Harmful Occurrence of Rosy Rustic Moth (*Hydraecia micacea*) (Noctuidae, Lepidoptera) on Hop in the Czech Republic

Josef ŠEDIVÝ[1], Petr BORN[2] and Josef VOSTŘEL[3]

[1]Department of Entomology, Division of Plant Health, Research Institute of Crop Production, Prague-Ruzyně, Czech Republic; [2]State Phytosanitary Administration, Rakovník, Czech Republic; [3]Hop Research Institute, Co., Ltd., Žatec, Czech Republic

Abstract

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The Rosy rustic moth (*Hydraecia micacea*) has been a pest of hop in Czech hop regions for a long time. It causes most severe damages in hop gardens infested by quackgrass (*Elytrigia repens*) on waterlogged areas. Larvae emerge from the second half of April to the middle of May. The sum of effective temperatures (SET) necessary for hatching larvae has been determined to be 78.6°C over a 4-year average. Young larvae first feed on leaves of quackgrass, and later move to hop plants where they feed inside the shoots and rootstocks. Occurrence and damage are most frequent at the edges of hop gardens and in places with anchorages between two hop gardens. The ichneumonid wasp *Ichneumon sarcitorius* and the fly *Lidella thompsoni* are the most common parasitoids of this pest. Numbers of males caught in pheromone traps were very low. More males were trapped near hop gardens typical for repeated harmful occurrence of the rosy rustic moth. Females trapped in a light trap from the second half of August to the last decade of September had already full-developed eggs in their ovaries.

Keywords: hatching of caterpillars; weeds; parasitoids; harmfulness; monitoring; antagonist

The Rosy rustic moth (*Hydraecia micacea* Esper) is a holoarctic widely polyphagous species that feeds on more than 50 species of plants from 20 families. It is known as a pest of some crops, mainly hop, potatoes and cereals. It rarely damages maize (Scherney 1970), sugar beet, onion, rhubarb, tomatoes and strawberry. Nevertheless, in the Czech Republic this pest was nearly entirely found on hop plants. In the middle of the 1970s, local occurrence on potatoes grown in the vicinity of infested hop gardens was reported as well (Kříž 1976). In 1997 it attacked potatoes in a potato region in Southern Bohemia. In Czech hop regions, the Rosy rustic moth (RRM) has been known as a potential hop pest since the beginning of the last century. In the beginning of the 20th century this pest multiplied excessively not only in older commercial hop gardens but also in newly established ones (Günzel 1904). Collection of caterpillars was a commonly recommended type of control at that time (Tölg 1911). Some economic damage also occurred in 1954–1956; approximately 150 ha of hop gardens were attacked and yields of hops were lowered by 8–10% (Kříž 1976). Harmful oc-

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currences of RRM were again observed from 1997 to 1999. Damages caused by this pest have so far been reported from some hop gardens. The pest attacks some new localities as well. The increasing occurrence of RRM in 1996 can be attributed to favourable conditions for its development, i.e. heavy rains connected with flooded hop gardens. Weihrauch (2000) summarised the literature data and present knowledge on the RRM in Germany and classified it as a regular hop pest there since 1970 (Scherney 1970; Liebl 1971). French *et al.* (1973) informed about attacks by this pest in England (1973) and Kondakov and Nogina (1968) in Russia. Damage by RRM was reported from Slovenia (Žolnir & Carnelutti 1995).

Repeated attacks by RRM on hop plants, lack of knowledge about the reasons for excessive multiplication and methods of hop protection led us to experiments and observations relevant to obtain necessary data for compilation of a target control against this pest. It is based on the knowledge of the influence of weed infestation, time of caterpillars hatching, infestation and harmfulness of RRM. The occurrence of natural enemies attacking imagines and pupae was studied as well. Pheromone and light traps were used to monitor the intensity of imagines and time of oviposition.

MATERIALS AND METHODS

Observations and experiments were carried out in the most important Czech hop region (Žatec-Saaz), where more than 80% of Czech hops are grown. Within this region we chose the district of Rakovník and selected six localities: Hředle, Krupá, Kozojedy, Nesuchyně, Vacov and Vlkov. Most observations and field trials were carried out at these localities. In 2000 the occurrence of RRM males was monitored by pheromone traps also at four sites in the district Louny, which belongs to the Žatec hop region as well. The locality Prague-Ruzyně, which lies outside the hop-growing area, was used in 2000 and 2001 to catch males in a pheromone trap, and females and males also in a light trap. The observations from this site were used to compare the different times and densities of RRM at locations where this pest causes no damage. Weed infestation of hop gardens attacked by RRM was assessed according to ground coverage, and the species of weeds occurring there were determined.

The time of hatching of caterpillars was studied from 1997 to 2000 in vessels containing plants of quackgrass infested with eggs of RRM. These vessels were placed near a meteorological station at Prague-Ruzyně. Data obtained from this station were used for accumulations of effective temperatures. Emergence of caterpillars was evaluated each year on 500 eggs in accordance with developmental time for eggs (DTE) with the help of the following formula:

$$DTE = \Sigma - \frac{t_{max} + t_{min}}{2} - LDT$$

The sum of effective temperatures (SET) was established by accumulation of the value "degree days" (DD) above LDT. Value of low development threshold (LDT) 6.83°C was taken from Bruce *et al.* (1985). The base of DD value are daily t_{max} + t_{min} divided by 2 and summed from January 01 of the given year.

The infestation was assessed and harmfulness of caterpillars in hop plants were observed from 1997 to 1999 in a hop garden of 15 ha at Nesuchyně. The number of healthy, injured and dead hop plants and of healthy and infested shoots were counted in the space between four hop poles, and in five replications. A total of 560 hop plants were evaluated: in the variant lying at the edge of the hop garden 288 hop plants were evaluated each year; the second variant with 112 plants were the spaces around anchorages between two hop gardens; the third variant were sites of focal distribution damage and 160 hop plants were regularly assessed. The evaluation was always done before harvest time (July 17–July 28). Harmfulness of RRM in an total infested hop garden (Vlkov) was evaluated in 2004 on 100 hop plants at the edge and in the middle rows.

The occurrence of parasitoids and predators was determined in caterpillars, pupae and in remnants of caterpillars and pupae found in soil infested with RRM. Soil rooted by wild boars in the vicinity of attacked hop plants was taken into account in some cases as well.

In 2000 and 2001 the dispersion of male imagines was monitored by pheromone traps. The active ingredient of the traps was tetradecyl acetate (common name Z9-14 Ac). The traps were placed next to three hop gardens in the district of Rakovník (Hředle, Krupá and Nesuchyně) and two hop gardens in the district of Louny (Očihov and Březno). Numbers of trapped males were checked at weekly intervals from the beginning of August to

the first decade of October. In the same years, the numbers of adults were monitored by a pheromone and a light trap installed at Prague-Ruzyně. The pheromone trap was approximately 500 m away from the light trap and near a plot heavily infested with curled-leaf dock (*Rumex crispus* L.).

RESULTS

During the years of our field trials there were only few harmful occurrences of RRM in Czech hop regions. Infested plants were dying during the season. In the period from 1997 to 2004 in the Žatec hop region, mostly those hop gardens infested by weeds and on sites with wet soil were damaged by RRM. Damage from this pest was more obvious in older hop gardens, at first at the edges and around anchorages between hop gardens, less frequently in focal distribution inside hop gardens. Nevertheless, in 1997 a widespread infestation was found in a hop garden that was only 2 years old. In 2004 a similarly total damaged hop garden was found at a site overgrown by quackgrass and with waterlogged plots in the vicinity.

Weed infestation

We did not observe any harmful occurrences of RRM in hop gardens that were free of weeds. The influence of weeds was assessed at spots where hop plants were drying up and later dying and damage of hop roots was visible. The following species of weeds were found to be dominant in hop gardens infested by RRM: quackgrass (*Elytrigia repens* L.), common lambs-quarter (*Chenopodium album* L.), glossy leaved orache (*Atriplex sagittata* Borkh.), common dandelion (*Taraxacum officinale* L.), creeping thistle (*Cirsium arvense* Scop.) and rarely also curled-leaf dock (*Rumex crispus* L.). If there was infestation by RRM at edges of hop gardens then there was also a dense cover of quackgrass at these edges; similarly in rows, where infestation was present and this weed accounted for up to 85% of the total ground cover. In hop gardens with total infection of RRM, this weed was common in rows and in inter-rows on more than 90% of the total ground covering. Other dominant weeds were annuals. They grew mostly in rows and inter-rows usually since the middle of June. At sites with anchorages and plants infested by RRM the following ground cover was found: quackgrass up to 25%, glossy leaved orache to 15% and common lambs-quarter to 50%. On the uncultivated part of places with anchorages local heavy densities of creeping thistle were visible. Inside hop gardens, typical for focal distribution damage and dead hop plants, quackgrass was common at the base of hop poles and in their vicinity in rows. Weed infestation by other species of weeds was the same as in the hop gardens attacked at their edges. During 9 years of observations, eggs of RRM were found only on quackgrass. Caterpillars were seen feeding on roots of curled leaf dock only in 2005. Other weed species were not infested by RRM.

Emergence of caterpillars

Females deposited their eggs in two to three rows under the leaf sheaths of quackgrass. They were observed sucking in the evening on flower heads of the genera *Arctium, Cirsium* and *Carduus,* mostly at edges infested with these weeds. Egg deposition was found in the neighbourhoods of hatching females. In the period between 1997 and 2001 eggs were observed usually during the first decade of August. Hatching of eggs in spring lasted only a short time. SET necessary for hatching of caterpillars varied only slightly between years (77.7°C in 1997; 79.0°C in 1998; 79.7°C in 1999 and 78.0°C in 2000), with an average value of SET at 78.6°C. This value was confirmed during observations of caterpillar hatching in damaged hop gardens in the Rakovník district. Mass hatching occurred there from the second half of April to the first decade of May. The mortality of eggs varied from 7 to 10%.

Infestation by and harmfulness of caterpillars

Individual larvae were found in surface tunnels eaten into blades of quackgrass. The tunnels were left at the end of April and during May. Caterpillars then attacked hop plants and gnawed tunnels into the tissue of sprouts and later rootstocks. Attacked sprouts faded and dried in the time from hop training to the beginning of hop cone formation, from April to July. Instars of caterpillars feeding inside rootstocks were very different. The length of larvae at the turn of May to June varied from 18 to 30 mm. Density of caterpillars was also variable. Their number per one hop plant averaged from four to six individuals. In the middle of June 2005 even 63 caterpillars of three instars were counted inside a hop rootstock. The highest densities of

larvae occurred in rootstocks of hop plants close to quackgrass. The damage to rootstocks showed as basipetal tunnels full of tissue detritus and larval excrement.

In the first decade of August (8. 8.) of 1997 and 1998 the number of pupae in a hop garden at Veclov were assessed. In 1997, a total of 266 pupae was found; of these, 179 pupae were before hatching, 59 were empty and 28 were dead. In 1998, the total was 111 pupae; 46 of them were before hatching, 17 were empty and 48 pupae were dead. Surprisingly, in the same year nine larvae only 18 mm long were found per plant.

Plants heavily damaged by RRM were also, though at various levels, infected by pathogens, probably by *Gibberella pulicaris* (Fr.) Sacc., (*Fusarium sambucinum* Fuckel) and *Peronospora citricola* Sawada, which secondarily increased wilting of plants, especially young rootstocks. However, this process was connected not only with damages caused by larvae of RRM but by other pathogens as well. In the first decade of June 2005, twenty dead young rootstocks were examined, but in only three of them were larvae of RRM present. The others were pest free and infected only by soil pathogens.

If no protection measures were carried out in an infested hop garden, the response of damaged hop plants was rather varied.

While the number of non-damaged plants at the edges of hop gardens was decreasing during 3 years of observations, at the places of anchorages between hop gardens and in the case of focal distribution damage the number of non-damaged plants was surprisingly increasing.

During the same 3 years the number of damaged hop plants decreased in all tested plots. The highest decline in the number of damaged plants was observed in 1997 in a plot where plants were infested by RRM at the edges of hop gardens. In the same years the number of dead rootstocks increased. The highest increase was observed in a plot with infestation occurring at the edges. In the other plots the increase in numbers of dead rootstocks was much lower. The number of non-damaged bines was also very varied in all the observed plots. In a plot infested at its edges it dropped sharply after 1997. In plots typical for their infestation at anchorages between two hop gardens and at focal distribution damage inside a hop garden, the quantity of damaged bines was approximately at the same level during those 3 years (Table 1). The number of damaged bines dropped during the following period. The highest infestation was recorded in 1997. Two years later the density of damaged plants decreased in all the observed plots (Table 2).

Natural enemies

On August 8, 1997, from the soil of a heavily infested hop garden at Veclov, 300 larvae or pupae were sampled. Only 51 larvae or pupae were parasitised. *Beauveria* sp. was found in 13 of them. *Ichneumon sarcitorius* L. (Hymenoptera, Ichneumonidae) was the most common parasitoid, it was

Table 1. Infestation and harmfulness of Rosy rustic moth caterpillars on hop plants from 1997 to 1999

State of health of plants	Plots of infestation in a hop garden		
	edge	sites with anchorages between hop gardens	focal distribution
Non-damaged			
1997	80	33	62
1998	77	38	67
1999	69	42	77
Damaged			
1997	161	59	80
1998	74	43	55
1999	41	26	31
Dead			
1997	47	20	18
1998	137	31	38
1999	178	44	52

Table 2. Hop bines damaged by Rosy rustic moth from 1997 to1999

State of health of plants	Plots of infestation in a hop-garden		
	edge	anchorages between hop gardens	focal distribution
Non-damaged			
1997	615	333	518
1998	394	318	432
1999	406	358	502
Damaged			
1997	299	120	126
1998	115	71	79
1999	51	39	43

found in 21 larvae or pupae. *Lidella thompsoni* Herting (Diptera, Tachinidae) (det. by J. Vaňhara) parasitised 16 larvae or pupae. The braconid *Macrocentrus blandus* Eady et Carg (Hymenoptera, Braconidae) (det. by M. Čapek) was found only once. Thus, parasitisation was obvious in 17 % of the investigated 300 larvae or pupae.

On August 5, 1998, only 41 of 150 caterpillars and pupae were parasitised. *Beauveria* sp. was found in nine cases. Parasitoids were found in 27 larvae or pupae. *Ichneumon sarcitorius* attacked 16 and *Lidella thompsoni* eight larvae. The group parasitoid *Coelopisthia extenta* Walker (det. by M. Čapek) was responsible for parasitisation of five individuals from which 5–12 parasitoids hatched from each pupa of RRM. *Macrocentrus blandus* was detected in three cases. From one parasitised cocoon by *M. blandus* emerged 61–86 parasitoids. Altogether, the level of parasitisation was 27% in 1998. The results show that during the 2 year study the level of parasitisation of larvae and pupae rose slightly at one experimental hop-garden.

Pospelov (1965) mentioned *Macrocentrus collaris* Spinola and *Lidella stabulans* Fll. as parasitoids of RRM. The carabid beetles *Harpalus pubescens* Sturm and *H. rufipes* De Geer were found to be the most frequent predators of larvae and pupae. Locally, 3–7 beetles of these species per infested hop plant were counted. Besides these parasitoids and predators we can also name wild boar (*Sus scrofa* L.) as a predator. The numerous rootings by this animal around infested hop-plants can only confirm it.

Table 3. Numbers of Rosy rustic moth males caught in pheromone traps in 2000–2001

Year / Locality	Week of the year											Total
	29	30	31	32	33	34	35	36	37	38	39	
2000												
Hředle		1		1	3			2		1		8
Krupá	1	1	1	2	4	2	4	2	2	2	1	22
Nesuchyně		1	1	1		1	1	2	2	1	1	11
Očihov			1	1	4	2	3	4	3	1		19
Březno				1	1	1						
2001												
Hředle		1			1			1				3
Krupá	2	2	1		1		2	2				10
Nesuchyně		1	1		2	4	4	2	1	2	3	20

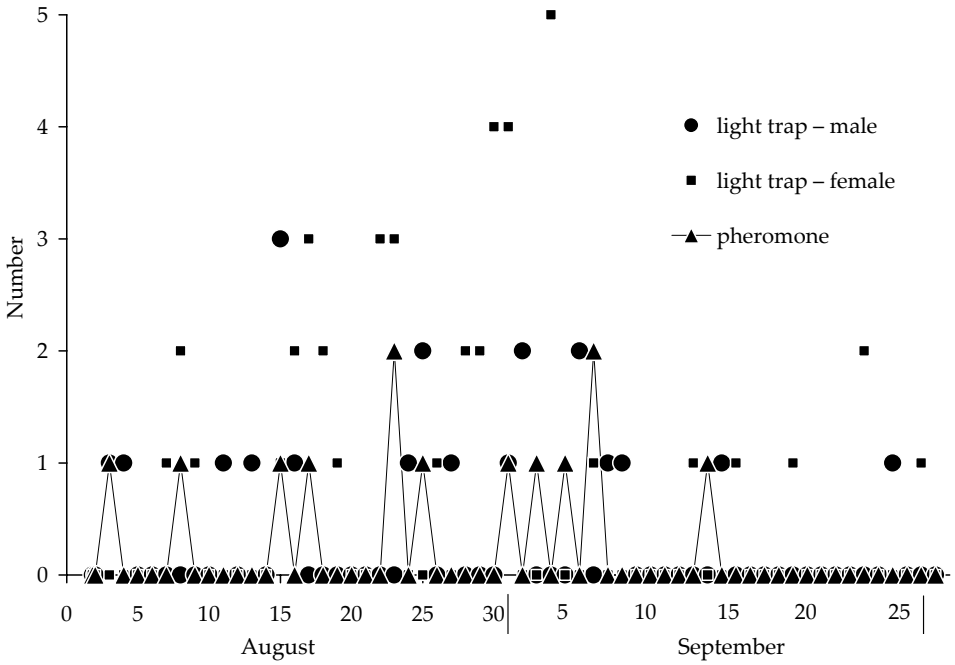

Figure l. Numbers of Rosy rustic moth males and females caught in a pheromone trap and in a light trap in 2000 (Prague-Ruzyně)

Monitoring of imagines dispersion

In hop gardens where monitoring was provided by pheromone traps at weekly intervals, the density of trapped males was higher in 2000 than in 2001. The highest number of males were caught at Krupá and Nesuchyně, that means at the localities with repeated damages by RRM. The number of males caught in a pheromone trap at Očihov was approximately the same as at Krupá. At Březno (district of Louny) males were trapped only occasionally (Table 3), while at Třeskonice and Ročov that also

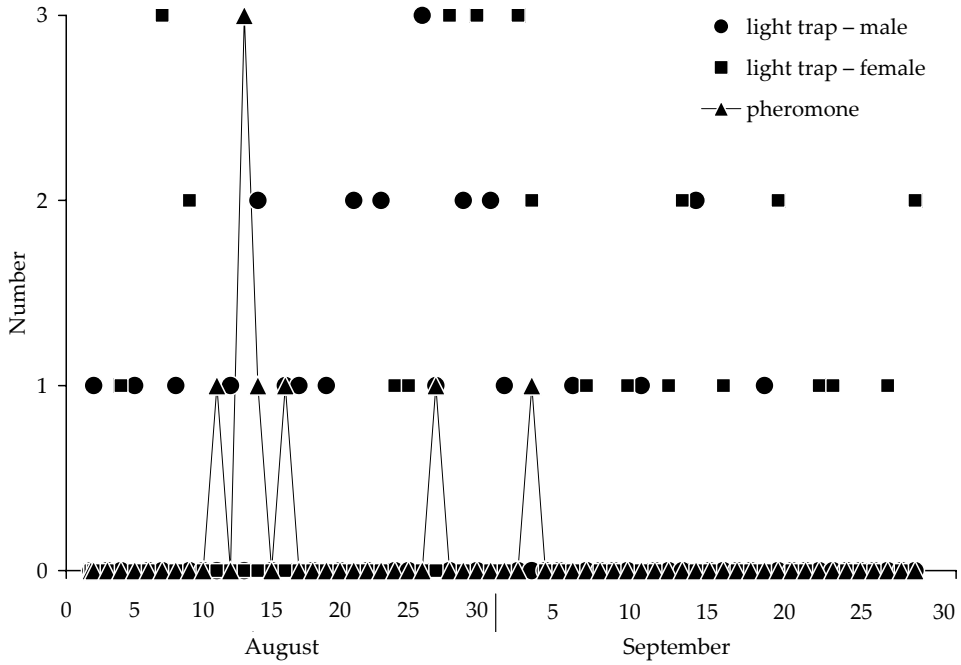

Figure 2. Numbers of Rosy rustic moth males and females caught in a pheromone trap and in a light trap in 2001 (Prague-Ruzyně)

lie inside this district no males were monitored at all. The number of males caught by a pheromone trap placed at Prague-Ruzyně was higher in 2000 (13 individuals) than in 2001 (8 individuals). The highest numbers of males (7 individuals) were trapped in the second half of August and at the beginning of September (15. 8.–2. 9.) (Figure 1).

The number of 21 males trapped in a light trap at Prague-Ruzyně in 2000 was lower than the 26 males caught in 2001. The highest density of males, if we take into account both studied years, was monitored from August 15 to September 5. Females caught in the light trap numbered 43 in 2000 and 32 in 2001; most of them occurred from August 27 to September 2. The first full-developed eggs in ovaries of females caught in the light trap were found on August 16, the last on September 25 (Figure 2).

DISCUSSION

Not only in old hop gardens but also in newly established ones there were repeated harmful occurrences of RRM. Waterlogged areas close to infested hop gardens may serve as reservoirs of RRM, especially in years with unfavourable weather conditions for the development of this pest. Presence of and harm by RRM are obvious only in hop gardens infested by quackgrass, as females deposit their eggs on this species. Neither eggs nor caterpillars were found on other dominant species of weeds growing inside hop gardens. Nevertheless, to prevent damage by caterpillars of RRM, the eradication not only of quackgrass but also green foxtail (*Setaria viridis* (L.) Beauv.), barnyard grass (*Echinochloa crus-galli* (L.) Beauv.) and other perennial weeds is recommended. Though we have so far not found any RRM eggs on these species, they may be suitable for egg deposition.

It is possible to determine the time of caterpillar hatching in spring with the help of SET, which is 78.6°C on average. To calculate SET we used an appropriate LDT = 6.83°C, taken from Bruce *et al.* (1985) who used this value for a U.S. population of RRM with a SET of 133°C. The difference in the SET between the Czech population and that from the U.S. may be caused by genetic variability of the pest or by a different time of diapauses. Our calculated SET value was confirmed in the Žatec (Saaz) hop region where it corresponded with the beginning of caterpillar hatching. Mass hatching lasted from the middle of April till May. Growth of caterpillars was variable during a season. The surprising appearance of young caterpillars at the beginning of August attests to their late hatching. Pospelov (1965) opines that part of the larval population may even hatch as late as autumn.

Based on present knowledge, mass hatching of larvae is a suitable time to determine their density in a hop garden and to decide on possible chemical control in spring. However, since it is not effective enough for the whole time of larvae hatching, the use of insecticides is considered to be a less effective method than early eradication of quackgrass.

Damage by RRM is most severe at edges of a hop garden and in places of anchorages between two hop gardens. It is increased by secondary infection of hop rootstocks by fungal pathogens from the soil. Young rootstocks used for replanting seem to be most sensitive to such secondary infections.

Pheromone traps are suitable for determining the population density of males. Results obtained from them can be considered only for the nearest neighbourhood. A higher population density of males was found at localities with repeated harmful occurrence of RRM. The numbers of males caught in light traps were higher than those in pheromone traps. Females caught in a light trap had the first full-developed eggs in their ovaries towards the end of August and in September.

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Abstrakt

Šedivý J., Born P., Vostřel J. (2005): **Škodlivý výskyt šedavky luční** (*Hydraecia micacea*) **na chmelu v České republice**. Plant Protect. Sci., **41**: 150–157.

Šedavka luční se opakovaně vyskytuje ve chmelnicích zaplevelených pýrem plazivým, na který klade vajíčka. SET líhnutí housenek při spodním prahu vývoje 6,83 °C činí v průměru 78,6 °C. Na jaře housenky zpočátku přijímají potravu na pýru, krátce nato se stěhují na chmel, kde vyžírají výhony a později škodí na podzemních částech rostlin. Způsobují vadnutí rév a odumírání napadených rostlin. Přelet samců na feromonové lapáky je sporadický. Více jedinců bylo uloveno na světelném lapáku. Včasná chemická likvidace pýru plazivého je efektivnější metodou ochrany než chemická ochrana insekticidy proti nejmladším instarům housenek.

Klíčová slova: líhnutí housenek; plevele; parazitoidi; škodlivost; monitoring; predátoři

Corresponding author:

Doc. RNDr. Josef Šedivý, DrSc., Výzkumný ústav rostlinné výroby, odbor rostlinolékařství, oddělení entomologie, 161 06 Praha 6-Ruzyně, Česká republika
tel: + 420 233 024 416, fax: + 420 230 310 636, e-mail: sedivy@vurv.cz