Acta entomologica serbica, 2010, 15(1): 81-90 UDC 595.77(497.11)

MONITORING OF FLIGHT PHENOLOGY OF RASPBERRY CANE MIDGE *RESSELIELLA THEOBALDI* BARNES (DIPTERA: CECIDOMYIIDAE) BY PHEROMONE TRAPS IN WESTERN SERBIA

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Abstract

The flight phenology of the raspberry cane midge *Resseliella (Thomasiniana) theobaldi* Barnes (Diptera, Cecidomyiidae) was monitored over three successive years (2006-2008) in a raspberry orchard of the Fruit Research Institute Čačak, at the 'Zdravljak' site. This was the first time that large white delta traps baited with the raspberry cane midge sex pheromone were used. No insecticides were used during the monitoring period. Throughout the period, over three growing seasons, the midge presence was detected from April-May to September-October. During the three years, there were variations in the numbers of midges caught per trap, as well as those in the total numbers of midges trapped across years and peak numbers per trap. The highest total number (2,419) of midges during the season and the highest number of midges per trap in a sample (729) were recorded in 2007. The earliest maximum catch per trap (729) occurred on 11 May, 2007.

KEY WORDS: *Resseliella (Thomasiniana) theobaldi,* pheromone trap, midge number

Introduction

Among the harmful organisms present in raspberry plantations throughout Europe, pests of the family Cecidomyiidae are becoming increasingly important in Serbia (MILENKOVIĆ *et al*., 2006; MILENKOVIĆ & TANASKOVIĆ, 2007, 2008; TANASKOVIĆ *et al*., 2008; TANASKOVIĆ & MILENKOVIĆ, 2009). The raspberry cane midge *Resseliella theobaldi* (Barns) was described in the 1920s as a pest of raspberry in South-East England. During the 20th century, it became a significant economic pest in raspberry plantations throughout Europe.

The raspberry cane midge causes damage to the primocanes of raspberries by larval feeding under the epidermis of the canes. In these wounds several fungal infections can occur (*Fusarim spp., Altrernaria spp., Phoma spp., Leptosphaeria coniothyrium*). Two types of vascular lesion are present on the canes: brown lobate lesions (patches) confined to midge feeding areas, and brown lesions spreading proximally and distally from the point of infection (stripes). Either or both types of lesion may be presented in individual canes (WILLIAMSON & HARGREAVES, 1979). This complex of larval feeding and fungal infection is called "Midge Blight". Symptoms of midge blight are dark, sunken lesions on the canes, and the following year heavily infested canes can die back or fail to produce lateral shoots.

The first information on the insects in former Yugoslavia dates back to the 1960s (MASTEN, 1958). In our region (Serbia), the first written record dates back to the 1970s (DOBRIVOJEVIĆ, 1968 and SIMOVA-TOŠIĆ, 1970) and the first significant economic damage and incidence of "Midge Blight" were reported by KOPRIVICA *et al*. (2002) and MILENKOVIĆ *et al*. (2004).

R. theobaldi and *L. rubi* of the Cecidomyiidae (Diptera) family are serious economic pests spread throughout Europe. Within the certification schemes OEEP/EPPO (1993) for the *Rubus* genus and hybrids PM 4/10(1), these two pest insects are deemed damaging organisms which require preventive measures of monitoring (compulsory visual monitoring) aimed at the elimination thereof from the growing field (for all categories of reproductive planting material utilized for the propagation of certified planting material). Compulsory chemical control measures are envisaged within good agricultural practice (GAP 2/26(1)) of OEEP/EPPO (2002) schemes.

Due to the high economic importance of the above pests, the need has arisen to establish an economic threshold for raspberry cane midge over a season. By defining this threshold, depending on the variety and growing areas, the optimal time to spray and suppress the first generation can be recommended as the most important treatment to control midge populations.

Pheromone traps for *R. theobaldi* were first used in the UK in 2005. Serbia participated in the ring test for this species as part of the Working Group “Integrated Plant Protection in Fruit Crops”, Sub Group “Soft Fruits” and through the Raspberry Cane Midge Sex Pheromone Trap research project of East Malling Research coordinated by J. Cross. Standard white delta traps with holders, lures and bases were supplied by EMR. In this way, Serbia was included in the collaborative ring test with 8 European countries in 2006, 2007 and 2008 (MILENKOVIĆ *et al*., 2006; MILENKOVIĆ & TANASKOVIĆ, 2007; CROSS *et al.*, 2008).

Material and Methods

The trial was set up in the raspberry orchard of the Fruit Research Institute Čačak, at the 'Zdravljak' site, the coordinates being N 43°50'19.2" and E 20°18'32.0", the altitude 649 m, southern orientation. The orchard was established in 2002. It included five genotypes planted in a random design in 10 north-east facing rows with at least four replications per genotype and 50 plants per replication. The intra-row and inter-row planting distance was 0.33 m and 2.5 m respectively. Throughout the research period no insecticides were used in the orchard.

The trail was set up according to the protocol designed by Jerry Cross (East Malling Research- EMR) and David Hall (Natural Resource Institute - NRI). Collaboration was established within the Working Group “Integrated Plant Protection in Fruit Crops”, Sub Group “Soft Fruits” (IOBC/WPRS, Working Group on

Integrated Protection of Small Fruits). The entire process of investigations was based on scientific collaboration. Standard large white delta traps (20 x 20 cm base) with a raspberry cane midge pheromone derived from EMR and NRI were provided at the beginning of each season. Traps, lures and bases were kept in a fridge.

The traps were set up on 4 April 2006, 4 May 2007 and 14 April 2008.

Two white delta pheromone traps were deployed in the centre of the plantation at a spacing of at least 30 m. The bases were suspended at a height of 0.5 m above the ground. One trap was oriented parallel to the rows, the second one at right angles. Traps were baited with standard lures loaded with 10 µg of racemate, a major component of the raspberry cane midge sex pheromone (CROSS & HALL, 2006). The lures were replaced at 1 month intervals.

The sticky bases were refreshed weekly, unless there were no or very few midges that could be removed. The exact number of midges was counted on each recording occasion.

Results and Discussion

The traps provided a simple and easy method to monitor the flight activity of midges over the season and during the refreshment of the sticky bases and lures. Variations in total numbers of caught midges were recorded over seasons, months and traps (parallel vs. at right angles to the row).

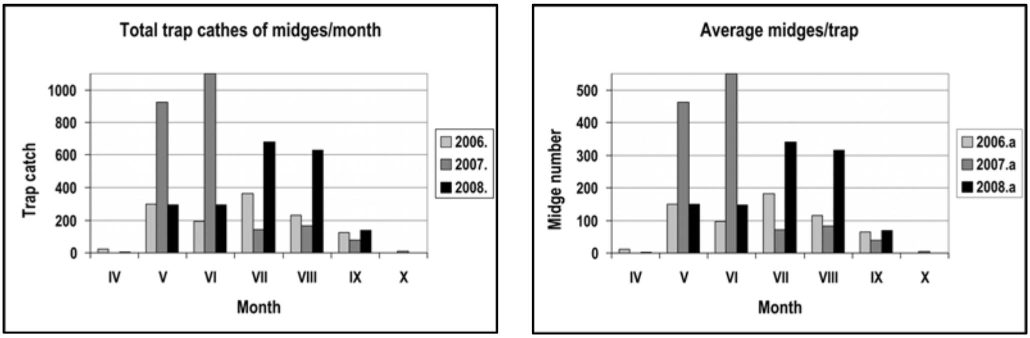

Figure 1. Total and average pheromone trap catches of midges in the tree years.

The lowest total number of midges (1,237) was captured during 2006 and the highest (2,419) during 2007. In the 2008 season, 2,046 midges were caught. These values, as compared to those obtained in 2006 at eight locations throughout Europe (CROSS & HALL, 2008), suggest that this site was highly endangered by the raspberry cane midge, the population thereof highly exceeding the nominal threshold of 30 midges/trap/week (Tab. I)

Table I. Pheromone trap catches of midges during vegetation.

week	Julian day			Number of imagoes on traps: T 1 parallel			T 2 at right angles			Monthly catches in: Traps parallel to the rows			Traps at right angles to the rows			Total monthly trap catches		
	'06	'07	'08	'06	'07	'08	'06	'07	'08	'06	'07	'08	'06	'07	'08	'06	'07	'08
14.	101			2			2											
15.	111		113	4		0	3		3	11			11			22		
16.	120		120	5		0	6		2			0			5			5
17.	128	131	127	8	498	NC	2	241	NC									
18.	136	138	134	39	92	36	18	60	70	198	603	106	101	322	192	299	925	298
19.	142	145	141	83	13	22	53	21	68									
20.	150	152	148	68	23	48	28	7	54									
21.	157	159	155	8	29	27	4	30	25									
22.	164	166	162	16	122	13	22	233	12	88	494	127	105	606	167	193	1100	294
23.	171	173	169	26	142	22	35	243	49									
24.	178	180	176	38	178	65	44	93	81									
25.	185	187	183	78	36	97	86	11	92									
26.	192	194	190	36	30	93	53	12	71	128	107		173	34		364	141	
27.	198	201	197	24	NC	33	17	NC	39			338			343			681
28.	204	208	204	44	41	37	16	11	54									
29.	211	215	211	65	12	78	73	14	87									
30.	218	222	218	5	7	44	13	3	72	105			127			232		
31.	225	229	225	35	6	79	41	2	154		78	259		89	371		167	630
32.	232	236	232	NC	48	136	NC	57	145									
33.	245	242	239	31	5	NC	57	13	NC									
34.	253	249	246	5	8	29	13	2	85	46			81			127		
35.	260	256	253	5	8	6	6	6	18		47	35		32	103		79	138
36.	267	263	260	5	9	0	5	9	0									
37.	276	270		0	22		0	15		0			0			0		
38.	283	277		0	0		0	3										
39.		284			2			2			2			5			7	
40.		291			0			0										
Total				630	1.331	865	597	1.088	1.181		2.826			2.866		1.237	2.419	2.046
															Total		5.702	

The largest catches of midges/month in the traps in 2007 were in May (925) and June (1,100). The highest number in the remaining two seasons was found in May (299) and July (364) in 2006 and in July (681) and August (630) in 2008.

A comparison of the total number of midges captured by trap (parallel: at right angles to the rows) revealed increasing differences in the number between the growing seasons (Tab. I). However, while in the first two growing seasons the highest number of midges were caught in traps placed in parallel, the largest difference in numbers was observed in the third year - but in the traps deployed at right angles to the rows.

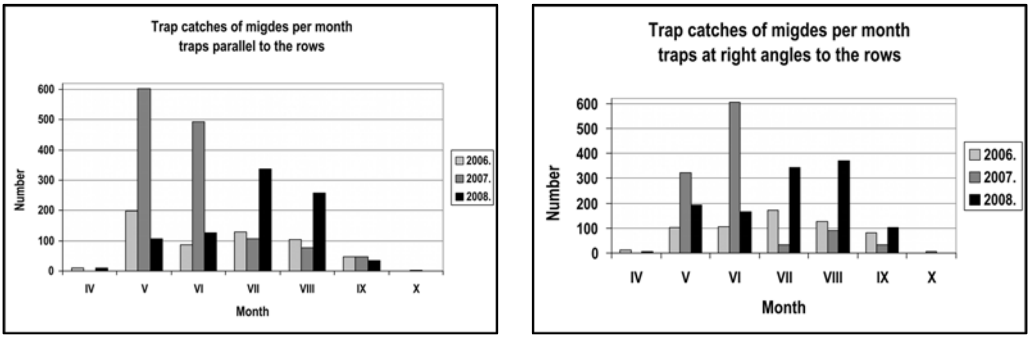

Figure 2. Pheromone trap catches of midges in traps deployed parallel and at right angles to the rows.

Based on the total number of captured midges and the calculated average value per trap (Fig. 1), four peaks are clearly observed. Variations in the numbers of midges are clearly visible. The first peak flight of the raspberry cane midge i.e. the maximum number of adult male midges captured was recorded during the intensive growth of primocanes (May). Considering the fact that the traps were deployed in an untreated plantation, the number remained at a very high level during June. Importantly, the number of captured midges grew in July-August during the three observed seasons. This indicated the necessity of applying chemical treatment after harvest with the aim of significantly reducing the raspberry cane midge population in plantations.

In general, the observed variations in the total numbers of captured adult males most likely reflect interactions among several factors, some of which include the history of insecticide use, age and susceptibility of a variety. Moreover, high importance is attached to the impact of meteorological factors (high temperature and humidity). The first investigated season was the first year of non-use of insecticides. The highest total number of captured midges was recorded in the second season.

The flight dynamics, as monitored by the weekly catches of midges (Tab. I and Figs. 3 & 4), clearly suggested peaks of adult flight.

Three peak catches of male midges were recorded in 2006 – on 22 May (136), 5 July (164) and 8 August (138). In the following growing season, lures were deployed a month later. The first inspection (11 May 2007) showed a peak catch of 739 specimens and a sudden drop in their number on the following three recording occasions.

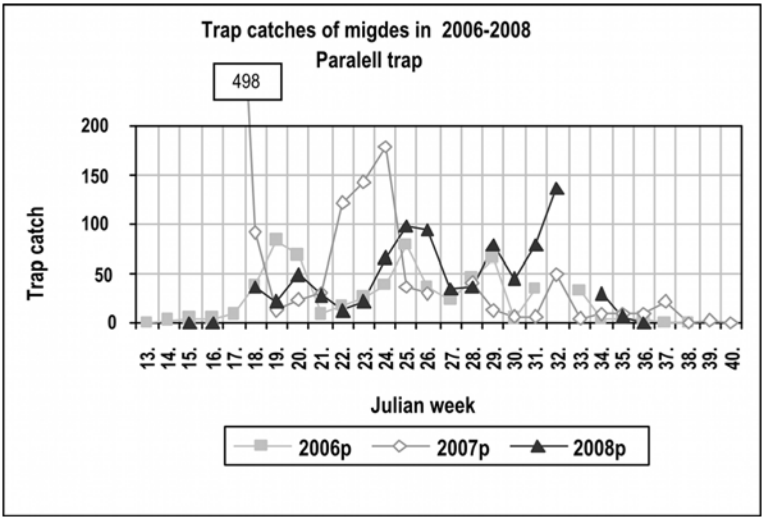

Figure 3. Pheromone catches of midges in traps parallel to the rows at the Zdravljak site in 2006-2008.

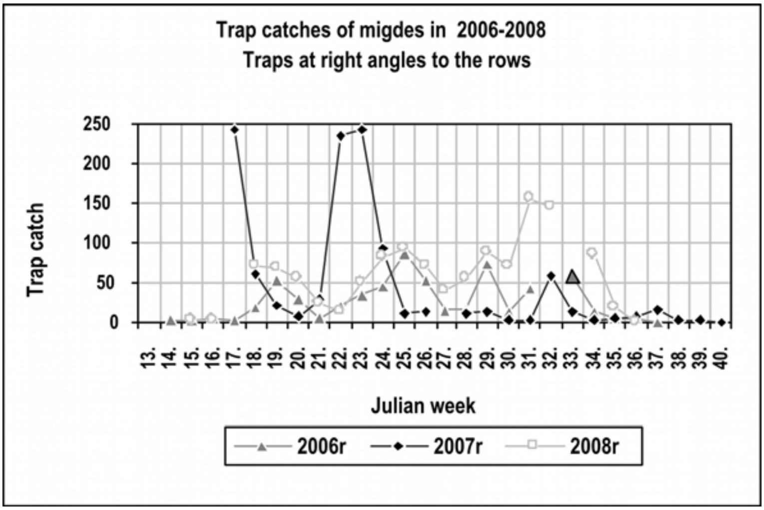

Figure 4. Pheromone catches of midges in traps at right angles to the rows at the Zdravljak site in 2006-2008.

The next peak was recorded on 22 June (385) but the number of captured midges decreased until 24 August (105). The 2007 growing season was characterized by much higher temperatures (> 35 °C). During 2008, three peak midge catches were recorded - on 22 May (106), 1 July (189) and 19 August (281). The final flight activity of the raspberry cane midge occurred from the second half of September to the end of October throughout the research period, over three growing seasons, recorded on 5 and 26 October (2006 and 2007, respectively) and 16 September 2008.

The objective of this study was to investigate the seasonal flight activity of the raspberry cane midge at the observed location. The protocol employed prescribed a nominal threshold of 30 midges captured per trap/week. One-year collaborative investigations conducted at 16 locations over the 2006 growing season revealed a high number, which had to be corrected for different cropping systems (protected or open-field cultivation) and varieties (CROSS & HALL, 2008).

According to Dr. Cross's data (personal communication) for Kent (UK), the number of caught midges varies under open-field conditions over the season. Our data on the Zdravljak location indicate that this location (with a high number of captured midges) is at great risk of being damaged if control measures are not applied. The first records of spraying under our conditions were provided by MILENKOVIĆ *et al*. (2004).

It is noteworthy that the raspberry orchard is situated outside the intensive raspberry growing area. The location is practically isolated; otherwise the number of captured midges would be several times higher under no-insecticide conditions.

The number of caught midges varied largely over the investigated period. It is of utmost importance to continue monitoring the flight activity of raspberry cane midge. The collected data indicated that the flight activity, flight peaks and the maximum number of captured specimens of this economically important pest were highly impacted by meteorological data (temperature and humidity), size of plantations, susceptibility of variety and intensity of agricultural practices in and around the raspberry plantations.

The occurrence of the first generation can be clearly distinct, with the increasing number of caught midges reaching a peak and declining thereafter. The following two generations overlapped. The fourth generation and the adult flight under open-field conditions resulted from the effect of temperatures and humidity. The above results fully comply with the data obtained at 16 monitoring sites across Europe under open-field conditions (CROSS & HALL, 2008).

The first data on the flight phenology of raspberry cane midge in the Balkan region were reported by MILENKOVIĆ *et al*. (2006) and MILENKOVIĆ & TANASKOVIĆ (2007). The wide occurrence and distribution of this pest and its high economic importance necessitate the need to redefine the current crop protection programme. The necessity is also highlighted by the data obtained during this study. Insecticides are recommended for use during the intensive primocane growth and after harvest to reduce midge numbers in the field.

In view of the importance of the raspberry crop, monitoring of all major growing areas is required because forecasts cannot predict future emergence of the pest based on that of the previous season, which is very important in signalling the optimum time for an insecticide application aimed at suppressing the first generation raspberry cane midges.

Therefore, effective control relies on predicting the accurate date of emergence of the adult midges and targeting the spraying with an insecticide to the base of the primocanes in spring. This will, accordingly, prevent the survival of enough midges to cause feeding damage and subsequent cane death ("Midge Blight") that will lead to loss of yield in the following year.

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ПРАЋЕЊЕ ЛЕТА МАЛИНИНИНЕ МУШИЦЕ *RESSELIELLA THEOBALDI* BARNES *(DIPTERA, CECIDOMYIIDAE)* ФЕРОМОНСКИМ КЛОПКАМА НА ПОДРУЧЈУ ЗАПАДНЕ СРБИЈЕ

СНЕЖАНА ТАНАСКОВИЋ И СЛОБОДАН МИЛЕНКОВИЋ

Извод

Малинина мушица *Resseliella* (*Thomasiniana*) *theobaldi* (Barnes) представља економски све значајнију штеточину у малинарским регијама широм Европе. Штете које причињава могу бити примарне (као последица исхране ларви малинине мушице) и секундарне - последица су гљивичних инфекција (*Fusarim spp., Altrernaria spp., Phoma spp., Leptosphaeria coniothyrium*) на местима исхране ларви. Синдром сушења настаје као последица интеракције штеточине и патогена, а идентификује се као цецидиозно сушење. Први подаци о малининој мушици на нашим просторима датирају из седамдесетих година прошлог века, DOBRIVOJEVIĆ (1968) и SIMOVA-TOŠIĆ (1970), а прве економски значајне штете региструју KOPRIVICA *et al*. (2002) и MILENKOVIĆ *et al*. (2004).

Због високе економске значајности намеће се потреба за одређивањем економског прага штетности малинине мушице током вегатације. Његовим утврђивањем, зависно од сорте и подручја гајења, препоручило би се и оптимално време за сузбијање прве генерације, као најважнији третман, у контроли бројности популације.

Током 2005. године по први пут су феромонске клопке за ову врсту коришћене у Великој Британији. У оквиру радне групе за интегралну заштиту јагодастог воћа, а кроз истраживачки пројекат East Malling Research, чији је руководилац J. Cross, "Raspberry Cane Midge Sex Pheromone Trap" добијене су стандардне беле делта клопке са држачима. На овај начин Србија је током 2006 (MILENKOVIĆ *et al*., 2006), 2007. и 2008. године укључена у RING TEST за ову инсекатску врсту.

Клопке су постављене у колекционом засаду малине Института за воћарство Чачак, на објекту „Здрављак“, са координатама N 43°50'19,2" и E 20°18'32,0", на надморској висини 649 m и смер S, подигнутом 2002. године. Замена лепљивих површина и пребројавање ухваћених имага обављано је седмично, приближно у исто доба дана, од почетка вегетације до краја септембра или октобра, током три године.

Клопке су постављене 4. (2006) и 14. априла (2008) односно 4. маја (2007). Током 2006. године издвајају се три максимума ухваћених мужјака и то 22. мај (136), 5. јул (164), 8. август (138). У првом прегледу, 11. маја 2007. године регистровано је 739 јединки и нагли пад бројности у наредна три прегледа. Наредни максимум регистрован је 22. јуна (385) са регистрованим падом бројности све до максимума 24. августа (105). Током 2008. године регистрована су три максимума, 13. маја (106), 1. јула (189) и 19. августа (281). Крај лета малинине мушице варира од половине септембра до краја октобра током трогодишњег периода, а регистрован је 5. и 26. октобра (2006. и 2007) односно 16. септембра 2008. године.

Из података се може уочити различита бројност ухваћених мужјака током посматраног периода, али и неопходност даљег праћења динамике лета ове штеточине. Прикупљени подаци указују да у оквиру локалитета висок утицај на динамику лета и максималну бројност ове економски значајне штеточине остварују абитски чиниоци (температура и влага), површина засада и интензивност агротехничких мера у парцелама око експерименталног засада.

Received October 16th, 2009
Accepted May 25th, 2010