Neoleucinodes elegantalis

Scientific Name
Neoleucinodes elegantalis
(Guenée) 1854

Synonyms:
Leucinodes elegantalis Guenée

Common Name
Tomato fruit borer, eggplant moth, cocona fruit borer

Type of Pest
Borer

Figure 1. *Neoleucinodes elegantalis* adult (Dr. M. Alma Solis, Systematic Entomology Laboratory, USDA-ARS, Beltsville (US)).

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

Reason for Inclusion
New Pest Advisory Group (NPAG) suggestion

Pest Description
Descriptions of all stages can be found in Capps (1948).

Eggs: Eggs are initially white and darken before they hatch. They are 0.5 mm long by 0.3 mm wide (EDA, 2007).

Larvae: Larvae are about 0.8 mm long when they emerge from the egg and can grow up to 2 cm (approx. $^{13}/_{16}$ in) (EDA, 2007). Mature larvae are white to pinkish with a brown head (EPPO, 2012b).

Capps (1948) described and illustrated the larva of *N. eleganatlis*.

Pupae: "Color light to dark brown; 12-15 mm. [approx. $^{1}/_{2}$ to $^{9}/_{16}$ in] long. Typical pyraustid…cremaster; dorsum of abdominal segments smooth and without spinelike armature; a prominent hoodlike protuberance above the spiracle on abdominal segments 2 and 3" (Capps, 1948).

Capps (1948) described and illustrated the pupa of *N. eleganatlis*.

Adults: Adults are around 24 mm (approx $^{15}/_{16}$ in), with the female larger than the male (EDA, 2007). "Wings are white, slightly transparent, anterior wings show three irregular brown blotches and posterior wings have scattered black dots" (EPPO, 2012b).

Male genitalia: “Genitalia with harpe slender, elongate, and apex much narrower than base; clasper slender, scalpel-like, and in relation to lower margin of harpe the clasper from near middle or distinctly nearer to base than to apex…Aedeagus…slender; cornutus a simple spine, not conspicuously expanded at base” (Capps, 1948).

Female genitalia: “Genitalia…with genital opening broad; ductus bursa long, slender, with a narrow sclerotized collarlike structure slightly anterior to origin of ductus seminalis; membranous or only slightly sclerotized between the collar and genital opening, the sclerotization, if present, stronger anteriorly; bursa copulatrix simple, expansion from junction with ductus bursa evident” (Capps, 1948).

Biology and Ecology

Females lay eggs singly or in small masses on the calyx or fruit of the host (Blackmer et al., 2001). Fruits chosen for oviposition are 1 to 3 cm (approx. $^{3}/_{8}$ to 1 $^{3}/_{16}$ in) in diameter (reviewed in Eiras et al., 2003). Female moths prefer laying eggs on the underside of the calyx versus the upperside (Blackmer et al., 2001). Females are capable of laying up to 160 eggs (EPPO, 2012b). Blackmer et al. (2001) found that most eggs were laid on the first four basal fruits of the fruit cluster. In cases where infestations are high, eggs may be laid on leaves (EPPO, 2012b).

At 20 to 25°C (68 to 77°F), eggs hatch after 5 to 7 days. The larva enters the host fruit soon after hatching, usually within 1 to 2 hours (reviewed in Eiras et al., 2003). Larvae spend their entire time feeding in the fruit, eating the seeds and fruit flesh (Blackmer et al., 2001; EDA, 2007). There are usually 1 to 3 larvae per fruit, but there can be as many as 18 (Capps, 1948). The larval stage lasts 15 to 19 days (EDA, 2007) and goes through 5 instars (Espinoza, 2008). Marcano (1991) found that the number of larval instars could vary (total of 4 to 5) and was dependent on temperature when studying the life cycle in eggplant.

Figure 2. Pupation site of *Neoleucinodes elegantalis* (Dr. Ana Elizabeth Diaz Montilla, Entomologist, Corpoica La Selva (Colombia)).

Once larvae are mature, they exit the damaged fruit and pupate in the nearby leaves (reviewed in Diaz, 2010) (pupation in leaf folds, Fig. 2) as well as in the soil or in plant debris at the plant base (EPPO, 2012b). The pre-pupal stage lasts 1 to 2 days (reviewed in Carneiro et al., 1998) while the pupal stage lasts around 11 days (EDA, 2007).

Adults are active at night, spending the day hidden in weeds or host crops. Females attract mates by emitting a sex pheromone (EDA, 2007). The adult lives for about 7 days (EDA, 2007).

The life cycle for this species lasts 34 days at 27°C (80.6°F) and 68% relative humidity (reviewed in Diaz, 2010) and at 20°C (66°F), the life cycle lasts 51 days. Oviposition does not occur below 14.7°C (58.5°F) or above 34.5°C (94.1°F) (EPPO, 2012b). Populations of *N. elegantalis* increase during the rainy season in Central America (EDA, 2007). Several generations per year occur in areas where *N. elegantlis* is currently established (EPPO, 2012b).

Damage

Initial damage is characterized as pimples or orifices on the fruit skin (reviewed in Diaz, 2010). When larvae enter the host plant, it leaves a small scar (EDA, 2007). The entrance scar is almost imperceptible (0.5 mm) and may be seen as a sunken area with a necrotic spot (Espinoza, 2008; EPPO, 2012b). An exit hole is present when larvae leave the fruit to pupate (EDA, 2007).

Figure 3. Entrance and exit holes of *Neoleucinodes elegantalis* on a tomato fruit (Dr. Ana Elizabeth Diaz Montilla, Entomologist, Corpoica La Selva (Colombia)).

Larval damage can cause fruits to fall prematurely, rendering them unmarketable (Diaz, 2010). Damage is usually more evident near harvest (EPPO, 2012b).

Pest Importance

Neoleucinodes elegantalis causes economic losses throughout South America in many solanaceous vegetable crops including *Solanum lycopersicum* (tomato), *S. melongena* (eggplant), and *Capsicum annuum* (pepper) as well as in tropical solanaceous fruits including *S. betaceum* (tomato tree) and *S. quitoense* (naranjilla) (Diaz and Solis, 2007). Damage in South America can range from 6 to 70% (reviewed in Diaz, 2010). Seed viability can be reduced by 30 to 100% versus

Figure 4. Damage of *Neoleucinodes elegantalis* in a tomato fruit (Dr. Ana Elizabeth Diaz Montilla, Entomologist, Corpoica La Selva (Colombia)).

seeds from undamaged fruits (reviewed in EPPO, 2012b).

This species is considered one of the most important pests in several tomato growing regions of Brazil (Blackmer et al., 2001) as well as in Venezuela and Columbia (Eiras et al., 2003; EPPO, 2012b). Estimated losses in Brazil due to *N. elegantalis* range from 45 to 90% (reviewed in Blackmer et al., 2001).

One larva per fruit is enough to make the fruit unmarketable. During moderate to severe infestations, up to 14 larvae per fruit have been reported (reviewed in Blackmer et al., 2001).

Current control measures (chemical and cultural) used in Brazil are not always effective in preventing the infestation of fruit, as the entire larval development occurs in the host fruit (EPPO, 2012b).

In some countries, there is little to no information available on damage caused by this species (EPPO, 2012b). Even so, *N. elegantalis* is considered a quarantine pest in the United States and can lead to grower losses if the pest is discovered in shipments to the United States (Espinoza, 2008; Anteparra et al., 2010).

Some countries only have reports of limited damage caused by *N. elegantalis*. In parts of Peru, infested fruits of *S. sessiliflorum* (cocona) only reach 4 to 5% (Anteparra et al., 2010). In Honduras, infestation rates of *S. melongena* (eggplant) are estimated at less than 1% (Espinoza, 2008).

Known Hosts

Major hosts

Capsicum annuum (green pepper), *Solanum lycopersicum* (tomato), *S. melongena* (eggplant), *S. ovigerum* (ornamental white eggplant), and *S. quitoense* (naranjilla) (Blackmer et al., 2001; Diaz, 2010).

Minor hosts

Solanum aethiopicum (scarlet eggplant), *S. betaceum* (=*Cyphomandra betacea*) (tree tomato), *S. capsicoides* (=*S. ciliatum*) (cockroach berry), *S. palinacanthum*, *S. racemiflorum*, *S. sessiliflorum* (cocona), and *S. sisymbriifolium* (sticky nightshade) (Aponte et al., 2005; EPPO, 2012a).

Wild hosts

Solanum acerifolium, *S. atropurpureum*, *S. hirtum*, *S. lycocarpum*, *S. mauritianum* (wild tobacco tree), *S. palinacathum*, *S. pseudolulo*, *S. reflexus*, *S. robustum*, *S. torvum* (turkey berry), and *S. viarum* (tropical soda apple) (reviewed in Carneiro et al., 1998; reviewed in Olckers et al., 2002; EPPO, 2012a; 2012b).

Intercepted on

Capsicum spp. (pepper), *Cereus* spp., *Solanum* spp., *S. lycopersicum* (tomato), *S. melongena* (eggplant), *S. quitoense* (naranjilla), and *S. torvum* (Robinson et al., 2011).

There are no reports of this species attacking potato.

Pathogen or Associated Organisms Vectored

Damage caused by emergence holes can lead to secondary fungal and bacterial infections (reviewed in EPPO, 2012b). This species is thought to spread antracnosis of *Solanum betaceum* (tree tomato) (Aponte et al., 2005).

Known Distribution

Caribbean: Cuba, Grenada, Jamaica, and Trinidad and Tobago; **Central America:** Costa Rica, El Salvador, Guatemala, Honduras, and Panama; **North America:** Mexico; **South America:** Argentina, Brazil, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela (Capps, 1948; McGuire and Crandall, 1967; reviewed in Carneiro et al., 1998; Diaz and Solis, 2007; EPPO, 2012a).

EPPO (2012a) states that *N. elegantalis* is not present in French Guiana and records stating such are unreliable.

Although this species has been reported to occur in Puerto Rico (Wolcott, 1936; Schaus, 1940; Capps, 1948; Marcano, 1991; Carneiro et al., 1998; EPPO, 2012b), M. A. Solis, a pyraloid moth expert at the Systematic Entomology Laboratory (SEL), Agricultural Research Service (ARS), concluded that it is likely a misidentification that has been perpetuated in later literature. M.A. Solis also found that there are no *N. elegantalis* larval and adult specimens from Puerto Rico in the U.S. National Collection located at the National Museum of Natural History, Washington, DC (M. A. Solis, personal communication). Puerto Rico is currently surveying for this species using a trap and the species-specific pheromone.

Pathway

This species may be introduced to new areas through international trade of infested fruits (EPPO, 2012b). According to AQAS (2012; queried April 10, 2012) this species has been intercepted over 1,150 times at U.S. ports of entry. All specified interceptions were on host material (mainly fruit with 1,082 interceptions). The most common plants *N. elegantalis* were intercepted on included: *Solanum* spp. (937), *Capisicum* spp. (79), and *Lycopersicon* spp. (52) (now *Solanum* spp.). 1,102 of the 1,175 interceptions originated from countries known to have the pest including Brazil (610), Venezuela (157), Ecuador (102), and Peru (59).

According to FAVIR (2012), *S. lycopersicum* (tomato) is allowed entry into the United States as fruit or fruit clusters from the following countries that have *N. elegantalis*: Costa Rica, Grenada, Guatemala, Honduras, Jamaica, Mexico, Panama, and Trinidad and Tobago. *Solanum melongena* (eggplant) is allowed entry into the United States as fruit from the following countries that have *N. elegantalis*: Columbia, Costa Rica, Grenada, Guatemala, Guyana, Honduras, Jamaica, Mexico, Panama, and Trinidad and Tobago. *Capsicum* spp. (pepper) is allowed entry into the United States from the

following countries with *N. elegantalis*: Grenada, Guyana, Jamaica, and Trinidad and Tobago.

Natural spread may occur through adult flight.

Potential Distribution within the United States

In Columbia, *N. elegantalis* is the only species in this genus that is reported to occur in both warm and cold climates (reviewed in Diaz and Solis, 2007). Landry (2012) states that this species may be able to establish in the United States within Plant Hardiness Zones 7 through 11 based on its current distribution and ability to survive in both warm and cold climates.

Host material for *N. elegantalis* is grown throughout the United States. According to the NASS 2007 Census of Agriculture, *S. lycopersicum* (tomato) is grown in all 50 states, in both the field and greenhouses. Both *S. melongena* (eggplant) and *Capsicum* spp. (bell peppers) are grown in 48 states (USDA, 2009).

Survey

CAPS-Approved Method*:

The CAPS-approved method is a trap and lure combination. The trap is the large plastic delta trap. The lure is effective for 30 days.

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

Large Plastic Delta Trap Kits, Orange
Large Plastic Delta Trap Kits, Red
Large Plastic Delta Trap Kits, White

The Lure Product Name is *Neoleucinodes elegantalis* Lure.

Trap color is up to the State and does not affect trap efficacy.

IMPORTANT: Do not place lures for two or more target species in a trap unless otherwise recommended.

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: Sex pheromone components have been identified for *N. elegantalis*. Traps baited with 1 mg of E11-16:OH captured a significant number of male moths, more so than traps baited with two virgin female moths. Z3,Z6,Z9-23:Hy enhanced attractiveness of E11-16:OH, but was not attractive by itself (Cabrera et al., 2001). The

concentrations used by Cabrera et al. (2001) were 1000 µg of E11-16:OH and 50 µg of Z3,Z6,Z9-23:Hy. Water traps suspended about 1 m (3.28 ft) aboveground at 20 m (65.6 ft) intervals were used to trap males (Cabrera et al., 2001).

In Venezuela where the moth is present, the National Agricultural Research Center recommends using 20 pheromone traps (water traps) per hectare with commercially produced sex pheromone lures (Neoelegantol ®). Eight of the traps should be placed at the edges of the crop field while the remaining 12 should be placed between the plants (Silva, 2008).

Survey Site Selection:
Host crops should be targeted when surveying this pest. The main crops include *Capsicum annuum* (green pepper), *S. lycopersicum* (tomato), and *S. melongena* (eggplant).

Trap placement:
Water traps suspended about 1 m (3.28 ft) aboveground at 20 m (65.6 ft) intervals were used to trap males by Cabrera et al. (2001). In Venezuela, about 40% of the traps were placed around the edges of the crop with the rest being interspersed among the host plant crop (Silva, 2008).

Time of year to survey:
Surveying may occur throughout the growing season of the host crop. Surveys in greenhouses may be conducted anytime the host crop is present.

Visual survey: Eggs can be observed on the fruit sepals (reviewed in Diaz, 2010).

Not recommended: Adults are attracted to light (EDA, 2007), but this method of survey is less effective than using pheromones. Light traps attract many non-targets; pheromone trapping is more specific (Gallegos et al., 2003).

Key Diagnostics/Identification

CAPS-Approved Method*:
Morphological.

*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 Pests

Species found in this genus can be hard to distinguish from one another. Capps (1948) published a new set of characters to reliably identify *N. elegantalis* after a review of the samples in the United States was found to contain a mixture of several different species. Keys to distinguish male and female adults of *Neoleucinodes* spp. in the New World (including *N. elegantalis*) are found in Capps (1948).

Neoleucinodes elegantalis is almost identical externally to the newly described species *N. silvaniae*. *Neoleucinodes silvaniae* can be distinguished from *N. elegantalis* by the short third labial palpal segment in females and males. "The labial palpi in *N. elegantalis* are sexually dimorphic, the females have a long third labial palpal segment and in the males it is shorter" (Diaz and Solis, 2007). Other differences between the two species are listed in Diaz and Solis (2007).

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