JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 47, No. 1 (2007)

INCIDENCE, HARMFULNESS AND SOME ELEMENTS OF THE HORSE CHESTNUT LEAFMINER (*CAMERARIA OHRIDELLA* DESCHKA & DIMIC) CONTROL ON WHITE HORSE CHESTNUT (*AESCULUS HIPPOCASTANUM* L.)

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Accepted: March 15, 2007

Abstract: Observations on the incidence, harmfulness and some elements of *Cameraria ohridella* control on white horse chestnut (*Aesculus hippocastanum* L.) were carried out in Wrocław, Poland, in 2001–2003. Three generations of the pest developed on *A. hippocastanum*. The leaf infestation by pest's larvae increased systematically throughout the spring-summer season. Cultural control by removing the fallen leaves was suggested. Using this procedure, the abundance of the pest was considerably reduced, therefore, the percentage of the leaf damage was lower and the trees lost these leaves later in the season.

Key words: *Cameraria ohridella*, horse chestnut leafminer, *Aesculus hippocastanum*, white horse chestnut, development, damage, leaf litter removal, cultural control

INTRODUCTION

White horse chestnut (*Aesculus hippocastanum* L.) has been considered as a plant species rarely infested by herbivores or infected by pathogens for a long time (Siewniak 1999). Before horse chestnut leafminer (*Cameraria ohridella* Deschka & Dimic) appeared, the plant had been occasionally infested by caterpillars of other *Lepidoptera* (*Tortricidae*) (Butin and Führer 1994). At present, those other herbivore species are unable to compete with *C. ohridella*. The pest already conquered almost entire Europe and nothing indicates that its spreading might slow down in the foreseeable future (Ambrosi and Hellrigl 2000).

Up to now, all strategies to control the horse chestnut leafminer have failed. Cultural control by removing the fallen leaves, where the horse chestnut leafminer overwinters as a pupa, is the only advisable control method (Kehrli and Bacher 2004). By

disposing of the fallen leaves, the number of moths emerging in the following spring is reduced and consequently the impact of the pest on *A. hippocastanum* is lower (Gilbert et al. 2003).

In Poland, *C. ohridella* was identified for the first time in 1998, in Lower Silesia (Łabanowski and Soika 1998). Therefore, the aim of the study was to examine its development, harmfulness and some elements of control on the white horse chestnut within the city of Wrocław, the largest city of Lower Silesia.

MATERIALS AND METHODS

Pest development

The study was carried out in Wrocław, Lower Silesia, Poland in 2001–2003, in a number of sites where *A. hippocastanum* grew within the city. On each site 5 trees were randomly chosen and on each tree, a square of 400 cm^2 (20 x 20 cm) was marked on the bark, 1.5 m above ground level. Within these squares moths of the leafminer were counted weekly. Of the total moth number recorded at each site the mean number per one tree was calculated. Densities of eggs, larvae and pupae, as well as the extent of leaf damage, were determined as means of 10 "single" leaves from each site, i.e. from single 10 leaf blades detached from 10 different compound leaves sampled from the studied trees. Eggs, larvae and pupae were counted under binocular microscope, and the leaf damage was estimated visually and recorded as percentage of the leaf covered with mines relative to the entire area of the leaf blade. In one year (2003), during such observations, the sex of pupae according to Freise and Heitland (1999) was determined as well. The observations were carried out once a week, during the whole horse chestnut vegetation period.

Impact of leaf litter removal on the *C. ohridella* population

Two kinds of stands were chosen for these studies: where fallen leaves were raked and disposed in autumn or early in spring in the following year and where leaves were left for the year after. On each site 5 trees were chosen randomly. The numbers of developmental stages of horse chestnut leafminer as well as the leaf damage were recorded according to above-mentioned method. The statistical differences of the pest particular stages in these two sites were analyzed using the Kolmogorov-Smirnov test ($p \leq 0.05$).

RESULTS

Pest development and harmfulness of *C. ohridella*

a) Moths density on tree trunks

In each year of the study, the adults of *C. ohridella* emerging from the overwintering pupae appeared on the tree trunks of *A. hippocastanum* at the end of April or in the first days of May (Fig. 1). Trees were at the beginning of flowering stage at that time. The next generation of the pest, *i.e.* the first one in any particular year, settled tree trunks in the second decade of June and, consequently, the adults of the second generation appeared in the first decade of August. In 2001 and 2003 the moth density of the first generation was the greatest, whereas in 2002 the second generation was the most abundant one. During the 3 year study, the least numerous were always moths of the overwintering generation.

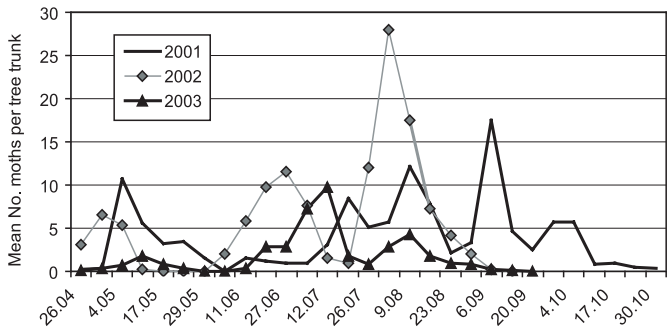

Fig. 1. Density of *C. ohridella* moths on tree trunks; Wrocław 2001–2003

When the overall abundance is considered, i.e. throughout the whole growing season, of all the study years *C. ohridella* appeared at its greatest number in 2002. The summer 2002 was remarkably warm and humid, and the sum of mean daily temperatures since January to December 2002 was much higher – 121.6°C, compared to 110.1°C in 2001 and 112.2°C in 2003. Furthermore, in 2002 the second flowering of the trees of *A. hippocastanum* was observed in September. It seems likely that all these factors affected the pest abundance that year.

b) Occurrence of eggs, larvae and pupae

Every year, first single eggs were laid on leaves by moths of overwintering generation in the first decade of May (Fig. 2). Females of the first generation started laying eggs at the beginning of July, whereas the females of the second generation laid them in August. The eggs laid by the overwintering generation were the least numerous. The first and the second generation of *C. ohridella* usually overlapped. Therefore, it is difficult to distinguish precisely which generation of females laid more eggs.

Proportion of dead eggs of *C. ohridella* found on white horse chestnut leaves was small. It was up to 15% of all the eggs found.

Larvae of the first generation most often started feeding in the *A. hippocastanum* leaves in the second half of May (Fig. 3). Their number was low. Usually, the most numerous were larvae of the second generation. Also larvae of the third generation were numerous. The last larvae in the season were found in leaves at the end of October in 2001 and 2002, but as early as at the second decade of September in 2003. During the whole growing season the greatest number of larvae was recorded in 2001 (144.4 individuals), which was 2.7 times more than in 2003 (53.3). In 2003, trees were infected by powdery mildew, which presumably modified the host quality for the larvae, thus affecting their mortality and, consequently, their abundance.

During the 3-year study mortality of the pest larvae was very low (Fig. 3). Most often it did not exceed 4.4% of all larvae feeding in leaves. Only in 2003 it increased to 9.9%. The dead larvae were found in leaves at the highest number in September and at the beginning of October. One may presume that the course of the weather affected the larvae mortality at that time. Although September 2003 was relatively warm compared to the two previous years, the temperatures rapidly falling down at the end of that month could increase the percentage of the dead larvae.

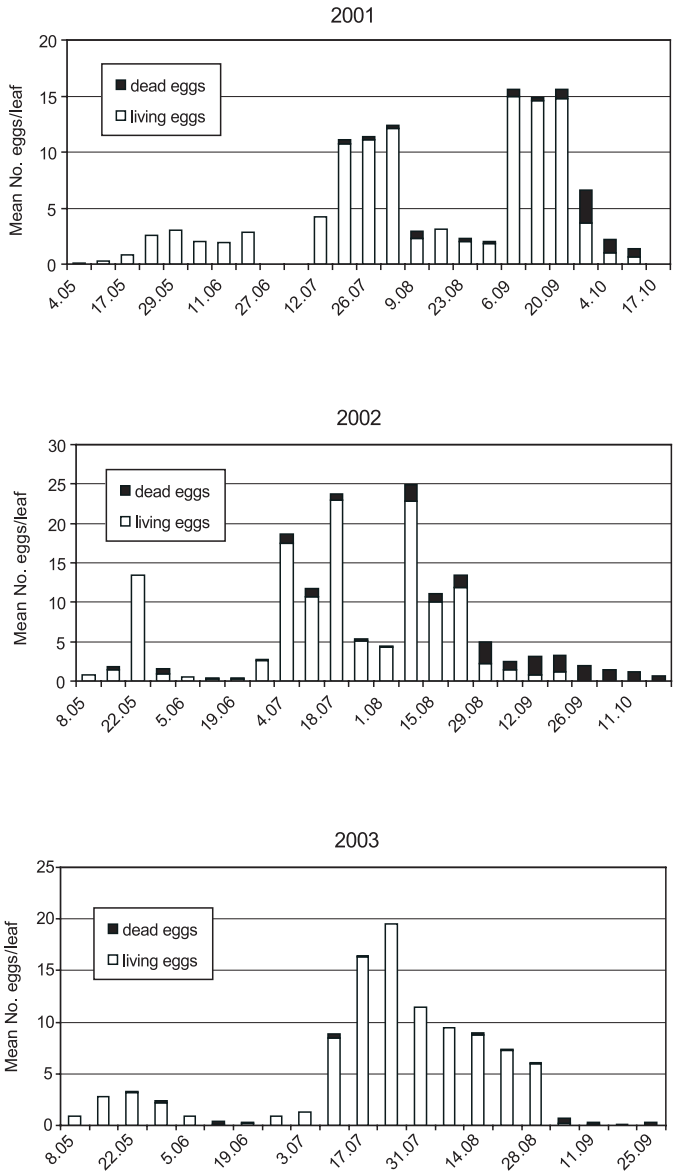

Fig. 2. Mean number of *C. ohridella* eggs on white horse chestnut; Wrocław 2001–2003

The pupae of horse chestnut leafminer were usually found in leaves in the first decade of June, but they were always the most abundant in August. These were the pupae of the second generation of the pest. The highest density of the pupae in the leaves was recorded in 2002 and the lowest one – in 2003 (mean numbers from the sampled leaf batch were 73.2 and 56.5, respectively).

The sex of the pupae was determined in 2003. The male to female proportion was variable, depending on the sampling time (Fig. 4). In the whole 2003, the mean numbers of male and female pupae per leaf were 17.0 and 17.6, respectively, therefore the sex ratio was close to 1:1.

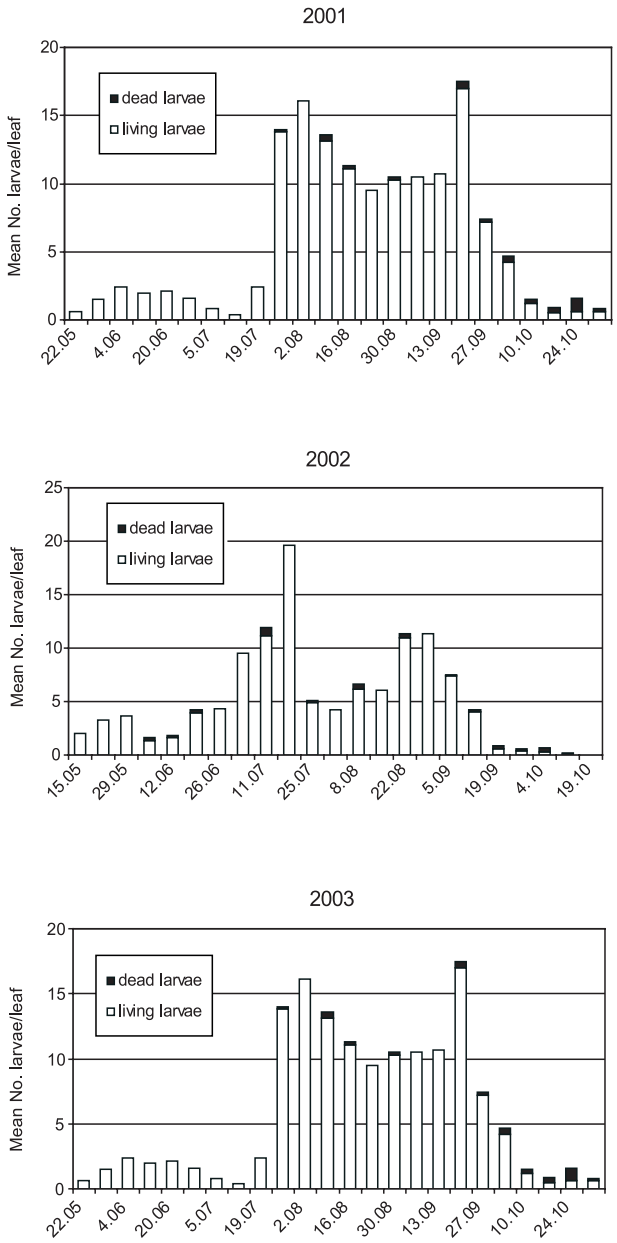

Fig. 3. Mean number of larvae in the white horse chestnut leaves; Wrocław 2001–2003

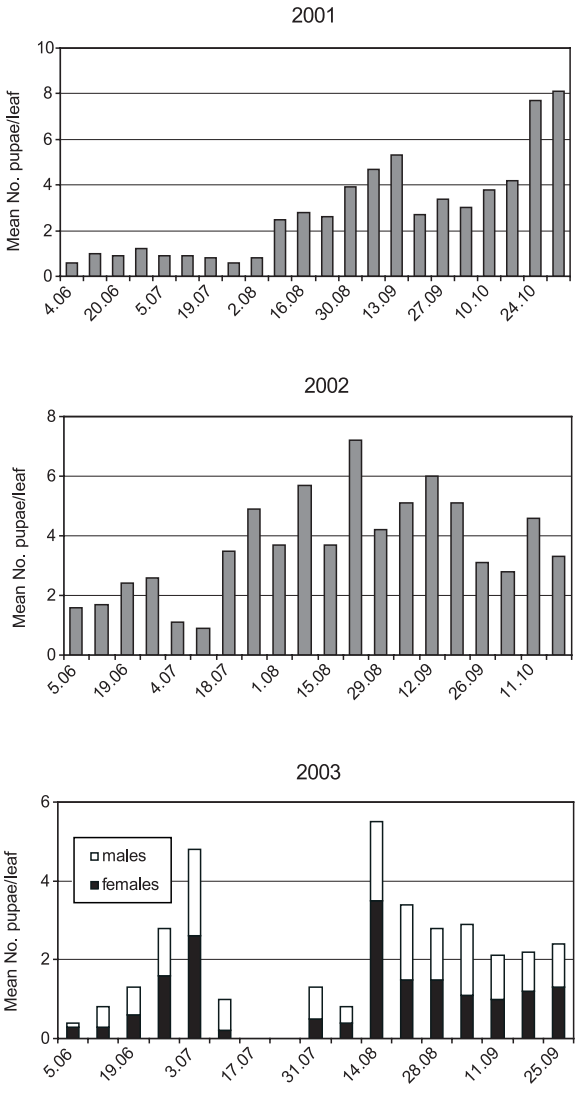

Fig. 4. Mean number of the leafminer pupae in the white horse chestnut leaves; Wrocław 2001–2003

Harmfulness of *C. ohridella*

Single mines on leaves were recorded each year in mid-May (Fig. 5). Due to the gradual hatching and development of larvae, the number of mines and the proportion of the leaf area they covered increased at the following sampling dates. During the initial time of the leafminer development the increase of the leaf blade damage was directly proportional to the number of mines. Later, at the end of July in 2002 and 2003, or at the beginning of August in 2001, the mines were covering most of the leaf area and started to merge. As the result, while the damaged leaf area systematically increased, the mine number seemingly decreased at that time.

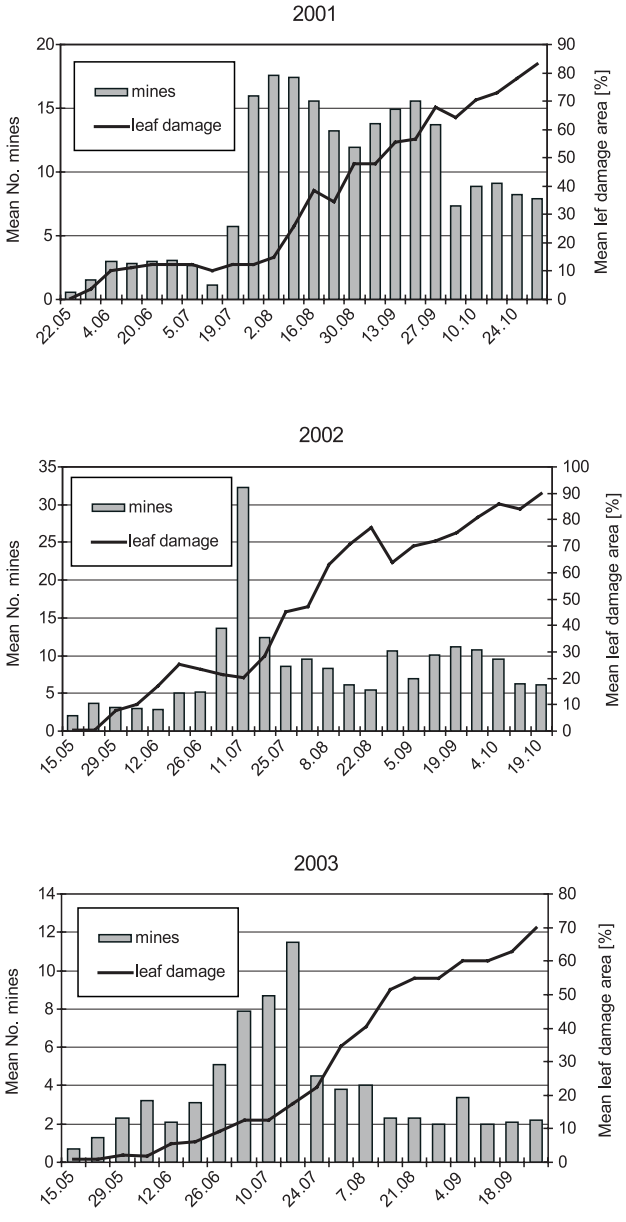

Fig. 5. Mean number of mines and percentage of leaf damage area of the white horse chestnut; Wrocław 2001–2003

The white horse chestnut trees were most often loosing their leaves when damage exceeded 50% of the individual leaf area. The leaf falling started in the third decade of August in 2003, in the first decade of September in 2002, and only in 2001 – in the second decade of September.

Impact of leaf litter removal on horse chestnut leafminer population

The numbers of moths, eggs, larvae and pupae were considerably greater at sites where the fallen leaves were left to the next year under the horse chestnut trees, than at sites with leaf litter removal. The differences were statistically significant (Kolmogorov-Smirnov test; $p \leq 0.05$). The results were very similar every year, therefore, here we have presented only the 2003 data (Fig. 6).

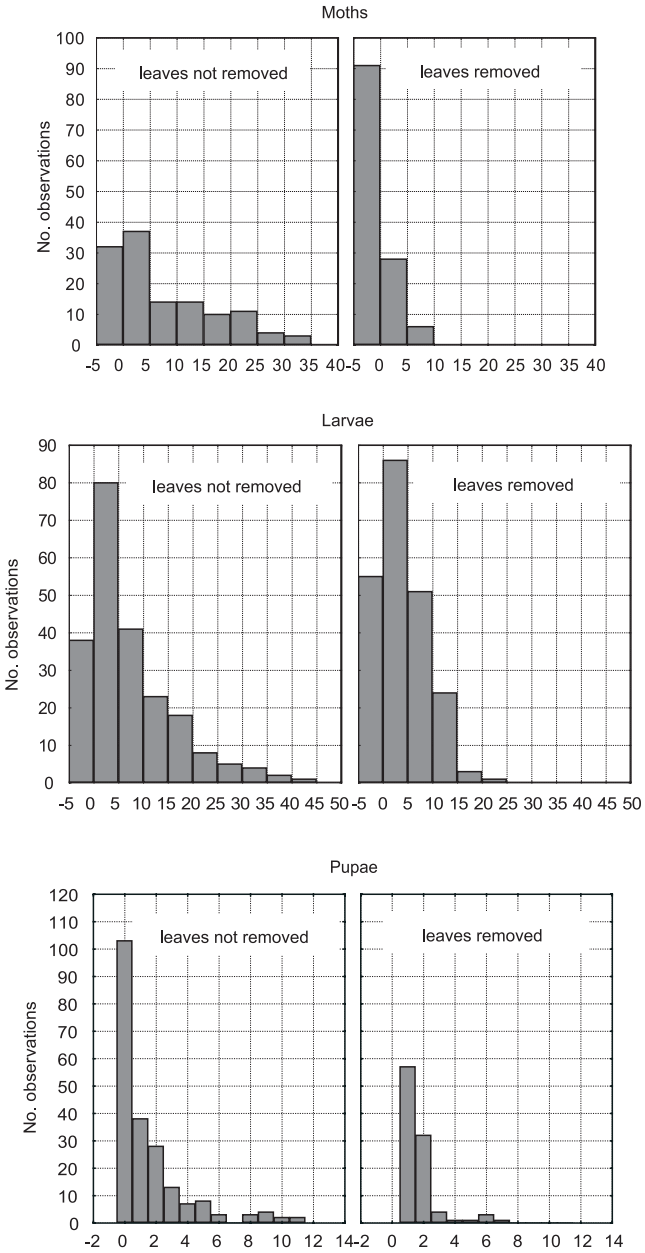

Fig. 6. Abundance of the leafminer moths, larvae and pupae; Wrocław 2003

As it was mentioned earlier, at sites without leaf litter removal, the abundance of larvae was greater, therefore, the infestation of leaves increased considerably faster (Fig. 7). In these sites leaves started to fall much earlier (second half of July) in comparison to the sites with leaf litter removal (second half of August). Then, raking and disposing of the fallen leaves significantly reduced the pest's density in the next year.

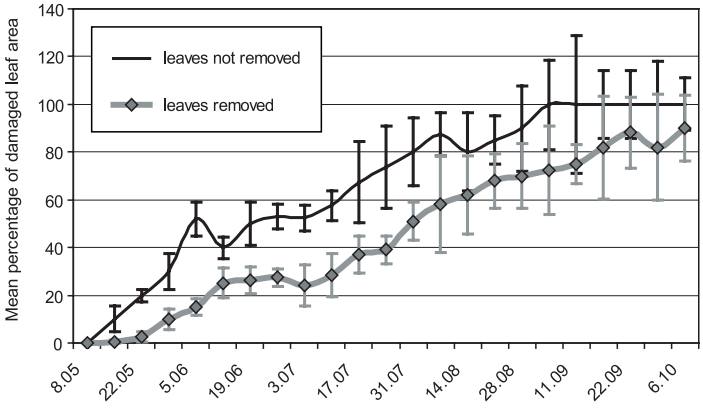

Fig. 7. Leaf damage of the white horse chestnut; Wrocław 2003

DISCUSSION

The study carried out in 2001–2003 showed that *C. ohridella* developed three generations in Wrocław. In majority of other European countries, the pest usually develops also three generations, although some authors claim that this number can be higher. In Greece, Croatia or Macedonia, the air temperatures higher than in the Northern Europe allow the development of four generations of the pest (Santi et al. 2000). Similarly, four generations were recorded in Czech Republic (Skuhravy 1999), whereas in Northern Italy (Tyrol) it reached five generations (Ambrosi and Hellrigl 2000).

The first moths of *C. ohridella* emerging from the overwintering pupae were always found on trees in Wrocław in the third decade of April. Trees were at the beginning of flowering stage at that time. Also in other European countries, the emergence of moths of the overwintering generation coincided with the trees flowering (Dimič and Lazić 1996; Dautbašić 2002).

The small number of dead eggs of the pest on the white horse chestnut leaves was found. Most often their number increased slightly towards the end of the trees vegetation. At that time 60–70% of the sampled leaf blade area was covered with mines and therefore, the second generation females had almost no space to lay their eggs. Similar situation was observed by Zùbrik and Turčani (2000) in Slovakia, and by Dautbašić (2002) in Sarajevo. Most of the dead eggs reported by these authors were laid on the desiccated parts of the leaf blades – on mines produced by feeding larvae of the previous generation.

The results obtained in 2003 showed that the sex ratio was approximately 1:1. These results are different from those reported by Majzlan et al. (2001), who demonstrated male to female proportion in each generation of *C. ohridella* being 1:2.

In the course of our study the extent of the leaf area damaged by the pest was increasing gradually with the appearance of the consecutive pest generations. In every year, initially, the number of the observed mines increased, to be seemingly reduced since July, with the simultaneous further increase in the overall leaf area covered with mines. As the feeding larvae were growing, the mines became larger and started merging, producing few extended mines covering almost entire leaf blade. Other authors also reported merging of the mines and observed larvae cannibalism resulting from it (Dautbašić 2002). This may to some extent, explain the increase of larvae mortality in the second generation of the pest, observed in Wrocław, particularly in 2003.

The study showed that raking and disposing of fallen leaves in autumn or early in spring substantially reduced the abundance of the pest, mainly moths of the overwintering generation. The abundance of eggs, larvae and pupae was also considerably lower at the place with leaf litter removal. Consequently, the percentage of leaf surface damage was lower and trees lost their leaves later. According to many authors (Skuhravy 1999; Grabenweger 2001; Dautbašić 2002; Gilbert et al. 2003), the removing of the fallen leaves was an effective method of *C.ohridella* control. In cities, moths of horse chestnut leafminer migrate from more infested sites to less infested ones. Therefore, it is more important to regularly dispose the falling leaves during the vegetation period, not only in autumn or spring (Pavan et al. 2003).

CONCLUSIONS

1. Three generations of *C. ohridella* were recorded on the white horse chestnut, *Aesculus hippocastanum* in Wrocław. Adults emerging from the overwintered pupae started to appear on tree trunks in the third decade of April, which coincided with the beginning of flowering. The flight of the first generation moths was observed at the second decade of June, whereas that of the second generation – at the first decade of August.
2. Eggs, larvae and pupae were found on the leaves from May until September or even October, depending on the course of the weather. The pest's generations overlap in time, therefore it is difficult to draw precisely any borderline between them.
3. The egg and larval mortality of *C. ohridella* was low and did not exceed 15 and 9.9% of eggs and larvae, respectively.
4. The sex ratio in the pest population was approximately 1:1.
5. The leaf infestation by the pest larvae increases systematically throughout the spring-summer season. Trees start loosing their leaves when the damaged area of the individual leaf blades exceeds 50%.
6. Raking and disposing of fallen leaves substantially reduced the abundance of all developmental stages of the horse chestnut leafminer, particularly moths emerging from the overwintering pupae. As the effect, the leaf damage was lower and trees lost their leaves later. Therefore, this method is the effective control measure against *C. ohridella.*

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POLISH SUMMARY

WYSTĘPOWANIE, SZKODLIWOŚĆ ORAZ ELEMENTY ZWALCZANIA SZROTÓWKA KASZTANOWCOWIACZKA (*CAMERARIA OHRIDELLA* DESCHKA & DIMIC) NA KASZTANOWCU BIAŁYM (*AESCULUS HIPPOCASTANUM* L.)

Badania dotyczące rozwoju oraz elementów zwalczania szrotówka kasztanowcowiaczka na kasztanowcu białym prowadzono w latach 2001–2003 w Polsce, na terenie miasta Wrocławia. Na kasztanowcu białym odnotowano rozwój trzech pokoleń szrotówka. Zniszczenie powierzchni blaszek liściowych przez żerujące w nich larwy szkodnika, wzrastało systematycznie w ciągu całego okresu wegetacji drzew. Obserwacje wykazały, że grabienie i usuwanie opadłych liści kasztanowca w istotnym stopniu ograniczyły liczebność owada w roku następnym. W efekcie, prowadziło to do mniejszego zniszczenia liści oraz opóźniało ich opadanie z drzew.