

# The oak processionary moth

## Background knowledge and recommended action

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The oak processionary moth is a moth native to Europe that develops mainly on oak trees. In Switzerland, it is mainly found in western and north-western regions, and on the southern side of the Alps. After hatching, its caterpillars feed in gregarious clusters on

the leaves of oak trees, and large populations can lead to the complete defoliation of infested trees. The oak processionary moth attracts particular attention because the urticating (stinging) hairs of its caterpillars can cause allergic reactions in humans and animals.



Caterpillar of the oak processionary moth (*Thaumetopoea processionea* [L.]).

## Range and means of dispersal

The range of the oak processionary moth (*Thaumetopoea processionea* [L.]) extends across southern and central Europe, from the Black Sea to the Iberian Peninsula (GODEFROID *et al.* 2020). In 2006, this moth species was also detected for the first time in the UK, where it was probably introduced accidentally on imported plants and plant products (MINDLIN *et al.* 2012). In Switzerland, occurrences of the oak processionary

moth are currently focused mainly in a few small areas of infestation in western and north-western Switzerland, and on the southern side of the Alps. Other isolated cases have been reported from the Central Plateau, the Zurich area, and north-eastern Switzerland (fig. 1).

In Central Europe, there has been an increase in both the frequency and intensity of occurrences of the oak processionary moth over the last four decades. This development is often linked to the rise in temperature caused by climate change (GROENEN and MEURISSE

2012). However, historical records from museums and private collections have shown that the species was already present in many parts of Europe in the 19th century, and that in the long term, there has been no climate-induced range shift to more northern latitudes (GROENEN and MEURISSE 2012). The northern limit of the range of *T. processionea* as observed today is not as far north as that of its host plants, the oaks (*Quercus* spp.). Lowest winter temperatures of around -18 °C are considered to be the northern limit of its range (MEURISSE *et al.* 2012). However, the main oak sites in Switzerland are not in areas with winter temperatures as low as this, so that according to models, all oak stands could potentially be colonised even today (KÖNZ *et al.* 2021).

The oak processionary moth spreads both naturally and through accidental introduction as a result of human activities (BAKER 2009). The females are heavier than the males and are thus considered to be somewhat sluggish flyers (STIGTER *et al.* 1997), flying a distance of up to 20 kilometres annually. Males, on the other hand, fly up to 100 kilometres a year. The most significant anthropogenic cause of the spread of *T. processionea* is considered to be the trade in young oak plants, on which it is easy to overlook any egg masses, caterpillars, or pupae. Another possible pathway for its spread is the transport of oak roundwood with bark present from oak processionary moth infestation areas (BAKER 2009).

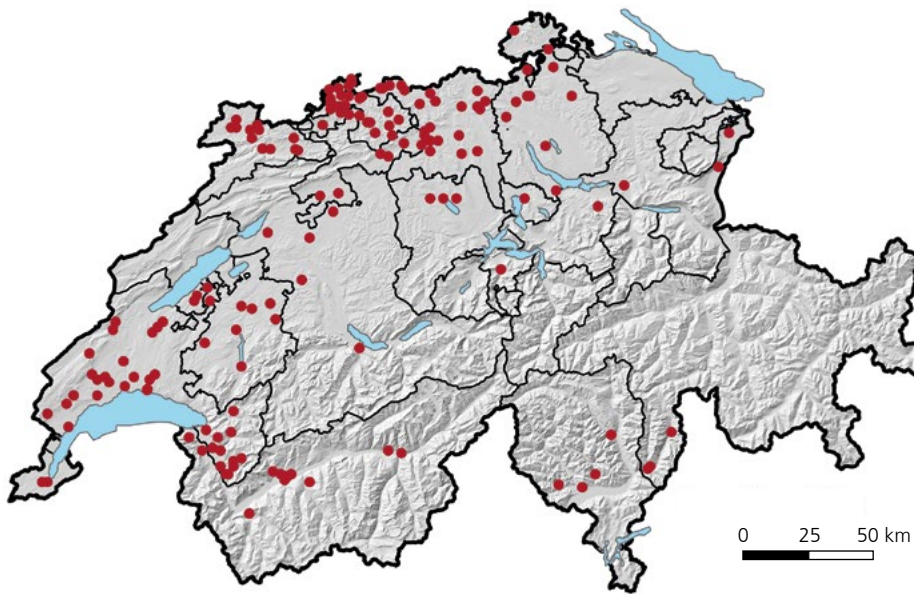


Fig. 1. Map of the distribution of the oak processionary moth in Switzerland, based on confirmed reporting data of Swiss Forest Protection Group from 1988-2020. Geobasis data: Federal Office of Topography swisstopo.



Fig. 2. Adult male oak processionary moth. © Bernd Krüger (www.bkmakro.de)

## Biology

The oak processionary moth has a one-year development cycle. The adults (fig. 2) emerge from the pupae and fly between mid-July and mid-September (BATTISTI *et al.* 2014). The moths are nocturnal and have grey forewings with white and dark grey markings, and a wingspan of around 30 millimetres. Mating often takes place in or on the nest, and is followed by oviposition on one- to two-year-old twigs of older oaks (STIGTER *et al.* 1997). The eggs are laid in plaque-like batches (fig. 3) of up to 200 eggs, and free-standing trees or south-facing forest edges are preferred laying sites (BATTISTI *et al.* 2014). The diameter of the eggs is about one milli-

metre. The young caterpillars hatch synchronously with the bud burst of the oaks between April and mid-May, and normally pass through a total of six larval growth stages (known as instars and numbered L1-L6; STIGTER *et al.* 1997). The young larvae feed gregariously and mainly during the day. Older caterpillars are nocturnal and retreat to communal nests during the day (BATTISTI *et al.* 2014). During the first larval stages, the caterpillars rest in spun together leaves and twigs. The typical, densely spun silken nests on trunks and thicker branches (fig. 4), which can be up to one metre long and several decimetres wide, do not appear until the fifth instar (L5; STIGTER *et al.* 1997). The caterpillars leave these nests in a characteristic procession of several rows at night to move up into the tree canopy (fig. 5), where they feed on the oak leaves, stripping them to the leaf midrib (fig. 6; STIGTER *et al.* 1997). If the foliage supply is exhausted, the caterpillars migrate collectively in processions to colonise another host tree nearby (STIGTER *et al.* 1997). The subsequent pupation of the adult caterpillars (fig. 7), which are up to 35 millimetres in length, takes place in spun cocoons inside the nests in mid to

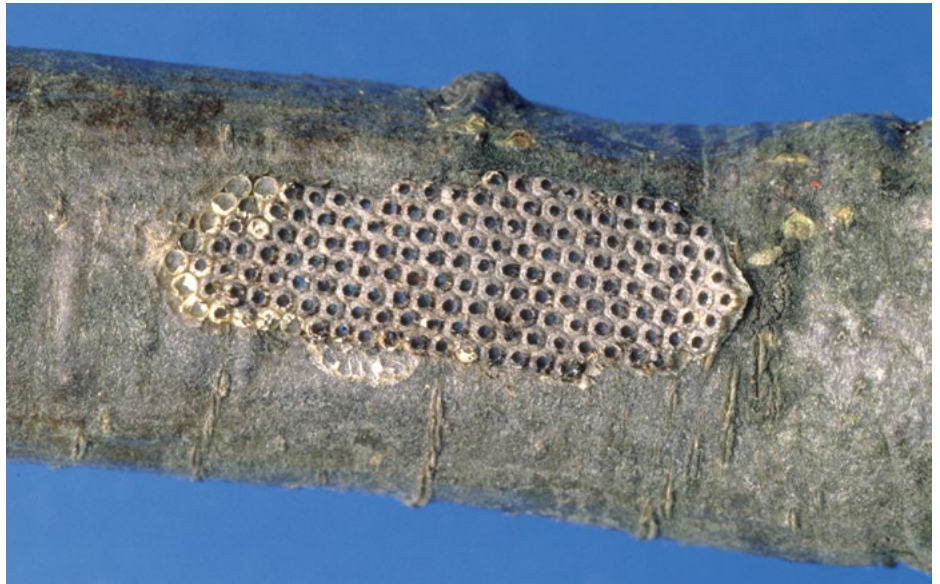


Fig. 3. Plaque-like mass of empty eggs of the oak processionary moth.



Fig. 5. Head-to-toe, several abreast: a procession of oak processionary caterpillars.



Fig. 4. Densely woven silken nests of the oak processionary moth on oaks.

late June, depending on the temperature (BATTISTI *et al.* 2014). These nests of silken webbing, faeces, exuviae and pupal cases can remain hanging for several years after the adult moths have hatched (BATTISTI *et al.* 2014).

Under favourable climatic conditions and given a sufficient supply of host plants, the oak processionary moth tends to mass propagate (gradation).

This can involve a gradation cycle lasting up to ten years, which ultimately ends in a collapse of the population (BATTISTI *et al.* 2014; SOBCZYK 2014). However, the mechanisms of these population dynamics are not yet understood in detail (BATTISTI *et al.* 2014; WAGENHOFF and VEIT 2011). The population collapse is thought to be caused by an interplay of climate factors, resource limitations,

and the development of populations of natural enemies in sufficiently high numbers (SOBCZYK 2014; WAGENHOFF and VEIT 2011). As the oak processionary moth is very dependent on warm temperatures, mass propagation is relatively rare here in Switzerland.

The preferred host plants of the oak processionary moth are the common or pedunculate oak (*Q. robur*), the sessile oak (*Q. petraea*), the downy oak (*Q. pubescens*), the Pyrenean oak (*Q. pyrenaica*) and the Turkey oak or Austrian oak (*Q. cerris*; BATTISTI *et al.* 2014). *T. processionea* has also occasionally been observed on other broad-leaved deciduous tree species such as birch (*Betula* spp.), beech (*Fagus* spp.), sorbus (*Sorbus* spp.), robinia (*Robinia* spp.) and hawthorn (*Crataegus* spp.; BATTISTI *et al.* 2014). However, its development cycle can only be completed successfully on oak and beech (STIGTER *et al.* 1997).



Fig. 6. Larvae of the oak processionary moth in 4th instar, stripping oak leaves as they feed.



Fig. 7. Older caterpillar of the oak processionary moth.

## Natural predators

Processionary moth species are well protected against natural predators at all stages of development (DE BOER and HARVEY 2020). The eggs are protected by hairs from the mother animal. The caterpillars retreat into densely woven nests during the day, and from the third instar onwards, the larva produces urticulating hairs (DE BOER and HARVEY 2020). The adult moths are also well camouflaged. Natural predators have nevertheless been identified for all developmental stages of processionary moths, although there is little data available on this specifically for the oak processionary moth (DE BOER and HARVEY 2020).

Studies have shown that the egg plaques can be parasitised by chalcid wasps such as *Anastatus bifasciatus* (ROVERSI 1991). Parasitoid caterpillar flies such as *Carcelia iliaca* or *Pales processioneae*, and some Braconidae and ichneumon wasps are considered to be natural predators of the caterpillars and pupae (BATTISTI *et al.* 2014). The two pupal predators *Calosoma sycophanta* (fig. 8) and *C. inquisitor* are among the most significant predators of the caterpillars and pupae (BATTISTI *et al.* 2014). Generalists such as spiders or ants also prey on the caterpillars of oak processionary moths (BATTISTI *et al.* 2014).



Fig. 8. A forest caterpillar hunter (*Calosoma sycophanta*) feeding on a butterfly caterpillar.

Among vertebrates, bats are known to be natural enemies, as well as birds, including the cuckoo (*Cuculus canorus*) and tits (Paridae), for example (SOBCZYK 2014). Pathogenic microorganisms associated with the oak processionary moth are the bacterium *Bacillus thuringiensis*, various microsporidian species (HOCH *et al.* 2008) and a virus (VAGO and VASILJEVIC 1955). However, their impact on the population dynamics of the insects is still largely unknown.

## Damage potential

Infestation by the oak processionary moth can lead to the complete defoliation of entire trees (fig. 9; LOBINGER 2013). This can be largely compensated for by a second sprouting of leaves in the same year. Since oaks form their earlywood vessels before the bud burst, using reserve materials from previous years, the effects of a complete stripping of the foliage due to foliar feeding are largely shifted to the following years (RUBTSOV 1996; THOMAS *et al.* 2002). If the assimilating leaf surface is temporarily lost due to insect defoliation, much less reserve material is produced. At the same time, existing resources are tapped to enable the second bud burst (THOMAS *et al.* 2002). The limited availability of



Fig. 9. Oak trees (*Quercus* spp.) defoliated by the oak processionary moth.

reserves impairs the formation of earlywood and latewood vessels in the following years, which can lead to a physiologically induced water deficiency of the trees even in soils with a sufficient water supply (THOMAS *et al.* 2002). While oaks usually survive a single defoliation without problems, repeated defoliation can significantly weaken the vigour of the host plants, which also increases the susceptibility of the trees to other stress factors, such as secondary pests and pathogens as well as drought or frost (BATTISTI *et al.* 2014; LOBINGER 2013).

## Health hazards

Thaumetopoein is a toxic protein in the urticulating hairs of various species of processionary moths. From the third instar (around the end of May), the caterpillars begin to develop thousands of these tiny stinging hairs as a defence (length 0.1–0.2 mm; STIGTER *et al.* 1997). As the caterpillars develop, the number of stinging hairs increases (SOBCZYK 2014). Even with little pressure, they break off and are easily shed, especially towards the end of moulting phases (FENK *et al.* 2007; STIGTER *et al.*

1997). Since stinging hairs are also present in the exuviae, the nests contain large concentrations of them (SOBCZYK 2014). The stinging hairs can also be blown about by the wind; model calculations showed that they can be transported over 500 m (FENK *et al.* 2007).

Contact with the stinging hairs can cause allergic reactions to the eyes, skin and upper respiratory tract in humans and animals (STIGTER *et al.* 1997). The pathological symptoms are caused by the penetration of the hairs into the skin, where they break off and release the toxin thaumetopoein (SOBCZYK 2014). Possible allergic reactions are reddening of the eyes and skin, itching, swollen red patches and rashes, or irritation of the mucous membranes of the mouth and nose (fig. 10; SOBCZYK 2014). Other general symptoms may include fever, dizziness, fatigue and conjunctivitis (STIGTER *et al.* 1997). These symptoms usually disappear within two weeks. In rare cases, contact with the stinging hairs of *T. processionea* can lead to allergic shock.

The stinging hairs can remain toxic over several years. In the case of the pine processionary moth (*T. pityocampa*), the hairs have been found to be still toxic even 12 years later (HASE 1939). Old nests of processionary moths are therefore also a particular hazard. In the

vicinity of infested oaks, the stinging hairs can also accumulate over several years in the ground vegetation and undergrowth, and cause allergic reactions after contact with clothing and shoes (LOBINGER and WALLERER 2020). Processionary moth caterpillars, their nests and accumulations of stinging hairs are thus an ongoing health hazard during management operations and recreational activities in forests (LOBINGER and WALLERER 2020).

### Experiences in dealing with oak processionary moth

Forest protection officers from the Swiss cantons particularly affected (Basel-Country, Geneva, Jura, Ticino, Vaud and Zurich), and arborists operating in Switzerland and Germany have been interviewed on their experiences in dealing with the oak processionary moth. Between 2010 and 2020, up to nine cases of infestation were registered annually in the participating Swiss cantons. Most of these were single reports; information on recurrence at the same site over several years has so far only been reported from one site in the canton of Jura. It is however to be assumed that not all infestations are discovered or reported and thus recorded by the authorities.

Since infested oaks are not usually discovered in the forest, but in gardens, agricultural areas, cemeteries, school playgrounds or on other public land, decisions on potential countermeasures are often not within the competence of the forest protection officers. According to the statements of several forest protection officers, however, there are not fewer infestations in the forest than in urban areas. They are however less noticeable, as the nests are often only noticed when the first allergic reactions in people occur. Due to the lower footfall and shorter time spent in the vicinity of trees in the forest, this is less often the case in forests than in settled areas.

In urban areas, the nests are generally removed from the tree in the course of tree care measures, as they pose a high risk to health. They are scraped, burned or vacuumed off the tree by arborists with the appropriate protective equipment. Spraying the caterpillar nests with water or hair spray before removal has proven useful during vacuuming and scraping off operations, as it prevents the stinging hairs being dislodged, and spreading into the air and surroundings. Outside the forest, oak processionary moths are sometimes also sprayed with agents approved for this purpose.

In Swiss forests, the risk to health posed by oak processionary moth infest-



Fig. 10. Allergic skin reactions caused by the stinging hairs of the oak processionary moth.

ations can usually be minimised by restricting access to trees or paths, and by systematically implementing measures to raise awareness among the population. Only in rare cases, such as on forest edges where mowing is required, is *T. processionea* actively treated. The use of environmentally hazardous substances is generally prohibited in the Swiss forest. In exceptional cases, agents approved by the canton's authorities for the oak processionary moth and specifically for the forest may be applied. If these are plant protection products (PPPs), the person applying them requires a special permit for the application of PPPs in the forest (SR 814.812.36, VFW-W).

In northern Germany, the situation is different. The widespread occurrence of the oak processionary moth has become a serious problem there, sometimes infesting entire sections of forest. Control measures are therefore often also carried out on a large scale, using insecticides applied using helicopters or trucks. Alternatively, positive experiences have been made in Germany with the targeted application of a water-based sugar solution as a fixative in dealing with the oak processionary. This sugar solution traps both the caterpillars and the stinging hairs directly in the webbing of the nests, and forms a solid, glass-like structure once it has dried. Since the stinging hairs are no longer a danger and the product is biodegradable, the treated nests do not have to be removed.

## Recommended action

No measures are currently necessary to protect the forest and timber production from this pest in Switzerland. In the event of any infestation, the question generally arises as to whether the risk posed by the caterpillars is acceptable from a health point of view. Especially in places with a high footfall, countermeasures must be considered, taking the local circumstances into account. As well as raising public awareness by erecting information boards and by cordoning off sections of path, measures may include the removal of the nests by specialist arborist companies or public services (forestry service, fire brigade). If the health risk is deemed to be low

## What to do if you suspect an infestation

In Switzerland, the occurrence of the oak processionary moth should be reported to the cantonal forest protection officers or the responsible local forestry services. [bafu.admin.ch](http://bafu.admin.ch) → Schadorganismen (in German)

## What to do if someone has allergic symptoms

If allergic symptoms occur after contact with the stinging hairs of the oak processionary moth, aha! Allergy Centre Switzerland advises you to contact your general practitioner or an allergy specialist. [www.aha.ch](http://www.aha.ch)  
aha!infoline: +41 31 359 90 50

after a risk assessment – in a section of forest or field copse with no access by path, for example – measures can be dispensed with entirely.

In residential areas with oak stands where the oak processionary moth is known to occur, regular monitoring is recommended, in the form of visual inspections of the trees. If the occurrence of infestations of the oak processionary moth increases in frequency and intensity in such places in the future, the introduction of obligatory control measures could be considered, as well as a recommendation to restrict or reduce the planting of oaks.

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