**VespAI Manuscript Structure**

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**Journal choice:**

* **1st choice: Nature Comms [Impact 17.69] or Communications Biology [6.55]** (article no more than 5000 words)
* **2nd choice:** [**Methods in Ecology and Evolution**](https://besjournals.onlinelibrary.wiley.com/journal/2041210X) **[8.33]** (no more than 7000-8000 words for Standard Articles, 3000-4000 words for Applications and Practical Tools)
* **PLoS Computational Biology**

## Abstract

Problem severity

Solution applicability

Impact substantial

## Introduction [JO]

There is a recognised need to utilise deep learning to develop monitoring systems for invertebrates [Hoye et al 2020] both for pest management purposes [ref] and also for conservation actions [ref]

**1.1 Background of *Vespa velutina* problem**

*Vespa velutina nigrithorax,* has been spreading rapidly across Europe since 20041. It is a voracious predator of honeybees, seen as a significant threat by beekeepers, and has caused ~30% losses of honeybee colonies in France1. AH colonies have been found in the UK since 2016 and destroyed, but incursions are ongoing, with one nest being found in 20212,3. As such, Defra and XXX countries in the EU have an active strategy aiming to prevent establishment and manage spread.

**1.2 Current methods and urgency of developing new systems**

Currently however, there is no effective method for rapidly detecting the presence of these insects beyond alerts from beekeepers or the public, and these yield an accuracy of only 0.01-0.02%, due to high rates of misidentification4

Additionally, methods such as trapping are of limited utility. If fatal/kill traps are used– then they result in considerable by-catch of native insects [ref]. The most effective forms of control require the capture of live hornets in order to determine the location of the colony5, but the monitoring of individual traps is time consuming.

**1.3 VespAI**

The aim of this research was to:

1. Develop a computationally optimised AH Detection programme ‘VespAI’, using deep learning to automatically analyse images from a bait station to detect visiting AH.
2. To integrate this into a prototype for a low-cost ‘VespAlert’ field monitor that can automatically detect the presence of AH in real time and trigger an alert.

We report on the development of a remote monitor that can automatically detect the presence of V.velutina at a bait trap, and signal this detection via an automated alert. It has the potential to transform the way AH is managed, reducing the chance of establishment, spread, and subsequent damage, by providing a reliable and passive early alert of AH presence in an area. Importantly it will not result in fatal “bycatch” of other insects, and also will provide be able to photographic evidence of AH presence that is required for Defra to initiate a rapid response. It is urgently needed at this crucial juncture on the invasion curve, as management costs will scale rapidly if AH becomes established6.

This paper demonstrates…..

The design paves the way for using AI more effectively to monitor for rare and distinctive insects that may be of invasive importance (like *Vespa velutina*) or conservation value (like *Vespa crabro*).

## Results

* 1. **Collecting & labelling training data [PK & TOW]**

The bait station:

Result = demonstrating the Vv and Vc go to the bait station, and what else was there…

Images collected & labelled for training:

Result = show images & quality & labelling

* 1. **Model development and optimisation** **[AC]**

The detector

The classifier

The model

Result: Show how training and augmentation improved performance

Result: Current detection accuracy

Result: Layer-wise relevance

Result: V velutina vs detecting V cabro

Results: lots of others that Andy has in mind but I don’t!

* 1. **Hardware for prototype** **[AC starts]**

The monitor

Combining monitor with bait station

Result: how it performed in first field trial

Result: preliminary market research/questionnaire…or maybe in discussion/introduction? **[PK]**

## Discussion

Our system works well for training and validation dataset

Our system can be used in the field.

Impact when considering the technological and biological landscape

Ecological and practical benefits over current methods

Plans for further development and application

A VespAI field monitor needs to be cost effective and easy to use by governments, organisations and beekeepers, ideally deploying and integrating the fully-trained model into a small piece of field equipment (<£60), with real-time processing and alert system, while minimising computational requirements and energy usage. This will enable flexibility across environmental settings and use over long deployments.

Use beyond Vespa velutina…. To our knowledge, such a robust environmental intelligence monitor for automatically alerting users to the presence of specific insects does not yet exist [although see examples in Hoye et al 2020]. Whilst invaluable for the management of AH; this use of environmental intelligence could be applied to other pests, invasives, or rare species of conservation value: thus having broad utility across the crop protection, biosecurity and conservation sectors.

## Materials and Methods

* 1. **Collecting & labelling Training data** **[PK & TOW]**

The bait station:

Images collected & labelled for training:

**2.4 Model development and optimisation** **[AC]**

Detector

Classifier

Model

**2.5 Hardware for prototype** **[AC starts]**

The monitor

Combining monitor with bait station

## Supplementary material

Think about it

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**Data availability**

Consider CC licence for journal open access. CC-BY allows all use. CC-BY-NC does not allow commercial use

**Code availability**

Ditto

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