Thaumatotibia leucotreta

Scientific Name
Thaumatotibia leucotreta (Meyrick)

Synonyms:
Cryptophlebia leucotreta (Meyrick),
Cryptophlebia roerigii Zacher
Olethreutes leucotreta Meyrick
Thaumatotibia roerigii Zacher

Common Name(s)
False codling moth, citrus codling moth, orange moth, and orange codling moth

Type of Pest
Moth

Figure 1. Larva of *Thaumatotibia leucotreta* (T. Grove and W. Styn, bugwood.org).

Taxonomic Position
Class: Insecta, **Order:** Lepidoptera, **Family:** Tortricidae

Reason for Inclusion
CAPS Target: AHP Prioritized Pest List - 2003 through 2014

Pest Description
Eggs: Eggs are flat, oval (0.77 mm long by 0.60 mm wide) shaped discs with a granulated surface. The eggs are white to cream colored when initially laid. They change to a reddish color before the black head capsule of the larvae becomes visible under the chorion prior to hatching (Daiber, 1979a).

Larvae: First instar (neonate) larvae approximately 1 to 1.2 mm (<$^{1}/_{16}$ in) in length with dark pinacula giving a spotted appearance, fifth instar larvae are orangey-pink, becoming more pale on sides and yellow in ventral region, 12 to 18 mm (approx. $^{1}/_{2}$ to $^{11}/_{16}$ in) long, with a brown head capsule and prothoracic shield (Fig. 1). [Note this coloration is only present in live specimens.] The last abdominal segment bears an anal comb with two to ten “teeth.” The mean head capsule width for the first through fifth instar larvae has been recorded as: 0.22, 0.37, 0.61, 0.94 and 1.37 mm, respectively (Daiber, 1979b).

Diagnostic characters would include the anal comb with two to ten teeth in addition to: L pinaculum on T1 enlarged and extending beneath and beyond (posterad of) the spiracle; spiracle on A8 displaced posterad of SD pinaculum; crochets unevenly triordinal, 36-42; L-group on A9 usually trisetose (all setae usually on same pinaulum) (Brown, 2011).

Pupae: Pre-pupae and pupae form inside a lightly woven silk and soil cocoon created by the fifth instar larvae on the ground. Length is 8 to 10 mm (approx. $^{5}/_{16}$ to $^{3}/_{8}$ in) (Daiber, 1979c).

Adults: Adults are grayish brown to dark brown with an average forewing length of 7 to 8 mm (approx. $^{5}/_{16}$ to in) for males and 9 to 10 mm (approx. $^{3}/_{8}$ in) for females. Adult body length 6 to 8 mm (approx. $^{1}/_{4}$ to $^{5}/_{16}$ in), wingspan of female and male moth is 15 to 20 mm (approx. $^{9}/_{16}$ to $^{13}/_{16}$ in) and 15 to 18 mm (approx. $^{9}/_{16}$ to $^{11}/_{16}$ in), respectively. The body is brown; the thorax has a posterior double crest. The male forewing is triangular, with an acute apex, while the female forewing is more elongate with a rounded apex. Male (Fig. 2) is distinguished from female by its large, pale grayish genital tuft, the long, dense, grayish-white scales on the hindlegs, and its heavily tufted hind tibia (Gunn, 1921; Couilloud, 1988; CABI, 2009; Gilligan et al., 2011). Males also have a semicircular pocket of opalescent scales on the distal end of vein CuA2 on the distal end of vein CuA2 on the hindwing. This character can be used to separate *T. leucotreta* males from all other North American tortricids (Gilligan et al., 2011).

Figure 2. *Thaumatotibia leucotreta* adult male (Todd Gilligan, Colorado State University, bugwood.org).

Forewing pattern can vary between individuals of both sexes. In males, the forewing color and pattern expression is not as consistent as in females. Most individuals exhibit a combination of four forewing pattern elements: a small white dot near the end of the discal cell; a raised patch of scales near the middle of the wing (usually rust colored); a distinct 'question mark' shaped band of dark scales along the termen; and a semi-circular band of dark scales in the middle of the costa (Gilligan et al., 2011).

Male genitalia (Fig. 3) include: a rounded tegumen lacking an uncus or socii, large rounded valvae, and a tapered aedeagus that is upcurved distally. Female genitalia (Fig. 3) include: a semicircular sterigma, narrow ductus bursae, and a large rounded corpus bursae with a pair of thorn-shaped signa (Gilligan et al., 2011).

Descriptions of the life stages and images of adults can be found in Venette et al. (2003) and Gilligan et al. (2011).

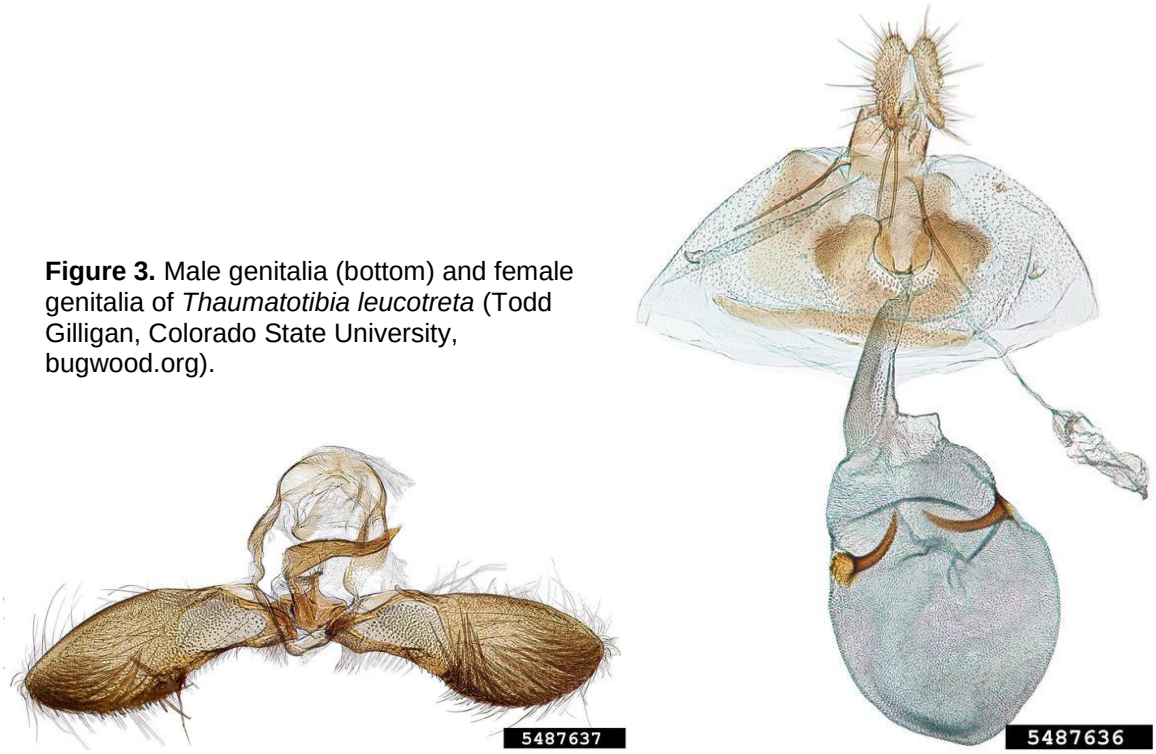

Figure 3. Male genitalia (bottom) and female genitalia of *Thaumatotibia leucotreta* (Todd Gilligan, Colorado State University, bugwood.org).

Biology and Ecology

Thaumatotibia leucotreta is an internal fruit-feeding tortricid that does not undergo diapause and may be found throughout the year in warm climates on suitable host crops.

In South Africa, *Thaumatotibia leucotreta* has four to ten non-discrete generations per year (Georgala, 1969; Stofberg, 1954). Mated female moths fly at night and deposit eggs singly or in small groups on suitable hosts. Females lay eggs (87 to 456 per female) on fruit or foliage. There are reports of females laying up to 800 eggs over their lifespan at optimal temperatures (USDA, 2010). Females lay eggs at random in depressions of the rind of host fruit; on smooth, non-pubescent surfaces; on fallen fruit; or on foliage. Females tend to oviposit on prematurely ripened fruit or wounded fruit when compared to healthy fruit at a normal state of development (Newton and Mastro, 1989).

Egg development requires two to 22 days depending on temperature. Eggs are extremely sensitive to cold temperatures and extended periods of low humidity. Temperatures below freezing over a two to three day period can kill eggs (Blomefield, 1978; Daiber, 1979a). Daiber (1980) showed that *T. leucotreta* adults live longest at 15°C (59°F) while most eggs were laid at 25°C (77°F). Egg laying at 20 and 25°C (68 and 77°F) increased rapidly soon after the first egg was laid but only gradually at 15°C to reach peak numbers sometime after the initial egg lay. Very few eggs were laid at 10°C (50°F).

Upon hatching, neonate larvae penetrate the fruit where larval development is completed. Larvae wander on the fruit before gnawing through the fruit rind/skin and make burrows about 1 mm (0.04 in) in diameter. The entrance is conspicuous due to the presence of frass and discoloration of the surrounding rind. If the host has a hard rind, such as an acorn, the entrance is made at the base or attachment to the cup where softer tissue exists. When the host has a soft rind/skin, such as citrus or peach, the larvae burrow into the rind almost anywhere, although larvae prefer the navel end, an injured area, or cut in the rind. In some rinds, such as avocado, the entrance is marked by the formation of a raised crater (USDA, 2010).

The larval period lasts 12 to 33 days in warm weather and 35 to 67 days in cool weather; there are five instars. Younger larvae feed near the surface; older larvae bore toward the center. Generally, only one to three larvae per fruit survive. Temperature and poor food quality can slow down the rate of larval development (USDA, 2010). By the time the larva is ready to leave the fruit, the fruit might have dropped. Mature larvae leave the fruit and spin cocoons near the soil or in bark crevices. Diapause or a resting stage has not been recorded (USDA, 2010).

Males live 14 to 57 days; females survive 16 to 70 days. Dispersal normally is limited to several hundred meters. Moth activity increases with the onset of host flowering. Females call males through pheromone release starting several hours after dark, peaking five hours later, and dropping off rapidly thereafter until daylight. Adults can mate several times per day (USDA, 2010).

Damage

In general, since *T. leucotreta* larvae feed internally, few symptoms are displayed on the fruit. Cannibalism among young larvae ensures that usually only one to three larvae can mature in each fruit. When full-grown, the larvae bore their way out of the fruit to seek a site for pupation. The rind around the point of infestation takes on a yellowish-brown color as the tissue decays and collapses. Larval feeding and development can affect fruit development at any stage, causing premature ripening, fruit drop, and secondary infections by bacteria and other organisms.

Avocado: Moths lay eggs superficially on the fruit of avocado. Larvae hatch, develop, and can enter through the skin. Larvae are unable to develop in avocado fruit. However, their entrance holes create lesions that lessen the marketability of the fruit. Lesions develop into a raised crater on the fruit surface, with an inconspicuous hole in the center where the larva has entered (reviewed in USDA, 2010). Larvae predominantly tunnel at the base of the fruit (Erichsen and Schoeman, 1992). Granular excreta can also be seen (USDA, 2010). The most susceptible cultivars are Edranol, Hass, and Pinkerton (Erichsen and Schoeman, 1994).

Citrus: All stages of citrus fruit are vulnerable to attack. *Thaumatotibia leucotreta* larvae are capable of developing in hard green fruit before control measures can be started. Emerging larvae bore into the spongy white tissue on the inside of the rind of the citrus fruit and usually feed just below the fruit surface. Once a fruit is damaged, it becomes

vulnerable to fungal organisms and scavengers. There is sometimes a scar visible on infested fruit (USDA, 2010). On oranges, look for a brown patch on the skin, usually with evidence of a hole bored in the center, sometimes with dark brown frass exuding from the hole. Oranges or other citrus can also drop fruit prematurely.

Cotton: *Thaumatotibia leucotreta* feeds mainly on large green bolls. The younger larvae feed almost entirely inside the boll wall itself, but the older larvae penetrate the inner septum and feed on the developing seeds and lint (Reed, 1974). Larval penetration of cotton bolls facilitates entry of other microorganisms that can rot and destroy the boll. The cultivars Edranol, Hass and Pinkerton were the most susceptible to attack by *T. leucotreta* (USDA, 2010).

Macadamia: Larvae damage the nuts by feeding on the developing kernel after they pierce the husk and shell. Nuts reaching 14 to 19 mm (approx. $^{9}/_{16}$ to $^{3}/_{4}$ in) diameter size are at the most risk because nutrient content is the greatest; concurrently, false codling moth reaches the adult stage by this point and is able to oviposit on the nuts (USDA, 2010).

Solanaceous: Damage by this species can lead to misshapen fruit of bell peppers (MANFQ, 2009).

Stone Fruit: All stages of stone fruits are vulnerable to attack. False codling moth larvae are capable of developing in hard green fruit before control measures can be started. Once a fruit is damaged, it becomes vulnerable to fungal organisms and scavengers. Larvae damage stone fruits as they burrow into the fruit at the stem end and begin to feed around the stone. Infestations can be identified by the brown spots and dark brown frass (Daiber, 1976). On peaches, eggs are almost always laid on the upper surface of peach leaves (USDA, 2010).

Minor Hosts:
Corn: Larvae damage corn by entering the ear from the husk through the silk channel (USDA, 2010). Larvae can be found in the corn stem as well (Reed, 1974). On corn, *T. leucotreta* has been reported laying eggs on the husk of the ear.

Grape: Fresh larval penetration holes in grapes can be seen, but require careful inspection of the fruit. Sometimes a few granules of frass can be found around a fresh penetration hole or a mass of frass may be found around older penetration holes. Other times, however, frass is not visible. The area around the penetration hole can become sunken and brown as damaged tissue decays (Johnson, date not known).

Pest Importance

False codling moth, *T. leucotreta,* is a pest of economic importance to many crops throughout sub-Saharan Africa, South Africa, and the islands of the Atlantic and Indian Oceans (USDA, 2010). Larval feeding and development can affect fruit development at any stage, causing premature ripening and fruit drop.

In Africa, *T. leucotreta* is a major pest of avocado, citrus, and cotton (Erichsen and Schoeman, 1994). This is considered the most significant moth pest of avocado fruits in South Africa (Erichsen and Schoeman, 1992). In the Citrusdal Valley region of South Africa, *T. leucotreta* caused from 2.9 to 15.2% crop loss on citrus depending on the farm and the pest control program (Schwartz and Anderson, 1983). In Ugandan cotton, boll rotting is a major cause of crop loss. Over 90% of rotten bolls had insect attack symptoms and at least 60% of those were caused by *T. leucotreta* (Reed, 1974). Approximately 44% of corn cobs examined contained larvae of *T. leucotreta* in Uganda (Reed, 1974).

According to CDFA (2008), commonly grown agricultural hosts in California for *T. leucotreta* include apricot, avocado, beans, cherry, citrus, corn, English walnut, grapes, olive, peach, pepper, persimmon, plum, pomegranate, and tomato. Based on its status as a pest in Africa, establishment of *T. leucotreta* in California and/or in other parts of the United States could result in significant economic losses. *Thaumatotibia leucotreta* would likely be a significant production and quarantine issue for numerous agricultural commodities. In California alone, the annual combined gross value of the top ten agricultural commodities which would be directly impacted by this pest is over $7.1 billion, which amounts to 22% of the total agricultural value for the State (USDA NASS, 2007).

Peaches become susceptible to damage about six weeks before harvest. Detecting infested peaches can be difficult if the fruit is still firm and abscission has not occurred; consequently, the danger of selling potentially infested fruit poses a serious threat to the peach industry (Daiber, 1976; USDA, 1984, 2010).

Hofmeyr and Pringle (1998) report resistance in *T. leucotreta* to the chitin synthesis inhibitor trifluron, commonly used for *T. leucotreta* control.

Known Hosts

Thaumatotibia leucotreta is a generalist with respect to host plant selection and has been recorded as feeding on over 50 different plant species. The generalist feeding strategy enables survival in marginal conditions as is necessary due to lack of diapause. Important host crops include avocado (*Persea americana*), citrus (*Citrus* spp.), corn (*Zea mays*), cotton (*Gossypium* spp.), macadamia (*Macadamia* spp.), and peach and plum (*Prunus* spp.) (USDA, 1984; 2010).

Main hosts

Abelmoschus esculentus (okra), *Abutilon* × *hybridum* (Chinese lantern), *Ananas comosus* (pineapple), *Averrhoa carambola* (carambola), *Camellia sinensis* (tea), *Capsicum* spp. (peppers), *Citrus* spp. (citrus), *Coffea arabica* (coffee), *Gossypium* spp. (cotton), *Litchi chinensis* (litchi), *Macadamia spp.* (macadamia), *Mangifera indica* (mango), *Olea* spp. (olive), *Persea americana* (avocado), *Prunus armeniaca* (apricot), *Prunus domestica* (plum), *Prunus persica* (peach), *Prunus* spp. (stone fruit), *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Quercus* spp. (oak, acorns), *Ricinus communis* (castor bean), *Sorghum bicolor* (sorghum), and *Zea mays* (corn).

Minor hosts
Abutilon spp. (Indian mallow), *Afrocarpus falcatus* (=*Podocarpus falcatus*) (yellowwood), *Annona cherimola* (cherimoya), *Annona glabra* (pond apple), *Annona muricata* (soursop), *Annona reticulata* (Bullock's heart, custard apple), *Annona squamosa* (sugar apple), *Bauhinia galpinii* (red bauhinia), *Caesalpinia pulcherrima* (pride-of-Barbados), *Caesalpinia* spp. (nicker), *Calotropis procera* (sodom apple), *Capparis tomentosa* (African caper), *Carya illinoensis* (pecan), *Catha edulis* (khat), *Ceiba pentandra* (kapok), *Chrysophyllum cainito* (star apple), *Chrysophyllum palismontatum* (stamvrugte), *Cola nitida* (bitter cola), *Combretum apiculatum* (apiculatum), *Combretum zeyheri* (raasblaar), *Diospyros mespiliformis* (Jjakkalsbessie), *Diospyros pallens* (=*Royena pallens*) (pale-branched Royena), *Diospyros* spp. (persimmon), *Englerophytum magalismontanum* (=*Bequaertiodendron magalismontanum*) (stamvrug), *Eriobotrya japonica* (loquat), *Eugenia uniflora* (Surinam cherry), *Ficus sur* (=*F. capensis*) (wild fig), *Flacourtia indica* (governor's-plum), *Garcinia mangostana* (mangosteen), *Harpephyllum caffrum* (kaffir-plum), *Hibiscus cannabinus* (kenaf), *Hibiscus spp.* (hibiscus), *Juglans regia* (English walnut), *Juglans spp.* (walnut), *Mimusops zeyheri* (Transvaal red milkwood), *Musa* x *paradisiaca* (banana), *Pennisetum purpureum* (elephant grass), *Phaseolus lunatus* (lima bean), *Phaseolus* spp. (bean), *Physalis philadelphica* (=*P. ixocarpa*) (tomatillo), *Physalis* spp. (groundcherry), *Piper* spp. (pepper plant/ peppercorns), *Podocarpus* spp. (plum pine), *Pseudolachnostylis maprouneifolia* (kudu berry), *Saccharum officinarum* (sugarcane), *Schotia* spp. (boerboon), *Sclerocarya birrea* (marula) *Sechium edule* (chayote), *Senna petersiana* (=*Cassia petersiana*) (monkey pod), *Sida* spp. (fanpetals), *Solanum betaceum* (=*Cyphomandra betacea*) (tree tomato), *Solanum lycopersicum* (=*Lycopersicon esculentum*) (tomato), *Solanum melongena* (eggplant), *Synsepalum dulcificum* (miraculous berry), *Syzygium cordatum* (waterbessie), *Syzygium jambos* (rose-apple), *Theobroma cacao* (cacao), *Thespesia garckeana* (=*Azanza garckeana*) (snot apple), *Triumfetta* spp. (bur weed), *Vachellia nilotica* (=*Acacia nilotica*) (acacia), *Vachellia tortilis* (=*Acacia tortilis*) (umbrella thorn), *Vangueria infausta* (wild medlar), *Vigna* spp. (cowpea), *Vitellaria paradoxa* (=*Butyrospermum parkii*) (shea butter tree), *Vitis* spp. (grape), *Xeroderris stuhlmannii* (wing bean), *Ximenia caffra* (suurpruim), *Yucca* spp. (yucca), and *Ziziphus* spp. (jujube).

Pathogens or Associated Organisms Vectored
Thaumatotibia leucotreta is not a known vector and does not have any associated organisms. The wounds produced by *T. leucotreta*, however, can provide an entrance for pathogens and can damage host plants under humid conditions.

Known Distribution
False codling moth is indigenous to Southern Africa and the Ethiopian region. It also occurs on the islands of Madagascar, Mauritius, Reunion, and St. Helena.

Africa: Angola, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Democratic Republic of Congo, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Ivory Coast, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Republic of Congo, Réunion, Rwanda, Saint

Helena, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zanzibar, and Zimbabwe; **Asia:** Israel[1]

[1]According to EPPO (2011) this species is locally present in Israel. "In Israel, it was first found in 1984 on macadamia nuts (a crop which is no longer grown for commercial purposes). In 2003, it was still present but with a limited distribution on cotton and castor bean which are minor crops for Israel (EPPO RS 2003/015)" (EPPO, 2011).

False codling moth has occasionally been found in Europe, where it was imported with produce from Africa (Bradley et al., 1979; Karvonen, 1983). Border inspections have intercepted false codling moth in Denmark, Finland, Netherlands, and United Kingdom; the countries have remained free of the pest (USDA, 2010).

Pathway

Infestation by *T. leucotreta* generally causes the fruit to drop before harvest. Larval entries, however, can take a few days to become visible. Those that occur near fruit harvest, therefore, are often not detected by the packing house fruit graders and infested fruit can be inadvertently packaged for export.

Increased international trade and tourism between the United States and many African countries in recent years has increased the risk of introduction of this pest. Since 1984, *T. leucotreta* has been intercepted over 1,500 times on 99 plant taxa at 34 U.S. ports of entry. Most interceptions of live and dead larvae occur in bell peppers (Capsicum sp.), eggplant (*Solanum melongena*), and clementines (*Citrus* sp.) (Brown, 2006; Gilligan et al., 2011).

Potential Distribution within the United States

In June 2005, live *T. leucotreta* caterpillars were found at California's border stations inside previously cold treated Clementine citrus from South Africa. Its discovery in California is a new record for the Americas. On June 16, 2005, California Department of Food and Agriculture (CDFA) inspectors found one live and one dead larva on a shipment of South African clementines at the California border station in Needles. The larvae were identified by both a CDFA lab and the USDA Systematic Entomology Laboratory (SEL) specialist as false codling moth. The fruit had entered the United States in the port of Philadelphia, PA off the vessel Nova Zembla. Initial review of the cold treatment records did not reveal failures in the treatment.

On June 20, 2005, a second live larva was intercepted on a separate shipment of South African clementines in California. This shipment came on the vessel Fuji Star on June 14, 2005. This larva was identified by CDFA as *T. leucotreta*.

During a 2008 CAPS survey in California, a single male was collected; no females or larvae were found. Surveys using traps and some fruit sampling has continued around the Ventura County find and no additional specimens have been collected (NAPIS, 2013). *Thaumatotibia leucotreta* is not known to be established in California.

A recent risk map developed by USDA-APHIS-PPQ-CPHST (Fig. 4) shows that portions of California, the southeastern United States, and the East Coast are at the greatest risk from *T. leucotreta* based on climate, host range, and pathway.

Survey

CAPS-Approved Method*:

The CAPS-approved method is a trap and lure combination. There are three different trap options: wing trap, diamond trap, and large plastic delta trap. The lure is effective for 56 days (8 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
Large Plastic Delta Trap Kits, Orange
Large Plastic Delta Trap Kits, Red
Large Plastic Delta Trap Kits, White

The lure name is "*Thaumatotibia leucotreta* Lure".

The wing trap and large plastic delta trap are the preferred traps for *Thaumatotibia leucotreta*. In order to standardize data and trap procurement, it is preferable that states use the wing or large plastic delta trap. However, if states find reason to use the diamond trap, it is acceptable for negative data reporting. Diamond traps will not be available through the IPHIS Survey Supply Ordering Database.

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

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

*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/.

Time of year to survey:
Surveys should occur when fruiting of host plants begins. Surveys are best conducted during warm, wet weather when the population of the pest increases.

Literature-Based Methods:

For early detection surveys in stone fruit, fields in close proximity to high risk areas such as citrus should be monitored utilizing pheromone traps. The pheromone traps should be placed at a frequency of one trap per four hectares and traps should be no closer than 150 to 200 m (492 to 656 ft) to each other. Traps should be inspected weekly. Other primary hosts should also be inspected visually for the presence of *T. leucotreta*

during the growing season. The first four rows bordering citrus or stone fruit orchards should be examined carefully.

Trapping: Male *T. leucotreta* are attracted to a two component blend of (*E*)-8-dodecenyl acetate and (*Z*)-8-dodecenyl acetate. These components are most effective when used in a ratio between 70:30 and 30:70 (*E*:*Z*) (Persoons et al., 1977; Venette et al., 2003). More recently, Newton et al. (1993) refined the sex pheromone and reported that a 90:10 ratio was optimal. USDA (2010) recommends utilizing a 50:50 ratio. Burger et al. (1990) showed that 7-vinyldecyl acetate, a by-product of the synthesis of one of the constituents of the pheromone blend, effectively disrupts the attraction of the male moths to virgin females or to synthetic lures.

A loading rate between 0.5 and 1.0 mg per septum was found to attract the greatest number of males. The pheromone blend (1 mg applied to a rubber septum) has been used effectively with Pherocon 1C traps to capture male *T. leucotreta* (Newton et al., 1993). Delta traps have also been used, but these have performed less well than either the Hoechst Biotrap or Pherocon 1C traps. Traps using closed polyethylene vials to dispense pheromones captured more moths than traps using rubber septa (using a 50:50 blend of (*E*)- and (*Z*)-8-dodecenyl acetate). Lures should be replaced every 8 weeks. Hofmeyr and Burger (1995) developed a prototype controlled release dispenser that was capable of releasing sex pheromone without replacement for more than seven months. Pheromone traps (homemade sticky trap with unspecified pheromone blend) have been used to monitor the number of *T. leucotreta* adult males in citrus orchards (Daiber, 1978) and detect the presence of the pest in peach orchards (Daiber, 1981).

Survey Site Selection:
Thaumatotibia leucotreta is a generalist with respect to host plant selection and has been recorded as feeding on over 50 different plant species. Important host crops include avocado, citrus, corn, cotton, macadamia, peach, and plum (USDA, 1984; 2010). Surveys should be focused on areas that have abundant host material. This can be in agricultural settings, nursery settings, or around ports of entry.

Trap placement:
Traps should be placed approximately 1.5 m (5 ft) high.

Visual survey: Visual inspections of plant materials may be used to detect eggs, larvae and adults of *T. leucotreta* (USDA, 1984). Look for plants showing signs of poor growth or rot; holes in fruit, nuts or bolls; adults hidden in foliage; and crawling larvae. Surveys are best conducted during warm, wet weather when the population of the pest increases (USDA, 1984). Eggs will commonly be found on fruits, foliage, and occasionally on branches (USDA, 1984). However, eggs are small and usually laid singly, which makes them difficult to detect. On corn, *T. leucotreta* has been reported laying eggs on the husk of the ear.

Fruit should be inspected for spots, mold, or shrunken areas with 1 mm (0.04 in) exit holes in the center. On citrus fruits and other fleshy hosts, dissections are needed to

detect larvae; larvae are likely to be found in the pulp (USDA, 1984). Infested fruits may be on or off the tree. In cotton, older larvae may be found in open bolls and cotton seed (USDA, 1984). Occasionally adults may be observed on the trunk and leaves of trees in infested orchards (USDA, 1984). For field crops, such as corn, the whole plant is the recommended sample unit. Because larvae of *T. leucotreta* have a strongly aggregated spatial distribution among corn plants, a large sample size (>60 plants) is recommended; however at low densities of the pest (<1 larva/plant) sample sizes needed to detect the pest may be prohibitively large.

Visual survey is not an approved method for CAPS surveys for *T. leucotreta.*

Soil Sampling: Collect soil samples within 183 meters (200 yards; 600 ft) of any larval or egg detection and at any spot where dropped, especially prematurely dropped, fruit occur. Soil samples should consist of loose surface soil and any debris. Examine soil for larvae, cocoons and pupae.

Soil sampling is not an approved method for CAPS surveys for *T. leucotreta.*

Not recommended: Robinson black light traps are ineffective at attracting adult *T. leucotreta* (Begemann and Schoeman, 1999). Therefore, black light traps should not be used. The effectiveness of black light traps may be improved if used in conjunction with pheromone lures (Möhr, 1973). Möhr (1973) speculates that pheromone may provide a long-distant attractant, but that attraction to black light becomes much stronger when moths are in close proximity to light traps.

Black light traps are not an approved method for CAPS surveys for *T. leucotreta.*

Key Diagnostics/Identification

CAPS-Approved Method*:

Confirmation of *T. leucotreta* is by morphological identification. "Males of *Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae) have variable wing color patterns and are very similar to other tortricids, a few of which are also attracted to the false codling moth pheromone" (Brambila, 2011). The nearly circular pocket of scales in the hind wing is not found in any other tortricid species (Gilligan, 2013). This is the only character need to identify *T. leucotreta* (T. Gilligan, personal communication, 2013). In addition, *T. leucotreta* males are larger than the *Grapholita* spp. most commonly seen in *T. leucotreta* traps as non-targets (T. Gilligan, personal communication, 2013).

For field screening and identification, use:
Brambila, J. 2011. *Thaumatotibia leucotreta* (False Codling Moth) Field Screening Aid and Diagnostic Aid.

Although not usually encountered in CAPS surveys, larval specimens must be examined under a dissecting microscope to observe diagnostic characters. Diagnostic characters include the anal comb with two to ten teeth in addition to: L pinaculum on T1 enlarged and extending beneath and beyond (posterad of) the spiracle; spiracle on A8

displaced posterad of SD pinaculum; crochets unevenly triordinal, 36-42; L-group on A9 usually trisetose (all setae usually on same pinaulum) (Brown, 2011). The presence of an anal comb separates *Thaumatotibia leucotreta* larvae from those of most *Cryptophlebia*.

Larval screening aid: http://caps.ceris.purdue.edu/dmm/544.

Additional Resources:
Passoa, S. 2009. Screening Key for CAPS Target Tortricidae in the Eastern and Midwestern United States (males). Lab Manual for the Lepidoptera Identification Workshop. University of Maryland.

Lucid Identification Tool:
Gilligan, T. M. and M. E. Epstein. 2012. TortAI: Tortricids of Agricultural Importance. Last updated April 2012.

*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/.

Images:
See PaDIL website for additional *T. leucotreta* images, including diagnostic characters (http://www.padil.gov.au/pests-and-diseases/Search?sortType=ScientificName&viewType=Details&pageSize=10&queryText1=Thaumatotibia&queryType1=scientificname).

Easily Confused Pests

Thaumatotibia leucotreta can be confused with many *Cydia* spp. including *C. pomonella* (codling moth) because of similar appearance and damage. However, unlike codling moth, its host range does not include apples, pears, or quince (USDA, 1984). In West Africa, *T. leucotreta* is often found in conjunction with *Mussidia nigrevenella* (pyralid moth), but the species can be distinguished by close examination of morphological characters (CABI, 2009). In South Africa, there is also an overlapping host range for *T. leucotreta, T. batrachopa* (macadamia nut borer) and *Cryptophelbia peltastica* (litchi moth), particularly on litchi and macadamia (Venette et al., 2003; USDA, 2010). The male litchi moth can be distinguished from similar species by a subtriangular or Y-shaped T8 with a pair of tufts of filiform scales from membranous pockets on each side (USDA, 2010). *Cydia toreuta*, *Ecdytolopha punctidiscana,* and some species of *Grapholita* are other species that may be confused with *T. leucotreta* (T. Gilligan, personal communication, 2013; USDA, 2010).

The larvae are creamy white in color and can be confused with fruit fly larvae in some cases. The distinct brown black head of *T. leucotreta* larvae, however, makes it readily distinguishable from fruit fly larvae (Economides, 1979).

Commonly Encountered Non-targets

Pheromone lures with (*E*)- and (*Z*)-8-dodecenyl acetate may also attract *Cydia*

cupressana (native), *Hyperstrotia spp*., *Cydia atlantic*a (exotic), *Cydia phaulomorpha* (exotic), *Cryptophlebia peltastica* (exotic), and some native species of *Grapholita* (T. Gilligan, personal communication, 2013).

References

Begemann, G. and A. Schoeman. 1999. The phenology of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), *Tortrix capsensana* (Walker), and *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae) on citrus at Ebediela, South Africa. African Entomology 7: 131-148.

Blomefield, T. 1978. Codling moth, false codling moth, and leafrollers on stone fruits. Information Bulletin Number 412, Fruit and Fruit Technology Research Institute, Stellenbach, South Africa.

Bradley, J. D., W. G. Tremewan, and A. Smith. 1979. British tortricid moths. Tortricidae: Olethreutinae. Vol. 2. London, England: British Museum (Natural History).

Brambila, J. 2011. *Thaumatotibia leucotreta* (False Codling Moth) Field Screening Aid and Diagnostic Aid. **http://caps.ceris.purdue.edu/webfm_send/1575**

Brown, J. W. 2006. Scientific names of pest species in Tortricidae (Lepidoptera) frequently cited erroneously in the entomological literature. American Entomologist 52(3): 182-189.

Brown, J. W. 2011. Tools for identifying the larvae of leafrollers (Lepidoptera: Tortricidae) frequently intercepted at U.S. ports of entry. Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture c/o National Museum of Natural History, Washington, D.C. 19 pp.

Burger, B. V., M. le Roux, W. M. Mackenroth, H. S. C. Spies, and J. H. Hofmeyr. 1990. 7-vinyl acetate, novel inhibitor of pheromonal attraction in the false codling moth, *Cryptophlebia leucotreta*. Tetrahedron Letters 31(40): 5771-5772.

CABI. 2009. Crop protection compendium: global module. Commonwealth Agricultural Bureau International, Wallingford, UK. http://www.cabi.org/compendia/cpc/.

Catling, H. D. and H. Aschenborn. 1974. Population studies of the false coding moth, *Cryptophlebia leucotreta* Meyr., on citrus in the Transvaal. Phytophylactica 6: 31-38. CDFA (California Department of Food and Agriculture). 2008. False Codling Moth Pest Profile.

Couilloud, R. 1988. *Cryptophlebia* (*Argyoploce*) *leucotreta* (Meyrick). Lepidoptera, Tortricidae, Olethreutinae. Coton et Fibres Tropicales 43: 319-351.

Daiber, C. C. 1976. A survey of false codling moth (*Cryptophlebia leucotreta* Meyr.) in peach orchards. Phytophylactica 8(4): 97-102.

Daiber, C. 1978. A survey of male flight of the false codling moth, *Cryptophliebia leucotreta* Meyr., by the use of the synthetic sex pheromone. Phytophylactica 10: 65-72.

Daiber, C. C. 1979a. A study of the biology of the false codling moth [*Cryptophlebia leucotreta* (Meyr.)]: the egg. Phytophylactica 11: 129-132.

Daiber, C. C. 1979b. A study of the biology of the false codling moth [*Cryptophlebia leucotreta* (Meyr.)]: the larvae. Phytophylactica 11: 141-144.

Daiber, C. C. 1979c. A study of the biology of the false codling moth [*Cryptophlebia leucotreta* (Meyr.)]: the cocoon. Phytophylactica 11: 151-157.

Daiber, C. C. 1980. A study of the biology of the false codling moth [*Cryptophlebia leucotreta* (Meyr.)]: the adult and generations during the year. Phytophylactica 12: 187-193.

Daiber, C. 1981. False codling moth, *Cryptophlebia leucotreta* (Meyr.) in peach orchards and home gardens of the summer rainfall area of South Africa. Phytophylactica 13: 105-107.

Economides, C. V. 1979. False codling moth, a serious pest of citrus in Zambia. Farming in Zambia 12(2): 4.

EPPO. 2011. *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae). False codling moth. Accessed January 16, 2014 from: http://www.eppo.int/QUARANTINE/Alert_List/insects/thaumatotibia_leucotreta.htm.

Erichsen, C. and A. S. Schoeman, 1992. Economic losses due to insect pests on avocado fruit in the Nelspruit/Hazyview region of South Africa during 1991. South African Avocado Growers' Association Yearbook 1992 15: 49-54.

Erichsen, C. and A. S. Schoeman. 1994. Moth pests of avocados. South African Avocado Growers' Association Yearbook 17: 109-112.

Georgala, M. B. 1969. Control of false codling moth and fruit flies in citrus orchards South African Citrus Journal. 421: 3, 5, 7.

Gilligan, T. M., M. E. Epstein, and K. M. Hoffman. 2011. Discovery of false codling moth, *Thaumatotibia leucotreta* (Meyrick), in California (Lepidoptera: Tortricidae) Proceedings of the Entomological Society of Washington 113(4): 426-435.

Gilligan, T. M. 2013. Identification method recommendations for *Thaumatotibia leucotreta.* Personal communication (email) to Lisa Jackson, USDA-APHIS-PPQ-CPHST on December 19, 2013 from Todd Gilligan, Research Scientist, USDA-APHIS-PPQ-CPHTS, Ft. Collins, Colorado.

Gunn, D. 1921. The false-codling moth (*Argyroploce leucotreta* Meyr.). Science Bulletin No. 21. Pretoria, South Africa: The Government Printing and Stationary office.

Hofmeyr, J. H. and K. L. Pringle. 1998. Resistance of false codling moth, *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), to the chitin synthesis inhibitor, triflumuron. African Entomology 6: 373-375.

Hofmeyr, J. H. and B. V. Burger. 1995. Controlled-release pheromone dispenser for use in traps to monitor flight activity of false codling moth. Journal of Chemical Ecology 21(3): 355-363.

Johnson, S. Date unknown. False codling moth on table grapes. http://www.satgi.co.za/export/sites/sati/galleries/protected/other/FCM_on_Table_Grapes.pdf.

Karvonen, J. 1983. *Cryptophlebia leucotreta* imported into Finland (Lepidoptera, Tortricidae). Notulae Entomologicae 63: 94.

National Agricultural Pest Information System (NAPIS). 2013. Survey Status of False Codling Moth - *Thaumatotibia leucotreta*. Purdue University. Published 06/25/2013. Accessed June 26, 2013 from: http://pest.ceris.purdue.edu/map.php?code=ITBUEUA&year=2013.

MANFQ. 2009. Pest Record – the Netherlands. Finding of *Thaumatotibia leucotreta* (Meyrick); Lepidoptera, fam. Tortricidae syn *Cryptophlebia leucotreta* (Meyrick); on *Capsicum chinense* (Habanero chilli peppers) in a greenhouse. Ministry of Agriculture, Nature and Food Quality, Plant Protection Service of the Netherlands. 2 pp.

Möhr, J. D. 1973. Light trap studies with the false codling moth. Citrus and Sub-tropical Fruit Journal 20-22.

Newton, P. J. and V. Mastro. 1989. Field evaluations of commercially available traps and synthetic sex pheromone lures of the false codling moth, *Cryptophlebia leucotreta* (Meyr.) (Lepidoptera: Tortricidae). Tropical Pest Management 35: 100-104.

Newton, P. J., C. D. Thomas, V. C. Mastro, and C. P. Schwalbe. 1993. Improved two component blend of the synthetic female sex pheromone of *Cryptophlebia leucotreta*, and identification of an attractant for *C. peltastica*. Entomologia Experimentalis et Applicata 66: 75-82.

Persoons, C. J., F. J. Ritter, and W. J. Nooijen. 1977. Sex pheromone of the false codling moth, *Cryptophlebia leucotreta* (Lepidoptera:Tortricidae): Evidence for a two component system. Journal Chemical Ecology 3: 717-722.

Reed, W. 1974. The false codling moth, *Cryptophlebia leucotreta* Meyr. (Lepidoptera: Olethreutidae) as a pest of cotton in Uganda. Cotton Grow. Rev. 51(3): 213-225.

Schwartz, A. and T. Anderson. 1983. Economic importance of false codling moth on navels in the Citrusdal Valley. Inligtingsbull Navorsingsinst Sitrus Subtop. Vrugte 130: 14-15.

Stofberg, F. J. 1948. Larvae structures as a basis for identification of false codling moth (*Argyroploce leucotreta*, Meyr.) larvae. Journal of Entomol. Soc. Of South Africa XI: 68-75.

Stofberg, F. J. 1954. False codling moth of citrus. Farm S. Afr. 29: 273-276, 294.

USDA. 1984. Pests not known to occur in the United States or of limited distribution, No. 48: False codling moth. USDA- APHIS-PPQ.

USDA. 2010. New Pest Response Guidelines: False Codling Moth *Thaumatotibia leucotreta*. U.S. Department Of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine, Emergency and Domestic Programs. Riverdale, Maryland
http://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/nprg-fcm.pdf

USDA NASS. 2007. California Agricultural Statistics, 2006 Crop Year. USDA, National Agricultural Statistics Service, California Field Office, Sacramento, California. 92 pp.
http://www.nass.usda.gov/Statistics_by_State/California/Publications/California_Ag_Statistics/2006casall.pdf.

Venette, R. C., E. E. Davis, M. DaCosta, H. Heisler, and M. Larson. 2003. Mini Risk Assessment - False codling moth, *Thaumatotibia* (=*Cryptophlebia*) *leucotreta* (Meyrick)[Lepidoptera: Tortricidae]. Cooperative Agricultural Pest Survey, Animal and Plant Health Inspection Service, US Department of Agriculture.
http://www.aphis.usda.gov/plant_health/plant_pest_info/pest_detection/downloads/pra/tleucotretapra.pdf

This datasheet was developed by USDA-APHIS-PPQ-CPHST staff. Cite this document as:

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Revisions

January 2014
1) *Thaumatotibia roerigii* added as a synonym.
2) Diagnostic larval characters added.
3) Number of generations increased from “four to six” to “four to ten.”
4) Added Israel to distribution as “locally present.”
5) Emphasized the nearly circular pocket of scales in the hind wing as the important identifying character for this species.