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Smart traps for earlier detection and better surveillance of a spreading invasive insect pest in Europe

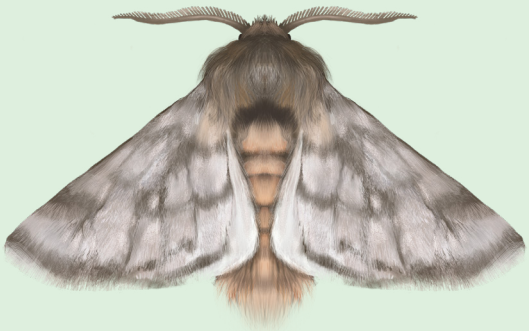
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POLICY BRIEF

BACKGROUND

The pine processionary moth: An invasive species spreading in Europe



Pine processionary moth (*Thaumetopoea pityocampa*)

The pine processionary moth (PPM), *Thaumetopoea pityocampa*, is one of the most damaging pine defoliators of the Mediterranean region. Its larvae feed on pines and cedars through autumn and winter, with their urticating hairs proving to be a public health concern for people and animals in forests, parks and cities. The PPM is also one of the few species for which a causal link between climate warming and range expansion has been firmly demonstrated. In southern Europe, this winter-active species is expanding northwards and upwards due to the warming in winter that bolsters its feeding and survival rate (Battisti et al., 2005). Newly colonised areas are first occupied at very low densities, so spread can go unnoticed until nests become conspicuous. Monitoring flight activity and detecting the moth early in new areas is therefore essential to track its spreading pattern, assess potential risk and time management measures.

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Smart traps: A new generation of forest pest monitoring tools

Conventional pest monitoring of species such as the PPM often relies on pheromone, sticky or light traps that require trained personnel and frequent trap assessment visits. These take time, imply travel costs and can delay decisions. Insects may also escape, deteriorate or be removed by predators before the next inspection, while traps can collect other non-target species, including natural enemies of the pests or other key elements of the forest food web. Technologies based on artificial intelligence (AI) may help to simplify the process and to apply it over larger areas with better precision and reduced costs (Preti et al., 2021). These systems are increasingly used to monitor agricultural pests, but their deployment in forests is still limited. Such biomes can be extensive and difficult to access, making remote monitoring especially useful. **This document reports the first large-scale test of an AI-based camera trap for monitoring the PPMs across four European countries and different habitats, conducted as part of the EU-funded FORSAID project (Bourougaaoui et al., 2026).**



An automated Trapview FUNNEL SC smart trap deployed in the field

ANALYSIS

Conventional traps vs. smart traps (Trapview) in four countries

A comparison was made between automated Trapview FUNNEL SC smart traps and standard funnel traps across forest and urban sites in four countries during the 2025 flight season: France (Orléans, northern expansion front), Italy (Venosta valley, high-altitude Alps), Portugal (Lisbon area) and Slovenia (Hrpelje, edge of the range). Conventional traps were emptied and counted weekly. Smart traps photographed the sticky surface three times every night and sent images as well as temperature and humidity statistics to the cloud, where an AI model (Faster R-CNN) identified and counted the moths.

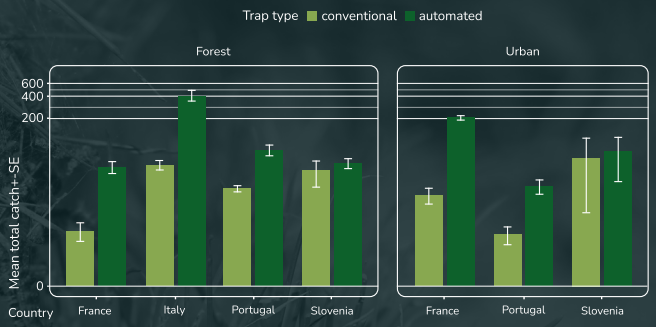
What was measured

- **Catch & accuracy:** total catch per trap type and AI identification accuracy
- **Early detection:** date of first catch as well as probability of detection at low densities
- **Non-target insects:** by-catch and predation on trapped moths (Italy and Portugal)
- **Weather:** relationship between nightly temperature/humidity and daily catch
- **Infestation prediction ability:** relationship between adult catch and winter nest density (Italy and France)

RESULTS

1. Catch and identification performance

Mean catches were consistently higher in automated traps than in conventional traps. Automated traps caught 7.2 times as many moths in Italy, 8.7 times as many in French forests, and 3.5 and 5.4 times as many in Portuguese forests and urban sites, respectively. In Slovenia, catches were also higher on average in automated traps, but the difference was not statistically significant.



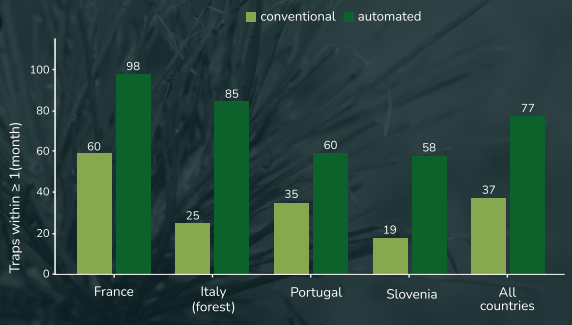
Mean total catch (±SE, log scale) by trap type, habitat and country

Overall, the AI identified moths reliably (mean Average Precision 0.98). In 4,440 manually checked images, the F1-score was 1.00 and 0.987 at low and high catches, respectively.

2. Early detection and non-target catches

In forests, smart traps detected the first moth earlier: by 10.3 days in France, 7.8 in Italy and 5.2 in Portugal. The difference was not significant in Slovenia or in urban sites. During the first four weeks of flight (low density), 77% of smart traps detected moth presence against a score of 37% for conventional traps.

Non-target catch in smart traps was low, mostly flies. Predation on trapped moths was rare.



Proportion of traps detecting moths at low densities of flying males

3. Meteorological data utility

Meteorological data allows for interpretation of variability in flight patterns. Smart traps record temperature and humidity daily in synch with the catch.

Catches rose with temperature in most sites. However, the relationship between temperature and catch depended on country and habitat. By contrast, higher humidity was generally associated with lower catches, but there was also a variation across countries and habitats, which might reflect local microclimate conditions.

4. Monitoring to predict nest density

In pooled data from France and Italy, a linear relationship was found between adult catches and winter nest density for both automated traps and conventional traps. The linkages were similar for both trap types, even though automated traps caught more moths. The catch explained about half of the variation in nest density. The relationship could not be assessed in Portugal or Slovenia, where moth densities were lower, and no visible nests were detected in most sites.

CONCLUSIONS

Smart traps are:



More sensitive 1

More moths are caught, with detection occurring earlier (chances are higher at low density).



Abundant in data 3

Daily counts plus temperature and humidity statistics support flight and phenology models.



Reliable and selective 2

AI identification is near-perfect and the method results in fewer non-target catches and far fewer field visits.



Informative on infestation risk 4

Traps keep track of about half of the variation in nest density, helping to target surveys.

Important to note: *Smart traps require a higher initial investment than conventional traps. Savings in labour and travel are expected, but cost-benefit and wider validation studies, especially at low densities and range edges, are still needed.*

POLICY RECOMMENDATION

Camera-based smart traps should be integrated into national and EU forest-pest surveillance, starting where early detection matters most – the expanding range edges of the PPM's spread, namely urban areas and remote forests.

Prioritise smart traps where early detection pays off 1

Target northern and high-altitude fronts, towns and recreational areas as well as remote stands that are costly to visit.

Integrate with nest surveillance 2

Keep winter nest surveys for calibration and use smart-trap catches to prioritise nest surveys and time control measures.

Standardise and share data 3

Agree on common protocols for image validation and data formats while feeding catch, temperature and humidity records into open platforms and flight-forecasting models.

Research existing gaps 4

Conduct long-term cost-benefit assessments and validation surveys at low densities and range edges.

Deploy smart traps for other forest pests 5

Extend the approach to more threat-posing species, especially the oak processionary moth (*Thaumetopoea processionea*).

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