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SCIENTIFIC OPINION

Evaluation of a pest risk analysis on *Thaumetopoea processionea* L., the oak processionary moth, prepared by the UK and extension of its scope to the EU territory[1]

Scientific Opinion of the Panel on Plant Health

(Question No EFSA-Q-2008-711)

Adopted on 14 May 2009

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SUMMARY

Following a request from the European Commission, the Panel on Plant Health was asked to deliver a scientific opinion on a pest risk analysis for *Thaumetopoea processionea* L. prepared by the UK. The Panel was also asked to consider in its opinion the plant health risk of *T. processionea* to the whole EU territory.

The oak processionary moth, *Thaumetopoea processionea*, is established in Europe and feeds primarily on deciduous oak (*Quercus*) species. The insect has one generation per year and overwinters as eggs laid on branches of oak trees. After emergence, the larvae feed gregariously and from the 5th instar form a communal silken nest on the tree from which they typically migrate in procession to feed. Feeding may result in partial or complete tree defoliation. From the third instar, the larvae produce urticating hairs which may cause allergic reactions in humans and animals.

[1] For citation purposes: Scientific Opinion of the Panel on Plant Heath on a pest risk analysis on *Thaumetopoea processionea* L., the oak processionary moth, prepared by the UK and extension of its scope to the EU territory. *The EFSA Journal* (2009) 1195, 1-64.

[2] The EFSA journal number has been corrected.

*One member of the Panel declared an interest and did not vote on the adoption of the opinion.

The Panel examined in detail the UK document to determine whether the evidence presented in the document supports the conclusions reached for the assessment area of the UK, including Northern Ireland and the Channel Islands.

To consider the risks posed to the whole area of the European Community, the Panel analysed additional information obtained from a review of the literature and from consultation with experts in the EU. The Panel conducted a preliminary climatic analysis to explore the establishment in the whole EU area, based on temperature accumulation.

Based on the above, the Panel reaches the following conclusions:

1. With regard to the evaluation of the UK document:

- the Panel agrees that the probability for entry on the plants for planting pathway is moderate to high. It further agrees that the probability of entry of *T. processionea* on the oak roundwood pathway is low;

- the Panel agrees that the probability of establishment of *T. processionea* in the southern area of the UK is high given the presence of breeding populations in London and Jersey, the widespread distribution of oak trees and the favourable climatic conditions in the southern part of the assessment area;

- in the UK document evidence is not presented to support the statement that the impact of the oak processionary moth on oak trees is major. Pest management measures applied in areas where the pest is established relate primarily to human health effects and thus are not considered to be a reliable indicator of the magnitude of plant health impact of *T. processionea;*

- the Panel concludes from an evaluation of the risk assessment provided for the assessment area of the UK and review of additional information, that *T. processionea* may enter, establish and spread in the UK and has the potential to cause negative effects on the health of *Quercus* spp. although there is a high level of uncertainty relating to the magnitude of the effects on wood yield and quality which are directly attributed to *T. processionea;*

- for the plants for planting pathway, visual inspection, pest surveillance and the establishment of pest free areas or places of production are proposed as risk management options in the UK document. The Panel agrees that uncertainties relating to adult dispersal and the absence of tested surveillance methods may influence the effectiveness and practical implementation of the management options proposed. Further analysis on natural dispersal by flight would assist in evaluation of entry pathways and risk management measures, including those taken in the area of the UK where the pest is present and under official control;

- the Panel agrees that the management options proposed for the roundwood pathway can reduce the risk of introduction i.e. removal of bark, restriction of time of year of felling and export of roundwood. There are uncertainties regarding the effectiveness of visual inspection for the presence of nests and the practicality of bark removal for oaks.

2. With regard to the risk assessment conducted for the whole EU territory:

- *T. processionea* occurs in many Member States of the EU territory, but the Panel found no reports to suggest that the pest is established in Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Malta or Sweden;
- the presence of the pest in many areas of the EU territory provides opportunity for natural dispersal of *T. processionea* into adjacent areas where it is not currently established. Natural dispersal of adults may be restricted by geographic barriers (e.g. sea, mountains);
- the results from the exploratory analysis conducted by the Panel indicate that spring and summer temperatures are suitable for larval and pupal development in parts of all EU member states where the pest is currently absent. Overwintering survival is not considered to be a key factor in defining the northern limits to the distribution. Limited availability of host plants (*Quercus* spp.) and low summer temperatures are likely to restrict the potential area of establishment to southern areas of the most northern EU member states;
- reports of the plant health impact of *T. processionea* range from low to high. Due to the high level of variation in the level of plant health impact in the pest's current area of distribution, more detailed analysis is required to assess the consequences of further spread in areas where it is not currently established in the EU;
- the Panel considers that the degree of uncertainty is high. The main uncertainties relate to:
  - differences in the magnitude of the pest effects reported from different areas of the EU where the pest is established,
  - the plant health impact directly attributed to *T. processionea* alone and in combination with other stress factors contributing to tree mortality,
  - factors affecting the health status and susceptibility of *Quercus* spp. to defoliation by *T. processionea*,
  - the current distribution of *T. processionea* in the EU territory and lack of biological data needed to estimate the potential expansion of the range of *T. processionea*,
  - natural dispersal capabilities of *T. processionea* females and effectiveness of surveillance methods.

Phytosanitary measures are unlikely to prevent natural dispersal of the pest. Phytosanitary measures aimed at plants for planting could, however, reduce the probability of introduction of the pest into areas of the EU territory where the pest is currently absent, or present but under official control. Therefore, the Panel concludes that *T. processionea* may be considered as a harmful organism and hence is potentially eligible for addition to the list of harmful organisms in Council Directive 2000/29/EC.[3]

[3] A minority opinion was received in relation to this conclusion, based on the view that the lack of published evidence on the plant health damage and high level of uncertainty on the magnitude of impact arising directly from *T. processionea* in areas of the EU where it has been established for many years, does not support the conclusion that the organism is potentially eligible for addition to the list of harmful organisms.

Key words: ***Thaumetopoea processionea*, United Kingdom, pest risk analysis, plant health risk, oak processionary moth**

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION[4]

The current Community plant health regime is established by Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community (OJ L 169, 10.7.2000, p.1).

The Directive lays down, amongst others, the technical phytosanitary provisions to be met by plants and plant products and the control checks to be carried out at the place of origin on plants and plant products destined for the Community or to be moved within the Community, the list of harmful organisms whose introduction into or spread within the EU is prohibited and the control measures to be carried out at the outer border of the Community on arrival of plants and plant products.

The oak processionary moth *Thaumetopoea processionea* L., (Order Lepidoptera; Family Thaumetopoeidae), is presently not listed as a harmful organism in Council Directive 2000/29/EC. *T. processionea* is a native species of central and southern Europe, where it is widely distributed, but its range has been expanding northwards. It is now firmly established in northern France, Belgium and the Netherlands, and has been reported as far north as southern Sweden. It is usually found at the edges of woods or in open spaces, such as parkland, forming communal nests on the trunks of oak trees, feeding on their foliage. It is described as a defoliator of oak, although the trees usually recover. Apart from its impact on plant health, *T. processionea* also poses a public health problem because the larvae are covered by minute urticating hairs which contain a toxin, and contact with these can cause severe and persistent skin irritations, eye problems, sore throats and respiratory problems. Consequently some Member States where *T. processionea* is present have introduced national and regional control programmes for public health reasons. Still, other Member States have indicated that measures were taken also for plant health reasons.

During the Standing Committee on Plant Health (SCPH) meeting of October 2006 the UK reported the first finding of the larvae on *T. processionea* in central London. Local action was taken to eradicate it. In September 2007 the UK informed the Commission that monitoring carried out in May 2007 revealed that not all nests had been treated the previous year (larvae were detected). Limited defoliation in different oak species was observed. The UK Forestry Commission implemented a contingency plan, which involves widespread monitoring, nest destruction and placing of pheromone traps across London to assess extent of outbreak. Some evidence points out that the pathway of introduction of the pest has been via oak trees used for landscape planting originating probably from the Netherlands. The Pest Risk Analysis prepared by the Tree Division of Forest Research, an Agency of the UK Forestry Commission, in 2007 also identified plants intended for planting as the most probable introduction pathway. The situation of the outbreak in the UK, as well as a UK request for a common approach against this pest, were discussed at the SCPH meeting of October 2007.

In a letter dated 3 December 2007 the UK informed the Commission that it would favour regulation of this organism at Community level for reasons of plant health protection. The suggested approach would introduce a protected zone status for the territory of Great Britain (i.e. the UK minus Northern Ireland) to avoid further introductions of *T. processionea* . However, since agreement and implementation of such approach would require time, the UK announced that it intended to put in place provisional emergency measures under Article 16.2 of Council Directive 2000/29/EC, before the start of the main import season for plants, to prevent the further introduction into and the spread within Great Britain of *T. processionea*. These provisional emergency measures, implemented through The Plant Health (Forestry)

[4] Submitted by the European Commission, ref.E1/GC/al D (2008) 510614.

(Amendment) Order 2008 N°644, came into force on 31st March 2008 in the territory of Great Britain. As requested by Article 16.3 of Council Directive 2000/29/EC article, the UK provisional emergency measures were discussed within the SCPH in the meeting of May 2008. The Committee decided to seek a scientific opinion from EFSA before considering further steps in this matter.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

EFSA is requested, pursuant to Article 29(1) and Article 22(5) of Regulation (EC) N°178/2002, to provide a scientific opinion on the Pest Risk Analysis for *Thaumetopoea processionea* provided by the United Kingdom, with regards as to whether this organism can be considered as a harmful organism, in the meaning of the definition mentioned in Article 2.1 (e) of Council Directive 2000/29/EC, and therefore whether it is potentially eligible for addition to the list of harmful organisms in Council Directive 2000/29/EC. In this context EFSA is requested to broaden the geographic scope of the UK PRA so as to cover in its opinion the whole EU territory.

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ASSESSMENT

1. Introduction

This document presents the opinion of the Panel on Plant Health on the pest risk analysis conducted by the UK on *Thaumetopoea processionea* L. with the UK, including Northern Ireland and the Channel Islands, considered as the PRA area. In addition, the Panel considered the plant health risk of *T. processionea* in the whole EU territory. The opinion is presented following the structure of the UK document, with additional information provided in relation to the whole EU territory within each section as relevant.

1.1. General introduction to *Thaumetopoea processionea* L.

The oak processionary moth, *Thaumetopoea processionea* L. is native to parts of Europe. It is mainly reported as a pest on oak trees (*Quercus robur* L. and *Quercus cerris* L. but it also attacks other native and exotic oak species like *Q. petraea* (Mattuschka) Liebl.and *Q. rubra* L.), and has been occasionally observed on other broadleaved species (e.g. *Robinia*, *Betula*, *Crataegus*, *Fagus*, and *Sorbus*). The species is univoltine. The adults emerge and fly between the end of July and mid September. They have grey forewings with white and darker grey markings and a wingspan of ca. 30 mm. Mating often occurs within or on the nest (Eckstein, 1915), and oviposition occurs on one to two year-old twigs. The eggs (with up to 300 eggs per batch) are laid in contiguous rows along the shoots and covered by hairs from the female. The first instar larvae overwinter within the eggs and hatch in mid- or late April, usually before bud burst. The larvae are nocturnal and feed gregariously. The newly emerged larvae are brown. In later instars, their body becomes grey. At the third instar, each larva starts producing thousands of very small, barbed urticating hairs (ca. 0.1 mm) on the eleventh dorsal segment. These hairs contain an allergenic protein, thaumetopoein; which can be actively released in the air when the larvae are disturbed. After moulting, the previous stage's hairs remain on the exuvia, but can become airborne and are still allergenic. From the fourth larval instar on, hairs are produced on additional segments (tenth segment in the 4^{th} instar, all abdominal segments in the 5^{th}-6^{th} instars). In dry weather, these urticating hairs can remain allergenic for months; on the soil, they may even remain allergenic for several years. From the 5^{th} instar on, the larvae start building silken nests at the base of lower branches, on the trunks or at the base of the trunks. These nests may also contain exuviae, urticating hairs and faeces. Several broods can produce a common nest, which may shelter thousands of individuals. The larvae usually stay in their nests during the day leaving at night in a characteristic procession to feed in the canopy of the trees. If the leaves on a tree become scarce, the larvae move away from the tree collectively to colonise another host nearby. At pupation time (late June, early July), the larvae spin cocoons inside the nests (Maksymov, 1978; Stigter *et al*., 1997).

1.2. The document under scrutiny

The document presented for evaluation, is a pest risk analysis on the oak processionary moth, *Thaumetopoea processionea,* prepared by the UK according to the Guidelines of the European and Mediterranean Plant Protection Organisation (EPPO) pest risk analysis scheme, based on EPPO Standard PM 5/3 (1) (EPPO, 1997). The document comprises 30 pages and includes 21 cited references. It is arranged in three parts: Stage 1 outlines the reason for preparation of a pest risk analysis in 2007 following the first report of *Thaumetopoea processionea* in London, UK. Stage 2 documents the pest risk assessment. Stage 3 outlines the pest risk management options proposed. The document presented for evaluation by the Panel represents a revised version prepared in June 2008 (Evans, 2008).

1.3. Evaluation procedure

The evaluation was undertaken following the EFSA "Guidelines for evaluation of pest risk assessments made by third parties for phytosanitary purposes" (EFSA, 2009) which makes reference to the International Standard for Phytosanitary Measures ISPM No. 11 (FAO, 2007): "Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms".

The Panel examined the UK document in detail, to determine whether the evidence presented in the risk assessment and analysis of risk management options supports the conclusion reached. The public health effects are noted but are not evaluated further.

To consider the plant health risk of *T. processionea* to the whole EU territory and broaden the scope of the UK document, the Panel:

a) conducted a review of the scientific literature to extend the information provided in the UK document,

b) sought additional information through contacts with forestry specialists in areas where the pest is known to be established to clarify the pest distribution and reported impacts on plant health,

c) requested information on official measures undertaken in member states where the pest is established in the EU from EFSA's Advisory Forum representatives on Plant Health,

d) conducted an exploratory analysis, based on the limited available data, to determine the climatic suitability of the northern EU territory, where establishment of *T. processionea* is not reported.

Reference to the "assessment area" or "PRA area" is restricted to the UK, including Northern Ireland and the Channel Islands. The Panel presents its opinion based on an evaluation of the UK document submitted, and subsequent review of additional information in relation to the whole EU territory within each sub-section of the opinion as relevant.

2. Evaluation of the UK pest risk analysis and extension to the whole EU area

2.1. Pest categorization

2.1.1. Identity of pest

T. processionea L. is a distinct species and its life stages can be readily identified, based on morphological characteristics (Forster and Wohlfahrt, 1960; De Freina and Witt, 1987).

2.1.2. Presence or absence in the PRA area and the EU territory

In the PRA area of the UK, including Northern Ireland and the Channel Islands the document states that *T. processionea* is currently restricted to parts of London. However, the Panel found evidence that the organism is established on Jersey, the Channel Islands (Waring *et al*., 2003; Long, 2007). Males of *T. processionea* are regularly observed on the south coast of England, but these are likely to have flown over from the European continent (Waring *et al*., 2003). In a review of the Thaumetopoeidae, Maksymov (1978) noted that *T. processionea* occurs in England, but did not provide a reference to substantiate its alleged presence there. Karsholt and Razowski (1996) also state that the insect is present in Great Britain, but provide no details of its exact distribution there or references to support this statement. The Panel concludes that reproducing populations of *T. processionea* are present on the island of Jersey and in London, but that there is currently no evidence that these occur elsewhere in the assessment area.

Considering the whole EU territory, established populations of *T. processionea* are recorded in Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, France, Germany, Greece, Hungary, Italy, Poland, Romania, Slovenia, Slovakia, Spain, and the Netherlands. There are no recent records for Portugal or Luxemburg but the presence of established populations of *T. processionea* in adjacent areas suggests that the insect may also be present there. Established populations of *T. processionea* are not known to be present in Ireland, Denmark, Sweden, Finland, Latvia, Estonia, Lithuania, or Malta (see section 2.2.2.2).

2.1.3. Regulatory status

T. processionea is not listed as a harmful organism for the European Community in Council Directive 2000/29/EC.

Provisional emergency measures [The Plant Health (Forestry) (Amendment) Order 2008 N°644] are taken under Article 16.2 of Council Directive 2000/29/EC, to prevent the further introduction and spread of *T. processionea* within Great Britain.and implemented through This requires that trees, other than seeds, of *Quercus* L., intended for planting, must be accompanied by an official statement that they have been grown in a nursery and that no symptoms of *T. processionea* have been observed at the place of production or in its immediate vicinity since the beginning of the last complete cycle of vegetation. On 1 April 2009 a further amendment was made through The Plant Health (Forestry) (Amendment) Order 2009 N°594 restricting the requirement to trees not more than 2 metres in height.Information on regulatory measures was requested from the EFSA Advisory Forum representatives on Plant Health. The country responses are summarised in Appendix A. The responses confirmed the official plant health measures in the UK and indicated that where measures were taken in Member States, this was primarily due to public health issues.

2.1.4. Potential for establishment and spread

Considering the presence of suitable host plants (*Quercus* spp.), the existence of the pest in the UK and the current widespread geographical distribution of the pest in the EU, including areas with similar climates, the Panel agrees that *T. processionea* has a potential for further establishment and spread in the assessment area.

T. processionea is widely established in the EU territory. The potential for establishment in northern Member States, where it is not currently reported, is discussed in detail in section 2.2.2 and an exploratory analysis conducted by the Panel is presented in Appendix B.

2.1.5. Potential for consequences

Due to the release of urticating hairs that can cause allergic reactions, *T. processionea* is considered a pest of human and animal health concern in many parts of the area of its current distribution (e.g. Grison, 1952; Lamy, 1990; Tomiczek and Krehan, 2003; Gottschling and Meyer, 2006; Jans and Franssen, 2008). Insect defoliation is reported as a contributing factor to oak decline and results in reduced earlywood formation (Thomas *et al*., 2002). Plant health impacts are reported to arise from defoliation by *T. processionea* and are discussed in detail in section 3.3.

2.1.6. Conclusion of pest categorisation

Thaumetopoea processionea is a distinct species. It is present in parts of the UK, namely in London, where it is under official control, and on Jersey (the Channel Islands), where it is not under official control. The insect has the potential for establishment and spread and for negative consequences in the PRA area and in the whole EU territory.

2.2. Assessment of the probability of introduction and spread

2.2.1. Probability of entry of the pest: Identification of pathways

The UK risk assessment on *T. processionea* lists four pathways:

- trade in plants for planting (i.e., whole plants mainly of the genus *Quercus*)
- trade in cut branches of host trees
- trade in oak roundwood
- natural spread

The document investigates in detail two pathways: trade in plants for planting and trade in oak roundwood. In the assessment provided, the trade in cut branches is considered to be unlikely and natural spread of the insect as a pathway is not analysed in detail, based upon the assumption that, in contrast to the male adult, the female is not a strong flier and is unlikely to migrate directly to the UK. No references are given to substantiate this statement.

In view of the pest's presence both in the UK (Channel Islands and London) and in neighbouring countries e.g. France, the Netherlands, the Panel notes that natural spread based on flight, aided or not by wind, should have been analyzed in more detail in the assessment. After a review of the available literature, the Panel found that much of the information on the flight capability of *T. processionea* is based on circumstantial evidence and there have been no specific studies on this issue. Based on the scarce information available, the Panel agrees with the UK document that males are much more mobile than females. From field observations in the Netherlands and Belgium, Stigter *et al*. (1997) estimated that males of *T. processionea* can fly distances of 50-100 km. However, records of males caught in light traps on the south coast of England (Waring *et al*., 2003), in Denmark (Skule and Vilhelmsen, 1997) and the south of Sweden (Franzen and Johanneson, 2004; Lövgren and Dalsved, 2005), where females or larval nests have not been reported. It was estimated from field observations that female moths fly 5-20 km per year only (Stigter *et al*., 1997). The Panel agrees that females are unlikely to fly across the Channel.

2.2.1.1. Pathway no. 1: Plants for planting

<u>Probability of the pest being associated with the pathway at origin</u>

The document states that the pest is likely to be associated with plants for planting, as these could be a source of egg masses, and when nests are present, of larvae or pupae.

The Panel agrees that depending on the season, eggs (from August to April), and larvae and pupae (from April to July) of *T. processionea* may be present on oak trees in nurseries or other sites of production in an area where the pest is present. Eggs are laid in large batches of on average 100-200 eggs that are partly covered with greyish scales. Batches are usually deposited on the 1-2 year old branches of oak trees and more often in the upper part of the crown and on the south side of the tree (Grison, 1952; Maksymov, 1978; Pascual, 1988). The Panel acknowledges that detection of eggs upon visual inspection may not be straightforward, particularly in the case of more mature trees that are imported for instant landscaping.

During the growing season, the gregarious larvae may be present on twigs, branches and trunks. Early instars may feed inside leaf buds (Grison, 1952). Larger larvae (5^{th}-6^{th} instar) and pupae may be present in silken nests locatedunder branches or on the trunk. Nests may vary in size, depending on how many larvae are present. At high population densities, nests can shelter thousands of larvae and cover a large proportion of the trunks, reaching up to 1 m in width (Maksymov, 1978). However, when pest densities are low, the nests may not be larger than the size of a tennis ball (Stigter *et al*., 1997) and thus more easily escape detection, particularly in the case of larger trees.

The UK risk assessor judges the volume of movement along the pathway to be moderate but no information is available to substantiate this judgement. The document mentions the increasing trade in larger trees for instant landscaping, but does not specify the plant species involved or provide details on the trade. Accurate data on trade of such plant material within the EU is not readily available at the species level.

The UK document states in relation to the degree of uncertainty, that although it has not been shown unequivocally, there is a very high probability that the populations of *T. processionea* in London are associated with this pathway. The Panel notes that additional information provided by the UK risk assessor[5] confirmed that initial findings of *T. processionea* in London (eggs, early larval stages) were on newly planted fastigiate oaks (*Q. robur* 'Fastigiata') originating from outside the UK, which indicate that the trees were highly likely to have been infested prior to arrival in the UK.

<u>Probability of survival during transport or storage</u>

The Panel agrees with the document that the egg stage of the pest is very likely to survive transport when present on whole plants for planting from August to April, and that larvae and pupae are likely to survive in well formed nests. However, since transportation of deciduous trees for planting is most likely to occur in winter, the major risk is considered to be represented by the eggs.

The Panel also agrees that it is highly unlikely that *T. processionea* would multiply on plants for planting in transit, as this would require that adults emerge, mate and lay eggs during the short period of transit.

<u>Probability of pest surviving existing pest management procedures</u>

In response to the question whether the pest is likely to survive or remain undetected during existing phytosanitary measures, the UK risk assessor mentions that *T. processionea* is currently not regulated under Council Directive 2000/29/EC and therefore no inspection regimes are in place for this pest. However, the question in the scheme refers in general to any existing phytosanitary measures. The Panel acknowledges that the pest may escape detection during normal handling of the commodity, particularly when in the egg stage and on larger trees imported for instant landscaping.

<u>Probability of transfer to a suitable host</u>

The Panel agrees that plants for planting could be widely distributed following importation. The Panel also agrees that consignments very likely arrive at a suitable time in the year for pest establishment and are able to transfer to a suitable host. Usually, oak trees for planting are shipped in a dormant stage, and such plants may be infested with eggs of *T. processionea*. In the spring eggs hatch around the time when the tree buds start breaking and the emerging

[5] Available from EFSA on request

larvae can immediately start feeding on bud tissue if available or can lie dormant until the buds open. If eggs would be present on host plants other than *Quercus* spp. larval development may not be successful. Complete larval development on plants outside the genus *Quercus* has only been reported on beech (*Fagus*) (Stigter *et al.*, 1997). Larvae or pupae imported on oak trees during the growing season may continue to develop into adults which then disperse.

2.2.1.2. Pathway no. 2: Roundwood of oak with bark present

<u>Probability of the pest being associated with the pathway at origin</u>

The Panel agrees that the trunks of affected oak trees may have small or extensive nests produced by the feeding larvae of *T. processionea*, that these nests may still be present when the tree is felled and that they could contain viable larvae or pupae, from April to late July. However, the Panel notes that oak trees are normally felled during winter when they are highly unlikely to have nests with living larvae or pupae.

The Panel also agrees that the concentration of the pest on the trunks will only be sporadically high:

- because the presence of the pest in oak stands would likely affect felling practice because of the urticating hairs of the larvae and this may result in avoidance of infested trees, and
- given the relatively short duration of larvae/pupae associated with nests on the trunks (as opposed to larvae feeding in the crowns).

<u>Probability of survival during transport or storage</u>

The UK document states that any larvae or pupae present in nests on oak logs will survive transport provided that the duration is within ca. 2 months of felling the tree. Mature larvae and pupae become adults within 4-6 weeks (Maksymov, 1978; Pascual, 1988) and thus have higher chances of survival during transport. The Panel agrees that there is a very low probability that the pest would be able to reproduce during transportation.

<u>Probability of pest surviving existing pest management procedures</u>

The UK document states that, because *T. processionea* is not currently regulated under Council Directive 2000/29/EC, there is no inspection regime for this organism. However, no information is provided on existing controls not specifically directed towards *T. processionea*.

<u>Probability of transfer to a suitable host</u>

The Panel agrees that, once in the country, the commodity will be distributed widely. Regarding the time of arrival and its relationship to the presence of larval/pupal stages (April to July), no data regarding actual felling and transportation time is provided. The document states that pupae represent a higher risk because females would be fertilized at a very early stage and would therefore be likely to lay fertilized eggs almost immediately after emergence from the nest (Eckstein, 1915). The Panel notes, however, that this hypothesis needs to be supported by experimental evidence. Any larvae emerging from eggs on the bark or shoots of imported trunks are highly likely to perish due to a lack of food in the immediate vicinity and their inability to move to live host trees in search of food.

The document further states that the end point of this commodity is conversion into timber or veneer, resulting in complete destruction of the pest. However, the risk connected to storage of the timber prior to processing has not been discussed.

2.2.1.3. Conclusion on the probability of entry

The UK risk assessor concludes that the probability of entry as eggs on plants for planting is medium to high when the plants originate from areas where the pest is present, and refers to the increasing distribution of the pest in Europe. Also it is stated that there is a high likelihood that larvae present on plants shipped in the growing season could complete development to the adult stage. The probability of entry on oak roundwood with bark is considered to be low, given the limited time window for entry and the end use of the commodity that would result in the destruction of any viable individuals of the pest.

The Panel agrees with the ratings given. Uncertainties are noted, however, regarding the quantities of plants for planting moving in trade within the EU territory and the occurrence of the pest in areas surrounding plant production premises, which may influence the ratings given.

The natural dispersal pathway should have been analysed in more detail in the UK assessment to determine the potential for spread within the PRA area in the absence of phytosanitary measures.

With regard to the risk assessment for the whole EU area, the presence of the pest in many areas of the EU territory provides opportunity for natural dispersal of *T. processionea* into adjacent areas where it is not currently established, although natural dispersal of adults may be restricted by geographic barriers (e.g. sea, mountains).

2.2.2. Probability of establishment

2.2.2.1. Availability of suitable hosts, alternate hosts and vectors in the assessment area

The UK document states that host plants include *Quercus* spp. and to a lesser extent, species within the genera *Betula, Carpinus, Castanea, Corylus* and *Fagus,* but no references are given to substantiate this information. A review of the literature indicates that suitable host plants sustaining larval development are mainly restricted to *Quercus* spp. At peak outbreaks larvae have been noted to migrate to neighbouring trees of the genera *Betula, Carpinus, Castanea, Corylus* and *Fagus* after oak trees have been completely defoliated, but this is usually associated with high mortality of the larvae (Grison, 1952). First instars hatching from eggs deposited on *Castanea* trees in France failed to develop despite some feeding (Grison, 1952). In the Netherlands, Stigter *et al*. (1997) mentioned occasional occurrence of *T. processionea* on *Acacia, Betula, Crataegus, Fagus* and *Sorbus*, but noted that reports of larvae developing to adults on those trees were confined to *Fagus*. Carter (1984) mentioned walnut (*Juglans regia*) as a possible host plant, and Gomez Bustillo (1978) refers to its occurrence on coniferous trees.

A survey of the literature indicates that native or exotic species within the genus *Quercus* attacked include *Q. robur, Q. rubra, Q. petraea, Q. cerris, Q. sessiliflora, Q. pyrenaica, Q. pubescens, Q. frainetto,* and *Q. ilex*. In the Netherlands and Belgium, *T. processionea* has been noted to be most abundant on *Q. robur*, and to a lesser extent on *Q. rubra* and *Q. petraea* (Stigter *et al*., 1997) and on *Q. frainetto* (Fransen *et al*., 2008). In Italy, the insect is mainly reported to occur on *Q. cerris* and *Q. robur* (Bin and Tiberi, 1983; Roversi, 2008), whereas in Austria *Q. cerris* has been found to be more affected than *Q. robur* and *Q. petraea* (Tomiczek and Krehan, 2003). According to Rosnev *et al*. (2006) and Csóka and Hirka, (personal communication, 2009), the pest is particularly prevalent on *Q. cerris* in Bulgaria and Hungary, respectively. Based upon a literature review, Pascual (1988) concluded that in Spain *T. processionea* has a preference for deciduous *Quercus* spp. over evergreen species like *Q. ilex.* Differences in prevalence on *Quercus* spp. may be related in part to synchronism between pest phenology, more in particular egg hatch, and bud flushing, which varies considerably among oak species. In some cases, the prevalence of *T. processionea* on certain oak species may be rather the result of habitat preference of the pest: for instance, higher prevalence on *Q. cerris* may be explained by the fact that this species of oak grows in drier, warmer habitats, which appear to also favour development of the pest (Grison, 1952; Moraal, 1996).

According to the UK document, there are over 220,000 ha of oak woodlands in Great Britain, which combined with trees in urban and peri-urban environments is estimated to account for 400 million oak trees.

In conclusion, the Panel agrees that suitable host plants (i.e., within the genus *Quercus*) are widespread in the assessment area of the UK and throughout the EU territory.

2.2.2.2. Suitability of environment

The UK risk assessor considers *T. processionea* as having a southern European range and refers in several places to a northward progression of the insect in Europe during the 20th century. In this context the document also refers to the recent establishment of the pest in Belgium and also in the Netherlands, where it is noted as being recorded for the first time in 1991.

The southern half of the UK area is indicated as a suitable environment. The document does not give any further specification, but claims that climate change could increase the potential ecoclimatic range of the pest. The UK risk assessor considers the climatic conditions in the UK and the area of the pest's current distribution to be completely similar, referring to the recent establishment of the pest in northern France, Belgium and the Netherlands. The fact that *T. processionea* has survived for at least two winters in London since it was first recorded there in 2006 is used to support the statement that the pest is well adapted to the climatic conditions in the UK.

Finally, the document states that competition with existing oak defoliators and the impact of generalist natural enemies are (very) unlikely to prevent establishment of the pest.

The Panel notes that little or no scientific evidence is provided by the UK risk assessor to substantiate the above statements. In order to evaluate their accuracy, the Panel reviewed the literature and contacted experts regarding the historical and current range of *T. processionea*, its climatic response and the potential impact of natural enemies and competitors. An exploratory analysis was also undertaken by the Panel to investigate climatic suitability in areas where it is not currently present. This is outlined in detail in Appendix B.

Historical and current distribution

The Panel has reviewed the historical and present distribution of *T. processionea* and has found information indicating the occurrence of *T. processionea* in the Netherlands and Belgium in the 19th century. The insect was recorded again in Belgium in 1971 (Rutten, 1994) and in the Netherlands in 1987 (Stigter and Romeijn, 1992). Thereafter, dense populations remained present in parts of the Netherlands and Belgium (Stigter *et al*., 1997; Moraal, 1999, Moraal 2002; Moraal, 2006; Sioen *et al*., 2008; van Oudenhoven, 2008).

In a distributional checklist of European Lepidoptera, Karsholt and Razowski (1996) report *T. processionea* to be present in an area consisting of the countries Russia, Ukraine, Belarus, and Moldavia (without further specification), in Poland, Czech Republic, Slovakia, Germany, the Netherlands, Great Britain, Belgium, Luxemburg, France, Spain, Portugal, Italy, Switzerland, Austria, Hungary, the former Yugoslavia, Romania, Bulgaria, and Greece, but the editors of this checklist do not provide the background information to the above distribution.

In the last two decades, reproducing populations of *T. processionea* have been reported in the literature from the following EU member states: Belgium (Sioen *et al*., 2008), the Netherlands (Fransen *et al*., 2008), France (Martin and Bonneau, 2006), Germany (Wulf and Schumacher, 2008), Austria (Tomiczek and Krehan, 2003), Spain (Pascual *et al*., 1990), Italy (Roversi *et al*., 2007), Hungary (Hirka and Csóka, 2007), Greece (Kailides, 1991), Bulgaria (Mirchev *et al*., 2003), Romania (Teodorescu and Simionescu, 1994), and Slovenia (Jurc, 2006). No printed records were found but formal consultation of country plant health representatives confirmed its presence in Cyprus and Slovakia (Appendix A). According to Gomez Bustillo (1978) the species is established in the major part of Spain and Portugal. Furthermore, nests have been observed in the southeast of the province of Salamanca, less than 20 km from the Portuguese border (Pascual, 1988). There are no confirmed records of *T. processionea* in the Grand Duchy of Luxemburg but there are recent records of larvae in the vicinity of Orscholz, Germany, about 10 km from the border (Werno, 2008), and in the neighbouring Belgian province of Luxemburg (Nassogne) (FES, 2009) indicating that the insect is very likely to be present in the country. The Panel did not find recent published information confirming the presence of *T. processionea* in Poland and the Czech Republic but the presence of the pest was confirmed by the Advisory Forum representatives on Plant Health (Appendix A). Based on a literature search and on contacts with local experts, the Panel found no evidence of established populations of *T. processionea* in Ireland, Denmark, Sweden, Finland, Latvia, Estonia, Lithuania, and Malta.

In the UK, reproducing populations have been reported in London (Townsend, 2007; 2008) and Jersey (Waring *et al*., 2003; Long, 2007). Records from the south coast of England and Guernsey (Waring *et al*., 2003) and from Denmark (Skule and Vilhelmsen, 1997) and the south of Sweden (Franzen and Johanneson, 2005; Lövgren and Dalsved, 2005) are based on light trap catches of males, but no reproducing populations have been reported from those locations. As males of *T. processionea* may fly over 50-100 km (Stigter *et al*., 1997), individuals caught in traps do not represent areas of pest establishment as adult males may have flown over from areas with established populations; in some cases male dispersal may have been aided by strong winds, which could explain catches of males in Sweden (Franzen and Johanneson, 2005; Lövgren and Dalsved, 2005).

Outside the European Union, the species is reported to be present in Switzerland (Koordinationsgruppe Arbeitssicherheit SUD, 2006), Ukraine (Meshkova, 2008), Croatia (Matosevic, personal communication 2009) and Serbia (Glavendekic, personal communication 2009). Further, *T. processionea* was reported to occur in southeast Anatolia, Turkey (Kanat and Akbulut, 2005). A report of *T. processionea pseudosolitaria* (Daniel) from Mount Hermon, Israel, by Halperin and Sauter (1999) is questionable, as the authors state that their identification was provisional and further taxonomic studies were required. Likewise, the identity of a *Thaumetopoea* species found by Démolin and Nemert (1999) in Lebanon was unclear and the authors pointed out that the taxonomic position of different *Thaumetopoea* species reported to occur in the Near East is largely unsettled. Therefore, records of *T. processionea* from the Near East may not be reliable.

Expected long-term temporal changes in the European climate may lead to range shifts in many insects, including defoliators (Battisti *et al*., 2005; Vanhanen *et al*., 2007). Van Oudenhoven (2008) tried to link population densities of *T. processionea* with climatic factors (temperature, precipitation) in the Netherlands and Belgium in the period from 1990 to 2006. Temperature was considered to be the most important factor affecting population dynamics of the pest in that area. However, reliable long term projections for the further incidence and spread of the insect could not be made from that study. In several other areas of its known European range, an increase in the population densities of *T. processionea* has been reported since the early 1990s and outbreaks have been recorded in areas where the insect had previously not been noted, like in Germany (Wulf and Schumacher, 2008) and Switzerland (Koordinationsgruppe

Arbeitssicherheit SUD, 2006). Increased frequency of outbreaks in areas where the pest was already present and the expansion of the area where outbreaks occur in the last two decades has been attributed in the UK PRA and in some reports (e.g., Custers, 2003) to climate change in Europe, creating more favourable conditions for the insect. However, no experimental data are available in the literature to support this hypothesis. Further analysis of historical data is being undertaken which may provide further information on changes in distribution of *T. processionea* over time (Groenen, 2009, personal communication).

Alternatively, the strong natural fluctuations in the abundance of *T. processionea* may also be responsible for the apparent temporal trends in its occurrence in certain areas: in years of low abundance, populations of this insect may easily be overlooked, particularly in forested areas. Furthermore, control programmes carried out to prevent negative impacts of the pest may strongly affect its population levels.

Climatic adaptation

Although the insect has been noted in the UK document to have had a southern European range, the above review of its historical and present distribution in Europe suggests that it was originally more widely distributed, including areas adjacent to the UK.

The Panel reviewed the literature and found that there is very little information to confirm the favourable climatic conditions for survival, development, and reproduction of *T. processionea*. Thermal budgets for total immature development have not been reported. Based on small scale experiments, Custers (2003) estimated the lower thermal threshold and thermal budget of *T. processionea* eggs in the Netherlands to be 2.6 °C and 350-370 degree days, respectively. However, these figures need to be considered with caution, given the preliminary nature of the experimental work.

From his exploratory analysis, Van Oudenhoven (2008) identified a positive relationship between outbreaks of the pest and warmer and drier periods in the Netherlands and Belgium. Other authors have also noted that warm and dry conditions in spring contribute to *T. processionea* outbreaks (Grison, 1952; Moraal, 1996). This was in part attributed to the effects of drought reducing the resistance of oak trees to damage from defoliators (Grison, 1952).

There is no evidence that cold winters may suppress population densities of *T. processionea*. Winter survival depends on the ability of the egg stage to withstand freezing temperatures. There is very little published information on winter survival of *T. processionea* but recent studies have demonstrated that eggs from populations in France have freezing points below minus 20°C (Meurisse, 2009 personal communication), suggesting that eggs are very likely to survive average winters in western Europe. In accordance, Stigter and Das (1996) reported that prolonged periods of severe frost between December 1995 and March 1996 did not affect survival of overwintering eggs.

Further, prolonged periods of rain and summer storms have been reported to reduce adult populations and their fecundities (Grison, 1952).

The Panel conducted an analysis to determine the climatic suitability of northern areas of the EU where the pest is not currently present. This analysis, described in detail in Appendix B, suggests that, with the warmer climatic conditions that have occurred in recent years, large areas of England, Lithuania, Latvia and some southern areas of all the northern EU member states have sufficient temperature accumulation for *T. processionea* to complete its development from egg hatch to adult emergence.

Competitors and natural enemies

The major lepidopteran defoliators of oak in Europe, including, *Tortrix viridana* L., *Erannis defoliaria* Clerk and *Operophtera brumata* L., are also established in the PRA area (South *et* *al*., 1961; Waring *et al*., 2003). *Lymantria. dispar* L. has been reported as present but became extinct around 1900 and official measures have been taken for populations found in the London area since. Hunter (1998), for instance, reported that interspecific competition among *O. brumata* and *T. viridana* determined population growth of the former in oak stands in the UK. Population growth of *T. processionea* in the PRA area may therefore also be affected by negative feedback from interspecific competition with existing oak defoliators. However, *T. processionea* might be at an advantage in intraspecific competition because of the capacity of its larvae to survive starvation if egg hatching occurs before budburst, whilst *O. brumata* suffers high mortality (Feeny 1970; Visser and Holleman, 2001; Tikkanen and Julkunen-Tiitto, 2003). The Panel therefore agrees with the UK document that establishment of *T. processionea* is not likely to be prevented by competing species existing in the PRA area.

The different life stages of *T. processionea* are attacked by a number of arthropod natural enemies. The eggs are parasitized by different chalcidoid parasitoids (Hymenoptera), but where information is available, the level of parasitism is generally low (Biliotti, 1952; Dissescu and Ceianu, 1968; Maksymov, 1978; Bin and Tiberi, 1983; Mirchev *et al*., 2003). Larvae and pupae of the pest are attacked by species of Tachinidae (Diptera), Ichneumonidae (Hymenoptera), and Braconidae (Hymenoptera) (Biliotti, 1952; Dissescu and Ceianu, 1968; Maksymov, 1978; Stigter *et al*., 1997). Zwakhals (2005) reported that in the Netherlands pupae of *T. processionea* are attacked by two closely related ichneumonids: the specialist *Pimpla processioneae* Ratz. and the generalist *Pimpla rufipes* Miller; latter species has been reported to be present in the PRA area (Townsend, 2009). Tachinid parasitoids, including the host specific species *Carcelia iliaca* Ratz. (synonym of *Carcelia processionea* Ratz.) and *Pales processionea* Ratz., appear to have the highest impact on *T. processionea* populations, with reported parasitism levels of 20-30% (Stigter *et al*., 1997) or even up to 60-70% (Grison, 1952). Tschorsnig (1993) reared tachinids from *T. processionea* nests in Germany and measured a parasitism rate of 32%. The host specific tachinids *C. iliaca* and *P. processioneae* have not been reported from the PRA area, but the generalist species *Compsilura concinnata* Meigen is present (Raper and Smith, 2007). In addition, some generalist predators feed on the larval and pupal stages, including the beetles *Xylodrepa quadripunctata* L., *Calosoma sycophanta* L. and *Calosoma inquisitor* L., and the predatory bugs *Picromerus bidens L.*, *Troilus luridus* Fabricius and *Rhinocoris* spp. (Grison, 1952; Maksymov, 1978; Dajoz, 2000); several of the above listed species also occur in the PRA area (Linssen, 1959; Southwood and Leston, 1959). The ground beetles *C. sycophanta* and to a lesser extent *C. inquisitor* have received particular attention as predators of *T. processionea* larvae (e.g., Ferrero, 1985), but their impact on populations of the pest appears to be variable (Dissescu and Ceianu, 1968) and in some parts of Europe, including the PRA area, these beetle have become very rare (Stigter *et al*., 1997). In addition to arthropod predators, bird species such as the cuckoo have been observed to feed on larvae (Pascu, 1944).

There is little information on micro-organisms that are pathogenic to the different life stages of *T. processionea*. The larvae are susceptible to *Bacillus thuringiensis*, formulations of which are routinely used to control populations of the pest (see section 2.3.). Further, several microsporidian species (Hoch *et al*., 2008) and a nuclear polyhedrosis baculovirus (Murphy *et al*., 1995) have been found to be associated with *T. processionea*, but their impact on the population dynamics of the insect is largely unknown.

Abundance of natural enemies has been hypothesized to contribute to population collapses following outbreaks (Stigter *et al*., 1997), but there are no detailed studies on this aspect for *T. processionea*. Nevertheless, many studies, e.g. Berryman (1996), conclude that the population cycles of forest Lepidoptera occur due to the delayed negative feedback caused by insect natural enemies. There is little or no information available on parasitism and predation levels of *T. processionea* in the PRA area. The Panel concludes that although some species of natural enemies are present the establishment of the pest is not likely to be prevented by natural enemies already present in the PRA area.

2.2.2.3. Cultural practices and control measures

The managed environment in the PRA area is judged in the UK document to be highly favourable for establishment of *T. processionea*. The document further indicates that particularly urban environments, with stressed trees and locally more favourable climatic conditions for the insect, favour the establishment of the moth, but it does not provide scientific data to support this hypothesis. Oaks planted in urban environments and along road sides may be exposed to different stress factors or regulating factors than in forest areas. However, the Panel did not find evidence that establishment of *T. processionea* in urban areas is more likely to take place than elsewhere. A meta-analysis by Koricheva *et al*. (1998) shows that stress levels suffered by plants may not necessarily favour the population build up of pests on woody plants and even indicated that overall stress negatively affects the performance of chewing insects.

In response to the question whether establishment of the pest would be prevented by existing control or husbandry measures, information on monitoring of the pest after the planting of imported host trees is given. However, the question relates to control measures in place against existing pests, not on those directed towards *T. processionea* specifically. The UK document does not provide any information on the management of leaf-feeding oak pests in the PRA area. As laid out in section 2.3.1, microbial formulations based on *B. thuringiensis* and some chemical insecticides are the main tools to control outbreaks of lepidopteran defoliators of oak, including *T. processionea*. The Panel found that in the PRA area routine measures are rarely taken to suppress oak defoliators. Therefore, the Panel agrees that the existing control measures are unlikely to prevent establishment of the pest once introduced.

Further, the UK document states that it is moderately likely that *T. processionea* can survive eradication programmes in the PRA area. This rating is somewhat in contradiction with later statments claiming that if populations can be located early in the establishment phase, application of insecticides and physical removal of nests could result in eradication. In the UK analysis of management options, eradication is also considered to be feasible, although it is thought to require concerted action and be demanding of resources. The continued presence of the pest in London since 2006 reflects the difficulties of achieving eradication of *T. processionea*.

2.2.2.4. Other characteristics of the pest affecting the probability of establishment

A review of the literature shows that in its area of current distribution, *T. processionea* has a single generation per year and has an average fecundity of 30-300 eggs per female (Maksymov, 1978; Pascual 1988). Survival of the overwintering eggs can exceed 90%, even after severe winters (Bin and Tiberi, 1983; Stigter and Das, 1996). However, as very little data are available on survival rates of all life stages of *T. processionea*, the Panel does not have sufficient information to conclude on the contribution of the pest's reproductive strategy to its establishment potential.

The recent northward spread of *T. processionea*, reflecting its ability to adapt to changing climatic conditions, and its ability to feed on many *Quercus* species are given by the UK risk assessor as evidence to support of the rating that the pest is highly adaptable. The Panel points out that a relationship between changes in climate and the distribution of the pest has not been demonstrated. The apparent northward spread of the insect does not necessarily reflect the ability of *T. processionea* to adapt, but may just indicate that the moth can move to areas that become climatically more favourable, as was reported for *Thaumetopoea pityocampa* Dennis & Schiff. (Battisti *et al*., 2005) and *Lymantria* spp. (Vanhanen *et al*., 2007). The Panel concludes that there is no evidence to support that the pest is highly adaptable.

The UK document states that the pest has often been introduced in areas outside its original area of distribution. It refers to the recent northward spread of the insect and adds that it has extended its original area of distribution very widely. However, little evidence is presented to support these statements and the Panel notes a number of uncertainties relating to the interpretation of historical records to confirm the original and subsequent occurrence of the pest throughout the EU in the absence of systematic surveillance.

The UK document states the plants for planting pathway is likely to allow transient populations to occur in the PRA area, whereas natural migration is considered unlikely to lead to the occurrence of transient populations. This is not supported by any argumentation and there are no detailed studies on the flight capability or wind dispersal of female adults to clarify this point. In contrast to other statements made elsewhere in the document, it is stated that it is not known whether the populations in London are transient or established populations. The Panel notes that the fact that *T. processionea* has survived consecutive winters in the London area indicates that the populations there are unlikely to be transient.

2.2.2.5. Conclusion on the probability of establishment

The Panel agrees that the probability of establishment of *T. processionea* in the PRA area is high given the widespread distribution of oak trees and the favourable climatic conditions in part of that area. Based upon an exploratory climatic analysis, England, especially the south and east of the country, was estimated to be especially suitable for the establishment of the pest.

Considering the whole EU territory, the Panel adds that the pest may also expand its range to climatically favourable areas where it is currently not present and where oak is prevalent. The exploratory climatic analysis (Appendix B) indicated that large parts of Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, and Sweden could be suitable for the pest to establish. In the northernmost EU member states, e.g. Finland, deciduous oaks are most commonly found in parks and gardens. In the most southern areas, e.g., Malta, evergreen *Quercus* species are predominant.

2.2.3. Probability of spread after establishment

The UK document considers that spread in the PRA area is likely to be rapid by natural means given the combination of increasingly suitable climate and the wide distribution of hosts within the genus *Quercus.* The document also states that spread is very likely to be rapid on the plants for planting pathway through national and international movements.

The Panel again notes that natural spread of *T. processionea* has not been analyzed in detail but acknowledges that there are very few data in the literature on this aspect. The natural dispersal stage is the adult moth, but few studies have addressed flight capacities of adults. Males of *T. processionea* are more mobile than the heavier females. Stigter *et al*. (1997) estimated from field observations that individual males may fly distances of 50-100 km and that the females move only 5-20 km throughout their lifetime. Dispersal distancedepends on weather conditions during the flight period and on the quality and structure of the habitat to be crossed. Stigter *et al*. (1997) observed that females could be dispersed over longer distances by exceptionally strong winds. Certain landscape features may influence the rate of dispersal: for instance, avenue trees are linear landscape elements that function as ideal routes for the rapid dispersal of moths. One factor limiting active dispersal is the extremely short duration of adult life (maximum 4 days, according to Pascual, 1988).

The Panel agrees that movement of infested planting materials may cause further spread of the pest after its establishment in the PRA area, but notes that there are insufficient data to make a reliable prediction of the rate of dispersal by human assistance.

An analysis of the insect's spread in the Netherlands from 1991 (the year of its apparent reappearance) to 2007 shows that *T. processionea* has spread in a north-easterly direction with an average speed of 2 km per year for both the north-south and east-west directions (Van Oudenhoven, 2008). This pattern of spread was in part attributed to an increase of the oak cultivation area in the north-east of the Netherlands and the movement of planting materials from infested areas in the south of the country.

The assessor considers the likelihood that the pest cannot be contained within the PRA area to be moderate. The Panel agrees that early detection of newly emerging populations outside the currently infested area within the UK (London) and effective eradication programmes are imperative to prevent further spread, but low levels of the pest may be easily overlooked and eradication programmes carried out against *T. processionea* in the London area have so far not resulted in eradication.

The UK risk assessor concludes that the probability of spread is high if it would not appear possible to eradicate or severely contain the pest in its current known infested area. The Panel agrees that the probability of spread is high but notes that the rate of spread may be low.

2.2.4. Conclusion on probability of introduction and spread

Taking into account the successful breeding of *T. processionea* in London, the UK risk assessor considers the overall probability of introduction and spread to be high.

The Panel does not conclude on combined ratings and refers to its conclusions for each of the respective sections.

2.3. Assessment of potential consequences

2.3.1. Wood quality and/or yield loss

Potential plant health consequences arise from foliar feeding of the larval stages of *T. processionea* causing defoliation. *Quercus* spp. is the main host, although larvae may feed occasionally on other species of broadleaved trees growing near to heavily defoliated oaks at high pest densities.

Oak is noted as both a timber tree and an important amenity tree in the UK document and the effect of the pest is rated as major in both its main and expanding range because of the loss of growth increment as a result of complete defoliation and in combination with other organisms such as buprestid beetles (*Agrilus* spp.) or fungi (e.g. *Armillaria* spp.). However, no detailed analysis of the direct impact of *T. processionea* is available. The Panel, therefore, explored further the potential plant health impact caused by defoliations of *T. processionea* based on a review of the literature and information obtained from experts.

A review of the literature yielded few published reports on the importance of *T. processionea* as a pest of oak in terms of the impact of its defoliations on the health condition of oak stands. The majority of papers relate to the effects of *T. processionea* on human and animal health (see section "Public health effects" below). The human health effects may reduce specific research on the organism due to additional precautionary measures needed to protect workers from exposure.

Very few studies have tried to quantify the leaf damage specifically caused by *T. processionea* to oaks. Based on laboratory feeding tests, Dissescu and Ceianu (1968) estimated that *T. processionea* consumes on average 7 to 8 oak leaves during its entire larval stage. However, extrapolation of this figure to damage at the level of individual trees infested with a given number of larvae yielded unrealistically high damage estimates that do not equate with observations of damage in the field (Stigter and Romeijn, 1992).

Insect defoliation is identified (Blank, 1997), as a specific risk factor for oak, with repeated defoliation in spring causing a shortage of carbohydrates and reduced earlywood width resulting in failure of latewood formation. The reduced efficiency of water transport also increases tree susceptibility to drought, frost or other secondary pests and stress factors. Defoliation is noted in the UK document as a contributing factor in oak decline, and described in more detail under environmental consequences (2.3.2). However, the specific effect of *T. processionea* is unknown.

The Panel notes that *T. processionea* is one of several species of Lepidoptera which feed on oak including the tortricid *Tortrix viridana*, the geometrids *Operophtera brumata* and *Erannis defoliaria*, and the lymantriid *Lymantria dispar* (e.g., Luciano and Roversi, 2001; Moller, 2006; Caroulle, 2007). However, *T. processionea* and *L. dispar* are considered to exert a stronger impact on the health of oak trees than the geometrids because of their longer period for larval feeding (Nageleisen 2008). Another important difference between *T. processionea* and *O. brumata* or *T. viridana*, is that the latter species are vitally dependent upon synchrony with budburst. When egg hatching occurs before budburst, their neonate larvae starve and rapidly meet high mortality (Tikkanen and Julkunen-Tiitto, 2003); when egg hatch occurs after budburst, the larvae suffer from increased tannin content in the leaves, affecting the digestibility of the ingested proteins (Feeny, 1970; Watt and McFarlane, 1991; Hunter, 1992; Van Dongen *et al*., 1997; Visser and Holleman, 2001). As weather differentially affects the phenology of the insects and of the host trees, significant asynchronies may occur as reported for *O. brumata* in the Netherlands by Visser and Holleman (2001). The oak processionary moth does not appear to be as dependent on synchronisation with the host's phenology. Newly hatched, neonate larvae have been noted to survive when hatching prior to budburst (Stigter *et al*., 1997).

The Panel found differences in the susceptibility of oak species to stress factors with pedunculate oak (*Q. robur*) reported as more susceptible to defoliation (Caroulle, 2007) and more susceptible to extreme events such as drought (Breda and Badeau, 2008). In Hungary, *Q. cerris* is mostly attacked, although it occupies a smaller area (11.1% of the total forests) than that of *Q. robur* and *Q. petraea* combined (18.9%). This could be linked to the warmer and drier sites where *Q. cerris* grows, which are more favourable to *T. processionea* (Csóka and Hirka, 2009, personal communication).

The oak processionary moth is considered a minor pest of oak in Hungary (Hirka and Csóka, 2007), Romania ((Teodorescu and Simionescu, 1994), Slovenia (Jurc, 2006), and Ukraine (Meshkova, 2008). In the Netherlands, human health is the main concern and outbreaks are not linked with potential effects on the health of oak trees (Moraal, 2006; Fransen *et al*., 2008). In Austria, Tomiczek and Krehan (2003) considered that there was no need to take control measures for forest health reasons. Pascual *et al*. (1990) stated that *T. processionea* only caused important damage to an area smaller than 1000 ha in the southwest of the Salamanca province; there are no reports of damage in Spain thereafter. In Germany, a number of papers only refer to outbreaks of the pest because of the consequences for human health (Wulf and Pehl, 2005; Wulf and Schumacher, 2005; 2008), but others do indicate potential effects on the health of oak stands (Flemming *et al*., 1997; Kontzog and Veldmann, 1997; Möller, 2006). In central Italy, Roversi *et al*. (1999) and Roversi (2008) noted negative effects on the health of oak trees as a result of defoliations by *T. processionea*. In Belgium and France, weakening of oak trees as a result of (repeated) defoliation was noted by Grison (1952), Breuer and De Loof (1998), Chauvel (2000) and Nageleisen (2008).

Defoliation by *T. processionea* varies in time, following the population dynamics of the pest. The reasons for such population changes are still uncertain and very speculative (e.g., late frosts, natural enemies). Meshkova (2008) reported outbreaks in Ukraine in 1952–1955, 1957–1960, 1963–1966, 1972, 1978–1981, 1992 and 2003–2004.

Maksymov (1978) provided figures for outbreaks of *T. processionea* with heavy defoliations in the 1936-1970 period:

1936-1939	Austria and Italy
1936 and 1948-1950	western and eastern Germany
1950	Poland
1950-1954	France
1950-1955 and 1958-1962	Romania
1954-1956	Yugoslavia
1958-1959	Moldavia
1959	Bulgaria
1970	former DDR

Reuter and Poirot (2008, personal communication), reported records of outbreaks of OPM in France:

late 19th century	Bois de Boulogne (Paris)
1902-1906	Aube, Yonne, Côte d’Or
early 1950s	Oise, Hérault
1988-1990	Alsace, Aube, Yonne
1996	Lorraine
2002	Vitrimont, and Languimberg.

Roversi (pers. com., 2009) provided figures for heavily defoliated oak stands in Italy:

1996-1997	1300 ha, Toscana
2000-2001	3000 ha, Lombardia
2003-2004	1500 ha, Toscana
2006-2007	4500 ha, Toscana

In addition to a review of the published information, specialists in Europe were contacted to determine the level of defoliation by *T. processionea* and its plant health impact on oak. Some specialists considered the defoliation levels and plant health impact to be low. However, reports from Germany, (Lobinger and Skatulla, 2004) and north-eastern France (Bréda, 2009, personal communication), indicate high levels of defoliation and that a first defoliation by *T. processionea* affects the tree growth and that repeated defoliation leads to a high risk of attack by secondary phloem feeding insects such as *Agrilus biguttatus* Fab. Flot (2005) reports that, near Lunéville and Sarrebourg 7500 ha were defoliated in 2003, among which 4500 ha suffered more than 65% defoliation, although the contribution of other defoliating species cannot be excluded.

In conclusion, information from the published literature and from the consulted experts indicates that the impact of *T. processionea* on the health of oak trees is highly variable. In many areas feeding damage by the insect is not considered to substantially impact on the health of oak trees, but in some areas (e.g., Germany, France, Italy) there are indications that defoliations by *T. processionea* particularly in combination with other factors, may negatively affect the viability of oak stands.

2.3.2. Control measures and their efficacy

Control measures against *T. processionea* are primarily undertaken to prevent negative impacts on human and animal health. This is confirmed by the majority of the papers available in the scientific literature. However, some studies report that control measures were undertaken to prevent impacts on the health of oak stands (e.g., Pascual *et al*., 1990; Kontzog and Veldmann, 1997; Caroulle, 2005; DSF, 2006; Roversi, 2008). Insecticide applications against larval stages are primarily based on the use of products containing *Bacillus thuringiensis* var. *kurstaki* (Btk) (Pascual *et al*., 1990; Stigter *et al*., 1997; Martin and Bonneau, 2006; Roversi, 2008; Fransen *et al*., 2008) or insect growth regulators (IGR), such as diflubenzuron (Pascual *et al*., 1990; Stigter *et al*., 1997). The use of azadirachtin has also been reported (Flemming *et al*., 1997; Stigter *et al*., 1997; Breuer and De Loof, 1998), but the results are variable and inconclusive.

The following issues are identified with regard to control measures against *T. processionea*:

- timing of application of insecticides, such as *B. thuringiensis* and insect growth regulators is critical. Treatment is most effectively targeted against second and third instar (Fransen *et al.*, 2008) and 75-90% mortality can be achieved (Stigter *et al.*, 1997). In the first larval stage, the leaf area index is too low. Good coverage of leaf area is necessary and temperature should be high enough for larval feeding activity to ensure ingestion and activity of the toxin (>15 °C);
- insecticide treatment presents a number of operational difficulties in relation to applications to trees in urban environments and large-scale aerial applications which may require additional authorization. Access to large trees (> 15m) may require specialised machinery.
- physical removal of nests (manually or using an industrial vacuum cleaner or burner) requires protective equipment to prevent exposure to urticating hairs.
- monitoring relies on egg counting, nest counting, or visual assessments of defoliation (Möller 2006; Lobinger and Skatulla, 2004) and the use of pheromone traps (Fransen *et al*., 2008). No mating disruption methods have been developed for *T. processionea*.

The frequent applications of *B. thuringiensis* formulations to control the pest are considered in the UK assessment as an indirect measure of the pest's impact, but the Panel notes that many of these treatments are undertaken due to the human health impact of *T. processionea*, and may also be difficult to attribute to the impact of *T. processionea* alone, as defoliation may be caused by other defoliating species of Lepidoptera occurring on oak.

2.3.3. Environmental consequences

The UK document considers that environmental damage in the current range of *T. processionea* is moderate, as the pest may be a contributing factor to the general syndrome of oak decline (Thomas *et al*., 2002).

Oak decline is caused by a complex of biotic and abiotic factors and the Panel found that it has been frequently linked in the literature to defoliation of oak by lepidopteran larvae. The majority of the published literature refers to defoliation by lepidopteran species other than *T. processionea* – and particularly with *Lymantria. dispar*. A first review of the oak decline phenomenon has been made by Delatour (1983); more recent reviews include those of Siwecki and Ufnalski (1998) and Thomas *et al*. (2002). The role of defoliating insects as predisposing factors is stressed in all of these review papers, but the most in-depth analysis is to be found in Thomas *et al*. (2002), as cited in the UK document. From a review of several studies, Thomas *et al*. (2002) conclude that the combination of severe insect defoliation in at least two consecutive years with climatic extremes is the most significant complex of factors in the incidence of oak decline in north-western Germany, and that significant damage to oaks due to severe defoliation by lepidopteran larvae has also been reported from France, Russia, Romania and Hungary. Bréda and Badeau (2008) report on the effect of extreme events and noted that complete defoliation by *Lymantria dispar* for two consecutive years, and subsequent infection of replacement shoots by mildew led toheavy and rapid mortality, and reduced growth rings in those trees that survived. Similarly, successive entomological and fungal defoliations have been observed to lead to plant death, especially if additional pests or diseases such as buprestid beetles and *Armillaria* spp. are also involved (Thomas *et al*., 2002; Marçais and Bréda, 2006; Möller, 2006). *Quercus robur* is usually more affected by oak decline episodes than *Q. petraea* (Delatour 1983). Most often, a combination of water logging and repeated defoliation, or repeated defoliation and spring frosts, or repeated defoliation and severe spring or summer drought has been observed before a decline episode. Thomas *et al*. (2002) consider that insect defoliation is most important because of its overriding effect in reducing the trees' carbohydrate supply (and hence in subsequent frost resistance) and because it leads to reduced diameters of earlywood vessels and hence to impaired hydraulic conductance. Studies by N. Bréda in north-eastern France (Bréda, 2009, personal communication) focusing on dendrological and chemical analyses (carbohydrates) of artificially defoliated pedunculate oaks confirm the hypothesis that water and carbon relationships are severely affected by defoliation. Further studies are being undertaken which may provide further evidence of effects from defoliation by *T. processionea*. The Panel adds that control measures against *T. processionea* using non selective chemical or biological control agents may cause negative effects on non target organisms, which may include endangered species of Lepidoptera occurring in the same habitat.

2.3.4. Public health effects

The most significant impact of *T. processionea* is considered to be in relation to human (and animal) health, because of the thousands of small (0.1 – 0.2 mm) urticating hairs released by the larvae from the 3rd instar onward (Grison, 1952; Lamy, 1990; Neumann and Koekkoek, 1996; Hesler *et al*., 1999; Maier *et al*., 2004; Gottschling and Meyer, 2006). These hairs contain a protein, thaumetopoein, which, in contact with the skin, eyes, etc. can affect human and animal health. Repeated exposures increase the severity of response. Direct contact with the larvae, nests or pupal cases is not always necessary for the hairs to affect people and animals, as they can also be transported by wind. In dry conditions or in the soil, these urticating hairs can keep their allergenic activity for several years after an outbreak (Fransen *et al*., 2008). Most human and animal health effects occur from contact with larvae in the 5th and 6th stage, due to accumulation of exuviae from earlier stages and release of hairs of the larvae themselves (Lamy, 1990) which can seriously impair both forest management activities and tourism by restricting access to forest areas.

Public and animal health effects and social impacts are not considered by the Panel in its evaluation of the plant health risk of *T. processionea*.

2.3.5. Conclusion of the assessment of potential consequences

The UK risk assessor concludes that the economic and social impacts are likely to be periodically high in the assessment area, depending on the cyclicity of defoliation episodes. The Panel does not agree with the conclusion of the UK assessment that the impact of the oak processionary moth on oak trees in the UK is major, as insufficient evidence is presented to support this rating.

Evidence from a review of the literature and from information obtained from experts suggests that the plant health impact of *T. processionea* in its area of current distribution may range from low to high. Pest management measures applied in areas where the pest is established relate primarily to human health effects and thus are not a reliable indicator of the magnitude of plant health impact of *T. processionea*. Plant health effects may also be under-recorded due to the higher importance associated with human health effects.

There is, therefore, a high level of uncertainty of the direct plant health effect of *T. processionea* on oak stands in its area of current distribution. Although considered to be low in some cases, high levels of defoliation and negative plant health effects have been attributed to *T. processionea* in localised areas, particularly north-eastern France, where control measures are reported to be undertaken to prevent impacts on the health of oak stands (Flot, 2006).

Defoliation by insects is acknowledged as a factor contributing to oak decline. Repeated defoliation, in combination with additional stress factors, can lead to a depletion of the trees' carbohydrate supply and reduced diameters of earlywood vessels and reduction or failure of latewood formation. Although direct evidence to support the importance of defoliating insects is derived from other species, and there is high uncertainty regarding the impact of *T. processionea* alone, the Panel considers *T. processionea* as a late season defoliator i.e. a species with an extended larval development period, presents a risk of adverse plant health effects due to a) the limited opportunity for foliage regeneration compared with early season defoliators and b) the increased risk of secondary infection e.g. by oak mildew which contributes to increased mortality.

Variable reports of impact of *T. processionea* may be explained by differences in local biotic and abiotic conditions and further analysis is needed to identify the endangered areas of the whole EU territory.

2.4. Comments on the conclusion of the pest risk assessment

The UK document concludes that:

- the probability of entry of *T. processionea* is high on the plants for planting pathway and low to medium, depending on the time of year, on the oak roundwood pathway. The plants for planting pathway is considered high risk given the active trade and the cyclic high population levels of *T. processionea* in Europe;
- the probability of establishment is high for southern Britain;
- the economic impact is high, particularly due to weakening of the trees as a result of defoliation and consequent interaction with secondary pests and fungal diseases.

The overall conclusion of the UK pest risk assessment is that the pest poses a major threat to oak forests and woodlands and therefore represents a significant phytosanitary threat that warrants longer-term management of the pest. The UK risk assessor adds that attacks on oak by *T. processionea* would exacerbate the already serious problem of oak decline in the UK.

The Panel notes that the ratings given here are not fully consistent with those given in the corresponding sections earlier in the document.

The Panel concludes that the probability of entry is moderate to high on the plants for planting pathway and considers the probability of entry to be low on the oak roundwood pathway. Further, it adds that in its area of current distribution, outbreaks of *T. processionea* are not necessarily cyclic: population densities may be periodically variable in some areas, whereas they appear to be more constant in other areas.

The Panel agrees that the probability of establishment of *T. processionea* in the PRA area is high given the widespread distribution of oak trees and the favourable climatic conditions in part of that area. An exploratory climatic analysis performed by the Panel indicated that England, especially the south and east of the country, is especially suitable for the establishment of the pest.

Based on information derived from the literature and provided by experts, the Panel concludes that the impact of *T. processionea* on the health of oaks in its area of current distribution is highly variable, and may range from negligible to high. In many areas feeding damage by the insect is not considered to impact on the health of oak trees, but in some areas (e.g. Germany, France, Belgium, Italy) there are indications that, particularly in combination with other factors, defoliations may contribute to the oak decline phenomenon.

2.5. Degree of uncertainty

The UK document provides no detailed analysis of uncertainty at the end of the pest risk assessment stage. The Panel considers that the degree of uncertainty is high. The main uncertainties are related to:

- the current distribution of *T. processionea* in the whole EU territory: the absence of recent published information on the presence or absence of the pest for all member states. In the absence of specific surveillance programmes, the fact that the insect has not been (recently) reported in a certain area may not necessarily mean that it is not present;
- natural spread: the capability of spread of *T. processionea* females by flight has not been studied in detail and the current scientific views are based on circumstantial evidence;
- climatic response of *T. processionea* and the potential expansion of its range in response to climate change: there is insufficient information on the thermal biology of *T. processionea* to allow reliable predictions of the potential for further spread in the PRA area and the European territory. Further research is needed to determine its climatic responses, in particular the minimum threshold for larval and pupal development and the number of degree days required to complete these stages of the life cycle;
- plant health impact of *T. processionea*: the reported impact of the pest as a defoliator of oak is highly variable and ranges from low to high. Reports vary on the level of defoliation and effects of the pest on the health of oaks and on the specific role of *T. processionea* as a contributing factor to oak decline.

2.6. Evaluation of pest risk management options

Two pathways are identified in the UK document: a) plants for planting of host plants, and b) roundwood of host plants. Host plants are presented earlier in the risk assessment as including species of *Quercus, Betula, Carpinus, Castanea, Corylus* and *Fagus*. However, only oak is considered in the pest risk management options presented. The Panel agrees that oak is the major host and considers there is no evidence to support consideration of management options for other hosts.

2.6.1. Pathway no. 1: Plants for planting

2.6.1.1. Options for consignments

Inspection

The document states that the pest can be reliably detected by visual inspection of a consignment at the time of export, during transport or storage, or at import. Careful visual examination of egg masses on plants during the dormant season, the presence of nests on the trees and in the vicinity of the place of production, and observation of larvae in the period from April to late June – early July or defoliation as a result of their presence are presented to be reliable indicators for infestation of the consignment by the pest. However, the Panel notes that the eggs of *T. processionea* are usually deposited on the tips of branches (Grison, 1952) and are partially covered with greyish scales (Schwerdtfeger, 1981). Eggs may thus escape detection particularly in the case of higher, semi-mature trees which according to the UK risk assessor constitute a considerable proportion of the imported oak trees for planting. Furthermore, correct identification of eggs may not be straightforward, as other species (e.g. *Colotois pennaria* L., Geometridae) deposit their eggs in a similar way (Luciano and Roversi, 2001). The Panel also notes that not all defoliation may be from *T. processionea*, as oak trees may be attacked by other defoliators including *T. viridana, L. dispar, E. defoliaria,* and *O.brumata* (Luciano and Roversi, 2001).

Treatment of consignments (post harvest)

The document states that there is no reliable measure to remove eggs from the consignment, other than physical removal or topical application of contact insecticides, which is not considered to be practical, and that larval stages during the growing season can be destroyed by application of a suitable insecticide. The Panel agrees that removal of branches with eggs may damage the plant or reduce its value. As with other species of defoliators (Webb *et al*., 1994; Williamson, 2004), dormant oil sprays applied in winter to the branches may kill the eggs, although there have been no studies demonstrating the effectiveness of this measure for *T. processionea*. The Panel also acknowledges that in the growing season several chemical and biological insecticides are available to kill the larvae of *T. processionea*. However, older instars of the pest are usually less susceptible to insecticides (e.g. *B. thuringiensis*) and older larvae and pupae may be partially protected as they remain mainly in the nests during the daytime when the insecticides are applied (Forestry Commission, 2008). Removal of nests is considered an effective measure, although this needs to be done with considerable care to reduce the risk of workers being exposed to urticating hairs.

Restrictions on periods of entry

As life stages of *T. processionea* may be present on plants for planting at any time of the year (eggs from August to April, larvae or pupae from April to July), the Panel agrees that restricting periods of entry is not an effective measure to prevent introduction of the pest.

2.6.1.2. Options for the prevention or reduction of infestation in the crop

Treatment of the crop

The document states that infestation of the crop may be prevented by killing the adults using chemical treatments. The Panel notes that there have been no studies confirming the effectiveness of this approach. Routine application of a contact or systemic insecticide to trees was indicated as a potential second strategy for preventing infestation, but this method was not elaborated in detail. The Panel agrees that this would require full coverage of the crop and high kill rates to prevent establishment of a population of larvae.

Harvesting of plants at a certain age or a specified time of year

The Panel agrees that harvesting plants for planting only at certain times of the year cannot reduce the risk of introduction of the pest, since imported plants can have life stages of the pest present at any time of the year.

Options ensuring that the area, place or site of production or crop is free from the pest

The UK document states that area freedom from the pest may be feasible to reliably prevent infestation of the commodity, and notes that this would require that nurseries assess their proximity to known infestations and set up measures to survey for the moth in the surrounding area and in the immediate vicinity of the nursery (which is defined to be "up to 1 km", a figure that is not substantiated). Here, the risk of infestation is linked to oviposition by female moths flying into the place of production. Monitoring in and around nurseries based on traps and visual surveys for larvae or nests is considered by the assessor to reliably guarantee pest freedom of the crop/place of production/area.

Monitoring of adult *T. processionea* is based on the use of light traps, which catch males and females, or on pheromone traps that attract only the more mobile males. There is high uncertainty regarding flight capabilities of *T. processionea* adults, as flight distances reported do not distinguish whether aided by wind. Males were reported to fly large distances in favourable weather conditions (over 50-100 km), whereas females have been noted to fly 5-20 km per year depending on the weather conditions (Stigter *et al*. 1997). Gravid females are reported to actively fly at least 2 km (Skatulla and Lobinger, 2006). Male catches would not, therefore be reliable to predict the presence of females in the vicinity. Furthermore, the relationship between catches in pheromone traps and the presence of larval populations is uncertain (Fransen *et al*., 2008): pheromone traps can yield negative results in spots even if visual samplings have shown the presence of nests. Light traps are not specific and require some entomological skills to sort and distinguish individual species in the total catches. Interestingly, Grison (1952) noted that of the 16,000 individuals caught in light traps in 1951 in the Paris region, more than 90% were males whilst Pascual (1988) observed a 40:60 female:male ratio in natural populations. Additional work on light traps is still required to measure their capacity in revealing small local populations. Concerning the visual inspection of larval and pupal populations, smaller nests or well hidden nests in and around nurseries may be overlooked, especially when population densities are low and/or when trees are large.

The use of screened greenhouses may be an option to prevent infestation although the practical implementation of this measure for medium- to large-sized oak trees is uncertain.

The Panel agrees with the UK assessment that a rigorous regime of inspection in both the vicinity (to detect moth populations on standing trees) and in the place of production could allow a clean plant regime to be developed. It notes however that there are uncertainties regarding the effectiveness of monitoring methods, the size of the pest-free areas and the practicality of their maintenance and operation. Up to 1 km around the production nursery is proposed by the UK risk assessor, compared with the mobility of the females [5-20 km during their lifetime according to Stigter *et al*. (1997)].

2.6.1.3. Other possible measures

Surveillance and eradication are mentioned in the UK assessment to be possible measures that can be taken in the importing country to effectively prevent impacts, albeit at high effort. The Panel notes that the pest has not been eradicated from the London area since it was first detected there in 2006. A recent report by Townsend (2009) indicates that although the overall numbers of *T. processionea* have decreased since 2007, in some areas populations have increased, which was attributed to ineffective control measures related to practical difficulties and high caterpillar densities. Thus the report concluded that eradication is likely to prove extremely difficult but control appears possible. The Panel agrees with this statement and concludes that populations of the pest may be suppressed and the negative consequences may be prevented by implementing intensive control programmes.

2.6.2. Pathway no. 2: Roundwood of host plants

2.6.2.1. Options for consignments

<u>Inspection</u>

The Panel agrees that the pest can be reliably detected by visual inspection of imported logs for larval and pupal nests.

<u>Treatment of consignments</u>

The Panel agrees that fumigation, heat treatment, kiln drying, debarking, and physical removal of nests are effective in removing the pest from the consignment. However, effective alternatives to methyl bromide fumigation are needed and oak debarking and physical removal of nests may not be practical or reliable options in some cases.

<u>Restrictions on periods of entry</u>

The Panel agrees that the period April to August poses a risk of importation of larvae and pupae. Importation outside this period will prevent introduction on this pathway.

2.6.2.2. Options for the prevention or reduction of infestation in the crop

<u>Treatment of the crop</u>

The Panel does not agree with the UK document that infestation of oak stands can be reliably prevented by application of insecticides, although such measures may reduce pest populations and as a consequence also the risk of nests being formed on the bark of trees. Usually, treatments are targeting second to third instars of the pest, as these are the more susceptible stages, and good timing of application is crucial for effective control (Forestry Commission, 2008). Moreover, large-scale application of insecticides, including *B. thuringiensis*, in oak stands may have adverse effects on non-target organisms (Pascual *et al*., 1990; Stigter *et al*., 1997; Roversi, 2008).

<u>Harvesting of plants at a certain age or a specified time of year</u>

The Panel agrees that felling of oak trees outside the larval or pupal periods (October-March) can reliably prevent infestation of the commodity. Any eggs present on trunks in the indicated period are unlikely to lead to successful establishment of the pest.

<u>Options ensuring that the area, place or site of production or crop is free from the pest</u>

As for the plants for planting pathway, the Panel agrees that a pest free area or place of production may not be reliably guaranteed. The usefulness of the proposed management option is complicated by uncertainties about the flight capabilities of adults and the effectiveness of monitoring techniques.

2.6.2.3. Other possible measures

Surveillance and eradication are mentioned also for this pathway as possible measures that can be taken in the importing country to effectively prevent impacts. The Panel judges that eradication of *T. processionea* from the PRA area may be extremely difficult but agrees that populations of the pest may be suppressed and negative consequences may largely be prevented by implementing intensive control programmes.

2.6.3. Additional pathways

Additional pathways are not analysed in the UK document. However, to consider the risk in the whole EU territory, the Panel has considered the relevance of natural dispersal by flight for the risk management in those parts of the EU mainland where *T. processionea* is still absent.

The natural dispersal stage of *T. processionea* is the adult moth, but few studies have addressed flight capacities of adults and most of the evidence is circumstantial. As outlined above (see add number of the relevant section Risk assessment), the males of *T. processionea* are more mobile than the heavier females. Stigter *et al*. (1997) estimated from field observations that males may fly distances of 50-100 km. Males observed in Sweden and Denmark and on the south coast of England, where nests have never been reported, likely flew over from neighbouring areas where the insect is established, being presumably North Germany and France, respectively. Stigter *et al*. (1997) further noted that the females move 5-20 km per year. Dispersal of females was thought by latter authors to depend on weather conditions during the flight period and on the quality and structure of the habitat to be crossed. Stigter *et al*. (1997) also observed that females could be dispersed over longer distances by exceptionally strong winds, e.g. during summer storms. They also noted that certain landscape features may influence the rate of dispersal: for instance, avenue trees are linear landscape elements that function as ideal routes for the rapid dispersal of moths. Given the distances they can fly, aided or not by wind, it would thus not be unlikely to catch males in light or pheromone traps in areas where the insect has not established (i.e. where nests are not present).

As outlined in section 2.5.1.2., the natural dispersal of female moths may also limit the practicality of maintaining pest free areas. The Panel concludes that given the reported mobility of the female moths (5-20 km during their life time), pest free areas of about 1 km around nurseries, as suggested, may not be effective to prevent the spread of the pest.

2.6.4. Uncertainties

The UK document has rated the degree of uncertainty to be low to medium based on:

- the strong circumstantial evidence that the infestations in London were initiated through importation of plants for planting;
- the fact that methods for determining place of production freedom would need to be established and tested.

The Panel agrees that the degree of uncertainty is low to medium regarding the origin of the infestations in the London area and the current distribution of the pest in the PRA area. The

Panel notes uncertainty in the following areas related to assuring pest freedom in the place of production:

- effectiveness of visual inspection of consignments, particularly as related to detection of eggs on semi-mature trees;
- efficacy of insecticide applications to prevent infestation of the crop;
- accuracy and reliability of trapping methods (light, pheromones) and visual monitoring techniques in the crop;
- flight capability and natural dispersal of adult moths.

2.6.5. Conclusions

The combination of inspection methods and either a pest free area or place of production is considered by the UK risk assessor to effectively reduce the risk of introduction of the pest, without undesirable social or environmental effects and with minimal interference with international trade.

The Panel judges that natural dispersal of the organism should have been analyzed as a potential pathway as it may influence the effectiveness of the management options and their practical implementation.

The Panel agrees that restriction of time of year of felling and importation of roundwood can reduce the risk of introduction but notes that restricting periods of entry for planting materials is not an effective measure to prevent introduction of the pest as life stages of the pest may be present throughout the year.

The Panel concludes that uncertainties regarding flight capabilities of adults and the effectiveness of monitoring methods may influence the potential effectiveness of a pest-free area/place of production proposed as management options.

CONCLUSIONS AND RECOMMENDATIONS

Based on the above, the Panel reaches the following conclusions:

1. With regard to the evaluation of the UK document:

- the Panel agrees that the probability for entry on the plants for planting pathway is moderate to high. It further agrees that the probability of entry of *T. processionea* on the oak roundwood pathway is low;

- the Panel agrees that the probability of establishment of *T. processionea* in the southern area of the UK is high given the presence of breeding populations in London and Jersey, the widespread distribution of oak trees and the favourable climatic conditions in the southern part of the assessment area;

- in the UK document evidence is not presented to support the statement that the impact of the oak processionary moth on oak trees is major. Pest management measures applied in areas where the pest is established relate primarily to human health effects and thus are not considered to be a reliable indicator of the magnitude of plant health impact of *T. processionea;*

- the Panel concludes from an evaluation of the risk assessment provided for the assessment area of the UK and review of additional information, that *T. processionea* may enter, establish and spread in the UK and has the potential to cause negative effects on the health of *Quercus* spp. although there is a high level of uncertainty relating to the magnitude of the effects on wood yield and quality which are directly attributed to *T. processionea;*

- for the plants for planting pathway, visual inspection, pest surveillance and the establishment of pest free areas or places of production are proposed as risk management options in the UK document. The Panel agrees that uncertainties relating to adult dispersal and the absence of tested surveillance methods may influence the effectiveness and practical implementation of the management options proposed. Further analysis on natural dispersal by flight would assist in evaluation of entry pathways and risk management measures, including those taken in the area of the UK where the pest is present and under official control;

- the Panel agrees that the management options proposed for the roundwood pathway can reduce the risk of introduction i.e. removal of bark, restriction of time of year of felling and export of roundwood. There are uncertainties regarding the effectiveness of visual inspection for the presence of nests and the practicality of bark removal for oaks.

2. With regard to the risk assessment conducted for the whole EU territory:

- *T. processionea* occurs in many Member States of the EU territory, but the Panel found no reports to suggest that the pest is established in Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Malta or Sweden;
- the presence of the pest in many areas of the EU territory provides opportunity for natural dispersal of *T. processionea* into adjacent areas where it is not currently established. Natural dispersal of adults may be restricted by geographic barriers (e.g. sea, mountains);

- the results from the exploratory analysis conducted by the Panel indicate that spring and summer temperatures are suitable for larval and pupal development in parts of all EU member states where the pest is currently absent. Overwintering survival is not considered to be a key factor in defining the northern limits to the distribution. Limited availability of host plants (*Quercus* spp.) and low summer temperatures are likely to restrict the potential area of establishment to southern areas of the most northern EU member states;

- reports of the plant health impact of *T. processionea* range from low to high. Due to the high level of variation in the level of plant health impact in the pest's current area of distribution, more detailed analysis is required to assess the consequences of further spread in areas where it is not currently established in the EU;

- the Panel considers that the degree of uncertainty is high. The main uncertainties relate to and uncertainties related to;

  - differences in the magnitude of the pest effects reported from different areas of the EU where the pest is established,
  - the plant health impact directly attributed to *T. processionea* alone and in combination with other stress factors contributing to tree mortality,

- factors affecting the health status and susceptibility of *Quercus* spp. to defoliation by *T. processionea,*
- the current distribution of *T. processionea* in the EU territory and lack of biological data needed to estimate the potential expansion of the range of *T. processionea,*
- natural dispersal capabilities of *T. processionea* females and effectiveness of surveillance methods.

Phytosanitary measures are unlikely to prevent natural dispersal of the pest. Phytosanitary measures aimed at plants for planting could, however, reduce the probability of introduction of the pest into areas of the EU territory where the pest is currently absent, or present but under official control. Therefore, the Panel concludes that *T. processionea* may be considered as a harmful organism and hence is potentially eligible for addition to the list of harmful organisms in Council Directive 2000/29/EC.

N.B. A minority opinion was received (see Appendix C), based on the view that the lack of published evidence on the plant health damage and high level of uncertainty on the magnitude of impact arising directly from T. processionea in areas of the EU where it has been established for many years, does not support the conclusion that the organism is potentially eligible for addition to the list of harmful organisms.

Documentation provided to EFSA

1. Letter, dated 15 October 2008 with ref. SANCO E/1/GC/al D(2008) 510614 from P. Testori Coggi to C. Geslain-Lanéelle
2. Evans HF, 2008. Oak processionary moth Pest Risk Analysis. Revision June 2008. Forest Research, Tree Health Division. pp 30.

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APPENDIX A

EFSA request of information from Member States

To: EFSA's Advisory Forum representatives on Plant Health (29 members: 27 member states and Norway and Switzerland as observer countries)

Sent: 23/04/2009 **Deadline:** 14/04/2009 **Deadline extension:** 21/04/2009

N° of responses: 23

<u>Text of the request:</u>

Dear Advisory Forum representatives on Plant Health,

We would like to draw your attention on the European Commission's request to the European Food Safety Authority (EFSA) to provide a scientific opinion on a pest risk analysis on *Thaumetopoea processionea*, the oak processionary moth, prepared for the UK and to consider the phytosanitary risks caused by this pest for the whole European Union territory. The details of the European Commission's request (EFSA-Q-2008-711) are publically available in EFSA's Register of Questions accessible from the following web page:

http://www.efsa.europa.eu/EFSA/ScientificOpinionPublicationReport/efsa_locale-1178620753812_RequestsAndMandates.htm

A working group of the Scientific Panel on Plant Health composed of European experts in entomology has reviewed the information provided for the UK, and is seeking your assistance with obtaining the following information for EU Member States where this pest is established:

- Are control measures taken against *Thaumetopoea processionea* for Public Health reasons in your country?

  Yes **No**

- Are control measures taken against *Thaumetopoea processionea* for Plant Health purposes in your country?

  Yes **No**

If Yes, is there a regulation underlying the measures against this pest at a national or regional level in your country? (please refer to the official document).

Alternatively, if you can provide contact details for your country where the EFSA Panel on Plant Health may seek further information on this issue, this would be most helpful.

Responses to the request[i]

	Country	AF representative	Organisation	Pest presence	Are control measures taken against *T. processionea* for		Cited official document underlying the measures
					Plant Health purposes	Public Health purposes	
1	Belgium[1]	Van Herzele Lieven	Federal Public Service of Public Health, Food Chain Safety and Environment, DG Animals, Plants and Food, Sanitary Policy regarding Animals and Plants, Division Plant protection	Yes	Yes[1]	Yes[1]	No, subsidiarity principle federal/local government
2	Bulgaria	Ana E. Traykova	Scientific Unit Plant Protection Institute, Virology Department Kostinbrod, Bulgaria	Yes	No	No	No
3	Cyprus	Andreas Patsias	Department of Agriculture	Yes	No	No	No
4	Czech Republic	Vaclav Stejskal	Scientific Committee on Phytosanitary and Environment	Yes	No	No	No
5	Denmark	Christiane Scheel	Department for Plants and Plant Health	No	No	No	No
6	Estonia	Raina Mõttus	Plant Production Inspectorate	No	No	No	No
7	Finland	Hannu Kukkonen	Plant Health Unit, Finnish Food Safety Authority Evira	No	No	No	No
8	France	David Caffier	National Laboratory for Plant Health	Yes	No	Yes[2]	Yes, specifically for *T. processionea* Note de Service DGAL/SDQPV/N2005-8219 DGFAR/SDFB/N2005-5029 of 13 September 2005
9	Germany	Jens-Georg Unger	Julius Kühn Institut, Federal Research Centre for Cultivated Plants, Institute for National and International Plant Health	Yes	Yes	Yes	No specific regulations but the legal background of the control measures is the German Plant Protection Law

[1] The pest is being dealt with at Province level/local government based on subsidiarity.
[2] Normally, only restriction of access are taken in forests where the problem is important.

10	Greece	Nikolaos Koulis	Ministry of Rural Development and Food, General Directorate of Plant Produce, Directorate of Plant Produce Protection, Department of Phytosanitary Control	Yes	No	No	No
11	Hungary	Növényvédelmi Osztály	Department of Food Chain Control Ministry of Agriculture and Rural Development	Yes	No	Yes	No
12	Ireland	Barry Delany	Horticulture & Plant Health Division, Department of Agriculture, Fisheries and Food	No	No	No	No
13	Lithuania	Silvija Pupeliene	Plant Quarantine Department State Plant Protection Service	No	No	No	No
14	Malta	Marica Gatt	Plant Health Department, Plant Biotechnology Center	No	No	No	No
15	Netherlands	Dirk Jan van der Gaag	Department Plant Health Strategy & Development Plant Protection Service, Wageningen	Yes	No[3]	Yes	No specific regulations but the legal background of the control measures are the civil code art.162 and the Housing act revision of 01/04/2007 art.1a
16	Poland	Witold Karnkowski	Plant Health and Seed Inspection Service Central Laboratory,	Yes	No	No	No
17	Romania	Elena Leaota	National Phytosanitary Agency Ministry of Agriculture, Forests and Rural Development	Yes	No	No	No
18	Slovakia	Jaroslav Franko	Central Controlling and Testing Institute in Agriculture, Bratislava	Yes	No	No	No
19	Slovenia	Katarina Groznik	Phytosanitary Administration of Slovenia, Ministry of Agriculture Forestry and Food	Yes	No	No[4]	No
20	Spain	Ana Troncoso	Agencia Española de Seguridad Alimentaria y Nutrición	Yes[5]	No	No	No
21	Sweden	Karin Nordin	Swedish Board of Agriculture - Plant Protection Service	No	No	No	No

[3] The pest is only considered when infestation affect tree nurseries
[4] In some cases control measures are undertaken around schools and kindergardens
[5] The pest is generally being dealt with at Autonomy level

22	United Kingdom	Roddie Burgess	Plant Health Service	Yes	Yes	No	Yes, control measures taken for Plant Health purposes are considered under The Plant Health (Forestry) Order 2005 N°2517 in particular art 31 and 32, amended in The Plant Health (Forestry) (Amendment) Order 2008 N° 644 and The Plant Health (Forestry) (Amendment) Order 2009 N° 594
xx	Norway	Elin Thingnæs	Panel on plant health, Norwegian Scientific Committee for Food Safety	No	No	No	No

[i] The full responses are available at EFSA upon request..

APPENDIX B

Mapping the establishment potential of the oak processionary moth in the EU based on climatic mapping and phenology modelling

1. INTRODUCTION

The precise distribution of the oak processionary moth (OPM), *Thaumetopoea processionea* is difficult to determine since many records, particularly at the edge of its distribution, often do not represent breeding populations since they are based only on adult males caught in light traps. In addition, the factors affecting the duration and successful completion of its life cycle are also very poorly known. The Panel found that there is very little information in the literature on favourable climatic conditions for survival, development, and reproduction of *T. processionea*. Thermal budgets for total immature development have not been reported. Based on small scale experiments, Custers (2003) estimated the lower thermal threshold and thermal budget of *T. processionea* eggs in The Netherlands to be 2.6 °C and 350-370 degree days, respectively. However, these figures need to be considered with caution, given the preliminary nature of the experimental work.

The lack of precise distribution data makes it particularly difficult to apply (a) inductive methods, such as Maxent, that base predictions on creating a climate envelope that represents suitable climate and (b) integrated methods, such as CLIMEX, which take both the distribution and any known climatic responses into account to generate an index of suitability, the ecoclimatic index. However, two simpler methods can also be used for species, such as *T. processionea*, for which successful completion of the life cycle is likely to be critically dependent on temperature during development:

- climatic matching: comparing the temperatures in the areas where the pest is present with the area of interest;
- phenology modelling: basing the pest's potential distribution on the extent to which there are sufficient degree days to complete critical stages of a pest's life cycle in the area of interest.

The Panel has undertaken exploratory studies using both methods with a particular emphasis on determining the establishment potential of *T. processionea* in the northern countries of the EU where the pest is currently absent or under official control.

2. METHODOLOGY

2.1. Survey of the literature and unpublished studies

A detailed survey of the literature and unpublished studies in the EU and surrounding countries was undertaken. However, sufficient information to conduct an exploratory study using both climatic matching and phenology modelling was obtained only from the following locations:

(i) Climatic matching:

- Survey data from the Netherlands (Meppel, 6.22°E and 52.67°N) in 2007, De Natuurkalender (2009) and Germany (Ludwigslust province in Mecklenberg-Vorpommern Länder, at approximately 11.22°E and 53.37°N) in 2007 and 2008

(Wulf *et al.*, 2009) that provide the northernmost confirmed locations of *T. processionea* breeding in the EU that can be related to climatic data.

Most of the other European distribution datasets do not distinguish between records of males, females and breeding colonies and so cannot be used to help identify the most northerly locations.

(ii) Phenology modelling:

- One outdoor location in the Netherlands (Goirle, at 5.07°E, 51.20°N) in 2005 with accurate phenological (egg hatch and adult emergence) observations that can be related to meteorological data. The first *T. processionea* larvae hatched out on the 11th April and the first adults emerged on the 14th July, 95 days later (Fransen, 2006).

The following datasets were investigated but due to incomplete data could not be used for phenology modelling:

- Fransen (2006) provided phenological information from other locations in the Netherlands in 2005 but only those from Goirle covered the whole period from egg hatch to adult emergence.
- Pascual (1988) recorded OPM development in Spain (Salamanca province) at Villasrubias (40.32°N, 6°57'W) and Robieda (40.38°N, 6°60'W) in 1986-1987 but the meteorological data from neighbouring weather stations at Navasfrias (40.30°N, 6°82'W) and Fuenteguinaldo (40.43°N, 6°67'W) needed to calculate degree days were not available.
- Dissescu and Ceianu (1968) provided information, primarily on *T. processionea* larval development (90 days), from the Romanian forests of Codru, Pusnicu, Gyarmat, Cerhat, the Caugagia valley and Visterna in 1959-1962. However, the measurements were sporadic, the locations are imprecise, the complex topography makes them difficult to relate to weather stations and only average climatic data could be obtained from the area.
- Veresciaghin and Plugaru (1962) cited in Dissescu and Ceianu (1968) provided information on *T. processionea* development in Moldavia in 1959. However, no precise location was specified and the information is conflicting: both 69-72 and 100 days were reported for larval development in 1959.
- Roversi (2002) provided information on population dynamics, mortality and fecundity data from Santa Luce Forest, Pisa, Tuscany (Italy) in 2003-2004 but no phenological observations.
- Serafimowski (1958) cited in Dissescu and Ceianu (1968) provided information on *T. processionea* development (larvae 69-72 days, pupae 26-63 days) in Macedonia in 1955-1957. An insectarium providing conditions similar to those in the forest was used to study development but only overall maximum and minimum temperatures for the whole study were given. No location was specified. Weather station data needed to calculate degree days were not available.
- Grison (1952) provided information on *T. processionea* larval development (81 days) in France in 1951. No precise location was given.
- Lozinski (1957) cited in Dissescu and Ceianu (1968) provided information on *T. processionea* larval development at Odessa (62 days) in Ukraine. No date was provided.

- Jupe (1956) cited in Dissescu and Ceianu (1968) provided information on *T. processionea* pupal development at Altmark (20 days) in the Saxony-Anhalt area of Germany. No year or precise location was given.

2.2. Calculating representative degree day thresholds in the EU

The following methods were used for the climatic matching and phenology modelling exercise.

Methods	**Climatic matching**	**Phenology Modelling**
Obtain relevant climatic data	Select the nearest JRC-IPSC MARS meteorological database 25 km grid cell to Meppel (the Netherlands) and the four grid cells surrounding the town of Ludwigslust (Germany). Obtain daily interpolated maximum and minimum temperatures for 2007 (Meppel) and 2007 and 2008 (Ludwigslust).	Select the JRC-IPSC MARS meteorological database 25 km grid cell nearest to Goirle (the Netherlands) and obtain daily interpolated maximum and minimum temperatures for 2005.
Select start date	April 1^{st}	April 1^{st}
Select end date	August 31^{st}	August 31^{st}
Select minimum threshold of development	8°C and 10°C (by analogy with *Lymantria dispar*, see below)	8°C and 10°C (by analogy with *Lymantria dispar*, see below)
Degree Day calculation method	Weather data from the JRC AGRI4CAST 25 km grid were used to build maps of Growing Degree Days (GDD) according to the formula: GDD = (Tmax + Tmin) / 2 – Tbase; If GDD < 0 then GDD = 0 Where: Tmax = Daily maximum air temperature Tmin = Daily minimum air temperature Tbase = base temperature (values used: 8° and 10°C)	Weather data from the JRC AGRI4CAST 25 km grid were used to build maps of Growing Degree Days (GDD) according to the formula: GDD = (Tmax + Tmin) / 2 – Tbase; If GDD < 0 then GDD = 0 Where: Tmax = Daily maximum air temperature Tmin = Daily minimum air temperature Tbase = base temperature (values used: 8° and 10°C)
Determine number of degree days required for larval and pupal development	Not calculated	Calculate the number of degree days that accumulated at the 25km grid cell representative of Goirle between 11^{th} April and 14^{th} July 2005 (541 degree days

		at a base temperature of 10°C and 771 at a base temperature of 8°C)
Obtain a degree day estimate representative of the northernmost breeding colonies of OPM for climatic matching	Calculate and compare the number of degree days that accumulated at the 25km grid cell representative of Meppel in 2005 (859 base 10°C and 1148 base 8°C) and the minimum of the four grid cells representative of Ludwigslust in 2007 and 2008 (865 base 10°C and 1132 base 8°C). Round the average between the values of Meppel and Ludwigslust to obtain a degree day estimate representative of the northernmost breeding colonies of OPM (860, base 10°C, and 1140, base 8°C)	Not calculated
Calculate degree day accumulations throughout Europe	Calculate degree day accumulations base 10°C and 8°C between April 1st and August 31st in 1980-1989, 1990-1999, 2005, 2006, 2007, 2008 and 2000-2008 for all JRC-IPSC MARS 25km grid cells, import to ArcGIS9.3 (© ESRI Inc) and map.	Calculate degree day accumulations base 10°C and 8°C between April 1st and August 31st in 1980-1989, 1990-1999, 2005, 2006, 2007, 2008 and 2000-2008 for all JRC-IPSC MARS 25km grid cells, import to ArcGIS9.3 (© ESRI Inc) and map.
Compare degree day accumulations throughout Europe with the degree day thresholds	Subtract the degree day accumulations in the northernmost OPM locations of Meppel and Ludwigslust (860 base 10°C and 1140 base 8°C) from the degree day accumulations in every European grid cell and map.	Subtract the degree day accumulations for larval and pupal development at Goirle (541 base 10°C and 771 base 8°C) from the degree day accumulations in every European grid cell and map.
Obtain the number of grid cells which equals or exceeds the degree day thresholds in each northerly EU member state where OPM is absent or under official control and calculate the proportion of the total area this represents.	Extract degree day accumulation values for all 25 km grid cells in Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Sweden and the United Kingdom, count those that equal or exceed the degree day thresholds and calculate the proportion of the total number of grid cells in the country.	Extract degree day accumulation values for all 25 km grid cells in Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Sweden and the United Kingdom, count those that equal or exceed the degree day thresholds and calculate the proportion of the total number of grid cells in the country.

2.3. Assumptions

A number of assumptions have been made. Some of these are common to many climatic matching and phenology modelling exercises.

(a) Temperature is the most important climatic factor for *T. processionea* development and survival and degree day models can be used to predict establishment because:

- Insects are poikilothermic and temperature is critical to development and survival. Numerous successful models have been developed to predict the timing of the life cycle based on degree day accumulations. However, successful overwintering is much more difficult to model because numerous factors are involved: diapause, the rate of cooling, the duration of cold conditions, the minimum survival temperature, the interaction between temperature and humidity etc.

(b) Sufficient warmth (degree days) for *T. processionea* to complete its development in summer from egg hatch to adult emergence (larval and pupal development) is the most critical factor for establishment in northern EU member states because:

- *T. processionea* is established in areas with very cold winters, e.g. Romania, so overwintering is unlikely to be difficult in the rest of the EU unless mild or variable winter temperatures can affect survival, e.g. by preventing diapause or causing premature egg hatch before oak buds break. As such, the development of the embryo in the egg is less likely to be critical for establishment and has not been taken into account. It is also assumed that, if adults emerge by late August, the nocturnal temperatures will be sufficient for adult flight, mating and oviposition.

(c) A start date of 1st April for degree day calculations is appropriate because:

- It is not possible to give a precise date for every 25 km grid cell throughout Europe because of host variability (different *Quercus* species and genotypes), the lack of an oak bud burst phenology model for all species and topographic complexity that makes the average climatic values for each grid cell less representative in areas with variable altitudes, slopes and aspects.
- *T. processionea* egg hatch is approximately synchronised with oak bud burst, though the young larvae can survive even if they hatch out three weeks before, and bud burst occurs throughout Europe during April.
- Lack of precision in the start date is not too critical because in early April there is relatively little degree day accumulation compared to the rest of the summer and larval development during this period may be delayed even in warm weather by poor synchrony between egg hatch and bud burst.

(d) An end date of 31st August for degree day calculations is appropriate because:

- Apart from in the London area and the Netherlands, where adults have been recorded up to the middle of September, the flight period of adult *T. processionea* in Europe generally ends in August. However, it is not known whether insufficient degree day accumulation and a delay in adult emergence until later in the autumn could prevent successful completion of the *T. processionea* life cycle, e.g. by leaving insufficient time for egg maturation to a stage where overwintering survival is possible.

(e) A minimum threshold for larval and pupal development of 8°C and 10°C is appropriate because:

- the gypsy moth (*Lymantria dispar*) has been given a development threshold of 7.65°C by Carter *et al.* (1992). The GMPHEN gypsy moth phenology model (Sheehan, 1992) gives a value of 8.1°C for female larvae and lower values for male larvae and pupae. However, since this species occurs much further north than OPM in Europe, exceeding latitude 60°N in Norway, Sweden and Finland (de Freina & Witt, 1987; Leraut, 2006), it is appropriate to consider a higher threshold with degree accumulation also starting at 10°C. The gypsy moth provides an appropriate model because it has a similar life cycle (overwintering at the egg stage) and attacks the same tree species.

- Choosing two values provides some sensitivity analysis.

- There is intraspecific variation in the mimimum threshold and, even when experimental results are available, errors arise due to the difficulty in obtaining a large sample size at conditions close to mortality and the common use of linear regression to obtain the base temperature even though the relationship is curvilinear near the minimum threshold.

- More complex phenology models have been applied to predict the timing of insect life stages but these are inappropriate for this species because there is so much uncertainty concerning the parameters such models would require.

(f) The location (Goirle) where egg hatch, larval development, pupal development and adult emergences were recorded provides data that are representative for *T. processionea* in the EU because:

- The population genotype in this area is likely to be one of the principal potential invaders of the northernmost countries of the EU. However, there is likely to be considerable variation in genotypes in the populations at this latitude and further north across central Europe to longitude 30°E. In addition, the degree to which the minimum larval and pupal development time of 95 days in 2005 is representative at this location is dependent on the sample size and the frequency and accuracy of observations.

- The Netherlands is relatively flat topographically and thus the average climatic conditions in the 25 km grid cell are likely to be comparable. However, even in relatively flat areas, the locations where the pest is present can have a different microclimate to that recorded by weather stations, e.g. due to extra warmth in urban areas, higher minimum temperatures near water bodies, and cooling caused by shading, lack of shelter from the wind etc.

(g) The northernmost locations where breeding has been found in Germany and the Netherlands are representative because:

- The topography around Meppel and Ludwigslust is relatively flat and thus the average climatic conditions in the 25 km grid cell are likely to be comparable, although, even in flat areas, the microclimate where the pest is present may be different to that recorded at weather stations (see above).

- The April to August degree day accumulations at 8°C and 10°C are very similar in 2007 and 2008. However, since the species may still be spreading, these locations may not represent its climatic limits.

(h) Hosts and natural enemies are not key factors limiting the distribution of *T. processionea*

- *Quercus* species are very widespread in Europe. Even in Sweden and Finland, they are widely planted in gardens and parks, even if they are absent in the wild

- Some parasitoids, e.g. tachinids, have been found in high densities but they are unlikely to prevent the establishment of OPM populations

(i) Establishment in the southern EU member states is not limited by low temperatures but might be hindered by high summer temperatures and dry conditions. However, there is no evidence for this and its limited presence in the southern EU may also be related to the dominance of evergreen *Quercus* species (Jalas & Suoimine, 1976) which appear to be less favourable hosts (Pascual, 1988).

3. RESULTS

3.1. Climatic matching

Maps (see Figures 1-5) showing the results for 2005, 2007, 2008 and the average for 2000-2008 have been prepared for the two thresholds and base temperatures: 860 degree days at a base temperature of 10°C and 1140 degree days at a base temperature of 8°C.

Tables 1 and 2 show the number of grid cells and the proportion of the total grid cells with degree day accumulations in Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Sweden and the United Kingdom that equal or exceed those found at the northernmost locations in the EU.

The maps and data for both base temperatures show a very similar picture. The degree day accumulation at the northernmost locations of *T. processionea* breeding in the EU is only rarely equalled or exceeded in EU member states to the north and west during hot summers in recent years.

3.2. Phenology Modelling

Maps (see Figures 1 to 4) showing the results for 2005, 2007, 2008 and the average for 2000-2008 have been prepared for the two thresholds and base temperatures: 541 degree days at a base temperature of 10°C and 771 at a base temperature of 8°C.

Tables 3 and 4 show the number of grid cells and the proportion of the total grid cells with degree day accumulations in Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Sweden and the United Kingdom that equal or exceed those needed for larval and pupal development.

Except for Finland and Denmark, large parts of these countries, particularly southern areas, have sufficient degree day accumulation for successful larval and pupal development at both base temperatures.

The maps and data for the northernmost EU countries are similar for both base temperature thresholds, indicating that the uncertainty in the choice of base temperatures is not of critical importance.

3.3. Climate Change

Figure 5 shows the considerable increase in degree day accumulation that has occurred in the 1990s and 2000s compared with the 1980s. Even the coolest recent years, e.g. 2005, are warmer than the average of the 1980s. Table 5 shows that this has dramatically increased the area with degree day accumulation sufficient for successful larval and pupal development in all northern EU countries but especially Finland, Ireland and Sweden.

CONCLUSIONS

Based on field phenology observations at one location in the Netherlands, the Panel's exploratory study showed that, with the warmer climatic conditions that have occurred in recent years, large areas of England, Lithuania, Latvia and some southern areas of all the northern EU member states have sufficient temperature degree days for *T. processionea* to complete its development from egg hatch to adult emergence.

While this indicates that *T. processionea* establishment may be possible in parts of all northern EU member states, a number of assumptions have had to be made in coming to this conclusion. The principal reasons for the high levels of uncertainty are due to the poor knowledge of *T. processionea*'s distribution and climatic responses. To explore this issue further, the Panel compared the degree day accumulations at the two northernmost locations where breeding has been currently observed in the Netherlands and Germany with those in northern EU member states where it is currently absent or under official control. Although it is not known whether these two locations represent a true climatic limit for *T. processionea* or whether they just indicate the current boundary of a species that is still spreading, it was found that the number of degree days accumulating in northern EU member states were generally close to or below the values at the two locations. Although this suggests that *T. processionea* has considerable potential for further spread in the northern parts of the EU, a more accurate knowledge of the locations where *T. processionea* has established breeding colonies and a greater understanding of its climatic responses is required to determine the endangered area of the EU for establishment.

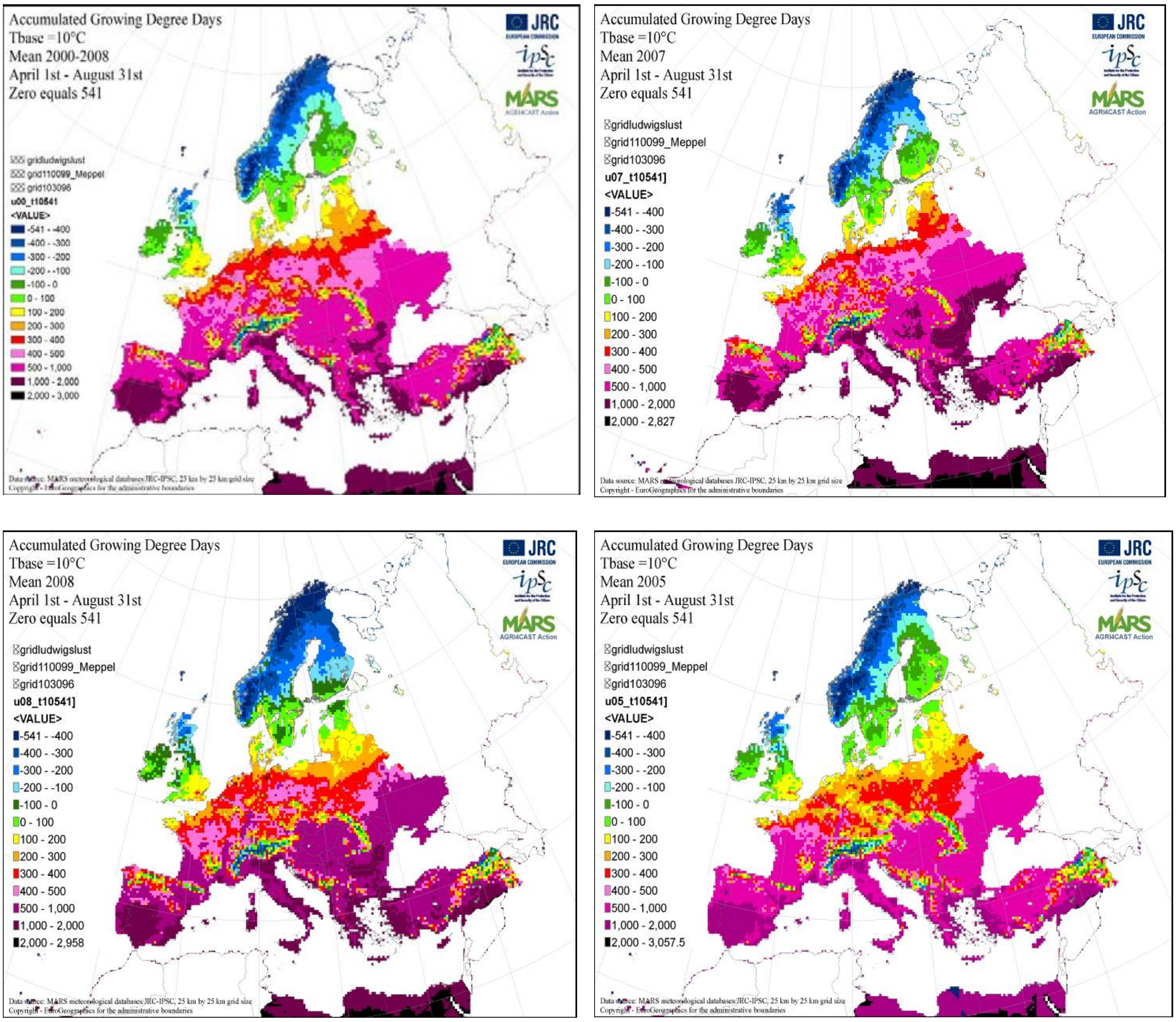

Figure 1. **Areas with degree days base 10°C for April 1st – August 31st greater or less than 541 (the minimum degree days needed for egg hatch – adult emergence in the oak processionary moth) in 2005, 2007, 2008 and an average of 2000-2008**

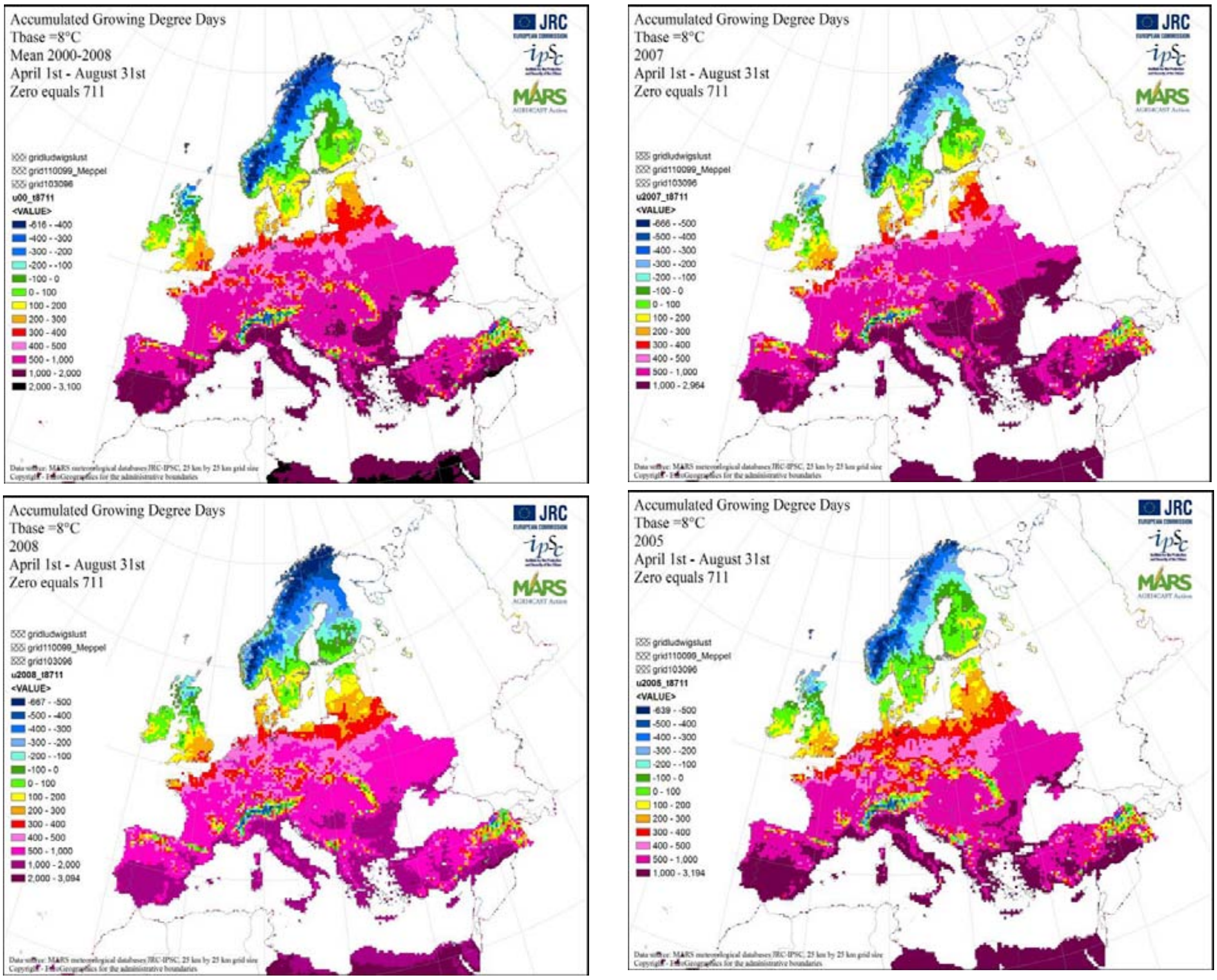

Figure 2. **Areas with degree days base 8°C for April 1st – August 31st greater or less than 711 (the minimum degree days needed for egg hatch – adult emergence in the oak processionary moth) in 2005, 2007, 2008 and an average of 2000-2008**

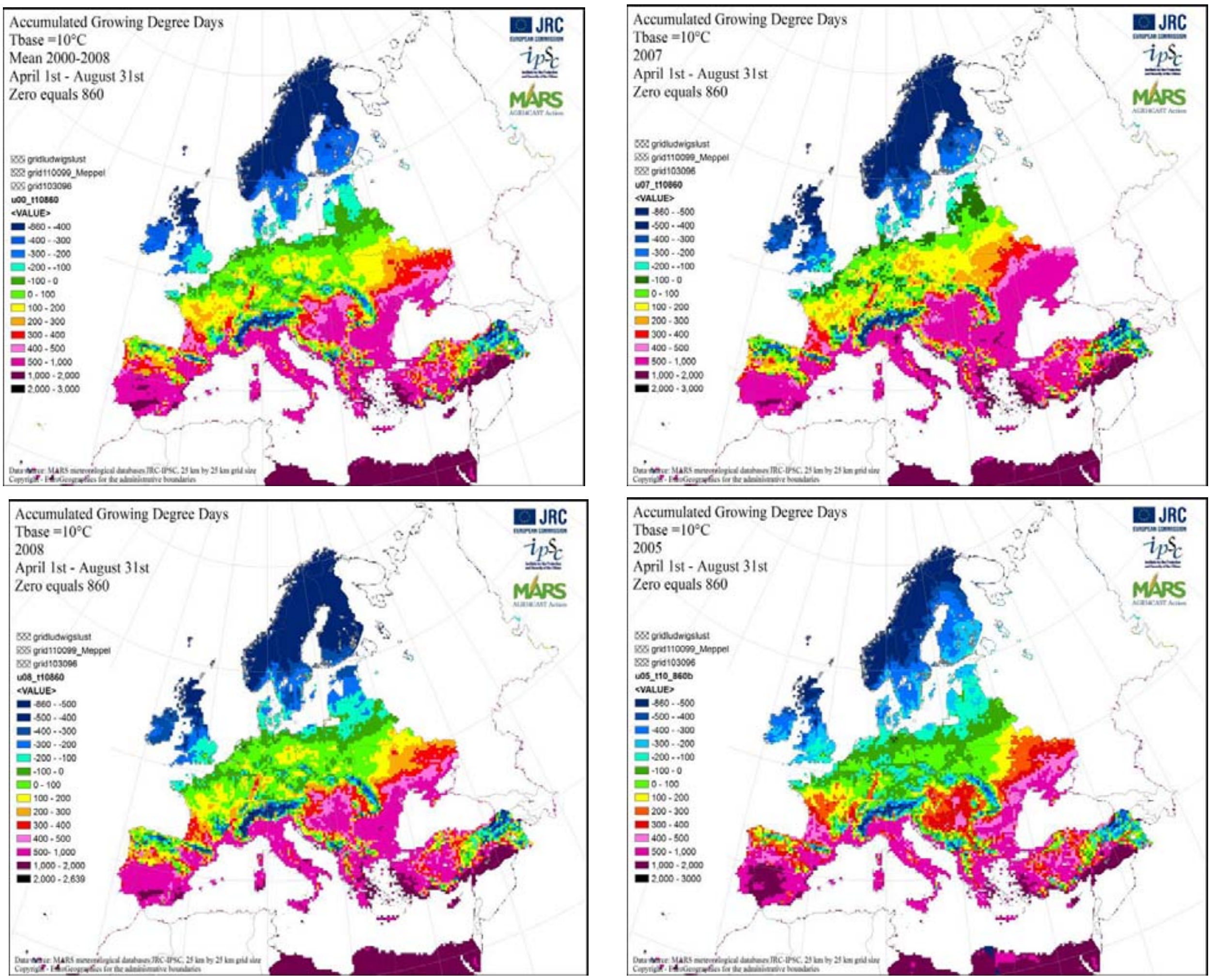

Figure 3. **Areas with degree days base 10°C for April 1st – August 31st greater or less than 860 (the degree days available for oak processionary moth development at the northernmost limits to its distribution in Germany and the Netherlands) in 2005, 2007, 2008 and an average of 2000-2008**

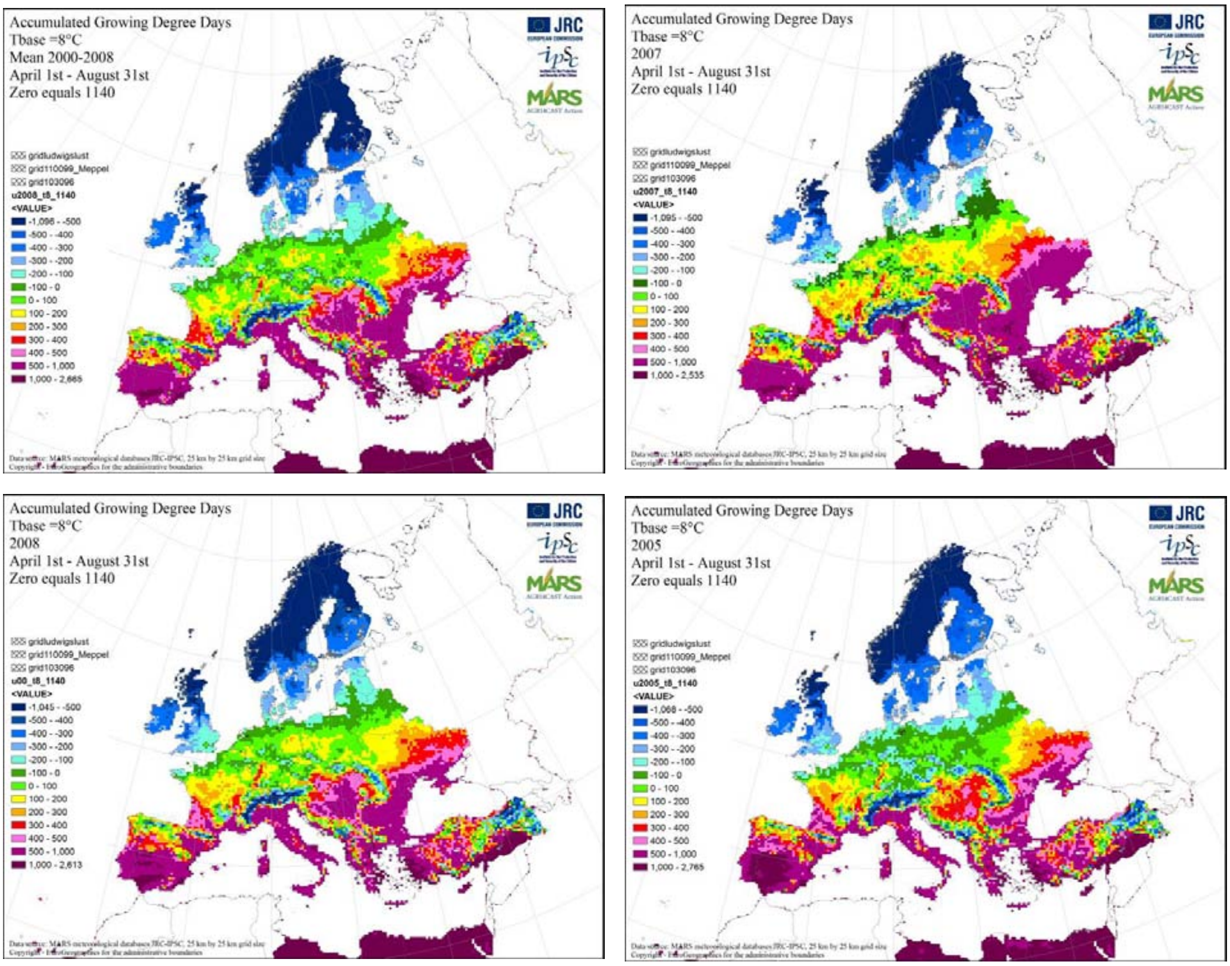

Figure 4. **Areas with degree days base 8°C for April 1st – August 31st greater or less than 1140 (the degree days available for oak processionary moth development at the northernmost limits to its distribution in Germany and the Netherlands) in 2005, 2007, 2008 and an average of 2000-2008**

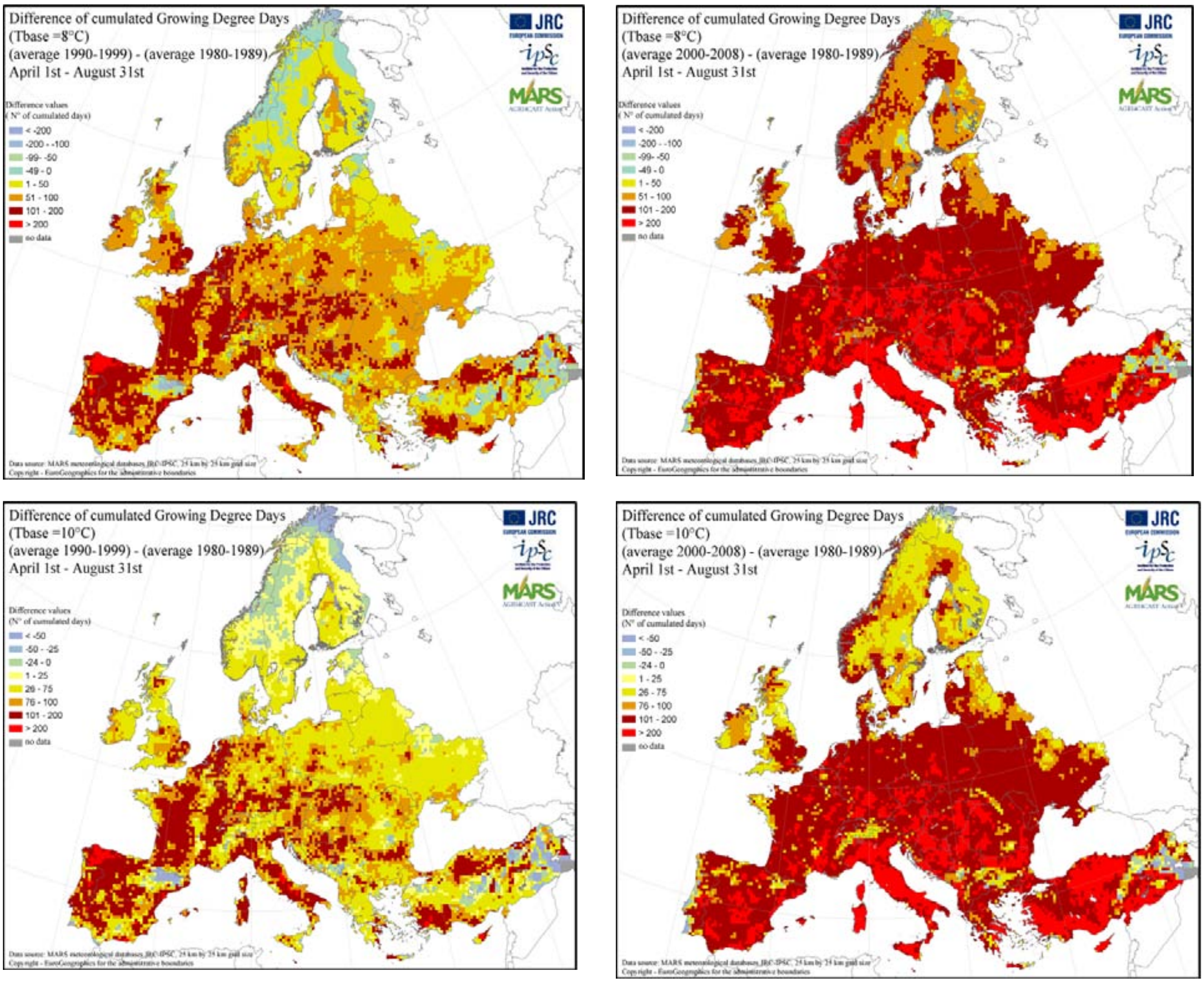

Figure 5. **The change in the accumulation of degree days with a base of 8°C and 10°C for April 1st –August 31st between the 1980's, the 1990's and 2000-2008**

Table 1 **Number of 25 km grids in northern EU member states with accumulated daily temperatures required for egg hatch to adult emergence greater or equal than the degree day thresholds (541 degree days at a base temperature of 10°C and 771 degree days at a base temperature of 8°C)**

		Base 10°C							Base 8°C			
Country	**Grid Cells**	**1980-1989**	**1990-1999**	**2000-2008**	**2005**	**2006**	**2007**	**2008**	**2000-2008**	**2005**	**2007**	**2008**
UK	247	96	140	144	141	174	130	137	173	166	165	177
Ireland	69	3	14	27	37	63	23	23	67	67	67	68
Estonia	45	44	43	45	45	45	45	24	45	45	45	42
Latvia	68	63	68	68	68	68	68	68	68	68	68	68
Lithuania	75	75	75	75	75	75	75	75	75	75	75	75
Finland	441	34	88	156	199	222	174	10	206	258	216	32
Sweden	588	53	116	169	123	220	165	139	196	180	194	189
Denmark	31	22	31	31	29	31	31	31	0	31	9	0

Table 2 **Percentage of the total number of 25 km grids in northern EU member states with accumulated daily temperatures required for egg hatch to adult emergence greater or equal than the degree day thresholds (541 degree days at a base temperature of 10°C and 771 degree days at a base temperature of 8°C)**

		Base 10°C							Base 8°C			
	Grid Cells	**1980-1989**	**1990-1999**	**2000-2008**	**2005**	**2006**	**2007**	**2008**	**2000-2008**	**2005**	**2007**	**2008**
UK	247	39%	57%	58%	57%	70%	53%	55%	70%	67%	67%	72%
Ireland	69	4%	20%	39%	54%	91%	33%	33%	97%	97%	97%	99%
Estonia	45	98%	96%	100%	100%	100%	100%	53%	100%	100%	100%	93%
Latvia	68	93%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lithuania	75	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Finland	441	8%	20%	35%	45%	50%	39%	2%	47%	59%	49%	7%
Sweden	588	9%	20%	29%	21%	37%	28%	24%	33%	31%	33%	32%
Denmark	31	71%	100%	100%	94%	100%	100%	100%	0%	100%	29%	0%

Table 3 **Number of 25 km grids in northern EU member states with accumulated daily temperatures greater or equal to those at the northernmost limits of its current distribution in Germany and the Netherlands (860 degree days at a base temperature of 10°C and 1140 degree days at a base temperature of 8°C)**

		Base 10°C							Base 8°C			
	Grid Cells	**1980-1989**	**1990-1999**	**2000-2008**	**2005**	**2006**	**2007**	**2008**	**2000-2008**	**2005**	**2007**	**2008**
UK	247	0	0	1	1	6	2	2	1	1	2	2
Ireland	69	0	0	0	0	0	0	0	0	0	0	0
Estonia	45	0	0	0	0	0	1	0	0	0	0	0
Latvia	68	0	0	0	0	1	1	0	0	0	0	0
Lithuania	75	0	0	0	0	21	46	0	0	0	16	0
Finland	441	0	0	0	0	0	0	0	0	0	0	0
Sweden	588	0	0	0	0	0	0	0	0	0	0	0
Denmark	31	0	0	0	0	0	0	0	0	0	0	0

Table 4. **Percentage of the total number of 25 km grids in northern EU member states with accumulated daily temperatures greater or equal to those at the northernmost limits of its current distribution in Germany and the Netherlands (860 degree days at a base temperature of 10°C and 1140 degree days at a base temperature of 8°C)**

		Base 10°C							Base 8°C			
	Grid Cells	**1980-1989**	**1990-1999**	**2000-2008**	**2005**	**2006**	**2007**	**2008**	**2000-2008**	**2005**	**2007**	**2008**
UK	247	0%	0%	0%	0%	2%	1%	1%	0%	0%	1%	1%
Ireland	69	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Estonia	45	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%
Latvia	68	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%
Lithuania	75	0%	0%	0%	0%	28%	61%	0%	0%	0%	21%	0%
Finland	441	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sweden	588	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Denmark	31	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 5 **The increase in degree day accumulation with a base of 10°C that has occurred in the 1990s and 2000s compared with the 1980s in northern EU member states**

	1990-1999	**2000-2008**
UK	146%	150%
Ireland	467%	900%
Estonia	98%	102%
Latvia	108%	108%
Lithuania	100%	100%
Finland	259%	459%
Sweden	219%	319%
Denmark	141%	141%

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APPENDIX C

Minority opinion by J.C. van Lenteren

The opinion on *T. processionea* gives a careful and complete analysis of the problems it might cause in the EU. I agree with almost all conclusions presented in the opinion. However, based on the fact that no published information is available on oak mortality or oak quality as a direct effect of the attack by *T. processionea*, combined with the high uncertainty on the magnitude of impact of *T. processionea* on the health of oak trees, and the fact that *T. processionea* is reported to occur for several hundreds of years in the EU without apparently causing serious plant health damage, I disagree with the last sentence in the final conclusion that *T. processionea* may be considered as a harmful organism and hence is potentially eligible for addition to the list of harmful organisms in Council Directive 2000/29/EC. Based on the above mentioned reasoning, it is my opinion that *T. processionea* should not be considered as a harmful organism and is not potentially eligible for addition to the list of harmful organisms in Council Directive 2000/29/EC.