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FIELD GUIDE TO INVASIVE ALIEN PLANT PESTS IN THE CARIBBEAN UK OVERSEAS TERRITORIES

PART 5 – HEMIPTERA (Scale insects)

Chris Malumphy, Sharon Reid, Rachel Down, Jackie Dunn and Debbie Collins

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Frontispiece

Top row: Giant African land snail *Lissachatina fulica* © C. Malumphy; Mediterranean fruit fly *Ceratitis capitata* © Crown copyright; Sri Lankan weevil, *Myllocerus undecimpustulatus undatus* adult © Gary R. McClellan. Second row: Cactus moth *Cactoblastis cactorum* caterpillar © C. Malumphy; Cottony cushion scale *Icerya purcashi* © Crown copyright; Red palm mite *Raoiella indica* adults © USDA. Third row: Tomato potato psyllid *Bactericera cockerelli* © Fera; Cotton bollworm *Helicoverpa armiger*a © Crown copyright; Croton scale *Phalacrococcus howertoni* © C. Malumphy. Bottom row: Red palm weevil *Rhynchophorus ferrugineus* © Fera; Tobacco whitefly *Bemisia tabaci* © Crown copyright; Brown marmorated stink bug *Halyomorpha halys* © David R. Lance, USDA APHIS PPQ, Bugwood.org.

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PART 3 – INSECTS (except Hemiptera)

HEMIPTERA (Scale insects)

6.31 Pink wax scale

Order: Hemiptera
Family: Coccidae
Species: *Ceroplastes rubens* Maskell

	Present I Absent ¡	Threat		
		Bio	HIth	Econ
Ang	¡	ü		ü
Ber	¡	ü		ü
BVI	I			
Cay	¡	ü		ü
Mon	¡	ü		ü
TCI	¡	ü		ü

Figure 6.31.1 Colony of pink wax scale *Ceroplastes rubens* on Rubiaceae, BVI. The scales can be seen to feed on the main leaf veins © C. Malumphy

Background

Ceroplastes rubens is a scale insect, commonly known as the pink or red wax scale, that occurs widely in tropical and subtropical regions. It is broadly polyphagous and a serious pest of many tropical and subtropical crops and ornamental plants. Large populations have been observed damaging plants in Tortola, British Virgin Islands and *C. rubens* presents a potential plant health threat to all the UKOTs with tropical climates, particularly to those located in the Caribbean.

Geographical Distribution

Ceroplastes rubens is suspected to be native to the Afrotropical region (Qin *et al*., 1994) but now occurs widely in tropical and subtropical regions of the Americas, Africa, Asia, Australia and the Pacific. It also extends into neighbouring warm temperate areas. In the Caribbean it has been recorded from the British Virgin Islands, Guadeloupe, Haiti, Martinique, and Puerto Rico & Vieques Island (García Morales *et al*., 2016).

Host Plants

Ceroplastes rubens is extremely polyphagous, occurring on hundreds of plant species assigned to at least 80 families including many tropical and sub-tropical crops, and ornamental plants. It also feeds on several species of Pinus, including important forestry species. Host genera that are economically or environmentally important in the Caribbean include: *Acacia, Annona, Anthurium, Bougainvillea,*

Camellia, Cinnamomum, Citrus, Coccoloba, Cocos, Coffea, Ficus, Heliconia, Hibiscus, Malus, Mangifera, Musa, Nerium, Persea, Philodendron, Pinus, Piper, Plumeria, Psidium, Punica, Schefflera and *Zingiber*.

Figure 6.31.2 Pink wax scale adult females on Rubiaceae in BVI © C. Malumphy

Figure 6.31.3 Teneral adult female pink wax scales on Rubiaceae in BVI © C. Malumphy

Figure 6.31.4 Sooty mould growing on honeydew egested by pink wax scales in BVI © C. Malumphy

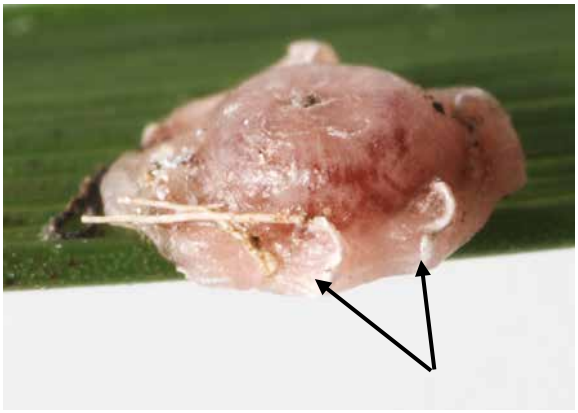

Figure 6.31.5 Pink wax scale adult female profile to show the diagnostic white lines, Thailand © Crown copyright

Figure 6.31.6 Close-up of pink wax scale adult female on *Aglaonema* from Sri Lanka © Crown copyright

Figure 6.31.7 Close-up of pink wax scale male cover on *Aglaonema* from Sri Lanka © Crown copyright

Description

Adult females (Figs 6.31.1-6.31.4 and 6.31.6) are covered in a dense layer of watery wax which varies in colour from white (Fig. 6.31.6), cream (Fig. 6.31.2), pink (Fig. 6.31.4) to reddish (Fig. 6.31.1). They

are strongly convex, longer than wide, and have two conspicuous pairs of white bands that extend dorsally from the anterior margin and half-way along the body (the bands are most conspicuous in Figs 6.31.1, 6.31.3 and 6.31.5); female wax cover length 3.5 to 4.5 mm. Adult female pink wax scales can usually be recognised in life by the presence of these white bands, particularly by the anterior bands which often almost touch each other. The nymphs are pinkish in colour with distinct white wax blocks, and the immature males (Fig. 6.31.7) form a whitish translucent, elongate, oval scale. Wax scales (*Ceroplastes* spp.) frequently occur in mixed populations.

Recently published keys for the identification of slide-mounted adult female *C. rubens* include: Mohammad & Moharum (2013); Fetykó & Kozár (2012); Hodgson & Peronti (2012); Hodson *et al*. (2009); and Hodges 2002.

Biology

Adult and nymph pink wax scales feed on the stems, twigs, and foliage, apparently preferring the upper leaf surface. They are often ant attended. Pink wax scale has two generations a year in Australia. The average number of eggs laid per female is about 300, although females have been recorded laying as many as 1,187 eggs. Females have four instars and males have five, although males (Fig. 6.31.7) are very rarely recorded. The first nymphal instars or 'crawlers' show a preference for settling to feed on new (current year) growth.

Dispersal and Detection

Ceroplastes rubens has a relatively low natural dispersal potential and the crawlers often settle to feed within a short distance of their parent. Some of the crawlers may be dispersed over longer distances by air currents or be transported by other animals. Dispersal is likely to occur more rapidly and over longer distances with the movement of infested plants in trade.

Infestations of pink wax scale are readily detected by the highly conspicuous wax covers (Figs 6.31.1-6.31.7), which protect the scales from attack by predators and from injury and desiccation. The foliage is contaminated with honeydew egested by the scales, which serves as a medium for the growth of sooty moulds, which can disfigure the plants. The scales may also be detected by the presence of ants, and less frequently wasps and flies, which feed on the honeydew egested by the insects.

Economic and other Impacts

Pink wax scale is a widespread pest of citrus (*Citrus* spp.), coffee (*Coffea* spp.), tea (*Camellia sinensis*), cinnamon (*Cinnamomum* spp.), mango (*Mangifera indica*), avocado (*Persea americana*) and litchi (*Litchi chinensis*). It is a major pest of citrus in Australia, Hawaii, Korea, China and Japan. Economic damage is caused directly through phloem feeding and indirectly through the promotion of sooty mould growth on the egested honeydew, which lowers the market value of fresh fruit and can reduce photosynthetic efficiency and gas exchange, causing reduced growth. Large populations cause necrosis of the foliage, leaf loss, die back, and death of susceptible plants. It is a regulated pest in some countries where it has not already established.

6.32 Croton Scale

Order: Hemiptera
Family: Coccidae
Species: *Phalacrococcus howertoni* Hodges & Hodgson

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡	ü		ü
Ber	¡	ü		ü
BVI	¡	ü		ü
Cay	l			
Mon	¡	ü		ü
TCI	¡	ü		ü

Figure 6.32.1 Adult females and first instars of croton scale *Phalacrococcus howertoni* infesting croton *Codiaeum variegatum*, Bahamas © C. Malumphy

Background

A soft scale (Hemiptera: Coccidae), first recorded in Florida (USA) in 2008 and subsequently becoming a serious pest, was described by Hodges and Hodgson (2010) under the name *Phalacrococcus howertoni*. It is commonly known as the croton scale and has spread widely in the Caribbean region.

Within the UKOTs, *P. howertoni* was first detected in the Cayman Islands in 2012 where it has since been found on a range of plants, including fruit trees (guava (*Psidium guajava*), mango (*Mangifera indica*), avocado (*Persea Americana*), soursop (*Annona muricata*), breadfruit (*Artocarpus altilis*), June plum (*Spondias dulcis*), and Cayman red plum (*Spondias purpurea*)), ornamental plants (croton (*Codiaeum variegatum*), copperleaf (*Acalypha wilkesiana*), Florida strangler fig (*Ficus aurea*), and West Indian jasmine (*Ixora* spp.)) and the native plant red birch (*Bursera simaruba*). Croton scale poses an economic and environmental plant health risk to all the UKOTs with tropical climates, especially those in the Caribbean where it is currently rapidly expanding its geographical range.

Geographical Distribution

Phalacrococcus howertoni is an invasive species in Florida and the Caribbean but its origin is unknown. In the Caribbean it has been recorded from the Bahamas, Cayman Islands and Puerto Rico.

Figure 6.32.2 *Phalacrococcus howertoni* adult females (green) feeding on the veins and male tests (translucent) on the lamina © C. Malumphy

Figure 6.32.3 large infestation of *Phalacrococcus howertoni* on the foliage of *Codiaeum variegatum* © C. Malumphy

Figure 6.32.4 *Phalacrococcus howertoni* nymphal stages feeding on *Codiaeum variegatum* © C. Malumphy

Figure 6.32.5 A ladybird *Chilocorus* sp. feeding on immature *Phalacrococcus howertoni* © C. Malumphy

Figure 6.32.6 Large infestation of *Phalacrococcus howertoni* on *Codiaeumvariegatum* causing premature leaf loss © C. Malumphy

Figure 6.32.7 Young *Codiaeum variegatum* plant killed by huge infestation of *Phalacrococcus howertoni* © C. Malumphy

Host Plants

Phalacrococcus howertoni is polyphagous, feeding mostly on woody dicotyledonous plants belonging to at least 36 families. It shows a preference for plants assigned to the families' Euphorbiaceae (especially *Codiaeum*), Rubiaceae and Sapotaceae.

Description

Adult female scales are approximately 4 mm long by 2 mm wide, green to yellow-green in colour, with dark striations on dorsum (Figs 6.32.1-6.32.2). The females are common along the main veins on the under surface of the foliage (Figs 6.32.1-6.32.2) and on the apical stems (Fig. 6.32.7). Male tests often occur in high densities on the foliage lamina (Figs 6.32.3-6.32.6). Nymphs are pale green (Fig. 6.32.4). Hodges & Hodgson (2010) provide detailed morphological descriptions and illustrations of adult and immature stages of *P. howertoni*. The genus *Phalacrococcus* is monotypic. Adult female *P. howertoni* are similar in appearance to *Philephedra tuberculosa* but the latter produce a conspicuous elongate white waxy ovisac whereas *P. howertoni* does not.

Biology

Each female *P. howertoni* can lay about 400 eggs, which exhibit ovoviviparity (eggs hatch immediately). Females have three immature stages prior to becoming adults, while males have four immature stages (including a pre-pupa and pupa) (Amarasekare & Mannion, 2011). Multiple overlapping generations occur each year, averaging about one a month in tropical conditions; *P. howertoni* overwinters as the adult female. Natural Enemies in Florida include the predators *Cryptolaemus montrouzieri* (Coleoptera: Coccinellidae) and *Laelilla coccidivora* (Lepidoptera: Pyralidae).

Dispersal and Detection

The main natural dispersal stage for *P. howertoni* is the first nymphal instar or crawler. They have a relatively low natural dispersal potential as most crawlers often settle to feed within a short distance of their parent. Crawlers may be dispersed over longer distances by air currents or be transported by other animals. Dispersal is likely to occur more rapidly and over longer distances with the movement of infested plants in trade.

Detection involves close inspection of host plants. Large infestations are relatively easy to detect but low-density populations and early nymphal instars can be very difficult to detect. The foliage of infested plants often turns black due to sooty mould growing on honeydew egested by the insects. The scales may also be detected by the presence of ants, and less frequently wasps and flies, which feed on the honeydew egested by the insects.

Economic and other Impacts

Large populations of *P. howertoni* cause premature leaf loss and dieback on woody hosts. Smaller plants may be killed, particularly those of *Codiaeum* (Fig. 6.32.7). *Phalacrococcus howertoni* egests copious quantities of honeydew and this inhibits photosynthesis and encourages the growth of sooty moulds. *Phalacrococcus howertoni* is potentially a serious pest of tropical and subtropical ornamental and fruit plants, and the environment, due in part to its polyphagous nature and prodigious reproductive capacity.

6.33 Pine Tortoise Scale

Order: Hemiptera
Family: Coccidae
Species: *Toumeyella parvicornis* (Cockerell)

	Present l Absent ¡	Threat Bio	Hlth	Econ
Ang	¡	ü		ü
Ber	¡	ü		ü
BVI	¡	ü		ü
Cay	¡	ü		ü
Mon	¡	ü		ü
TCI	l			

Figure 6.33.1 Pine tortoise scale *Toumeyella parvicornis* adult females on Virginia pine *Pinus virginiana*, U.S.A. © Lacy Hyche, Auburn University, Bugwood.org

Background

Pine tortoise scale *Toumeyella parvicornis* is a Nearctic pest of pine reported from Europe in Italy for the first time in 2015 (Garonna *et al*., 2015). It is contributing to the decline and mortality of stone pine (*Pinus pinea*) in and around Naples, Campania region, particularly in urban areas. In North America it is a sporadic pest of pine around the Great Lakes and as far north as Canada. It is a highly invasive pest in the Caribbean, where in the last decade it has decimated the native Caicos pine (*Pinus caribaea* var. *bahamensis*) forests in the TCI, causing 95% tree mortality and changing the ecology in large areas of the islands (Malumphy *et al*., 2012).

Geographical Distribution

Toumeyella parvicornis is native to the Nearctic region, occurring from Mexico, throughout the United States except the north-west, and into south-central Canada. It has recently been introduced to Puerto Rico, Turks and Caicos Islands (TCI) and Italy (Malumphy *et al*., 2012; Garonna *et al*., 2015).

Figure 6.33.2 *Toumeyella parvicornis* immatures on *Pinus pinea* needles, Italy © C. Malumphy

Figure 6.33.3 *Toumeyella parvicornis* male wax tests (protective covers), Italy © C. Malumphy

Figure 6.33.4 Bark-feeding adult female *Toumeyella parvicornis* are globular, the small orange dots are first instars; on *Pinus sylvestris*, U.S.A. © Jill O'Donnell, MSU Extension, Bugwood.org

Figure 6.33.5 Needle-feeding adult female *Toumeyella parvicornis* are elongate-oval and moderately convex, U.S.A. © Albert Mayfield, USDA Forest Service, Bugwood.org

Figure 6.33.6 *Pinus pinea* bark covered in sooty mould growing on honeydew egested by *Toumeyella parvicornis*, Italy © C. Malumphy

Figure 6.33.7 *Pinus pinea* infested with *Toumeyella parvicornis* showing severe needle loss, flagging and decline, Italy © C. Malumphy

Figure 6.33.8 New growth of *Pinus caribaea* is white due to a conspicuous covering of wax secreted by *Toumeyella parvicornis*, TCI © C. Malumphy

Figure 6.33.9 New growth of *Pinus caribaea* infested with *Toumeyella parvicornis* appears to be covered in snow, TCI © C. Malumphy

Host Plants

Toumeyella parvicornis feeds exclusively on *Pinus* species (Pinaceae) including jack pine (*P. banksiana*), lodgepole pine (*P. contorta*), shortleaf pine (*P. echinata*), slash pine (*P. elliotti*), spruce pine (*P. glabra*), mugo pine (*P. mugo*), longleaf pine (*P. palustris*), stone pine (*P. pinea*), Scots pine (*P. sylvestris*), loblolly pine (*P. taeda*) and Virginia pine (*P. virginiana*) (Malumphy *et al*., 2012; Garonna *et al*., 2015; García Morales *et al*., 2016).

Description

Toumeyella parvicornis eggs are ovoid, pinkish, almost transparent, and about 0.4 mm long. First-instar nymphs, commonly called crawlers, are oval, orange or reddish and have six legs (Fig. 6.33.4). Older nymphs are pinkish, legless, oval and convex (Fig. 6.33.2). Adult females occur in two distinct forms being oval and strongly convex in shape when feeding on the bark (Fig. 6.33.4), or elongate and moderately convex when on the needles (Fig. 6.33.5). They are initially greenish (Fig. 6.33.5), becoming reddish-brown with cream or dark brown speckles or stripes (Fig. 6.33.1), and they may secrete large quantities of white powdery wax (Fig. 6.33.4). This wax quickly disappears with wind and rain. Mature females are a uniform dark brown (Figs 6.33.1 and 6.33.4). At times the adult females overlap each other on the twigs or needles. They attain a maximum length of 4.4 mm and width of 4 mm. The male wax tests (protective covers) are oval, white, translucent, and about 3.0 mm long (Fig. 6.33.3). Adult males are winged and resemble small flies but are rarely seen (Malumphy *et al*., 2012).

Biology

Toumeyella parvicornis is highly adaptable with the number of generations varying according to abiotic conditions; it has one generation per year in the northern limit of its range in Canada and North-East U.S.A., three or four generations in southern U.S.A., and breeds continuously under the tropical conditions in the Caribbean with five or more generations each year. *Toumeyella parvicornis* is sexually reproductive, and each adult female can lay about 500 eggs, which are protected under the female body. Females have three immature stages prior to becoming adults, while males have four immature stages (including a pre-pupa and pupa) (Malumphy *et al*., 2012; Garonna *et al*., 2015).

Dispersal and Detection

The main natural dispersal stage is the first nymphal-instar, often referred to as the crawler. Crawlers wander over the host in search of a suitable feeding site and once they have inserted their mouthparts the females are largely sessile. Adult males are winged and fly in search of a mate, but cannot establish new populations. Natural dispersal over longer distances is primarily by wind (recently demonstrated in the TCI using sticky traps – Malumphy *et al*., 2016) and phoresy (being carried on other animals). International spread is most likely to occur in plant trade. The pathway of introduction to the TCI is suspected to be with the import of infested Christmas trees, whereas the pathway of introduction to Italy is unknown (Malumphy *et al*., 2012; Garonna *et al*., 2015).

In Italy the first signs of an infestation of *T. parvicornis* may be seen in early spring when the first generation starts to feed (Garonna *et al*., 2015). The scales egest enormous quantities of honeydew, which can give the pine tree a shiny appearance particularly on the bark. Thick black sooty moulds develop on the honeydew turning the bark and needles black (Fig. 6.33.6). The ground and objects below the infestation can also turn black. New growth may turn white due to large quantities of wax secreted by the young females (Figs 6.33.8-9) although this quickly disappears with wind and rain. There is yellowing, needle loss, and flagging (die back) (Figs 6.33.7-9). There can be a general decline in the health of the tree and eventually susceptible trees may be killed.

Surveying and monitoring for the scale can be very difficult on mature *P. pinea* due to the height of the trees (often 15-20 m) and the lack of branches or needles available for inspection at the base of the tree. Therefore, a cherry-picker is essential to monitor the pest and to take samples.

Toumeyella parvicornis can easily be confused in the field with related species, such as striped pine scale *Toumeyella pini*, a Nearctic pest of pine that has a similar biology to *T. parvicornis*, and has recently been introduced to the Bahamas.

Economic and other Impacts

Toumeyella parvicornis periodically causes mortality of seedlings and saplings of hard pines and severe damage to pole stands in North America. Feeding by the nymphs and adult females causes needle loss and branches to die. Heavily attacked trees turn yellow and finally die. The honeydew egested by the scale insects and associated sooty moulds hinders photosynthesis and contributes to tree weakening (Garonna *et al*., 2015).

Toumeyella parvicornis rapidly killed pine trees in the TCI and devastated the pine forests, causing expiration of the pine in many areas (Malumphy *et al*., 2012). The tropical climate allowed the scales to breed continuously throughout the year and there was a lack of natural enemies. The pines appear to have been environmentally stressed, largely due to insufficient water, and were, therefore, more vulnerable and less resilient to an introduced exotic pest species. *Toumeyella parvicornis* could kill pines elsewhere in the Caribbean particularly if the trees are already stressed. It is highly unlikely that *T. parvicornis* will have a similar dramatic impact to the pine forests in Europe due to less favourable climatic conditions for the scale insect, and the forests are likely to be more resilient.

6.34 Cycad Aulacaspis Scale

Order: Hemiptera
Family: Diaspididae
Species: *Aulacaspis yasumatsui* Takagi

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡	ü		ü
Ber	¡	ü		ü
BVI	¡	ü		ü
Cay	l			
Mon	¡	ü		ü
TCI	¡	ü		ü

Figure 6.34.1 Cycad Aulacaspis Scale *Aulacaspis yasumatsui* infesting a cycad in Florida © Holly Glen, University of Florida

Background

Aulacaspis yasumatsui is a serious pest of cycads (Fig. 6.34.1), frequently killing susceptible species, including horticulturally important and endangered plant species. It has many common names including cycad aulacaspis scale (CAS), cycad scale, sago palm scale, and Asian cycad scale. It originates in Asia and has spread around the world with trade in ornamental cycads. It is very difficult to control, forming dense populations on all parts of the plant, including the roots (Malumphy & Marquart, 2012), spreading rapidly, and has few natural enemies in most localities where it has been introduced. The scale poses a plant health risk to all the UKOTs in the Caribbean, wherever cyads are grown.

Geographical Distribution

Aulacaspis yasumatsui is native to tropical and sub-tropical parts of southeastern Asia, but since the early 1990s has spread rapidly in plant trade and is now recorded in China, Hong Kong, Singapore, Taiwan, Vietnam, Ivory Coast, Hawaii, USA (Florida), Bahamas, Cayman Islands, Guadeloupe, Guam, Martinique, Puerto Rico and the US Virgin Islands (García Morales et al., 2016). It has been intercepted and eradicated in New Zealand.

Host Plants

Aulacaspis yasumatsui feeds on cycads belonging to the following three families and genera: Cycadaceae – *Cycas*; Stangeriaceae – *Stangeria*; Zamiaceae – *Dioon*, *Encephalartos* and *Microcycas* (García Morales et al., 2016). *Cycas* spp. seem to be the preferred hosts, particularly those of Asian origin, such as the 'king sago' (*C. revoluta*) and the 'queen sago' (*C. rumphii*).

Figure 6.34.2 *Aulacaspis yasumatsui* adult female scale cover in the UK on *Cycas* imported from Vietnam © C. Malumphy

Figure 6.34.3 *Aulacaspis yasumatsui* male tests; closeup of male tests showing the longitudinal ridges © C. Malumphy

Figure 6.34.4 Small infestation of *Aulacaspis yasumatsui* causing chlorosis on *Cycas*, U.S.A. © C. Malumphy

Figure 6.34.5 Large infestation of *Aulacaspis yasumatsui* on *Cycas*, Canary Islands © C. Malumphy

Figure 6.34.6 *Cycas* stump, killed by *Aulacaspis yasumatsui*, South Africa © C. Malumphy

Figure 6.34.7 Large infestation of *Aulacaspis yasumatsui* on *Cycas*, China © C. Malumphy

Figure 6.34.8 Two cycads in the background with foliage pruned due to massive infestation of *Aulacaspis yasumatsui*, China © C. Malumphy

Description

The scales of mature *A. yasumatsui* females (Fig. 6.34.2) are white, 1.2 to1.6 mm long and highly variable in form. They tend to be pear-shaped but are often irregular, conforming to the leaf veins, adjacent scales, and other objects. The scale of the male (Figs. 6.34.3) is 0.5 to 0.6 mm long, white, elongated with three longitudinal ridges (Malumphy & Marquart, 2012).

Biology

Females have three instars, and the average time from egg hatch to adulthood is 28 days. Each female can lay more than 100 eggs, which hatch in 8 to 12 days at 25°C. Most females live for up to 75 days. The scales are unusual in that they also infest the roots of the host plant at depths of up to 60 cm. In containerised cycads, the scale insects usually aggregate on the larger roots (about 10 mm in diameter). They also occur at lower densities on the smaller roots near the sides of the plant container (Malumphy & Marquart, 2012).

Dispersal and Detection

The main natural dispersal stage or the first-nymphal instar or crawler which may crawl over the mother plant or be carried by wind or on other animals. Long distance dispersal is by infested plants moving in plant trade (Malumphy & Marquart, 2012).

Aulacaspis yasumatsui is usually first detected by symptoms resulting from feeding damage. The initial damage is typical of many diaspids, consisting of chlorotic spotting (Fig. 6.34.4), but most of the fronds eventually become brown, desiccated and may be dropped (Fig. 6.34.8). Highly infested cycads are almost completely coated with a white crust that includes scales of live and dead insects (Figs 6.34.1, 6.34.5 and 6.34.7). Susceptible plants are frequently killed (6.34.6). The scale insects are consistently more numerous on the lower than on the upper surfaces of leaflets (6.34.1), and in light infestations they occupy the lower leaf surfaces exclusively. Male scales are nearly always more numerous than those of females. Crusts composed of several layers of scales of males are common on rachides, where up to 500 scales per cm^2 have been observed.

The scales of *A. yasumatsui* are also remarkably persistent. The dead scales detract from the appearance of ornamental plants. Cycads continue to appear to be highly infested after most of the scale insects have been killed because the scales do not readily drop off.

Economic and other Impacts

Aulacaspis yasumatsui threatens both ornamental and wild cycad populations. It has the potential to spread rapidly and can smother a large cycad plant within weeks (Haynes & Marler, 2005). It has been observed to kill 100% of a *C. revoluta* population in cultivation within one year of infestation (Howard *et al.*, 1999). It has had a considerable impact on the horticultural industry and amenity plantings in countries where it has been introduced without any natural enemies. For example, in Hong Kong it causes 70-100% mortality of ornamental cycads. It has also killed large numbers of native cycad trees in forests in Guam (see *Cycas micronesica* in IUCN Red List of Threatened Species) (Haynes & Marler, 2005). It also threatens the survival of several rare and already endangered species conserved in botanical collections (Howard *et al.*, 1999).

6.35 Bermuda Cedar or Minute Cypress Scale

	Present	Absent	Threat		
			Bio	Hlth	Econ
Ang	¡		ü		ü
Ber					
BVI	¡		ü		ü
Cay	¡		ü		ü
Mon	¡		ü		ü
TCI	¡		ü		ü

Order: Hemiptera
Family: Diaspididae
Species: *Carulaspis minima* (Signoret)

Figure 6.35.1 Bermuda cedar scale *Carulaspis minima* on *Callitris* sp., UK © Crown copyright

Background

The Bermuda cedar scale or minute cypress scale *Carulaspis minima* (Figs 6.35.2 and 6.35.4-6.35.5) is native to Europe and has been transported by man worldwide with ornamental conifers. It was accidently introduced to Bermuda on coniferous nursery stock imported from California in the early 1940s. This resulted in a catastrophic decline of the natural forest of Bermuda red cedar (*Juniperus bermudiana*), despite various attempts at biological control (Challinor & Wingate, 1971; Wingate, 2001, 2011). The small numbers of remaining Bermuda red cedar trees which exhibit some resistance to the scale insect, have provided some natural regeneration but the plant is still classed as critically endangered on the IUCH Red List (Wingate *et al*., 2011). It is hoped that Bermuda cedar will thus survive long enough to develop an inherent resistance, as have the closely-related mainland junipers.

Carulaspis minima presents a potential plant health threat to Cupressaceae in all the UKOTs, particularly to those located in the Caribbean.

Geographical Distribution

Carulaspis minima is native to Europe, where there is a complex of about five similar species (Gill, 1997). Due to anthropogenic activities, it is now widely distributed in Africa, the Middle East, South America and North America. In the Caribbean it has only been recorded from Bermuda and Cuba.

Figure 6.35.2 *Carulaspis minima*, large infestation on *Juniperus virginiana*, UK © Crown copyright

Figure 6.35.3 *Carulaspis minima* on young cone of *Juniperus scopulorum*, UK © Crown copyright

Figure 6.35.4 *Carulaspis minima*, large infestation on Sequoia, UK © Crown copyright

Figure 6.35.5 *Carulaspis minima*, large infestation on *Juniperus chinensis*, UK © Crown copyright

Figure 6.35.6. *Carulaspis minima*, immature male scale covers on *Juniperus*, UK © Crown copyright

Figure 6.35.7. *Carulaspis minima*, adult females on *Sequoia*, UK © Crown copyright

Host Plants

Carulaspis minima has been recorded from hosts belonging to three families of evergreen conifers (Cephalotaxaceae, Cupressaceae and Taxodiaceae) but especially on *Juniperus* (Davidson & Miller, 1990; Danzig & Pellizzari, 1998). Hosts include species of *Callitris*, *Cephalotaxus*, *Chamaecyparis*, *Cryptomeria*, *Cupressus*, *Juniperus*, *Sequoia* and *Thuja*.

Description

In life, the scale cover of the adult female is 0.5-2.0 mm diameter, circular, moderately convex, and white with central or subcentral yellow exuviae (Figs 6.35.1, 3 and 7). Male scale covers are elongate oval, white, with a slight median longitudinal ridge and yellow terminal exuviae (Fig. 6.35.6). The exposed body of adult female is yellow with green mottling (Gill, 1997). The adult male is winged.

Carulaspis minima is almost identical in the field to *Carulaspis juniperi* (Bouché), commonly known as juniper scale, which is also oligophagous on Cupressaceae and has also been spread worldwide with plant trade. The two species can only be separated by microscopic examination of slide-mounted adult females.

Biology

Reproduction is sexual and there are one or more generations per year, depending on climatic conditions (Kosztarab and Kozár, 1988). *Carulaspis minima* overwinters in the adult female stage (Davidson and Miller, 1990; Zahradník, 1990a; Gill, 1997). Each adult lays up to 40 eggs (average 20), and they hatch after about one week (Kosztarab, 1996).

Dispersal and Detection

The first instars or crawlers are the primary natural dispersal stage and move to new areas of the plant or are dispersed by wind or animal contact. Mortality due to abiotic factors is high at this stage. Dispersal of sessile adults and eggs over long distances occurs through human transport of infested plant material.

Heavy infestations cause premature yellowing (chlorosis) and dieback of green needles or branchlets, branch dieback (Gill, 1997) and even plant death (Kosztarab, 1996). Low density populations can be very difficult to detect due to the small size and cryptic habits of the insects. It is best to closely examine leaflets of appropriate hosts with a hand lens for small, circular white scale covers. Heavy infestation may be accompanied by yellowing of foliage near their feeding sites.

Economic and other Impacts

Carulaspis minima is a serious pest of *Juniperus bermudiana* in Bermuda. The catastrophic decline of the Bermuda cedar following the introduction of the scale insect into Bermuda had severe economic, environmental and social impacts. Bermuda cedar is the National tree of Bermuda and a valuable timber resource and of great cultural value to Bermudians. It was a nesting habitat for birds and home to numerous insects and other invertebrates. Many species that were adapted to life in the cedar-dominated forest seriously declined, such as the native bluebird (*Sialia sialis bermudensis*) and the endemic cicada (*Tibicen bermudiana*), which is now extinct.

Carulaspis minima is also occasionally a serious pest of ornamental Cupressaceae in central and southern Europe and North America. Plants that are already stressed due to abiotic factors such as drought, compaction or root cramping (for example potted plants) are more susceptible. Infestations cause yellowing of the needles and, in heavy infestations, branch dieback and mortality.

6.36 Cactus Scale

Order: Hemiptera
Family: Diaspididae
Species: *Diaspis echinocacti* (Bouché)

	Present I Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	¡			ü
BVI	I			
Cay	¡			ü
Mon	¡			ü
TCI	¡			ü

Figure 6.36.1 Infestation of Cactus scale *Diaspis echinocacti* on *Opuntia* pad, Canary Islands © C. Malumphy

Background

Diaspis echinocacti is native to the Americas and has spread throughout the warmer parts of the world with plant trade. It is oligophagous on Cactaceae and occasionally found on succulent plants belonging to other families (Davidson & Miller, 1990; Miller & Davidson, 1990, 2005; Garcia *et al*., 2016). Large populations (Figs 6.36.1-6.36.5) can severely damage cacti and susceptible species may be killed. This can be significant if rare or endangered species of cacti are attacked.

Geographical Distribution

Diaspis echinocacti is native to the New World and has spread throughout the tropical and subtropical areas of the world wherever cacti are found. In temperate areas the species is frequently found on indoor plantings (Danzig & Pellizzari, 1998). In the Caribbean it has been recorded from the British Virgin Islands, Barbados, Haiti, Jamaica, Puerto Rico, Trinidad and Tobago, and the U.S. Virgin Islands (Garcia *et al*., 2016).

Host Plants

Diaspis echinocacti is oligophagous on Cactaceae and occasionally found on succulent plants belonging to other families. Cacti host genera include: *Acanthocereus*, *Ariocarpus*, *Astrophytum, Brasiliopuntia, Carnegiea, Cephalocereus*, *Cereus*, *Copiapoa*, *Corryocactus*, *Coryphantha*, *Dendrocereus*, *Disocactus*, *Echinocactus*, *Echinocereus*, *Echinopsis*, *Epiphyllum, Ferocactus*, *Gymnocalycium*, *Harrisia*, *Hatiora*, *Hylocereus*, *Leuchtenbergia*, *Mammillaria*, *Melocactus*, *Myrtillocactus*, *Nopalea, Opuntia, Pachycereus*, *Parodia*, *Pelecyphora*, *Peniocereus*, *Pereskia*, *Pilosocereus, Pterocactus*, *Rebutia*, *Schlumbergera*, *Sclerocactus*, *Tacinga, Thelocactus*, *Weberocereus* (Davidson & Miller, 1990; Miller & Davidson, 1990, 2005; Garcia *et al*., 2016).

Figure 6.36.2 *Diaspis echinocacti* smothering an *Opuntia* fruit, Canary Islands © C. Malumphy

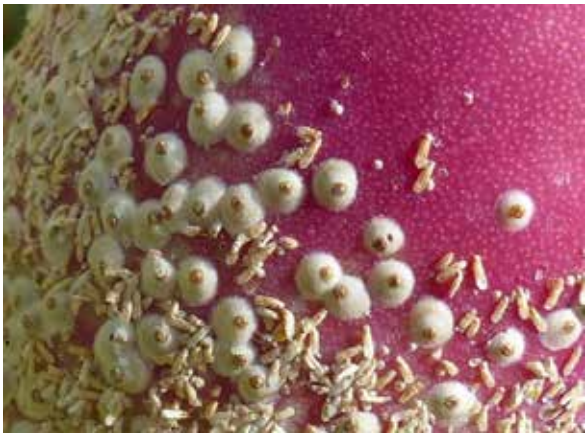

Figure 6.36.3 *Diaspis echinocacti* female scale covers are round and male covers are smaller and elongate oval, Canary Islands © C. Malumphy

Figure 6.36.4 Huge infestation of *Diaspis echinocacti* on cactus, BVI © Nancy Woodfield Pascoe

Figure 6.36.5 Huge infestation of *Diaspis echinocacti* on cactus, Canary Islands © C. Malumphy

Figure 6.36.6 *Diaspis echinocacti* on columnar cactus, Canary Islands © C. Malumphy

Figure 6.36.7 Close up of *Diaspis echinocacti* adult female intercepted on a cactus fruit imported from Israel © Crown copyright

Figure 6.36.8 *Diaspis echinocacti* adult females on a cactus, Italy © Crown copyright

Description

In life, the adult female scale cover is 1.5-2.5 mm in diameter, circular and slightly convex, whitish to tan with brown subcentral exuviae (cast skins) (Figs 6.36.3 and 6.36.7-6.36.8). The male scale cover is white, elongate oval, with three weak longitudinal ridges and yellow terminal exuviae (6.36.3) (Davidson & Miller, 1990). Occasionally, male scales can occur in huge numbers turning parts of the host plant white (Fig. 6.36.1). The adult female body is greenish-yellow (Gill, 1997).

Biology

Diaspis echinocacti reproduces sexually and has multiple, overlapping generations each year (Oetting, 1984). Each female lays about 150 eggs (276 maximum) and lives for up to 230 days. Development from egg to adult takes about 23 days for females and 24 days for males at 27°C, and a generation takes about 50 days (Gill, 1997).

Dispersal and Detection

First instars or crawlers are the primary natural dispersal stage and move to new areas of the plant or are dispersed by wind or animal contact. Mortality due to abiotic factors is high in this stage. Dispersal of sessile adults and eggs occurs through human transport of infested plant material.

Diaspis echinocacti may be detected by examining all the aerial parts of the cactus (pads, stems and fruit) for circular, slightly convex, whitish to tan scale covers with brown subcentral exuviae. There may be signs of wilting or desiccation associated with the scale insects.

Economic and other Impacts

There are mixed reports on the impact of cactus scale with some publications saying it is not an important pest of cacti whereas others say it is significant. This variation probably reflects differences in the host species and health (and therefore susceptibility), climatic conditions and presence or absence of natural enemies. *Diaspis echinocacti* can cause entire cactus pads or even whole plants to wither and die (Davidson & Miller, 1990). In Sicily feeding by the scales caused chlorotic areas on *Opuntia* fruits (Russo & Siscaro, 1994). This also occurs in the Canary Islands where the cactus fruit or tuno are used in traditional Canrian cuisine (Chris Malumphy, pers. comm., 2018). It can be a particularly serious pest of susceptible hosts in greenhouses, sometimes causing entire cactus pads or even whole plants to wither and die (Davidson & Miller, 1990). It was reported as a pest in French Polynesia by Reboul (1976), California by Gill (1997), France by Foldi (2001), Sicily by Russo and Siscaro (1994), and in the Palaearctic region by Danzig and Pellizzari (1998). In Argentina, it caused desiccation of cacti growing at high altitudes. It is a pest of 'forage palm' (*Opuntia cochonillifera*) in Brazil (Lima & Barbosa, 1988). Huge populations have been found on native cacti in BVI (Nancy Woodfield Pascoe, pers. comm., 2016).

6.37 Lesser snow scale

Order: Hemiptera
Family: Diaspididae
Species: *Pinnaspis strachani* (Cooley)

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡	ü		ü
Ber	¡	ü		ü
BVI	l			
Cay	¡	ü		ü
Mon	¡	ü		ü
TCI	l			

Figure 6.37.1 Lesser snow scale *Pinnaspis strachani* colony smothering the bark of the critically endangered *Varronia rupicola* in the British Virgin Islands © Crown copyright

Background

Pinnaspis strachani, commonly known as lesser snow scale due to the white male tests turning the bark of the host plant white (Figs. 6.37.1, 6.37.3-6.37.9), is a cosmopolitan scale insect pest, restricted to indoor plantings in cooler temperate regions. It is broadly polyphagous, feeding on plants belonging to at least 84 families, and is a serious pest of many crops, ornamentals and wild plants. It frequently kills susceptible hosts and has recently been found killing the critically endangered *Varronia rupicola* in Anegada, BVI (Malumphy, Sanchez & Hamilton, 2015). It poses a potential plant health risk to all the UKOTs in the Caribbean.

Geographical Distribution

Pinnaspis strachani probably originated in the Oriental region but is now a cosmopolitan species in tropical and subtropical regions. It also occurs on indoor plantings in some temperate regions. In the Caribbean it is recorded from Antigua and Barbuda, Bahamas, Barbados, Bermuda, British and US Virgin Islands, Cuba, Dominica, Jamaica, Puerto Rico, Saint Kitts, Saint Vincent and the Grenadines, Trinidad and the Turks and Caicos (García Morales *et* al., 2016).

Figure 6.37.2 *Pinnaspis strachani* female scale cover on *Annona reticulata* fruit, Saint Lucia © Crown copyright

Figure 6.37.3 *Pinnaspis strachani* male tests on *Annona reticulata* fruit, Saint Lucia © Crown copyright

Figure 6.37.4 *Pinnaspis strachani* scales on *Dracaena* © C. Malumphy

Figure 6.37.5 *Pinnaspis strachani* causing dieback to *Hibiscus rosa-sinensis*, Canary I. © C. Malumphy

Figure 6.37.6 *Pinnaspis strachani* killing a *Crotons flavens* plant, BVI © C. Malumphy

Figure 6.37.7 *Pinnaspis strachani* killing a *Hibiscus roas-sinensis* plant, Antigua © C. Malumphy

Figure 6.37.9 *Pinnaspis strachani* causing dieback to a *Murraya* plant, BVI © C. Malumphy

Host Plants

Pinnaspis strachani is broadly polyphagous, feeding on woody and herbaceous plants belonging to 74 families and 244 genera, with a preference for Fabaceae, Malvaceae and Rutaceae. It feeds on both woody and herbaceous plants (García Morales *et al*., 2016). Commonly infested economically important plants in the Americas include avocado (*Persea americana*), *Annona* spp., chili peppers (Capsicum), cassava (*Manihot esculenta*), citrus (Citrus spp.), coconut (Cocos nucifera), *Cordyline* sp., cotton (*Gossypium* spp.), *Hibiscus* spp., mango (*Mangifera indica*), yam (*Ipomoea batatas*) and palms.

Description

Adult female *P. strachani* scale cover is 1.5-2.5 mm long, usually mussel-shaped, slightly curved, and white to grey in colour (Fig. 6.37.2). The cast skins of the nymph form a yellowish-brown spot, called a terminal exuviae, at the narrow end of the scale cover. The scale cover of the male is shorter (1 mm long), elongate, narrow, snow-white and has with three ridges (Fig. 6.37.3). Accurate identification of *Pinnaspis* species requires specimens to be examined in a laboratory. The microscopic features of *P. strachani* are described and illustrated by Williams & Watson (1988).

Biology

Lesser snow scale reproduces continuously throughout the year in the tropics and subtropics, producing several generations each year. The female lays eggs underneath the scale cover and dies upon completion of oviposition. Upon hatching, the first instar or 'crawlers' seek out feeding sites on the stems and leaves of the host. After a short time (usually a few hours) they settle to feed and build their scale colour or 'armour' and go through several moults before becoming adult. The males are more noticeable than the females and more common on heavily infested plants. After several moults the males winged male develops, the male lives only a few hours and does not feed (Jackson, 2017). In Cuba, development time for the males and females is approximately 23 and 45 days respectively (Fernandez *et al.*, 1993).

Dispersal and Detection

Pinnaspis strachani are sessile apart from the crawler and the adult male life stages. Short range dispersal happens as crawlers search out places to settle and feed, but they can also be carried directly from place to place by humans, animals, and wind currents (Beardsley & Gonzalez, 1975). Long range dispersal occurs wih international trade in infested host plants (Malumphy, 2017). It is one of the most commonly transported scale species in international plant trade (based on Fera unpublished interception data).

Scales can be detected by closely examining leaves, bark or fruits of the host-plants, for mussel-shaped, whitish-grey scale covers of the females and the more conspicuous snow-white ridged covers of the males.

Economic and other Impacts

Pinnaspis strachani is a serious pest of many crops and ornamentals, frequently causing dieback and mortality, particularly to *Hibiscus* (Figs. 6.37.1 and 6.37.5-6.37.9). It can have a significant environmental impact when it kills endangered plants such as *Varronia rupicola* in BVI (Fig. 6.37.1).

6.38 White Peach Scale

Order: Hemiptera
Family: Diaspididae
Species: *Pseudaulacaspis pentagona* (Targioni Tozzetti)

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	¡			ü
BVI	l			
Cay	l			
Mon	l			
TCI	¡			ü

Figure 6.38.1 White peach scale *Pseudaulacaspis pentagona* on *Bougainvillea*, BVI © Crown copyright

Background

White peach scale *Pseudaulacaspis pentagona* is native to Asia but has spread throughout the world in tropical and subtropical areas. It is broadly polyphagous attacking numerous crops, ornamentals and wild plants. It can cause severe damage and kill susceptible plants. Huge populations have been recently found causing dieback to *Bougainvillea* (Fig. 6.38.1) and *Nerium* (Fig. 6.38.11) in BVI and it poses a plant health risk to all the UKOTs in the Caribbean.

Geographical Distribution

Pseudaulacaspis pentagona originates from eastern Asia and has spread widely to all warmer regions of the world, including all the major continents (Fig. 6.38.2) (García Morales *et al*., 2016). In the Caribbean it has been recorded from Antigua and Barbuda, Bahamas, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Guadeloupe, Jamaica, Martinique, Montserrat, Puerto Rico, Saint Kitts and Nevis Islands, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, and the US Virgin Islands.

Host Plants

Pseudaulacaspis pentagona is one of the most polyphagous scale insect species in the world, being recorded from well over 100 plant genera, including numerous crop and ornamental plants. The following list includes only some of the host genera found in the Caribbean: *Abelmoschus, Acacia, Albizia, Actinidia, Brassica, Calotropis, Capsicum, Catalpa*, *Citrus, Cocos, Codiaeum, Croton, Cucurbita,*

Cycas, Dracaena, Dypsis, Euphorbia, Ficus, *Glycine, Hibiscus, Hydrangea, Jatropha*, *Lantana, Malus*, *Mangifera, Manihot, Melia, Morinda, Morus*, *Nephelium, Nerium*, *Passiflora*, *Pelargonium, Philodendron*, *Phoenix, Pinus, Piper, Plumeria, Psidium, Ribes*, *Ricinus*, *Schefflera*, *Spondias, Solanum, Sorbus, Stachytarpheta, Strelitzia, Vitis, Zanthoxylum and Ziziphus* (García Morales *et al*., 2016).

Figure 6.38.2 *Pseudaulacaspis pentagona* distribution map © CABI

Figure 6.38.3 *Pseudaulacaspis pentagona* adult female scale cover on *Syringa* © C. Malumphy

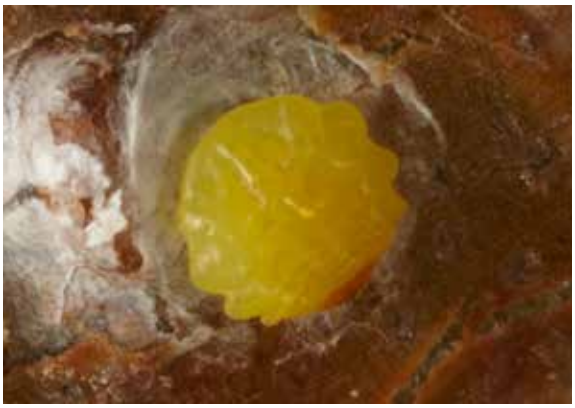

Figure 6.38.4 *Pseudaulacaspis pentagona* adult female scale with cover removed to reveal the insect © C. Malumphy

Figure 6.38.5 *Pseudaulacaspis pentagona* adult females on *Morus*, Greece © C. Malumphy

Figure 6.38.6 *Pseudaulacaspis pentagona* adult females and swarming first instars on *Catalpa bignonioides*, UK © Fera

Figure 6.38.7 *Pseudaulacaspis pentagona* colony covering the bark of *Catalpa bignonioides* © Fera

Figure 6.38.8 *Pseudaulacaspis pentagona* adult male © C. Malumphy

Figure 6.38.9 *Pseudaulacaspis pentagona* on *Nerium*, BVI © C. Malumphy

Figure 6.38.10 *Pseudaulacaspis pentagona* on *Prunus persicae*, China © C. Malumphy

Figure 6.38.11 Large infestation of *Pseudaulacaspis pentagona* on *Nerium*, BVI © C. Malumphy

Description

Adult female scale covers (Figs 6.38.3) are convex, circular to oval, dull white with a sub-central yellow spot (exuviae or shed skins), and 2.0 –2.5 mm in length. The body of the adult female is yellow (Fig. 6.38.4). They are often obscured beneath bark flakes on tree trunks or beneath the epidermis on fruit (especially kiwifruit (*Actinidia* spp.)). The male cover (test) (Fig. 6.38.1) is smaller, felted, white, elongate, often ridged with a terminal yellow spot (shed skin), and 1.0-1.5 mm in length. The male tests often occur in conspicuous masses (Fig. 6.38.7 and 6.38.9-6.38.11), occasionally smothering the bark and turning it white (they are often described as looking like snow). The adult males (Fig. 6.38.8) are winged and mobile in order to locate a mate. *Pseudaulacaspis pentagona* may be confused with *Pinnaspis strachani* (see Fact sheet 6.37) in the field but the female scale cover of *P. pentagona* is circular to oval with the exuviae sub-central whereas *P. strachani* are mussel or pear-shaped with the exuviae at the narrow end of the scale cover.

Biology

Each female lays between 100 and 150 eggs, depending largely on host plant species. Male eggs are orange and female eggs are white. The eggs hatch three or four days after being laid and the first instars (Fig. 6.38.6) actively swarm over the host, searching for a suitable feeding site. The females have three instars and males five. There are from one to four generations per year, depending upon climate, although in the UK one is most likely. In the USA a generation is completed in 36 to 40 days during the summer at 25°C average temperature and in 80 to 90 days during the winter. The adult females overwinter and can survive temperatures as low as –20°C although there is high mortality at such temperatures.

Dispersal and Detection

Like other diaspidids, the main dispersal stage of *P. pentagona* is the mobile first instar (Fig. 6.38.6), which can disperse up to 1 m, but are distributed across much greater distances by wind, flying insects and birds. Ornamental plants can be important in facilitating the spread of this pest since they are not so well protected from the insect in nurseries, i.e. compared to the quantity of chemical sprays applied to cut flowers. A batch of infested ornamental shrubs from a single nursery can easily spread the pest widely since such hosts could be planted in private and public gardens.

Economic and other Impacts

Pseudaulacaspis pentagona is one of the most important armoured scale insect pests in the world. It removes sap from the host plant, which reduces vigour. Foliage of infested trees may become sparse and yellow. Fruit size may be reduced, and premature fruit drop is likely to occur, especially if scale feeding is accompanied by other stresses. Heavy infestations can result in the drying out and death of twigs, branches, and even large mature trees if left unattended. Young plants can die very quickly after infestation.

Pseudaulacaspis pentagona has caused major problems in areas where it was accidentally introduced in the absence of its natural enemies. The efficiency of natural enemies is reduced in urban areas by pollution; consequently, *P. pentagona* can cause severe damage to ornamental plants in towns and cities. In the southeastern USA, *P. pentagona* is a serious pest of *Prunus* spp. (especially peach) and *Pyrus* (pear) where infestation can become significant and thousands of dollars are spent each year on the control of the pest. In the northeastern USA it is a very destructive pest, especially on flowering cherry (*Prunus* spp., mulberry (*Morus* spp.), peach and other deciduous fruit trees. Heavy outbreaks have occurred on ornamental plants in Hungary where infested *Morus* trees exhibit dieback and can be killed after a few years. The pest has also caused significant damage in France, Greece, Italy and Switzerland, and more recently in BVI. It is also known as a glasshouse pest in cooler countries such as Sweden and the UK.

6.39 Lobate Lac Scale

Order: Hemiptera
Family: Kerriidae
Species: *Paratachardina pseudolobata* Kondo & Gullan

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	¡			ü
BVI	l			
Cay	l			
Mon	¡			ü
TCI	l			

Figure 6.39.1 Lobate lac scales *Paratachardina lobata* on *Ficus* in Grand Bahama © C. Malumphy

Background

A lac insect, originally identified as *Paratachardina lobata*, was first recorded in Florida (USA) in 1999 (Pemberton, 2003; Hamon & Hodges, 2013). It subsequently became a serious pest, in part due to its polyphagy, feeding on more than 300 species of mostly woody plants assigned to 69 families. Kondo & Gullan (2007) published a comprehensive review of the genus *Paratachardina* in which they determined, based on morphological and molecular data, that the lac insect scale occurring in Florida (and the Bahamas and Christmas Island) was a new species, which they named *Paratachardina pseudolobata*. This pest is commonly known as the lobate lac scale.

Within the UK Overseas Territories *P. pseudolobata* has been recorded from the British Virgin Islands, Cayman Islands and the Turks and Caicos Islands. Lobate lac scale poses a plant health risk to native and exotic plants in all the UKOTs in the Caribbean.

Geographical Distribution

Paratachardina pseudolobata is likely to be native to Asia (since all of the other eight described species of *Paratachardina* are reported from Asia), and has been introduced to the Indian Ocean, North America and the Caribbean (Fig. 6.39.2). In the Caribbean it has been recorded from the Bahamas (since 1992), British Virgin Islands (New record), Cayman Islands (New record), Cuba (since 2005), Puerto Rico (since 2010) and Turks and Caicos Islands (New record). It is likely to be more widespread in the Caribbean than currently reported.

Figure 6.39.2 *Paratachardina pseudolobata* distribution map © CABI

Figure 6.39.3 Typical resinous cases (test) of *Paratachardina pseudolobata* © Fera

Figure 6.39.4 *Paratachardina pseudolobata* adult female showing the hole through which honeydew is ejected and the "fat bow tie" appearance © Fera

Figure 6.39.5 Sooty mould growing on the foliage of a *Ficus* heavily infested with lobate lac scales © C. Malumphy

Host Plants

Paratachardina pseudolobata is highly polyphagous, feeding on hundreds of species assigned to more than 200 genera in 62 families, mostly on woody dicotyledonous plants (Howard *et al*., 2006). It shows a preference for plants in the Fabaceae, Myrtaceae and Moraceae families. Some of the more important crop genera are *Annona, Artocarpus, Cinnamomum, Citrus*, *Diospyros, Duranta, Hibiscus, Ficus, Fortunella*, *Garcinia, Litchi, Malus*, *Mangifera, Morus, Murraya*, *Ocimum, Piper, Psidium, Pyrus*, *Rosmarinus, Salvia, Solanum, Spondias* and *Vitis*.

Description

The resinous scale covering (lac test) is light purplish red to dark reddish brown although old individuals will frequently appear black because of the sooty moulds (Figs 6.39.1 and 3). The scales smother infested twigs and branches of the host. The shape is globose with four lobes, the anterior lobes are smaller than the posterior lobes (Fig. 6.39.4), and young individuals generally appear more lobed than mature adults. Individuals in close proximity will frequently coalesce forming masses of several individuals. Young individuals often appear like a fat bow tie. The first instar test is incorporated into the adult test on the mid-dorsum, with a circular opening, on an elevated area just posterior to the first instar test, for the egestion of honeydew (Fig. 6.39.4). The adult female test is 1.2–2.0 mm long, 0.7-2.0 mm wide and 1.0–1.5 mm high. The lac texture is very hard, brittle, and shiny.

Kondo and Gullan (2007) provide detailed morphological descriptions and illustrations of the adult female, second and first instars of *P. pseudolobata*, and a key to the nine species that are assigned to the genus *Paratachardina*.

Biology

Paratachardina pseudolobata is parthenogenetic, lays eggs and has two nymphal instars. The life cycle is relatively long taking 8-12 months. The scales feed on the bark and often occur in dense colonies. They egest honeydew which serves as a medium for the growth of sooty moulds (Fig. 6.39.5).

Dispersal and Detection

The first instar (which is bright red) is the main natural dispersal stage and either crawls over the host plant in search of a suitable feeding site or may be carried in air currents or on other animals. They may also be dispersed over long distance in plant trade.

Paratachardina pseudolobata can be difficult to detect (or at least be recognised) in the field due to their small size, dark colour and unusual appearance, particularly when occurring on plants with dark bark.

Economic and other Impacts

Dense infestations are associated with branch dieback of some plant species, and in severe cases, highly infested shrubs and small trees have died (Howard & Pemberton, 2003). However, the lobate lac scale has not been a major economic pest in commercial plant nurseries in Florida and the Caribbean, but it is a common landscape pest. It frequently occurs on native plant species in natural habitats and its potential environmental impact is unknown.

6.40 Fluted scale

Order: Hemiptera
Family: Monophlebidae
Species: *Crypticerya genistae* Hempel

	Present I Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	¡			ü
BVI	¡			ü
Cay	I			
Mon	¡			ü
TCI	I			

Figure 6.40.1 Adult female fluted scale *Crypticerya genistae* with fully developed ovisac on *Euphorbia mesembryanthemifolia*, BVI © C. Malumphy

Background

Crypticerya genistae was originally described from specimens collected in Brazil and was introduced into Florida (U.S.A.) in about 2005 (Hodges, 2008). Since then it appears to have spread widely in the Caribbean and has been reported to be a significant economic pest of eggplants, peppers, tomatoes and peanuts and other legumes in Barbados and Puerto Rico. It is also a pest of chili peppers in Colombia (Hodges, 2008; García Morales *et* al., 2016; Kondo, et al., 2016). It is frequently found on roadside plants and in natural environments, feeding on a wide range of native plants. It has recently been found in the BVI and the TCI in urban parks and natural environments. It poses a potential plant health risk to vegetable crops, peanuts and native plants in all the UKOTs in the Caribbean.

Geographical Distribution

It is suspected to be native to South America (possibly Brazil) and in the last decade or more has spread in Florida, USA and parts of the Caribbean (Malumphy, 2014; García Morales *et* al., 2016).

Host Plants

Crypticerya genistae is broadly polyphagous feeding on plants assigned to at least 68 genera in 25 plant families (García Morales *et al*., 2016). The majority of the host plants belong to the Asteraceae and Fabaceae. Host plant genera that are economically important in the Caribbean include *Arachis, Cajanus, Capsicum, Ipomoea, Momordica, Solanum, Vicia, Vigna and Vitis.*

Figure 6.40.2 *Crypticerya genistae* adult females on *Croton discolour* seedling, BVI © C. Malumphy

Figure 6.40.3 *Crypticerya genistae* adult females on unspecified plant, USA © 2014 Rich, bugguide.net

Figure 6.40.4 *Crypticerya genistae* adult female on *Corchorus hirsutus* seedling, showing the dorsal was tuft, BVI © C. Malumphy

Figure 6.40.5 *Crypticerya genistae* with fully developed ovisac on *Euphorbia mesembryanthemifolia*, BVI © C. Malumphy

Description

Adult females have a yellowish body with black legs and antennae. They appear whitish as their bodies are covered in a layer of mealy white wax, and they have dorsum and marginal tufts of wax. There are 18-20 pairs of short tufts of wax, the longest at the anterior and posterior ends of the body. There is usually a characteristic central dorsal tuft of wax, that curves backwards (Fig. 6.40.4), although this is easily knocked off and lost. The females bear a very long white striated wax ovisac, that can be two or three times the body length (Figs 6.40.1-6.40.5). The ovisac is truncated at the posterior end (Unruh & Gullan, 2008). Adults and nymphs occur on the foliage and smaller branches of the host plant.

Crypticerya genistae may be identified using the keys and morphological descriptions provided by Unruh & Gullan (2008), Kondo & Unruh (2009) and Kondo *et al.* (2012).

Biology

There appears to be very little detailed information published on the biology of *C. genistae*. It is likely to be multivoltine in the Caribbean as related species are multivoltine in tropical climates. The females have five developmental stages: eggs, three nymphal instars and the adult. Unlike most other

scale insects, it retains its legs and its mobility throughout its life. The nymphs and adults have piercing-sucking mouthparts that are inserted into leaves, stems, and branches of host plants and cause damage by sucking sap and removing nutrients. While feeding they egest sugary honeydew, a highly attractive food source for ants and flies, and also some species of natural enemies. Several natural enemies, mostly ladybug beetles (Coccinellidae), have been recorded (García Morales *et* al., 2016).

Dispersal and Detection

The first nymphal instar or crawler of *C. genistae* is the main natural dispersal stage. The crawlers emerge from the ovisac as it splits and can disperse either by walking, by being blown by the wind, or by hitch-hiking on other organisms. Prunings of infested plants, and the clothing, tools and vehicles of agricultural workers, can become contaminated with crawlers and so aid in their dispersal. Long distance (international) dispersal is most likely to be due to the movement of infested plants for planting.

Mature females with their exceptionally long ovisacs are usually the first sign of an infestation. *Crypticerya genistae* nymphs and adults are usually found along major veins on the lower surfaces of the leaves, and on the stems of host plants. They occasionally congregate in large masses with their ovisacs hanging down vertically (Fig. 6.40.3), making the colony very conspicuous and distinctive, making detection easy. When heavy infestations develop on plants it is typical to find all life stages present. Large infestations are typically surrounded by sooty mould growing on egested honeydew, and may be attended by ants.

Economic and other Impacts

Crypicerya genistae has been reported to be a significant economic pest of eggplants, peppers, tomatoes and peanuts in Barbados, a devastating pest of soybeans and other legumes in Puerto Rico and a pest of chili peppers in Colombia (Hodges, 2008; García Morales *et* al., 2016; Kondo, et al., 2016). They feed by depleting the sap, which may cause the shoots to dry up, die, and defoliation to occur. Most damage appears to occur from the feeding of the immature stages of on the leaves, where they settle in rows along the midrib and veins, and on the smaller twigs. In addition, the honeydew egested by the scales coats the leaves, blocking the stomata and impeding gas exchange. Growth of sooty moulds occurs over the leaf surfaces, which blocks light from the mesophyll, so reducing photosynthesis. Large infestations can also reduce the aesthetic appearance of ornamental plants.

Crypicerya genistae has been found in natural areas feeding on a range of native plants, however, its potential environmental impact is unknown.

6.41 Cottony Cushion Scale

Order: Hemiptera
Family: Monophlebidae
Species: *Icerya purchasi* (Maskell)

	Present l Absent ¡	Threat Bio	Threat Hlth	Threat Econ
Ang	¡	ü		ü
Ber	¡	ü		ü
BVI	l			
Cay	l			
Mon	l			
TCI	l			

Figure 6.41.1 Cottony cushion scale *Icerya purchasi* adult females with ovisacs on *Acacia farnesiana*, Canary Islands © C. Malumphy

Background

Commonly called the cottony cushion scale or fluted scale due to the appearance of its waxy ovsac, *Icerya purchasi* is a highly distinctive scale insect (Fig. 6.41.1). It originates from Australia and has spread throughout the world on infested host plants. It is well established in the tropics and subtropics and under glass or outdoors in hot spots in some temperate regions. It is highly polyphagous, feeding on over 200 species of plant, but is most commonly reported as a pest of citrus and ornamental plants.

Geographical Distribution

Icerya purchasi is native to Australia and has spread throughout the world, being well established wherever citrus is grown. It has a wide climatic tolerance and in recent decades it has expanded its range northwards in Europe and is now naturalised in urban areas in southern England, with large populations developing which kill susceptible plants. It is periodically discovered in greenhouses and indoor plantings in temperate regions but is not generally a pest in these situations (CABI, 2017).

It is widespread throughout the Caribbean and Central America, and has been introduced to Antigua and Barbuda, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Curaçao, Dominica, Dominican Republic, El Salvador, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Trinidad and Tobago, and the Turks and Caicos Islands.

Figure 6.41.2 *Icerya purchasi* young adult female before oviposition, Netherlands © Crown copyright

Figure 6.41.3 *Icerya purchasi* nymphs on *Pittosporum*, UK © Crown copyright

Figure 6.41.4 *Icerya purchasi* nymphs on *Pittosporum*, UK © Crown copyright

Figure 6.41.5 *Icerya purchasi* on *Acacia*, UK © Crown copyright

Figure 6.41.6 *Icerya purchasi* colony attended by ants, on *Acacia farnesiana*, Canary Islands © C. Malumphy

Figure 6.41.7 *Pittosporum* hedge dying due to a massive infestation of *Icerya purchasi*, UK © Mike Copland

Host Plants

Icerya purchasi is highly polyphagous and a known pest on over 200 different plant species assigned to 167 genera in 68 families, mostly woody plants (García Morales *et al*., 2016). It is an important pest of *Citrus, Acacia, Casuarina* and *Pittosporum* in the USA, but can damage many types of fruit and forest trees, and ornamental shrubs.

Description

Adult female *I. purchasi* are medium sized (6-8 mm long), reddish body colour (Fig. 6.41.2) and covered in white or pale-yellow wax. The legs, antennae and long body setae are conspicuously black. On reaching maturity, the female produces a white, fluted, wax ovisac with a series of uniform ridges running lengthwise over the surface and containing 600 to 800 red eggs (Figs 6.41.1 and 6.41.4-6.41.6). As the ovisac is produced, the rear end of the body is tilted upwards, sometimes almost perpendicular to the plant surface. The ovisac may reach the same length as the body, giving an overall combined length of up to 15 mm.

There are three nymphal instars which have brown-black limbs and an orange-brown body that is coated with a cottony white and yellow wax, the density of wax increasing as they develop (Fig. 6.41.3). Each time the scale moults, it leaves behind its white, cottony moulting skin. Nymphs and adult females produce long, hair-like, transparent rods of wax from the body (Williams & Watson, 1990; CABI, 2017)

Adult males, which are very rarely observed, have well developed antennae, one pair of dusky wings, a red body and tufts of long setae at the end of the abdomen. They resemble small flies. Pupation occurs in a fluffy, oblong white cocoon or test (CABI, 2017).

Precise identification of *Icerya* species requires specimens to be mounted on microscope slides and to be studied under high magnification by a specialist. The microscopic features of *I. purchasi* are described and illustrated by Williams and Watson (1990).

Biology

Icerya purchasi is a functional hermaphrodite and very rarely winged males are produced which are short-lived. Cottony cushion scale has two to three generations a year and completes its life cycle in three months during warm weather conditions. Eggs hatch into crawlers (first instar) in a few days to a week after being produced during warm weather but can take up to two months to hatch in winter. Second instar nymphs settle on twigs and leaves, usually along leaf veins. Third instar nymphs move to branches, and adults may be found on branches or on the trunk of trees. This scale is seldom found on the fruit. Unlike most other scales, it retains its legs and its mobility throughout its life.

Icerya purchasi nymphs and adults have piercing-sucking mouthparts that are inserted into leaves, stems, and branches of host plants and cause damage by sucking sap and removing nutrients. While feeding they egest sugary honeydew as waste, a highly attractive food source for ants, and some species of natural enemies, including *Rodolia cardinalis* (Coleoptera: Coccinellidae). The ladybird *R. cardinalis* is a highly successful specialist predator, restricted to preying upon family Monophlebidae and widely used as a bio-control agent against *I. purchasi* (Hoddle, 2013).

Dispersal and Detection

The crawlers of *I. purchasi* emerge from the ovisac as it splits and are able to disperse either by walking, by being blown by the wind, or by hitch-hiking on other organisms. Prunings of infested plants, and the clothing, tools and vehicles of agricultural workers, can become contaminated with crawlers and so aid in their dispersal (CABI, 2017). Consequently, when heavy infestations of *I. purchasi* develop on plants it is typical to find all life stages present (reproductive adults, nymphs, and crawlers) (Hoddle, 2013). Hill (1980) recorded crawlers being carried by the wind 3.5 Km and to an altitude of 6 m.

Icerya purchasi nymphs and adults are usually found along major veins on the lower surfaces of the leaves, and on the stems of host plants. They congregate in large masses and are very conspicuous, making detection relatively easy (Figs 6.41.1-6.41.6). Long-established infestations are often surrounded by sooty mould growth, and may be attended by ants (CABI, 2017) (Fig. 6.41.6).

Economic and other Impacts

Icerya purchasi can severely damage host plants, particularly when in large numbers. They feed by depleting the sap, which causes the shoots to dry up, die, and defoliation to occur. This leads to decreased tree vitality, fruit drop, and in severe cases death of a host plant (Fig. 6.33.7). Most damage occurs from the feeding of the early immature stages of the scale on the leaves, where they settle in rows along the midrib and veins, and on the smaller twigs. In addition, the copious quantities of honeydew egested by the scales coat the leaves, blocking the stomata and impeding gas exchange. Growth of sooty moulds occurs over the leaf surfaces, which blocks light from the mesophyll, so reducing photosynthesis (Hamon & Fasulo, 2017; Plantwise, 2018).

After its introduction into California, USA, in the late nineteenth century, it was recorded devastating citrus orchards, killing large trees and was said to have threatened to destroy the entire citrus industry (Bartlett, 1978). Serious damage to citrus orchards by *I. purchasi* was also recorded in many other countries when the cottony cushion scale first arrived (Williams & Watson, 1990), but with successful biological control this insect has become relatively unimportant in fruit orchards in many countries (Plantwise, 2018).

In Anhui, China, *I. purchasi* is one of the most important pests of pomegranates (*Punica granatum*) (Wang *et al.*, 2002), and in Zhejiang, China, the cottony cushion scale is the main pest damaging Formosan-gum (*Liquidambar formosana*) (Hua *et al.*, 1999).

Icerya purchasi arrived in the Galapagos Islands 20 years ago, and quickly spread and attacked a wide range of endemic plants and threatened the biodiversity of this unique habitat. It was considered one of the six most damaging invasive alien species to the Islands. A biological control programme using *R. cardinalis* was initiated in 2002 and the bio-control agent quickly dispersed and spread naturally to two islands. The pest has been suppressed to non-damaging levels on many important native host plants, including white mangrove, *Acacia, Waltheria*, *Prosopis*, *Parkinsonia*, *Darwiniothamnus* and *Scalesia.* Further monitoring is recommended to determine whether this biological control agent has successfully reduced scale insect numbers on other valued plant species (Hoddle, 2013).

6.42 Greenhouse Orthezia or Kew bug

Order: Hemiptera
Family: Ortheziidae
Species: *Insignorthezia insignis* (Browne)

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡	ü		
Ber	¡	ü		
BVI	l			
Cay	l			
Mon	l			
TCI	¡	ü		

Figure 6.42.1 Greenhouse orthezia *Insignorthezia insignis*; colony infesting a shrub in Saint Lucia (left); closeup of adult females bearing ovisacs on *Ilex* sp. in the Bahamas (right) © C. Malumphy

Background

Greenhouse orthezia, *Insignorthezia insignis* (Fig. 6.42.1), has spread throughout the world in tropical and subtropical countries. It also occurs in botanical collections grown in heated glasshouses in temperate regions. It is an occasional pest and has the potential to damage a wide range of crops, ornamentals and native plants. For example, it was introduced into Saint Helena in the late 1980s where, in the absence of any natural enemies, the pest was destroying the last remaining stands of the endemic gumwood, *Commidendrum robustum* (Booth *et al.,* 1995).

Geographical Distribution

Insignorthezia insignis is reported to be native to the Neotropical region, probably to Guyana and neighbouring countries, and has spread throughout the world in tropical and subtropical countries. It occurs widely in the Caribbean region (Garcia *et al.,* 2016). It also occurs in temperate regions in botanical collections with heated glasshouses. Ezzat (1956) provides a world map showing isotherms defining areas of the world where conditions exist in which he considered *I. insignis* could survive.

Figure 6.42.2 Adult female *Insignorthezia insignis* with ovisac, collected in 1930 from Royal Botanic Gardens, Kew, UK © Crown copyright

Figure 6.42.3 *Insignorthezia insignis* adult found in the UK on fresh herbs imported from Uganda © Crown copyright

Figure 6.42.4 Adult and immature *Insignorthezia insignis* on *Plocama pendula*, Canary Islands © Crown copyright

Figure 6.42.5 Colony of *Insignorthezia insignis* on Asteraceae, Canary Islands © C. Malumphy

Figure 6.42.6 Large infestation of *Insignorthezia insignis* on ornamental Citrus, UK © Crown copyright

Figure 6.42.7 Young orange *Citrus sinensis* plant covered in sticky honeydew egested by *Insignorthezia insignis* which serves as a medium for black sooty moulds, UK © Crown copyright

Host Plants

Insignorthezia insignis is broadly polyphagous, feeding on plants assigned to more than 119 genera in 45 families (Garcia *et al.,* 2016). It appears to prefer woody hosts, occurring mainly on the shoots and twigs. It is most often found on trees and shrubs of the Verbenaceae (especially *Lantana*, *Clerodendron* and *Duranta* species), Solanaceae (especially *Capsicum* and *Solanum*), Acanthaceae,

Asteraceae (especially *Eupatorium* and other ornamentals) and Rubiaceae (including *Coffea*). In Egypt it has been recorded damaging a wide range of crops and utility plants such as sugarcane, *Citrus*, potatoes, tomatoes, chrysanthemums, shade trees such as *Jacaranda*, and windbreaks such as *Casuarina* (Ezzat, 1956).

Description

Adult female body is brownish olive green, and about 1.5 mm long and 1.3 mm wide. The dorsum is mostly bare of wax except for two narrow longitudinal rows of 12 small white wax processes, these rows situated on either side of the mid-line; the dorsal wax processes are fairly short, the longest and most curled occurring towards the posterior end (Figs 6.42.1-6.42.3). The ovisac up to 3.5 mm long and composed of brittle wax plates, nearly parallel-sided, curving slightly upwards posteriorly (Ezzat, 1956). Immature females resemble smaller versions of the adult. Males are rarely present.

Biology

The biology has been studied by Green (1922) and Ezzat (1956). There are three immature instars in the female and reproduction is parthenogenetic. Males do occur, but are very rare. Females lay between 58-95 eggs. There are up to three overlapping generations each year. The minimum and maximum critical temperatures for successful survival of colonies are 14° and 34° C, respectively.

Dispersal and Detection

The main natural dispersal stage is the first instar or crawler. They can disperse either by walking, by being blown by the wind, or by hitch-hiking on other organisms. Long distance dispersal and accidental introductions to new countries occur on infested planting material.

Insignorthezia insignis may be detected by careful examination of shrubs or trees. Sooty mould or sticky honeydew on leaves and stems, or ants running about may indicate the presence of the scale insect. The insects may be found attached to twigs and stems (and sometimes on the underside of leaf midribs).

Economic and other Impacts

Insignorthezia insignis is rarely damaging in the Caribbean region, although large populations may develop on and damage stressed plants. It is primarily a glasshouse pest in subtropical and temperate regions. Over much of its geographical range it is regarded as a minor pest, but in Hawaii, East Africa and South and Central America it has at times become a severe problem on *Citrus*, coffee, olive, *Jacaranda*, *Lantana* and other ornamental plants (CABI, 2017).

6.43 Citrus Orthezia

Order: Hemiptera
Family: Ortheziidae
Species: *Praelongorthezia praelonga* (Douglas)

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	¡			ü
BVI	l			
Cay	¡			ü
Mon	¡			ü
TCI	¡			ü

Figure 6.43.1 *Praelongorthezia praelonga* infestation on the lower surface of foliage of sea grape *Coccoloba uvifera*, Saint Lucia © C. Malumphy

Background

The citrus orthezia, *Praelongorthezia praelonga*, is a highly polyphagous scale insect that causes plant damage both directly by its feeding and indirectly due to its associated sooty moulds growing on the honeydew egested by the insects (Figs 6.43.1 and 6.43.4-6.43.7). It occurs widely in the Neotropical region, and during the last decade it has become a more common and significant pest in many parts of the Caribbean. It has been comprehensively reviewed by Kondo *et al.* (2013) and most of the data presented here is from this source or references cited therein.

Within the UKOTs it was recently recorded from the British Virgin Islands and poses a plant health risk to all the Territories in the Caribbean.

Geographical Distribution

Praelongorthezia praelonga occurs widely in the Neotropical region although its precise native range is unknown. It has recently been introduced to Africa (Kondo *et al.*, 2013). In the Caribbean region it has been recorded from Antigua and Barbuda, Barbados, British Virgin Islands, Dominica, Grenada, Guadeloupe, Jamaica, Martinique, Puerto Rico and Vieques Island, Saint Barthélemy, Saint Lucia, Saint Martin, Trinidad and Tobago, and the US Virgin Islands (Kondo *et al.*, 2013; Malumphy, 2014; García Morales *et al*., 2016).

Figure 6.43.2 *Praelongorthezia praelonga* teneral adult female, showing the dorsum mostly covered with white wax plates, BVI © Fera

Figure 6.43.3 *Praelongorthezia praelonga* adult females with ovisacs and early instar nymphs, BVI © C. Malumphy

Figure 6.43.4 Large infestation of *Praelongorthezia praelonga* on bougainvillea, Saint Lucia © C. Malumphy

Figure 6.43.5 *Praelongorthezia praelonga* infestation on croton *Codaieum*, Saint Lucia © C. Malumphy

Figure 6.43.6 *Praelongorthezia praelonga* nymphs feeding along main veins on lower surface of foliage of *Colubrina arborescens*, BVI © C. Malumphy

Figure 6.43.7 Black sooty mould growing on honeydew egested by *Praelongorthezia praelonga* on upper surface of foliage of *Bastardiopsis eggersii*, BVI © C. Malumphy

Host Plants

Praelongorthezia praelonga is highly polyphagous and has been recorded feeding on more than 180 host plant species in 50 plant families, including many crop, ornamental and native plants (Kondo *et al*., 2013). It shows a preference for the Asteraceae, Euphorbiaceae, Fabaceae and Malvaceae.

Description

The adult female (Fig. 6.43.2) is nearly 2.0 mm long, 1.25 mm wide, with the body dorsally completely covered with fragile white secretion, showing a more or less distinct but narrow bare streak near each margin, separating the dorsal and marginal plates. The secretions are arranged in lateral and dorsal tufts. Mature females carry a posterior, elongate ovisac, up to 6.0 mm long (Fig. 6.43.3).

Kondo *et al.* (2013) provide detailed morphological descriptions, illustration and photographs of the adult female, and a key to the genera in the tribe Ortheziini. Kozár (2004) provides identification keys in a monograph to the Ortheziidae of the world.

Praelongorthezia praelonga may easily be confused in the field with the greenhouse orthezia *Insignorthezia insignis* (see Fact sheet 6.42). The latter species occurs throughout the tropics and subtropics, including most of the UKOTs, and is an occasional glasshouse pest in temperate regions. It is also highly polyphagous and shares many of the host plants with *P. praelonga*. They may be separated using a x10 hand lens; the dorsum of *P. praelonga* is mostly covered with wax plates (Fig. 6.40.2), whereas the dorsum of *I. insignis* has large bare patches.

Biology

Praelongorthezia praelonga is sexually reproductive, lays eggs in an ovisac that is carried by the adult female, has multiple overlapping generations per year and a lengthy life cycle lasting between 40 and 200 days. The duration of the life cycle is affected by the host species and temperature. The optimal temperature for development is about 25°C, with a maximum temperature limit of 38°C, and a minimum limit of 15°C (Kondo *et al.*, 2013).

Dispersal and Detection

All developmental stages (except the eggs) are mobile. First instars may be dispersed in air currents and *P. praelonga* may be transported over long distances in plant trade (Kondo *et al.*, 2013).

Large infestations of *P. praelonga* are highly conspicuous due to the white wax secretions but low-density populations may be difficult to detect during routine phytosanitary inspections due to its relatively small size and sessile nature.

Economic and other Impacts

Praelongorthezia praelonga is an economic pest of citrus in the Neotropics, causing dieback, premature leaf loss, reduction in yield (due in part to the fruit being smothered with sooty moulds growing on the honeydew egested by the insects) and occasional death of trees. It can also be a serious pest of many ornamental plants including *Bougainvillea* (Fig 6.43.4), *Coccoloba* (Fig. 6.43.1), *Codiaeum* (Fig. 6.43.5), *Malpighia*, *Plumeria* and *Spathodea*, causing leaf loss, dieback, and occasional mortality. The economic importance, damage and control are reviewed by Kondo *et al.* (2013).

6.44 Pink Hibiscus Mealybug

Order: Hemiptera
Family: Pseudococcidae
Species: *Maconellicoccus hirsutus* (Green)

	Present I Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	¡			ü
BVI	I			
Cay	¡			ü
Mon	I			
TCI	¡			ü

Figure 6.44.1 Pink hibiscus mealybug *Maconellicoccus hirsutus* young adult female on a sugar apple *Annona squamosa*, Pakistan © Crown copyright

Background

Maconellicoccus hirsutus commonly known as the pink hibiscus mealybug (or PHM in the Caribbean), hirsutus mealybug or pink mealybug (Figure 6.44.1) is a highly invasive and polyphagous species that has been recorded feeding on hosts from 76 plant families (Ben-Dov & German, 2003) and over 200 plant genera (Levy, 1996). When introduced into tropical countries, *M. hirsutus* attacks a wide range of (usually woody) plants including agricultural, horticultural and forest species. It is a very serious pest in the Caribbean where it attacks many hosts of economic importance and disrupts Caribbean agricultural trade and commerce. Ornamental hibiscus *Hibiscus rosa-sinensis* is one of the preferred hosts and cannot be grown in parts of the Caribbean as the mealybug rapidly kills the plants (Figs 6.44.2-6.44.6).

Geographical Distribution

Maconellicoccus hirsutus is native to southern Asia and occurs in most tropical areas of the world, including Asia, the Middle East, Africa, Australia, and Oceania (OEPP/EPPO, 2005). It has more recently spread to North America and the Caribbean, where it is still extending its range (Kairo *et al*., 2000). Almost all serious damage by *M. hirsutus* has been recorded between 7º and 30º latitude north (Williams, 1996).

Maconellicoccus hirsutus was accidentally introduced into Grenada in 1994 and spread to Anguilla, the British Virgin Islands, Guadeloupe, Jamaica, Martinique, Montserrat, Netherlands Antilles, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, and the US Virgin Islands in the 1990s; and Antigua and Barbuda, Aruba, Bahamas, Barbados and Dominica in the 2000s (OEPP/EPPO, 2005).

Figure 6.44.2 Distorted new growth on a *Hibiscus* plant due to an infestation of *Maconellicoccus hirsutus*, Antigua © C. Malumphy

Figure 6.44.3 *Hibiscus* plant exhibiting leaf loss due to *Maconellicoccus hirsutus*, Antigua © C. Malumphy

Figure 6.44.4 *Maconellicoccus hirsutus* ovisacs on a *Hibiscus* plant, Antigua © C. Malumphy

Figure 6.44.5 *Maconellicoccus hirsutus* are hidden amongst the distorted new growth on a *Hibiscus* plant, Antigua © C. Malumphy

Figure 6.44.6 *Hibiscus* plant killed by *Maconellicoccus hirsutus*. All the adjacent hibiscus plants are infested, Antigua © C. Malumphy

Figure 6.44.7 *Maconellicoccus hirsutus* adult female hiding in a cervice on a sugar apple *Annona squamosa*, India © Crown copyright

Figure 6.44.8 *Maconellicoccus hirsutus* adult female covered in wax on *Hibiscus sabdariffa*, Jamaica © Crown copyright

Host Plants

Maconellicoccus hirsutus attacks a wide range of predominantly woody plants, including many ornamentals, with a preference for Fabaceae, Malvaceae and Moraceae (Mani, 1989; Garland, 1998). The ornamental hibiscus (*Hibiscus rosa-sinensis*) is a typical host which is frequently attacked. However, in the Caribbean it has only developed seriously damaging populations on fewer than 20 plant species (Kairo *et al*., 2000) including soursop (*Annona muricata*), sugar apple (*A. squamosa*), hog plum (*Spondias mombin*), red plum (*S. purpurea*), okra (*Abelmoschus esculentus*), mango (*Mangifera indica*), cotton (*Gossypium hirsutum*), cocoa (*Theobroma cacao*), citrus (*Citrus* spp.), sapodilla (*Manilkara zapota*), Barbados cherry (*Malpighia glabra*), roselle (*Hibiscus sabdariffa*), marsave tree (*Albizia saman*); as well as other ornamentals important to the tourist industry, and forest trees, e.g. blue mahoe (*Hibiscus elatus*) and teak (*Tectona grandis*) (Kairo, 1997; Pollard, 1995).

Description

The description of the life stages of *M. hirsutus* are described by Chong *et al*. (2015) and Mani (1989). Eggs are oval, 0.3 mm in length, orange when freshly laid, turning pink before hatching. Newly hatched nymphs (crawlers) are 0.3 mm long, pink, oval with well-developed legs and antennae. Later instars turn grey-pink and start to secrete a white waxy body coating. There are three immature instars in the female with the males having an additional fourth 'pupal-like' instar. Second instar nymphs average 0.7 mm, third instar nymphs 1.1 mm and male 'pupae' 1.1 mm (Aristizabal *et al.,* 2012). Male second instar nymphs often become bright pink before moulting into the third (pre-pupa) instar. Both the third and fourth instar nymphs are wrapped in tubes of tightly woven wax filaments. Adult females are wingless, oval, flattened, 2-3 mm in length, and purple or grey-pink in colour covered with a wax secretion (Figs 6.44.1 and 6.44.7-6.44.8). Posterior tufts of cotton-like waxy deposits are often present. Adult males have one pair of wings, but are weak fliers, are pink-orange, 1 mm in length and have two long waxy filaments at the posterior end of the abdomen.

Biology

Details of the biology of *M. hirsutus* are provided by Chong *et al.*, (2015) and Mani (1989). *Maconellicoccus hirsutus* forms dense colonies in cracks and crevices within the plant (Figure 6.44.4). Females lay several hundred eggs over 4 to 8 days, into sacs comprising of loosely woven white wax filaments. The eggs hatch after about a week with the entire lifecycle being completed within a month at temperatures above 25ºC (Sagarra & Peterkin, 1999). After egg laying the female dies. Female adults live for about 20 days whereas males only live for a couple of days. Crawlers are very mobile and can survive a day or so without feeding. Crawlers settle at a feeding site in cracks and crevices, usually on new growth, and form densely packed colonies. The upper and lower thresholds for development are 15ºC and 35ºC. There may be as many as 15 generations a year in the Caribbean (Pollard, 1995). The insects inject phytotoxic saliva into the host plant while feeding on the phloem tissues, preferentially attacking growing portions and young stems, flowers and fruits. Host plants differ in their susceptibility to the toxin. More tolerant plant species tend to be infested at their growing points and in stem axils and infested new growth becomes stunted, with reduced internode extension and leaf expansion. In more sensitive plants, stunting is more marked and new growth forms cabbage-like clusters, with the mealybugs hidden in the creases. In highly susceptible plants, even brief probing of unexpanded leaves causes severe crumpling of the leaves (Figs 6.44.2 and 6.44.5), while established infestations can cause total defoliation and even death of the whole plant (Figs 6.44.3 and 6.44.6).

Dispersal and Detection

The first instar or crawler is the main natural dispersal stage. Crawlers cannot walk far but are passively transported over long distances by wind, water, animals and man (CABI, 2017). Cutting down infested plants aids distribution by dispersing the crawlers into the air (Dale & Maddison, 1984). Prunings of infested plants, and the clothing, tools and vehicles of agricultural workers can become contaminated with the crawlers which aids in their dispersal. Agricultural commerce is also responsible for spread of the pest. Accidental introduction to new territories is highly possible through the movement of infested living plant material through shipping or air transport/mail, particularly of ornamental plants, cut flowers, vegetative propagation other than meristem culture, fruit and vegetables (CABI, 2017).

Examination of host plants with the characteristic symptoms of mealybug infestation is the simplest method to detect the pest. Symptoms include: buds not opening, shrivelling and dying, small and deformed fruits, fruits and leaves covered in a white waxy coating, curling and contortion of leaves, bunched or unopened leaves, stunted plant growth, shoot tips with a bushy appearance, stunted and swollen growth points and twisted twigs. Honeydew egested by mealybugs coats the outside of fruits and leaves and promotes the growth of sooty mould fungus that inhibits photosynthesis, weakens the plant, attracts ants and makes fruit unattractive. For larger scale surveys, sticky cards baited with a sex pheromone can be used to catch adult males and allow for detection in areas where mealybug densities are low and infestations not readily apparent (Francis *et al*., 2007).

Economic and other Impacts

In the first few years of the mealybug problem in the Caribbean, affected countries suffered serious loss of trade because other countries would not accept shipments of agricultural produce (Peters & Watson, 1999). Transport of fruit and vegetables between the Caribbean islands virtually ceased with the imposition of quarantine restrictions on the importation of fresh produce into Trinidad (Pollard, 1995), although pre-export inspections did allow imports from some affected countries to continue.

Before biological control programmes were implemented, *M. hirsutus* had a devastating impact on the agriculture, natural forests and tourism of Grenada (Peters & Watson, 1999), damaging foreign exchange, trade in agricultural products, and the local ecology and water economy. Francois (1996) estimated annual losses in Grenada due to *M. hirsutus* damage to be US$ 3.5 million before biological controls were established. Peters (1999) estimated Grenada's overall losses and costs at US$ 18.3 million, of which the control programme cost US$ 1.1 million. Overall losses and costs to Saint Kitts in 1995-1997 were estimated by Francis (1999) as US$ 280,000, inclusive of control costs. For Saint Lucia, losses were estimated at US$ 67,000 (Anon., 1999), and for Saint Vincent and the Grenadines losses were estimated at US$ 3.4 million between 1996-1998 (Edwards, 1999). Costs of over US$ 5.1 million were incurred in Trinidad in 1997 because of the socio-economic impact of *M. hirsutus* (Singh, 1999).

In Grenada, the mealybug was unchecked for the first year and it caused extensive damage to amenity plantings and landscaped gardens in hotels, resulting in serious losses to the tourist industry. Cash crops produced little or no return for 1-2 years, which impacted on farming income and agricultural trade (Peters & Watson, 1999). Severe devastation was also observed in natural habitats, for example, a stand of 38 ha of blue mahoe (*H. elatus*) was destroyed (Peters & Watson, 1999; Kairo *et al.*, 2000).

6.45 Lantana mealybug

Order: Hemiptera
Family: Pseudococcidae
Species: *Phenacoccus parvus* Morrison

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	l			
BVI	¡			ü
Cay	l			
Mon	¡			ü
TCI	¡			ü

Figure 6.45.1 Lantana mealybug *Phenacoccus parvus* adult female on *Hygrophila*, Sri Lanka © Crown copyright

Background

Phenacoccus parvus is native to the Neotropical region and has spread rapidly in the warmer parts of the world since the 1980s (Williams & Cox, 1984; Williams & Granara de Willink, 1992). It is commonly known as the Lantana mealybug and Morrison's small mealybug. Attributes that have facilitated its naturalization in new areas after accidental transport on host plant material include: small size; the fact that it is relatively cryptic and may occur on the roots; that it is widely polyphagous on perennial plants; its parthenogenetic nature; and that it has a high biotic potential. It is a serious pest of *Lantana* and can also feed on a range of crops. It poses a threat to all the UKOTs in the Caribbean.

Geographical Distribution

Phenacoccus parvus occurs widely in the Neotropical region (Fig. 6.45.2) although its precise native range is unclear. It has recently spread widely in tropical and subtropical areas throughout the world. In the Caribbean it has been recorded from Antigua and Barbuda, Bahamas, Bermuda, Cayman Islands, Cuba, Dominica, Guadeloupe, Martinique, Puerto Rico & Vieques Island, Saint Kitts and Nevis Islands, Saint Lucia, Trinidad and Tobago, and the U.S. Virgin Islands (Williams & Granara de Willink, 1992; Williams & Cox, 1984).

Figure 6.45.2 *Phenacoccus parvus* distribution map © CABI

Host Plants

Phenacoccus parvus is broadly polyphagous and has been recorded feeding on more than 70 host plant species in 28 plant families, including many crop and ornamental plants. However, it exhibits a strong preference for *Lantana*. Marohasy (1997), who conducted extensive experimental work on host preferences, showed that many recorded hosts were incapable of sustaining populations of the mealybug for more than a couple of generations, unless an infested lantana was nearby to keep re-populating them. It is recorded on many tropical, subtropical and temperate crops including okra (*Abelmoschus esculentus*), kiwi fruit (*Actinidia deliciosa*), garlic (*Allium sativum*), celery (*Apium graveolens*), beet (*Beta vulgaris*), bell or sweet peppers (*Capsicum annuum*), chilli pepper (*Capsicum frutescens*), cucumber (*Cucumis sativus*), carrot (*Daucus carota*), soya bean (*Glycine max*), cotton (*Gossypium* spp.), sunflower (*Helianthus annuus*), tomato (*Solanum lycopersicum*), purple bush bean (*Macroptilium atropurpureum*), mango (*Mangifera indica*), curry plant (*Murraya paniculata*), banana (*Musa* spp.), black pepper (*Piper nigrum*), guava (*Psidium guajava*), sugarcane (*Saccharum officinarum*), Ethiopian eggplant (*Solanum aethiopicum*), aubergine (*Solanum melongena*), Turkey berry (*Solanum torvum*), and potato (*Solanum tuberosum*). It has also been recorded feeding on ornamental plants, including chrysanthemum (*Chrysanthemum* spp.), poinsettia (*Euphorbia pulcherrima*), and orchids (*Oncidium* spp.); and on weeds, e.g. dandelion (*Sonchus oleraceus*), and grasses (Poaceae).

Description

All developmental stages of *P. parvus* occur on the bark, foliage, fruits and shallow roots of the host plant. Adult females (Fig. 6.45.1) are oval, somewhat flattened dorso-ventrally, light yellow, covered by a thin, white, mealy wax, with 18 pairs of short marginal wax filaments. Each female produces an ovisac ventrally, that is long and cylindrical, and up to 3 times the length of her body. It cannot be identified in the field as it is similar in appearance to many other mealybug pest species.

Phenacoccus is one of the largest genera of pseudococcids, with 201 species currently assigned to it. *Phenacoccus parvus* can only be identified accurately by microscopic examination of a slide-mounted, teneral adult female. Morphological descriptions and illustrations are provided by Williams and Watson (1988), Williams and Granara de Willink (1992), Williams (2004) and by Granara de Willink and Szumik (2007).

Biology

The biology of *P. parvus* has been studied in Australia (Marohasy, 1997). It is facultatively parthenogenetic, with fecundity and generation times varying with host species. Each female can produce an average of 337 crawlers when reared on tomato plants, and generation times generally fall within the range of 25-33 days under laboratory conditions (Marohasy, 1997). It therefore has a high biotic potential (i.e. many offspring per individual and many generations per year).

Dispersal and Detection

The first nymphal instar or crawler of *P. parvus* is the main natural dispersal stage. They may wander over the host plant or be dispersed by being blown by the wind, or by hitch-hiking on other organisms. Prunings of infested plants, and the clothing, tools and vehicles of agricultural workers, can become contaminated with crawlers and so aid in their dispersal. The rapid expansion in distribution of *P. parvus* in recent decades can only be explained by the mealybug being accidently transported over long distances in shipments of infested commodities, particularly plants for planting.

Phenaococcus parvus nymphs and adults are usually found along major veins on the lower surfaces of the leaves, on the stems, growing points and fruit of host plants. The mealybugs congregate in large masses and the white ovisacs can be conspicuous. Long-established infestations may be often surrounded by sooty mould growth, and may be attended by ants.

Economic and other Impacts

Phenacoccus parvus feeds on the plant phloem, which weakens the host. Susceptible plants can suffer complete leaf loss, a reduction in the number of flowers and fruit, and dieback. Young leaves are distorted, and fruit may be unmarketable due to the presence of the insect. In addition, the mealybug egests excess sugar-rich plant sap as 'honeydew'; this encourages the growth of black sooty mould, detracting from the aesthetic appeal of ornamental plants, reducing their area of photosynthesis and gas exchange, and promoting leaf drop.

In Queensland, Australia, *P. parvus* developed heavy populations on *Lantana camara* and caused severe damage to this weed, to the extent that this mealybug species was considered for use as a biological control agent (Marohasy, 1994, 1997). However, Swarbrick & Donaldson (1991) demonstrated its wide range of host plants and found that it developed heavy infestations on celery (*A. graveolens)*, cucumber (*C. sativus*), tomato (*S. lycopersicum*) and mango (*M. indica*) in greenhouse studies. Despite the fact that it can feed on numerous important crops and ornamental plants, there have been very few reports of it causing economic damage (Marohasy, 1994, 1997). It has only recently spread widely in Africa, Asia and the Pacific, and to the eastern Mediterranean, and may have a greater negative impact in the future, as it becomes more abundant.

6.46 Bougainvillea Mealybug

Order: Hemiptera
Family: Pseudococcidae
Species: *Phenacoccus peruvianus* Granara de Willink

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	¡			ü
BVI	¡			ü
Cay	¡			ü
Mon	¡			ü
TCI	¡			ü

Figure 6.46.1 Colony of Bougainvillea mealybug *Phenacoccus peruvianus* on *Bougainvillea* causing necrosis and dieback © Fera

Background

Phenacoccus peruvianus is a South American mealybug pest of bougainvillea and was first described in 2007. Prior to being named, however, it had already been introduced into Europe and was spreading rapidly in the western Mediterranean (Beltrà *et al*., 2010). It is commonly known as the bougainvillea mealybug because of its preference for this host. The mealybug populations damage the plants by causing necrosis of the foliage, leaf loss and die back (Fig. 6.46.1).

Geographical Distribution

Bougainvillea mealybug is native to South America (Argentina, Peru) and has been introduced into Europe, being first recorded in 1999 from Almeria, Spain. Since then it has naturalised along the Mediterranean coast of France, Monaco and Spain, southern coast of Portugal, and in the Balearic Islands, Corsica and Sicily (Beltrà *et al*., 2010). It has also been found in glasshouses in Austria, and incursions have occurred in England on indoor plantings and on sheltered plants outdoors (Malumphy, 2011; Malumphy & Eyre, 2011).

Host Plants

Bougainvillea mealybug is polyphagous, occurring on woody plants belonging to nine families: Acanthaceae (*Justicia* spp.); Amaranthaceae (*Alternanthera* spp.); Asclepiadaceae (*Araujia* spp.); Asteraceae (*Baccharis* spp., *Eupatorium* spp.); Aucubaceae (*Aucuba* spp.); Myoporaceae (*Myoporum* spp.); Nyctaginaceae (*Bougainvillea* spp.); Scrophulariaceae (*Budleja* spp.); Solanaceae (*Capsicum* spp., *Cestrum* spp., *Solanum* spp.). It occurs most frequently on bougainvillea (Beltrà *et al*., 2010; García Morales *et al*., 2016).

Figure 6.46.2 Bougainvillea mealybug female, UK © Fera

Figure 6.46.3 Bougainvillea mealybug, second nymphal instar female; they can wander over the foliage relatively quickly, UK © Fera

Figure 6.46.4 Bougainvillea mealybug ovisacs occur in conspicuous clusters on the foliage and stems © Fera

Figure 6.46.5 Bougainvillea mealybug, close-up of the dense white waxy ovisacs and an adult female © Fera

Figure 6.46.6 Apical stem on a bougainvillea plant killed by an infestation of bougainvillea mealybug, Morocco © C. Malumphy

Figure 6.46.7 Bougainvillea mealybug infestation attended by ants, Morocco © C. Malumphy

Description

Adult females (Figs 6.46.2 and 6.46.5) are elongate oval, greyish with a green tinge, covered in a thin layer of mealy white wax, and attain a length of 3.0 mm (Malumphy & Eyre, 2011). They may be may

be distinguished in life from other mealybugs commonly found on indoor plantings in Britain by the lack of marginal and caudal wax filaments, which are well developed in *Pseudococcus* species and moderately developed in citrus mealybug *Planococcus citri*. The immature stages (Fig. 6.46.2) are similar in appearance to the adults but smaller. They can move relatively quickly, or at least more quickly than most mealybugs encountered in Britain. The first instars are a pale-orange colour and are very small being about 0.4 mm long. Bougainvillea mealybug forms dense colonies, usually on the apical shoots (Figs 6.46.6-6.46.7).

Biology

Adult and nymph bougainvillea mealybugs feed mainly on the lower surfaces of the foliage, but are also found on the growing shoots, bark, and occasionally the upper leaf surfaces. In Britain, all developmental stages have been found in July and September; this mealybug appears to be able to breed continuously if environmental conditions are favourable. No males have been observed suggesting that reproduction may be parthenogenetic, although this has not been proven (Malumphy & Eyre, 2011).

Dispersal and Detection

The first nymphal instars, or crawlers, have a relatively low natural dispersal potential and often settle to feed within a short distance of their parent. Some of the crawlers may be dispersed over longer distances by air currents or by other animals. Dispersal is likely to occur more rapidly and over longer distances with the movement of infested plants in trade. The rapid spread in the western Mediterranean is most likely to be due to movement of mealybugs in trade (Malumphy, 2011).

Infestations of bougainvillea mealybug are readily detected by the highly conspicuous white wax, elongate ovisacs that form dense groups on the undersides of the foliage and on the stems (Figs 6.46.1 and 6.46.4-6.46.6). The foliage is contaminated with honeydew egested by the mealybugs, which serves as a medium for the growth of sooty moulds that can disfigure the plants. The mealybugs may also be detected by the presence of ants (Fig. 6.46.7), and less frequently wasps and flies, which feed on the honeydew egested by the insects (Malumphy & Eyre, 2011).

Economic and other Impacts

There is very little information published on the economic importance of bougainvillea mealybug, but it has caused significant damage to ornamental bougainvillea plants in Britain, ruining their aesthetic appearance and reducing their market value. It has also damaged a crop of sweet peppers grown in a glasshouse in Austria. Large mealybug populations cause necrosis of the foliage, leaf loss, die back, and moulds grow on the egested honeydew (Malumphy, 2011; Malumphy & Eyre, 2011).

6.47 Cotton Mealybug or Solenopsis Mealybug

Order: Hemiptera
Family: Pseudococcidae
Species: *Phenacoccus solenopsis* Tinsley

	Present l Absent ¡	Threat		
		Bio	Hlth	Econ
Ang	¡			ü
Ber	¡			ü
BVI	¡			ü
Cay	l			
Mon	¡			ü
TCI	¡			ü

Figure 6.47.1 Cotton mealybug *Phenacoccus solenopsis* adult female showing the characteristic dark dorsal markings, on basil *Ocimum* basilicum from Jordan © C. Malumphy

Background

Phenacoccus solenopsis is native to North America and a major mealybug pest of many crops, particularly cotton and herbs. Over the last few decades, this highly invasive pest has spread throughout the subtropical and tropical areas of the world. It is commonly known as the solenopsis or cotton mealybug because of its preference for those host plants, it is however a highly polyphagous pest recorded on more than 200 plant species. The mealybug populations damage the plants by causing yellowing and malformation of the foliage, leaf and fruit drop, die back and death of susceptible plants.

Geographical Distribution

Phenacoccus solenopsis is thought to have originated from North America, as it was first described from New Mexico, USA in 1898, and is widespread in the south-eastern states (Miller, 2005). With the increase in international trade over the last few decades, this invasive pest expanded widely outside its native range and has established in the Afrotropical, Australasian, Nearctic, Neotropical and Oriental regions. By July 2009, it had been recorded from 24 countries on five continents. The publication of ten new country records since 2008 indicates that its distribution has expanded rapidly. In 2010 it reached Europe (Cyprus) and has since become a damaging pest of a range of ornamental plants, vegetable crops, and grapevine (EPPO, 2014).

Figure 6.47.2 *Phenacoccus solenopsis* first instar nymphs or crawlers on the calyx of an aubergine *Solanum melongena* from Kenya © Crown copyright

Figure 6.47.3 *Phenacoccus solenopsis* adult female on *Amaranthus tricolor* from Bangladesh © Crown copyright

Figure 6.47.4 *Phenacoccus solenopsis* adult female hiding amongst the foliage of basil *Ocimum* basilicum from Israel © C. Malumphy

Figure 6.47.5 *Phenacoccus solenopsis* adult female on a vegetable from West Africa. The characteristic dark narkings are obscured by wax © Crown copyright

Figure 6.47.6 Large infestation of *Phenacoccus solenopsis*, Turkey © Zeynel Cebeci, Wikimedia commons

Figure 6.47.7 *Phenacoccus solenopsis* adult females, Turkey © Zeynel Cebeci, Wikimedia commons

The first records for *P. solenopsis* in the Caribbean Islands and Central America are from 1986 onwards (Wang *et al*., 2010). Specifically, in the Caribbean it has been introduced to the Cayman Islands, Cuba, Dominican Republic, Guadeloupe, Haiti, Jamaica and Saint Martin and Saint Barthelemy (CABI, 2017; García Morales *et al*., 2016).

Host Plants

Cotton mealybug is highly polyphagous as it attacks numerous crops, weeds, ornamentals and medicinal plants in 61 Families and 186 Genera (García Morales *et al*., 2016). Cotton (*Gossypium hirsutum*) is one of its most favoured hosts and it is most commonly found on plants the families Fabaceae, Amaranthaceae, Malvaceae and Asteraceae.

Description

Adult females are 2-5 mm long, oval, dark green to almost black in colour and covered with a white powdery, waxy secretion. They usually have a pair of broken, longitudinal blackish lines on the dorsum. These are typically highly conspicuous (Figs. 6.47.1 and 6.47.3-6.47.4) but may be obscured by waxy secretions (6.47.5) or completely missing in teneral adults. A series of waxy filaments extend from around the margin of the body with the pair of terminal filaments longest. These are easily knocked off and lost (Fig. 6.47.4). The ovisac is composed of fluffy, loose-textured wax strands (McKenzie, 1967).

Hodgson *et* al. (2008) provided comprehensive morphological descriptions and illustrations for the immature stages of the mealybug. The female has three nymphal stages and the male has five.

Accurate identification of *Phenacoccus* species requires specimens to be mounted on microscope slides and to be studied under high magnification by a specialist. The microscopic features of *P. solenopsis* are described and illustrated by Williams & Willink (1992).

Biology

According to Huang *et al*. (2013) and Suroshe, *et al.* (2016), *P. solenopsis* only reproduces sexually and not parthenogenetically. Their studies have shown that only eggs produced by mated females develop into progeny. Unmated females lay unfertile eggs. Each female lay between 150 to 600 eggs, protected within a waxy ovisac (Lu *et al.,* 2008). The period of development from crawler to adult stage is approximately 25-30 days, depending upon the weather and temperature. This species can produce multiple generations annually (CABI, 2017)

Phenacoccus solenopsis usually feeds above ground, but sometimes can be found living mutualistically in ants' nests (*Solenopsis* sp.), on the roots of its host plants (García Morales *et al*., 2016). The mealybugs feed on the plant by extracting sap from cells in the leaves or stems using their piercing-sucking mouthparts.

Dispersal and Detection

The first nymphal instars, or crawlers, have a relatively low natural dispersal potential and often settle to feed within a short distance of their parent. Some of the crawlers may be dispersed over longer distances by air currents or by other animals, on cuttings, farm machinery and on human clothing. Dispersal is likely to occur more rapidly and over longer distances with the movement of infested plant material, partcilarly plants for planting, in trade. The mealybug was reportedly introduced to India on cotton boll imported from the USA (Cabi, 2017).

Above ground infestations of cotton mealybug are readily detected by the highly conspicuous white wax, elongate ovisacs that form dense groups on the undersides of the foliage and on the stems. The foliage is contaminated with honeydew egested by the mealybugs, which serves as a medium for the

growth of sooty moulds that can disfigure the plants. The mealybugs may also be detected by the presence of ants, and less frequently wasps and flies, which feed on the honeydew egested by the insects.

Economic and other Impacts

Phenacoccus solenopsis is a major economic pest in many parts of the world. It recently invaded the Indian subcontinent, where it has become a major pest of cotton, reducing yields by around 35%. Infested plants are stunted, leaves become distorted, turn yellow and drop, and only a few small bolls may be produced. In addition, the honeydew egested by the mealybug is colonized by sooty mould, which inhibits photosynthesis and further retards cotton growth and reduces market value. It causes serious damage to commercially grown crops, including a variety of vegetables, including grapes (*Vitis vinifera*), jute (*Corchorus* spp.), mesta (*Hibiscus cannabinus*) and tobacco (*Nicotiana* spp) (CABI, 2017). It is commonly intercepted in the UK on fresh herbs imported from Africa and the Middles East.

Pakistan and India are heavily dependent on the production of cotton and this mealybug has had a significant economic, environmental and social impact since its arrival in 2005. In Pakistan, economic crop losses of an estimated 14% and a 44% reduction in seed-cotton yields occurred during that year (CABI, 2017). Numerous expensive applications of insecticides have been required to produce and protect the cotton crop (e.g. US$ 121.4million was used in the Punjab region in just two months in 2007) (Hodgson *et al*., 2008). The additional pest control requirements lead to a reduced profit margin for producers and impact negatively on the environment (CABI, 2017).