

Combining high-resolution smartphone images with new open-source software based on deep learning techniques will make *varroa* diagnosis easier and more efficient

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Introduction

Varroosis is a significant threat to beekeeping, severely impacting *Apis mellifera* by weakening their immune system, shortening their lifespan, and facilitating the spread of viral diseases, which can lead to colony collapse. Given the vital role of bees in pollination and food security, controlling *Varroa destructor* is essential for hive health.

Although eradication is unfeasible, effective management strategies are crucial to mitigating its impact. One of the most accurate infestation monitoring methods involves analyzing mites that naturally fall onto adhesive plates at the hive base. However, this process is manual, time-consuming, and resource-intensive, limiting its large-scale implementation.

Our goal

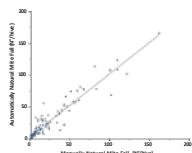
To develop an optimized and accessible deep learning-based system for automated detection and quantification of *Varroa destructor* in images of sticky plates placed at the base of the hive.

Results



A Deep Learning Model

YOLOv11 Nano was utilized to detect and quantify *Varroa* mites in images of sticky sheets. The model achieved a mAP score of 0.956, ensuring accurate and efficient mite detection without the need for a GPU.



Innovative and realistic dataset

The dataset included 357 images of *Varroa* mites from 90 sticky sheets, randomly split into training and validation sets. Experts manually annotated each mite using bounding boxes.



Image processing system

VarroDetector employs color-based filtering, Hough transform for boundary detection, and a one-stage neural network for accurate *Varroa* identification. It provides a user-friendly interface, allowing for zooming, manual correction of detections, and region-of-interest selection.



Easy application

VarroDetector is free, requires no installation or internet connection, and runs on low-end computers. Its user-friendly interface allows image uploading, sensitivity adjustment, and result export in CSV format.



Conclusion

The automatic counting method exhibits a strong correlation with the manual approach, achieving an mAP of 0.956, which indicates accurate mite detection regardless of their population density. It enhances efficiency by significantly reducing the time and effort required compared to the manual process, which is more prone to human error due to observer fatigue or subjectivity.

By providing a precise, cost-effective, and easily implementable alternative, this method can greatly benefit beekeepers and researchers, improving experimental protocols and hive health management.

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VarroDetector



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Varroosis represent a critical threat to apiculture, causing one of the most devastating diseases impacting honey bee (*Apis mellifera*) populations through compromising their immune systems, reducing their lifespans, transmitting viral diseases and potentially leading to colony collapse. Given the essential role of honey bees in pollination and the global food supply chain, effective management of Varroa mite infestations is paramount. Considering that the eradication of varroosis does not appear to be a realistic goal, control measures to mitigate its negative impact are essential. In any control strategy, monitoring the level of Varroa infestation is crucial. One of the most accurate and least invasive Varroa monitoring method is analyzing the daily mite fall onto sticky boards placed at the base of the hive. However this procedure, typically performed by visual inspection, demands substantial time and effort and is prone to errors and inconsistencies. The objective of this study was to develop an improved and simplified deep learning-based approach for the automated detection and counting of Varroa mites using images of sticky boards captured with smartphone cameras. A novel, realistic dataset was developed for this purpose, incorporating images with diverse artifacts and blurred regions, thereby increasing the complexity of the task. From this dataset, a new open-source software has been released. The software is completely free, no installation and no internet connection are required, working in low-range computers (no GPU is needed). It is based on a one-stage detector: the Yolo nano neuronal network, achieving a mean average precision (mAP) of 0.956 on the validation set. Being a free tool compatible with widely used commercial smartphones and computers, it can be highly beneficial for both beekeepers seeking to monitor varroa infestation levels in their hives and researchers, as it will facilitate the development of experimental protocols. This work was supported by the Spanish AEI-MICIN (grant PID2023-148475OB-I00), the EU Horizon Europe (grant 101082073), the DGA-FSE (grant A07_23R) and La Rioja Government (grant INICIA2023/02).