THE LIFESTYLE OF THE INVASIVE ZIGZAG ELM SAWFLY (*APROCEROS LEUCOPODA* TAKEUCHI, 1939)

Thesis of doctoral (Ph.D) dissertation

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Budapest

2018

PhD School

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1. BACKGROUND AND OBJECTIVES

The overpopulation of any insect species in natural and semi-natural ecosystems can cause serious economic or environmental harm and can also have negative effect on the health of humans, animals or plants. This is especially true for some non-native species, when climatic factors and food sources are adequate and available, and natural enemies (predators, parasitoids, microorganisms) are only presented in a limited number or not presented at all in the new area, so their population can grow faster than in their native habitat. These non-native or introduced species that have become widespread are called invasive species. One of the earliest and perhaps the most known invasive species in our country is the phylloxera (*Daktulosphaira vitifoliae*) that destroyed most of the vineyards in Hungary. The subject of my dissertation, the zigzag elm sawfly (*Aproceros leucopoda*) is also one of these pests.

The territory of elms in Hungary (ca. 12,000 ha) is not so significant, but they are ecologically and economically important members of the broadleaf forest plant communities. There are specialist and also generalist pests among herbivours of elms, however the most harmful damage of the last 100 years was not caused by insects. Bark beetles are the main vectors of fungus *Ophiostoma novo-ulmi*, which causes the Dutch elm disease (DED). As a result of DED, during the last century elms suffered major losses with the near-total disappearance of adult trees in many European areas. The territorial coverage of the domestic elm species has also decreased considerably in Hungary, so it is important now that we protect them from the new pests and pathogens. By introducing resistant Asian elm species (for example *Ulmus pumila*), the damage of the DED can be reduced.

The appearance of zigzag elm sawfly in Hungary has brought new challenges for the plant and forest protection experts, because *U. pumila* seems to be a preferred host of *A. leucopoda* and having already suffered severe defoliation based on the literature. The early detection of non-native, invasive species and the knowledge of their biology are essential to develop an effective plant protection strategy to mitigate the damage.

The aims of my study were the following:

- to carry out studies to obtain information on the overwintering and cold tolerance strategy of *Aproceros leucopoda*.
- to gain information on the influence of temperature on the development rate and survival of *A. leucopoda* under laboratory conditions in order to extend the knowledge about its biology.
- to determine the lower threshold temperature and the thermal constant of *A. leucopoda*, to help develop an effective pest management program to control adequately the populations of the species.
- to identify possible host plant species beyond the *Ulmus* species, that have already been known from the literature
- to develop an efficient trapping method in order to help the signalization of the species.

2. MATERIALS AND METHODS

Aproceros leucopoda individuals were collected from a 15 ha large mixed forest plantation comprising Siberian elm (*Ulmus pumila*) and black locust (*Robinia pseudoacacia*) located at Kecskemét (46.9901°N, 19.6729°E). The plantation was established in 1999, and since 2011 *A. leucopoda* has been observed to cause significant loss of foliage there.

2.1. Examination of overwintering and cold hardiness of *Aproceros leucopoda*

2.1.1. The overwintering of *Aproceros leucopoda*

The zigzag elm sawfly overwinters in the soil as eonymph within a solid double-walled cocoon. The eonymphs need cold effect to break their diapause. I have tried to identify time span and extent of the cold effect that is needed to continue the development. I have examined two aspects at the same time in order to provide the answer for my questions. Firstly, I collected overwintering specimens in autumn (9th and 16th October 2014) and kept them for a different length of time (10 to 50 days) at low temperatures (5.6°C and 8.8°C), and on the other hand, I collected field samples during the winter season in every two weeks. In both experiments, I put the cocoons into a climate chamber after the cold treatment and kept under same conditions (23°C).

2.1.2. The cold tolerance strategy of *Aproceros leucopoda*

To identify the lowest temperature that the *A. leucopoda* eonymphs can survive I measured their SCP values. I repeated the measurement several times: during the winter of 2013-14, and in March of 2015 and of 2017 in the laboratory of the Institute of Forest Entomology, Forest Pathology and Forest Protection, University of Natural Resources and Life Sciences Vienna, Austria. In 2015, I also measured the values of SCP of two samples from Italy. During the statistical analyses, the effect of weight, year and geographic location, and the role of cocoons affecting the SCP values was examined.

2.2. Identifying lower temperature threshold and sum effective temperature

2.2.1. Thermal influence on development

To improve our knowledge of the biology of *A. leucopoda*, the development of the species was studied under laboratory conditions at six constant temperatures: 10.9°C, 15°C, 19.5°C, 23°C, 24.3°C and 27°C. The relative humidity was between 65 and 80 % and the day lengths was 16L:8D. *U. pumila* is known as a preferred host plant of *A. leucopoda* so I used this plant as a host in all experiments. The larvae were reared individually in Petri dishes (except on 27°C), because development the different larval stages can not be reliable distinguished by morphological characters. The development of the individuals were checked every 24 hours.

2.2.2. Development time of *Aproceros leucopoda*

The relationship between temperature and development rates of eggs, larvae, prepupae, pupae and one generation was described by the linear degree-day model and by the non-linear Lactin-2 model. The lower development threshold (T_{min}) and the sum of effective temperatures (K) of developmental stages and one generation were determined using these two.

The upper temperature thresholds (T_{max}) and the optimum temperature (T_{opt}) of development of *A. leucopoda* were also estimated by the Lactin-2 model. The R^2 values, the model parameters together with the significances of the models and of their parameters were also calculated. The thermal constants (K) were estimated by the T_{min} value determined by the Lactin-2 model.

2.2.3. Numbers of generations of *Aproceros leucopoda* in Hungary

The number of generations of *A. leucopoda* was calculated for five sites in Hungary that represent a range of climates within the country. *A. leucopoda* overwinters as an eonymph. Although the exact environmental conditions that induce and terminate diapause of the species have not yet been determined, the potential time available for seasonal population growth at each site was calculated for a hypothetically 'long season' (1 April – 30 September) and a 'short season' (1 May – 31 August). The estimated numbers of degree-days (thermal accumulation) available for *A. leucopoda* development at each site were then calculated from daily average temperatures with a developmental threshold of T_{min} (estimated with linear and Lactin-2 model). The potential number of generations per annum was then estimated from the thermal accumulation/K.

2.3. Host-specificity testing of *Aproceros leucopoda*

2.3.1. Field experiment

The oviposition test as a preliminary trial of the host-specificity test was carried out in 2013 in the territory of the National Botanical Garden, Vácrátót and in Buda Arboretum, Budapest. During the examination of the host specificity of the zigzag elm sawfly, I examined nine plant species under field conditions. From the nine species, there was one that was a preferred host plant (*U. pumila*) and an *Ulmus* species from Europe (*U. laevis*), from North- America (*U. crassifolia*) and from the Far East (U. *parvifolia*). I examined two species that belong to the Ulmaceae family, but are not *Ulmus* genus (*Z. serrata, H. davidii*). Two *Celtis* species in the field study were in a wider relationship with *Ulmus* genus (*C. occidentalis, C. australis*). Finally, subspecies of the narrow-leafed ash, the *F. angustifolia* subsp. *pannonica* species was included in the experiment, because it appears often in the oak-ash-elm mixed forests. Seven insect rearing bags were placed on every abovementioned plant species, each with an *A. leucopoda* pupae. At the end of the experiment I checked, whether the females emerged, egg laying was carried out, larvae hatched from the eggs, and the hatched specimens were able to developed further.

2.3.2. Laboratory experiment

I continued the host-specificity tests during the summer of 2015 in laboratory conditions. For the oviposition and feeding tests a non-choice test was applied. In the study, based on my previous experience, five species – *H. davidii, U. crassifolia, U. laevis, U. parvifolia* and *U. pumila* – were involved.

2.4. Trapping studies

2.4.1. Applicability of coloured traps for the monitoring

The first aim of the trapping studies was to test the applicability and effectiveness of traps of three different colours. White, yellow, fluorescent yellow "cloak" trap with a sticky surface Csalomon® (PAL) were tested. The trapping period was set to coincide with the peak of the second emergence of adults at the study site, in order to catch as many specimens as possible with the different traps.

2.4.2. Determination of the effective trapping height

For the selection of the most effective trapping heights of the emerging overwintering imagines fluorescent yellow "cloak" traps, three different heights were used: 0.5 meters, 2 meters and 8 meters. The experiments were carried out in two consecutive years (2013, 2014).

3. RESULTS

3.1. Overwintering and cold hardiness of *Aproceros leucopoda*

3.1.1. Results of overwintering studies

Under laboratory conditions, only limited number of imagines emerged from the cocoons that got shorter cold effect. However with increasing of the length of cold effect it was gradually increased. After 50 days (the longest period) of 8.8°C and 5.6°C cold, 68.8% and 71% of the overwintering eonymphs developed further respectively. In field conditions individuals have effected by quantity and quality of cold by mid–December that was sufficient for more than 80% of them to develop further.

During the overwintering studies, I managed to develop a new parasitoid wasp of the zigzag elm sawfly from the overwintering cocoons, called *Aptesis cretatoides* (Hymenoptera: Ichneumonidae), which is a newly described species.

3.1.2. The cold tolerance strategy of *Aproceros leucopoda*

Based on the results of the repeated measurements, the mean SCP value of the pest was about –18°C. In most cases, the value of SCP was not affected by the body mass of the individuals. I found significant differences when comparing samples from different collecting periods and collection sites. The SCP value was also influenced by the presence of cocoon. After reaching the SCP temperature, *A. leucopoda* eonymphs were kept at room temperature for 24 hours to examine, whether the individuals survived the treatment despite the ice crystalline formation. As a result they did not show any signs of life at all.

3.2. The development of *Aproceros leucopoda*

3.2.1. Thermal influence on development

Aproceros leucopoda completed development at all temperatures examined except 27.0°C where all individuals died in the eonymphal stage at the latest. The mean development time (days) decreased with increasing temperature in all stages and the increase was significant in most cases. The egg stage was the shortest at 27.0°C, averaging 4.1 days. By contrast, egg development was about five times slower at 10.9°C, averaging 20.2 days. For the development of a whole generation, approx. 23.5 and 85 days were required at 24.3°C and 10.9°C, respectively.

Aproceros leucopoda developed through 4–7 larval instars before spinning a cocoon to pupate. However, at each temperature, more than 50% of the individuals developed into eonymphs following the sixth instar.

The highest mortality was observed at the two extreme temperatures. At 27.0°C and 10.9°C, 100% and 98% of the individuals died, respectively.

The average adult lifespan was the shortest at 24.3°C, approx. 3 days, and the longest at 10.9°C, almost 8 days. The average number of eggs laid by a female was the highest (36.7) at 15°C, but more than 10% of the individuals at this temperature laid more than 60 eggs as a total. Based on the average daily fecundity data of the females reared at different temperatures, it was found that, except for 10.9°C, females deposited most eggs on the first day after emergence and more than 65% of the eggs were laid during the first two days after emergence.

3.2.2. Developmental time of *Aproceros leucopoda*

Using the linear and Lactin-2 models, the lower (T_{min}) and upper (T_{max}) threshold temperatures, optimal developmental temperature (T_{opt}) and the sum of effective temperatures (K) for development were calculated (Table 1). T_{min} and K can be considered almost identical for the two models. For one generation, T_{min} in the case of the linear model and the Lactin-2 model were 7.3°C and 7.1°C, while K was 426.5 DD and 432.7 DD, respectively.

Table 1 Calculated parameters derived from the estimated parameters of the linear and the Lactin-2 models used to describe the effect of temperature on the development of *Aproceros leucopoda* egg, larval, prepupal and pupal stages and one whole generation (temperature is expressed in °C, and the thermal constant K in degree-days; N: Number of specimens)

<table>
<tr><th></th><th></th><th>Egg</th><th>N</th><th>Larva</th><th>N</th><th>Prepupa</th><th>N</th><th>Pupa</th><th>N</th><th>One generation</th><th>N</th></tr>
<tr><td rowspan="2">Linear model</td><td>T_{min}</td><td>9.2</td><td rowspan="6">584</td><td>6.9</td><td rowspan="6">324</td><td>5.9</td><td rowspan="6">315</td><td>8.7</td><td rowspan="6">306</td><td>7.3</td><td rowspan="6">306</td></tr>
<tr><td>K</td><td>77.5</td><td>240.4</td><td>41.1</td><td>53.9</td><td>426.5</td></tr>
<tr><td rowspan="4">Lactin-2 model</td><td>T_{min}</td><td>8.6</td><td>6.6</td><td>5.1</td><td>8.1</td><td>7.1</td></tr>
<tr><td>T_{max}</td><td>34.7</td><td>29.0</td><td>27.0</td><td>27.0</td><td>27.0</td></tr>
<tr><td>T_{opt}</td><td>33.6</td><td>29.0</td><td>24.9</td><td>26.5</td><td>26.4</td></tr>
<tr><td>K</td><td>86.5</td><td>245.9</td><td>42.9</td><td>57.2</td><td>432.7</td></tr>
</table>

I compared the results with the data gained in an open field study that was carried out in Martonvásár, 2011 (LOVAS 2012). I tried to predict the peaks of flight activity with the results based on the Lactin-2 model, and I got accurate prediction, but with the results based on the linear model, I predicted the peaks for 5-6 days later than it was observed in the nature.

3.2.3. Number of generations of *Aproceros leucopoda* in Hungary

The number of degree-days above 7.3°C in the case of the linear model or 7.1°C in the case of the Lactin-2 model available for development at each site indicates that the zigzag elm sawfly may be capable of producing 4–5 generations per year in Hungary. The temperature data for the individual years also demonstrated that some seasonal variation may occur. For example, in Budapest there may be 6 generations in a warm year (in a 'long season', e.g. 2003 and 2009), but only 4 generations in a cool year (in a 'short season', e.g. 2004–2006). Development in the western part of Hungary (site Szombathely) is limited to 4 generations a year

3.3. The host-specificity of *Aproceros leucopoda*

3.3.1. The results of the field experiment

During the field experiment Aproceros leucopoda females laid eggs on only four species: *U. pumila*, *U. laevis*, *Z. serrata* and *H. davidii*. On the leaves of *U. pumila* I did not find the marks of eggs laying in every cases as the larvae fed the whole leaves by the evaluation. There were only one case when females laid eggs on *U. laevis* and *Z. serrata*, but on *H. davidii* leaves average 27.8 eggs were found. On these last three species, only short feeding traces were observed, while living larvae were not.

3.3.2. Results of the laboratory experiment

In the laboratory most of the eggs (185 pcs in total) were laid on *U. pumila* leaves. The lowest egg mortality was observed in case of *U. parvifolia*. The average development time of egg stage was 8 days, except on *U. laevis* where it was 10 days. The zigzag elm sawfly larvae were only able to complete their development on the *U. pumila* leaves.

3.4. A Trapping studies

3.4.1. Applicability of coloured traps

Most *A. leucopoda* adults (N = 5199) were captured with the yellow sticky ”cloak” (PALs) traps followed by the fluorescent yellow (PALz) traps (N = 3441; one trap was found dropped to the ground). The white (PALf) traps were the least attractive (N = 332) to the sawfly species. There was no significant difference between the catches of the PALs and PALz traps, and both of them proved significantly more effective compared to the PALf traps

3.4.1. Selecting the effective trapping height

In both years, traps at 2 meters height captured the most species. In 2013, according to the data of catching, no significant difference was detected between the mean number of individuals captured on 2 meters and 8 meters. In 2014 I detected difference on these heights. The traps on 0.5 meters caught only few individuals.

3.5. New scientific results

1. I have proved that overwintering *A. leucopoda* eonymphs require several weeks of cold effect for diapause break.
2. The SCP value of the overwintering *A. leucopoda* eonymphs is around -18°C.
3. *A. leucopoda* is not freeze-tolerant.
4. I have identified a new parasitoid of *A. leucopoda* called *Aptesis cretatoides* (Hymenoptera: Ichneumonidae).
5. The lower developmental threshold and the thermal constant of *A. leucopoda* were determined by the linear model for egg (9.2°C, 77.5 DD), larval (6.9°C, 240.4 DD), prepupal (5.9°C, 41.1 DD) and pupal stages (8.7°C, 53.9 DD) and one whole generation (7.3°C, 426.5 DD).
6. The lower developmental threshold and the thermal constant of *A. leucopoda* were determined by the Lactin-2 model for egg (8.6°C, 86.5 DD), larval (6.6°C, 245.9 DD), prepupal (5.1°C, 42.9 DD) and pupal stages (8.1°C, 57.2 DD) and one whole generation (7.1°C, 432.7 DD).
7. The lower developmental threshold and the thermal constant was validated by the Lactin-2 model with flight activity data collected in the field.
8. It was estimated that *A. leucopoda* might potentially develop through up to four or five generations per year in Hungary.
9. I identified that *A. leucopoda* may lay eggs on several plant species from the family of Ulmaceae, but the main host plant of it is *U. pumila*
10. Both yellow and fluorescent yellow sticky ”cloak” traps are suitable to capture high numbers of individuals of *A. leucopoda*, while white traps have caught significantly less adults, while trapping with former coloured traps is recommended less for the detection of the pest.
11. Traps placed at the 2 meters height can be recommended for the detection and for tracking flight activity of adults in the practice.

4. CONCLUSIONS AND RECOMMENDATIONS

Overwintering and cold tolerance of *Aproceros leucopoda*

4.1.1. The overwintering of *Aproceros leucopoda*

Based on the results of the overwintering studies it seems eonymphs of zigzag elm sawfly need about 1-1.5 months of cold at around 10°C to be able to develop to imagines in the spring, when the weather gets warmer. *A. leucopoda* eonymphs, like other species from the order of Hymenoptera, require a proper cold effect to continue their development with the arrival of spring.

Aptesis cretatoides, the new parasitoid of *A. leucopoda,* won't have an appropriate population control effect in Hungary, since the parasitism did not reach 2% in all examined samples.

4.1.2. The cold tolerance strategy of *Aproceros leucopoda*

The mean SCP of the eonymphs is about –18°C. This value is almost constant during the winter. The cold tolerance of individuals are not affected by the body mass. I compared the results of collected samples from different times and locations and I have noticed significant difference among them.

Geographical variations in supercooling ability within species should be expected, in particular in species exposed to fluctuating air temperatures (SØMME 1982). Winter-acclimatised *Agrilus planipennis* (Coleoptera: Buprestidae) prepupae reduced their cold tolerance in response to mid-winter warm periods (SOBEK-SWANT et al. 2012), however, there was no seasonal variation in larval resistance to freezing *Cephus cinctus* (Hymenoptera: Cephidae) (MORILL et al. 1993). It seems that in case of *A. leucopoda* the seasonal variation – and maybe with some other factors – can change the SCP value of the individuals.

The SCP value was statistically influenced by the individuals being in or without the cocoon during the measurements. SCP was lower in case the eonymphs without cocoons. The mature larvae of soybean pod borer [*Leguminivora glycinivorella* (Lepidoptera: Tortricidae)] overwinter in the soil in cocoons as the eonymphs of zigzag elm sawfly. SAKAGAMI et al. (1985) examined the role of the cocoon in overwintering of the species. They found that cocoons are ineffective in insulting the larvae from temperature decrease. However, the larvae are in contact with water have frozen by ice inoculation at temperature much higher than larvae are not in contact with water. Based on these results, I have come to the conclusion that the reason for the experienced difference in case of *A. leucopoda* may due to the higher moisture content in the solid-walled cocoon, so the formation of ice crystals may have started sooner.

It can be concluded from the results that *A. leucopoda* is not freeze-tolerant since the mortality rate of the eonymphs was 100% after they reached their SCP values.

4.2. Development of *Aproceros leucopoda*

I succeeded to rear *A. leucopoda* individuals in laboratory condition. Based on the results of the experiments I have gained new information about the biology of *A. leucopoda*. During the experiment settings, I did not provide food source for the females, but they were able to produce viable eggs as well as MARTYNOV and NIKULINA (2017) reported it earlier.

Based on the results, I have been able to get more accurate data about the length of developmental stages than it was available in the literature before. In Table 2 I compare the values from the literature (BLANK et al. 2010) with my results.

Table 2: The developmental time for egg, larvae, prepupa and pupa (combined) and a whole generation of *A. leucopoda*

	Data based on BLANK et al. 2010	**Own results**
egg	4–8	4–20
larvae	15–18	13–43
prepupa and pupa (combined)	4–7	5–21
a whole generation	24–29	24–85

According to BLANK et al. (2010), females produced 7–49 eggs, while the females in my experiments laid 0–71 eggs, and the average number of eggs varied depending on the temperature. At 15.0°C and 19.5°C, approx. 2 to 3 times more eggs were deposited than in the other temperatures, which indicates the positive effect of this range of temperature on the fecundity of *A. leucopoda*.

According to my observations, the number of larval stages of the zigzag elm sawfly is not always six. Variation of numbers of larval instars have also been observed in experiments with other sawfly species, which is believed to be caused by extreme temperature stress (CHARLES et ALLAN 2000, MATHIEU et al. 2014). In case of *A. leucopoda*, the deviation from the six-instar larval development might not be due only to the extreme low or high temperatures. The use of constant temperatures might also be a stress factor for the individuals, and, moreover, the detached leaves, being not optimal food source, might also have a modifying effect on larval development as it was indicated by HILLEBRAND and TUBA (2013) in the case of the gipsy moth (*Lymantria dispar*).

The relatively high mortality rates observed during the experiments even at moderate temperatures might be caused by, for example, stress due to having kept the individuals at constant temperatures, and also other factors related to the circumstances of the experiments (e.g. the different water content of the leaves).

The lower development threshold and the sum of effective temperatures were determined by using two different models: linear and the Lactin-2. I compared these results with the data gained from an open field study and with the results of the Lactin-2 model. Based on than I was able to predict more accurately the flight activity peaks than with the results of linear model. The number of degree-days above 7.3°C (linear model) or 7.1°C (Lactin-2 model) available for development between 2003 and 2010 at the five sites indicate that the zigzag elm sawfly may be capable of producing 4–5 generations per year in Hungary. This average number of generations of *A. leucopoda* coincides with that known from the available literature

From the Lactin-2 model, the optimum temperature for development and the upper development threshold could also be calculated, but these data should be considered with caution. The part of the curves of the Lactin-2 model that predicts these data is inaccurate, as we did not have enough relevant data from the upper temperature range during the rearing experiments. Although the development of species accelerated as the temperature increased, I assume that the optimal temperature was different from what I have calculated with Lactin-2 model. Based on the survival and fecundity rates, the optimal temperature range for the species is rather between 15.0°C and 19.5°C.

4.3. The host preference of *Aproceros leucopoda*

During the host specificity tests I conducted experiments in field and also in laboratory. Based on the results *F. angustifolia* subsp. *pannonica* is not a host plant of the zigzag elm sawfly, as we expected, just as the two *Celtis* species. Therefore the appearance of the pest does not pose any risk neither to the main species of the natural oak–ash–elm communities, nor to the *Celtis* species, which are often planted in public area.

According to literature, the damage of *A. leucopoda* larvae has already detected on *U. laevis* leaves several times, however, no significant damage was reported. The results of my studies also supports the idea that a lower risk of damage is expected on *U. laevis* than, for example on Siberian elm. In case of the other two studied species of the genus *Ulmus* – *U. crassifolia* and *U. parvifolia* –, the larvae hatched from eggs in laboratory conditions, but were not able to develop them to adult. It seems that these species are not adequate host plant of the zigzag elm sawfly. *Z. serrata* will probably also not increase the number of host plants of the pest, however in case of *H. davidii* the results are inconclusive and it required further experiments.

U. pumila proved to be a preferred host plant for the larvae and the adults as well. However, in the leaves of the other species from the *Ulmus* genus, the females laid eggs, the larvae could not survive, so I concluded that even if *A. leucopoda* causes some damage on the leaves of these species, it would not be significant.

4.4. Trapping methods of *Aproceros leucopoda*

Based on the results, both the yellow and fluorescent yellow sticky "cloak" traps are equally suitable for catching *A. leucopoda* adults. The effectiveness of the yellow-coloured traps was expected since in other studies it had already proved more effective for collecting sawflies compared to different further colours, for example blue and white, applied (RÜHL 1978, SCHUSTER 1985). Similar observations were also made in case of *Athalia rosae* (Hymenoptera: Tenthredinidae), with 71% of the specimens being caught by yellow traps and the remaining 29% with white ones (RITZAU 1988).

Applicability of coloured traps may depend not only on the choice of the right color, but also on the background composition and trap positioning. During the experiments of effective trapping height, I found that traps at 2 meters captured the most imagines. In some cases the trapping height does not influence the effectivness of catching such as in case of horse chestnut leaf miner [*Cameraria ohridella* (Lepidoptera: Gracillariidae)] that overwinters also in the soil (SUKOVATA et al. 2009). However, in an experience with the overwintering population of *Rhagoletis cingulata* (Diptera: Tephritidae) significantly more flies were captured on traps hung at 4.6 meters in the canopy of cherry trees than on traps hung at 2.1 meters or at a low position of 1.2 meters (PELZ-STELINSKI et al. 2006).

Based on the evaluation of the data, yellow or fluorescent yellow traps placed at the 2 meters height are recommended for the detection and for tracking of the adults' flight activity in the practice. Although searching for the easily recognizable zigzag feeding pattern on leaves caused by the young larval stages may be recommended for supporting monitoring programs, trapping with yellow or fluorescent yellow sticky traps also help detect the pest and develop an effective pest management program to control adequately the populations of the species if it is necessary.

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