FORSAID

forsaid.eu

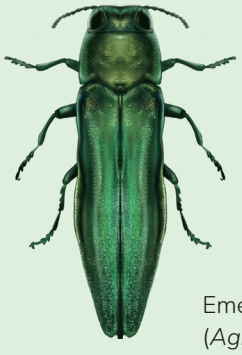
AI-driven surveillance for quarantine *Agrilus beetles* in Europe

Valerio Caruso[1], Davide Rassati[1], Hossein Shirali[2], Christian Pylatiuk[2]

1 Department of Agronomy, Food, Natural Resources, Animals and Environment, University of Padua (UNIPD)
2 Institute for Automation and Applied Informatics (IAI), Karlsruhe Institute of Technology (KIT)

POLICY BRIEF

Bronze birch borer (*Agrilus anxius*)



Emerald ash borer (*Agrilus planipennis*)

KEY MESSAGES

- AI-enabled surveillance systems can significantly enhance early detection of quarantine forest pests, particularly high-risk *Agrilus* species such as the bronze birch borer *A. anxius* and the emerald ash borer *A. planipennis* (Coleoptera: Buprestidae).
- The tested Entomoscope + deep learning workflow achieved 100% accuracy for the two priority quarantine species *A. anxius* and *A. planipennis*.
- AI tools can function as high-throughput triage systems, reducing the burden on taxonomic experts and enabling faster response.
- However, AI does not replace expert validation and must be integrated into hybrid surveillance workflows.
- Robust validation (including real-world testing) is essential – standard laboratory accuracy can overestimate operational performance.

Funded by the European Union

FORSAID receives funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement No. 101134200. Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the EU nor REA can be held responsible for them.

CONTEXT

Globalisation, trade and climate change are accelerating the spread of invasive forest insects, with the genus *Agrilus* being particularly problematic due to its diversity and mobility. Two species, *Agrilus anxius* (bronze birch borer) and *Agrilus planipennis* (emerald ash borer), are of major phytosanitary concern and are regulated under EU legislation, requiring systematic surveillance by member states.

Current surveillance relies heavily on green traps, which capture both target and non-target species. This leads to high sorting and identification workload, dependence on scarce taxonomic expertise and delays in detection and response.

The study provides a proof-of-concept that a low-cost imaging device combined with deep learning can support specimen triage in surveillance workflows. The current validation covers 11 native and 2 exotic *Agrilus* species and indicates particularly strong performance for the two quarantine target species.

POLICY RECOMMENDATIONS

Integrate AI-based identification into EU phytosanitary surveillance 1

- progressively integrating AI-supported imaging systems into monitoring programmes following operational validation
- using AI as a first-line screening tool to prioritise high-risk specimens

Adopt hybrid surveillance workflows 2

- combining AI classification with expert taxonomic validation
- establishing protocols for handling low-confidence predictions and “unknown” species detections

Invest in shared European reference datasets 3

- expanding image libraries across species diversity, geographic regions and environmental conditions
- promoting standardised data collection protocols

Support capacity building and training: 4

- training phytosanitary personnel in AI-assisted identification tools and interpretation of model outputs
- encouraging cross-country knowledge exchange

Develop interoperable digital infrastructure 5

- supporting future integration into interoperable digital identification workflows
- integrating AI tools into existing EU biosecurity systems (e.g. plant health monitoring networks)

POLICY IMPLICATIONS

1 Enhanced biosecurity efficiency

AI-driven systems can process large volumes of trap data, enabling:

- faster detection of quarantine species
- more targeted use of expert resources
- reduced response times

2 Cost-effectiveness

Low-cost, open-source technologies like the Entomoscope make deployment feasible across Member States, including regions with limited resources.

3 Risk management and early warning

The ability to reliably detect priority pests and flag unknown species supports proactive biosecurity and early warning systems.

4 Limitations and governance needs

- AI models may misclassify morphologically similar native species.
- The approach requires clear governance on decision-support vs. automated decisions.

5 Standardisation and harmonisation

EU-wide adoption will require:

- harmonised protocols
- shared data infrastructures
- interoperability across national systems

The Entomoscope photomicroscope in operation, with the PC monitor displaying an image of an *Agrilus* beetle acquired by the instrument

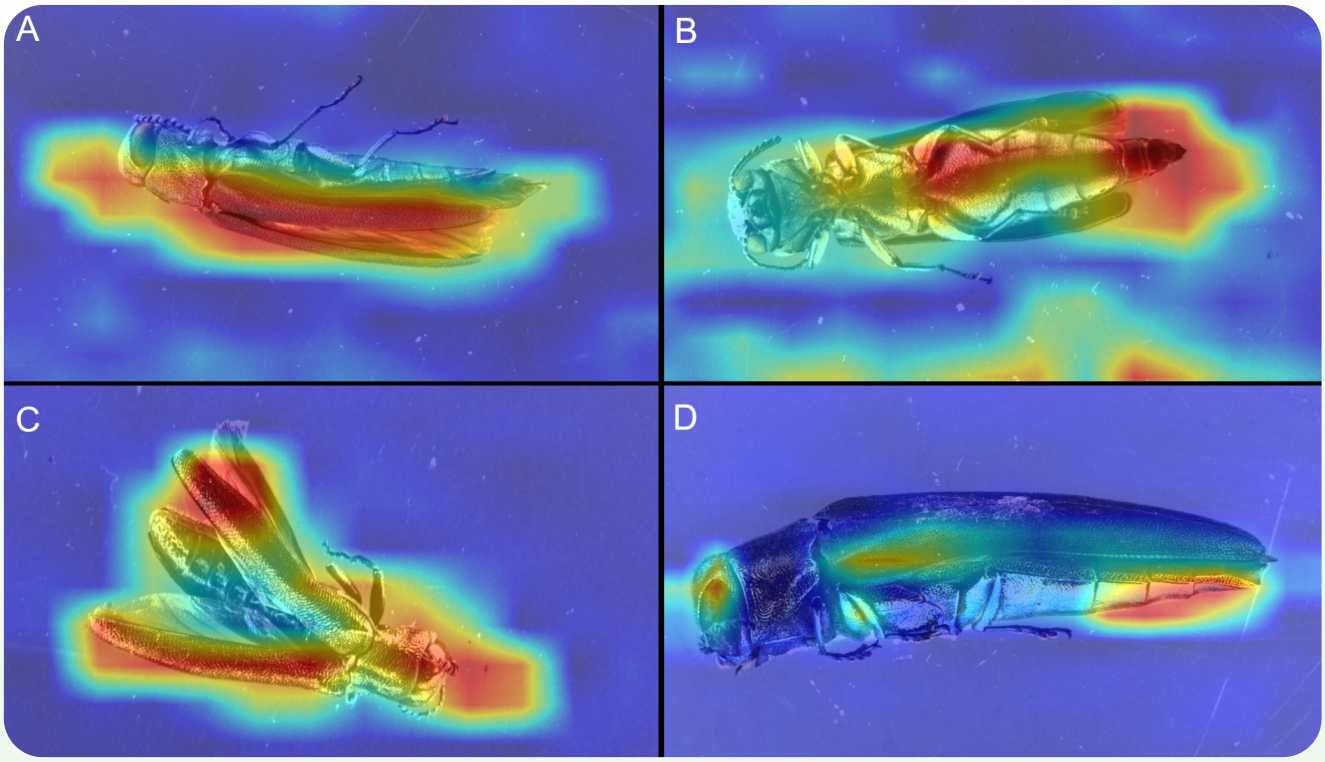
CONCLUSION

AI-based image recognition systems represent a transformative opportunity for pest surveillance in Europe. The demonstrated approach provides a robust, scalable and cost-effective triage tool capable of accurately identifying high-risk invasive species and supporting early detection efforts.

However, effective deployment requires:

- integration into hybrid human-AI workflows
- investment in data, infrastructure and training
- adoption of rigorous validation standards

Within Horizon projects, these technologies can underpin next-generation biosecurity frameworks, improving preparedness and resilience against biological invasions.



Example of class activation heatmaps obtained for pictures of: **A.** *Agrilus angustulus* (laterodorsal view); **B.** *A. angustulus* (ventral view); **C.** *A. olivicolor* (dorsal view); **D.** *A. planipennis* (lateral view). The heatmaps indicate the image regions most influential for the model's prediction (from red = high influence to blue = low influence).

REFERENCES

Caruso V, Shirali H, Bouget C, Cerretti P, Curletti G, de Groot M, Groznik E, Gutowski JM, Pylatiuk C, Plewa R, Roques A, Sallé A, Sweeney J, Van Rooyen K, Wührl L, Rassati D (2026) Image-based recognition using advanced neural networks can aid surveillance of *Agrilus* jewel beetles. *NeoBiota*, 105, 319-336

Wührl L, Rettenberger L, Meier R, Hartop E, Graf J, Pylatiuk C (2024) Entomoscope: An open-source photomicroscope for biodiversity discovery. *IEEE Access*, 12, 11785–11794.