Rapid Pest Risk Analysis for

Thaumetopoea pityocampa (the Pine Processionary Moth)

This document provides a rapid assessment of the risks posed by the pest to the UK in order to assist Risk Managers decide on a response to a new or revised pest threat. It does not constitute a detailed Pest Risk Analysis (PRA) but includes advice on whether it would be helpful to develop such a PRA and, if so, whether the PRA area should be the UK or the EU and whether to use the UK or the EPPO PRA scheme.

STAGE 1: INITIATION

1. What is the name of the pest?
Thaumetopoea pityocampa (Denis & Schiffermüller) (Lepidoptera, Thaumetopoeidae). Pine processionary moth (PPM). The name pine processionary moth may also be applied to Thaumetopoea wilkinsoni, which is now generally considered to be a separate species on molecular evidence (Erkan, 2011).

2. What is the pest’s status in the EC Plant Health Directive (Council Directive 2000/29/EC1) and in the lists of EPPO2?
The pest is no longer listed in the EC Plant Health Directive (in 2008 T. pityocampa was removed from Section II, part B: for the protected zone of the island of Ibiza only, it was formerly listed on plants of Pinus intended for planting). It is not listed by EPPO although detailed information is available in the EPPO Global Database3.

3. What is the reason for the rapid assessment?
Forestry Commission and Fera pest risk analysts have identified PPM as a priority pest for evaluation. The northward expansion of PPM in France has raised concerns for the UK (Jordan, 2011)

STAGE 2: RISK ASSESSMENT

4. What is the pest’s present geographical distribution?
Until recently it was only found in the Mediterranean region, North Africa and some areas of the Middle East and southern Europe. Responding to climate change, since the 1990s the pest has been moving north through France and is now breeding near Paris (Robinet et al., 2011) (see Fig. 7 in Appendix 1). The full list of countries where it has been recorded is: Albania, Algeria, Austria, Bulgaria, Croatia, Cyprus, France (including Corsica), Greece (including Crete), Hungary, Italy (including Sardinia and Sicily), Libya, Macedonia, Montenegro, Morocco, Portugal, Serbia, Slovenia, Spain (including the Balearic Islands), Switzerland, Syria and Tunisia (CABI, 2011). CABI (2011) also states that T. pityocampa is found in the USA and Canada, citing Chinese authors, but no other source can be found to substantiate this.
Thaumetopoea wilkinsoni is now generally considered to be a separate species on morphological and molecular evidence, and is found in Turkey and the Middle East (Erkan, 2011). Records of T. pityocampa from Lebanon, Israel and Turkey thus appear likely to be T. wilkinsoni (CABI, 2011).

2 http://www.eppo.org/QUARANTINE/quarantine.htm
3 http://gd3.eppo.int/organism.php/THAUPI
5. Is the pest established or transient, or suspected to be established/transient in the UK? *(Include information on interceptions and outbreaks here).*

The pest is not established in the UK. One transient population of larvae was found in a UK nursery in 1995 on *Pinus sylvestris* imported from Italy in 1994. The affected trees and soil were treated, and subsequent monitoring did not detect the pest (Starzewski, 1998). In 1966 an adult was caught in a light trap in Berkshire, but the origin of the moth is unclear (Waring & Townsend, 2003). A colony in Kent survived from 1872-74 and then died out (Heath & Emmett, 1979). However, there is a likelihood that this is fictitious since it was reported during a period of rivalry between unscrupulous collectors (Allan, 1943).

6. What are the pest's natural and experimental host plants; of these, which are of economic and/or environmental importance in the UK?

The genus *Pinus* is most susceptible to attack and the following species are particularly susceptible: *P. nigra* (Austrian pine), *P. sylvestris* (Scots pine), *P. pinea* (stone pine), *P. halepensis* (Jerusalem pine), *P. pinaster* (cluster pine), *P. contorta* (lodgepole pine), *P. radiata* (Monterey pine) and *P. canariensis* (Canary Island pine) (EPPO, 2004). Other recorded hosts include the conifers *Cedrus atlantica* (atlas cedar) and *Larix decidua* (European larch) (EPPO, 2004). CABI (2011) also states that *Crateagus laevigata* (midland hawthorn) is a host, though no other sources can be found that record non-coniferous trees as hosts.

*Pinus sylvestris* grows very widely in the UK, as do other *Pinus* host species (see Fig. 2). In 2011 there was a total of 1,406,000 hectares of coniferous woodland in Great Britain including 227,000 ha of *P. sylvestris*, 135,000 ha of *P. contorta* and 47,000 ha of *P. nigra*.4 Maps showing the distribution of the key hosts are provided in Appendix 1. All the known hosts may be bought commercially from nurseries in the UK (RHS Plant Finder, 2012).

7. If the pest needs a vector, is it present in the UK?

No vector is required. This is a free-living organism.

8. What are the pathways on which the pest is likely to move and how likely is the pest to enter the UK? *(By pathway):*

Plants for planting: Caterpillars of *T. pityocampa* were found on a UK nursery in 1995 on pot grown pine saplings, which had been imported from Italy the previous year (Starzewski, 1998). There is therefore a potential danger for caterpillars associated with plants for planting being brought into the UK. However, these caterpillars are gregarious, forming white silken nests up to the size of a football on host plants, in which they overwinter, occasionally coming out to feed (Starzewski, 1998). In the majority of cases, these nests (see Fig. 3) and the associated caterpillars would be clearly visible prior to, or at import, greatly lowering the risk of movement. Egg masses are considered to be a low risk by Robinet *et al.* (2011) due to pine trees not usually being planted in the summer months when adult moths lay their eggs and adult females are short lived and unlikely to remain with planting material being moved. Although a low risk, it is more likely that pupae could be brought into the UK in the soil of plants for planting – most likely with hosts, but potentially with any plants which have been growing in the vicinity of infested host trees prior to export. Pupae are unlikely to be detected by inspection and may remain in the soil for up to three years before the moths emerge (Starzewski, 1998). This is the pathway by which it is believed that PPM moved to the Paris area in France (Robinet *et al*., 2011). Although plants for planting of a wide range of genera enter the UK annually and there are no requirements for plants to be free of this pest, the volume of imports of host plants (or species growing in vicinity) with soil from areas where PPM is present is not likely to be large. Appendix 3 shows that according to the Forest Reproductive Material Database, the UK only imported hosts (*Pinus sylvestris*, *P. pinaster* and *Larix eurolepis*) in containers from countries with *T. pityocampa* on six occasions between 2003 and 2012. This is a key area of uncertainty and additional data are being sought.

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Plants for planting | Very unlikely | Unlikely | Moderately likely | Likely | Very likely

Wood: Association of this pest with wood or wood products is unlikely. There is potential that larvae may hitchhike, but the likelihood of them being associated with this pathway is very low.

Wood / wood products | Very unlikely | Unlikely | Moderately likely | Likely | Very likely

Hitchhiking on vehicles / containers: Again very low likelihood of association with the pathway.

Vehicles / containers | Very unlikely | Unlikely | Moderately likely | Likely | Very likely

Natural Spread: Adults have wings and both sexes can fly. Reports have been made of possible migrants to the UK (Waring & Townsend, 2003; Starzewski, 1998). However, natural dispersal is dependent on the flight capacity of female moths, which is lower than that of males. Robinet et al. (2011) conducted experiments to estimate the females flight capacity in laboratory conditions. The average flying distance recorded was 1.7km, with the maximum being 10.5 km. This experimental data is consistent with the rate of spread of this moth in the south of the Paris Basin, which has been reported as 5.6 km per year (Battisti et al., 2005; Robinet et al., 2007). Based on the moth's current known distribution, the risk of natural spread is still low compared to the movement with plants for planting, however, the increasing northwards movement does increase the chance of natural spread to the UK.

Natural Spread | Very unlikely | Unlikely | Moderately likely | Likely | Very likely

9. How likely is the pest to establish outdoors or under protection in the UK? Appendix 1 shows that the Pinus host species of PPM, particularly P. sylvestris, are widespread in the UK. The greatest diversity is found near the coast in Southern England between Bournemouth and Southampton where non-native Pinus host species, such as P. nigra, P. radiata and P. pinaster, are grown. The larvae overwinter in nests and do not diapause. Late winter temperatures, when the larvae are beginning to emerge from overwintering nests on warmer days, may be critical, particularly if larvae are still outside the nest when temperatures drop rapidly at night. Survival at the northern edge of its range in France is related to nest temperatures (maximum daily temperature and solar radiation) which is correlated with mean minimum winter temperatures (Robinet et al., 2007). Appendix 2 shows that the mean minimum winter temperatures at Hurn (Bournemouth) Airport are very similar to those in Orleans where the pest can reach damaging population densities. Winter temperatures are likely to be higher nearer to the coast and in urban areas. However, prolonged cold periods and/or lack of winter sunshine will greatly reduce the likelihood of survival and, if present, the species may be at the edge of its potential range.

On this basis, the likelihood of establishment is assessed as low but there is a high uncertainty. To reduce the uncertainty, it is recommended that further work is undertaken to explore factors such as: (a) the influence of solar radiation (sunshine allows the larvae to feed and prolonged lack of sunshine can cause starvation), (b) the possibility that winters with long cold periods could destroy colonies and (c) the limits to the area suitable for establishment. The hosts are not generally grown in protected cultivation.
10. How quickly could the pest spread in the UK?
The natural rate of dispersal appears to be quite low, with records from France indicating a range of expansion of around 5.6 km per year (Robinet et al., 2007). In a flight mill, the average flying distance of 47 females was 1.7 km with a maximum of 10.5 km. This suggests that natural spread would be slow.

However, as found in France, the spread of pupae in plants with soil can produce satellite populations greatly increasing the speed of spread (Robinet et al., 2007). The pest could establish over a wide area if infested consignments were split between a number of different locations, although slow natural spread would mean that these remain quite isolated.

11. What is the area endangered by the pest?
Appendices 1 and 2 show that the south coast between Bournemouth and Southampton has (a) a high density and diversity of host Pinus species and (b) mean winter minimum temperatures similar to those in Orleans where damaging populations occur. Pinus species and similar minimum winter temperatures are likely to occur along much of the south coast. Urban areas and the coastal fringe will have higher minimum temperatures and this is the area at highest risk. However, as noted in section 9 and Appendix 2, any colonies that do establish may be vulnerable to low winter temperatures and solar radiation, particularly in late winter, and further work is required to identify the limits to the area suitable for establishment.

12. What is the pest's economic, environmental or social impact within its existing distribution?
The pest can be a serious defoliator of Pinus species in Mediterranean Europe where it occurs in high densities. Controlling for the effects of climate, Laurent-Hervouët (1986) found that defoliation could in severely infested years affect the trees to such an extent that visible growth rings were absent in southern France. However, in Corsica, the pattern of infestation was different, and only affected tree growth in 2 of the 28 years studied (Laurent-Hervouët, 1986). Impacts on Pinus sylvestris nevadensis in the Sierra Nevada mountains in southern Spain included reduced tree growth, but severely affected trees also produced fewer and lighter seeds, thus potentially affecting regeneration of the forest for years to come (Hódar et al., 2003). In north-eastern Portugal, the pest was calculated to cause an economic loss of around €100 per hectare in Pinus pinaster after heavy defoliation (Arnaldo et al., 2010). In Portugal there is some evidence that trees weakened by PPM become more vulnerable to attack by other biotic agents, particularly bark beetles.

Additionally, social impacts are caused by the urticating hairs of the older larvae which become detached from the larvae and contaminate the environment more widely. If they come into contact with skin, these setae cause severe rashes in both humans and other mammals due to a toxic protein they contain. If airborne setae are inhaled, they may cause breathing difficulties, e.g., asthma. If the setae enter the eye, severe corneal inflammation can occur (Portero et al., 2012). The larval nest also contains shed hairs that continue to pose a risk to those that handle it for months or even years afterwards.
13. What is the pest's potential to cause economic, environmental or social impacts in the UK?

Mean minimum winter temperatures (a parameter that is correlated with winter survival in France) at one location near the coast in southern England are similar to those in Orleans where the pest is present and can reach damage population levels (see Appendix 2). However, although this suggests that establishment along the south coast of England is possible, it is likely that the pest would be at the edge of its range. Population densities are therefore likely to remain low and economic and environmental damage through tree defoliation will be minimal apart from in exceptionally mild sunny winters when minor damage could be sustained. Nevertheless, even very low densities could cause major health problems. In common with normal practice the risk rating given (small) is related to its plant health impacts and not to its human health impacts.

14. What is the pest's potential as a vector of plant pathogens?

The pest is not a known vector of plant pathogens.

STAGE 3: PEST RISK MANAGEMENT

15. What are the risk management options for the UK? (Consider exclusion, eradication, containment, and non-statutory controls; under protection and/or outdoors).

Exclusion

This pest is currently absent from the UK. However it is present and spreading naturally in other EU Member States. Currently the major hosts of PPM, Pinus, Cedrus and Larix spp, are prohibited from all non-European third countries. However as PPM is present in much of southern and central Europe including a number of EU Member States this prohibition provides little protection against PPM. PPM is not a regulated pest within the EU and, therefore, there are no existing phytosanitary measures against this pest. Exclusion of this pest would be an effective means of preventing establishment in the UK. This would require the adoption of new legislation which would impose requirements to ensure that plants for planting arriving in the UK from EU Member States and European third countries were free from PPM. However the measures which would be required to ensure that PPM does not enter the UK are likely to be very difficult for infested countries to meet and therefore unacceptable to other EU Member States.

Pathways

Plants for planting

It is possible that egg masses and larvae could be imported with plants for planting of host species and that pupae could be imported with soil associated with plants for planting of any species from an infested area.

Appropriate measures for the exclusion of PPM egg masses and larvae from the UK would be a requirement for careful visual examination of host plants on places of production and in the immediate vicinity of places of production to ensure freedom from egg masses, larvae and nests either on the trees themselves or the surrounding area.

Detection of pupae in the soil associated with plants for planting would not be possible and it is likely that pupae could be associated with any plant for planting from an infested area not just the host species. This adds a significant complication to any measure aimed at
excluding the pest as any plant with soil attached from an infested area carries the risk of introducing PPM pupae which could potentially complete their life cycle and emerge as adult moths which could infest hosts plants. In order to prevent movement of pupae, restrictions would have to be placed on the movement of all plants for planting with soil attached from infested areas. In France it is thought that PPM has made jumps in its distribution associated with human activity and it is considered most likely that pupae of PPM have been moved long distances associated with soil attached to plants.

Appropriate measures would be a requirement for all known hosts to have come from a place of production which has been subject to an official inspection at an appropriate time and has been found free from signs of PPM. The immediate vicinity of the nursery would also need to be inspected and found free from PPM. The immediate vicinity around the nursery would have to be defined and would need to be further than the average flight distance of the female moth which was considered by Robinet et al (2011) to be 1.7 km (although it should be noted that there will be female moths which can fly significantly further, up to 10.5 km was recorded by Robinet et al. 2011). To ensure freedom from PPM pupae all plants for planting from infested area should either have come from a place of production within an immediate vicinity which has been inspected and found free from PPM or should be moved without soil (bare roots) which would have huge implications for the movement of plants for planting within the EU.

16. Summary and conclusion of rapid assessment.
(Highlight key uncertainties and topics that will require particular emphasis in a detailed PRA)

This rapid risk assessment shows:

**Risk of entry:** the likelihood of entry is low to moderate for pupae transported with soil attached to the host plants or plants growing in the vicinity. Import data are being sought but the volume of such imports from the area where PPM is present is likely to be small. The risks of entry by other pathways, e.g. natural spread or movement with eggs, larvae and adults, is very low.

**Risk of establishment:** the likelihood of colonisation is low along the south coast of England where Pinus species are present and minimum winter temperatures are comparable to those in areas, such as Orleans, where PPM is present. However, there is a high uncertainty. To reduce the uncertainty, it is recommended that further work is undertaken to explore factors such as: (a) the influence of solar radiation (sunshine allows the larvae to feed and prolonged lack of sunshine can cause starvation), (b) the possibility that winters with long cold, cloudy periods could destroy colonies and (c) the limits to the area suitable for establishment.

**Economic impact**
Only low population densities are likely and these will cause minimal to minor economic and environmental damage. However, even small populations can cause severe skin rashes and ocular damage from the larval hairs.

**Endangered area**
The south coast of England, particularly in urban areas.

**Risk management**
Although eggs and adults are unlikely to be present on imports and larvae can be readily detected by inspection, the only measures likely to be effective in preventing pupae from being transported in soil attached to plants for planting, such as place of production, area freedom or a requirement for bare roots, are likely to be very disruptive to trade.

17. Is there a need for a detailed PRA? If yes, select the PRA area (UK or EU) and the PRA scheme (UK or EPPO) to be used.

As outlined in Section 9 and Appendix 2, a detailed PRA is required primarily (a) to explore the influence of solar radiation on winter survival, (b) to determine the possibility that winters with long cold periods could destroy colonies and (c) to define the limits to the area suitable for establishment. Such an analysis would also help to assess the extent to which economic and environmental impacts can be expected. In addition, data on the import of plants for planting from areas where the pest is already present in the EU need to be obtained to clarify the risk of entry.

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Further detail is required, primarily to assess the climatic suitability of the UK and define the endangered area (see Appendix 2) and quantify the imports of host plants for planting from areas where the pest is already present in the EU.

18. IMAGES OF THE PEST

Fig. 1 *Thaumetopoea pityocampa* larvae on the outside of the silk larval nest © John H. Ghent, USDA Forest Service, Bugwood.org

Fig. 2 *Thaumetopoea pityocampa* adult © Andrea Battisti, Universita di Padova, Bugwood.org
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Appendix 1 Pine Processionary Moth: *Pinus* Host Distribution in the UK

Figures 4, 5 and 6 show that many of the principal *Pinus* host species for PPM (see section 6) are widespread in the UK. The highest diversity is found near the coast in central southern England particularly between Bournemouth and Southampton.

Fig. 4 Species distribution maps for *Pinus sylvestris*, *P. nigra* and *P. radiata* reproduced from the Botanic Society of the British Isles Atlas Tetrad (2 km x 2 km) maps [http://www.bsbimaps.org.uk/mstetrads/main.php](http://www.bsbimaps.org.uk/mstetrads/main.php)

Fig. 5 Species distribution maps for *Pinus pinaster*, and *P. contorta* reproduced from the Botanic Society of the British Isles Atlas Tetrad (2 km x 2 km) maps [http://www.bsbimaps.org.uk/mstetrads/main.php](http://www.bsbimaps.org.uk/mstetrads/main.php)
Fig. 6 Species distribution maps in southern England for *Pinus* pinaster, and *P. radiata* reproduced from the Botanic Society of the British Isles Atlas Tetrads (2 km x 2 km) maps http://www.bsbimaps.org.uk/mstetrads/main.php. The black circle is centred around Bournemouth where there is a high diversity of *Pinus* species.
Appendix 2 Pine Processionary Moth: Suitability of the climate in the UK (A Preliminary Analysis)

2A The Objectives of this Appendix

This appendix describes a preliminary study that has been undertaken (a) to determine whether southern England might provide a suitable climate for establishment and (b) to identify the key topics for further research that would clarify the risk of establishment and identify the area at highest risk.

The research has concentrated on an assessment of the capacity for PPM larvae to overwinter successfully. The species overwinters as larvae living in silken tents (Fig. 3) from which they emerge on warm nights to feed. Since they do not diapause, winter temperatures (and solar radiation) are critical both to survival and the avoidance of starvation (Hoch et al., 2009).

2B Methods

The following preliminary work has been undertaken:

- Clarification of the key factors influencing establishment based on research undertaken by:
  - INRA, Orleans, France (Christelle Robinet et al.)
  - University of Natural Resources and Life Sciences, Vienna, Austria (Peter Baier et al.)
  - University of Padua, Italy (Andrea Battisti et al.)

- Identification of the areas of the UK with the warmest and sunniest winters and high densities of PPM hosts - the areas with the highest risk of establishment

- Calculation of the mean minimum winter temperatures for one location in the areas with the highest risk of establishment and a comparison of these data with those from locations where PPM is spreading northwards in France.

2C Climate and PPM in northern France

The situation is complex because the pest is spreading northwards in France (see Fig. 7) and the climatic factors that previously provided a good correlation with its distribution needed to be modified to help explain its expansion northwards in France (Robinet et al., 2007).
Robinet et al. (2007) showed that overwintering survival is related to the maximum daily temperature in the larval nest recorded in a "hypothetical" nest ($T_{nest}$) and that an estimate of this temperature can be obtained by calculating the maximum air temperature and the solar radiation. Since daily solar radiation data are only recorded at a few weather stations they explored other parameters in the search for correlations. They found that in the range expansion area near Paris there was a good correlation between the mean daily minimum winter (October to March) temperature and $T_{nest}$ and that therefore this parameter can be used when solar radiation data are unavailable.
2D The areas of the UK with the warmest and sunniest winters and high densities of PPM hosts (the areas with the highest risk of establishment)

The following maps of winter minimum and maximum temperatures and sunshine duration taken from the UK Met. Office website show that the southern coastal areas have the warmest sunniest winters. For each parameter, a separate map for south-east England is included. This shows that the coastal area between Bournemouth and Southampton is one of the warmest and sunniest in England.

![Mean Minimum Temperature Winter Average 1971-2000](http://www.metoffice.gov.uk/climate/uk/averages/ukmapavge.html)

Fig. 8 UK mean minimum winter temperature 1971-2000
(http://www.metoffice.gov.uk/climate/uk/averages/ukmapavge.html)
Fig. 9 SE England mean minimum winter temperature 1971-2000
(http://www.metoffice.gov.uk/climate/uk/averages/ukmapavge.html)

Fig. 10 UK mean maximum winter temperature 1971-2000
(http://www.metoffice.gov.uk/climate/uk/averages/ukmapavge.html)
Fig.11 SE England mean maximum winter temperature 1971-2000
(http://www.metoffice.gov.uk/climate/uk/averages/ukmapavge.html)
Fig. 12 UK mean winter sunshine duration 1971-2000
(http://www.metoffice.gov.uk/climate/uk/averages/ukmapavge.html)
Fig. 13 SE England mean winter sunshine duration 1971-2000
(http://www.metoffice.gov.uk/climate/uk/averages/ukmapavge.html)

2E Comparison of mean minimum winter temperatures for one location in the UK area of the highest risk of establishment with Orleans, France

Daily minimum winter (October 1st - March 31st) temperatures were obtained for Hurn (Bournemouth) Airport\(^5\) and compared with data\(^6\) from weather stations in Paris and Orleans in France (in the area where the pest is expanding northwards). Fig. 14 shows that the winter temperatures for Hurn Airport and Orleans are very similar (in 2006-9 they are almost identical). Paris is much warmer because it is affected by the urban heat island.

\(^5\) http://badc.nerc.ac.uk/view/badc.nerc.ac.uk__ATOM__dataent_ukmo-midas
\(^6\) http://eca.knmi.nl/dailydata/index.php
2F Preliminary conclusions and the need for a detailed analysis

Coastal central southern England has the highest diversity of PPM host *Pinus* species in the UK and some of the warmest, sunniest winters. The mean minimum winter temperatures in the area represented by Hurn (Bournemouth) Airport are very similar to those in Orleans where the pest has damaging pest populations. This suggests that parts of southern coastal England have sufficient warmth to sustain populations of PPM. Nearer the coast and in towns, minimum winter temperatures are likely to be even higher. However, solar radiation is also key to the overwintering survival of PPM and southern England may well be cloudier than the northern limits of PPM's range in northern France.

It is clear that a detailed analysis to evaluate the climatic suitability of the UK for PPM is required. The work undertaken by the following teams needs to be followed up and extrapolated to the UK:

- INRA, Orleans, France (Christelle Robinet *et al.*).
- University of Natural Resources and Life Sciences, Vienna, Austria (Peter Baier *et al.*).
- University of Padua, Italy (Andrea Battisti *et al.*).

This will focus on:

- obtaining, calculating and interpolating winter solar radiation at weather stations in southern UK and combining this with maximum temperatures to obtain and map $T_{\text{nest}}$ from which the likelihood of larval starvation can be estimated.
- calculating the inter-annual variation in winter temperatures and solar radiation to explore the possibility that winters with long cold cloudy periods could destroy colonies.
- expanding the calculation of minimum winter temperatures and solar radiation to determine the limits to the area suitable for establishment.

The decision support scheme for assessing climatic suitability (Eyre *et al.*, 2012) and the areas at highest risk (Baker *et al.*, 2012) should be used to structure this work and ensure that all the information available on PPM's climatic responses and distribution is captured. A CLIMEX model constructed by Kriticos *et al* (submitted) also needs to be studied.
## Appendix 3 Extract from the Forest Reproductive Material Database (2003-2012): Exports to the UK for *Pinus*, *Cedrus*, and *Larix* in containers

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