# EPPO Datasheet: *Thaumetopoea pityocampa*

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## IDENTITY

**Preferred name:** *Thaumetopoea pityocampa*
**Authority:** (Denis & Schiffermüller)
**Taxonomic position:** Animalia: Arthropoda: Hexapoda: Insecta: Lepidoptera: Notodontidae
**Other scientific names:** *Cnethocampa pityocampa* (Denis & Schiffermüller)
**Common names:** pine processionary, pine processionary caterpillar, stone-pine processionary caterpillar
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**EU Categorization:** PZ Quarantine pest (Annex III)
**EPPO Code:** THAUPI

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### Notes on taxonomy and nomenclature

The genus name *Thaumetopoea* originates from the Greek words "?????" (=miracle) and "????" (=do), quite likely due to some biological traits that seems remarkable as for example the gregarious behaviour through egg and larval stages, the urticating setae for the protection against vertebrate predators and the prolonged (up to nine years) diapause as pupa in soil in order to avoid unfavourable environmental conditions that could put its survival at risk (Battisti *et al.*, 2015). The species name on the other hand is much more straightforward, as *pitus* is Aleppo Pine ( *Pinus halepensis*) and *campa* is larva in Ancient Greek (Roques and Battisti, 2015).

## HOSTS

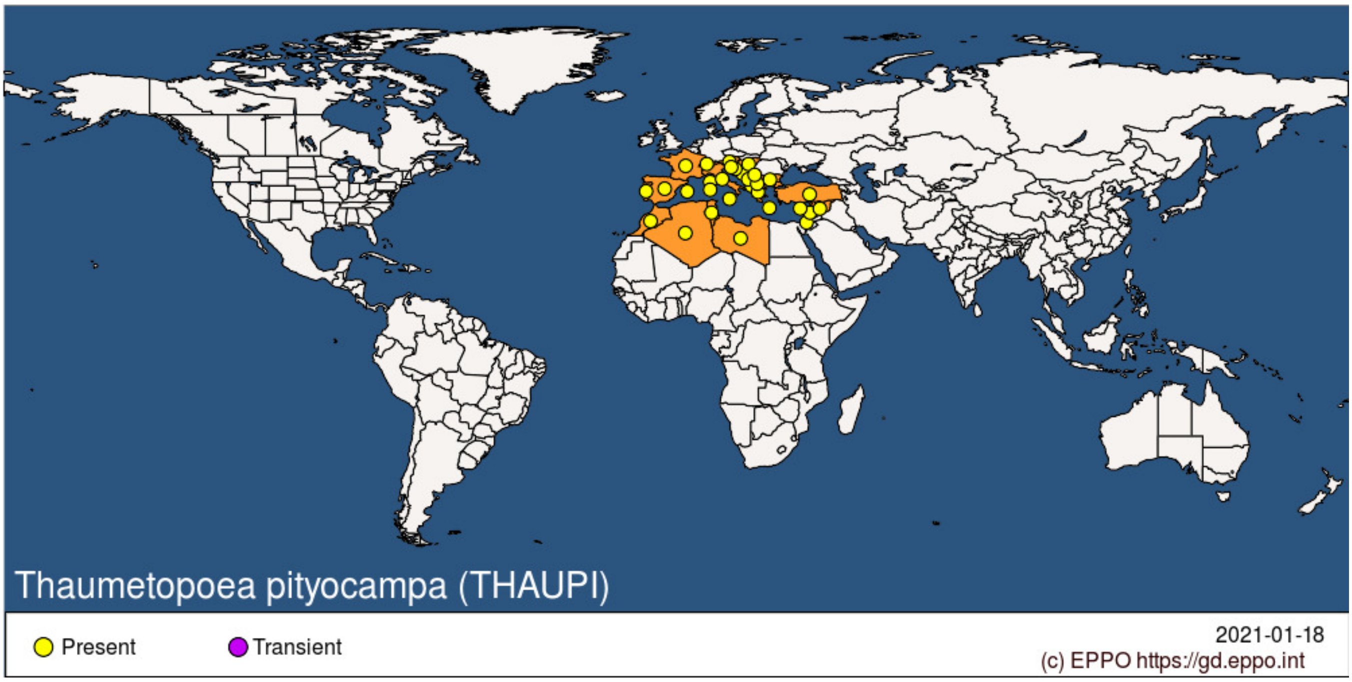
*Thaumetopoea pityocampa* is considered oligophagous on *Pinus* and *Cedrus*, both native European and introduced species, while it can also occasionally attack *Pseudotsuga menziesii*, *Larix decidua* and *Abies concolor* (Battisti 1988; Masutti and Battisti, 1990; Martin 2005; Zamoum and Démolin, 2005; Pimentel *et al.*, 2006; Stastny *et al.*, 2006; Mirchev *et al.*, 2007; Jacquet *et al.*, 2013; Sebti and Chakalli, 2014; Battisti *et al.* 2015, Jactel *et al.* 2015). Even within the same genus, species vary in susceptibility, due to physical features (dimensions, morphology) and chemical composition of needles (Schopf and Avtzis, 1987; Devkota and Schmidt, 1990), that influences larval development and growth (Avtzis, 1986; Hódar *et al.*, 2002; Petrakis *et al.*, 2005). Based on their susceptibility, Demolin first (1969a) concluded a list of the preferred host species, that was later on revised by EPPO (2004) and currently includes (in order of preference): *Pinus nigra* var. *austriaca, P. sylvestris, P. nigra* var. *laricio, P. pinea, P. halepensis, P. pinaster, P. canariensis*, followed by *Cedrus atlantica* and finally *Larix decidua*.

However, it should be mentioned that differences in host selection do not necessarily apply outside the regions where the pest were originally observed. For example, *Cedrus* has been observed to remain undamaged in the Mont Ventoux area (France), but is infested with high population levels of the pest in North Africa (Géri, 1980).

**Host list:** *Cedrus atlantica*, *Larix decidua*, *Pinus brutia*, *Pinus canariensis*, *Pinus halepensis*, *Pinus nigra subsp. laricio*, *Pinus nigra*, *Pinus pinaster*, *Pinus pinea*, *Pinus radiata*, *Pinus sylvestris*

## GEOGRAPHICAL DISTRIBUTION

*T. pityocampa* has long been considered a circum-Mediterranean pest, with climatic parameters limiting its broader occurrence (Huchon and Démolin, 1970; Battisti *et al.*, 2005). However, in the last decades, human-mediated transport (Robinet *et al.*, 2011) in concert with the observed increase in temperature has allowed the pine processionary moth to expand its range both in elevation and latitude (Hódar & Zamora, 2004; Battisti *et al.*, 2005; Buffo *et al.*, 2007; Robinet *et al.*, 2007; Robinet *et al*., 2013; Roques *et al.* 2015).




**EPPO Region:** Albania, Algeria, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, France (mainland, Corse), Greece (mainland, Kriti), Hungary, Israel, Italy (mainland, Sardegna, Sicilia), Montenegro, Morocco, North Macedonia, Portugal (mainland), Serbia, Slovenia, Spain (mainland, Islas Baleares), Switzerland, Tunisia, Turkey
**Africa:** Algeria, Libya, Morocco, Tunisia
**Asia:** Israel, Lebanon, Syria

## BIOLOGY

*T. pityocampa* is normally a univoltine species, with the main feeding activity taking place during winter, contrary to other congeneric species and defoliators in general. However, the life cycle may extend up to two years (semivoltine) in specific parts of its range (e.g. the mountains of Corsica) (Géri, 1983). Recently, an atypical population of *T. pityocampa* was discovered in a plantation of maritime pine in Portugal, with its larvae feeding during summer (Pimentel *et al.*, 2006; Santos *et al.*, 2007; Pimentel *et al.*, 2010).

In general, the life cycle of this pest consists of two phases, one aerial (egg, caterpillar and adult) and one hypogeal (pupa). Depending on the environmental conditions (Géri 1980; Zovi *et al*., 2008; Pimentel *et al.* 2012) females lay about 150-350 eggs in helicoid-arranged batches on needles or twigs at the periphery of the crown, which they then cover with scales. Eggs hatch 30-45 days afterwards, with young larvae boring a very distinctive opening in the chorion of the egg. Larvae from the same egg batch are full siblings and their development goes through five instars. Right after hatching, larvae begin building silk tents which gradually become larger and thicker until the 4$^{th}$ instar, when they build their definitive winter tent which is situated at the branch tips in the upper part of the crown. From the 3$^{rd}$ instar, larvae develop urticating setae which they actively release when disturbed, causing severe allergic reactions in humans and other vertebrates (Démolin 1963; Kaszak *et al.* 2015; Moneo *et al.*,2015; Battisti *et al.* 2017). For later instars, each silk tent may contain aggregates of several hundred individuals (Battisti *et al.* 2015).

Larvae of the 5$^{th}$ instar leave trees in a typical head-to-tail procession in search for a suitable site (e.g. open areas, forest edges) to tunnel underground and pupate in the soil (Démolin, 1969b; Démolin, 1971). A colony was observed to travel 37 m in 2 days in a cold mountainous area of Spain, the first 35 m being covered during the first day (Robredo, 1963). Typically, these processions occur between February and May, though they may appear in December at warmer sites and years (Battisti *et al.*, 2015).

Pupation takes place at a depth of about 5-20 cm and pupae enter diapause which is interrupted one month before adult emergence. However, a certain proportion of pupae may not yield adults in the year of pupation, and experience a prolonged diapause that can be extended over several years (Démolin, 1969b; Géri *et al.*, 1983; Vega *et al.*, 1999; Démolin, 1990; Salman *et al.*, 2016; Salman *et al.*, 2018).

A few hours after the emergence of the adults from the soil, they mate and females oviposit on the nearest pines. Males however, can fly several kilometres (Battisti *et al.*, 2005; Mirchev and Geshev, 2013), something critical for the currently observed northward expansion of the species due to combined effect of climate change and human-mediated long-distance spread (Battisti *et al.* 2005; Robinet *et al.*, 2007; Robinet *et al.*, 2011).

## DETECTION AND IDENTIFICATION

### Symptoms

The symptoms attributed to *T. pityocampa* infestation in pine stands change during the course of the year depending on the development stage of the insect. The most striking symptoms of *T. pityocampa* infestation are the partially or completely defoliated branches of the host trees, as first instar larvae feed on the current-year needles near the egg batches, and gradually switch over to older needles for the later instars. The partially consumed needles gradually turn to yellow and brown, remaining attached on the twigs.

The typical silken communal tents can be distinctly observed from a distance on branches, while on younger trees, these tents are located in the upper part of the crown. The nests are 12–25 cm long, usually oblong in shape and white to light grey in colour.

Pupal cocoons can be found in the upper layers of the soil mostly during spring (late February to late May), whereas under unfavourable condition, pupae may enter a prolonged diapause lasting up to three years. Adults finally, emerge in mid to late summer (June to end of August).

### Morphology

#### *Eggs*

Individual eggs are spherical and white, and the female lays them in typical cylindrical egg-masses which are 25–40 mm wide and about 5 mm high and can contain 70–300 eggs in total. Egg masses are covered with scales produced by the female from the tip of her abdomen and are a grey-brown colour which resembles the branches so they are well camouflaged.

#### *Larva*

The larvae develop through five instars, which are mainly identified by differences in head capsule width that remains black throughout the instars. The body of the 1$^{st}$ instar larva is dull apple-green, with a head capsule width that ranges between 0.6-0.8 mm. In the 2$^{nd}$ instar, the larval body becomes brownish, and the head capsule width may increase to 1.00 mm. After the second moult (3$^{rd}$ instar), larvae assume their typical appearance with the reddish dorsal urticating hair patches on each body segment appearing arranged in pairs. The pleural setae vary from white to dark-yellow, while the dorsal setae range from yellow to dull orange. The head capsule width of the 3$^{rd}$ instar larvae varies between 1.3 and 1.6 mm. In the 4$^{th}$ instar the width of head capsule reaches 2.3-2.6mm, whereas in the 5$^{th}$ instar this can be doubled, (up to 5mm). The fully-grown larva of the 5th instar is about 40 mm in length.

#### *Pupa*

The pupa is in an oval, brown-white silken cocoon. The obtect pupae are about 20 mm in length, oval, and a pale brownish-yellow that later turns to dark reddish-brown.

#### *Adult*

Male and female moths have a wing-span of 30-40 mm and 35-50 mm, respectively. Antennae are filiform in females and pectinate in males, but they both have a hairy thorax. In females, the abdomen is stout and its last segments are covered with a tuft of large scales with which they cover the egg batches, while the abdomen of males is brushy and sharp. The forewings are dull ashen-grey; the veins, margins and three transverse bands are darker. The hindwings are white, grey-fringed, with a characteristic dark spot in the anal region.

For further details, see the EPPO Diagnostic Protocol PM 7/37 *Thaumetopoea pityocampa* (EPPO, 2004), Avtzis *et al.* (2013) and Battisti *et al.* (2015).

### Detection and inspection methods

*T. pityocampa* adults prefer taller trees which are located at stand edges (Démolin, 1969a; Démolin, 1969b; Samalens and Rossi, 2011; Dulaurent *et al.*, 2012) that can be associated with higher solar radiation (Buffo *et al.*, 2007) but also with the proximity to open forest areas where pupae burial takes place (Barbaro *et al.*, 2007; Dulaurent *et al.*, 2011). As a consequence, the cylindrical egg batches are easily detectable as they are situated at the lower branches and needles of the crown. Silk tents, particularly those of the later instars which are located on the upper part of the crown, are also clearly visible and typical for the species. Finally, both sexes are attracted to UV light traps, while males can be captured using traps baited with sex pheromones.

## PATHWAYS FOR MOVEMENT

Though initially it was assumed that female flight is limited compared to male based on release-recapture field trials (Démolin, 1969b), recent studies in a flight mill found that female flight averaged about 5km, with a maximum distance of 27 km (Battisti *et al.*, 2005). Recently however, it has been shown that, in addition to natural dispersal, human-mediated transportation plays a decisive role in the expansion of the species over long distances (Robinet *et al.*, 2011). However, the risk of human-mediated transport is not uniform in all stages; eggs and larvae can be easily detected on imports while adults are highly unlikely to be present on imported plants. Pupae, on the other hand, may be transported with plants for planting as they are buried in the attached growing medium or soil and thus any plant cultivated near an area where *T. pityocampa* is present may harbour pupae (Starzewski, 1998). The impact of this pathway is magnified by climate change, as previously unfavourable environmental conditions become suitable for *T. pityocampa* (Robinet *et al.*, 2007). From 1972 to 2004, *T. pityocampa* has expanded northwards in France by 87 km and in altitude by 110-230 m (in Italy) (Battisti *et al.*, 2005).

## PEST SIGNIFICANCE

### Economic impact

*T. pityocampa* is one of the most important forest pests throughout the temperate regions of the Mediterranean basin, infesting mainly pine but also cedar trees (the latter in North Africa). Defoliation caused by *T. pityocampa* significantly impairs the vitality of host trees, affecting both their growth (Cadahía and Insua, 1970; Carus, 2004; Jacquet *et al.*, 2013) and their susceptibility to other secondary, bark and wood boring insects (Masutti & Battisti, 1990; Zamoun, 2002).

In recreational and residential areas infestation by *T. pityocampa* has an additional aesthetic impact, in addition to the severe deterioration of the trees and greater maintenance costs. The urticating setae that larvae develop from the 3$^{rd}$ instar onward induces a variety of allergic reactions such as skin irritation, conjunctivitis, respiratory congestions and asthma in humans and animals (Vega *et al.*, 1999; Battisti *et al.*, 2011; Vega *et al.*, 2011). These effects occur not only when the caterpillars are present, but also during the following summer because of the persistence of allergenic setae in the remains of winter nests (Moneo *et al.*, 2015). This problem not only affects recreational and residential areas but also hinders sylvicultural operations and grazing in forests (Marti Morera and Barri Baya, 1959).

### Control

Chemical control treatment initially involved the application of DDT (Grison *et al.*, 1959) that was soon replaced by Diflubenzuron (Robredo, 1980; Démolin and Millet, 1983; Démolin *et al.*, 1993) and pyrethroids (Robredo and Obama, 1991) that had a reduced impact on beneficial insects. However, shortly after this, treatment based on preparations of the bacterium *Bacillus thuringiensis* HD-1 subsp. *kurstaki* were developed (Fernandez de Cordova and Cabezuolo, 1995; Démolin and Martin, 1998), the use of chemical insecticides was drastically reduced in favour of *Btk*-based products (Battisti *et al.*, 1998; Rausell *et al.*, 1999; Cebeci *et al.*, 2010), which are currently recognized as the most effective control agents against *T. pityocampa* particularly during population outbreaks.

In small areas or areas with low population densities, additional alternative control approaches have been suggested and assessed. For example, mechanical control by removing egg mases and larval colonies or destroying winter tents can effectively control the population of *T. pityocampa* particularly in urban green areas (Martin, 2015), while sex pheromone traps can also be used primarily for monitoring and even for mass trapping of adults (Cadahía *et al.*, 1975; Montoya, 1984; 1988). Trunk barrier and adhesive barrier trap devices have been recently developed and evaluated with the results clearly showing their potential particularly on isolated trees (Martin *et al.*, 2012; Colacci *et al.*, 2018). Mating disruption has also been successfully tested (Martin and Frérot, 2006; Michaelakis *et al.* 2020) while the repulsive effect of volatiles emitted from broadleaf branches constitutes also an alternative and promising control approach (Jactel *et al.*, 2011; Jactel *et al.*, 2012).

Natural populations of *T. pityocampa* are effectively regulated by a number of parasitoids and predators (Biliotti, 1958; Biliotti *et al.*, 1965; Cadahía *et al.*, 1967; Démolin and Delmas, 1967; Battisti, 1989; Buxton, 1990; Tiberi *et al.*, 1991; Mirchev *et al.*, 1998; Tsankov *et al.*, 1998; Battisti *et al.*, 2000; Mirchev *et al.*, 2004; Mirchev *et al.*, 2007; Barbaro *et al.*, 2008; Branco *et al.*, 2008; Barbaro and Battisti, 2011; Charbonnier *et al.* 2014; Martin, 2015), each of which is effective against a specific development stage of *T. pityocampa*. It should be noted however that, in most of the cases, these biocontrol programs proved to be not cost-effective (Masutti *et al.*, 1993).

- **- On eggs**, the major parasitoids are *Baryscapus servadeii* and *Ooencyrtus pityocampae* and the predators *Ephippiger ephippiger* and *Barbitistes fischeri*.
- **- Larvae** are predominantly parasitized by *Phryxe caudata* and predated by *Xanthandrus comtus* while later instars are also effectively attacked by tits (*Parus* sp.). Entomopathogenic organisms affecting larvae also include cytoplasmic and nuclear viruses, nematodes and fungi, some of which have shown promising results that should however be further explored (Vago, 1958; Atger, 1964; Triggiani and Tarasco, 2002; Er *et al.*, 2007).
- **- Pupae** are mostly parasitized by *Villa brunnea* and *Coelichneumon rudis*, while their most common predator is hoopoe *Upupa epops.*
- **- Adults** are effectively hunted by bats, which has been increasingly studied in recent years (Garin *et al.*, 2019).

### Phytosanitary risk

*T. pityocampa* is not listed as a quarantine pest by EPPO or by any National Plant Protection Organization in the EPPO region. Within the EPPO region *T. pityocampa* is likely to be a damaging pest primarily in pine forests of the Mediterranean region but also in stands of the other hosts as well. Currently, it is not present only on a few islands (e.g. the Canary Islands are protected by phytosanitary measures taken by the Spanish Department of Agriculture). *T. pityocampa* is a risk for any region that has Mediterranean climate and where *Pinus* or the other host species are either native or planted.

## PHYTOSANITARY MEASURES

Plants for planting of the host genera, with a particular focus on *Pinus*, should be inspected for the presence of egg masses and larval colonies of *T. pityocampa*. In the same manner, nursery plants with attached soil or growing medium should be inspected for the presence of pupae. It should be noted, that pupae could be associated with any plant for planting from an infested area, not just the host species, as they can be found in the soil or growing medium attached to them. Ideally, consignments of plants for planting, in particular those with attached growing medium, should come from an area and its surroundings that are free from *T. pityocampa*.

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