Monitoring of San Jose Scale (*Diaspidiotus perniciosus*) Occurrence and Comparison of Temperature Models

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Abstract: The San Jose scale (*Diaspidiotus perniciosus*) is a wide spread pest all over the world. Its harmfulness is increasing over the last years in the Czech Republic (especially in South Moravia), where our experiment was based. Firstly we were testing different pheromone traps (Wing Trap, Delta Trap, open trap) suitable for monitoring of the San Jose scale male occurrence in two different orchards. The second area of our research was to compare different temperature models with our measured effective temperature sums that were set mainly for biofix (occurrence of first male in a trap) and occurrence of crawlers. Delta Trap appeared as the best to catch the San Jose scale male. Temperature model according to Buhroo et al. [1] is the most suitable in prediction of males and crawlers in the Czech Republic. Nevertheless it is necessary to observe the occurrence of this pest also directly on trees.

Key-Words: San Jose scale, pheromone, trap, crawler, effective temperature sum, degree day

Introduction

The San Jose scale (*Diaspidiotus perniciosus*) is known all over the world and it is widely distributed. This pest is important especially in fruit production and it is often intercepted in quarantine mainly on oranges and tangerines [2]. The European Union deleted it from the list of quarantine pests because of its extension in almost all European states. Significant damages are recorded on apples, pears, peaches, plums, currants and many other plants. The scale develops on vegetative organs, blossoms and fruits. It occurs the most on bark of strain and branches. Due to suction of plant saps the trees may die [3]. The population of the San Jose scale started to graduate at the end of the 90s because of elimination of nonselective pesticides in the integrated pest management in the Czech Republic [4].

The San Jose scale is almost all its life protected by cover that makes a protection against this pest very difficult. The applied pesticides can not get to any sensitive part of its body. Consequently they have none or very low effect. The only stage that is sensitive to treatments is larva (crawler) that crawl out of female cover after 33 to 40 days after fertilization. When the crawlers find a suitable place to suck they settle down and start to make their own cover. It can happen even after two hours if the conditions are appropriate. Therefore it is necessary to manage the application of pesticides in time [2]. The emergence of males is observed using pheromone traps.

Modeling of effective temperature sum can be used to predict the emergence of males and crawlers. The crawlers from overwintering generation (the first generation) need less than 500 day degrees (DD) to develop, crawlers from the second generation need 770 DD (for the lower developmental threshold 7.3°C) [5].

The aim of this research was to find the suitable combination of a pheromone trap and a model of effective temperature sum for exact determination of time to apply the treatments against the crawlers of the San Jose scale.

Material and Methods

The experiment was done in 2014 in pear orchard (using biological control) in Kobyli and in apple orchard and peach orchard (using integrated pest management) in Tesetice.

We cut 20 two-year branches (20 cm long) on March 10th in Kobyli and on March 14th in Tesetice in each orchard. Then the overwintering scales were counted using a microscope and it was determined the average counts of scales per one meter of branch. The total attack of trees was defined.

The presumed terms of emergence of males and crawlers were set according to Alston et al. [6] and using of data from online meteorological station in our localities.

The pheromone traps for observing amount of males were installed on April 18th on three places (A, B, C) in each orchard. We used three types of traps on each place. The small open trap was constructed from white sticky board and wire (Fig. 1). Then we tested common Delta Trap (Fig. 2) and Wing Trap (Fig. 3). The parameters of the traps are written in the following table 1.

Sexual pheromone of San Jose scale female from International Pheromone Systems Ltd was used in all traps.

Table 1 Types of pheromone traps

Type of trap	Size (cm)	Sticky surface (cm^2)	Producer
Open trap	12 × 14	168	White sticky board by Biocont Laboratory
Delta Trap	12 × 20	240	Csalomon
Wing Trap	17.5 × 22.5	393.75	Gemplers

The traps had been observing daily since April 20th to determinate the exact term of biofix (the first male catch in a trap). Then the control had been doing twice a week till the end of male flying. The sticky boards in the traps had been changing regularly depending on other insects that get on sticky board. Males were counted using microscope in laboratory. The results are in the table 2.

Occurrence of crawlers was determined using double site sticky tape on branches. They were checked every day in expected period of crawler emergence.

The effective temperature sums were recorded from data from meteorological stations (operated by AMET – association Litschmann & Suchy) in orchards for biofix and time of crawler emergence. These effective temperature sums were compared with temperature models according to Alston et al. [6], Buhroo et al. [1], Jorgensen et al. [7] and Rice et al. [8]. The observing was done in two generations of San Jose scale. The pheromone was changed on July 10th.

Results and Discussion

Comparison of different type of pheromone traps

We determined the attack of San Jose scale. There were 44.5 overwintering scales per meter of branch in Kobyli and 267.75 overwintering scales per meter of branch in Tesetice. The male counts in different traps are written in the tables 2 and 3 for the location Kobyli and Tesetice respectively.

In Kobyli the biggest amounts of males were found in Wing Traps in two places and in Delta Trap in one place. In Tesetice the biggest amounts of males were found in Delta Traps in two places and in open trap in one place. The males from overwintering generation were not register in Tesetice at all.

Table 2 Comparison of different types of pheromone traps in Kobyli

	A		B		C	
	2nd generation	1st generation	2nd generation	1st generation	2nd generation	1st generation
Open trap	58	16	27	20	12	25
Delta trap	**66**	**44**	31	33	13	49
Wing trap	28	30	**270**	**38**	**34**	**101**

Legend: 2nd generation – males from the overwintering generation; 1st generation – males from the summer generation

Table 3 Comparison of different types of pheromone traps in Tesetice

	A		B		C	
	2nd generation	1st generation	2nd generation	1st generation	2nd generation	1st generation
Open trap	0	9	0	14	0	**67**
Delta trap	0	**12**	0	**28**	0	40
Wing trap	0	2	0	10	0	40

Legend: 2nd generation – males from the overwintering generation; 1st generation – males from the summer generation.

Efficiency of different types of traps for San Jose scale males had been checked in 1978 – 1980 in California, Washington and Oregon. They used two basic types of traps, open traps and closed traps similar to Delta Traps. The open trap was established as the most effective [9], but it has not been proved in our experiment.

In practical point of view the Delta traps appeared as the most convenient. It was difficult to count San Jose scale males from the Wing Trap due to big amount of other insects and results could be inexact.

Comparison of effective temperature sums

The effective temperature sums (with lower developmental threshold 10.6°C and upper developmental threshold 32.2°C) were calculated in terms of installation of the traps, biofix and emergence of crawlers in both generations and the length of generation in both localities (table 4). They can be compared with effective temperature sums set by Alston et al. [6], Buhroo et al. [1], Jorgensen et al. [7] and Rice et al. [8] in table 5.

The absence of males from overwintering generation was the main problem in Tesetice in comparison with Kobyli. It could be caused by different systems of pest management or climatic conditions.

San Jose scale males mate with the females immediately after eclosing, and then die after mating [9]. If they eclose in close proximity to the female, they can register her pheromone rather ten pheromone in the trap. The reason can be also small amount of males in the population, even though males should greatly outnumber females in the overwintering generation [2].

Temperature models that are based on biofix do not allow counting of next terms in case of biofix absence. Big differences are evident by comparison of our measured effective temperature sums and sums in temperature models. Therefore it is not possible to rely only on this prediction systems but it is necessary to observe the San Jose scale development by eye and using a microscope.

Table 4 Measured effective temperature sums in Kobyli and Tesetice

	Instalation of pheromone traps (DD)	Biofix 1 (DD)	Crawlers 1 (DD)	Biofix 2 (DD)	Crawlers 2 (DD)	Lenght of a generation (DD)
Kobyli	49	135	324 (189 since biofix 1)	726	1021	697
Tesetice	20	-	259	556	886	627

Legend: Biofix 1 – the first male catch from the overwintering generation; Crawlers 1 – crawlers from the first (summer) generation; DD – day degree; Biofix 2 – the first male catch from the summer generation; Crawlers 2 – crawlers from the second (overwintering) generation.

Table 5 Degree-day accumulation according to Alston et al. (2011), Buhroo et al. (2001), Jorgensen et al. (2000) and Rice et al. (1982)

	Instalation of pheromone traps (DD)	Biofix 1 (DD)	Crawlers 1 (DD)	Biofix 2 (DD)	Crawlers 2 (DD)	Lenght of a generation (DD)
Alston et al. (2011)	102	135	207 since biofix 1			
Buhroo et al. (2001)		141	279	692	736	457
Jorgensen et al. (2000)	111		128 since biofix 1			583
Rice et al. (1982)			225			583

Legend: Biofix 1 – the first male catch from the overwintering generation; Crawlers 1 – crawlers from the first (summer) generation; DD – day degree; Biofix 2 – the first male catch from the summer generation; Crawlers 2 – crawlers from the second (overwintering) generation.

Conclusion

The biggest amount of males was determined in the Wing Traps in Kobyli and in Delta Trap in Tesetice where was the problem to catch males from the overwintering generation. From practical point of view the Delta Trap is the most suitable.

The optimal temperature model for using in the Czech Republic is according to Buhroo et al. [1] due to the problems to set the first biofix. Although it is necessary to control the pest directly on plants and we can not rely only on the prediction system.

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Fig. 1 Open trap

Fig. 2 Delta trap

Fig. 3 Wing trap

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