidae). Proc Entomol Soc Wash 82:336–337

Williams DJ, Watson GW (1988a) The Scale Insects of the Tropical South Pacific Region. Part 1 The Armoured Scale Insects (Diaspididae). CAB International, Wallingford UK

Williams DJ, Watson GW (1988b) The Scale Insects of the Tropical South Pacific Region. Part 2 The Mealybugs (Pseudococcidae). CAB International, Wallingford UK

Williams DJ, Watson GW (1990) The Scale Insects of the Tropical South Pacific Region. Pt 3: The Soft Scales (Coccidae) and Other Families. CAB International, Wallingford UK

Wilson CE (1917) Some Florida scale insects. Q Bull Fla State Plant Board 2:2–65

Wunderlin RP, Hansen BF, Franck AR, Essig FB (2025) Atlas of Florida Plants [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa. http://florida.plantatlas.usf.edu/ Accessed 21 June 2025

Wysoki M (1997) Present status of arthropod fauna in mango orchards in Israel. Acta Hortic 455:805–811. https://doi.org/10.17660/ActaHortic.1997.455.102

Zeddies J, Schaab RP, Neuenschwander P et al (2001) Economics of biological control of cassava mealybug in Africa. Agric Econ 24:209–219. https://doi.org/10.1111/j.1574-0862.2001.tb00024.x

Zimmerman EC (1948) Homoptera: Sternorrhyncha. Insects Hawaii 5:1–464