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Full Length Research Paper

The possibility of automation of sex pheromone trapping: Tested on *Resseliella theobaldi* (Barnes) (Dip., Cecidomyiidae)

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The automated trap developed by our team makes it possible to observe the emergence of insect species whose sex pheromones are known. The automated trap is in fact a sex pheromone trap combined with a built-in meteorological meter, extended with a computer system used for recording data and other purposes and a camera. The equipment sends the photos and the recorded meteorological data to a central server via internet connection. The energy necessary for the operation of the trap is provided by a solar cell. Over the last three years, the trap has been tested by monitoring the raspberry cane midge *(Resseliella theobaldi).* Our experience shows that in the observed species - presumably due to the high abundance of catches- the exchange of sticky inserts is required every three or four days. After the exchange of the sticky insert, the males flew in a large number to the sex pheromone for 2 to 3 days, and then their flight stopped. The phenomenon was also observed when the surface of the sticky insert did not become saturated with specimens. The prediction of the start of emergence of the pest can be solved with this trap. On the basis of 24-h monitoring, males do not fly onto sex pheromone traps at night and on rainy days.

Key words: Activity, automated trap, *Resseliella theobaldi,* sex pheromone, monitoring system.

INTRODUCTION

The basis of environmentally friendly plant protection is the precise prediction of pests, for which it is essential to know their biology. The automation of trapping and monitoring of insects has been wished for a long time. However, technological development has recently reached the level where it is possible to build cost-effective high-tech equipments. The field testing of the automated trap developed by our team was carried out by monitoring the emergence and flight dynamics of the raspberry cane midge (*Resseliella theobaldi* (Barnes) (Dip., Cecidomyiidae)). The significance of the damage caused by the pest is that it contributes to the process of raspberry midge blight along with several pathogens (*Didymella applanata* (Niessl) and *Leptosphaeria coniothyrium* (Fuckel/Sacc.). The symptoms affecting the canes lead to the fast deterioration of the plantation, followed by eventual demise (Williamson and Hargreaves, 1979).

In our automated trap, we placed a capsule containing sex pheromone of raspberry cane midge identified by Cross and Hall (2006) and Hall et al. (2009). Over the past years the sex pheromone has been tested in traditional traps equipped with sticky sheets in several countries and it has been found suitable for monitoring the emergence of the males (Cross et al., 2008, Labanowska and Cross, 2008). However, data collection can be time consuming due to the daily or even more frequent recording of the catches of traditional sex pheromone traps placed in the plantations.

Although there are automated traps used for field

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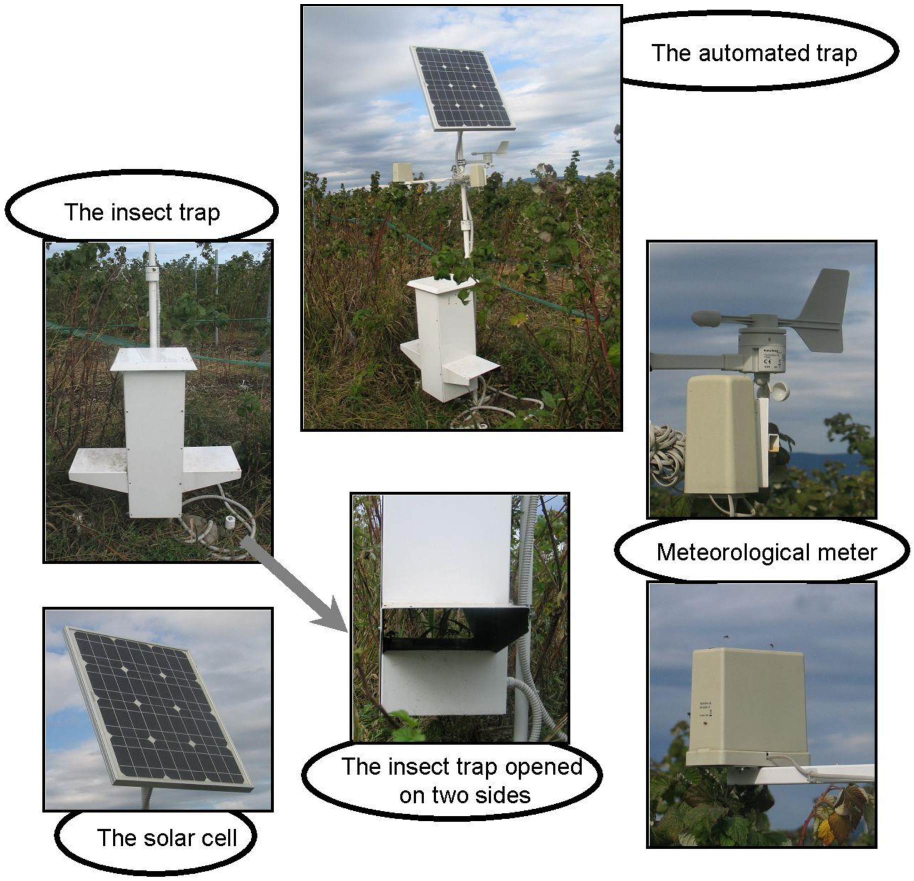

Figure 1. The automated sex pheromone trap system combined with a meteorological meter.

monitoring, none of them has the combination of characteristics developed by us. The emergence of the oriental fruit fly (*Bactocera dorsalis* (Hendel) (Dip.: Tephritidae)) was monitored with equipment using sex pheromone capsules (Jiang et al., 2008). The computer system of the insect trap used by Arbogast et al. (2000) recorded the number of insects flying through a light-stream. Toews et al. (2003) used the EGPIC system to count the catches of insect traps.

MATERIALS AND METHODS

Our experiments were carried out in a raspberry growing region in Hungary between 2008 and 2010.

The automated sex pheromone trap

An automated sex pheromone trap combined with a built-in meteorological meter (developed by Madomat Ltd.) was used to monitor the raspberry cane midge continuously. The trap is also equipped with a computer unit placed in a waterproof box as well as a camera. It takes photos of the specimens stuck on the sticky sheets at intervals set in advance (by hour, day, week etc.), and the information is saved on its hard disc. The meteorological meter is supplied with an internal and external thermometer, a hygrometer, a barometer, an anemometer and a rain gauge (Figure 1). The equipment sends the photos taken and the recorded meteorological data to a central server via internet connection. The energy necessary for the operation of the trap is provided by a solar cell and stored in a battery; therefore no external energy source is needed.

The automated trap system is fixed on a frame sinkable into the soil: the solar cell is placed on the top of the frame, whereas the anemometer and rain-gauge are placed on the cross-bar 50 cm away from the vertical axis in both directions. This makes it suitable for collecting rain water coming from any direction. The built-in frame allows using the trap in practically any culture (with or without trellis system; horticultural and agricultural plants). There's an insect trap that opens on two sides applied to the vertical axis, where the pheromone dispenser as odour source, the sticky sheet and the camera with lighting unit for night-time exposure are placed. The insect trap can be adjusted to the frame at different heights, allowing the collection of insects flying at different vertical levels (0 to 3 m).

Sex pheromone delta trap

The emergence of raspberry cane midge males was also monitored by traditional sex pheromone delta traps, thus we had the opportunity to test the efficiency of the trap developed. Each year of the experiments we operated two traditional sex pheromone traps in the plantation along with the automated trap. In the traps, sticky

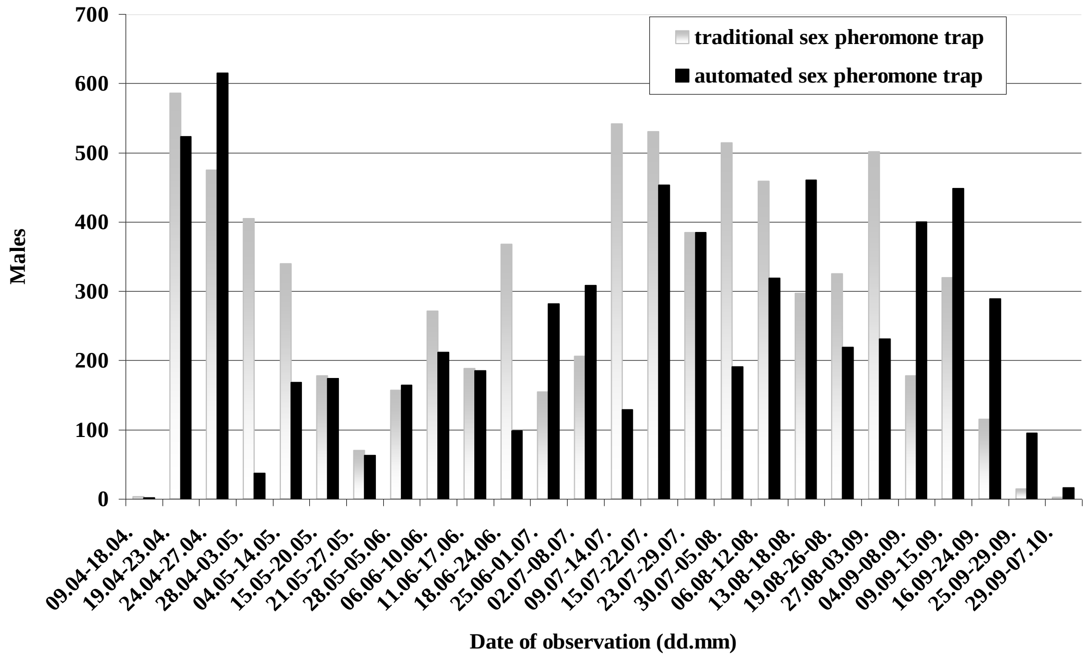

Figure 2. The number of raspberry cane midge males caught with the automated and traditional sex pheromone trap (2009, Hungary).

sheets were changed weekly, and capsules monthly. Catches were recorded weekly. The specimens stuck on the sticky sheets were identified with a stereomicroscope.

Statistical analysis

The data of catches of the traditional and automated traps were analysed by SPSS programme. First, the testing of normality was carried out (Kolgomorov-Smirnov Test), followed by t-test (Paired Sample Test).

RESULTS AND DISCUSSION

We have developed an automated sex pheromone trap combined with a built-in meteorological meter, which is suitable for trapping insect species whose sex pheromones are known. The system is multi-purpose: it can be used for the prediction of the vulnerable developmental stages of pests or for emergence, as well as for gaining thorough knowledge of the biology of certain species (such as daily activity, emergence, determining reproduction time, vertical location). The catches of the two types of traps were compared, and based on the statistical analysis, no significant difference was found ($t=1.389$; $df=25$; $p=0.177$) (Figure 2). On the basis of this, the design of the insect trap house is suitable, its openings are the right size and the spread of the pheromone is good. The resolution of the camera and the quality of the photos transmitted are suitable for identifying the specimens. The energy provided by the solar cell is enough to operate the computer, the camera and the lighting.

The catches of the automated trap counted weekly were assessed, on the basis of which the emergence of the pest is shown in Figure 2. The first males appeared in the second part of April every year and flew until the beginning of October. Many generations could be distinguished during the vegetation period, and usually the numbers of males of the first two generations were the highest. The next generations did not separate sharply. Catches were also analysed on a daily basis. It has been found that the sticky sheets catch males at a high level of efficiency for 2 to 3 days after being changed. After this, males decrease or often stop flying to the traps. This phenomenon was also observed when the surface of the sticky sheets was not full of specimens caught in the traps. According to our experience, in the case of the species observed change of the sticky sheets is necessary every 3 to 4 days, irrespective of the density of the catch. This assures continuous monitoring.

Besides monitoring the emergence, on the basis of the number of specimens caught hourly, it was found that in daytime the raspberry cane midge males fly in low numbers but continuously to the pheromone. Two peaks of emergence can be separated: one in the morning, and a stronger one early in the evening/at twilight (Figure 3).

The morning peak is often missing, whereas the strong emergence in the evening always takes place.

Conclusion

Analysing the meteorological data, it was concluded that

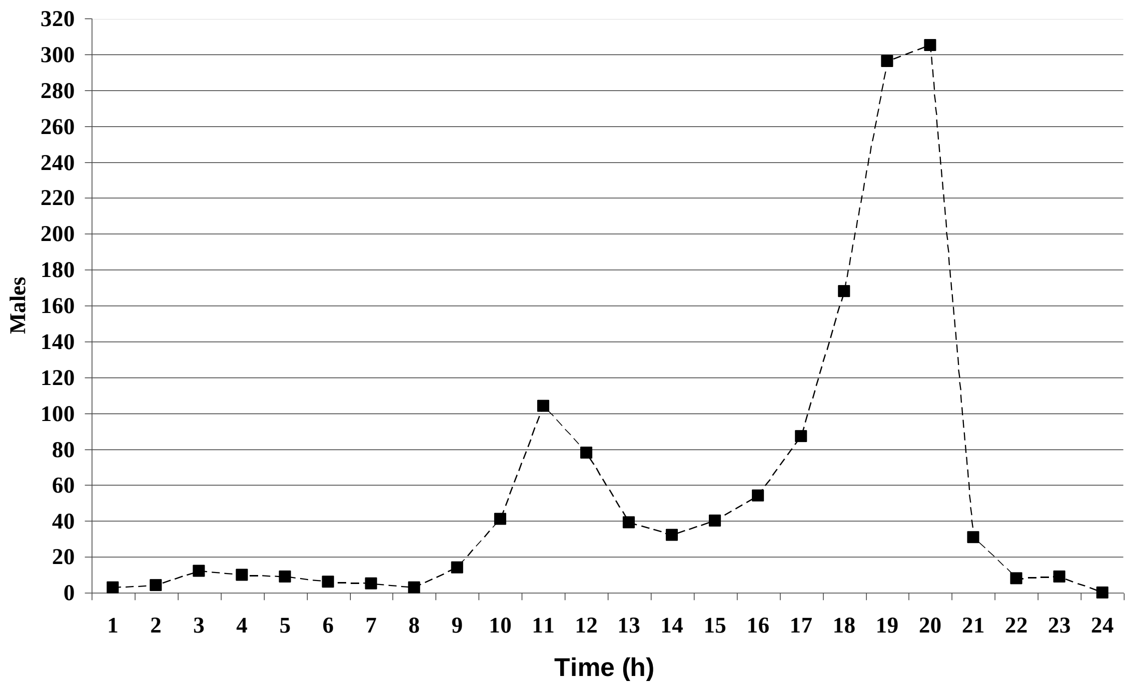

Figure 3. The daily flight activity of the raspberry cane midge males based on the catches of the automated trap (July 2009).

in rainy weather and strong winds the males do not fly to the traps. Unfortunately in the case of the raspberry cane midge, the automated trap requires regular attendance, since an automatic changing of sticky sheets has not been achieved. The sticky sheets should be changed according to the technical data sheet once a week. However, in order to monitor the flight of males continuously, changes twice a week are recommended.

In each of the three years of the experiment, based on the catches of the traps the emergence of the first specimens could be determined precisely to the day, due to continuous monitoring. The prediction of the beginning of the emergence of the pest can be solved by the automated trap, as the photos taken hourly or daily allow the detection of the flight of the first few specimens, which – combined with degree-day method – helps to predict the time of the oviposition or larva hatching en masse.

On the basis of the hourly catches of the automated trap the daily activity of certain species can be determined, or even the time of mass flight activity, which can be important in species where direct control measures should be taken against the imagos.

ACKNOWLEDGEMENT

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