

# *Chrysodeixis chalcites*

## Scientific Name

*Chrysodeixis chalcites* (Esper, 1789)

## Synonyms:

*Autographa chalcites*, *Chrysodeixis chalcytes*, *Noctua chalcites*, *Noctua chalcytes*, *Noctua chalsytis*, *Noctua questionis*, *Phalaena chalcites*, *Plusia buchholzi*, *Plusia chalcites*, *Plusia chalcytes*, *Plusia cohaerens*, *Phytometra chalcites*

Note: Zhang (1994) states that Asian and Australian citations referring to *Chrysodeixis chalcites* actually refer to *C. eriosoma*, whereas Murillo et al (2013) state that the relationship between the two species needs further clarification. Lafontaine and Schmidt (2013) state that the only way to distinguish between the two species is by looking at geographic range, DNA, and pheromones.

## Common Name(s)

**Golden twin-spot moth**, green garden looper, green looper, green semi-looper, groundnut semi-looper, tomato leafworm, tomato looper

## Type of Pest

Moth

## Taxonomic Position

**Class:** Insecta, **Order:** Lepidoptera, **Family:** Noctuidae

## Reason for Inclusion in Manual

National threat; Requested by the CAPS community

## Pest Description

Eggs: Eggs are pearly white to pale green and shiny. They are dome-shaped (hemispherical) with 28 to 32 vertical ribs from the micropyle to the base (Bretherton, 1983; Goodey, 1991). The eggs darken shortly before hatching (Harakly and Farag, 1975).

Larvae: Newly hatched larvae are dusky white, with head and thoracic shield blackish. The setae on the body are long and conspicuous, with thin,



**Figure 1.** Larva of *C. chalcites* (Steve Hatch, Bugwood.org).

longitudinal white lines along the sides; both become less obvious in the last instar. Soon after feeding, the larvae become light green in color (Harakly and Farag, 1975). Mature larvae are 34 to 38 mm (approx.  $1 \frac{5}{16}$  to  $1 \frac{1}{2}$  in) long, pale yellow-green with a glassy green to grey head edged with a black streak (Fig. 1). Above the spiracles on each side of the body is a thin dark green or black line stretching from the head to the seventh abdominal segment; below this is a thicker white line from the head to the tip of the anal proleg. Spiracles are black. The ventral region is speckled with white dots (Haggett, 1980; Bretherton, 1983; Passoa and Gilligan, 1995; Porter, 1997). Larvae have only three pairs of prolegs, instead of the normal five, resulting in the looping gait giving rise to some of the common names. Haggett (1980) provides a detailed description and color illustration of the final larval instar.

**Pupae:** The pupa is 20 mm (approx.  $\frac{3}{4}$  in) long, black in a white cocoon (Fig. 2), which turns brown then black (Harakly and Farag, 1975; Bretherton, 1983).

**Adults:** The adult wingspan is approximately 40 mm (approx.  $1 \frac{9}{16}$  in). The forewing is 15 to 17 mm (approx.  $\frac{9}{16}$  to  $1 \frac{1}{16}$  in), usually gold, although some individuals have more of a bronze color (Fig. 3). There are two oval silver spots on the forewings, although in some individuals these are united. The hindwing is paler than the forewing. There are two prominent crests on the thorax (Pinhey, 1979; Bretherton, 1983; Passoa, 1995a).

Further description of the life stages can be found in Goodey (1991) and Passoa (1995b).

## Biology and Ecology

*Chrysodeixis chalcites* is a polyvoltine species, with up to eight or nine generations per year in Egypt (Rashid et al., 1971). After emergence, females mate then begin oviposition within two or three days (Gasim and Younis, 1989). Eggs are laid on upper



**Figure 2.** Pupa of *C. chalcites* (Paolo Mazzei, Bugwood.org)



**Figure 3.** Adult of *C. chalcites* (Perry Hampson, Bugwood.org).

and lower leaf surfaces at night, whilst females are on the wing. Females only briefly touch the leaf to deposit one, two, or a few eggs at a time. Eggs are very widely scattered in the crop (Linden, 1996). At 20°C (68°F), egg incubation lasts between 5 and 26 days (Gaumont and Moreau, 1961).

Reports in the literature show considerable variation in the number of eggs oviposited by *C. chalcites*. Harakly and Farag (1975) reported females lay from 14 to 281 eggs with a mean of 149. In contrast, Gasim and Younis (1989) reported the mean number of eggs laid per female to be much higher with 385, 640, and 405 eggs at 20, 25 and 30°C (68, 77, 86°F), respectively.

Gasim and Younis (1989) studied the development rate of *C. chalcites* eggs at three temperatures, 20, 25, and 30°C (68, 77, 86°F). The mean length of time between oviposition and egg hatch decreased with increasing temperature. At 20°C (68°F), eggs took 4.5 days to hatch; at 25°C (77°F), they took an average of 3.0 days; and at 30°C (86°F), they took 2.0 days.

The majority of the larvae pass through six instars. Very few may have four or seven instars. At the optimal temperature of 25°C (77°F), there are six larval instars, each lasting approximately 2.5 to 3.5 days (Rashid et al., 1971; Harakly and Farag, 1975). First instar larvae graze on the underside of leaves feeding on parenchyma. They can be quite difficult to detect. A larva will drop from the leaf and hang on a silken thread if disturbed (Goodey, 1991). During the second and third instars, the larva begins to roll the edges of the leaves together, and silken threads are spun on infested leaves (Rashid et al., 1971). Later instars eat through the leaves making infested leaves appear skeletonized. The last two larval instars are the most voracious feeders and will usually eat the entire leaf but may avoid the midrib or other large veins. On legumes, they may excavate deep into pods, sometimes cutting them in two.

The mature larva stops feeding and enters a prepupal stage. It spins a cocoon within which it pupates. The cocoon is usually attached to the underside of a leaf but can be in the soil (Harakly and Farag, 1975). The pupal duration is affected by climatic conditions; duration increases in lower temperatures (Harakly and Farag, 1975). Gaumont and Moreau (1961) reported that the pupal period lasted 15 to 26 days, although at the optimal temperature of 25°C (77°F) it averaged 8.8 days (Rashid et al., 1971).

Adults emerge at dusk and throughout the night and soon begin to fly and mate. Males are ready to mate just after emergence, but females usually mate one to four days after emergence (Harakly and Farag, 1975). Females reach peak activity on the 4th night after emergence. Adults rest with their wings folded over their back like a tent. Adults are seminocturnal and usually avoid strong sunlight. Generations continually breed through the year with no diapause. There are nine generations per year in Egypt (Harakly and Farag, 1975).

## Damage

Leaves may be skeletonized by larval feeding (Taylor and Kunjecku, 1983). Leaves may also be rolled with webbing (CABI, 2007). Frass may or may not be visible. The last two larval instars are the most voracious feeders and will usually eat the entire leaf but may avoid the midrib or other large veins. It has been reported that on legumes *C. chalcites* may excavate deep into pods, sometimes cutting them in two.

### Solanaceous Hosts:

In tomato, this species can cause considerable damage to the leaves and vegetative parts of the plant. According to Harakly and Farag (1975), larvae never bore into fruit. However, Daricheva et al. (1983) found that larvae damaged both the leaves and fruits of tomatoes, leading to reduced yield. Napiórkowska-Kowalik and Gawłowska (2006) also recorded this species feeding on both leaves and fruits of tomatoes.

## Pest Importance

*Chrysodeixis chalcites* is a polyphagous polyvoltine species that feeds on the foliage and fruit of vegetable, fruit, and ornamental crops. It is considered one of the most serious lepidopteran pests in many countries, although quantitative data measuring damage is lacking (CABI, 2007). In Egypt, *C. chalcites* is considered the most serious of all semi-loopers attacking field fruit and vegetables (Anon., 1984). Hill (1983) lists this species as a minor pest of *Brassica* spp., cotton, okra, tobacco, and tomato.

In Israel, *C. chalcites* is also one of the most important noctuid pests of fodder crops, such as alfalfa and clover (Avidov and Harpaz, 1969). This species also feeds on alfalfa, maize, and soybean in Spain (Amate et al., 1998). It also attacks fields of artichokes (Ippolito and Parenzan, 1985).

### Greenhouse crops:

In protected cultivation, *C. chalcites* can occur at any time of the year and can reach high levels of infestation on vegetables and ornamental plants. *Chrysodeixis chalcites* is one of the four main noctuid pests of greenhouse crops in Sicily (Inserra and Calabretta, 1985) and a continual pest in greenhouses in the Netherlands (Vos and Rutten, 1995) and Belgium (Veire, 1983).

### Solanaceous hosts:

Larvae of *C. chalcites* feed on the leaves of solanaceous plants (EPPO, 2004). *Chrysodeixis chalcites* is the major pest of tomato in Israel during the growing season (Broza and Sneh, 1994). It causes considerable damage to the leaves and vegetative parts of the plant although it does not bore into the fruit (Harakly and Farag, 1975). Daricheva et al. (1983) state that larvae were found to damage leaves and fruits of tomatoes in greenhouses in Turkmenistan. Yield was reduced by 10 to 15%, especially in soft-fruited varieties. Most damage was attributed to mid- and late instar larvae (Daricheva et al., 1983). *C. chalcites* is reported as a serious pest in Bulgaria and Turkey (Loginova, 1992; Uygun and Ozgur, 1980) affecting tomato, cucumber and peppers. This species is also a major pest in Dutch greenhouses on both sweet pepper

and tomato (van Oers et al., 2004). It is a serious pest of potato in Mauritius (Anon., 1984).

#### Soybean:

In northern Italy, *C. chalcites* is one of the principal arthropod pests on soybean (Zandigiacomo, 1990). Yield loss can be seen if larvae feed during the soybean reproductive stages (Taylor and Kunjeku, 1983).

### Known Hosts

“*Chrysodeixis chalcites* is highly polyphagous, feeding on many fruit, vegetable and ornamental crops, and weeds in many plant families including Acanthaceae, Asteraceae, Bignoniaceae, Boraginaceae, Brassicaceae, Convolvulaceae, Crassulaceae, Lamiaceae, Fabaceae, Malvaceae, Orchidaceae, Rosaceae, Scrophulariaceae, Solanaceae, Verbenaceae and Violaceae. It can be a pest of crops grown outdoors and in protection, including both shade and greenhouses” (CABI, 2007). An abbreviated record of hosts follows (CABI, 2007):

#### Major hosts

*Glycine max* (soybean), *Gossypium herbaceum* (short staple cotton), *Nicotiana tabacum* (tobacco), *Phaseolus* spp. (beans), *Phaseolus vulgaris* (common bean), *Solanum lycopersicum* (tomato), and *Solanum tuberosum* (potato).

#### Minor hosts

*Anethum graveolens* (dill), *Arachis hypogaea* (peanut), *Aster* spp., *Brassica oleracea* var. *botrytis* (cauliflower), *Brassica oleracea* var. *capitata* (cabbage), *Brassica* spp., *Capsicum annuum* (bell pepper), *Chrysanthemum indicum* (chrysanthemum), *Citrus* spp., *Coffea arabica* (coffee), *Cucumis sativus* (cucumber), *Cucurbita pepo* (zucchini), *Cynara cardunculus* subsp. *cardunculus* (= *C. scolymus*) (artichoke), *Dahlia* spp., *Dianthus* spp. (carnation), *Ficus carica* (fig), *Fragaria* spp., *Helianthus tuberosus* (Jerusalem artichoke), *Hippeastrum* hybrids (amaryllis), *Lactuca sativa* (lettuce), *Medicago sativa* (alfalfa), *Musa* spp. (banana), *Pelargonium* spp. (geranium), *Salvia officinalis* (common sage), *Stachytarpheta jamaicensis* (Jamaica vervain), *Trifolium repens* (white clover), *Triticum aestivum* (wheat), and *Zea mays* (corn).

#### Wild hosts

*Echium vulgare* (viper's-bugloss), *Marrubium* spp. (horehound), *Teucrium scorodonia* (wood germander), and *Urtica dioica* (stinging nettle).

This species has been found on tomato and green beans in Canada (Murillo et al., 2013).

### Pathogens or Associated Organisms Vektored

*Chrysodeixis chalcites* is not a known vector and does not have any associated organisms.

## Known Distribution

Distribution information for *C. chalcites* is difficult to ascertain because older records are now considered to be two species, *C. chalcites* (Africa, Mediterranean, and the Middle East) and *C. eriosoma* (Asian tropics, Australia, and New Zealand).

*Chrysodeixis chalcites* is primarily distributed between 45°N and 35°S, from southern Europe and the Mediterranean and the Middle East to Africa (CABI, 2007; Murillo et al., 2013).

**Africa:** Algeria, Angola, Cameroon, Cape Verde, Comoros, Congo, Cote d'Ivoire, Egypt, Gambia, Guinea, Kenya, Libya, Madagascar, Malawi, Mauritius, Morocco, Mozambique, Nigeria, Reunion, Saint Helena, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Tunisia, Uganda, Zambia, and Zimbabwe;  
**Europe:** Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, France (including Corsica), Germany, Gibraltar, Greece (including Crete, Cyclades Islands, and Dodecanese Islands), Hungary, Italy (including Sardinia and Sicily), Macedonia, Malta, Moldova, Netherlands, Poland, Portugal (including Azores and Madeira), Romania, Serbia, Slovenia, Spain (including Balearic Islands and Canary Islands), Sweden, Switzerland, Ukraine, and the United Kingdom;  
**Middle East:** Iran, Iraq, Israel, Jordan, Lebanon, Syria, Turkey and Turkmenistan;  
**North America:** Canada (Daricheva et al., 1983; CABI, 2007; Fibiger and Skule, 2011).

“*Chrysodeixis chalcites* immigrants from North Africa or southern Europe, borne on strong southerly winds, are sometimes recorded in central and northern Europe (Austria, Denmark, Germany, Sweden, Switzerland and the United Kingdom) in the late summer or autumn (Jor, 1973; Bretherton, 1983; Hachler et al., 1998; Palmqvist, 1998, 2002). There are about 50 records of *C. chalcites* as a migrant to the UK between 1943 and 1990 (Bretherton, 1983). Outdoor breeding populations occur in Europe as far north as northern Spain and northern Italy. No successful breeding is reported outdoors in northern Europe” (CABI, 2007).

“Lempke (1982) and Vos and Rutten (1995) noted that *C. chalcites* is present all year round in greenhouses in the Netherlands. Veire (1993) reported populations established in greenhouses in Belgium. However, there is no evidence that *C. chalcites* can overwinter outdoors in the Netherlands (Lempke, 1982) or elsewhere in northern Europe” (CABI, 2007).

In January 2006, a detection of either *C. chalcites* or *C. eriosoma* was made in two vegetable production greenhouses in Delta, British Columbia Canada. The pest has been found in subsequent surveys; delimitation surveys continue; and the area has been put under compliance agreement to prevent further spread. As of May 2007, no further detections have been made and the greenhouses have been released from quarantine. See the following pest alerts for further information:

<http://www.pestalert.org/oprDetail.cfm?oprID=187>,  
<http://www.pestalert.org/oprDetail.cfm?oprID=237>,

<http://www.pestalert.org/oprDetail.cfm?oprID=264>.

This species was recently found in the counties of Essex and Chatham-Kent, southwestern Ontario, Canada in tomato and bean crops. It is unknown whether the moth overwinters in southwestern Ontario or if it overwinters further south, migrating to Ontario during the spring. Murillo et al. (2013) suggest that this species is most likely established in field tomato crops in the United States, specifically in Michigan, Ohio, and New York (Murillo et al., 2013). However, this has not been confirmed by surveys conducted in the United States.

Note: Lafontaine and Schmidt (2013) state that this species is present in Michigan; however, this record cannot be verified. Lafontaine and Schmidt (2013) cited Murillo et al. (2013). Murillo et al. (2013) state that they believe *C. chalcites* is present in Michigan, but they do not provide any records of its occurrence there. There are currently no known records of this species from Michigan.

## Pathway

There have been over 300 interceptions of this pest from 1984 to the present. This species has been intercepted on material originating from multiple countries. The most interceptions have occurred on material originating from the Netherlands (229) and Israel (28). The species has been intercepted on many different plant species including: *Lycopersicon* sp. (57), *Capsicum* sp. (22), *Bupleurum* sp. (12), *Ocimum* sp. (11), *Cymbidium* sp. (11), *Celosia* sp. (10), *Gloriosa* sp. (10), *Hydrangea* sp. (12), and *Mentha* sp. (10). *Chrysodeixis chalcites* has also been intercepted on non-host material including: aircraft (3), cargo (1), containers (1), and tiles (1) (AQAS, 2012; queried June 28, 2012). This species has also been intercepted by California (CDFA, 2005).

This species can easily travel through international trade. It has been found in *Pelargonium* from Germany to Hungary, on *Chrysanthemum morifolium* and *Pelargonium* from the Canary Isles to the UK, on bananas from the Canary Isles to Italy as well as from the Netherlands to the UK, and on *Impatiens* from Israel to the UK (EPPO, 1998; EPPO, 2000; reviewed in CABI, 2007). Larvae have been frequently imported into Britain on chrysanthemum (Carter, 1984) and particular attention should be paid to this commodity.

Passoa (2007) states that interceptions originating from Hawaii are *Chrysodeixis eriosoma*; *Pseudoplusia includens* if originating from the New World; and either *C. chalcites* or *C. eriosoma* (depending on locality) if originating from the Old World.

## Potential Distribution within the United States

In 1995, a specimen of *C. chalcites* was found on *Pelargonium* (geraniums) in a greenhouse in Ohio. This pest is not known to be established in the United States (CABI, 2007).

This species is likely to establish in the United States wherever host material and suitable climate are found. Based on its native distribution and migratory behavior

(CABI, 2012), it would likely find suitable climate for establishment in Plant Hardiness Zones 6 to 11 and may migrate farther north during the spring and summer. Further investigation is needed to determine where exactly in the continental United States it could overwinter. This species can also establish in areas with unfavorable climates by establishing in greenhouses as it has in parts of northern Europe (CABI, 2007).

## Survey

**CAPS-Approved Method\***: The CAPS-approved method is a trap and lure combination. The trap is a wing trap. The lure is effective for 28 days (4 weeks).

Any of the following Trap Product Names in the IPHIS Survey Supply Ordering System may be used for this target:

- Wing Trap Kit, Paper
- Wing Trap Kit, Plastic

The Lure Product Name is “*Chrysodeixis chalcites* Lure.”

**IMPORTANT:** Do not include lures for other target species in the trap when trapping for this target.

**Trap spacing:** When trapping for more than one species of moth, separate traps for different moth species by at least 20 meters (65 feet).

\*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at <http://caps.ceris.purdue.edu/>.

### **Literature-Based Methods:**

**Trapping:** A pheromone for trapping *C. chalcites* is available. The lure (a 5:1:1 mixture of (Z)-7-dodecenyl acetate, (Z)-9-tetradecenyl acetate, and (Z)-9-dodecenyl acetate) (Dunkelblum et al., 1987) is dispensed from a rubber septum and the recommended replacement interval is every four weeks.

Dunkelblum and Mazor (1993) captured this species using a lure containing 2,500 µg of Z7-12:AC, 50 µg of Z9-12:AC, and 2,000 µg of Z9-14:Ac.

This species was caught in Ontario, Canada, using universal moth traps baited with pheromone lures for *Trichoplusia ni* (Murillo et al., 2013). The lures for both species have similar components (Dunkelblum and Mazor, 1993).

### **Survey Site Selection:**

Traps should be placed in areas where host material is present. This can include host crop fields and greenhouses with host material. States with ports that import produce, vegetables, and cut flowers from the Old World or infested areas of Canada are especially at risk for the introduction of *Chrysodeixis* species.

### **Trap placement:**



Traps should be placed near the highest point of the plant, about 1 m (approx. 3 1/4 ft) from the ground on supporting posts or higher if the crop is higher.

Time of year to survey:

This species can be present year-round in a greenhouse setting. In warmer climates, this species continually breeds throughout the year with no diapause. In more northern climates, adults are more likely to be found during warmer periods. This species is known to migrate to northern areas in the spring.

Not recommended: This species is sometimes found in light traps (Deans, 2005; Kimber, 2008); however, this survey method is not species specific.

Leaves should be examined on upper and lower surfaces for larvae during visual surveys. Damage symptoms, such as skeletonized or rolled leaves with webbing may be easier to detect (CABI, 2007).

For CAPS surveys, light traps and visual surveys are not approved survey methods for this species.

## Key Diagnostics/Identification

**CAPS-Approved Method\*:** Confirmation of *Chrysodeixis* (*chalcites* or *eriosoma*) is by morphological identification. Identification of adults requires dissection of the male genitalia; use Passoa (1995a) as an aid. Molecular analysis is required for identification at the species level.

*Chrysodeixis chalcites* is externally identical to *Chrysodeixis eriosoma* which has not been found in the continental United States (Brambila and Passoa, 2013). Because *C. chalcites* is very similar to several North American Plusiinae, especially *Chrysodeixis includens* (soybean looper), dissection of genitalia and DNA-barcoding is necessary for final species determination (Brambila and Passoa, 2013).

For field level screening and diagnostics, use:

[Brambila, J. and S. Passoa. 2013. \*Chrysodeixis chalcites\* - Golden Twin Spot Moth: Level 1 - Field Screening Aid.](#)

[Brambila, J. and S. Passoa. 2013. \*Chrysodeixis chalcites\* - Golden Twin Spot Moth: Level 2 - Wing Diagnostic Aid with Non-targets.](#)

For identification and differentiation from non-targets, use:

[Brambila, J. and S. Passoa. 2013. \*Chrysodeixis chalcites\* - Golden Twin Spot Moth: Level 3 - identification aid with genitalia.](#)

A screening aid for CAPS target Noctuidae (males), including *C. chalcites*, can be found in Passoa (2009). Adult genitalia are shown in Passoa (1995a) and Passoa and Gilligan (1995).

\*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at <http://caps.ceris.purdue.edu/>.

## Easily Confused Species

In Africa and Europe, *Chrysodeixis chalcites* may be confused with *C. acuta*, although *C. acuta* is larger and has a more pointed forewing. The silver spots are also larger (Bretherton, 1983).

In the United States, *Chrysodeixis chalcites* could be confused with *C. includens* (soybean looper) or *Trichoplusia ni* (cabbage looper moth). Dissection of genitalia is necessary to differentiate *C. chalcites* from these species.

A key to the genera of Noctuoidea (subfamily Plusiinae) found in the United States and Canada for both adults and larvae can be found in Lafontaine and Poole (1991).

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## Revisions

January 2014

- 1) Revised the **Damage** section; added specific information for Solanaceous Hosts.
- 2) Revised the **Pest Importance** section; added specific information for Solanaceous Hosts.
- 3) Revised the **Known Distribution** section; added Canada. Added note about a comment from Lafontaine and Schmidt (2013) implying that the species is present in Michigan.
- 3) Added the **Pathway** section.
- 4) Revised the **Potential Distribution within the United States** section.
- 5) Added two Risk Maps.
- 6) Updated the **Survey** section into the most current format.
- 7) Revised the **Key Diagnostics/Identification** section. Added:
  - Brambila, J. and S. Passoa. 2013. *Chrysodeixis chalcites* - Golden Twin Spot Moth: Level 1 - Field Screening Aid.
  - Brambila, J. and S. Passoa. 2013. *Chrysodeixis chalcites* - Golden Twin Spot Moth: Level 2 - Wing Diagnostic Aid with Non-targets.
  - Brambila, J. and S. Passoa. 2013. *Chrysodeixis chalcites* - Golden Twin Spot Moth: Level 3 - identification aid with genitalia.
- 8) Revised the **Easily Confused Species** section.