Prevalence of cutaneous reactions to the pine processionary moth (*Thaumetopoea pityocampa*) in an adult population

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Summary

**Background.** *Thaumetopoea pityocampa* [pine processionary moth (PPM)] is one of the most important lepidopteran agents causing urticant cutaneous reactions in humans in Mediterranean countries. This species is also expanding northwards, because of global warming.

**Objectives.** To investigate the prevalence, distribution by habitat group and possible risk factors of PPM cutaneous reactions in adults.

**Methods.** A randomly designed survey was carried out on 1224 adults.

**Results.** A point prevalence, estimated after corrections, of 8.7% was obtained (12% rural areas, 9.6% for semi-urban areas, and 4.4% for urban areas). The data showed a significantly higher risk of self-reported symptoms according to sex (*p* < 0.005; males, adjusted odds ratio (aOR) 1.84), habitat (*p* < 0.0005; rural, aOR 1.8; semi-urban, aOR 1.2), frequency of visits to pinewood areas (*p* < 0.005; daily exposure, aOR 2.1), and occupational exposure (*p* < 0.0001; aOR 5.04. 90% were males). Airborne contamination was the most important cause of reactions (83.3% of 48 participants who visited the hospital and fulfilled the criteria for a convincing reaction presented with symptoms after walking on/passing by pine tree areas).

**Conclusions.** These findings show that PPM cutaneous reactions are common in this southern European population, including peripheral urban areas, and that the main risk is related to exposure to this insect.

**Key words:** cutaneous reaction; pine processionary caterpillar; prevalence; *Thaumetopoea pityocampa*.
Materials and Methods

Study population

Valladolid province (north-west Spain) was selected for this study. It is an endemic area for PPM, with extensive defoliation (loss of needles) of trees in pine forests as well as of ornamental pine trees. It has 532,575 inhabitants, 317,864 of whom live in the municipality of Valladolid, and it is one of the major Spanish pine-nut producers.

A random sample cross-sectional study, stratified by habitat (rural, <5000 inhabitants; semi-urban, 5000–22,000 inhabitants; and urban, Valladolid city), age and sex was carried out on men and women ≥18 years of age in 2009. For the purpose of this study, we selected two rural and four semi-urban areas containing pine forest zones with extensive defoliation caused by PPM infestation.

This study was carried out in two phases. In the first phase, we conducted a telephone survey. In the second phase, a more detailed interview at the hospital was performed. In this phase, patients with self-reported cutaneous reactions in pinewood areas who agreed to participate were visited.

The study adhered to the guidelines of the Declaration of Helsinki. Verbal informed consent was obtained during the telephone interview, and subject confidentiality was strictly preserved. Patients who participated in the second phase also gave their written informed consent. The study was approved by the local Ethics Committee, and was performed according to Spanish data protection law.

Telephone/questionnaire survey

A specialized company (Telecyl Studies, Spain) carried out a telephone survey of households by use of a structured questionnaire [computer-assisted telephone interviewing system]. The questions were created by the researchers, reviewed by the specialized company for better understanding, and previously checked in volunteers and in patients who visited the hospital (unpublished data). The telephone interviews were conducted by experts in the field of surveying who were specifically trained in the objectives of this study. A random sample was selected from the telephone directory, and equally distributed as much as possible according to sex, age, and area. Non-residential calls were excluded. For every telephone call, only one person was interviewed. Suspected PPM reactions were only included when the affected adult was personally interviewed. Respondents were eligible if they were >17 years of age, were living...
Table 1. Structured questionnaire administered via telephone interview (computer-assisted telephone interviewing system)

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
<th>Interviewer Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How often do you visit pinewood areas?</td>
<td>Daily, Several days in a month, Not every month, Very seldom or never</td>
<td>If the answer is ‘yes’ go to question 5</td>
</tr>
<tr>
<td>2. Do you work in pinewood areas?</td>
<td>Yes, No</td>
<td>If the answer is ‘no’ go to question 3</td>
</tr>
<tr>
<td>3. Could you tell us what is your occupation?</td>
<td>Pine cone collector, Lumberman, Resin collector, Forester, Farmer, Breeder, Gardener, Bricklayer, Truck, Other (please specify)</td>
<td></td>
</tr>
<tr>
<td>4. Have you any allergies?</td>
<td>Yes, No</td>
<td>If the answer is ‘yes’ go to question 5</td>
</tr>
<tr>
<td>5. Could you describe your allergic disease(s)?</td>
<td>Asthma, Rhinitis, Conjunctivitis, Eczema, Food allergy, Other (please specify)</td>
<td></td>
</tr>
<tr>
<td>6. Do you have hives or dermatitis when visiting pine tree areas that do not appear in other circumstances?</td>
<td>Yes, No</td>
<td></td>
</tr>
<tr>
<td>7. If an allergist were to call you to ask questions about these reactions, would you be interested in participating?</td>
<td>Yes, No</td>
<td></td>
</tr>
</tbody>
</table>

in the household, and understood the questions in Spanish. Demographic information was obtained from all participating households.

The questionnaire included seven questions (Table 1). For individuals who reported suspected PPM reactions and agreed to participate in an allergy investigation at the hospital, additional questions were asked to specify the details of the reactions.

The inclusion criteria for considering a ‘convincing’ PPM cutaneous reaction were as follows: (i) hives, papular rash or dermatitis within 24 hr of visiting pine areas; (ii) characteristic distribution of the rash on the body; (iii) according to the insect’s life cycle, the rash appeared at least during the months when the caterpillar is ‘urticating’ (October to April), unless it was associated with the collection of wood, pine cones or sand from a PPM-infested pine forest – in this case, dead larvae, cocoons, nests and debris from an infested pine forest can cause reactions throughout the whole year (10, 21); and (iv) the rash did not appear in other circumstances.

Statistics
All analyses were performed with SPSS™ statistical software version 12.0. Results were expressed as percentages of the responses, and compared with the Pearson chi-square test. A Z-test with Bonferroni correction was used for multiple comparisons.

The adjusted odds ratio (aOR) and its 95% confidence interval (CI) were calculated. P-values < 0.05 were considered to be significant for all statistical analyses.

Results
Participation rate
A total of 4904 telephone calls were made. Of these, 3680 (75%) were not considered for the study for reasons that included the following: no answer (1597), immediate refusal (194), refusal after the object of the survey was given (477), an alternative interview time suggested (144), an answering machine (182), busy line (37), or the interview could not be completed (8). Additional households (1041) were ineligible for other reasons (age < 18 years, hearing deficit or confusion, or foreign nationality). The survey also included records that were discarded because they exceeded the predetermined time quotas. Thus, 1224 of the 4904 subjects participated (25%).

Prevalence of self-reported cutaneous reactions when visiting pine areas, and exclusion of subjects without convincing PPM reactions
Cutaneous reactions when visiting pine areas were self-reported for 125 individuals (10.2%). In 56 individuals, details of the reactions were obtained. No significant differences in age, sex, habitat, frequency of exposure or occupational exposure were found between these 56 individuals who visited the hospital and the 69 with suspected PPM reactions who refused the visit. Eight (14.3%) of these 56 individuals were excluded: 1 for not having symptoms, and 7 for having unconvincing symptoms (4 reported hay fever, 2 chronic urticaria, and
First phase: TELEPHONE SURVEY

- Number of calls: n = 4904
- Completed interviews: n = 1224 (25%)
- Rejected: n = 3680 (75%)

Stratification criteria
- Patients: n = 56/125 (44.8%)
- Other causes: n = 8/56 (14.28%)
- Suspected PPM reaction: n = 125 (10.2%)
- Refused investigation: n = 69/125 (55.2%)

Habitat: urban 405 / semi-urban 408 / rural 411
- Sex: male 613 / female 611
- Age (years): 18-35: 339 / 36-50: 327 / >50: 558

Second phase: HOSPITAL INVESTIGATION

- PPM reaction: n = 48
- Urban: 4.4% / semi-urban: 9.6% / rural: 12.2%
- Male 11.1% / female 6.4%
- 18-35: 10.9% / 36-50: 7.6% / >50: 8.1%

Fig. 3. Flow chart of the study and investigations performed.

Analysis of risk factors for PPM cutaneous reactions

Influence of age, atopic status, and area of residence. No significant differences were found with regard to age and atopic diseases (Table 2). The prevalence of PPM cutaneous reactions was significantly higher \((p < 0.0005)\) among participants from rural areas \((aOR 1.84; 95\% CI 1.2–2.7)\) and semi-urban areas \((aOR 1.16; 95\% CI 0.8–1.8)\) than among participants from urban areas \((aOR 0.38; 95\% CI 0.3–0.5)\).

Influence of gender and occupation. The data show a significantly higher risk of self-reported symptoms in the male group \((aOR 1.84; 95\% CI 1.2–2.8; p < 0.005)\), in participants with daily exposure \((aOR 2.1; 95\% CI 1.4–3.2; p < 0.005)\), and in exposed workers \((aOR 5.04; 95\% CI 2.8–10.2; p < 0.0001)\) (Table 2). The analysis of risk factors according to habitat showed similar differences among participants from rural areas with regard to occupational exposure \((aOR 6.61; 95\% CI 5.8–26.2; p < 0.0001)\) and sex \((males: aOR 3.42; 95\% CI 1.7–6.9; p < 0.005)\), but not in terms of daily exposure. However, none of these significant associations was seen among urban and semi-urban participants.

A total of 50 (4.1%) participants had occupational exposure, of whom 45 (90%) were males. Fifteen of these 50 participants (14%) self-reported PPM reactions. Pine cone collectors were the most common group of exposed workers interviewed (17.3%). Most of them (88%) lived in a rural area. Among these workers, PPM cutaneous
Table 2. Risk factors for cutaneous reactions to pine processionary moth (PPM; *Thaumetopoea pityocampa*) in 1224 subjects of the Valladolid area who completed a questionnaire

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>PPM reaction, n = 107 [% (no.)]</th>
<th>No PPM reaction, n = 1117 [% (no.)]</th>
<th>p-value</th>
<th>aOR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–35</td>
<td>10.9 (37)</td>
<td>89.1 (301)</td>
<td>2.242</td>
<td>1.43 (0.9–2.2)</td>
</tr>
<tr>
<td>36–50</td>
<td>7.6 (25)</td>
<td>92.4 (302)</td>
<td></td>
<td>0.82 (0.5–2.3)</td>
</tr>
<tr>
<td>&gt;50</td>
<td>8.1 (45)</td>
<td>91.9 (514)</td>
<td></td>
<td>0.85 (0.6–1.1)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11.1 (68)</td>
<td>88.9 (544)</td>
<td>&lt;0.005</td>
<td>1.84 (1.2–2.8)</td>
</tr>
<tr>
<td>Female</td>
<td>6.4 (39)</td>
<td>93.6 (573)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atopic diseasesb</td>
<td>13.1 (14)</td>
<td>10.5 (131)</td>
<td>0.566</td>
<td>1.29 (0.7–2.3)</td>
</tr>
<tr>
<td>Habitat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>4.4 (18)</td>
<td>95.6 (387)</td>
<td>&lt;0.0001</td>
<td>0.38 (0.3–0.5)</td>
</tr>
<tr>
<td>Semi-urban</td>
<td>9.6 (39)</td>
<td>90.4 (369)</td>
<td></td>
<td>1.16 (0.8–1.8)</td>
</tr>
<tr>
<td>Rural</td>
<td>12.2 (50)</td>
<td>87.8 (361)</td>
<td></td>
<td>1.84 (1.2–2.7)</td>
</tr>
<tr>
<td>Exposurec</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily</td>
<td>43.0 (46)</td>
<td>26.4 (296)</td>
<td>&lt;0.001</td>
<td>2.1 (1.4–3.2)</td>
</tr>
<tr>
<td>Monthly</td>
<td>15.9 (17)</td>
<td>14.7 (164)</td>
<td>1.1</td>
<td>0.6 (0.6–1.9)</td>
</tr>
<tr>
<td>Occasionally</td>
<td>25.2 (27)</td>
<td>32.8 (366)</td>
<td>0.69</td>
<td>1.1 (0.4–1.1)</td>
</tr>
<tr>
<td>Very seldom</td>
<td>15.9 (17)</td>
<td>26.1 (292)</td>
<td>0.53</td>
<td>0.3 (0.3–0.9)</td>
</tr>
<tr>
<td>Occupational exposure</td>
<td>14.0 (15)</td>
<td>3.1 (35)</td>
<td>&lt;0.0001</td>
<td>5.04 (2.8–10.2)</td>
</tr>
<tr>
<td>Pine cone collectors</td>
<td>6.5 (7)</td>
<td>0.9 (10)</td>
<td>&lt;0.0001</td>
<td>7.75 (2.9–20.8)</td>
</tr>
</tbody>
</table>

aOR, adjusted odds ratio; CI, confidence interval.

With statistical correction (minus 14.3% false positives after interview at the hospital).

Atopic diseases (allergic asthma, rhinoconjunctivitis, eczema, or food allergy).

Frequency of visits to pinewood areas.

reactions were eight times more frequent (aOR 7.75; 95% CI 2.9–20.8, \( p < 0.0001 \)), and up 41.2% self-reported cutaneous reactions in their work.

Analysis of the 48 participants with PPM cutaneous reactions confirmed at the hospital

Symptoms. The most frequent symptom mentioned by the participants was pruritus (100%). Other cutaneous reactions reported were as follows: 25 (52.1%) weal and flare reactions, and 24 (50%) persistent itchy papules/dermatitis; 2 (4.2%) were unable to specify the type of cutaneous reaction. Two participants reported persistent itchy papules in their first reactions, and later weal and flare reactions.

Affected areas. The parts of the body most often affected were the extremities in 41 (85.4%) and the neck in 33 (68.7%). The trunk and the face were affected in 14 (29.2%). Fifteen participants (31.25%) reported oedema on the face (87.5% on the eyelids, and 12.5% on the lips). Seventeen participants had non-cutaneous symptoms such as conjunctivitis (29.2%), rhinitis (18.7%), dyspnoea (4.2%), keratitis (4.2%), and malaise (4.2%). Nine (18.7%) participants required treatment in an emergency department.

Number of episodes and months of the year. A total of 4 (8.3%) participants reported one episode, 44 reported (91.7%) two or more, and 37 (77.1%) reported more than five. Twenty-nine (60.4%) participants had experienced a reaction in the last year and 40 (83.3%) in the last 5 years. Of the 8 participants who had the last reaction more than 5 years before, 5 had not returned to a pine wood since.

Most participants had reactions in the months in which the larvae are ‘urticating’ (46, 95.8%). Two participants only had reactions in summer (non-urticating larval stages), in 1 case while collecting sand and in 1 case after collecting wood. Most of them (45, 93.7%) had a reaction in the months corresponding to larval stage 5 (L5), and among these, 20 (41.7%) only had reactions in these months. The distribution for months corresponding to other larval stages was as follows: 16 (33.3%) for L4, 16 (33.3%) for L3, 21 (43.7%) for egg stage/L1/L2, and 13 (27%) throughout the year.

Influence of area of residence and risk factor analyses. Eleven (22.9%) participants with PPM reactions confirmed at the hospital were from urban areas. Six of these (54.6%) had reactions in urban peripheral areas (3 had infested trees at home, and the other 3 lived/worked near infested
trees). The other 5 (45.4%) had symptoms when they visited PPM-infested non-urban areas.

The most important risk factor for the development of PPM cutaneous reactions was passing by pine tree areas on foot (40 participants, 83.3%). Direct contact with setae from caterpillars was reported for 31 (64.6%) participants: 17 (35.4%) after collection of pine cones; 5 (10.45%) after collection of wood or forest sand; 2 (4.2%) by sweeping the caterpillars; 2 (4.2%) when accompanying their dog into a pine forest; 2 (4.2%) when playing football in a field surrounded by infested pine trees; and 1 (2%) by stepping on the caterpillars.

Discussion

To our knowledge, this is the first study of the prevalence of PPM cutaneous reactions in an adult general population. This study shows that PPM cutaneous reactions are common in populations in affected areas.

The urticating properties of the setae have been explained by the combination of a mechanical phenomenon (penetration of the seta) and, in some cases, an IgE-mediated mechanism (6–17, 19, 24), possibly regulated by chitin and its breakdown products (1). Immediate, repeated and progressively more severe reactions after visiting pine areas suggest the involvement of an IgE-mediated hypersensitivity mechanism; this has already been demonstrated by prick tests, immunoblotting and specific IgE determination with crude larval extract (9–17, 19, 25, 26).

With point prevalences of 12% among people from rural areas, 9.6% in semi-urban areas, and 4.4% in urban areas, our results show that the importance of reactions caused by contact with species of the genus *Thaumetopoea* at endemic density has probably been underestimated in the scientific literature. Most studies describe isolated cases (9, 13, 15, 17, 18, 27–30) or series of patients attending a hospital (10, 11, 14, 16), or are incidence studies after outbreaks, such as one for PPM (6% of 1025 persons living within a radius of 500 m from infested trees in a town) (20) and one for *Thaumetopoea pinivora* (18% of 4300 persons living in an infested area of about 3500 ha) (31). However, a prevalence study of PPM reactions in 653 children living in a rural area where PPM is endemic has been reported (12). In that study, 9.2% of the children had reactions with PPM, which is a value within the range that we found here, but only 6.7% of these children (4 cases) had a positive prick test reaction with crude larval extract.

There are a number of limitations to this study, some with regard to telephone surveys, and others concerning the self-reported diagnosis of allergy. Telephone surveys may be biased in several respects: over-representation of persons with a high socio-economic status may occur, because homes without telephones are excluded, and those with multiple voice lines are slightly more likely to be selected; and ethnic and racial biases may also occur, and men and younger people are usually under-represented (22). Also, the questionnaire should be simple, to ensure the cooperation of participants, and there was difficulty in creating valid questions that reflect the real situation, especially for discriminating atopic diseases. The diagnosis of a PPM reaction is obvious when a person has handled or been in contact with a caterpillar. In many cases, however, the caterpillar may not have been seen, and the diagnosis may be obscure, because none of the manifestations is absolutely specific (7, 20). In addition, our study was based on a retrospective investigation, and although 45% of the participants with suspected PPM reactions were examined in the hospital, most of them were asymptomatic at that time.

However, several aspects support the reliability of our data. Only people presenting symptoms showing a clear association with previous presence in an area with pine trees were included in the study group. Moreover, in accordance with the insect’s life cycle (Fig. 4), in 96% of participants with PPM reactions the rash occurred at least during the months in which the caterpillar is ‘urticating’. Most of these individuals (90%) had reactions during the time of the last larval stage (L5). This is the time when exposure is highest, because caterpillars leave trees to pupate in the soil. Only 2 participants did not show symptoms during this time period. Furthermore, the rather large proportion (27%) of participants with PPM reactions who had symptoms throughout the whole year showed that sensitivity to this insect

![Fig. 4. Annual biological cycle of Thaumetopoea pityocampa Schiff (Lepidoptera). Larval development occurring during autumn and winter is highly sensitive to variations in temperature. The insects can remain in the pupal stage for several years.](image-url)
can be even greater in some groups. The rash occurred as urticaria, papular rash or dermatitis lasting for several days and more often affecting uncovered parts, mainly the extremities and neck. On the other hand, participants who had similar reactions in different circumstances were excluded from the telephone survey. Moreover, we excluded 7 participants of 56 with suspected PPM reactions after hospital investigation, because they had unconvincing symptoms. Finally, the large number of participants (92%) with repeated cutaneous reactions within a historically infested area supports the plausibility of our findings.

Our study shows that the main risk of skin reactions caused by PPM is related to exposure to this insect, and not to sex, age, or atopic status, and that airborne contamination with setae is the most important cause of these reactions. Setae have been detected in the air with the use of techniques designed for airborne microorganisms and pollen research (32). Although an increased risk of reactions in males was found, when the risk was analysed in accordance with habitat, only rural areas showed a higher prevalence of disease. This can be explained by the risk of PPM cutaneous reactions being five times higher in exposed workers, who were mostly males (90%). Exposure and the risk of PPM reactions was greater in rural and semi-urban areas with pine trees, because there are more exposed workers and residents who live in or frequently walk through these areas. However, peripheral urban areas with isolated pines, pine hedges, parks and pine trees nearby are also areas of high and repeated exposure with a high prevalence of PPM reactions, and where the treatment of the pest is particularly difficult.

For correct diagnosis of a suspected reaction to this insect, the following procedure may prove helpful: (i) a history of previous exposure in an infested area at any time of year (most commonly from February to April, but depending on the type of contact); (ii) examination of the rash (hives, papular rash, or dermatitis) (Fig. 5), which mainly affects uncovered areas—the palms of the hands and the interdigital areas are most often affected in children; (iii) identification, if possible, of setae on clothing or skin by the tape-strip method; and (iv) exclusion of false-positive diagnoses with the same cutaneous lesions. Moreover, this study shows that the telephone interview is useful as a diagnostic screening method, especially in peripheral urban and rural endemic areas, where people know well the reactions to this insect. In most cases, for the treatment of reactions caused by PPM, it is adequate to use systemic antihistamines, antipruritic lotions, and, for persistent cutaneous reactions, topical steroids. Systemic steroids were prescribed only in severe cases.

For anaphylactic reactions, immediate treatment with epinephrine is essential.

In conclusion, PPM cutaneous reactions are common in the human population of south-western Europe, where
PPM is endemic. Although the symptoms are more prevalent in people from rural and semi-urban areas, the medical impact is also important in peripheral urban areas. Moreover, the moth is expanding its range northwards in Europe, with warmer winters, and its urticating larvae are infesting highly populated urban and semi-urban areas, for example in the Paris Basin in France, where this kind of hazard is at present unknown (4). In endemic areas, the possible role of global warming in PPM population dynamics is not yet precisely known, but may have the effect of modifying the moth cycle, leading to more frequent high densities of urticating larvae, representing a serious threat to public health. Several preventive and curative methods have been developed and economically evaluated for controlling PPM infestations in forests (33, 34). However, they remain to be adapted to the particular situation of urban and semi-urban areas.

Acknowledgements

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