

# EPPO Datasheet: *Neoleucinodes elegantalis*

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## IDENTITY

**Preferred name:** *Neoleucinodes elegantalis*

**Authority:** (Guenée)

**Taxonomic position:** Animalia: Arthropoda: Hexapoda: Insecta:  
Lepidoptera: Crambidae

**Other scientific names:** *Leucinodes elegantalis* Guenée

**Common names:** cocona fruit borer, eggplant moth, small tomato borer, tomato fruit borer

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**EPPO Categorization:** A1 list

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**EU Categorization:** A1 Quarantine pest (Annex II A)

**EPPO Code:** NEOLEL



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## Notes on taxonomy and nomenclature

*Neoleucinodes elegantalis* (Guenée) was initially described as *Leucinodes elegantalis* Guenée and recorded as a South American species attacking tomato in the states of Paraná and Minas Gerais in Brazil. Capps (1948) regarded *L. elegantalis* sufficiently different from other *Leucinodes* species known from the Old World, and created the genus *Neoleucinodes* in which he assigned this New World species as *Neoleucinodes elegantalis*. Recent studies have shown genetic divergence between populations of *N. elegantalis* from different areas and different hosts (Maia *et al.*, 2016; Diaz-Montilla *et al.*, 2013; Noboa, 2017a - see also under *Hosts*).

## HOSTS

*N. elegantalis* is an oligophagous pest that attacks only fruits of plants belonging to the family Solanaceae. Its host list includes major crops, such as tomato (*Solanum lycopersicum*), eggplant (*S. melongena*) and pepper (*Capsicum annuum*), as well as some tropical plants cultivated for fruit, especially *S. quitoense* (naranjilla), *S. betaceum* (tree tomato), *S. sessiliflorum* (cocona), *S. pseudolulo* (lulo del Pacifico), *S. aethiopicum* (gilo) and *S. sisymbriifolium* (litchi tomato). Other hosts in the list below are wild solanaceous plants, mostly belonging to the *Leptostemonum* subgenus.

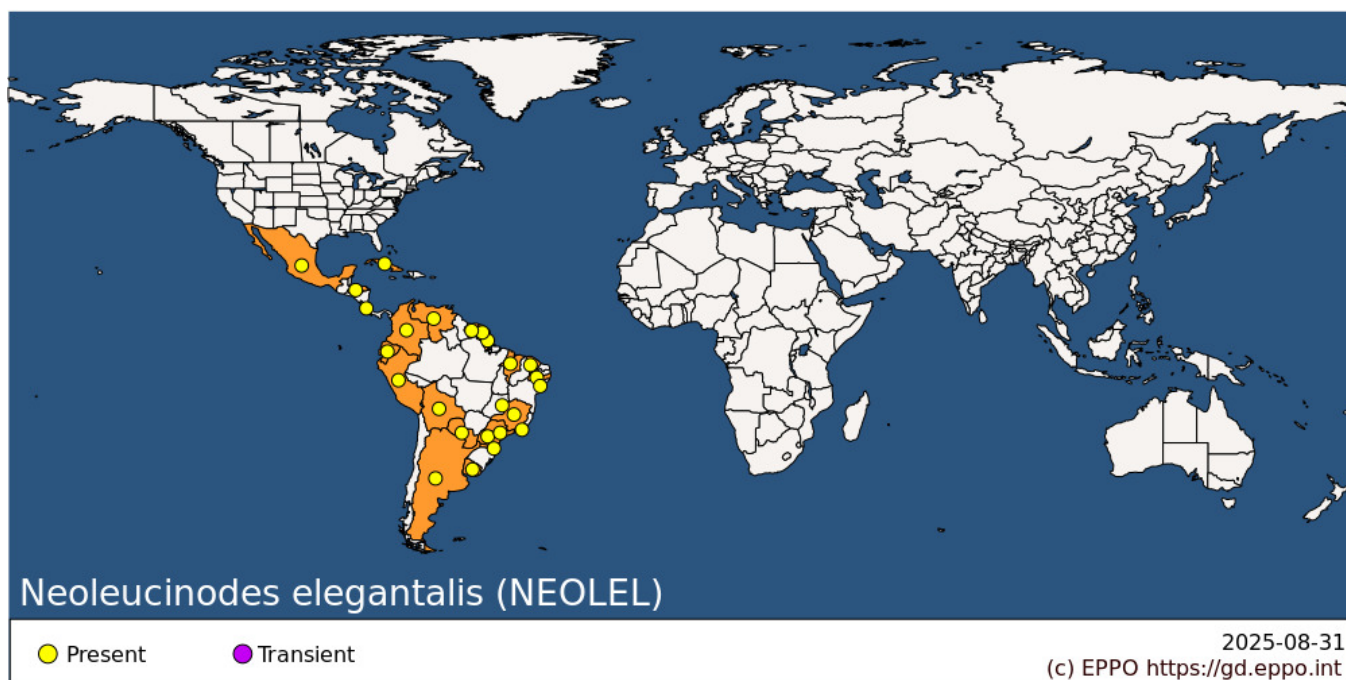
It is noteworthy that in Colombia there are areas where the insect was not found on some host crop plants planted at certain altitudes. In Ecuador, the insect causes damage to *S. quitoense* and *S. betaceum* in some areas, but in the same areas it has not been observed on *S. lycopersicum* and *C. annuum* (Paredes *et al.*, 2010; Noboa *et al.*, 2017). Recent studies on the diversity of populations of *N. elegantalis* in Colombia showed the presence of biotypes or host races separated by the Andes mountain range, with some level of morphological, biological and genetic differences, and in some cases a decrease of reproductive compatibility between races (Diaz-Montilla *et al.* 2013, 2017a&b, 2018).

**Host list:** *Capsicum annuum*, *Solanum acerifolium*, *Solanum aethiopicum*, *Solanum arboreum*, *Solanum atropurpureum*, *Solanum betaceum*, *Solanum crinitum*, *Solanum hirtum*, *Solanum lycocarpum*, *Solanum lycopersicum*, *Solanum melongena*, *Solanum pseudolulo*, *Solanum quitoense*, *Solanum sessiliflorum*, *Solanum sisymbriifolium*, *Solanum torvum*, *Solanum umbellatum*

## GEOGRAPHICAL DISTRIBUTION

*N. elegantalis* is reported only from the Neotropics. In addition to the distribution records below, it has been reported in several countries of South America, Central America and the Caribbean, where its current presence is nevertheless in doubt. This is the case for old records (Capps, 1948) that are not supported by more recent publications (Grenada,

Guatemala, Guyana, Jamaica, Nicaragua, Panama, Trinidad and Tobago), as well as for Nicaragua, El Salvador and Puerto Rico.



**North America:** Mexico

**Central America and Caribbean:** Costa Rica, Cuba, Honduras

**South America:** Argentina, Bolivia, Brazil (Amapa, Ceara, Distrito Federal, Maranhao, Minas Gerais, Parana, Pernambuco, Rio de Janeiro, Santa Catarina, Sao Paulo, Sergipe), Colombia, Ecuador, French Guiana, Paraguay, Peru, Suriname, Uruguay, Venezuela

## BIOLOGY

Eggs are oviposited singly or in groups of 2-3 eggs (Blackmer *et al.*, 2001; Eiras and Blackmer, 2003). The oviposition sites differ depending on the host plant. On tomato, eggs are oviposited under or on the calyx, or at the surface of the fruit (Salas *et al.*, 1991; Marcano, 1991a, Blackmer *et al.*, 2001; Rodrigues Filho *et al.*, 2003; Jaramillo *et al.*, 2007). A large proportion of eggs are laid on small fruits of 1-3 cm diameter (Blackmer *et al.*, 2001; Carneiro *et al.*, 1998; Eiras and Blackmer, 2003; Rodrigues Filho *et al.*, 2003). Eggs may also be oviposited on floral stalks and flower buds and, when the pest is present at high densities, on leaves (Carneiro *et al.*, 1998). On eggplant, eggs are mostly laid on the calyx or directly on the fruit and below the sepals (Espinoza, 2008; Serrano *et al.*, 1992). There is a great variation in the number of eggs per female, but the average number appear to be around 30-50 (Fernandez and Salas, 1985, Marcano, 1991a&b; de Moraes & Foerster, 2014).

Larvae of *N. elegantalis* pass through 4 larval instars at 20°C and 25°C and five larval instars at 15°C and 30°C (Marcano *et al.*, 1991b). Neonate larvae enter the fruit within a short time after hatching (approximately one to a few hours) (Eiras and Blackmer, 2003; Diaz-Montilla, pers. comm.). Larvae develop only inside fruit. Usually, there are only a few larvae per fruit. Depending on fruit size, fruit of tomato can for example host 1 to 34 larvae (Serrano *et al.*, 1992).

Mature larvae exit the fruit and develop into pupae, which are protected by a delicate sticky cocoon (Carneiro *et al.*, 1998). The pupation site varies according to the morphology of the host plant and the material that the larvae encounters when exiting the fruit. In tomato, pupae are formed on enfolded leaves on the plant, and can still develop after the leaves fall onto the ground. In *S. quitoense*, pupae are formed on leaves and dry flower buds in the aerial part of the plant, but also between the fruits of a cluster or in plant debris accumulated in the axils of the plants. In sweet pepper, pupae may be formed on plastic mulch on the ground at the base of the plant (Capps, 1948; Salas *et al.*, 1991; Marcano 1991a; EDA, 2007; Asaquibay *et al.*, 2009; Salas *et al.*, 1991, Serrano *et al.*, 1992; Viáfara *et al.*, 1999).

Adults are nocturnal, including mating and oviposition activities. During the day, they remain motionless hidden under the leaves of weeds or crop hosts (Marcano *et al.*, 1991a). Females attract mates by emitting a sex pheromone. They mate within 48 to 72 h after emergence, and oviposition typically occurs shortly after mating (Marcano *et al.*, 1991a, de Moraes & Foerster, 2014).

It is important to note, especially in relation to control, that life stages of *N. elegantalis* are not easily accessible: eggs may be under the calyx on some hosts; neonate larvae are at the surface of fruits for a very short time before entering the fruit for their entire life; pupae are enclosed in a cocoon attached to leaves or in debris, and adults are nocturnal.

At temperatures around 20-25°C, the life cycle lasts 30-60 days, and it was found to last 115 days on tomato at 14.7°C (Marcano *et al.*, 1991a&b; Serrano *et al.* 1992; de Moraes & Foerster, 2014). *N. elegantalis* has several generations per year, but no precise data is available in the literature. In some areas, the pest is present throughout the year in the crops and generations overlap (Barbosa *et al.*, 2010). There is no evidence that *N. elegantalis* has a diapause. Models based on climatic data showed that, in Colombia, there may be 2 to 11 generations per year depending on locations (EPPO, 2014), and in Brazil 5 to 10 generations per year (De Moraes & Foerster, 2015).

Development is favoured by a relative humidity above 65% and a maximum temperature of 25°C (Marcano (1991 a&b). Regarding temperature thresholds, Marcano *et al.* (1991 a&b, with respectively tomato and eggplant as food) did not obtain oviposition at 14.7°C, no hatching at 30.2°C, and no development to the adult stage at 34.5°C. In similar trials, de Moraes & Foerster (2015) obtained similar results, with however some oviposition occurred at 15°C, and *N. elegantalis* from different regions of Brazil completed their life cycle and reproduced between 15°C and 27°C (de Moraes & Foerster, 2015). On the basis of a linear regression with existing data, EPPO (2014) estimated that development of *N. elegantalis* stops at 10.5°C, while de Moraes & Foerster (2015) estimated that the lower temperature threshold for immature stages of *N. elegantalis* is 8.8°C.

## **DETECTION AND IDENTIFICATION**

### **Symptoms**

Larvae entry and exit holes are present on fruit. The entry hole is very small and heals over time, leaving a scar consisting of a depressed area with a necrotic spot of about 0.5 mm, which is almost imperceptible (Espinoza, 2008). Exit holes are larger. There may be excrement on the fruit (especially on fruit of *S. quitoense* and *S. betaceum*). Fruit may have a slight abnormal coloration, and may fall (EPPO, 2014).

### **Morphology**

#### **Eggs**

Flat, slightly textured, oval, measuring 0.5 mm long and 0.3 mm wide. Just-oviposited eggs are white, turning light yellow and becoming brown prior to hatching.

#### **Larva**

Mature larvae measure 15 and 20 mm in length. Body colour from white to pink with a brown head. Body pinacula without sclerotization and pigmentation. The colour of the pinacula is similar to that of the body; they are present as a slightly raised blister particularly on the meso- and meta-thorax. Prothoracic shield pale yellow with light-brown markings.

#### **Pupa**

Obtect. Colour varying from light to dark brown, measuring 12–15 mm, with a cremaster. Dorsum of the abdominal segments smooth. The 2nd and 3rd abdominal segment with a protruding cover above each spiracle.

#### **Adult**

The adult is a moth with white wings, somewhat hyaline with dark brown or black scaly areas. Dorsally the abdomen has a striking white band covering the entire 1st abdominal segment and part of the 2nd and 3rd segments, the rest of the segments covered by a mixture of dark- brown and black scales. The abdomen in ventral view, with the entire 1st abdominal segment and a large portion of the 2nd and 3rd segment white in colour, the other segments paler than the dorsum. Laterally, the abdomen has small tufts of scales of the same colour, often difficult to see in descaled specimens. There is a sexual dimorphism. In the females, the third labial palp is longer than in the males. The male wingspan is 15–33 mm and the female wingspan 15–30 mm.

### **Detection and inspection methods**

The pest is difficult to detect visually. Symptoms of infestation are not readily observed at early stages of infestation. Eggs are very small, larvae are inside the fruit, entry holes are very small and may be hidden under the calyx, pupae are hidden, and adults are nocturnal. Nevertheless, detection of eggs can be used to determine the timing of plant protection products applications (see *Control*) (Serrano *et al.*, 1992; Benvenega *et al.*, 2010; da Silva *et al.*, 2019). Damage is more likely to be first observed at harvest of the first fruit (Carneiro *et al.*, 1998).

Trapping is available and relies on a sex pheromone. A synthetic pheromone blend has been available commercially since 2001 in Venezuela (Silva, 2008) and has been used in several countries (Jaffe *et al.*, 2007). However, it does not work on all populations and host races (K. Jaffe, pers. comm.). More recently, a study demonstrated differences between populations and host races in their response to pheromones (Diaz-Montilla *et al.*, 2017a).

Positive identification of *N. elegantalis* is required to confirm the presence of the pest. *N. elegantalis* is morphologically very similar to several other species of Crambidae that occur in Central and South America. Keys are available in Diaz & Solis (2007).

## **PATHWAYS FOR MOVEMENT**

International movement of *N. elegantalis* could occur on infested host fruit and plants for planting bearing fruit, as well as on infested fruit packaging. Host fruit is known to be a pathway for the introduction of the pest into Suriname, and there have been numerous interceptions of *N. elegantalis* on fruit imported into the USA and the Netherlands. A key factor for the successful entry of *N. elegantalis* into a country would be that packing and handling facilities for imported fruit are situated close to production areas. Regarding plants for planting, only plants with fruit may be a pathway, which may be the case for plants for ornamental purposes. Finally, fruit or plants for planting carried in travellers' luggage are a potential pathway, although successful entry is less likely than for commercial consignments (EPPO, 2014).

## **PEST SIGNIFICANCE**

### **Economic impact**

*N. elegantalis* has had a negative economic impact on Solanaceae production in Latin America. It causes fruit losses either directly or through secondary infection by other organisms, and also has negative impacts on export markets.

Fruit losses on tomato crops were reported to reach 60 % in Colombia, 77% in Brazil and 41 % in Venezuela during the rainy season (Perez Rosero, 2010, citing others). In Argentina, losses on glasshouse tomatoes reached 12 % (Puch and Mollinedo, 2009).

In tomatoes, eggplants and sweet pepper destined for the fresh market, almost any insect making an entry or exit hole on the fruit will result in fruit loss through secondary bacterial or fungal infection, cosmetic damage, or insect contamination. *N. elegantalis* has been a major problem for export of Solanaceae fruit from infested countries (Diaz-Montilla *et al.*, 2018). In Honduras losses of 1% were recorded on eggplant (Diaz & Brochero, 2012), but were associated with significant impact on export. For processing tomatoes, the primary losses are due to fruit shipments that are rejected because of larval contamination: the presence of any recognizable insect larvae or portion of a larva in consumer products is unacceptable to most consumers (Espinoza, 2008).

## Control

The management of *N. elegantalis* has relied on the application of insecticides, and integrated measures combining chemical control based on the results of monitoring, biological control and cultural practices have been developed (Silva, 2008; SENESA Honduras, 2012). The timing of insecticide applications needs to be adapted to the life stage targeted (eggs, young larvae or adults), as each life stage is accessible only during a limited time (Espinoza, 2008, da Silva *et al.*, 2018). Pheromone traps or visual inspection for eggs can be used for monitoring, depending on the life stage targeted (EPPO, 2014; da Silva *et al.*, 2019). Several life stages may be present at the same time because of overlapping generations, which also hamper control as different active substances need to be used against different life stages.

Egg parasitoids of the genus *Trichogramma* have been widely studied as a biological control agent of *N. elegantalis*. The following species of *Trichogramma* have been reported in the literature as potential biological control agents to control *N. elegantalis*: *T. exiguum*, *T. pretiosum* and *T. minutum* (Berti and Marcano 1995, Cross 1996, Viáfara *et al.*, 1999, Blackmer *et al.*, 2001; Leiderman & Sauer, 1953; Parra & Zucchi, 2004. Silva, 2008, de Oliveira *et al.*, 2017).

Mating disruption using sex pheromones has been investigated as a promising control technique (De França *et al.*, 2013 & 2017). However, pheromones should be adapted to the different populations/biotypes as Diaz-Montilla *et al.* (2017a) showed that different populations and host races may respond differently to pheromones traps.

Finally promising results were obtained recently in the selection of a hybrid of *S. quitoense* with resistance to *N. elegantalis* (Polanco-Puerta *et al.*, 2018).

## Phytosanitary risk

*N. elegantalis* is an EPPO A1 quarantine pest (EPPO, 2019). This species is potentially a serious pest of tomato, eggplant, and sweet pepper, which are widely grown in the EPPO region. It also presents a risk for tropical host fruit which are grown to a limited extent in the EPPO region, such as tree tomato (*S. betaceum*). In the EPPO region, the endangered area is considered to be the Mediterranean Basin and Portugal (EPPO, 2014; da Silva *et al.*, 2017). Establishment outdoors in the rest of the EPPO region is considered unlikely. In northern areas of the EPPO region, only transient field populations are expected, but permanent populations may establish in greenhouses. *N. elegantalis* may cause damage in protected conditions, even if it does not establish permanently. In case of establishment, losses are likely to occur at least until control methods are added to the current integrated management programmes. Human-assisted pathways, especially fruit, may spread the pest over long distances within the EPPO region. Eradication or containment of this species will be difficult and costly, and unlikely to be successful other than in protected conditions (EPPO, 2014).

## PHYTOSANITARY MEASURES

EPPO recommended that phytosanitary measures should be taken for fruits and plants for planting of cultivated host species. Fruit should originate from a pest-free area or pest-free place of production in screened glasshouses, in both cases pheromone trapping should be used. Alternatively, a systems approach may be required, combining growing under screenhouses, monitoring, treatment and good agricultural practices, as well as inspection and sorting at packing, and visual inspection of the consignment. New packaging should be used before export, and packaging should be destroyed or safely disposed of after import. In importing countries, it is important that the trade and production flows are separated, and that surveillance systems (including trapping at packing stations) are in place (EPPO, 2014). No treatment schedule for host fruit appears to be available to date. In experiments, 100 and 200 Gy (gamma irradiation) were lethal doses against eggs and larvae of *N. elegantalis* (Costa *et al.*, 2009). For plants for planting, similar options of pest-free area or pest-free place of production were recommended, as well as importing plants that have never borne fruit (e.g. seedlings). Plants and containers should be free from plant debris. Finally, raising awareness and inspection of luggage would mitigate the risk of entry with travellers (EPPO, 2014).

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