



Public Health
England

Protecting and improving the nation's health

Health effects of exposure to setae of oak processionary moth larvae

Systematic review

About Public Health England

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Abbreviations

CON	Chronic ophthalmia nodosa
COPD	Chronic obstructive pulmonary disease
HSE	Health and Safety Executive
IgE	Immunoglobulin E
kDa	Kilodalton
L1-6	Larval stages 1 to 6
MeSH	Medical subject headings
OPM	Oak processionary moth
PHE	Public Health England
PPE	Personal protective equipment
PPM	Pine processionary moth
SOB	Shortness of breath
SPT	Skin prick test

Executive summary

Human contact with the hairs (setae) of some caterpillar species has been associated with a range of symptoms of varying severity, from urticarial rash¹ and dermatitis to anaphylaxis (1). The accidental introduction of Oak Processionary Moth (OPM) to England was discovered in 2006, following the investigation of an outbreak of dermatitis in a group of residents living in South West London (2). Subsequently, concerns were raised about the potential health risks to the population, with particular anxiety about the potential of the caterpillar setae to trigger anaphylaxis-like reactions.

This systematic review was conducted to assess the evidence around the potential health effects associated with exposure to OPM, with a particular focus on anaphylaxis. The objectives of the review were to identify and critique all relevant peer-reviewed papers on this topic, to identify gaps in the existing knowledge and to use this information to inform the health risk assessment of exposure to OPM. This, in turn, aids the development of guidance for the public health management of OPM exposure. A total of 258 papers were identified, of which 45 underwent full review. Only 13 papers were found to refer to health effects specifically related to OPM.

Due to the limited evidence available, it was not possible to reliably deduce a generalizable value for the prevalence of health effects associated with outbreaks of OPM. Despite this evidence gap, there is some consistency between the findings of the two largest epidemiological studies (3, 4). These studies found that in areas where OPM was present, approximately 5-7% of the 'exposed' population reported experiencing health complaints that they attributed to OPM. Across other studies there was reasonable consistency in the types of symptoms reported and the proportion of individuals affected by each symptom; the majority of individuals exposed experienced no symptoms at all, and of those who reported experiencing symptoms that they attributed to OPM the majority reported experiencing dermal symptoms only. A much smaller proportion experienced other symptoms, such as breathing difficulties and malaise.

Broadly, the number of people affected will depend on the population density of OPM in a particular area and the density of the human population in that area. The types of interaction between OPM and the human population are also relevant. In circumstances where human activities result in direct contact with the insects - for example, where children are playing with the caterpillars – the release of large numbers of setae has been associated with a number of outbreaks. However, direct contact is not necessary

¹ Urticaria is defined as itchy skin eruption with wheal-like swelling and erythema in the skin; dermatitis is defined as skin inflammation due to direct contact with an irritating substance or allergic reaction.

for human health effects to occur and outbreaks of dermatitis have also been reported in the absence of direct contact with OPM caterpillars and their nests (2).

Where OPM larvae are present, children are at higher risk of exposure due to their proximity to the ground and their tendency to disturb or play with the caterpillars if they come into contact with them, thus releasing high numbers of setae. Arboculturalists and other individuals who work in and amongst oak trees are more at risk of exposure due to their close contact with the larvae. These individuals also have a greater risk of becoming sensitised due to their repeated exposure to OPM setae. Pre-existing atopy does not appear to be predictive of an allergic response or a more severe response following exposure to OPM larvae.

Recent Forestry Commission surveys indicate that OPM is restricted to the Greater London area and a couple of small pockets in the south east of England, where the availability of their preferred food resource is relatively limited. However, evidence from the literature indicates that it is possible for a small number of trees to host sufficient numbers of the caterpillar to cause human health effects. Therefore, further outbreaks of human health effects associated with exposure to OPM are possible in those areas where the insect has colonised, although such outbreaks are likely to be localised.

As the majority of affected individuals are likely to experience self-limiting dermal symptoms only, they may be directed to their local pharmacy for over-the-counter treatments. As such, it is recommended that off-the-shelf treatment advice for professionals and the public is developed in anticipation of further outbreaks. It is also recommended that PHE continue to work with their partners to develop communication material aimed at groups at higher risk of exposure (namely occupationally exposed individuals and children).

Background

Human contact with the hairs (setae) of some caterpillar species has been associated with a range of symptoms of varying severity, from urticarial rash and dermatitis to anaphylaxis² (1, 5-8). Outbreaks of dermatitis associated with different species of processionary caterpillars have been reported from a range of countries including Austria (3), Germany (9, 10), the Netherlands (11, 12), Sweden (13), Spain (14), England (2), and Israel (15, 16).

The accidental introduction of Oak Processionary Moth (OPM) to England was discovered in 2006 following the investigation of an outbreak of dermatitis in a group of residents living in South West London (2). Subsequently, concerns were raised about the potential health risks to the population, with particular anxiety about the potential of the caterpillar setae to trigger anaphylaxis-like reactions. This systematic review was conducted to assess the evidence around the health effects associated with exposure to OPM, with a particular focus on anaphylaxis.

Aims and objectives

The aim of the review is to establish the health effects associated with exposure to OPM, with particular reference to anaphylaxis. The objectives of the review were to identify and critique all relevant peer-reviewed papers on this topic, to identify gaps in the existing knowledge and to use this information to inform the health risk assessment of exposure to OPM and thus, to support the development of guidance for the public health management of the issue.

² Urticaria is defined as itchy skin eruption with wheal-like swelling and erythema in the skin; dermatitis is defined as skin inflammation due to direct contact with an irritating substance or allergic reaction.

Methods

Search strategy

Studies were identified via an electronic search of Medline, Embase and Scopus using the following algorithms, with no limits on the year of publication or the language of the publication. The search was conducted in January, 2013 using the following search criteria:

Medline:

Key text word “Caterpillar*” OR MeSH³ term “Lepidoptera” (exploded) AND key text word “dermatitis” OR MeSH terms “Dermatitis” OR “Allergic contact”.

Embase

Key text word “Caterpillar*” OR MeSH term “Lepidoptera” (exploded) AND key text word “dermatitis” OR MeSH term “Contact dermatitis” exploded. Caterpillar* OR MeSH terms (‘Caterpillar’ exploded OR ‘Poisonous caterpillar’ exploded) AND ‘Anaphyl*’ OR MeSH terms (‘Anaphylaxis’ exploded OR ‘Allergy’ exploded).

Results from the two databases were then filtered for duplicate citations. The reference lists of the reviewed papers were also manually searched to retrieve additional studies.

Grey literature

A formal search of the grey literature was not conducted: a Scopus literature search and several internet searches⁴ indicated that the majority of the English language grey literature was published by the Health Protection Agency (now PHE) and added little to the current research question, which focused specifically on the potential for health effects at the more severe end of the spectrum. Several policy documents from other European countries (eg, the Netherlands) were identified through these *ad hoc* searches; however, given the cost involved in translating these, a formal review of these was not included in the scope of the study.

Review

The titles and abstracts of all studies were extracted and assessed by two researchers (EOC and TI). A subset of these papers were selected for full review using the exclusion criteria (see Figure 1). Where there was disagreement between the researchers about

³ Medical Subject Headings – National Library of Medicine controlled vocabulary thesaurus used for indexing articles.

⁴ www.google.co.uk was used to search for the terms ‘Oak Processionary Moth’ AND health / ‘Oak Processionary Moth’ AND anaphyl* ; www.google.co.uk Scholar was used to search for the terms ‘Oak Processionary Moth’ AND health / ‘Oak Processionary Moth’ AND anaphyl*)

whether to include a paper for full review, these papers were discussed further until agreement was reached on inclusion\exclusion.

Exclusion criteria

Papers were not included for full review and critical appraisal if they related to the following:

- health effects in animals only
- other species of caterpillar, although papers detailing health effects related to exposure to other processionary species were included
- case reports of dermatitis involving one or two cases
- the same information published in another journal under a different title (ie effectively duplicate information)

Data extraction and analysis

Studies in languages other than English were professionally translated. The following information was extracted from each included study, if available: author's names, publication date, study location, species described, and type of study design. Reviewers were not blinded to the names of authors, study institutions or journals. Each study was critically appraised and assessed for bias at the study level. Due to the nature of the studies identified (eg, case reports, outbreak reports), it was not possible to extract data items to create summary measures.

Results

The formal literature review identified a total of 258 papers, two of these were duplicate citations, leaving 256 papers for screening. Of these, a total of 45 papers were selected for full appraisal. Only two papers were not identified for inclusion by both researchers in the initial screen; following discussion, both were included in the final review.

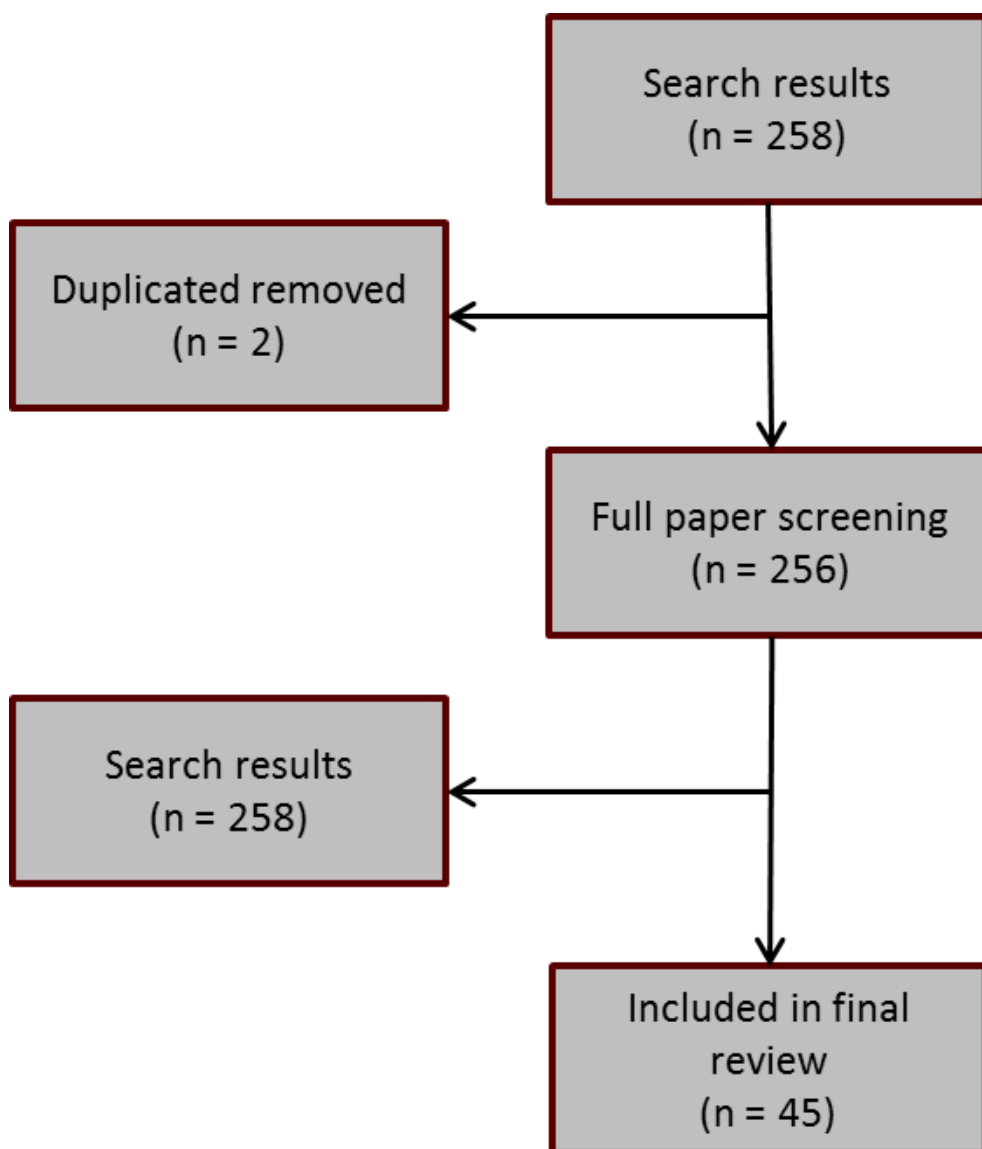


Figure 1. Flow chart of papers selected for full appraisal.

The search results indicated that the terms ‘erucism’ and ‘lepidopterism’ are used interchangeably in the literature with different interpretations of each term. Strictly, erucism is the localised skin reaction (dermatitis and urticarial) associated with exposure to urticating caterpillar or butterfly/moth hairs, spines or toxic haemolymph. Lepidopterism is the systemic response characterised by generalised urticaria, headache, conjunctivitis, nausea, vomiting and respiratory effects associated with

exposure to caterpillar or butterfly/moth hairs, spines or toxic haemolymph (1, 6). Therefore, any future literature search investigating health effects associated with exposure to caterpillars and butterflies/moths should avoid using these terms exclusively to define their search strategy.

Of the 45 papers identified for a full review, only 13 referred specifically to OPM (see Table 1) and of these, only five papers included new information, illustrating the limited published evidence on this topic. A summary of each of the reviewed papers is available on the PHE website in the document, 'Health effects associated with Oak Processionary Moth: a systematic review. Summary of findings'.

Species considered	Number of papers in review
Miscellaneous spp.	9
Miscellaneous processionary spp.	2
<i>T. pityocampa</i> (PPM)	17
<i>T. wilkinsonii</i>	1
<i>T. pinovora</i>	3
<i>T. processionea</i> (OPM)	13
Total	45

Table 1. Species of processionary moth considered in the papers extracted for full review

Evidence from the literature: background

Characteristics of the species

Hairy caterpillars are not new to England; a report from 1930 describes the urticaria and conjunctivitis of 'nursemaid's disease' associated with sitting under trees in Hyde Park in which the larvae from the vapourer moth were found (17). Among hairy caterpillars, there are three 'processionary' species common to Europe (so called due to their habit of processing in line formation from their nest to feed station); *Thaumetopoea pinivora* (Northern Pine Processionary Moth, NPM) eats pine leaves and is found in South East and Central Europe; *Thaumetopoea pityocampa* (Pine Processionary Moth, PPM) also eats pine leaves but is commonly found in the Mediterranean region; and *Thaumetopoea processionea* (Oak Processionary Moth, OPM), primarily eats oak leaves and is found in central and southern Europe (18). The larvae from all three species have similar morphology, and a similar mechanism(s) of human exposure and toxicity is suspected (19).

Life cycle

OPM tend to infest trees on the edges of woodland or those that are standing alone (10). OPM eggs are laid in plaques on branches at the end of the summer (August/September) and hatch the following spring. The timing of the eggs hatching is coordinated with the budding of the oak trees; emergence can be delayed (embryonic diapause) if the budding of the oak tree is delayed.

The caterpillar form passes through six larval stages (L1–L6) over the course of about three months (9, 20). During L3, which usually occurs in April–June, urticating hairs start to grow on the dorsal surface of two body segments and by L6 all body segments have setae. Setae density increases through the instar stages, with a significant increase in setae density from L5–L6.

At L4, the larvae establish a silk nest to which they return after feeding. These nests are usually built at the intersection of branches, on the protected side, and can reach up to 1m in size (20). The caterpillars are nocturnal, feeding on the leaves at the edges of the canopy at night and processioning back to their nest during the day. It has been suggested that this nocturnal behaviour means that most human exposures are indirect, through skin contact or inhalation (21). Larval development is usually finished by July/August, at which point each individual caterpillar spins a cocoon within the nest from which it emerges about 20 days later to reproduce (20).

Evidence from the literature indicates that the species has mass gradations (ie seasons when the population increases dramatically)(18). Warm and dry weather in previous years and increased availability of food resource have been suggested as triggers for this (10). In mainland Europe, parasitic wasps are a natural predator; it is believed that the higher prevalence of OPM nests along roadways and railways in the region is due to the cutting of the grass verges, which removes the natural habitat of these wasp species (22).

Routes of human exposure to setae

OPM caterpillars have two types of hair; the easily visible longer hairs on the body are not associated with any health effects, it is the smaller hairs not immediately visible to

the naked eye that are responsible for the associated health effects (23). These hairs are known as 'true' setae and are detachable urticating hairs found in Lepidoptera species and New World tarantula (23). The hairs are small (100 - 250µm long) and ampoule-shaped, with a core containing a protein (20). The shape of the hairs makes it easy to penetrate the skin, resulting in mechanical irritation. When the fine setae embedded in the skin break, it is postulated that they release the protein into the skin triggering the release of a number of enzymes, including phospholipase A, resulting in the release of histamine and other vasodilators which can cause both local and generalised effects (20, 21, 24).

There are numerous possible sources of exposure to setae; direct contact may occur through handling of a caterpillar or nest, indirect contact may occur through contaminated fomites (5, 8) or airborne setae (6, 10, 19, 25, 26). Direct contact with the caterpillars themselves may result in exposure to a relatively high number of setae; the caterpillars can actively shoot off setae if disturbed (11, 27). Once the insects have been disturbed, other individuals without direct contact may also be affected, probably due to airborne setae and contact with contaminated fomites (9). Nests themselves contain many shed setae and old nests can continue to be an environmental source of setae after emergence of the moth, with a high concentration of hairs from shed skin and cocoons associated with processionary species (11, 23, 28, 29). Setae of OPM are known to exist in the environment for at least a year (3). Therefore, exposure to setae may continue throughout the year and may not be confined to the period associated with L3–L6.

Dispersion modelling suggests that setae may be able to travel long distances from the source colony, eg 2km (18); however, this model was not validated and assumed that OPM nests are situated at the top of the oak tree. OPM tend to build their nests on the underside of branching points along the tree, presumably to protect the nest and insects from the elements – therefore, the true dispersion is likely to be significantly less than the distance predicted using this model. Werno and Lamy (30) found that airborne concentration of setae in areas infested with PPM were lowest when the caterpillars were in their intact nests; therefore, airborne concentrations of OPM setae may also be lowest during the day, when the caterpillars tend to be inside their nests, thus minimising human exposures.

Exposure can be direct or indirect and can occur via several routes (11); dermal, ocular, inhalation and (less commonly) ingestion (29). Exposed areas of the body are more likely to be affected (31) but multiple areas may be affected simultaneously (23).

Mechanisms of action

Generally, reactions following contact with insects, including bites or stings, are localised and limited to papular urticaria, recurrent pruritic papules and varying degrees

of local oedema (32). Immediate allergen-mediated responses, apart from those associated with wasp and bee stings, are rare (33).

Several mechanisms have been suggested for the health effects associated with exposure to OPM: mechanical, toxic-irritative and allergen-mediated. The evidence from clinical and epidemiological studies of allergen-mediated reactions associated with exposures to setae from all species with urticating hairs is ambiguous (23, 27), however, and some researchers have referred to these reactions as 'pseudo-allergic' (21, 27). An immediate hypersensitivity response to PPM and other species of hairy caterpillars has been described in the literature for a sub-group of people (8, 19, 34) and has also been reported anecdotally among individuals working on OPM nest removals in London.

Mechanical / toxic-irritative

Mechanical penetration of setae of the mucosa has been observed to induce inflammation. Fagrell et al. (19) observed that the early phase of the reaction to individuals exposed to whole setae of the Northern PPM (*T. pinovora*) mimics a foreign body reaction with increased blood perfusion and the release of effector substances, such as histamine.

The toxic-irritative mechanism is postulated to occur when setae penetrate the skin and break, releasing the protein with a direct effect on mast cells, subsequent basophil degranulation and histamine release (8, 35). Other studies have observed that setae treated with alcohol and heat maintain their ability to cause dermal effects, suggesting that the mechanism is not related to a protein (19).

IgE-mediated / IgE-independent allergic reaction

Typically, IgE-mediated allergic reactions are immediate, occurring within seconds or minutes of the exposure. However, many of the documented reactions to exposure to setae, even those at the more severe end of the spectrum, have developed more slowly than that (eg the case report by Bosma and Jans (11)). Therefore, it has been suggested that other mechanisms may be involved (19, 23). For example, chitin and chitin-metabolites associated with the setae could also cause the inflammatory and immune response observed in some of the more severe and hypersensitised reactions. Variation in genetically determined chitinase response may explain the variation in sensitivity to setae exposure (23).

Although there is uncertainty as to whether an IgE or IgE-independent mediated response is involved, two IgE-associated antigens have been described for PPM; thaumetopoein, the protein described by Lamy et al. (24) is a soluble 28-kDa dimeric protein found in extracts of PPM setae which caused skin reactions in humans and

guinea pigs, the authors also noted degranulation of mast cells (IgE-independent reaction). Moneo et al. (36) isolated a second protein (15-kDa) from whole PPM larvae which they refer to as Tha p1.

While some studies have reported that these proteins were recognised by IgE antibodies from patients with a previous history of severe reaction (20, 24, 36), other studies have failed to identify IgE antibodies to larval antigens (19). PPM-derived antibodies to thaumetopoein recognise an antigen to OPM, suggesting that the protein in OPM setae is very similar, if not identical, to that found in PPM setae (20). Therefore, an IgE-mediated reaction to OPM setae is deemed to be possible, particularly in sensitised individuals (23).

Several studies report positive skin prick tests (SPTs) using extract from whole larvae on individuals with a history of reacting to exposure to PPM, however, not all of those who report experiencing symptoms previously developed a positive SPT (7, 8, 37, 38) - the relationship between previous exposure and risk for sensitisation is not clear.

In summary, most reactions are likely to be due to combination of mechanical irritation from the setae penetrating the skin and/or mucous membranes and direct non-IgE mediated release of mediator proteins. While Type 1 IgE-mediated reactions may be possible, these are likely to be rare (10).

Evidence from the literature: human health

Evidence from case reports

In general, the presentation of symptoms depends on previous exposure and the degree of exposure (39). Reactions can be either generalised or localised (27).

Dermal effects

Several types of cutaneous reactions to processionary caterpillars have been described including urticaria, persistent itchy papules (10), localised pain, erythema, oedema (7, 19), angioedema (40), cutaneous lesions (38), and bullous (blistering) dermatitis (19, 27, 39). Papular urticaria and dermatitis are the most common manifestation of dermal symptoms. Maculopapular dermatitis is the typical delayed cutaneous reaction (39) and occurs within about eight hours of exposure (27). Dermal symptoms generally resolve within three weeks (19).

It has been suggested that diffuse rash is associated with the toxic-irritative reaction while rashes that appear over a shorter period of time and persist for longer are caused by an IgE mediated mechanism (39, 41).

Ocular effects

Ocular effects following exposure to caterpillar setae are rare (42). Ocular irritation (7), conjunctivitis (27), keratitis (42), chorioretinitis, papillitis (42) and ocular lesions (35, 42) have been reported.

Chronic ophthalmia nodosa (CON) has also been described and may occur months after exposure (21, 42). It is characterised initially by conjunctivitis followed by pan-uveitis, with subsequent intraocular migration of the seta(e) (43). CON may be difficult to diagnose as it may be due to a single seta in the eye, which may not easily be seen. CON may require surgical intervention to remove the seta(e) (27); treatment should be overseen by an ophthalmologist (43).

Respiratory effects

Setae can become airborne and are small enough to penetrate the human respiratory system as far as the trachea and zones of the primary bronchi (35). Cough, shortness of breath (SOB) and asthma-like symptoms (wheeze) have all been described following exposure to OPM (10, 44).

Ingestion

Health effects associated with ingestion of caterpillar setae or items contaminated with setae from processionary species have occasionally been reported in the literature (6, 29, 45) but none of the papers identified in this review related to OPM exposure specifically. Setae may become embedded in the lips, tongue and oesophagus and mimic an allergic reaction (45). Symptoms reported following oral contact with other caterpillar species include dysphagia, erythema at the site of contact, pain, drooling, pruritus and shortness of breath (29).

General symptoms

General symptoms, such as malaise, fever, dizziness and vomiting, have also been reported in both adults and children following exposure to OPM (4, 10, 44).

Anaphylaxis

There is a single case report in the literature of an anaphylaxis-type response following exposure to OPM setae (11). However, there is some uncertainty around the attribution of this response as the case was concurrently exposed to the pesticide Dimilin, and it is debatable whether it can be characterised as a 'true' anaphylaxis response as the full reaction occurred about three hours after the initial exposure (46). It has not yet been fully demonstrated that a specific IgE is formed following exposure to OPM setae or the proteins within the setae. Due to the lack of certainty around the mechanism involved and the delay in onset of symptoms, several authors have described the clinical symptoms at the more severe end of the spectrum as 'pseudo-allergic' reactions (4).

There are a small number of case reports in the literature of anaphylaxis-type reactions following exposure to other processionary species of caterpillar (7, 37, 47). Most of these are associated with PPM exposure and none describe the exposure and / or subsequent reaction in sufficient detail to conclude with certainty that these were true anaphylaxes. These severe reactions generally followed a previous exposure ie sensitisation (7, 47). Given the ubiquitous nature of processionary caterpillars in some areas (eg Valladolid in Spain, Vienna in Austria) and the rarity of case reports detailing reactions of this level of severity, it would appear that these are the exception (10).

Evidence from outbreak reports.

The evidence from outbreak reports related to processionary caterpillars indicates that many of the individuals exposed to setae do not experience any reaction (13, 23). Of those who did experience health effects, the majority reported dermatitis and/or pruritus, with a much smaller proportion reporting respiratory distress, general malaise/fever, and ocular symptoms (10, 11, 13, 38).

None of the outbreaks reports associated with exposure to OPM indicated that hospital admission was necessary, although there were reports of individuals attending hospital; therefore, it is assumed that the symptoms experienced were on the less severe end of the spectrum.

Outbreak associated with three OPM-infested trees beside a kindergarten in Germany

Gottschling et al. (10) conducted a survey of parents of children attending a kindergarten where OPM had infested three nearby trees. The survey had a 51% (24/47) response rate with 42% (10/24) reporting having experienced symptoms. Of those who reported experiencing symptoms, dermatitis was the predominant complaint (80%, 8/10), followed by rash (50%, 5/10), respiratory distress (50%, 5/10), malaise/fever (40%, 4/10) and conjunctivitis (10%, 1/10). The low response rate and retrospective nature of the survey had the potential to introduce bias and inflate the estimated incidence rates. Additionally, the number of overall respondents was low.

Outbreak associated with exposure to OPM at a rest area in Germany

An outbreak associated with OPM exposure occurred when a group of about 90 people attended a rest site in Germany where OPM were present nearby (~20m) (9). Children were observed playing with the caterpillars. Later that day, a number of individuals reported itching, visible weal and flare lesions, and pin-sized papules. Five members of the group reported respiratory distress (bronchoconstriction, cough and wheeze). A total of 42 individuals saw a doctor; all were treated as out-patients with a combination of anti-histamines and/or topical or systemic steroids. Six individuals were treated with systemic steroids; two of them were children had been in direct contact with the caterpillars and had presented with dyspnoea and bronchoconstriction. The other four individuals were adults with no direct contact; one had Quincke's oedema and the other three presented with respiratory distress. Of those who received systemic steroids, their symptoms resolved within an hour.

While this report illustrates the importance of public education and, in particular, ensuring that children are advised not to play with the pests, it provides little insight in terms of estimating incidence rates associated with direct and/or indirect contact with OPM; the authors do not provide a denominator or a clear indication of the total number of people affected.

Outbreak of dermatitis associated with first identification of OPM in London

An outbreak of dermatitis in London in 2006 was the sentinel event leading to the discovery of OPM in England (2). In 2006, residents of an apartment complex reported itchy rash. Upon investigation, the source of the exposure was identified as OPM infestation of oak trees planted 30m away from the residential block. The authors delivered a questionnaire to all households in the buildings near the affected trees and also conducted active case finding via GP alert, dermatologists and hospital emergency departments. The response rate for the questionnaire was 63% (20/32) of all households (the authors have not indicated a person denominator), corresponding to responses for 69 individuals. The attack rate for individual respondents was 68% (47/69): all cases reported rash (47/47), 20% reported itchy eyes, and 3% reported breathing problems. Few reported symptoms having occurred in previous years although the oak trees upon which the OPM was identified had been imported and planted there two years previously.

Residents from 10 households sought medical care and five different diagnoses were received, none of which were caterpillar dermatitis. None of the individuals who sought medical care was referred to secondary care or required hospital treatment. Two of the workers removing the caterpillars developed symptoms as inadequate protective equipment had been used.

Evidence from epidemiological studies

Survey of households within 500m of OPM infested trees in Vienna

The authors identified three isolated trees, 100m apart, near Vienna that were infested with OPM at instar L3-L6 (3). They conducted a telephone survey of all households and institutions within 500m of an infested tree and collected information on demographics, symptoms experienced and the treatment received. Individuals that reported cutaneous symptoms during the initial phone survey received a second postal questionnaire requesting more detailed information on possible exposure(s), onset, clinical appearance, frequency and duration of rash, atopy, and treatment. 67% (230/342) of households/institutions responded, corresponding to 1,025 people (the authors don't include an estimate for the denominator or the number of responses which were by proxy).

Of the 5.6% (57/1,025) of respondents/proxy responses who reported having experienced one or more symptom, approximately 95% experienced pruritus and/or dermatitis. Two individuals reported having severe symptoms; both were exacerbations of respiratory conditions (asthmatic/chronic obstructive pulmonary disease (COPD), and both cases reported direct contact with OPM.

The postal survey also asked individuals to report their route of exposure to OPM (with multiple possible exposure routes listed): 97% (36/37) reported having passed infested trees on foot; 97% (36/37) passed an infested tree on a main road; 57% (21/37) reported an infested tree in neighbouring garden; 32% (12/37) reported an infested tree in their own garden; only 38% (14/37) reported having had direct contact with larvae or exuviae. Symptoms were reportedly worse on windy days.

Evaluation of response to OPM epidemic in Holland and Belgium

In 1996 in part of southern Netherlands and Belgium, a large number of health complaints relating to OPM were reported, with GPs reporting having to deal with dozens of patients each day. Subsequently, a public information campaign took place in the part of the southern Netherlands and Belgium where OPM was present (4).

A survey was conducted in 1997 and then again in 1998 to evaluate the effectiveness of the public information campaigns that took place in 1997 and 1998, following the 'plague' year in 1996. Doctors, schools, camping sites and tourism offices were targeted for the information campaign. The authors attempted to survey GPs but achieved very poor response rates. They conducted a population-based random survey of 5,000 households selected from the national postcode registries in both regions. In 1997, 2,500 households in Netherlands and 2,500 in Belgium were selected. In 1998, 3,650 (73%) households in the Netherlands and 1,350 (27%) in Belgium were selected as OPM had spread so the distribution of sampling was altered to be more representative.

The surveys in both years collated information on a large number of people (1997 n=3,185 and 1998 n=3,090). However, as the household was the unit for the survey and no associated person denominator was estimated, it is not possible to deduce a response rate for the surveys. The proportion of respondents reporting complaints that they attributed to OPM was 6% (191/3,185) in 1997 and 7.5% (232/3,090) in 1998. The survey in 1998 found that 89% (206/232) of respondents who had experienced symptoms reported skin complaints, 39% (90/232) reported eye complaints and 21% (49/232) reported respiratory complaints. This survey included a 'red herring' question about muscle pain and the authors report that 7% (17/232) also reported experiencing muscle pain, a symptom not documented as being associated with OPM. Of those who reported experiencing symptoms, 30% (70/232) sought medical care. The number of people who did nothing despite having complaints attributable to OPM rose from 13% in 1997 to 27% in 1998, and purchasing of over-the-counter treatments fell from 23% to 10%. The authors concluded that the problem was primarily a recreational one as most complaints were associated with exposures that occurred in woodland/wilderness during recreational activities.

In the survey conducted in 1997, the proportion of respondents who reported having experienced health complaints during the 1996 season was approximately doubled; the authors state that this suggests significant recall bias in reporting symptoms retrospectively.

Health problems associated with Northern PPM in Gotland, Sweden

This study aimed to estimate the number of individuals affected by exposure to Northern PPM across seven regions in Gotland, Sweden, where this pest is present (13). A survey was conducted in 2007 asking about the type and severity of symptoms experienced the previous summer (2006) that the individual attributed to the Northern PPM.

A postal questionnaire was sent to the owners of all properties identified through the land registry for the seven parishes in Gotland (1,373 properties were included); one person in the household completed the questionnaire on behalf of all of those present the previous summer (2006). The authors achieved a good response rate with 70% (963/1,373) of all individual properties responding, equating to 4,277 individuals who were resident during the study period.

Tree surveys were conducted to measure moth density in the study areas; a study area was selected (it is not clear how this was identified) and three pine stands were each searched for 10mins to count colonies. Areas were classified as low, medium, high density for PPM.

Of the 18% (766/4,277) of individuals who reported having experienced symptoms that they attributed to exposure to the caterpillar, 35% (271/766) rated their symptoms as severe (this equates to 6% (271/4,277) of all respondents). The majority of those who experienced symptoms reported experiencing skin complaints – redness, itching, blistering were reported by 95% (731/766) with 1-2% of all respondents reporting having experienced other symptoms such as eye inflammation and respiratory irritation. 2% (103/4,277) of all respondents visited a doctor and 6% (276/4,277) reported taking medication for their symptoms. Despite the large number of respondents, no cases of anaphylaxis or keratitis were reported. Asthmatic bronchitis was reported but could not be distinguished from asthma from other causes.

The reported prevalence of symptoms ranged from 4-41% in the seven parishes surveyed: the authors suggest that the range in prevalence of reported symptoms may be associated with local density of larvae as the proportion of residents with symptoms was highest in the areas with highest density of caterpillars but they acknowledge that other factors were also likely. 75% of those living in low density PPM areas who reported symptoms indicated that they developed their symptoms after visiting the heavily infested areas.

The authors concluded that a considerable proportion of the population do not experience symptoms in spite of exposure to setae, whilst others can have a severe reaction to their first exposure. They postulate that the parts of the body exposed as well as genetic or other factors, such as sweating, may be important in determining severity.

Health-seeking behaviour

In the outbreaks reported in the literature, a significant number of individuals sought medical help (eg an estimated 13% of residents in Gotland (13)). There was an even greater tendency to use medication, whether this was available in the home already or purchased as a result of the symptoms; 36% of respondents with symptoms reported using medication to manage their symptoms (13). During a 'plague' OPM year in North Brabant and Limberg (Netherlands), 20,000 residents consulted their GP. The majority of these consultations related to dermal symptoms (89% complained of rash and itchiness).

Risk characterisation

Estimating the prevalence of health complaints associated with exposure to OPM

Due to the small number of studies on OPM that have been published - and their documented limitations - it is not possible to deduce a generalizable value for the prevalence of health effects associated with outbreaks of OPM. Broadly, the number of people affected will depend on the density of OPM present, the human population density of the area in which they are present, and the type of interaction between the OPM habitat and the resident human population. Nonetheless, there is consistency between the two largest epidemiological studies that have been conducted on OPM – Maier et al. (3) and Rots de-Vries and Jans (4). Both report the proportion of individuals who reported having experienced health complaints as being between 5 and 7.5%.

In the outbreak reports and epidemiological studies on OPM, of those individuals who reported experiencing health complaints that they attributed to OPM, the majority experienced dermal symptoms with a much smaller proportion experiencing other symptoms such as breathing difficulties and malaise.

Given the complexities of the different mechanisms associated with health effects following exposure and issues with attribution, it is unlikely that it will be possible to describe a clear dose-response relationship for this environmental hazard. Similarly, it is unclear whether a threshold dose exists for the health effects associated with exposure to OPM larvae ie it is unclear the extent of exposure required to trigger a reaction – the evidence from the literature suggests that this may vary from individual to individual, depending on previous exposures and sensitisation (23).

Risk factors

Age and gender do not appear to be associated with symptoms or symptom severity following exposure (13), although children may be more likely to come into contact and/or ingest the caterpillars due to their natural curiosity and close contact with the ground (3, 6, 10). Processionary caterpillar-related health complaints have been reported for children who have been playing, or had direct contact, with the insects (9, 16, 48); direct contact and disturbance of the insect is likely to result in the release of a high density of setae and highlights the need for education aimed at parents and children who frequent recreational areas where the pests are present. It is possible that children are more likely to experience systemic and respiratory effects; in an outbreak beside a kindergarten, the authors observed that the proportion of children reporting fever/malaise and airway involvement was higher than that observed in studied of adults exposed to OPM.

However, it is important to note that this study involved a small number of children, with only 10 individuals in total reporting symptoms of any kind (10). Vega et al. (38) report that children may be less likely to be hypersensitive than adults, although the evidence to support this assertion is limited.

Pre-existing atopy does not appear to be associated with an increased risk of an IgE-mediated allergic response to OPM ie atopy is not predictive of allergic response or a more severe response (8, 37). Positive SPTs have been reported for both atopic and non-atopic individuals with a previous history of exposure (31, 35, 49).

Occupational exposure

Repeated exposure has been identified a risk factor for sensitisation to other processionary species, with those who are sensitised experiencing an increasingly severe response (48). While a previous history of exposure does not appear to be necessary for a reaction to occur (19), other authors have observed that individuals with no previous exposure who spend only a brief period in infested areas, do not experience symptoms (50). Occupational exposure has been documented as a risk factor for sensitisation to PPM (8, 49, 51) and it is reasonable to assume that individuals who are occupationally exposed to OPM may become similarly sensitised and should therefore take appropriate measures to minimise their risk, such as wearing Personal Protective Equipment (PPE).

Is evidence from studies on other processionary species applicable to OPM?

Much of the evidence base for health effects associated with processionary moth larvae is derived from studies on individuals exposed to PPM, rather than OPM; while the species share many characteristics, in terms of assessing human exposures and potential health risk(s), there are some important differences.

OPM progresses through L3-L6 larval stages in a matter of a few weeks (3, 20) whereas in areas with endemic PPM, there are approximately seven months of the year when L3-L6 larvae are present (8). The longer period during which PPM caterpillars are present is likely to result in a higher density of setae in the environment. Additionally, PPM larvae have a higher density of setae than OPM (1,000,000 v's ~630,000 per larva) (23).

If the conditions for emergence are not optimal, PPM can stay in chrysalis for years, hatching out in a mass-gradation with an explosion in the population density (8). There is no indication in the literature identified in this review that OPM chrysalis can delay their emergence in this way, although there is evidence in the literature that there are years where population density is relatively high with an accompanying increase in the number of health complaints associated with exposure (11, 21). PPM larvae bury themselves underground in chrysalis form while OPM do this in the trees with most nests remaining intact in the canopy. The large number of discarded PPM chrysalises in

the soil may act as an on-going source of setae close to the ground, with a reasonable risk of disturbance through human activities. Large numbers of setae have been reported in soil where Eastern PPM have buried themselves (50).

Each of these differing characteristics is likely to result in a relatively lower environmental load from OPM as compared with PPM. Therefore, even if the mechanisms through which the two species impact on human health are the same, the risk and intensity of the exposure experienced in areas with OPM may be considerably lower.

Prevention and treatment

There is little evidence available on the management and treatment of health effects associated with processionary species specifically. As a result, the approaches suggested in the literature tend to be generic and supportive in focus.

Prevention:

- avoid direct contact with the caterpillars and their nests
- wear long-sleeved tops and long trousers with the cuffs tucked in when working in areas where OPM are known to be present (6, 43)

Reducing exposure:

- gently remove the caterpillar using a pen or similar long thin object, disturbing the caterpillar as little as possible to reduce the risk of more setae being released (43)
- clear the skin: use soap and water to wash loose setae off the skin (6, 43); strip the skin with sticky tape (6, 27), rubber cement or facial peel solution (43); do not touch dry (43)
- remove clothes and launder them (6, 43)
- remove any constricting jewellery, in case of swelling (6)
- once exposure has been removed, dermal symptoms usually disappear within two weeks if there is no further exposure (27)

Treatment

There are no specific treatments for exposure to caterpillar setae and no therapeutic trials for symptoms related to caterpillar exposures were identified in this literature review or by other authors (6); treatment is supportive and aimed at reducing the symptoms (6, 52).

It not possible to easily or rapidly determine which mechanism is responsible for an individual's reaction to the exposure which may explain why antihistamines have commonly been used although their effectiveness is disputed.

Dermal:

- calamine lotion or other creams may be used to relieve the itch, corticosteroid cream has also been used where the itching has been severe and/or prolonged (6, 21, 27)
- ice-packs and initial topical swabbing with isopropyl alcohol or ammonia may be used (52)
- topical antihistamines are not advised because of their sensitising potential (6)
- the evidence for the use of oral antihistamines for the treatment of caterpillar-related dermatitis is mixed (6); therefore, for severe or prolonged reactions, oral or intramuscular antihistamines or corticosteroids may be advised, although the evidence to support their use is limited (6, 21, 52)

Systemic

Regardless of whether a severe anaphylaxis-type reaction is deemed to be a true allergic response or a pseudo-allergic response the treatment will be supportive and epinephrine (adrenaline) should be given (6). Nebulised bronchodilators may also be used (6). Corticosteroids may be helpful for persistent bronchial spasms and hypotension but are unlikely to be useful in an acute event (21).

Ocular

As with other outcomes associated with exposure to setae, there are no standard treatment recommendations. However, Fournier et al. (42) advise that the lesions can be classified according to the standard classification system for ocular lesions and treatment can be adjusted depending on severity. For treatment of CON associated with any caterpillar setae, it is advised that all seta visible under a microscope should be removed and topical or systemic corticosteroids should be applied for pruritic allergic response. Corticosteroid treatment is advised for the remaining hairs rather than corneal excision (52) and regular ophthalmic follow-up is required as the setae tend to migrate deeper into the eye tissue over time (6). Oral steroids should only be used for patients with severe intraocular reactions (6).

Oral

Only three of the papers identified in this review described oral exposure (6, 29, 45) and none related specifically to OPM. As with ocular exposure, treatment should focus on removal of the setae with direct laryngoscopy, bronchoscopy and oesophagoscopy with microscopy used, as setae can be difficult to see and may be embedded in tissue (29). It may be necessary to conduct this under conscious sedation (29). Following the removal of setae, steroids, antihistamines and antibiotics have been used (6, 29) but there is no evidence supporting their efficacy or otherwise.

Conclusions and London risk assessment

London risk assessment

In London and the surrounding suburbs, the preferred food resource for OPM is limited, apart from some of areas of parkland with oak trees and relatively small stands of trees in suburban areas. However, as the initial 'outbreak' associated with OPM in London indicated, it is possible for a small number of trees to host sufficient numbers of the caterpillar to cause human health effects (2). Therefore, further outbreaks of human health effects associated with exposure to OPM are possible, although these are likely to be localised. In the event of a localised outbreak related to an OPM infestation, most exposed individuals will not be affected. Of those who are, the predominant effects will be dermal and affected individuals may be advised to attend their local pharmacy for advice and over-the-counter treatment.

The ongoing management and control efforts to restrict the spread of OPM should ensure that the number of outbreaks is minimised. The evidence from continental Europe is generally reassuring; even in the middle of a widespread outbreak of OPM in Netherlands and Belgium in 1996-1998, OPM was rarely reported in the big cities (4). Conversely, however, the city of Vienna has reported problems (3); this may be due to the city and its surrounds having a higher density of oak trees. In Gotland, the northern PPM had been present for many years before becoming a health nuisance (13); the authors believe the increase in health complaints was due to an increase in the number of caterpillars in the area as well as increased use of the infested forest regions by visitors.

Likelihood

The likelihood of an outbreak associated with an infestation occurring = medium
Epidemics of OPM have been reported in the literature and the population dynamic of this OPM species is to invade, establish, thrive (boom) and crash (3). Therefore, there may be incidents in the future where infestations of OPM larvae result in human exposure and resultant health effects. Off the shelf advice on prevention and treatment should be developed for healthcare professionals and the public in anticipation of this eventuality.

Severity

Likely severity of impact on health = low

The majority of people who are exposed experience no health effects and of those who do, the most common effects are self-limiting dermal symptoms which can be treated with over-the-counter remedies. There are no documented case reports of death following exposure to OPM (21) or any other processionary caterpillar (6).

Impact on health and health services

Likely impact on health services = low (localised)

As the majority of affected individuals affected are likely to experience self-limiting dermal symptoms only, they can be directed to their local pharmacy for over-the-counter treatments. The Dutch experience suggests that as human populations become familiar with OPM as the species becomes more established in an area, they are less likely to seek medical attention, and are more likely to identify the symptoms as self-limiting and to treat them with over-the-counter therapies (22).

Evidence from the literature suggests that there is likely to be considerable media attention in the event of an outbreak (4).

Recommendations for PHE London

1. Develop guidance for treatment. Given the absence of trial data, this will have to be based on the findings of the literature review and consensus. Draft guidance has been developed (Update (May, 2015)) and is currently being reviewed by relevant stakeholders. In the interim, TOXBASE® may be used as a source of preliminary treatment guidance.
2. Focus the public health communication strategy to increase awareness of OPM among GPs and pharmacists in the affected areas, including the availability of treatment advice.
3. Work with partners to develop communication material aimed at groups at higher risk of exposure (namely, occupationally exposed individuals and children).
4. Support the OPM Advisory Group to develop links with the Health and Safety Executive (HSE) noting that it may be difficult to communicate information about potential occupational risks from OPM to members of the arboculturalist and gardening workforce who are not allied to any formal employer, or those who are involved in tree surgery in an informal capacity.

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