

### 3.3.3 Avocado

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#### INTRODUCTION

The avocado, *Persea americana* Mill. (Lauraceae) is of Central American origin. It is a crop of economic importance, being cultivated in many tropical and subtropical countries. The major producers, according to regions are: Americas (USA [California and Florida], Mexico, Brazil, Colombia, Venezuela and other countries of Central and South America, including the Caribbean Islands); Africa (South Africa, Zaire, Cameroon, Kenya, Egypt, Canary Islands); Asia (Philippines) and the Mediterranean region (Israel, Spain) (Ahmed and Barmore, 1980; Rehm and Espig, 1991). The total annual world production of avocado during 1979-1990 ranged between 1.4-1.5 million metric tons (FAO, 1991). The crop is affected by a variety of pests, including mites, moths, beetles, flies, thrips, scale insects and whiteflies. Forty-two species of soft scale insects are reported on avocado in this Section; however, only six are considered to be of economic importance, but are usually limited to a particular avocado variety or geographical region: *Protopulvinaria pyriformis* Cockerell (various countries), *Ceroplastes cirripediformis* Comstock (Bolivia), *Parthenolecanium corni* (Bouché) (Canary Islands, Caribbean Islands), *Coccus hesperidum* Linnaeus, *Saissetia coffeae* (Walker) and *S. oleae* (Olivier) (Caribbean Islands) (Perez Guerra, 1986; Pollard and Alleyne, 1986; Squire, 1972, Wysoki, 1987).

#### *Ceroplastes ceriferus* (Fabricius) (white wax scale of India)

*Ceroplastes ceriferus* is a minor pest of avocado in Queensland (Australia) (Smith, 1973).

#### *Ceroplastes cirripediformis* Comstock (barnacle scale)

*Ceroplastes cirripediformis* causes serious damage to avocado in Bolivia (Squire, 1972). The pteromalid *Scutellista caerulea* (Fonscolombe) (= *S. cyanea* Motschulsky) was imported from Italy into the gulf coast area of the USA during 1890's against *C. cirripediformis* and *C. floridensis* Comstock. Initial releases showed some promise, but subsequently, the incidence of *S. caerulea* was reduced, possibly due to the effect of secondary parasitoids. In 1964, the egg-feeding pteromalid *Anysis alcocki* (Ashmead) was imported from the Philippines to Hawaii against *Ceroplastes rubens* Maskell; it was recovered in 1967 in *C. cirripediformis*, but its effectiveness has not been assessed. The coccinellids *Orcus chalybeus* (Boisduval) and *Azya luteipes* Mulsant have also been recorded heavily preying on *C. cirripediformis* in Hawaii (Bartlett, 1978).

#### *Ceroplastes destructor* Newstead (white wax scale)

*Ceroplastes destructor* is a minor pest of avocado in Queensland, Australia (Ebeling, 1959; Smith, 1973). Because *C. destructor* was causing much concern to citrus farmers in Australia, efforts were made between 1935 and 1938 to import parasitoids from

Africa and India, but none became established. Further attempts in the late 1970's, included the importation of six parasitoids and one predaceous lepidopteran from South Africa, as well as one parasitoid from New Zealand (Sands et al., 1986). Four of the South African parasitoids became established, and at least two, namely *Anicetus communis* Annecke and *Paraceraptocherus nyasicus* (Compere) were found to regulate the population of the pest (Sands et al., 1986; Milne, 1981).

***Ceroplastes floridensis* Comstock (Florida wax scale)**

In Israel, low populations of *C. floridensis* have been found in many avocado orchards and in some cases the infestation was of medium intensity, but no chemical treatments were considered necessary (Swirski et al., 1991). See Section 3.3.4 - mango.

***Ceroplastes sinensis* Del Guercio (Chinese wax scale)**

In the Canary Islands, mild but frequent attacks on avocado have been recorded (Perez Guerra, 1986). See Section 3.3.6 - persimmon.

***Coccus hesperidum* Linnaeus (brown soft scale)**

*Coccus hesperidum* was common at one time along the coast in California, producing much honeydew and causing smutting (McKenzie, 1935). It is now generally controlled by many parasitoids, and only thrives on an occasional tree in an orchard (Ebeling, 1959). In Israel, low, non-injurious populations of this coccid have also been found in many orchards (Swirski et al., 1991). For the status in the Caribbean Islands - see under *Parthenolecanium corni* (Bouché). See Section 3.3.7.

***Parthenolecanium corni* (Bouché) (European fruit lecanium)**

On the Canary Islands, frequent and severe attacks have been recorded on avocado (Perez Guerra, 1986). In the Caribbean Islands, *P. corni* is an important pest of avocado, together with *Coccus hesperidum*, *Saissetia coffeae* and *S. oleae* (Pollard and Alleyne, 1986). As with *C. hesperidum*, *S. coffeae* and *S. oleae*, populations of *P. corni* in the USA are effectively curbed by parasitoids and only rarely do they reach pest status on an occasional tree in an orchard (Ebeling, 1959).

Generally, *P. corni* produces one generation annually in both California (Gill, 1988) and in Europe (Kosztarab and Kozár, 1988). However, Gill (1988) indicated that in California, an unnamed, uncommon variety develops two generations (see Section 3.3.9). On evergreen hosts the entire life cycle is completed on the foliage, but on deciduous hosts the winter is passed as nymphs on branches and twigs, the adults developing in the spring. On hatching, the crawlers settle and develop on the leaves. Later, the nymphs migrate to the twigs and branches before leaf fall (Gill, 1988).

The aphelinid *Coccophagus cowperi* Girault and the encyrtid *Metaphycus helvolus* (Compere), which were originally introduced against *Saissetia oleae*, have become established since 1939, on *P. corni* in southern California (Bartlett, 1978).

The following parasitoids of *P. corni* in the USA, were included in the lists of Peck (1963) and Krombein et al. (1979): the encyrtids: *Aphycus annulipes* (Ashmead), *Metaphycus pulvinariae* (Howard), *Encyrtus bicolor* Howard, *E. fuscus* (Howard), *Microterys flavus* (Howard); the aphelinids: *Coccophagus lycimnia* (Walker) and also *C. scutellaris* (Dalman); the eulophid *Tetrastichus minutus* (Howard) and the pteromalid *Scutellista caerulea* (Fonscolombe).

***Protopulvinaria pyriformis* Cockerell (pyriform scale)**

*Protopulvinaria pyriformis* is a polyphagous pest, attacking many agricultural crops, including avocado. It is widely distributed in the Mediterranean Basin, Asia, Africa and North and South America (Wysoki, 1987; Ben-Dov, 1993).

In Israel, *P. pyriformis* causes heavy damage to avocado plantations, especially to Nabal and Ein Vered cultivars and, to a lesser extent, to Reed, Hass, Fuerte and Ettinger

(De Meijer et al., 1989). In South Africa, the pest attacks Hass, Fuerte, Collinson and Ryan cultivars (Du Toit and De Villiers, 1988, 1990). Heavy infestations are found on the roadside, where the dust and cars' pollution disturb the biological equilibrium. Ants (*Pheidole* spp.) and possibly repeated fungicidal treatments also cause to the outbreaks of the pest (du Toit and De Villiers, 1990; Robertson and De Villiers, 1986). On the Canary Islands, mild and infrequent attacks on avocado have been recorded (Perez Guerra, 1986). *Protopulvinaria pyriformis* occurs mainly on the underside of the avocado leaves (not on the fruits). It sucks the sap and secretes large quantities of honeydew, which accumulates on the leaves, branches and fruits, where sooty mould develops. Heavy infestations result in serious damage to trees, causing folding of the leaf margin, early leaf drop, reduction of yield and increase of fruit cull. *Protopulvinaria pyriformis* reproduces parthenogenetically and males are very rare. In Israel, two generations of the scale are established on avocado, oviposition taking place mainly in May and October. On *Hedera helix*, on the other hand, it has three generations, oviposition taking place in March, August and October (Blumberg and Blumberg, 1991; D. Hadar, personal communication).

In Israel, various natural enemies attack *P. pyriformis* but they are unable to curb heavy infestations. Such hyperparasitoids as *Marietta javensis* (Howard) and *Pachyneuron concolor* (Foerster) sometimes cause considerable reductions in the primary parasitoids' populations. Additionally, encapsulation of the parasitoid eggs prevents their successful development and may interfere with efficient biocontrol of the pest. Thus, in the case of *Metaphycus stanleyi* Compere, encapsulation rates were low during winter (0-11%) but became high during the summer (49-75%) (Blumberg and Blumberg, 1991; Blumberg and Swirski, 1984; Blumberg et al., 1993) (see also Section 1.4.6 on Encapsulation). Local populations of the encyrtids *Microterys flavus* (Howard) (common), *Metaphycus flavus* (Howard) (rare), and *Diversinervus elegans* Silvestri (rare), and the aphelinid *Coccophagus lycimnia* (Walker) were re-enforced by the importation of the encyrtids *Metaphycus swirskii* Annecke and Mynhardt from Kenya, *M. stanleyi* Compere from South Africa, Florida, California and Spain, *M. helvolus* (Compere) from South Africa, California and Spain, as well as *M. galbus* Annecke from South Africa and Spain (Hadar et al., 1992; Y. Izhar, personal communication; Wysoki, 1985). Larvae of the green lacewing, *Chrysoperla carnea* (Stephens) (Chrysopidae) prey on *P. pyriformis*. The following coccinellids were found to be associated with the scale in Israel: *Chilocorus bipustulatus* (Linnaeus) (very common), *Lindorus lophantae* Blaisdell, *Adalia decempunctata* Linnaeus, *Scymnus subvillosus* (Goeze), *Exochomus quadripustulatus* (Linnaeus), *Oenopia (Synharmonia) conglobata* (Linnaeus) and *Coccinella septempunctata* Linnaeus. Two other coccinellids, *Cryptolaemus montrouzieri* Mulsant and *Nephus peyerimhoffi* Sicard, originally found preying upon *P. pyriformis* in avocado orchards in Malaga (Spain), were introduced into Israel (Y. Izhar, personal communication). The *C. montrouzieri* stock introduced from Spain to Israel was found to be more resistant to high temperatures than the stock previously reared in Israel, and was successfully established in avocado orchards of Israel (Swirski et al., 1991).

In South Africa, the following primary parasitoids of *P. pyriformis* were recorded: the encyrtids *Metaphycus stanleyi*, *M. galbus*, *M. helvolus*, the aphelinid *Coccophagus basalis* Compere and the hyperparasitoid *Cheiloneurus cyanonotus* Waterston (Encyrtidae). Predators belonging to the families Coccinellidae, Chrysopidae and Syrphidae were also found to be associated with the scale (Du Toit and De Villiers, 1988; Wysoki, 1985). Encapsulation probably plays an important role in the biocontrol of *P. pyriformis* in Spain, as high rates of encapsulation were observed in samples of scales parasitized by both *M. stanleyi* and *M. galbus* (Blumberg et al., 1993).

Sporadic outbreaks of *P. pyriformis* in avocado orchards in Florida have been controlled by organophosphorus insecticides (Ebeling, 1959). Recently in South Africa,

Insect Growth Regulators and organophosphorus scalicides were recommended against the pest (De Villiers, 1989; Du Toit and De Villiers, 1988). In Israel, where Integrated and Biological Pest Management is established in avocado orchards, mineral oils are used against the scale. Since young stages are susceptible to oils, and as they are the major component of the population in the two periods January-February and July-August, the treatments are carried out at these times. Topping and hedging of trees is recommended for better penetration of the spray, as well as for easier manipulation of the sprayers (Hadar et al., 1992).

***Saissetia coffeae* (Walker) (hemispherical scale)**

For damage in the USA and the Caribbean Islands, see under *Parthenolecanium corni*, in this Section.

***Saissetia oleae* (Olivier) (Mediterranean black scale)**

On the Canary Islands, frequent but mild attacks on avocado have been recorded (Perez Guerra, 1986). See Sections 3.3.1. and 3.3.2.

TABLE 3.3.3.1

Species of soft scale insects recorded on avocado and their geographical distribution.

Soft scale species	Distribution and references
<b><i>Persea americana</i> (avocado), <i>P. gratissima</i> (avocado pear)</b>	
<i>Ceroplastes ceriferus</i> (Fabricius)	Taiwan (Tao, 1978); Australia (De Lotto, 1971b; Waite and Pinese, 1991); USA (Florida) (Hamon and Williams, 1984).
<i>Ceroplastes cirripediformis</i> Comstock	USA (California, Florida), Mexico, West Indies (Ebeling, 1959); Bolivia (Squire, 1972).
<i>Ceroplastes cistudiformis</i> Cockerell	USA (California), Mexico (Ebeling, 1959).
<i>Ceroplastes destructor</i> Newstead	South Africa (Brain, 1920); Papua New Guinea (Williams and Watson, 1990); Australia (Ebeling, 1959; Waite and Pinese, 1991).
<i>Ceroplastes floridensis</i> Comstock	Israel (Avidov and Harpaz, 1969); Zanzibar (Le Pelley, 1959); USA (Florida), Mexico (Ebeling, 1959); Cuba (Bruner et al., 1975); Puerto Rico, Trinidad (Gimpel et al., 1974); Virgin Islands (US) (Nakahara, 1983); Brazil (Ebeling, 1959).
<i>Ceroplastes pseudoceriferus</i> Green	Taiwan (Tao et al., 1983).
<i>Ceroplastes rubens</i> Maskell	Ceylon (Ebeling, 1959); Taiwan (Tao et al., 1983); Australia (Ebeling, 1959; Waite and Pinese, 1991); French Polynesia, Norfolk Is., Papua New Guinea, Vanuatu, Western Samoa, New Caledonia (Williams and Watson, 1990); Puerto Rico (Medina-Gaud and Garcia Tuduri, 1977); Hawaii (Nakahara, 1981).
<i>Ceroplastes rusci</i> (Linnaeus)	Israel (Avidov and Harpaz, 1969); Argentina (Ebeling, 1959).
<i>Ceroplastes sinensis</i> Del Guercio	Portugal (Monteiro Guimaraes, 1973); Canary Islands (Perez Guerra, 1986).
<i>Chloropulvinaria floccifera</i> (Westwood)	Central America (Ebeling, 1959).

TABLE 3.3.3.1 (continued)

Soft scale species	Distribution and references
<i>Chloropulvinaria psidii</i> (Maskell)	USA (Florida), West Indies, Hawaii (Ebeling, 1959).
<i>Coccus acutissimus</i> (Green)	Mauritius (Williams and Williams, 1988); Western Samoa (Williams and Watson, 1990); USA (Florida) (Hamon and Williams, 1984).
<i>Coccus hesperidum</i> Linnaeus	Israel (Avidov and Harpaz, 1969); South Africa (De Villiers and van den Berg, 1987); Mauritius (De Lotto, 1959); Fiji, Western Samoa (Williams and Watson, 1990); Australia (Ebeling, 1959; Waite and Pinese, 1991); USA (California, Florida, Virginia) (Ebeling, 1959; Williams and Kosztarab, 1972); Mexico, West Indies, Central America (Ebeling, 1959); Caribbean Islands (Pollard and Alleyne, 1986); Virgin Islands (US) (Nakahara, 1983); Brazil (Ebeling, 1959); Argentina (Hayward, 1942).
<i>Coccus longulus</i> (Douglas)	Israel (Swirski et al., 1991); Fiji, Papua New Guinea, Tonga, New Caledonia (Williams and Watson, 1990).
<i>Coccus moestus</i> De Lotto	Vanuatu, Espiritu Santo (New Hebrides) (Williams and Watson, 1990).
<i>Coccus viridis</i> (Green)	Niue (Williams and Watson, 1990); USA (Florida) (Hamon and Williams, 1984).
<i>Cribolecanium andersoni</i> (Newstead)	South Africa (Brink and Bruwer, 1989).
<i>Eucalymnatus tessellatus</i> (Signoret)	Vietnam (Danzig and Konstantinova, 1990); USA (Florida), West Indies (Ebeling, 1959).
<i>Kilifita acuminata</i> (Signoret)	Mexico (Ben-Dov, 1979); Caribbean Islands (Schmutterer, 1990); USA (Florida) (Hamon and Williams, 1984); Hawaii (Nakahara, 1981).
<i>Milviscutulus mangiferae</i> (Green)	Israel (Swirski et al., 1991); Agalega Island (Indian Ocean) (Mamet, 1978); Western Samoa (Williams and Watson, 1990); Honduras (Ebeling, 1959); Caribbean Islands (Schmutterer, 1990).
<i>Milviscutulus spiculatus</i> Williams and Watson	Solomon Is. (Williams and Watson, 1990).
<i>Parasaissetia nigra</i> (Nietner)	Madeira Islands (Vieira et al., 1983); Sierra Leone, South Africa (Ben-Dov, 1978); Tonga (Williams and Watson, 1990); USA (California) (Ebeling, 1959); Trinidad and Tobago (Urich, 1919); Argentina (Lizery y Trelles, 1943).
<i>Parthenolecanium corni</i> (Bouché)	USA (California) (Ebeling, 1959).
<i>Parthenolecanium persicae</i> (Fabricius)	Canary Islands (Carnero Hernandez and Perez Guerra, 1986).

TABLE 3.3.3.1 (continued)

Soft scale species	Distribution and references
<i>Philephedra lutea</i> (Cockerell)	USA (Texas) (Nakahara and Gill, 1985).
<i>Platinglisia noacki</i> Cockerell	Brazil (Ebeling, 1959).
<i>Protospulvinaria longivalvata</i> Green	Brazil (Ebeling, 1959).
<i>Protospulvinaria pyriformis</i> Cockerell	Spain (Del Rivero, 1966); Madeira Islands (Vieira et al., 1983); Canary Islands (Carnero Hernandez and Perez Guerra, 1986); Israel (Ben-Dov and Amitai, 1980); South Africa (De Lotto, 1967); Danzig and Konstantinova, 1990); USA (California) (Gill, 1988), USA (Florida), Mexico (Ebeling, 1959); Bermuda (Waterston, 1940); Costa Rica (Wysoki, personal communication); Panama (Fisher, 1920); Dominican Republic (Russo, 1927); Guadeloupe (Wysoki, 1985); Virgin Islands (US) (Nakahara, 1983); Cuba (Bruner et al., 1975); Trinidad and Tobago (Urich, 1919); British Guyana (Bodkin, 1914); Brazil (Wysoki, personal communication); Peru (Anonymous, 1942); Paraguay, Chile, Argentina (Ebeling, 1959).
<i>Pulvinaria mammeae</i> Maskell	Hawaii (Ebeling, 1959).
<i>Pulvinaria simulans</i> Cockerell	Mexico (Ebeling, 1959).
<i>Saissetia coffeae</i> (Walker)	Israel (Swirski et al., 1991); Canary Islands (Carnero Hernandez and Perez Guerra, 1981); Madeira Islands (Vieira et al., 1983); New Caledonia (Williams and Watson, 1990); USA (California, Florida), Mexico (Ebeling, 1959); Puerto Rico (González Rios and Mayoral Reinat, 1931); Panama (Fisher, 1920); Bermuda (Hodgson and Hilburn, 1991); Caribbean Islands (Pollard and Alleyne, 1986); Cuba (Bruner et al., 1975); Chile (Ebeling, 1959); Argentina (Hayward, 1944); Brazil (Corseuil and Barbosa, 1971).
<i>Saissetia miranda</i> (Cockerell and Parrott)	America (De Lotto, 1971a).
<i>Saissetia neglecta</i> De Lotto	USA (Florida) (Hamon and Williams, 1984); Caribbean Islands (Pollard and Alleyne, 1986).
<i>Saissetia oleae</i> (Olivier)	Canary Islands (Carnero Hernandez and Perez Guerra, 1986); Israel (Ben-Dov, 1971); Australia (Ebeling, 1959); USA (Florida) (Hamon and Williams, 1984); USA (California) (McKenzie, 1935); Caribbean Islands (Pollard and Alleyne, 1986); Chile (Durán and Cortés, 1942); Argentina (Ebeling 1959); Brazil (Corseuil and Barbosa, 1971).
<i>Saissetia zanzibarensis</i> Williams	Zanzibar (Le Pelley, 1959).
<i>Taiwansaissetia formicarii</i> (Green)	Taiwan (Tao et al., 1983); Philippine Islands, USA (California, Florida), West Indies, Canal zone, Brazil (Ebeling, 1959).
<i>Toumeyella liriodendri</i> (Gmelin)	USA (Florida) (Ebeling, 1959).
<i>Udinia catori</i> (Green)	Sierra Leone (Hanford, 1974).

TABLE 3.3.3.1 (continued)

Soft scale species	Distribution and references
<b><i>Persea borbonia</i></b>	
<i>Ceroplastes floridensis</i> Comstock	USA (Florida) (Hamon and Williams, 1984).
<i>Coccus hesperidum</i> Linnaeus	USA (Virginia) (Williams and Kosztarab, 1972); Florida (Hamon and Williams, 1984).
<i>Coccus longulus</i> (Douglas)	USA (California) (Gill et al., 1977).
<i>Eucalymnatus tessellatus</i> (Signoret)	USA (Florida) (Hamon and Williams, 1984).
<i>Inglisia vitrea</i> Cockerell	USA (Florida) (Hamon and Williams, 1984).
<i>Kilifia acuminata</i> (Signoret)	USA (Florida) (Hamon and Williams, 1984).
<i>Mesolecanium nigrofasciatum</i> (Pergande)	USA (Florida) (Hamon and Williams (1984).
<i>Neopulvinaria innumerabilis</i> (Rathvon)	USA (Florida) (Hamon and Williams (1984).
<i>Protapulvinaria pyriformis</i> Cockerell	USA (Florida, Virginia) (Williams and Kosztarab, 1972).
<i>Pulvinaria acericola</i> (Walsh and Riley)	USA (Florida) (Hamon and Williams, 1984).
<i>Toumeyella liriodendri</i> (Gmelin)	USA (Florida) (Hamon and Williams, 1984).

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