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Review Article

Automated Identification and Monitoring of Fruit Fly

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ABSTRACT

The fruit fly is an invasive pest that causes significant loss in horticultural crop production by damaging the fruit quality. For the integrated management of fruit fly, monitoring is a major component. Automated pest monitoring is most promising and advanced for monitoring and accurate assessment of the status of the fruit fly. The need of the hour is to automate and monitor pest populations using advanced technologies to save time and to examine the real-time situation of the field. The purpose of this paper is to discuss the approaches and sensors which detect and monitor fruit flies automatically. The review focuses on image-based sensors for identifying fruit flies, analyzing the wing beat biometric signature with optoelectronics sensors, direct counting with photo interruption sensors and E-Traps that can provide real-time field information, and presenting the various integrated systems available. With a real-time imaging system, all information about the fruit fly population and infection rate is recorded and maintained in a database. All of this has resulted in enhanced monitoring systems for fruit fly integrated pest management.

Keywords: *Fruit fly, Monitoring, Real-time system, Sensors, E-traps.*

INTRODUCTION

Fruit flies (Diptera: Tephritidae) are one of the invasive pests of horticulture crops all over the world, due to their ability to adapt to different environments, high polyphagia, and fast reproduction (Sarwar, 2015). Fruit fly causes direct significant damage to major export crops, resulting in severe losses ranging from 40% to 80% depending on the season, variety, and location (Kibira et al., 2015). Due to quarantine limitations enforced by countries, the existence of fruit fly species restricts access to global markets (Lanzavecchia et al., 2014).

One of the most successful fruit fly management tactics is prevention. Fruit fly monitoring is essential for determining population dynamics, comparing infection levels across different sites, and assessing the success of a treatment strategy (Eliopoulos, 2007).

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Fruit fly trap monitoring was done on a weekly basis manually. Moreover, this procedure is time-consuming, the accuracy rate low which results the suboptimal spraying frequency. (Goldshtein et al., 2017). The purpose of this review is to provide an in-depth assessment of recent research papers on the subject of automated fruit fly identification and monitoring. In addition, highlight the sensors used for fruit fly and their processing.

1. Automated Monitoring:

This approach is based on automated traps which contain several sensors and in some cases attractant, the main objective is for data gathering in the field, as well as hardware and software components for data transfer to a remote server that is accessible over the internet (Potamitis et al., 2017a; & Shaked et al., 2018). This method is becoming more advanced by the e-trap module which is modified from existing traps and it might incorporate an attractant that makes the trap more attractive or selective. E-traps contains attractant and various sensors which attract, detect and count the target insects. There are many sensors used for measuring wind speed, temperature, humidity, microcontroller, wingbeat, and mostly used image sensors.

1.1. Optoelectronics sensors

These sensors analyze the flow of light-regulated by a fruit flies wingbeats as it enters the trap. The wingbeat serves as a biometric characteristic, which allows us to distinguish between target and non-target specimens (Potamitis et al., 2014). Potamitis et al., (2017b) installed these sensors to track pest entry and identify incoming insect species using an optoacoustic spectrum analysis of their wingbeat. It has the ability to distinguish with 91% accuracy. For the identification in between the fruit fly species, a trap is designed which contains the Fresnel lens, bimodal optoelectronic sensor, and for the wingbeat sound recording a stereo-recording device and they claimed that their technology was able to identify between *Bactrocera oleae* and *Ceratitis capitata* with 98.99 percent accuracy (Potamitis et al., 2018).

1.2. Image sensors

They detect and transmit light waves to create an image. The sensor-based on camera must have a minimum 2 megapixels resolution that allows the captured insect to be correctly classified (Tabuchi et al., 2006). Only a few shorts can easily be captured due to high power consumption and only a few shots every day are supported (Shaked et al., 2018). *Anastrepha sororcula*, *Anastrepha obliqua*, and *Anastrepha fraterculus* were identified using a multimodal fusion classifier technique and in laboratory conditions, it accounts for 98.8% of classification accuracy (Faria et al., 2014).

1.3. Photo-interruption sensors

These sensors are initiated when the incident light is changed or interrupted by moving insects, and they count the number of times a fruit fly enters the trap. It transfers direct counts to a computer and it was one of the first systems (Goldshtein et al., 2017). Doitsidis et al. (2017) updated a trap for *Bactrocera oleae* with a McPhail, web system, and camera that can count fruit fly automatically and sends the photos to experts which predict the future threat and rate, minimizing the need for on-site visits and data collection. A different strategy is to use are hyperspectral pictures in post-harvest to identify spots created by fruit fly larvae in mangoes and provide information online with 87.7 % accuracy (Haff et al., 2013). Slovenia, EFOS, and TrapView make manufactures the commercial automatic trap with a high-resolution camera for monitoring *Ceratitis capitata* in peaches and citrus, and *Drosophila suzukii* in fruits and grapes.

2. Electronic traps

These traps can work with various sensors at a high degree of automation. One of its types is that camera captures images at predetermined intervals and transfers them to the web to the operator, which can interpret results by viewing the picture on a distant device in real-time (Shaked et al., 2018). Okuyama et al., (2011) used an automatic fly census in the field created by (Jiang et al., 2008), for tracking the abundance of *B. dorsalis*. This system reports the fruit fly status and environmental factors in real-time. The remote monitoring platform (RMP) can monitor and count the fruit fly entrance in the trap and records environmental conditions it contains in the infrared device. For the monitoring of *Bactrocera dorsalis* advanced and more features system is designed, which contains the two wireless protocols: ZigBee and GSM, it contains three major parts: a hosting control platform (HCP), wireless monitoring nodes (WMNs), and remote sensing information gateway (RSIG). The WMNs collect and transmit the data (illumination, temperature, relative humidity, and the number of fruit flies captured) to the next step RSIG, and it delivers the data to the (HCP) database server for analysis and storage (Liao et al., 2012).

Shaked et al. (2018) created an e-trap for monitoring different species of fruit flies at the adult stage, it is implemented in the field. The first trap was based on the attraction of *Rhagoletis cerasi, Dacus ciliates, Bactrocera oleae,* and Ceratitis capitata, and in the second trap the attractant is a yellow card for the *Dacus ciliates, Rhagoletis cerasi,* and *Bactrocera oleae*. These traps demonstrated 88% specificity across the various fruit fly species, and their results were comparable to those of conventional traps running at the same time (Shaked et al., 2018).

CONCLUSION

For the monitoring of fruit fly field surveys by traps are conducted once a week and occasionally twice. But there are some limitations like field inspector must reach the trap in the field, records the data on paper, then traveled back to the office, data entering and processing before sending them out to ultimate users, which causes delays in data collection and analysis. This whole process is troublesome and it has been simplified in part by inserting information immediately from the field using an e-trap that is portable, which can interface with a server that automatically archives the data. The developed image-based traps intend to send the fruit fly image to a professional, who can subsequently identify and count the fruit fly remotely in real-time. The E-traps make monitoring easiest and accurate for the fruit fly and the environmental conditions. All these advancements is for the effective control of this notorious pest management.

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