

INTRODUCED SCALE INSECTS (HEMIPTERA: COCCOIDEA) OF THE UNITED STATES AND THEIR IMPACT ON U.S. AGRICULTURE

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Abstract.—We provide information on 255 species of scale insects that are considered adventive or introduced in the United States. Included for each species, where applicable, is reference to: the state and earliest collection date in which the invader was first discovered; whether it is currently established in the United States; its pest status in the United States along with a validation citation; its principal hosts; and its zoogeographical region of origin. Information is provided about trends of pest introductions and on native scale-insect pests in the United States.

Key Words: scale insects, adventive species, invasive species, exotic species, pests, geographic origin

Scale insects are major agricultural pests and pose serious problems when introduced into new areas of the world without natural enemies. Historically, introduced scale insects have fostered the development of strategies for dealing with exotic pests either after they were detected in the United States or for prevention of new introductions. Devastation caused by the cottony cushion scale, *Icerya purchasi* Maskell, in California was one of the reasons for the beginning of a new subdiscipline in entomology called biological control (Van Driesche and Bellows 1996). The introduction of the San José scale, *Diaspidiotus perniciosus* (Comstock), a serious pest of stone fruit crops, also had major impact and was one of the primary reasons that Congress passed the U.S. Plant Quarantine Act in 1912 (Marlatt 1920).

In the past 20 years, 21 new exotic species of scale insects have been detected in the continental United States. Of these, 11 currently are considered pests and several others have pest potential. Some of the most serious pest introductions are: white mango scale, *Aulacaspis tubercularis* Newstead, a pest of mango first detected in 2002; cycad aulacaspis scale, *Aulacaspis yasmumatsui* Takagi, a pest of cycads detected in 1996; hibiscus mealybug, *Maconellicoccus hirsutus* (Green), a polyphagous pest that is common on hibiscus detected in 1999; miscanthus mealybug, *Miscanthicoccus miscanthi* (Takahashi), a pest of miscanthus grass detected in 1989; papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink, a pest of papaya and hibiscus detected in 1999; lobate lac scale, *Paratachardina lobata* (Cham-

berlin), a pest of numerous ornamental and native species detected in 1999; black parlatoria scale, *Parlatoria ziziphi* (Lucas), a pest of citrus detected in 1985; and vine mealybug, *Planococcus ficus* (Signoret), a pest of fig and grapes detected in 1994.

Although one of us (DRM) has participated in several programs aimed at gaining definitive data on introduced insects in the United States, e.g., McGregor (1973), Sailer (1978, 1983), no comprehensive analysis is available on the adventive scale insects of the United States. Therefore, the objectives of this study are to: 1) list the adventive scale insects of the United States and record data on: first detection date in the United States (with validation source), degree of certainty that the species is adventive, pest status in United States, reference to pest status when available, principal hosts, zoogeographic area of origin, validation source of origin when available, and eradication status; 2) analyze these data and determine if patterns exist; and 3) compare these data with those of Sailer (1978) for all insects.

MATERIALS AND METHODS

We have treated species as introduced only when they are established in an exterior environment. We have excluded species that were discovered in nurseries or greenhouses and ultimately were eradicated, or species that were taken in quarantine. As far as we are aware, no species have been purposefully introduced for biological control, although at least one, *Trabutina mannipara* (Hemprich and Ehrenberg), has been considered as a biological control agent of saltcedar, *Tamarix* spp. (DeLoach et al. 1996).

Some of the data that we have compiled are subjective. For example, in trying to determine the area of origin of a species, we have relied on statements in the literature, distribution of less widespread congeneric (and hopefully related), and, in a few instances, our best guess. Determining if a species is adventive or indigenous has not always been clear, particularly when it may have its origin from Nearctic Mexico or

Central America. In some cases, we have been unable to find evidence or area of origin, and in other situations we have been unable to decide which of two zoogeographic regions is the area of origin. Thus, the statistics given in the tables and charts do not always add up to the exact number of invasive species (255).

For recording the earliest record of an adventive in the United States, we have relied on published records and specimens examined in the collections of The National Entomological Collection of the National Museum of Natural History, Beltsville, Maryland (USNM); The Florida State Collection of Arthropods, Gainesville, Florida (FSCA); and The Bohart Museum, Davis, California (UCD). It is possible that older records exist for some species, but we anticipate that the dates reported here are close approximations of the first U.S. detections. Although some species may have been introduced in 1700's or earlier, little or no documentation to verify the time or location of these introductions is available. For most of these, the earliest detection record is from the 1870's or 1880's when specimens were first deposited in collections, even though these species might have been present decades earlier.

For determining the pest status of a species, we have relied on the literature. If statements are made that a species is a pest, is causing harm, requires control measures, is economically important, or some comparable comment, we are considering these species to be pests. Our decisions about pest-status intensity, i.e., minor pest, pest, or serious pest, are based on our experience or statements in the literature. We provided references on pest status when available.

The principal adventive scale hosts were grouped in categories that associated large numbers of scale-insect species. These host-plant groupings are not always comparable, e.g., polyphagous vs. tree species, but they provide useful information on high-risk host categories. Our definition of polyphagous is any known from 10 or more families of host plants.

In our previous papers (Miller et al. 2002, Miller and Miller 2003), we deviated from the strict definition of an invasive species and used it synonymously with adventive, alien, exotic, and immigrant (see Wheeler and Hobeke 2001 for discussion of terminology). Here, we restrict the definition of an invasive species to conform to prevailing usage, i.e., a species that has invaded a HABITAT (not necessarily a political unit) and is causing harm or has the potential of causing harm.

In compiling statistics about the scale insect fauna, we have grouped the scales into five categories, i.e., all scales, diaspidids, pseudococcids, coccids, and all other scale families.

RESULTS

Based on information in ScaleNet (Ben-Dov et al. 2003), there are 7,355 species of scale insects worldwide, 2,369 species of diaspidids (32% of all scales in the world), 2,048 pseudococcids (28%), 1,129 coccids (15%), and 1,179 species in all other families (16%). In the continental United States, there are 1,019 species of scales, 320 species of diaspidids (31% of all scales in the United States), 356 species of pseudococcids (35%), 105 coccids (10%), and 238 species in all other families (23%). Assuming that these groups have been equally collected and studied (which is unlikely), it appears that diaspidid diversity is about the same proportion in the United States as in the rest of the world, the diversity of pseudococcids and other scale families is high, and the diversity of coccids is low.

Table 1 provides information on 255 scale-insect species that are hypothesized as adventives in the United States (1 aclerdid, 10 asterolecaniids, 1 cerococcid, 43 coccids, 1 conchaspidid, 132 diaspidids, 5 eriococcids, 1 kerriid, 3 margarodids, 1 ortheziid, 1 phoenicococcid, and 56 pseudococcids). When comparing the number of introduced species in the United States with the total number of world species in the five categories, the percentages for each are

about the same. That is, 255 species of introduced scale insects comprise about 3% of the world's scale fauna; 132 introduced diaspidids constitute about 6% of the world's armored scale fauna; 56 pseudococcids is about 3% of the world's mealybug fauna; 43 coccids is about 4% of the soft scale fauna; and 24 is about 1% of the world's "all other families" fauna. The success rate of introduction appears relatively similar for the five categories of scale insects. The possible exception is the taxa placed in the "all other families" category, which may have a slightly lower rate of introduction success.

Examination of the relative size of the adventive scale diversity in the United States with that of the native fauna reveals that more than 25% of the species of all scale insects in the United States are introduced species. Even more surprising is that 40% of all U.S. diaspidids and coccids found in the United States are introduced. Although the adventive loads in the pseudococcids (15%) and "all other families" (10%) is considerably lower, they still are high compared with other insect groups. About 2,000 species of introduced insects occur in the continental United States, comprising only about 1–2% of the total insect fauna (Wheeler and Hobeke 2001). The 255 species of introduced scale insects in the United States represent about 13% of all adventive insects in the U.S. If we compare the number of United States scales with the total insect fauna (assuming that there are 90,000 species of insects in the United States (Kosztarab and Schaefer 1990)), then the 1,019 scale insects in the United States comprise only about 1% of the insect fauna. These numbers reflect an abnormally large number of introduced scale insects in the United States compared with other insect groups.

It is interesting to note that there was a peak of introductions between 1890 and 1920 (Fig. 1), and that there has been a steady decline to the present. This trend is reasonably consistent for all five categories

Table 1. List of adventive U.S. species of scale insects. Abbreviations: AFR = Afrotropical; AUS = Australasian; NEA = Nearctic; NEO = Neotropical; ORI = Oriental; PAL = Palearctic.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
Aclerodidae						
<i>Aclerda tokionis</i> (Cockerell)	established	CA, 1900 Kuwana 1902	likely	not a pest Gill 1993	bamboo	PAL Gill 1993
Asterolecaniidae						
<i>Asterodiaspis luteola</i> (Russell)	uncertain	PA, 1915 Russell 1941	likely	not a pest	<i>Quercus</i>	PAL Stumpf 2000
<i>Asterodiaspis variable</i> (Russell)	uncertain	NY, 1903 Russell 1941	likely	not a pest	<i>Quercus</i>	PAL Stumpf 2000
<i>Asterodiaspis variolosa</i> (Ratzeburg)	established	DC, 1879 Russell 1941	likely	serious pest Russell 1941	<i>Quercus</i>	PAL Stumpf 2000
<i>Asterolecanium epidendri</i> (Bouché)	established	FL, 1941 USNM	likely	not a pest	orchids	NEO Stumpf 2000
<i>Bambusaspis bambusae</i> (Boisduval)	established	FL, 1908 USNM	likely	pest Hamon 1980	bamboo	PAL or ORI Gill 1993
<i>Bambusaspis miliaris</i> (Boisduval)	established	FL, 1919 USNM	likely	pest Stumpf 2000	bamboo	uncertain
<i>Planchonia arabis</i> (Signoret)	established	CT, 1925 USNM	likely	pest Gill 1993	polyphagous including Pittosporum	PAL Gill 1993
<i>Planchonia stentae</i> (Brain)	established	CA, 1980 USNM	likely	pest Stumpf and Lambdin 2000	polyphagous	AFR Stumpf 2000
<i>Pollinia pollini</i> (Costa)	established	CA, 1944 Armitage and Mc- Kenzie 1952	likely	pest Gill 1993	olive	PAL Gill 1993
<i>Russellaspis pustulans</i> (Cockerell)	established	FL, 1882 USNM	likely	pest Stumpf 2000	polyphagous	NEO Stumpf 2000
Cerococcidae						
<i>Cerococcus deklei</i> Kostarab and Vest	established	TX, 1927 Kosztarab and Vest 1966	likely	pest Lambdin and Kosztar- ab 1977	polyphagous	NEO
Coccidae						
<i>Ceroplastes ceriferus</i> (Fabricius)	established but eradi- cated from CA, Gill 1988	CA, 1907 Carnes, 1907	likely	pest Gimpel et al. 1974	polyphagous	NEO Qin et al. 1998

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Ceroplastes cirripediformis</i> Comstock	established	FL, 1880 Gimpel et al. 1974	uncertain	pest Gimpel et al. 1974	polyphagous	NEO Qin et al. 1998
<i>Ceroplastes dugesii</i> Lichtenstein	established	FL, 1908 Gimpel et al. 1974	likely	pest Hamon and Williams 1984	polyphagous	NEO Gimpel et al. 1974
<i>Ceroplastes floridensis</i> Comstock	established	FL, 1828 Gimpel et al. 1974	uncertain	pest Gimpel et al. 1974	polyphagous, including citrus and ornamentals	uncertain Qin et al. 1998
<i>Ceroplastes rubens</i> Maskell	established	FL, 1955 Gimpel et al. 1974	likely	pest Gimpel et al. 1974	polyphagous, including citrus and ornamentals	AFR Qin et al. 1994
<i>Ceroplastes rusci</i> (Linnaeus)	uncertain	FL, 1994 Gimpel et al. 1974	likely	pest Ben-Dov 1988	polyphagous, including citrus and ornamentals	AFR Qin et al. 1994
<i>Ceroplastes sinensis</i> Del Guercio	uncertain	NC, 1920 Gimpel et al. 1974	likely	pest Gimpel et al. 1974	polyphagous, including citrus and ornamentals	NEO Qin et al. 1994
<i>Coccus capparidis</i> (Green)	established	FL, 1974 FSCA	likely	minor pest Gill et al. 1977	polyphagous	ORI
<i>Coccus hesperidum</i> Linnaeus	established	CA, 1880 USNM	likely	pest Ebeling 1959	polyphagous	ORI
<i>Coccus longulus</i> (Douglas)	established	FL, 1907 USNM	likely	not a pest in US Hamon and Williams 1984	polyphagous, including tropical fruits and ornamentals	ORI(?)
<i>Coccus pseudoheperidum</i> (Cockerell)	established	FL, 1923 Merrill and Chaffin 1923	likely	minor pest Gill 1988	orchids	NEO Gill et al. 1977
<i>Coccus pseudomagnoliarum</i> (Kuwana)	uncertain	CA, 1910 USNM	likely	serious pest Ebeling 1959	oligophagous, including citrus	PAL Gill et al. 1977
<i>Coccus viridis</i> (Green)	established	FL, 1921 FSCA	likely	serious pest Gill et al. 1977	polyphagous	AFR Gill et al. 1977
<i>Eriopletis festucae</i> (Boyer de Fonscolombe)	established	NY, 1899 USNM	likely	minor pest Williams and Kosztarab 1972	grasses	PAL

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Eucalymnatus tessellatus</i> (Signoret)	established	CA, 1897 UCD	likely	serious pest Dekle 1973	polyphagous, green-house pest	NEO Gill 1988
<i>Eulecanium cerasorum</i> (Cockerell)	established	CA, 1909 USNM	likely	serious pest Gill and Kosztarab 1997	deciduous trees	PAL Gill 1988
<i>Eulecanium kunoense</i> (Kuwana)	established	CA, 1896 USNM	likely	serious pest McKenzie 1951	deciduous fruit trees	PAL Gill 1988
<i>Eulecanium tiliae</i> (Linnaeus)	established	CA, 1908 USNM	likely	serious pest Kosztarab 1996	polyphagous	PAL Bartlett 1978
<i>Inglisia vitrea</i> Cockerell	reestablished FL eradicated from FL Dekle 1969	FL, 1917 USNM	likely	not a pest Hamon and Williams 1984	trees & shrubs	NEO Hamon and Williams 1984
<i>Kilifia acuminata</i> (Signoret)	established	FL, 1912 USNM	likely	pest Nada et al. 1990	polyphagous	ORI
<i>Milviscutulus mangiferae</i> (Green)	established	FL, 1917 Wilson 1917	likely	serious pest Avidov and Harpaz 1969	polyphagous	ORI
<i>Parasaissetia nigra</i> (Nietner)	established	FL, 1920 FSCA	likely	serious pest Gill 1988	polyphagous	AFR or ORI Gill 1988
<i>Parthenolecanium corni</i> (Bouché)	established	KS, 1874 USNM	uncertain	serious pest Hamon and Williams 1984	polyphagous	PAL
<i>Parthenolecanium fletcheri</i> (Cockerell)	established	IN, 1889 USNM	uncertain	pest Stimmel 1978	conifers	PAL
<i>Parthenolecanium persicae</i> (Fabricius)	established	CA, 1897 USNM	likely	serious pest Williams and Kosztarab 1972	polyphagous	PAL
<i>Physokermes hemicyphus</i> (Dalman)	established	CA, 1958 USNM	likely	pest Santas 1988	monophagous, including conifers	PAL Gill 1988
<i>Proccoccus acutissimus</i> (Green)	established	FL, 1956 Gill et al. 1977	likely	not a pest Gill et al. 1977	polyphagous	ORI
<i>Protospulvinaria pyriformis</i> (Cockerell)	established	FL, 1906 USNM	likely	serious pest Del Rivero 1966	polyphagous	NEO(?)
<i>Pulvinaria citricola</i> Kuwana	established	CA, 1939 Gill 1988	likely	serious pest Gill and Kosztarab 1997	oligophagous, including citrus and persimmon	PAL

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Pulvinaria delottoi</i> Gill	established	CA, 1973 Gill 1979	likely	serious pest Gill and Kosztarab 1997	iceplant	AFR Gill 1979
<i>Pulvinaria elongata</i> Newstead	established	FL, 1927 USNM	likely	minor pest Carnegie 1997	grasses, especially sug- arcane	AFR Williams and Watson 1990
<i>Pulvinaria floccifera</i> (Westwood)	established	GA, 1892 USNM	likely	pest Gill and Kosztarab 1997	polyphagous, including citrus and ornamen- tals	PAL Steinweden 1946
<i>Pulvinaria phaiiae</i> Lull	uncertain eradicated CA Gill 1988	CA, 1906 UCD	likely	minor pest Gill 1988	orchids	PAL Gill 1988
<i>Pulvinaria psidii</i> Maskell	established	FL, 1909 USNM	likely	pest Nada et al. 1990	polyphagous	ORI(?)
<i>Pulvinaria urbicola</i> Cockerell	established	FL, 1923 Merrill and Chaffin 1923	likely	serious pest Gill and Kosztarab 1997	polyphagous	NEO
<i>Pulvinaria vitis</i> (Linnaeus)	established	NY, 1880 USNM	likely	pest Kosztarab and Kozár 1988	polyphagous	PAL Hodgson 1994
<i>Pulvinariella mesembryanthemi</i> (Vallot)	established	CA, 1971 Gill 1979	likely	pest Donaldson et al. 1978	succulents	AFR Washburn and Frankie 1985
<i>Saissetia coffeae</i> (Walker)	established	CA, 1914 USNM	not sure	pest Hamon and Williams 1984	polyphagous	AFR Gill 1988
<i>Saissetia miranda</i> (Cockerell and Parrott)	established	FL, 1918 USNM	likely	pest Stauffer and Rose 1997	polyphagous	AFR?
<i>Saissetia neglecta</i> De Lotto	established	FL, 1921 USNM	likely	pest Stauffer and Rose 1997	polyphagous	AFR?
<i>Saissetia oleae</i> (Olivier)	established	CA, 1880 Bartlett 1978	likely	pest Bartlett 1978	polyphagous	AFR Bartlett 1978

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Sphaerolecanium prunastri</i> (Boyer de Fonscolombe)	established	PA, 1895 USNM	likely	serious pest Gill and Kosztarab 1997	fruit trees	PAL Hodgson 1994
<i>Vinsonia stellifera</i> (Westwood)	established	FL, 1953 Dekle 1969	likely	pest Dekle 1969	polyphagous	ORI?
Conchaspidae						
<i>Conchaspis angraeci</i> Cockerell	established	FL, 1905 USNM	uncertain	pest Hamon 1979	polyphagous	NEA Cockerell 1893
Diaspididae						
<i>Abgrallaspis cyanophylli</i> (Signoret)	established	AL, FL, 1921 USNM	uncertain	minor pest Dekle 1976	polyphagous	NEA or NEO
<i>Abgrallaspis degenerata</i> (Leonardi)	established	CA, 1931 McKenzie 1956	likely	minor pest Gill 1997	<i>Camellia</i>	PAL
<i>Acutaspis aliena</i> (Newstead)	established	FL, 1919 FSCA	likely	not a pest Dekle 1976	orchids	NEO
<i>Andaspis hawaiiensis</i> (Maskell)	established	FL, 1922 FSCA	likely	not a pest Dekle 1976	fruit trees including <i>Litchi</i>	AUS or ORI Williams and Watson 1988
<i>Andaspis mackieana</i> (McKenzie)	established but eradicated from CA Gill 1997	CA, 1942 McKenzie 1943a	likely	not a pest Dekle 1976	dendrobium orchids	ORI Williams 1963
<i>Andaspis punicae</i> (Laing)	established	FL, 1995 Halbert 1995	likely	pest	oligophagus <i>Litchi</i>	AFR or ORI
<i>Aonidia lauri</i> (Bouché)	established but eradicated from CA Gill 1997	NY, 1907 USNM	likely	not a pest	<i>Laurus</i>	PAL
<i>Aonidiella aurantii</i> Maskell	established	CA, 1875 Rosen and DeBach 1978	likely	serious pest Rosen and DeBach 1978	citrus	ORI McKenzie 1938
<i>Aonidiella citrina</i> (Coquillett)	established	CA, 1872 Rosen and DeBach 1978	likely	pest Rosen and DeBach 1978	citrus	ORI McKenzie 1938
<i>Aonidiella inornata</i> (McKenzie)	established?	TX, 1968 McDaniel 1968	uncertain	not a pest	polyphagous	ORI McKenzie 1938

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Aonidiella orientalis</i> (Newstead)	established	FL, 1908 USNM	likely	pest Dekle 1976	palms	ORI McKenzie 1938
<i>Aonidiella taxus</i> (Leonardi)	established but eradicated from CA Gill 1997	LA, 1921 Howard and Oliver 1985	likely	pest Johnson and Lyon 1991	<i>Podocarpus</i> and <i>Taxus</i>	ORI McKenzie 1938
<i>Aonidomytilus albus</i> (Cockerell)	established	FL, 1918 FSCA	uncertain	not a pest in US Dekle 1976	polyphagous <i>Manihot</i> (cassava)	NEO or NEA
<i>Aspidiella sacchari</i> (Cockerell)	established	FL, 1914 USNM	likely	minor pest Dekle 1976	grasses especially sugarcane	ORI?
<i>Aspidiotus cryptomeriae</i> Kuwana	established	NY, 1937 USNM	likely	pest Stimmel 1986	conifers	PAL
<i>Aspidiotus destructor</i> Signoret	established but eradicated from CA Gill 1997	FL, 1920 FSCA	likely	serious pest Taylor 1935, Balachowsky 1948	polyphagous, palms	AUS? Balachowsky 1948
<i>Aspidiotus excisus</i> Green	established	FL, 1964 Dekle 1966	likely	pest Dekle 1976	polyphagous, <i>Aglaonema</i>	ORI
<i>Aspidiotus nerii</i> Bouché	established	FL, CA, 1880 USNM	likely	serious pest Gill 1997	polyphagous	AUS? Ferris 1941 or AFR? Balachowsky 1948
<i>Aspidiotus spinosus</i> Comstock	established	FL, 1919 USNM	likely	minor pest Wysoki 1997	polyphagous	uncertain
<i>Aulacaspis rosae</i> (Bouché)	established	CA, FL, NY, 1880 USNM	likely	pest Gill 1997	oligophagous <i>Rosa</i> , <i>Rubus</i>	PAL Balachowsky 1954
<i>Aulacaspis tubercularis</i> Newstead	established	FL, 2002 Hamon 2002	likely	pest Labuschagne et al. 1995	polyphagous mango	ORI or PAL
<i>Aulacaspis yasumatsui</i> Takagi	established	FL, 1996 Howard et al. 1999	likely	serious pest Howard et al. 1999	cycads	ORI Howard et al. 1999
<i>Carulaspis juniperi</i> (Bouché)	established	MA, 1900 USNM	likely	pest Gill 1997	conifers especially junipers	PAL Balachowsky 1954
<i>Carulaspis minima</i> (Signoret)	established	CA, 1932 McKenzie 1956	likely	pest Gill 1997	conifers especially junipers, cypress	PAL Gill 1997
<i>Chionaspis etrusca</i> Leonardi	established	AZ, 1917 Liu et al. 1989	likely	not a pest Gill 1997	<i>Tamarix</i>	PAL Gill 1997

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Chionaspis gilli</i> Liu and Kosztarab	established	AZ, 1933 Liu et al. 1989	likely	not a pest Gill 1997	<i>Tamarix</i>	PAL Gill 1997
<i>Chionaspis salicis</i> (Linnaeus)	established	MN, 1898 Liu et al. 1989	uncertain	minor pest Lambdin 1990	polyphagous <i>Salix</i> , <i>Po- pulus</i>	PAL
<i>Chionaspis wistariae</i> Cooley	established	CA, 1926 Liu et al. 1989	likely	not a pest Gill 1997	<i>Wisteria</i>	PAL Gill 1997
<i>Chrysomphalus aonidum</i> (Linnaeus)	established	FL, 1880 USNM	likely	serious pest Dekle 1976	polyphagous	ORI Rosen and DeBach 1978
<i>Chrysomphalus bifascicu- latus</i> Ferris	established	CA, 1930 UCD	likely	minor pest Morrison 1946	polyphagous	ORI or AUS McKenzie 1939
<i>Chrysomphalus dictyos- permi</i> (Morgan)	established	FL, 1903 USNM	likely	pest Gill 1997	polyphagous	ORI or AUS McKenzie 1939
<i>Clavaspis herculeana</i> (Cockerell and Had- den)	established	FL, 1910 USNM	likely	minor pest Miller and Davidson 1990	polyphagous <i>Spondias</i>	NEO
<i>Diaspidiotus braunschvigi</i> Rungs	eradicated from US, Gill 1997	CA, 1935 McKenzie 1956	likely	not a pest Balachowsky 1950	<i>Ficus</i> , <i>Pistacia</i>	PAL Gill 1997
<i>Diaspidiotus gigas</i> (Thiem and Gerneck)	established	NY, OH, PA, 1902 USNM	likely	pest Baker 1972	<i>Populus</i> and <i>Salix</i>	PAL Balachowsky 1950
<i>Diaspidiotus ostreaeformis</i> (Curtis)	established	OH, 1895 USNM	likely	pest Richards 1962	polyphagous trees	PAL Balachowsky 1950
<i>Diaspidiotus perniciosus</i> (Comstock)	established	CA, 1870 Rosen and DeBach 1978	likely	serious pest Gonzalez 1981	polyphagous Rosaceae	PAL Rosen and DeBach 1978
<i>Diaspis boisduvalii</i> Signoret	established	FL, 1896 USNM	likely	serious pest Dekle 1976	polyphagous orchids and palms	NEO Balachowsky 1954
<i>Diaspis bromeliae</i> (Kerner)	established	FL, 1899 USNM	likely	not a pest in US Dekle 1976, Gill 1997	polyphagous bromeli- ads pineapple	NEO or NEA Ferris 1937
<i>Diaspis coccois</i> Lichtenstein	established	CA, 1919 UCD	likely	not a pest Gill 1997	palms	NEO or NEA
<i>Diaspis echinocacti</i> Bouché	established	TX, 1893 USNM	uncertain	pest	cactus	NEO or NEA Ferris 1937

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Duplachionaspis divergens</i> (Green)	uncertain	FL, 2001 USNM	likely	not a pest	grass	ORI or PAL
<i>Dynaspidiotus britannicus</i> (Newstead)	established	OR, 1898 USNM	likely	minor pest Miller and Davidson 1990	polyphagous <i>Ilex</i> and <i>Laurus</i>	PAL Balachowsky 1954
<i>Epidiaspis leperii</i> Signoret	established	CA, 1882 Gill 1997	likely	pest Gill 1997	walnuts and rosaceous trees and shrubs	PAL Gill 1997
<i>Fiorinia externa</i> Ferris	established	NY, 1908 McClure 1977	likely	serious pest McClure 1977	hemlock	PAL Murakami 1970
<i>Fiorinia fioriniae</i> (Targioni Tozzetti)	established	FL, 1906 USNM	likely	minor pest Dekle 1976	polyphagous palms, bay, camellia	ORI Balachowsky 1954
<i>Fiorinia japonica</i> Kuwana	established but eradicated from CA, Gill 1997	CA, 1910 Essig 1910	likely	not a pest	conifers	PAL Kuwana 1902
<i>Fiorinia pinicola</i> Maskell	established	CA, 1939 McKenzie 1956	likely	not a pest	conifer <i>Pinus</i>	PAL Balachowsky 1954
<i>Fiorinia theae</i> Green	established but eradicated from CA, Gill 1997	FL, 1898 USNM	likely	serious pest Munir and Sailer 1985	polyphagous <i>Camellia</i> , holly	ORI Munir and Sailer 1985
<i>Froggattiella penicillata</i> (Green)	established	LA, 1910 USNM	likely	minor pest Gill 1997	bamboo	ORI Balachowsky 1953
<i>Furcaspis biformis</i> (Cockerell)	established	FL, 1953 Merrill 1953	likely	minor pest Zimmerman 1948	orchid	NEO and NEA
<i>Furcadaspis zamiae</i> (Morgan)	established	CA, 1906 UCD	likely	pest Gill 1997	cycads	uncertain
<i>Gymnaspis aechmeae</i> Newstead	established	FL, 1917 USNM	likely	serious pest Dekle 1976	bromeliads	ORI Ferris 1937
<i>Hemiberlesia lataniae</i> (Signoret)	established	GA, NC, 1899 USNM	likely	serious pest Gill 1997	polyphagous	uncertain Gill 1997
<i>Hemiberlesia palmae</i> (Cockerell)	established but eradicated from CA, Gill 1997	FL, 1921 USNM	likely	not a pest Dekle 1976	polyphagous bromeliads	uncertain
<i>Hemiberlesia rapax</i> (Comstock)	established	CA, FL, 1880 USNM	likely	serious pest Gill 1997	polyphagous	PAL Gill 1997

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Howardia biclavis</i> (Comstock)	established but eradicated from CA, Gill 1997	CA, 1912 USNM	likely	pest Dekle 1976	polyphagous	AFR? Williams and Watson 1988
<i>Ischnaspis longirostris</i> (Signoret)	established but eradicated from CA, Gill 1997	FL, 1908 USNM	likely	pest Dekle 1976	polyphagous palms	AFR Ben-Dov 1974
<i>Kuwanaspis hikosani</i> (Kuwana)	established	SC, 1960 USNM	likely	not a pest	bamboo	PAL or ORI
<i>Kuwanaspis howardi</i> Cooley	established	TX, 1918 USNM	likely	not a pest Dekle 1976	bamboo	PAL or ORI
<i>Kuwanaspis pseudoleucaspis</i> (Kuwana)	established	FL, 1916 USNM	likely	not a pest Dekle 1976	bamboo	PAL Balachowsky 1953
<i>Kuwanaspis vermiformis</i> (Takahashi)	uncertain	FL, 1998 FSCA	likely	not a pest	bamboo	ORI
<i>Lepidosaphes beckii</i> (Newman)	established	FL, 1859 Gill 1997	likely	serious pest Ebeling 1959	polyphagous citrus	ORI Gill 1997
<i>Lepidosaphes camelliae</i> Hoke	established	GA, 1881 USNM	likely	pest Cooper and Oetting 1989	camellia and holly	PAL
<i>Lepidosaphes chinensis</i> Chamberlin	established	CA, 1927 UCD	likely	not a pest	oligophagous	PAL Chamberlin 1925
<i>Lepidosaphes conchiformis</i> (Gmelin)	established	CA, 1905 Gill 1997	likely	pest Stafford and Barnes 1948	polyphagous fig	PAL Rosen and DeBach 1978
<i>Lepidosaphes flava</i> (Signoret)	established	CA, 1952 McKenzie 1956	likely	not a pest Gill 1997	fig	PAL Gill 1997
<i>Lepidosphaes gloverii</i> (Packard)	established	FL, 1838 Gill 1997	likely	minor pest Rosen and DeBach 1978	polyphagous citrus	ORI Rosen and DeBach 1978
<i>Lepidosaphes newsteadi</i> (Sulc)	Although this species has been reported in the U.S. present in the U.S.					
<i>Lepidosphaes noxia</i> McKenzie	eradicated from U.S., Gill 1997	CA, 1944 McKenzie 1956	likely	minor pest Miller and Davidson 1990	orchids	ORI?

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Lepidosphaes pallida</i> (Maskell)	established	CA, 1890 USNM	likely	pest Dekle 1976	conifers	PAL?
<i>Lepidosaphes pini</i> (Maskell)	established	MD, 1952 USNM	likely	minor pest Stimmel 1994	conifers	ORI or PAL Stimmel 1994
<i>Lepidosaphes pinnaeformis</i> (Bouché)	established	FL, 1932 Dekle 1976	likely	minor pest Gill 1997	orchids	ORI?
<i>Lepidosaphes sciadopitysi</i> McKenzie	established but eradicated from CA, Gill 1997	CT, DC, 1908 McKenzie 1955	likely	not a pest	<i>Sciatopitysi</i>	PAL
<i>Lepidosaphes tokionis</i> (Kuwana)	established but eradicated from CA, Gill 1997	MS, 1921 UCD	likely	not a pest	oligophagous <i>Codaieum</i>	ORI or PAL
<i>Lepidosaphes ulmi</i> (Linnaeus)	established	ME, 1794 Howard 1894	likely	serious pest Miller and Davidson 1990	polyphagous Salicaceae, Rosaceae, Oleaceae	PAL Balachowsky 1953
<i>Lepidosaphes yanagicola</i> Kuwana	established	MA, 1925 USNM	likely	minor pest Kosztarab 1996	polyphagous winged euonymus	PAL
<i>Leucaspis portaeureae</i> Ferris	established	CA, 1938 McKenzie 1956	likely	not a pest Gill 1997	Podocarpus	AUS McKenzie 1956
<i>Lindingaspis floridana</i> Ferris	established	FL, 1921 FSCA	likely	not a pest Dekle 1976	polyphagous	ORI?
<i>Lindingaspis rossi</i> (Maskell)	established	CA, 1892 USNM	likely	serious pest Gill 1997	polyphagous <i>Sequoia</i> , <i>Araucaria</i>	AUS Gill 1997
<i>Lopholeucaspis cockerelli</i> (Granpre & Charmoy)	established but eradicated from CA, Gill 1997	FL, 1946 Dekle 1976	likely	not a pest Dekle 1976	polyphagous	Old World Balachowsky 1958
<i>Lopholeucaspis japonica</i> (Cockerell)	established	CT, 1914 USNM	likely	minor pest Miller and Davidson 1990	polyphagous maple	PAL Tabatadze and Yas-nosh 2001
<i>Melanaspis bromiliae</i> (Leonardi)	established	FL, 1923 FSCA	likely	not a pest in US Dekle 1976	<i>Ananas</i>	NEO
<i>Melanaspis odontoglossi</i> (Cockerell)	established	FL, 1975 USNM	uncertain	not a pest	polyphagous	NEA, NEO Deitz and Davidson 1986

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Mercetaspis halli</i> (Green)	eradicated from US, Gill 1997	CA, 1934 Fosen et al. 1953	likely	serious pest Fosen et al. 1953	Rosaceae	PAL
<i>Morganella longispina</i> (Morgan)	established	FL, 1980 Hamon 1981	likely	minor pest Talhouk 1975	polyphagous	uncertain Balachowsky 1948
<i>Mycetaspis apicata</i> (Newstead)	established	TX, 1962 USNM	uncertain	not a pest	oligophagus	NEA, NEO
<i>Mycetaspis personata</i> (Comstock)	established	FL, 1932 FSCA	not sure	not a pest Dekle 1976	oligophagus <i>Eugenia</i>	NEO Ferris 1941
<i>Mycetaspis sphaeriodes</i> (Cockerell)	established	LA, 1895 Howard and Oliver 1985	likely	not a pest	oligophagus	NEA, NEO Ferris 1941
<i>Neopinnaspis harperi</i> McKenzie	established	FL, 1946 Dekle 1976	likely	minor pest Miller and Davidson 1990	polyphagous	PAL or ORI Gill 1997
<i>Nuculaspis abietus</i> (Schränk)	established	OR, 1923 USNM	likely	not a pest	conifers	PAL Balachowsky 1948
<i>Nuculaspis pseudomeyeri</i> (Kuwana)	established	NY, 1953 USNM	likely	minor pest	conifers	PAL
<i>Nuculaspis tsugae</i> (Marlatt)	established	NY, 1900 McClure 1988	likely	pest McClure and Fergione 1977	<i>Tsuga</i> and other conifers	PAL Takagi 1961
<i>Oceanaspidiotus araucariae</i> (Adachi and Fullaway)	established	FL, 1985 FSCA	likely	pest Williams and Watson 1988	<i>Araucaria</i>	AUS Williams and Watson 1988
<i>Odonaspis ruthae</i> Kotinsky	established	LA, 1910 USNM	uncertain	pest Potter 1998	grasses especially <i>Cynodon dactylon</i>	uncertain
<i>Odonaspis saccharicaulis</i> (Zehntner)	established	FL, 1920 Ben-Dov 1988	likely	not a pest Dekle 1976	grasses	ORI?
<i>Odonaspis secreta</i> (Cockerell)	established	LA, 1910 Howard and Oliver 1985	likely	not a pest	bamboo	PAL
<i>Opuntiaspis carinata</i> (Cockerell)	established	FL, 1978 Hamon 1978 TX, 1978 USNM	likely	not a pest Hamon 1978	polyphagous	NEA or NEO

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Opuntiaspis javanensis</i> Green	established	FL, 1979 USNM	likely	not a pest	<i>Agave</i> , <i>Beaucarnea</i>	NEA
<i>Parlatoreopsis chinensis</i> (Marlatt)	established	MO, 1940 USNM	likely	minor pest Miller and Davidson 1990	polyphagous	PAL McKenzie 1945
<i>Parlatoreopsis pyri</i> (Marlatt)	established	DC, 1960 USNM	likely	not a pest	woody ornamentals	PAL McKenzie 1945
<i>Parlatoria blanchardi</i> (Targioni Tozzetti)	eradicated from US, Boyden 1941	CA, 1905 Gill 1997	likely	serious pest Boyden 1941	palms date palms	PAL Rosen and DeBach 1978
<i>Parlatoria camelliae</i> Comstock	established	CA, 1886 USNM	likely	pest Morrison 1946	polyphagous camellia	ORI or PAL
<i>Parlatoria cinerea</i> Hadden	Known only from limited infestations in greenhouses in DC and MD; thus not considered established in the U.S.					
<i>Parlatoria crotonis</i> Douglas	established but eradi- cated from CA, Gill 1997	CA, 1901 USNM	likely	not a pest Dekle 1976	<i>Codiaeum</i>	ORI?
<i>Parlatoria oleae</i> (Colvée)	established	CA, 1931 Rosen and DeBach 1978	likely	serious pest McKenzie 1945	polyphagous olive	ORI Rosen and DeBach 1978
<i>Parlatoria pergandii</i> Comstock	established	FL, 1880 Comstock 1881	likely	pest Ebeling 1959	polyphagous citrus	ORI or PAL
<i>Parlatoria pittospori</i> Maskell	established	CA, 1935 McKenzie 1956	likely	minor pest Gill 1997	polyphagous	AUS McKenzie 1945
<i>Parlatoria proteus</i> (Curtis)	established	LA, 1906 USNM	likely	pest	polyphagous	Old World McKenzie 1945
<i>Parlatoria pseudaspidi- otus</i> Lindinger	established	FL, 1908 USNM	likely	not a pest Dekle 1976	polyphagous vanda or- chids, mango	ORI?
<i>Parlatoria theae</i> Cockerell	established but eradi- cated from CA, Gill 1997	DC, 1899 USNM	likely	pest Westcott 1973	polyphagous	PAL Kuwana 1925
<i>Parlatoria vandae</i> McKenzie	eradicated from US	CA, 1960 McKenzie 1960b	likely	not a pest	orchids	ORI?

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Parlatoria ziziphi</i> (Lucas)	established	FL, 1895 FSCA	likely	serious pest Blackburn and Miller 1984	oligophagous citrus	ORI?
<i>Pinnaspis aspidistrae</i> (Signoret)	established	CA, 1896 USNM	likely	serious pest Dekle 1976	polyphagous ferns	ORI Ferris and Rao 1947
<i>Pinnaspis buxi</i> (Bouché)	established but eradicated from CA, Gill 1997	FL, 1922 FSCA	likely	not a pest Dekle 1976	polyphagous	ORI Ferris and Rao 1947
<i>Pinnaspis strachani</i> (Cooley)	established	FL, 1911 USNM	likely	serious pest Dekle 1976	polyphagous hibiscus	ORI Ferris and Rao 1947
<i>Poliaspis cycadis</i> Comstock	established	CA, 1993 Gill 1997	likely	not a pest Gill 1997	cycads	ORI?
<i>Pseudaonidia duplex</i> (Cockerell)	established	LA, 1921 UCD	likely	pest Ebeling 1959	polyphagous	PAL
<i>Pseudaonidia paeoniae</i> (Cockerell)	established	DC, 1909 USNM	likely	pest Dekle 1976	polyphagous azalea, camellia	PAL
<i>Pseudaonidia trilobitiformis</i> (Green)	established	FL, 1979 Hamon 1980	likely	not a pest in US Hamon 1980	polyphagous	PAL
<i>Pseudaulacaspis cockerelli</i> (Cooley)	established but eradicated from CA, Gill 1997	FL, 1942 Dekle 1965	likely	serious pest Dekle 1976	polyphagous magnolia, palms	PAL or ORI
<i>Pseudaulacaspis pentagona</i> (Targioni Tozzetti)	established but eradicated from CA, Gill 1997	DC, 1892 Howard 1895	likely	serious pest Kosztarab 1996	polyphagous	PAL or ORI Rosen and DeBach 1978
<i>Pseudaulacaspis prunicola</i> (Maskell)	established	DC, 1901 USNM	likely	pest Kosztarab 1996	polyphagous Rosaceae	PAL
<i>Pseudischnaspis boweryi</i> (Cockerell)	established	FL, 1890 Miller et al. 1984	uncertain	not a pest Dekle 1976	polyphagous	NEO?
<i>Pseudoparlatoria ostreata</i> Cockerell	established	FL, 1920 FSCA	uncertain	minor pest Dekle 1976	polyphagous	NEO
<i>Pseudoparlatoria parlatorioides</i> (Comstock)	established but eradicated from CA, Gill 1997	FL, 1880 Comstock 1883	uncertain	minor pest Miller and Davidson 1990	polyphagous	NEO
<i>Radionaspis indica</i> (Marlatt)	established	FL, 1907 Marlatt 1908	likely	not a pest Dekle 1976	mango	ORI Marlatt 1908

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Rutherfordia major</i> (Cockerell)	established	FL, 1955 FSCA	likely	minor pest Dekle 1976	polyphagous <i>Litchi</i>	ORI?
<i>Selenaspis albus</i> McKenzie	established	CA, 1934 McKenzie 1953	likely	minor pest Gill 1997	<i>Euphorbia</i>	AFR McKenzie 1953
<i>Selenaspis articulatus</i> (Morgan)	established but eradicated from CA, Gill 1997	FL, 1887 USNM	likely	minor pest Ebeling 1959	polyphagous	AFR McKenzie 1953
<i>Selenaspis rubidus</i> McKenzie	established but eradicated from CA, Gill 1997	CA, 1936 McKenzie 1953	likely	minor pest Gill 1997	<i>Euphorbia</i>	AFR McKenzie 1953
<i>Thysanoflorinia nephelii</i> (Maskell)	established	FL, 1996 FSCA	likely	not a pest	litchi, logan	ORI
<i>Unachionaspis tenuis</i> (Maskell)	established	TN, 1999 USNM	likely	not a pest	bamboo	PAL
<i>Unaspis citri</i> (Comstock)	established	LA, 1880 Comstock 1883	likely	serious pest Dekle 1976	oligophagous citrus	ORI Ferris 1937
<i>Unaspis euonymi</i> (Comstock)	established	VA, 1879 Gill et al. 1982	likely	serious pest	polyphagous euonymus	PAL Ferris 1937
Eriococcidae						
<i>Cryptococcus fagisuga</i> Lindinger	established	MA, 1919 Miller 1985	likely	pest Kosztarab 1996	<i>Fagus</i>	PAL Ehrlich 1932
<i>Eriococcus araucariae</i> Maskell	established	CA, 1880 Comstock 1881	likely	minor pest Gill 1993	<i>Araucaria</i> and <i>Juniperus</i>	AUS Hoy 1962
<i>Eriococcus insignis</i> Newstead	established	ID, 1924 Miller and Miller 1992	likely	minor pest	polyphagous Rosaceae and Gramineae	PAL Miller and Miller 1992
<i>Eriococcus pittospori</i> Ferris	established	CA, 1954 Miller and Miller 1992	likely	minor pest	polyphagous <i>Coprosma</i> and <i>Pittosporum</i>	AUS Miller and Miller 1992
<i>Eriococcus spurius</i> (Modeer)	established	NY, 1884 USNM	likely	pest	monophagous <i>Ulmus</i>	PAL Kosztarab 1996
Kerriidae						
<i>Paratachardina lobata</i> (Chamberlin)	established	FL, 1999 FSCA	likely	serious pest Hamon 2002	polyphagous	ORI Howard et al. 2002

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
Margarodidae						
<i>Icerya purchasi</i> Maskell	established	CA, 1868 Gill 1993	likely	serious pest Gill 1993	polyphagous	AUS Gill 1993
<i>Kuwania quercus</i> (Kuwana)	established	CA, 1965 USNM	uncertain	not a pest Gill 1993	<i>Quercus</i>	PAL Gill 1993
<i>Matsucoccus matsumurae</i> (Kuwana)	established	CT, 1946 Bean and Godwin 1955	likely	serious pest McClure 1983	<i>Pinus</i>	PAL Bean and Godwin 1955
Ortheziidae						
<i>Orthezia insignis</i> Browne	established	CA, 1911 UCD	likely	serious pest	polyphagous	NEO Bartlett 1978
Phoenicococcidae						
<i>Phoenicococcus marlatti</i> Cockerell	established	CA, AZ, 1905 USNM	likely	minor pest Gill 1993	palms	PAL Gill 1993
Pseudococcidae						
<i>Antonina crawi</i> Cockerell	uncertain	CA, 1900 Williams and Miller 2002	likely	minor pest Sasscer 1918	bamboo	PAL Williams and Miller 2002
<i>Antonina graminis</i> (Maskell)	established	TX, 1942 USNM	likely	pest Ben-Dov 1994	grass	ORI Chada and Wood 1960
<i>Antonina nakaharai</i> Williams and Miller	established	SC, 1911 Williams and Miller 2002	likely	not a pest	bamboo	ORI Williams and Miller 2002
<i>Antonina pretiosa</i> Ferris	established	CA, 1915 Hendricks and Kosz- tarab 1999	likely	minor pest Ferris 1953	bamboo	PAL Ferris 1953
<i>Balanococcus diminutus</i> (Leonardi)	established	CA, 1906 USNM	likely	pest Saakyan-Baranova 1954	<i>Phormium</i>	AUS Williams 1985a
<i>Brevennia rehi</i> (Lindinger)	established	CA, AZ, 1967 USNM	likely	pest Ben-Dov 1994	grass	ORI Miller 1975
<i>Chaetococcus bambusae</i> (Maskell)	established	FL, 1956 Hendricks and Kosz- tarab 1999	likely	not a pest	bamboo	PAL Hendricks and Kosz- tarab 1999

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Chaetococcus phragmitis</i> (Marchal)	established	NJ, 1975 USNM	likely	not a pest	phragmites	PAL Kosztarab 1996
<i>Crisicoccus azaleae</i> (Tinsley)	established	CA, 1898 USNM	likely	pest Fox-Wilson 1939	azalea	PAL Ferris 1953
<i>Crisicoccus pini</i> (Kuwana)	established	CA, 1918 USNM	likely	not a pest	pine	PAL Ferris 1950
<i>Dysmicoccus angustus</i> (Ezzat and McConnell)	uncertain	NJ, 1912 USNM	likely	not a pest	bamboo	PAL or ORI Ezzat and McConnell 1956
<i>Dysmicoccus boninsis</i> (Kuwana)	established	FL, 1895 USNM	likely	minor pest Ben-Dov 1994	sugar cane	PAL
<i>Dysmicoccus brevipes</i> (Cockerell)	established	FL, 1880 USNM	likely	minor pest Ben-Dov 1994	polyphagous	NEO Carter 1935
<i>Dysmicoccus grassii</i> (Leonardi)	established	FL, 1966 USNM	likely	pest Williams and Granara de Willink 1992	polyphagous	NEO
<i>Dysmicoccus wistariae</i> (Green)	established	NJ, 1915 USNM	likely	pest Hamilton 1942	<i>Taxus</i>	PAL Kosztarab 1996
<i>Ferrisia malvastra</i> (McDaniel)	established	FL, 1918 USNM	likely	pest Williams 1996	polyphagous	NEO(?)
<i>Ferrisia virgata</i> (Cockerell)	established	NM, 1896 USNM	likely	pest Ben-Dov 1994	polyphagous	NEO(?) Williams and Granara de Willink 1992
<i>Heterococcus nudus</i> (Green)	established	NH, 1921 USNM	likely	pest McKenzie 1967	grass	PAL
<i>Hypogeococcus pungens</i> Granara de Willink	eradicated from FL? Hamon 1984	FL, 1984 FSCA	likely	serious pest Hamon 1984	cactus	NEO Williams and Granara de Willink 1992
<i>Hypogeococcus spinosus</i> Ferris	established	CA, 1951 McKenzie 1967	likely	minor pest Ben-Dov 1994	cactus	NEA McKenzie 1967
<i>Idiococcus bambusae</i> Takahashi and Kanda	uncertain	NJ, 1916 USNM	likely	not a pest	bamboo	PAL Hendricks and Kosztarab 1999

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Maconellicoccus hirsutus</i> (Green)	established	CA, 1999 Miller 1999	likely	serious pest Ben-Dov 1994	polyphagous	ORI Williams 1996
<i>Miscanthicoccus miscanthi</i> (Takahashi)	established	MD, VA, 1989 USNM	likely	minor pest Stimmel 1996	<i>Miscanthus</i>	ORI or PAL Stimmel 1996
<i>Nipaecoccus aurilanatus</i> (Maskell)	established	CA, 1912 McKenzie 1967	likely	minor pest Brown and Eads 1967	<i>Auracaria</i>	AUS
<i>Nipaecoccus nipae</i> (Maskell)	established	CA, 1897 USNM	likely	pest Ben-Dov 1994	polyphagous	NEO
<i>Palmicultor browni</i> (Williams)	uncertain	FL, 1995 FSCA	likely	not a pest	palms	uncertain
<i>Palmicultor lumpurensis</i> (Takahashi)	uncertain	FL, 2002 FSCA	likely	minor pest?	bamboo	ORI(?) Williams 2003
<i>Palmicultor palmarum</i> (Ehrhorn)	established	FL, 1999 Hara et al. 1996	likely	minor pest Hara et al. 1996	palm	uncertain
<i>Paracoccus marginatus</i> Williams and Granara de Willink	established	FL, 1998 Miller and Miller 2002	likely	pest Williams and Granara de Willink 1992	polyphagous	NEA Miller and Miller 2002
<i>Phenacoccus aceris</i> (Signoret)	established	ME, 1910 Bartlett 1978	likely	pest Ben-Dov 1994	polyphagous (trees)	PAL Bartlett 1978
<i>Phenacoccus dearnessi</i> King	established	IL, 1894 USNM	likely	pest Cranshaw et al. 1998	fruit trees	PAL ?
<i>Phenacoccus graminicola</i> Leonardi	established	CA, 1953 McKenzie 1967	likely	pest Ward 1966	apples	PAL ?
<i>Phenacoccus parvus</i> Morrison	uncertain	FL, 1983 Williams and Hamon 1994	likely	pest Williams and Watson 1988	polyphagous	NEO Williams and Hamon 1994
<i>Planococcus citri</i> (Risso)	established	FL, 1880 USNM	likely	pest Ben-Dov 1994	polyphagous	ORI Bartlett 1978
<i>Planococcus ficus</i> (Signoret)	established	LA, 1924 CA, 1994 USNM	likely	pest Ben-Dov 1994	polyphagous, including grapes	PAL
<i>Planococcus japonicus</i> Cox	established	MD, 1978 Cox 1989	likely	pest Cox 1989	azalea	PAL Cox 1989
<i>Planococcus kraunhiae</i> (Kuwana)	uncertain	CA, 1915 McKenzie 1967	likely	pest Park and Hong 1992	polyphagous	PAL Cox 1989

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Pseudococcus calceolariae</i> (Maskell)	established	CA, 1913 Bartlett 1978	likely	pest Ben-Dov 1994	polyphagous, including citrus	AUS Bartlett 1978
<i>Pseudococcus comstocki</i> (Kuwana)	established	DC, 1906 USNM	likely	pest Ben-Dov 1994	fruit trees and ornamental plants	PAL Bartlett 1978
<i>Pseudococcus elisae</i> Borchsenius	uncertain	FL, 1995 Gimpel and Miller 1996	likely	pest Gimpel and Miller 1996	polyphagous	NEO Gimpel and Miller 1996
<i>Pseudococcus importatus</i> McKenzie	established	CA, 1949 McKenzie 1960a	likely	minor pest Johnston 1964	orchids	NEO Gimpel and Miller 1996
<i>Pseudococcus jackbeardsleyi</i> Gimpel and Miller	established	FL, 1921 Gimpel and Miller 1996	likely	pest Gimpel and Miller 1996	polyphagous	NEO Gimpel and Miller 1996
<i>Pseudococcus longispinus</i> (Targioni Tozzetti)	established	DC, 1881 USNM	likely	serious pest Ben-Dov 1994	polyphagous	AUS
<i>Pseudococcus microcirculus</i> McKenzie	established	CA, 1954 McKenzie 1967	likely	minor pest	orchids	NEO Gimpel and Miller 1996
<i>Pseudococcus nakaharai</i> Gimpel and Miller	uncertain	CA, 1973 Gimpel and Miller 1996	uncertain	not a pest	cacti	NEA Gimpel and Miller 1996
<i>Pseudococcus odermatti</i> Miller and Williams	established	FL, 1973 Miller and Williams 1997	likely	pest Miller and Williams 1997	citrus	ORI
<i>Rhizoecus americanus</i> (Hambleton)	established	FL, 1959 Hambleton 1973	uncertain	pest Hambleton 1976	polyphagous	NEO Hambleton 1973
<i>Rhizoecus dianthi</i> Green	established	CA, 1954 McKenzie 1967	likely	pest Snetsinger 1966	polyphagous	uncertain Williams and Nakahara 1980
<i>Rhizoecus falcifer</i> Kunckel d'Herculeais	established	CA, 1917 McKenzie 1967	likely	pest Cox 1987	polyphagous	PAL Hambleton 1976
<i>Rhizoecus hibisci</i> Kawai and Takagi	established	FL, 1978 USNM	likely	pest Kawai and Takagi 1971	polyphagous	PAL or ORI Williams 1996

Table 1. Continued.

Introduced Species	Eradication Status	Earliest U.S. Record	Introduced	Pest Status in U.S. Reference to Pest Status	Principal Hosts	Origin
<i>Rhizococcus kondonis</i> Kuwana	established	CA, 1921 McKenzie 1967	likely	pest Godfrey and Pickel 1998	alfalfa	PAL Hambleton 1976
<i>Saccharicoccus sacchari</i> (Cockerell)	established	FL, 1944 USNM	likely	minor pest Ben-Dov 1994	sugar cane	ORI ?
<i>Spilococcus mamillariae</i> (Bouche)	established	CA, 1938 McKenzie 1967	uncertain	pest Manichote and Mid- dlekauff 1967	cactus	NEA Williams and Granara de Willink 1992
<i>Vryburgia amaryllidis</i> (Bouche)	uncertain	CA, 1925 McKenzie 1967	likely	minor pest Ben-Dov 1994	lilies	AFR
<i>Vryburgia brevicurvis</i> (McKenzie)	uncertain	CA, 1935 McKenzie 1967	likely	pest McKenzie 1967	succulents	AFR
<i>Vyrburgia trionymoides</i> (De Lotto)	established	CA, 1994 USNM	likely	minor pest Gill, in press	<i>Caralluma</i>	AFR

of scale insects (Fig. 2), although a few more pseudococcids have been introduced over the past 60 years. We do not see the increase that might have been anticipated with rapid international transit and expanded world trade. As suggested by Sailer (1978), the enactment of the Plant Quarantine Act in 1912, and its intensive implementation in 1920, might explain some apparent success in preventing more invaders from becoming established (Fig. 1). However, complacency should not be the *modus operandi*! Examination of the accumulation curve (Fig. 3) shows a substantial increase in the adventive scale-insect load with a rate of about one species each year. The economic impact of this load is considerable; the impact will intensify as additional problematic invaders become established.

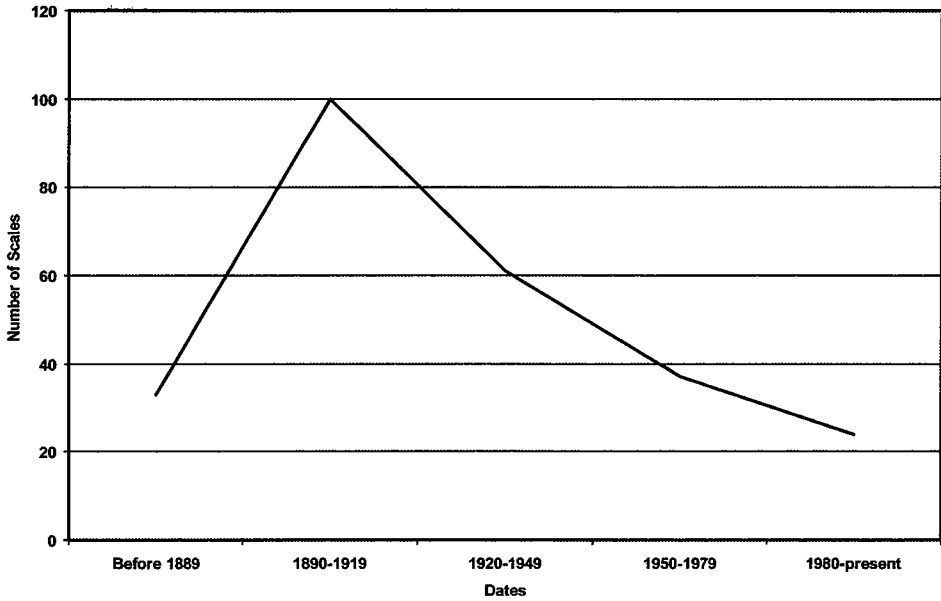
The majority of U. S. adventive scale insects (Fig. 4) originated in the Palearctic Region (105 species), followed by the Oriental (67), Neotropical (43), Afrotropical regions (22), Australasian (16), and Nearctic (16). Some scales with uncertain origins (e.g., *Bambusaspis bambusae* (Boisduval)) are included within two regions. These data are similar to Sailer (1978). Although he divided his geographic information more finely than ours, by combining his subunits into zoogeographic regions his results were similar: most species were from the Palearctic, followed by the Neotropical, Oriental, Afrotropical, and Australasia. He considered Mexico as strictly Neotropical Region.

In analyzing host data (Fig. 5), the overwhelming majority of invasive scale species are polyphagous (112 species); 47 species are primarily found on trees; 32 are on grasses, including bamboo; 13 on orchids, bromeliads, or cacti; 12 on tropical fruit; 9 primarily on shrubs; and 30 on other hosts.

To evaluate the pest status of invasive scale insects, we analyzed the data in two ways: 1) Of the 255 introduced species of scale insects in the United States, 191 (75%) are considered pests, and of these, 48 (25%) are considered to be serious pests (Fig. 6); 2) We also compared native (Table 2) and adventive pests. There are 65 species

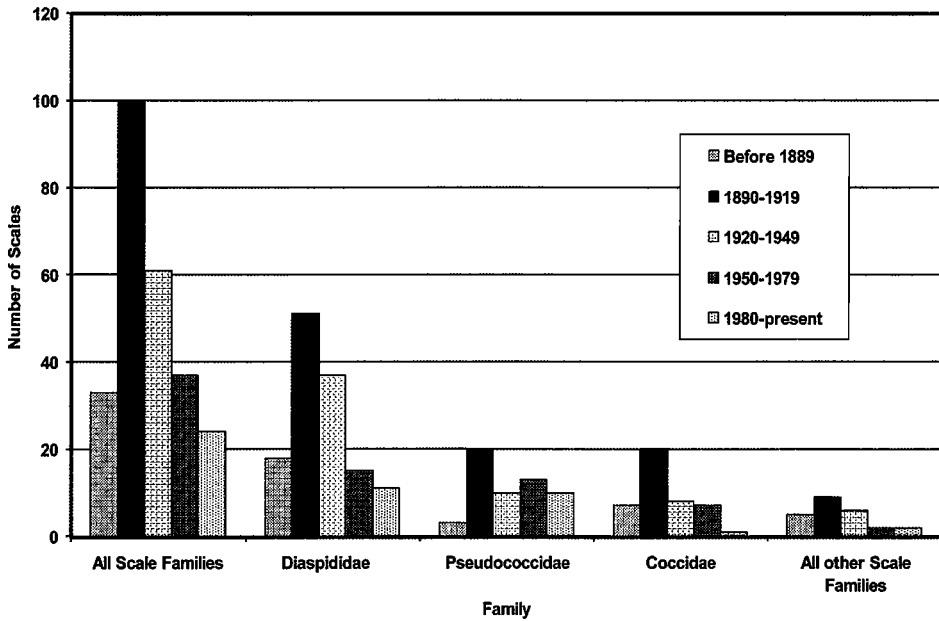
1

Number of Adventive Scales at 30-year Intervals



2

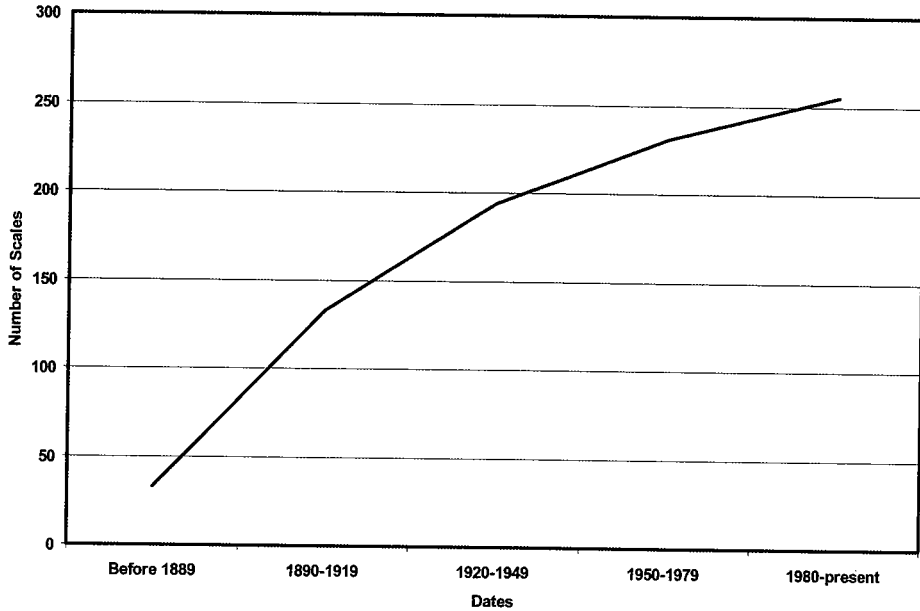
Introduction of Scale Families (Overall and Selected) in the U.S.



Figs. 1-2. Adventive scales. 1, Number of adventive scales in the United States recorded at 30-year intervals. 2, Number of adventive scales (overall and selected families) in the United States reported at 30-year intervals.

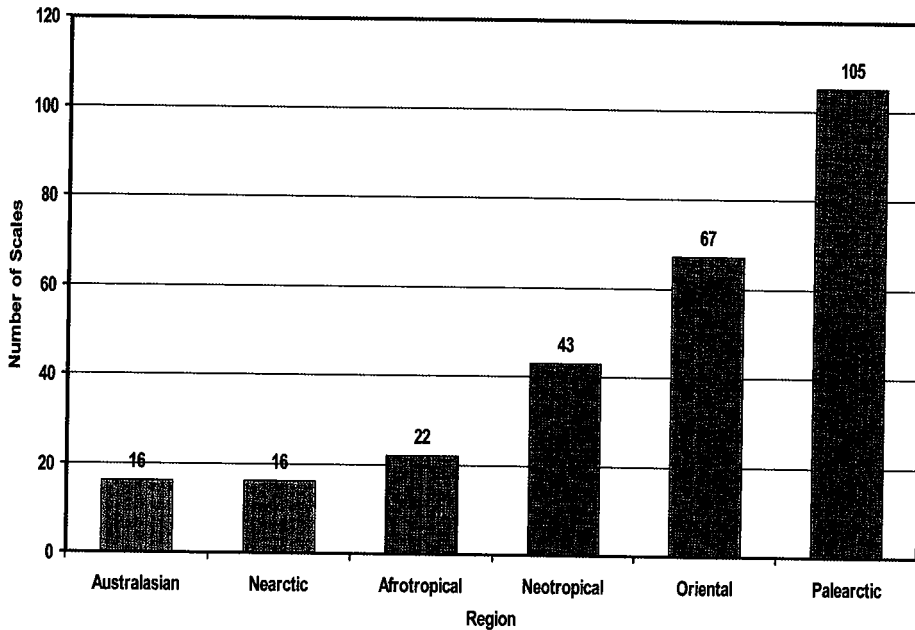
3

Accumulated Number of Adventive Scales at 30-year Intervals



4

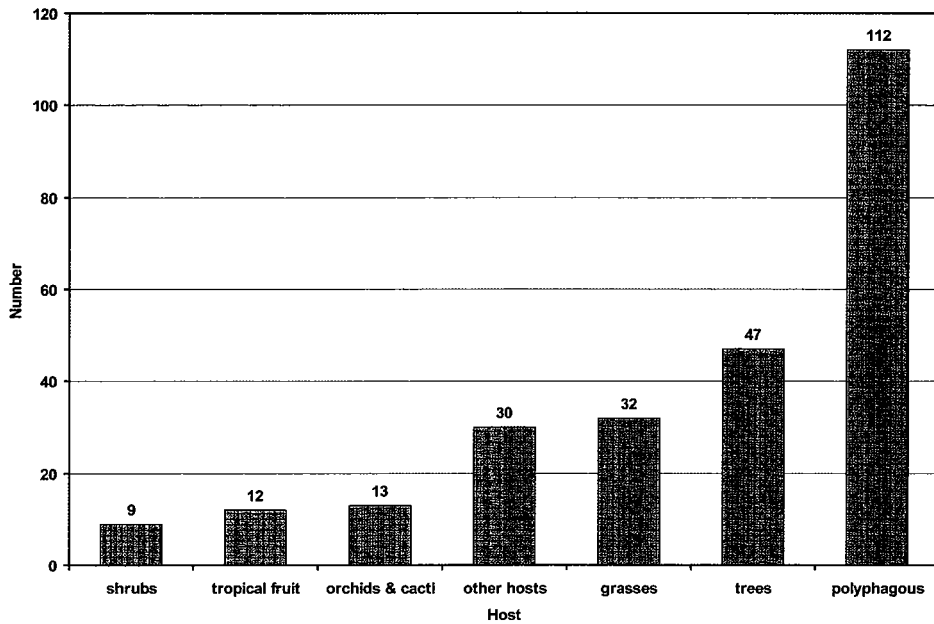
Origin of Adventive Scales in the U.S.



Figs. 3-4. Adventive scales. 3, Accumulated number of adventive scales in the United States at 30-year intervals. 4, Origin of adventive scale species in the United States.

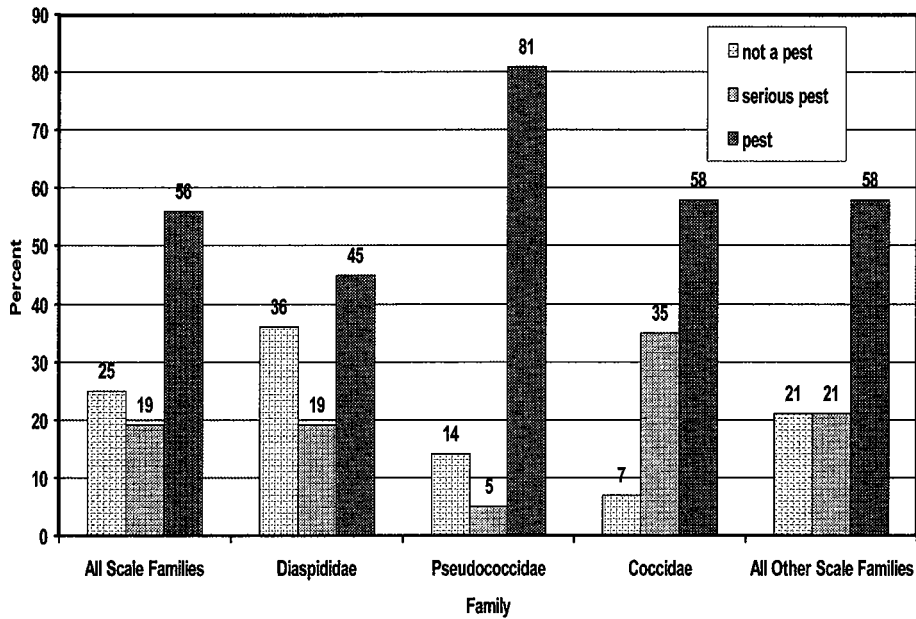
5

Host Plants of Adventive Scales to the U.S.



6

Percent of Adventive Scale Pests



Figs. 5–6. Adventive scales. 5, Number of adventive scale species in the United States on specified hosts. 6, Percent of adventive scale species that are pests in the United States.

Table 2. List of native U.S. species of scale insects considered pests.

Name of Native Scale	Reference to Pest Status	Pest Status
Cerococcidae		
<i>Cerococcus parrotti</i> (Hunter)	Lambdin and Kosztarab 1977	minor pest
<i>Cerococcus quercus</i> Comstock	Lambdin and Kosztarab 1977	minor pest
<i>Cerococcus kalmiae</i> Ferris	Lambdin and Kosztarab 1977	minor pest
Coccidae		
<i>Mesolecanium nigrofasciatum</i> (Pergande)	Kosztarab 1996	pest
<i>Neolecanium cornuparvum</i> (Thro)	Williams and Kosztarab 1972	pest
<i>Pseudophilippia quaintancii</i> Cockerell	Hamon and Williams 1984	minor pest
<i>Pulvinaria acericola</i> (Walsh and Riley)	Kosztarab 1996	pest
<i>Pulvinaria hydrangeae</i> Steinweden	Williams and Kosztarab 1972	minor pest
<i>Pulvinaria innumerabilis</i> (Rathvon)	Williams and Kosztarab 1972	pest
<i>Toumeyella liriodendri</i> (Gmelin)	Kosztarab 1996	pest
<i>Toumeyella parvicornis</i> (Cockerell)	MacAloney 1961	minor pest
<i>Toumeyella pini</i> (King)	Kosztarab 1996	minor pest
Diaspididae		
<i>Abgrallaspis ithacae</i> (Ferris)	Pirone 1970	pest
<i>Chionaspis americana</i> Johnson	Dodge and Rickett 1943	minor pest
<i>Chionaspis corni</i> Cooley	Baker 1972	minor pest
<i>Chionaspis furfura</i> (Fitch)	Kosztarab 1996	pest
<i>Chionaspis heterophyllae</i> Cooley	Negron and Clarke 1995	serious pest
<i>Chionaspis pinifoliae</i> (Fitch)	Kosztarab 1996	serious pest
<i>Clavaspis ulmi</i> (Johnson)	Miller and Davidson 1990	minor pest
<i>Comstockiella sabalis</i> (Comstock)	Miller and Davidson 1990	pest
<i>Cupressaspis shastae</i> (Coleman)	Michener et al. 1957	minor pest
<i>Diaspidiotus ancylus</i> (Putnam)	Polavarapu et al. 2000	pest
<i>Diaspidiotus forbesi</i> (Johnson)	Beardsley and González 1975	pest
<i>Diaspidiotus juglansregiae</i> (Comstock)	Gill 1997	pest
<i>Diaspidiotus liquidambaris</i> (Kotinsky)	Baker 1972	minor pest
<i>Diaspidiotus osborni</i> (Newell and Cockerell)	Miller and Davidson 1990	minor pest
<i>Diaspidiotus uvae</i> (Comstock)	Johnson et al. 1999	serious pest
<i>Hemiberlesia neodiffinis</i> Miller and Davidson	Miller and Davidson 1998	minor pest
<i>Melanaspis obscura</i> (Comstock)	Stoetzel and Davidson 1971	serious pest
<i>Melanaspis lilacina</i> (Cockerell)	Miller and Davidson 1990	minor pest
<i>Melanaspis tenebricosa</i> (Comstock)	Baker 1972	serious pest
<i>Nuculaspis californica</i> (Coleman)	Johnson and Lyon 1988	pest
<i>Quernaspis quercus</i> (Comstock)	Herbert 1936	minor pest
<i>Rhizaspidiotus dearnessi</i> (Cockerell)	Lacroix 1926	minor pest
Eriococcidae		
<i>Eriococcus azaleae</i> Comstock	Miller and Miller 1992	pest
<i>Eriococcus coccineus</i> Cockerell	Miller and Miller 1992	serious pest
<i>Eriococcus quercus</i> (Comstock)	Kosztarab 1996	pest
Kermesidae		
<i>Allokermes kingii</i> (Cockerell)	Kosztarab 1996	minor pest
<i>Eriokermes gillettei</i> (Tinsley)	Miller 1991	minor pest
<i>Nanokermes folium</i> Bullington and Kosztarab	McConnell and Davidson 1959	minor pest
Lecanodiaspididae		
<i>Lecanodiaspis prosopidis</i> (Maskell)	Kosztarab 1996	minor pest
Margarodidae		
<i>Eumargarodes laingi</i> Jakubski	Spink and Dogger 1961	minor pest
<i>Margarodes meridionalis</i> Morrison	Kouskolekas and Self 1973	pest
<i>Matsucoccus acalyptus</i> Herbert	McCambridge 1974	pest

Table 2. Continued.

Name of Native Scale	Reference to Pest Status	Pest Status
<i>Matsucoccus bisetosus</i> Morrison	McKenzie 1942	serious pest
<i>Matsucoccus gallicolus</i> Morrison	Parr 1939	minor pest
<i>Matsucoccus vexillorum</i> Morrison	McKenzie 1943b	pest
<i>Stomacoccus platani</i> Ferris	Gill 1993	serious pest
<i>Xylococculus betulae</i> (Pergande)	Gill 1993	minor pest
<i>Xylococculus macrocarpae</i> (Coleman)	Gill 1993	pest
Pseudococcidae		
<i>Ehrhornia cupressi</i> (Ehrhorn)	Herbert 1920	minor pest
<i>Oracella acuta</i> (Lobdell)	Negron and Clarke 1995	pest
<i>Paracoccus juniperi</i> (Ehrhorn)	Calkins 1946	minor pest
<i>Phenacoccus acericola</i> King	Britton 1924	minor pest
<i>Phenacoccus gossypii</i> Townsend and Cockerell	Myers 1932	minor pest
<i>Phenacoccus madeirensis</i> Green	Williams and Granara de Willink 1992	pest
<i>Phenacoccus minimus</i> Tinsley	Miller 1991	minor pest
<i>Phenacoccus solani</i> Ferris	Miller 1991	minor pest
<i>Pseudococcus maritimus</i> (Ehrhorn)	Geiger and Daane 2001	serious pest
<i>Pseudococcus viburni</i> (Signoret)	Whiting and Hoy 1998	pest
<i>Rhizoecus floridanus</i> Hambleton	Hamlen 1974	minor pest
<i>Rhizoecus simplex</i> (Hambleton)	Miller 1991	minor pest
<i>Trionymus haancheni</i> McKenzie	Osborn 1952	pest
Putoidae		
<i>Puto cupressi</i> (Coleman)	Miller 1991	minor pest
<i>Puto sandini</i> Washburn	Washburn 1965	minor pest

of native scale insects that are considered pests (Cercococcidae 3, Coccidae 9, Diaspididae 22, Eriococcidae 3, Kermesidae 3, Lecanodiaspididae 1, Margarodidae 9, Pseudococcidae 13, Putoidae 2). Of the native pests, only 9 (14%) are rated as serious, considerably less than the 25% figure for introduced pests. A surprisingly large number in the category "all other families" are native pest species (Fig. 7). The large percentages of these are margarodids, especially species of *Matsucoccus*.

The number of native pest species (65), in combination with the introduced pests (191), totals 256 species of scale insects that are considered pests in the United States or 25% of the all the scale insects in the U.S.

DISCUSSION

Many of our findings are similar to those reported by Sailer (1978, 1983) for all insects. The similarities are: the majority of in-

roduced species are indigenous to the Palearctic Region; introductions occurred at an increasing rate until about 1920 and declined since; the adventive species load is increasing at an alarming rate when the accumulation curve data are analyzed; within the adventive species that occur in the United States, slightly more than half are pests or minor pests, slightly less than one quarter are major pests, and slightly more than one quarter are non-pests.

There are some interesting differences between the statistics for all insects and scales. Sailer (1978) indicated that about 1% of the insect and mite fauna in the United States is introduced, but for scale insects, it is about 25%. Although scales make up only slightly more than 1% of the U.S. insect fauna, they represent about 12% of the adventive insect fauna. Scale insects may represent a substantial percentage of the adventive insect fauna in other countries as well. For example, Charles (1998) indicated

7

Native and Adventive Scale Pests in the U.S.

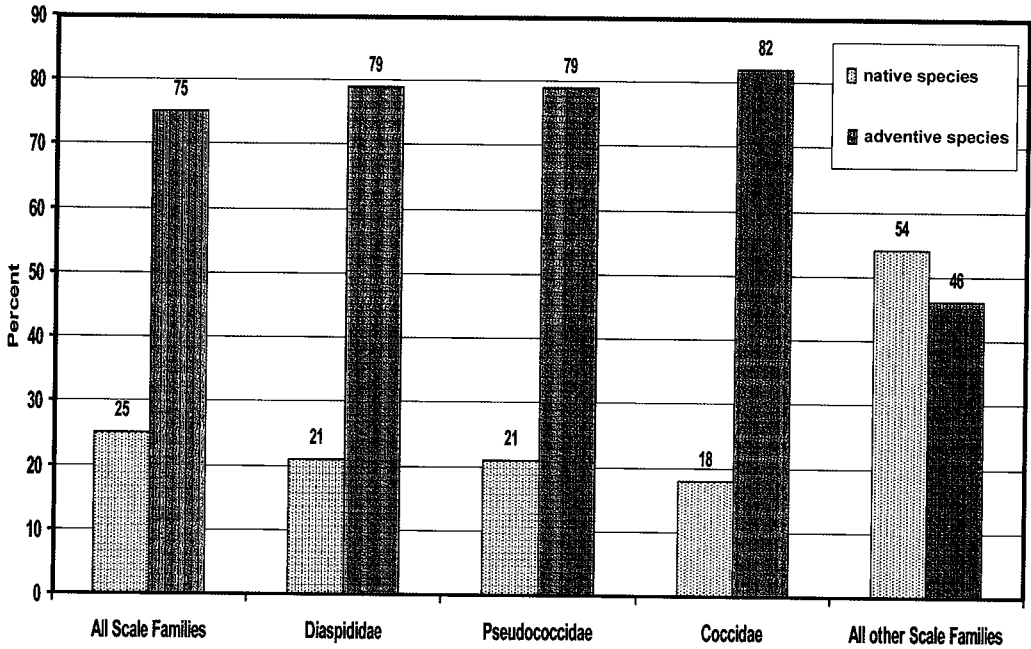


Fig. 7. Adventive scales in relation to native scales as pests in the United States.

that 24 species of Coccoidea represented 24% of the total "exotic" arthropod pests of fruit crops in New Zealand.

Gill (1997) summarized information on the rather impressive list of diaspidid species that have been eradicated or have not been detected after a period of establishment in California. Species such as Hall scale, *Mercetaspis halli* (Green), and date palm scale, *Parlatoria blanchardi* (Targioni Tozzetti), required major, long-term eradication effort (Boyden 1941, Fosen et al. 1953), but the successful elimination of these pests may have saved of millions of dollars annually. Gill (1997) mentioned 25 species of armored scales as having been eradicated or disappeared, an impressive record when compared with eradication success in many other invasive insects. Unfortunately, no comparable information on eradication efforts in other states is available.

SUMMARY

- 1) There are 255 introduced scale-insect species in the United States and a total scale-insect fauna of 1,019 species.
- 2) The U.S. fauna includes an unusually large number of introduced scale insects compared with most other insect groups.
- 3) The largest number of introduced scale insects originated in the Palearctic Region and they usually are polyphagous.
- 4) Of the 255 introduced species, about 75% are pests.
- 5) Of the 766 indigenous U.S. scale species, only about 8% are pests.
- 6) The largest number of introduced scale species was detected between 1890 and 1920, and the number of introductions has decreased over time.
- 7) Recent rates of detection are about one species each year, which is dramatically increasing the pest load, placing an ever-

increasing pest burden on U.S. agriculture.

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