

INVASIVE SOFT SCALES (HEMIPTERA: COCCIDAE) AND THEIR THREAT TO U.S. AGRICULTURE

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Abstract.—We provide a compilation of 147 species of soft scales that are considered either pests or represent a threat to United States agriculture. Included for each species, where applicable, is reference to origin and date of introduction if applicable, establishment in the United States, pest or threat status in the United States along with a validation citation, principal hosts, and biogeographical region of origin.

Key Words: Coccidae, soft scales, invasive species, biological control, quarantine, agriculture, forestry, horticulture, ornamentals, fruit trees

Invasive (non-native) species of insects represent an increasing concern to the United States. If non-native species become pests, the consequences include loss of production, diminished product quality, production cost increases, flexibility decreases in production/management decisions, increased risk of human disease, and damaging environmental and aesthetic effects (Huber et al. 2002). Various insects of agricultural concern have been identified as potentially damaging if introduced or reintroduced into the United States (Huber et al. 2002). Invasive species and potentially dangerous species of mealybugs (Pseudococcidae) have been recently examined as they pertain to agriculture in the United States (Miller et al. 2002). The Coccidae or soft scales, like all scale insects, are plant feeders. A few species of soft scales are valuable to man as biological control agents of noxious weeds, however, many are pests of economically important plants.

Because invasive species of insects represent a major concern to U.S. agriculture,

we have investigated several parameters concerning invasive soft scales. Objectives of this paper are: 1) To develop a preliminary world list of the pest soft scales; 2) provide a list of pest soft scales introduced to the continental United States; 3) to determine which species in the previous two objectives are either introduced or native to the continental United States; 3) examine data provided by the United States Department of Agriculture, Animal and Plant Health Inspection Service—Plant Protection and Quarantine (USDA, APHIS-PPQ) concerning the most commonly intercepted soft scales at the United States ports-of-entry; and 5) using all of this information, try to predict which soft scales are the most likely candidates for future invasions into the continental United States.

MATERIALS AND METHODS

Executive Order 13112 established the National Invasive Species Council and provided a definition of an invasive species as "... a species that is 1) non-native (or

alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health.” This definition not only includes species alien to the United States but also encompasses native species. The definition also has an economic or potentially economic component. By this definition, the tulip tree scale, *Toumeyella liriodendri* (Gmelin), would be an example of an invasive species in the United States even though it likely is native. Our definition is based on Miller et al. (2002) and is more simplistic. They considered invasive species to be those that are non-native [also introduced, nonindigenous, exotic, alien or invasive (Huber et al. 2002)] to the United States regardless of economic harm.

We have used a broad definition of the term “pest” to create a table of pest soft scales of the world (Table 1). If a soft scale is described in the literature as either a pest, causing damage, requiring control, or of economic importance, we have included it in the list. A pest species as defined by some authors (e.g., Ebeling 1959, Pfeiffer 1997) was regarded as any record of a soft scale on certain economic hosts. Ebeling’s (1959) justification was based on his consideration that some species not of economic importance become major pests through adaptation or by being transferred to regions of lower environmental resistance. However, Pfeiffer’s (1997) inclusion of *Eulecanium lespedezae* Danzig as a pest of deciduous fruit trees is probably an error because the only known host record of this species is *Lespedeza bicolor* Turcz. (Danzig 1986).

Our perspective for this paper has focused on the impact or potential impact of a pest soft scale on agriculture in the contiguous United States. For example, *Ceroplastes psidii* (Chavannes) is known only from *Psidium* spp. Therefore, because guavas are not widely grown in the contiguous United States, it is considered to have relatively minor pest potential in the United States even though it may be far more im-

portant in areas of the world where guava is of greater economic importance. Conversely, *Ceroplastes japonicus* Green, occurs on many different agricultural plants that are economically important in the United States and it is therefore considered a major threat. The term “threat” is used for species that are considered pests but do not occur in the United States. Determination of the date of introduction in the U.S. was established either from literature records or from the oldest collection record in the National Entomological Collection of the National Museum of Natural History, in Beltsville, Maryland. In at least one case (e.g., *Eriopeltis festucae* Boyer de Fonscolombe), the first literature record in the U.S. is Patch (1905) but the oldest collection record is 1899. Obviously, these dates are estimates of the date when a species first invaded the United States.

It is difficult to determine the zoogeographic area of origin for some species. Some distributional records for *Ceroplastes* spp. are from Qin et al. (1998) and *Coccus* spp. are from Gill et al. (1977). It is not always clear whether an invasive species is from the Old or New World. In some cases, we have simply made a supposition based on the current distribution of the species, the distribution of what appears to be its closest relatives, and the natural distribution of its primary host plants. We have used the same criteria to determine if a particular species is native to the United States. Our use of the terms polyphagous, oligophagous, and monophagous has been slightly modified for the current paper and are hereby defined for those species that have greater than 10 host-plant families, 3–10 host-plant families, and 1–2 host-plant families respectfully.

RESULTS

Table 1 provides information on 147 species of soft scales. The table includes one species [*Prococcus acutissimus* (Green)] that has been introduced and established into the United States but is not considered

Table 1. Pest or threat soft scale species to United States agriculture. Abbreviations for origin are Afrotropical Region (AF), Australasian Region (AU), Nearctic (NE), Neotropical Region (NT), Oriental Region (OR), Palearctic Region (PA).

| Pest or Threat Species | U.S. Origin and Date of Introduction | Established in U.S. | Pest or Threat Status in U.S. | Reference | Principal Hosts | Origin |
|--|--------------------------------------|---------------------|-------------------------------|---|--|--------|
| <i>Anapulvinaria pistaciae</i> (Bodenheimer) | | no | minor threat | Abu-Yaman 1970 | monophagous, including pistachio | PA |
| <i>Anthococcus keravatae</i> Williams and Watson | | no | minor threat | Gill and Kosztarab 1997 | oligophagous, including tropical plants | AU |
| <i>Ceroplastes actiniformis</i> Green | | no | threat | Swirski et al. 1997 | polyphagous, including tropical fruits | OR |
| <i>Ceroplastes bergi</i> Cockerell | | no | threat | Ebeling 1959 | oligophagous, including citrus | NT |
| <i>Ceroplastes brachyurus</i> Cockerell | native? | yes | minor pest | Gimpel et al. 1974 | oligophagous, including citrus and <i>Ilex</i> | NE(?) |
| <i>Ceroplastes brevicauda</i> Hall | | no | threat | Murphy 1997 | polyphagous, including coffee and citrus | AF |
| <i>Ceroplastes ceriferus</i> (Fabricius) | FL, 1908 | yes | pest | Gimpel et al. 1974 | polyphagous | NT |
| <i>Ceroplastes cirripediformis</i> Comstock | FL, 1881 | yes | pest | Gimpel et al. 1974 | polyphagous | NE |
| <i>Ceroplastes cistudiformis</i> Cockerell | native? | yes | minor pest | Gimpel et al. 1974 | polyphagous, including citrus | NE(?) |
| <i>Ceroplastes destructor</i> Newstead | | no | major threat | Sabine 1969 | polyphagous, including citrus | AF |
| <i>Ceroplastes dugesii</i> Lichtenstein | FL, 1908 | yes | pest | Hamon and Williams 1984 | polyphagous | NT |
| <i>Ceroplastes eugeniae</i> Hall | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | AF |
| <i>Ceroplastes floridensis</i> Comstock | FL, 1881 | yes | pest | Gimpel et al. 1974 | polyphagous, including citrus and ornamentals | NE |
| <i>Ceroplastes flosculoides</i> Matile-Ferrero | | no | minor threat | Matile-Ferrero and Couturier 1993 | monophagous, including <i>Myricaria dubia</i> | NT |
| <i>Ceroplastes grandis</i> Hempel | | no | major threat | Gill and Kosztarab 1997 | polyphagous, including ornamentals and fruit trees | NT |
| <i>Ceroplastes japonicus</i> Green | | no | major threat | Pellizzari-Scaltriti and Antonucci 1982 | polyphagous, including ornamentals | OR |
| <i>Ceroplastes pseudoceriferus</i> Green | | no | major threat | Swirski et al. 1997 | polyphagous, including tropical fruits and ornamentals | OR |
| <i>Ceroplastes psidii</i> (Chavannes) | | no | minor threat | Hempel 1920 | monophagous, including guava | NT |
| <i>Ceroplastes quadrilineatus</i> Newstead | | no | minor threat | Pfeiffer 1997 | oligophagous, including fruit trees | AF |
| <i>Ceroplastes rubens</i> Maskell | FL, 1955 | yes | pest | Gimpel et al. 1974 | polyphagous, including citrus and ornamentals | AF |

Table 1. Continued.

| Pest or Threat Species | U.S. Origin and Date of Introduction | Established in U.S. | Pest or Threat Status in U.S. | Reference | Principal Hosts | Origin |
|--|--------------------------------------|---------------------|-------------------------------|--------------------------|--|--------|
| <i>Ceroplastes rusci</i> (Linnaeus) | FL, 1994 | yes | pest | Ben-Dov 1988 | polyphagous, including citrus and ornamentals | AF |
| <i>Ceroplastes sinensis</i> Del Guercio | NC, 1920 | yes | pest | Gimpel et al. 1974 | polyphagous, including citrus and ornamentals | NT |
| <i>Ceroplastes sinoiae</i> Hall | | no | minor threat | Bedford 1968 | oligophagous, including ornamentals | AF |
| <i>Coccus africanus</i> (Newstead) | | no | minor threat | Ebeling 1959 | oligophagous, including tropical fruits and coffee | AF |
| <i>Coccus alpinus</i> De Lotto | | no | minor threat | Murphy 1997 | oligophagous, including tropical fruits and coffee | AF |
| <i>Coccus celatus</i> De Lotto | | no | minor threat | Murphy 1997 | polyphagous, including tropical fruits and coffee | AF |
| <i>Coccus capparidis</i> (Green) | FL, 1975 | yes | minor pest | Gill et al. 1977 | polyphagous | OR |
| <i>Coccus discrepans</i> (Green) | | no | threat | Ebeling 1959 | polyphagous, including tropical fruits | OR |
| <i>Coccus formicarii</i> (Green) | | no | minor threat | Pfeiffer 1997 | polyphagous, including tropical fruits | OR |
| <i>Coccus hesperidum</i> Linnaeus | CA, 1880 | yes | pest | Ebeling 1959 | polyphagous | OR |
| <i>Coccus longulus</i> (Douglas) | NY, 1921 | yes | major pest | Gill and Kosztarab 1997 | polyphagous, including tropical fruits and ornamentals | OR(?) |
| <i>Coccus pseudoesperidum</i> (Cockerell) | DC, 1912 | yes | major pest | Gill and Kosztarab 1997 | monophagous, including orchids | NT |
| <i>Coccus pseudomagnoliarum</i> (Kuwana) | CA, 1910 | yes | major pest | Ebeling 1959 | oligophagous, including citrus | PA |
| <i>Coccus viridis</i> (Green) | FL, 1949 | yes | major pest | Gill et al. 1977 | polyphagous | AF |
| <i>Coccus watti</i> (Green) | | no | threat | Ebeling 1959 | monophagous, including citrus and camellia | OR |
| <i>Cribrolecanium andersoni</i> (Newstead) | | no | threat | Brink and Bruwer 1989 | oligophagous, including tropical fruits | AF |
| <i>Crystallotesta fagi</i> (Maskell) | | no | threat | Hosking and Kershaw 1985 | monophagous, including beech trees | AU |
| <i>Didesmococcus koreanus</i> Borchsenius | | no | minor threat | Pfeiffer 1997 | monophagous, including deciduous fruit trees | PA |

Table 1. Continued.

| Pest or Threat Species | U.S. Origin and Date of Introduction | Established in U.S. | Pest or Threat Status in U.S. | Reference | Principal Hosts | Origin |
|---|--------------------------------------|---------------------|-------------------------------|-----------------------------|--|--------|
| <i>Didesmococcus unifasciatus</i> (Archangel-skaya) | | no | threat | Gill and Kosztarab 1997 | oligophagous, including deciduous fruit trees | OR |
| <i>Drepanococcus chiton</i> (Green) | | no | threat | Campbell 1997 | polyphagous, including tropical fruits | OR |
| <i>Ericerus pela</i> (Chavannes) | | no | threat | Kosztarab 1997b | monophagous, including deciduous forest trees | PA |
| <i>Eriopeltis festucae</i> (Boyer de Fonscolombe) | NY, 1899 | yes | minor pest | Williams and Kosztarab 1972 | monophagous, including grasses | PA |
| <i>Eucalymnatus tessellatus</i> (Signoret) | CA, 1901 | yes | major pest | Dekle 1973 | polyphagous, greenhouse pest | NT |
| <i>Eulecanium alnicola</i> Chen | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | PA |
| <i>Eulecanium cerasorum</i> (Cockerell) | CA, 1909 | yes | major pest | Gill and Kosztarab 1997 | oligophagous, including deciduous forest trees | PA |
| <i>Eulecanium ciliatum</i> (Douglas) | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous forest and fruit trees | PA |
| <i>Eulecanium douglasi</i> (Šulc) | | no | threat | Lagowska 1984 | oligophagous, including deciduous forest and fruit trees | PA |
| <i>Eulecanium kunoense</i> (Kuwana) | CA, 1896 | yes | major pest | McKenzie 1951 | oligophagous, including deciduous fruit trees | PA |
| <i>Eulecanium novicum</i> Borchsenius | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | PA |
| <i>Eulecanium rugulosum</i> (Archangel-skaya) | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | PA |
| <i>Eulecanium sericeum</i> (Lindinger) | | no | threat | Kosztarab 1997a | monophagous, including conifers | PA |
| <i>Eulecanium tiliae</i> (Linnaeus) | CA, 1908 | yes | major pest | Kosztarab 1996 | polyphagous | PA |
| <i>Eulecanium transcaasicum</i> Borchsenius | | no | minor threat | Pfeiffer 1997 | monophagous, including deciduous fruit trees | PA |
| <i>Filippia follicularis</i> (Targioni Tozzetti) | | no | minor threat | Gill and Kosztarab 1997 | oligophagous, including olive and pistachio | PA |
| <i>Kilifia acuminata</i> (Signoret) | MO, 1903 | yes | pest | Nada et al. 1990 | polyphagous | OR |
| <i>Lichtensia viburni</i> Signoret | | no | threat | Gill and Kosztarab 1997 | polyphagous, including ornamentals | PA |

Table 1. Continued.

| Pest or Threat Species | U.S. Origin and Date of Introduction | Established in U.S. | Pest or Threat Status in U.S. | Reference | Principal Hosts | Origin |
|--|--------------------------------------|---------------------|-------------------------------|-----------------------------|--|--------|
| <i>Maacoccus bicruciatu</i> s (Green) | | no | minor threat | Ebeling 1959 | oligophagous, including citrus and mango | OR |
| <i>Malloccoccus viteicola</i> Young | | no | minor threat | Wan et al. 1985 | oligophagous, including ornamentals and medical herb | PA |
| <i>Megapulvinaria maxima</i> (Green) | | no | threat | Chua 1997b | polyphagous, including tropical plants | OR |
| <i>Mesolecanium deltae</i> Lizer y Trelles | | no | major threat | Teran and Guyot 1969 | monophagous, including citrus | NT |
| <i>Mesolecanium nigrofasciatum</i> (Pergande) | native | yes | major pest | Kosztarab 1996 | polyphagous, including fruit trees and ornamentals | NE |
| <i>Milviscutulus mangiferae</i> (Green) | FL, 1935 | yes | major pest | Avidov and Harpaz 1969 | polyphagous | OR |
| <i>Milviscutulus pilosus</i> Williams and Watson | | no | minor threat | Chua 1997a | oligophagous, including coconut | AU |
| <i>Neolecanium cornuparvum</i> (Thro) | native | yes | minor pest | Williams and Kosztarab 1972 | monophagous, including magnolia | NE |
| <i>Neolecanium silveirai</i> (Hempel) | | no | major threat | Lepage and Piza 1941 | monophagous, including grapes | NT |
| <i>Neopulvinaria innumerabilis</i> (Rathvon) | native | yes | major pest | Kosztarab 1997c | polyphagous | NE |
| <i>Neosaissetia triangularum</i> (Morrison) | | no | minor threat | Chua 1997a | monophagous, including coconut | OR |
| <i>Palaeolecanium bituberculatum</i> (Signoret) | | no | major threat | Lagowska 1984 | oligophagous, including deciduous fruit trees | PA |
| <i>Palaeolecanium kosswigi</i> (Bodenheimer) | | no | minor threat | Pfeiffer 1997 | monophagous, including deciduous fruit trees | PA |
| <i>Paralecanium cocophyllae</i> Banks | | no | minor threat | Chua 1997a | monophagous, including coconut | OR |
| <i>Paralecanium milleri</i> Takahashi | | no | minor threat | Chua 1997a | oligophagous, including mango and coconut | OR |
| <i>Parasaissetia nigra</i> (Nietner) | AL, 1929 | yes | major pest | Gill 1988 | polyphagous | OR |
| <i>Parthenolecanium corni</i> (Bouché) | KS, 1874 | yes | major pest | Hamon and Williams 1984 | polyphagous | PA |
| <i>Parthenolecanium fletcheri</i> (Cockerell) | native | yes | pest | Kosztarab 1997a | monophagous, including conifers | NE |
| <i>Parthenolecanium glandi</i> (Kuwana) | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | PA |

Table 1. Continued.

| Pest or Threat Species | U.S. Origin and Date of Introduction | Established in U.S. | Pest or Threat Status in U.S. | Reference | Principal Hosts | Origin |
|--|--------------------------------------|---------------------|-------------------------------|-----------------------------|--|--------|
| <i>Parthenolecanium orientalis</i> Borchsenius | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | PA |
| <i>Parthenolecanium persicae</i> (Fabricius) | CA, 1897 | yes | major pest | Williams and Kosztarab 1972 | polyphagous | PA |
| <i>Parthenolecanium prunosum</i> (Coquillett) | native | yes | major pest | Gill and Kosztarab 1997 | oligophagous, including walnuts | NE |
| <i>Parthenolecanium putnami</i> (Phillips) | | no | minor pest | Pfeiffer 1997 | oligophagous, including deciduous forest and fruit trees | NE |
| <i>Parthenolecanium quercifex</i> (Fitch) | native | yes | major pest | Gill 1988 | oligophagous, including oaks | NE |
| <i>Parthenolecanium rufulum</i> (Cockerell) | | no | threat | Kosztarab 1997b | polyphagous, including deciduous forest trees | PA |
| <i>Philephedra Broadwayi</i> (Cockerell) | | no | threat | Nakahara and Gill 1985 | oligophagous, including tropical fruits | NT |
| <i>Philephedra tuberculosa</i> Nakahara and Gill | native | yes | major pest | Gill and Kosztarab 1997 | polyphagous | NE |
| <i>Physokermes hemicryphus</i> (Dalman) | CA, 1958 | yes | pest | Santas 1988 | monophagous, including conifers | PA |
| <i>Physokermes insignicola</i> (Craw) | native | yes | minor pest | Gill 1988 | monophagous, including pines | NE |
| <i>Physokermes piceae</i> (Schrank) | | no | threat | Santas 1988 | monophagous, including spruce | PA |
| <i>Physokermes taxifoliae</i> Coleman | native | yes | pest | Kosztarab 1997a | monophagous, including fir | NE |
| <i>Platinglisia noacki</i> Cockerell | | no | minor threat | Ebeling 1959 | polyphagous, including avocado and ornamentals | NT |
| <i>Platylecanium cocotis</i> Laing | | no | minor threat | Chua 1997a | monophagous, including coconut | AU |
| <i>Prococcus acutissimus</i> (Green) | FL, 1956 | yes | not a pest | Gill et al. 1977 | polyphagous | OR |
| <i>Protopulvinaria longivalvata</i> Green | | no | threat | Ebeling 1959 | polyphagous, including tropical fruits and ornamentals | OR |
| <i>Protopulvinaria pyriformis</i> (Cockerell) | FL, 1906 | yes | major pest | Del Rivero 1966 | polyphagous | NT |
| <i>Pseudophilippia lanigera</i> (Hempel) | | no | minor threat | Ebeling 1959 | oligophagous, including citrus | NT |
| <i>Pseudophilippia quaintancii</i> Cockerell | native | yes | pest | Ray and Williams 1980 | monophagous, including pines | NE |
| <i>Pulvinaria acericola</i> (Walsh and Riley) | native | yes | pest | Kosztarab 1997b | oligophagous, including deciduous forest trees | NE |
| <i>Pulvinaria amygdali</i> Cockerell | native | yes | minor pest | Pfeiffer 1997 | monophagous, including deciduous fruit trees | NE |

Table 1. Continued.

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|---|--------------------------------------|---------------------|-------------------------------|-------------------------|--|--------|
| <i>Pulvinaria aurantii</i> Cockerell | | no | threat | Gill 1997 | polyphagous, including citrus | PA |
| <i>Pulvinaria citricola</i> Kuwana | MD, 1941 | yes | major pest | Gill and Kosztarab 1997 | oligophagous, including citrus and persimmon | PA |
| <i>Pulvinaria decorata</i> Borchsenius | | no | minor threat | Ebeling 1959 | monophagous, including citrus | AU |
| <i>Pulvinaria delottoi</i> Gill | CA, 1973 | yes | major pest | Gill and Kosztarab 1997 | monophagous, including ice-plant | AF |
| <i>Pulvinaria elongata</i> Newstead | FL, 1927 | yes | minor pest | Carnegie 1997 | oligophagous, including sugarcane and grasses | NT(?) |
| <i>Pulvinaria ericicola</i> McConnell | native | yes | pest | Kosztarab 1997b | monophagous, including blueberries | NE |
| <i>Pulvinaria ficus</i> Hempel | | no | threat | Ebeling 1959 | polyphagous, including tropical fruits and ornamentals | NT |
| <i>Pulvinaria flavescens</i> Brethes | | no | major threat | Kitayama 1993 | oligophagous, including citrus | NT |
| <i>Pulvinaria floccifera</i> (Westwood) | GA, 1892 | yes | pest | Gill and Kosztarab 1997 | polyphagous, including citrus and ornamentals | PA(?) |
| <i>Pulvinaria fujisana</i> Kanda | | no | minor threat | Pfeiffer 1997 | monophagous, including deciduous fruit trees | PA |
| <i>Pulvinaria horii</i> Kuwana | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous forest and fruit trees | PA |
| <i>Pulvinaria hydrangeae</i> Steinweden | native | yes | pest | Tondeur et al. 1990 | polyphagous, including ornamentals | NE |
| <i>Pulvinaria iceryi</i> (Signoret) | | no | minor threat | Carnegie 1997 | monophagous, including grasses and sugarcane | AF |
| <i>Pulvinaria kuwacola</i> Kuwana | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | PA |
| <i>Pulvinaria mammeae</i> Maskell | | no | minor threat | Pfeiffer 1997 | polyphagous, including tropical fruits | AU |
| <i>Pulvinaria occidentalis</i> Cockerell | native | yes | minor pest | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | NE |
| <i>Pulvinaria okitsuensis</i> Kuwana | | no | minor threat | Ebeling 1959 | oligophagous, including citrus and tea | PA |
| <i>Pulvinaria peninsularis</i> Ferris | native | yes | minor pest | Ebeling 1959 | oligophagous, including citrus | NE |
| <i>Pulvinaria peregrina</i> (Borchsenius) | | no | minor threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | PA |

Table 1. Continued.

| Pest or Threat Species | U.S. Origin and Date of Introduction | Established in U.S. | Pest or Threat Status in U.S. | Reference | Principal Hosts | Origin |
|---|--------------------------------------|---------------------|-------------------------------|--------------------------|--|--------|
| <i>Pulvinaria persicae</i> Newstead | | no | minor threat | Pfeiffer 1997 | monophagous, including deciduous fruit trees | PA |
| <i>Pulvinaria phariae</i> Lull | MA, 1897 | yes | minor pest | Gill 1988 | monophagous, including orchids | PA(?) |
| <i>Pulvinaria polygonata</i> Cockerell | | no | threat | Gill 1997 | oligophagous, including citrus and mango | OR |
| <i>Pulvinaria pruni</i> Hunter | native | yes | minor pest | Pfeiffer 1997 | monophagous, including deciduous fruit trees | NE |
| <i>Pulvinaria psidii</i> Maskell | FL, 1909 | yes | pest | Nada et al. 1990 | polyphagous | OR(?) |
| <i>Pulvinaria regalis</i> Canard | | no | major threat | Kozar et al. 1994 | polyphagous, including ornamentals | PA |
| <i>Pulvinaria rhois</i> Ehrhorn | native | yes | minor pest | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | NE |
| <i>Pulvinaria urbicola</i> Cockerell | LA, 1925 | yes | major pest | Gill and Kosztarab 1997 | polyphagous | NT |
| <i>Pulvinaria vitis</i> (Linnaeus) | NY, 1880 | yes | pest | Kosztarab and Kozar 1988 | polyphagous | PA |
| <i>Pulvinariella mesembryanthemi</i> (Vallot) | CA, 1971 | yes | pest | Donaldson et al. 1978 | monophagous, including succulents | AF |
| <i>Rhodococcus perornatus</i> (Cockerell and Parrott) | | no | minor threat | Ordogh 1995 | monophagous, including roses | PA |
| <i>Rhodococcus sariuoni</i> Borchsenius | | no | minor threat | Pfeiffer 1997 | monophagous, including deciduous fruit trees | PA |
| <i>Rhodococcus turanicus</i> (Archangel-skaya) | | no | threat | Pfeiffer 1997 | oligophagous, including deciduous fruit trees | PA |
| <i>Saccharolecanium krugeri</i> (Zehntner) | | no | minor threat | Carnegie 1997 | monophagous, including sugar cane | OR |
| <i>Saissetia citricola</i> (Kuwana) | | no | minor threat | Pfeiffer 1997 | oligophagous, including citrus and deciduous fruit trees | PA |
| <i>Saissetia coffeae</i> (Walker) | CA, 1914 | yes | pest | Hamon and Williams 1984 | polyphagous | NT |
| <i>Saissetia miranda</i> (Cockerell and Parrott) | FL, 1918 | yes | pest | Stauffer and Rose 1997 | polyphagous | NE |
| <i>Saissetia neglecta</i> De Lotto | FL, 1921 | yes | pest | Stauffer and Rose 1997 | polyphagous | NT |
| <i>Saissetia oleae</i> (Olivier) | KS, 1905 | yes | pest | Bartlett 1978 | polyphagous | PA(?) |
| <i>Saissetia persimilis</i> (Newstead) | | no | threat | Pfeiffer 1997 | polyphagous, including ornamentals and deciduous fruit trees | AF |

Table 1. Continued.

| Pest or Threat Species | U.S. Origin and Date of Introduction | Established in U.S. | Pest or Threat Status in U.S. | Reference | Principal Hosts | Origin |
|--|--------------------------------------|---------------------|-------------------------------|-------------------------|---|--------|
| <i>Saissetia socialis</i> Hempel | | no | minor threat | Pfeiffer 1997 | monophagous, including deciduous fruit trees | NT |
| <i>Saissetia subpatelliforme</i> (Newstead) | | no | minor threat | Ebeling 1959 | oligophagous, including citrus | AF |
| <i>Saissetia zanzibarensis</i> Williams | | no | minor threat | Chua 1997a | polyphagous, including tropical fruit trees | AF |
| <i>Sphaerolecanium prunastris</i> (Boyer de Fonscolombe) | PA, 1895 | yes | major pest | Gill and Kosztarab 1997 | oligophagous, including fruit trees | PA |
| <i>Takahashia japonica</i> Cockerell | | no | minor threat | Pfeiffer 1997 | oligophagous, including ornamentals and deciduous fruit trees | PA |
| <i>Toumeyella cubensis</i> Heidel and Köhler | | no | threat | Gill 1997 | monophagous, including citrus | NT |
| <i>Toumeyella liriodendri</i> (Gmelin) | native | yes | major pest | Burns and Donley 1970 | oligophagous, including forest trees | NE |
| <i>Toumeyella parvicornis</i> (Cockerell) | native | yes | major pest | Rabkin and Lejeune 1955 | monophagous, including pines | NE |
| <i>Toumeyella pini</i> King | native | yes | pest | Clarke et al. 1992 | monophagous, including pines | NE |
| <i>Toumeyella pinicola</i> Ferris | native | yes | major pest | Gill and Kosztarab 1997 | monophagous, including pines | NE |
| <i>Toumeyella virginiana</i> Williams and Kosztarab | native | yes | pest | Kosztarab 1997a | monophagous, including pines | NE |
| <i>Vinsonia stellifera</i> (Westwood) | FL, 1953 | yes | pest | Dekle 1969 | polyphagous | OR |

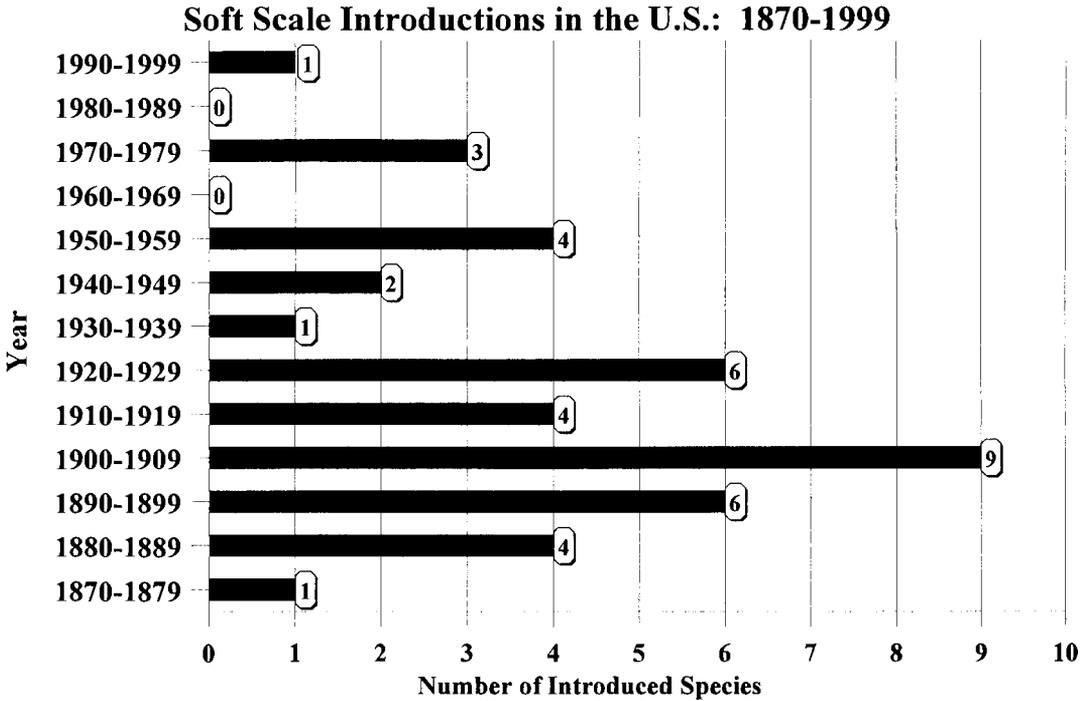


Fig. 1. Soft scale introductions in the United States from 1870–1999.

a pest. Therefore, we estimate that there are 146 species that are either pests or represent threats to U.S. agriculture. Of the 66 soft scales considered pests in the U.S., 25 are either native or possibly native species. Therefore, 41 of the soft-scale pests in the country are invasive. Based on Coccidae information presented in ScaleNet (Ben-Dov 2002), there are 105 species of soft scales in the United States; thus, the invasive component of the soft-scale fauna in the United States is approximately 39%. This percentage is much higher than the 13% of invasive species in the mealybug fauna of the U.S. (Miller et al. 2002). With the exception of the 1960's and the 1980's, at least one species of soft scale (Fig. 1) has been introduced every decade since the 1870's. The greatest number of introduced soft scales (nine species) occurred between 1900 and 1909. Two periods, the 1890's and the 1920's, witnessed the introduction of six species. More than 73% of the invasive soft scales were introduced in the

first 69 years of record keeping (1870–1939).

A summary of the region of origin of all invasive soft scales in the U.S. is as follows: Palearctic Region, 13; Neotropical Region, 11; Oriental Region, 9; Afrotropical Region, 5; Nearctic Region outside of the U.S., 3; and Australasian Region, 0. Of all of these species in the U.S., only *Proccoccus acutissimus* (Green) from the Oriental Region is not considered a pest.

Examination of the region of origin for pest soft scales worldwide provides the following results: Palearctic, 46; Nearctic, 29; Oriental, 25; Neotropical, 23; Afrotropical, 18; and Australasian, 6. Host characteristics of these pests include 38% polyphagous, 33% oligophagous, and 29% monophagous. Based on the characteristics of zoogeographic regional distributions of the highest number of soft-scale pests (Palearctic, Neotropical, and Oriental Regions, respectively), and greatest frequency of host plants (polyphagous and oligophagous), a list of

the species most likely to invade the United States was determined. Those species likely to invade from the Palearctic Region include *Eulecanium douglasi* (Šulc), *Lichtenisia viburni* Signoret, *Palaeolecanium bituberculatum* (Signoret), *Parthenolecanium rufulum* (Cockerell), *Pulvinaria aurantii* Cockerell, *Pulvinaria regalis* Canard, and *Rhodococcus turanicus* (Archangelskaya). Those species likely to invade from the Neotropical Region include *Ceroplastes bergi* Cockerell, *Ceroplastes grandis* Hempel, *Philephedra broadwayi* (Cockerell), *Pulvinaria ficus* Hempel, and *Pulvinaria flavescens* Brethes. Those species likely to invade from the Oriental Region include *Ceroplastes actiniformis* Green, *Ceroplastes japonicus* Green, *Ceroplastes pseudo-ceriferus* Green, *Coccus discrepans* (Green), *Didesmococcus unifasciatus* (Archangelskaya), *Drepanococcus chiton* (Green), *Megapulvinaria maxima* (Green), *Protopulvinaria longivalvata* Green, and *Pulvinaria polygonata* Cockerell.

USDA, APHIS-PPQ records from the past five years also were searched to determine which intercepted species of soft scales pose the greatest threat. A list of the top seven species most frequently intercepted at U.S. ports-of-entry are *Ceroplastes japonicus* Green, *Coccus moestus* De Lotto, *Philephedra broadwayi* (Cockerell), *Protopulvinaria longivalvata* Green, *Pulvinaria polygonata* Cockerell, *Tillancoccus mexicanus* Ben-Dov, and *Udinia catorii* (Green). Comparison of the two lists reveals the following four species common to both: *Ceroplastes japonicus*, *Philephedra broadwayi*, *Protopulvinaria longivalvata*, and *Pulvinaria polygonata*. While the possibility exists that other soft scales could invade the U.S., we suggest that the four aforementioned species are the most plausible candidates as the next invasive soft scales into the United States.

DISCUSSION

Our data indicate that the decade starting in 1900 had the largest number of soft scale

insect introductions into the U.S. Although Miller et al. (2002) speculated that high number of mealybug interceptions may be linked to detection strategies and procedures developed in conjunction with the Plant Quarantine Act in 1912, the number of soft scale introductions is not consistent with this hypothesis.

The introduction of even a single species is of concern to U.S. agriculture. Huber et al. (2002) hypothesized that if a pest can enter the United States, over time there is a strong likelihood for establishment. As a result, they believed more appropriate and cost-effective quarantine procedures must be developed. We think one step in this procedure is to identify those species of insects which pose the greatest threat.

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LITERATURE CITED

- Abu-Yaman, I. K. 1970. The pistachio cushion scale, *Anapulvinaria pistaciae* Boden., and its control in Iraq. *Zeitschrift für Angewandte Entomologie* 66: 242-247.
- Avidov, Z. and I. Harpaz. 1969. *Plant Pests of Israel*. Israel Universities Press, Jerusalem, 549 pp.
- Bartlett, B. R. 1978. Coccidae, pp. 57-74. In Clausen, C. P., ed. *Introduced Parasites and Predators of Arthropod Pests and Weeds: A World Review*. Agricultural Research Service, United States Department of Agriculture, Washington, D.C., 545 pp.
- Bedford, E. C. G. 1968. The biology of *Ceroplastes sinoiae* Hall, with special reference to the ecdysis

- and the morphology of the test. *Entomology Memoirs*. Department of Agricultural Technical Services. Republic of South Africa, Pretoria 14: 1–111.
- Ben-Dov, Y. 1988. The scale insects (Homoptera: Coccoidea) of citrus in Israel: diversity and pest status. *In* Goren, R. and K. Mendel, eds. *Proceedings of the Sixth International Citrus Congress*. Tel Aviv, Israel: March 6–11, 1988. Balaban, Philadelphia/Rehovot.
- . 2002. Coccidae. *In* ScaleNet [web page] <http://www.sel.barc.usda.gov/scalecgi/region.exe?region=N&family=Coccidae&country=USA&genus=&intro=A&subunit=®name=Nearctic&ctryname=&action=Submit+Query&querytype=Country+Query>. Accessed 1 April 2002.
- Brink, T. and I. J. Bruwer. 1989. Andersoni scale, *Cribrolecanium andersoni* (Newstead) (Homoptera: Coccidae) a pest on citrus in South Africa. *Citrus and Subtropical Fruit Journal* 645: 9, 25.
- Burns, D. P. and D. E. Donley. 1970. Biology of the tuliptree scale, *Toumeyella liriodendri* (Homoptera: Coccidae). *Annals of the Entomological Society of America* 63: 228–235.
- Campbell, C. A. M. 1997. 3.3.15 Cocoa, pp. 381–385. *In* Ben-Dov, Y. and C. J. Hodgson, eds. *Soft Scale Insects—Their Biology, Natural Enemies and Control*, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Carnegie, A. J. M. 1997. 3.3.10 Sugarcane and bamboo, pp. 333–341. *In* Ben-Dov, Y. and C. J. Hodgson, eds. *Soft Scale Insects—Their Biology, Natural Enemies and Control*, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Chua, T. H. 1997a. 3.3.17 Coconut, pp. 393–394. *In* Ben-Dov, Y. and C. J. Hodgson, eds. *Soft Scale Insects—Their Biology, Natural Enemies and Control*, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- . 1997b. 3.3.18 Rubber, pp. 395–399. *In* Ben-Dov, Y. and C. J. Hodgson, eds. *Soft Scale Insects—Their Biology, Natural Enemies and Control*, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Clarke, S. R., J. F. Negron, and G. L. Debarr. 1992. Effects of 4 pyrethroids on scale insect (Homoptera) populations and their natural enemies in loblolly and shortleaf pine seed orchards. *Journal of Economic Entomology* 85(4): 1246–1252.
- Danzig, E. M. 1986. Coccids of the Far-Eastern USSR (Homoptera: Coccinea). Phylogenetic analysis of coccids in the world fauna. Amerind Publishing Co., New Delhi, India, 450 pp.
- Dekle, G. W. 1969. Stellate scale *Vinsonia stellifera* (Westw.) (Homoptera—Coccidae). *Entomology Circular*, Florida Department of Agriculture and Consumer Services Division of Plant Industry 80: 1–2.
- . 1973. Tessellated scale, *Eucalymnatus tessellatus* (Signoret). *Entomology Circular*, Florida Department of Agriculture and Consumer Services Division of Plant Industry 138: 1–2.
- Del Rivero, J. M. 1966. Nota sobre una plaga de agrios y aguacates. *Boletín de Patología Vegetal y Entomología Agrícola*, Madrid 29: 59–62.
- Donaldson, D. R., W. S. Moore, C. S. Koehler, and J. L. Joos. 1978. Scales threaten iceplant in Bay area. *California Agriculture* 32: 4–7.
- Ebeling, W. 1959. Subtropical fruit pests. Division of Agricultural Sciences, University of California, Los Angeles, 436 pp.
- Gill, R. J. 1988. The Scale Insects of California: Part 1. The Soft Scales (Homoptera: Coccoidea: Coccidae). California Department of Food and Agriculture, Sacramento, California, 132 pp.
- . 1997. 3.3.1 Citrus, pp. 207–215. *In* Ben-Dov, Y. and C. J. Hodgson, eds. *Soft Scale Insects—Their Biology, Natural Enemies and Control*, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Gill, R. J. and M. Kosztarab. 1997. 3.1.1 Economic importance, pp. 161–163. *In* Ben-Dov, Y. and C. J. Hodgson, eds. *Soft Scale Insects—Their Biology, Natural Enemies and Control*, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Gill, R. J., S. Nakahara, and M. L. Williams. 1977. A review of the genus *Coccus* Linnaeus in America north of Panama (Homoptera: Coccoidea: Coccidae). *Occasional Papers in Entomology*, State of California, Department of Food and Agriculture 24: 1–44.
- Gimpel, W. F., D. R. Miller, and J. A. Davidson. 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 841: 1–85.
- Hamon, A. B. and M. L. Williams. 1984. The soft scale insects of Florida (Homoptera: Coccoidea: Coccidae). *Arthropods of Florida and Neighboring Land Areas*. Florida Department of Agriculture and Consumer Services Division of Plant Industry, Gainesville, 194 pp.
- Hempel, A. 1920. Descrições de coccidas novas e pouco conhecidas. *Revista do Museu Paulista*, São Paulo 12: 329–377.
- Hosking, G.P. and D.J. Kershaw. 1985. Red beech death in the Maruia Valley, South Island, New Zealand. *New Zealand Journal of Botany* 23: 201–211.
- Huber, D. M., M. E. Hugh-Jones, M. K. Rust, S. R. Sheffield, D. Simberloff, and C. R. Taylor. 2002. Invasive pest species: Impacts on agricultural production, natural resources, and the environment. *CAST Issue Paper* 20: 1–18.

- Kitayama, K. 1993. Ocorrência de *Pulvinaria flavescens* Brethes, 1918 (Homoptera: Coccidae) em *Citrus reticulata* Blanco em, Brasília, DF. Pesquisa Agropecuária Brasileira 28(8): 889–895.
- Kosztarab, M. 1996. Scale insects of Northeastern North America. Identification, biology, and distribution. Virginia Museum of Natural History, Martinsburg, Virginia, 650 pp.
- . 1997a. 3.3.11 Coniferous forest trees, pp. 343–346. In Ben-Dov, Y. and C. J. Hodgson, eds. Soft Scale Insects—Their Biology, Natural Enemies and Control, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- . 1997b. 3.3.12 Deciduous forest trees, pp. 347–355. In Ben-Dov, Y. and C. J. Hodgson, eds. Soft Scale Insects—Their Biology, Natural Enemies and Control, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- . 1997c. 3.3.13 Ornamental and house plants, pp. 357–366. In Ben-Dov, Y. and C. J. Hodgson, eds. Soft Scale Insects—Their Biology, Natural Enemies and Control, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Kosztarab, M. and F. Kozár. 1988. Scale Insects of Central Europe. Akademiai Kiado, Budapest, 456 pp.
- Kozár, F., E. Guignard, F. Bachmann, E. Mani, and C. Hippe. 1994. The scale insect and whitefly species of Switzerland (Homoptera: Coccoidea and Aleyrodoidea). Mitteilungen der Schweizerischen Entomologischen Gesellschaft/Bulletin of the Société Entomologique Suisse 67(1–2): 151–161.
- Lagowska, B. 1984. *Badania nad nasileniem występowania miseczników (Homoptera, Coccidae) na drzewach i krzewach owocowych w okolicach Lublina*. Roczniki Nauk Rolniczych, Seria E, 14 (1–2): 9–17. (In Polish; summary in English.)
- Lepage, H. S. and M. T. Piza. 1941. Redescription of '*Neolecanium silveirai* (Hempel)' (Homoptera—Coccoidea), a serious pest of grape, and its control. Arquivos do Instituto Biológico, São Paulo 12: 21–26. (In Portuguese; summary in English.)
- Matile-Ferrero, D. and G. Couturier. 1993. [Mealybugs of Myrtaceae in the Peruvian Amazon. I. Description of two new pests of *Myrciaria dubia* (Homoptera, Coccidae and Kerriidae).] Bulletin de la Société Entomologique de France 98(5): 441–448. (In French; summary in English.)
- McKenzie, H. L. 1951. Present status of the kuno scale, *Lecanium kunoensis* Kuwana, in California (Homoptera; Coccoidea; Coccidae). Bulletin Department of Agriculture, State of California 40: 105–109.
- Miller, D. R., G. L. Miller, and G. W. Watson. 2002. Invasive species of mealybugs (Hemiptera: Pseudococcidae) and their threat to U.S. agriculture. Proceedings of the Entomological Society of Washington 104: 825–836.
- Murphy, S. T. 1997. 3.3.14 Coffee, pp. 367–380. In Ben-Dov, Y. and C. J. Hodgson, eds. Soft Scale Insects—Their Biology, Natural Enemies and Control, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Nada, S., S. A. Rabo, and G. E. D. Hussein. 1990. Scale insects infesting mango trees in Egypt (Homoptera: Coccoidea), pp. 133–134. In Proceedings of the Sixth International Symposium of Scale Insect Studies, Part II. Cracow, Poland, August 6–12, 1990. Agricultural University Press, Cracow.
- Nakahara, S. and R. J. Gill. 1985. Revision of *Philephedra*, including a review of *Lichtensia* in North America and description of a new genus *Metapulvinaria* (Homoptera: Coccidae). Entomography 3: 1–42.
- Ordogh, G. 1995. Morphology of nymphs and biology of *Rhodococcus perornatus* (Cockerell and Parrott) (Homoptera: Coccidae) in Hungary. Israel Journal of Entomology 29: 93–96.
- Patch, E. M. 1905. The cottony grass scale. *Eriopeltis festucae* (Fons.) Bulletin of the Maine Agricultural Experiment Station 121: 169–180.
- Pellizzari-Scaltriti, G. and A. Antonucci. 1982. [Notes on some insects injurious to actindia crops.] Informatore Fitopatologia 32: 47–48. (In Italian; summary in English.)
- Pfeiffer, D. G. 1997. 3.3.8 Deciduous fruit trees, pp. 293–322. In Ben-Dov, Y. and C. J. Hodgson, eds. Soft Scale Insects—Their Biology, Natural Enemies and Control, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Qin, T. K., P. J. Gullan, and A. C. Beattie. 1998. Biogeography of the wax scales (Insecta: Hemiptera: Coccidae: Ceroplastinae). Journal of Biogeography 25: 37–45.
- Rabkin, F. B. and R. R. Lejeune. 1955. Some aspects of the biology and dispersal of the pine tortoise scale, *Toumeyella numismaticum* (Pettit and McDaniel) (Homoptera: Coccidae). Canadian Entomologist 86: 570–575.
- Ray, C. H. and M. L. Williams. 1980. Description of the immature stages and adult male of *Pseudophilippia quaintancii* (Homoptera: Coccidae). Annals of the Entomological Society of America 73: 437–447.
- Sabine, B. N. E. 1969. Insecticidal control of citrus pests in coastal central Queensland. Queensland Journal of Agricultural and Animal Sciences 26: 83–88.
- Santas, L. A. 1988. *Physokermes hemicyphus* (Dalman) a fir scale insect useful to apiculture in Greece. Entomologia Hellenica 6: 11–22.
- Stauffer, S. and M. Rose. 1997. 3.2.2 Biological control of soft scale insects in interior plantscapes in the USA, pp. 183–205. In Ben-Dov, Y. and C. J. Hodgson, eds. Soft Scale Insects—Their Biology,

- Natural Enemies and Control, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Swirski, E., Y. Ben-Dov, and M. Wysoki. 1997. 3.3.4 Mango, pp. 241–254. In Ben-Dov, Y. and C. J. Hodgson, eds. *Soft Scale Insects—Their Biology, Natural Enemies and Control*, Vol. 7B. Elsevier, Amsterdam and New York, 442 pp.
- Teran, A. L. and N. H. Guyot. 1969. La cochinilla del delta, *Lecanium deltae* (Lizer) (Hom., Coccoidea), en Tucumán. *Acta Zoologica Lilloana*. Tucumán 24: 135–149.
- Tondeur, R., B. Schiffers, C. Verstraeten, and J. Merlin. 1990. Chemical methods in an integrated action against *Eupulvinaria hydrangeae* in Belgium (Homoptera: Coccoidea: Coccidae). *Proceedings of the Sixth International Symposium of Scale Insects Studies*, Cracow, Poland, August 1990: 157–158.
- Wan, S.Y., M. Wan, and B.L. Young. 1985. [Studies on a new pest of medicinal herb, *Malloccoccus viticicola* Young, n. sp. (Homoptera: Coccoidea: Lecanodiaspididae).] *Contributions of the Shanghai Institute of Entomology* 5: 267–274. (In Chinese; summary in English.)
- Williams, M. L. and M. Kosztarab. 1972. Morphology and systematics of the Coccidae of Virginia with notes on their biology (Homoptera: Coccoidea). *Research Division Bulletin, Virginia Polytechnic Institute and State University* 74: 1–215.

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