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EVALUATION OF THE SELECTIVITY AND EFFICIENCY OF SYNTHETIC SEX PHEROMONES OF LEAF-ROLLERS FROM DIFFERENT MANUFACTURERS

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Abstract

In 2019 (May–September), the efficiency of pheromone lures for *Grapholita funebrana* Treitschke, 1835 and *Pandemis heparana* (Denis & Schiffermüller, 1775) from two manufacturers (Propher, Pherobank) were compared. Monitoring was performed in three study areas in South Moravia (Czech Republic): Kyjov (faunistic square 6968), Brno-Soběšice (6765) and Brno-Starý Lískovec (6865). A total of 14 pheromone traps, from both companies, were suspended. Both target species were found in the traps, with *Grapholita funebrana* present in all study areas (a total of 5107 adults) and *Pandemis heparana* was found in Kyjov (64 adults). Furthermore, 2061 individuals of non-target species from the Autostichidae, Noctuidae, Tortricidae and Yponomeutidae families were captured. And 7 non-target species were captured using the pheromone for *G. funebrana*, most numerously *Grapholita molesta* (Busck, 1916), *Cnephasia stephensiana* (Doubleday, 1849) and *Argyresthia trifasciata* Staudinger, 1871; while, only two non-target species were identified using the pheromone for *P. heparana*, *Noctua fimbriata* (Schreber, 1759) and *Yponomeuta malinellus* Zeller, 1838. Compared to Propher pheromones, Pherobank pheromones were more attractive for target species and less attractive for non-target species.

Keywords: pheromone lures, pheromone traps, *Grapholita funebrana*, *Pandemis heparana*, non-target species

INTRODUCTION

The chemical composition of pheromones in many insect species is currently known, for example the Dutch company Pherobank offers pheromone lures for more than 500 species (Pherobank, 2020). Synthetic sex pheromones make it possible to determine the number of adults (individuals) (in practice they are mainly used to monitor abundance of pests, especially species from the families: Tortricidae, Sesiidae, Crambidae and Pyralidae), and also help determine the time of occurrence for the most accurate timing of the plant control.

Leaf-rollers are among the most widespread and diverse Lepidoptera family (e.g. Scoble, 1995), with over 11,000 species known worldwide (Gilligan *et al*., 2018); in the Czech Republic, it is the largest of the Lepidoptera families, where Laštůvka and Liška (2011) state there are 476 species. Leaf-roller caterpillars are widespread and a serious pest in agriculture, forestry and ornamental plants, e.g. caterpillars of more species directly develop in the fruits and they distinctly reduce yield of fruit trees (Šefrová, 2014).

In the Czech Republic, several authors paid attention to the monitoring of abundance and seasonal dynamics using synthetic sex pheromones, such as Hrdý *et al.* (1979, 1989, 1993, 1994, 1997), Hrudová (2003, 2005), Hluchý (2011) and Jakubíková *et al.* (2016), by testing lures not only on *Grapholita funebrana* and *Pandemis heparana*, but also on *Grapholita molesta*, *G. janthinana*, *G. lobarzewskii*, *Cydia pomonella* and bud (*Spilonota ocellana*, *Hedya nubiferana*) and peel leaf-rollers (*Adoxophyes orana*). In Hungary, these experiments were performed by Sziráki (1978) on the *Grapholita molesta* pheromone, and on the pheromones for *G. funebrana* and *G. molesta* in Bulgaria by Velcheva (2000). Later, attention was paid to non-target species.

Using various types of traps, individual authors used lures that they either produced themselves or obtained from manufacturers from several countries (Czech Republic, Hungary, Netherlands).

MATERIALS AND METHODS

Study Areas

Monitoring was carried out in the 2019 season from May to September on three study areas in the South Moravian Region in the Czech Republic. Pheromone traps were installed in an old apple orchard in Brno-Soběšice – U Jezírka, in a plum orchard in Brno-Starý Lískovec and in an apricot orchard in Kyjov (Fig. 1).

The apple orchard in U Jezírka is located in the district of Brno-City, on the northern outskirts of the city (49°16'9.640"N, 16°37'47.925"E, faunistic square 6765). The total area of the orchard is 1.2 ha, at an altitude of 390 m. The apple trees in the orchard are not chemically treated. There are mixed forests around the area.

The plum orchard in Starý Lískovec falls in Starý Lískovec's fruit-growing cooperative. The cooperative is located in the district of Brno-City, on the southern outskirts of the city (49°09'31.4"N, 16°34'25.1"E, faunistic square: 6865). The total area of the orchard is 2 ha, at an altitude of 237 m. A protective intervention against sawflies was carried out here. Around the orchard are shrubs of various species and a large apple orchard.

The apricot orchard in Kyjov is located in the district of Hodonín, on the eastern outskirts of the city (49°00'33.3"N, 17°08'29.5"E, faunistic square: 6968). The total area of the orchard is 1.8 ha, with an altitude of 192 m. No chemical intervention was carried out on the orchard. To a lesser extent, there are also apple, plum and walnut trees in the orchard.

1: *The location of the study areas on a map of the South Moravian Region*

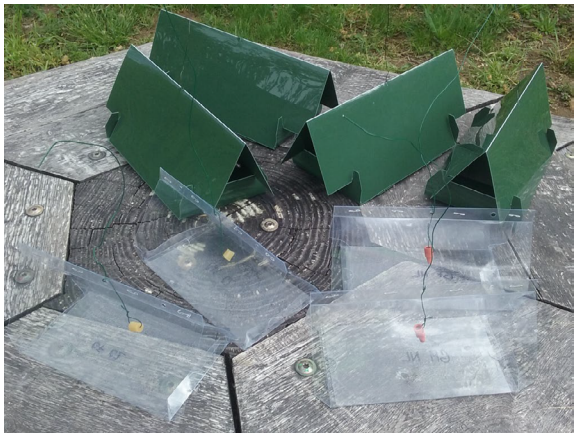
Pheromone Traps and Lures

Pheromone traps and synthetic sex pheromones (pheromone lures) were purchased from Pherobank (NL) and Propher (CZ). Green (Propher) and transparent (Pherobank) plastic pheromone traps of the delta type with four types of pheromone lures (Fig. 2) were used for monitoring. A lure from Propher was used for the *Grapholita funebrana* species (Březová near Zlín, Czech Republic) with the active substances: (E)-dodec-8-en-1-yl acetate (0.0012 g/kg), (Z)-dodec-8-en-1-ol (0.0204 g/kg), Chemstop Ecofix (20–25%) and dodecyl acetate (0.2784 g/kg). A lure that was supplied by Pherobank (from the Netherlands) was used as the second lure to monitor this species. Pheromone lures for the given pest differ in the mutual ratio of active substances, which is a trade secret of the company. Pheromones from Propher and Pherobank were also used to monitor *Pandemis heparana*, but neither company has published the composition of this pheromone.

The pheromone for *Pandemis heparana* was applied only in green traps on the study area in Kyjov (June–August). A total of 14 pheromone traps were suspended (Tab. I). Four pheromone traps were applied in the study areas in Soběšice and Starý Lískovec. Six pheromone traps were applied in the study area in Kyjov.

I: *Suspended pheromone traps in individual localities*

	Green traps (Propher)		Transparent traps (Pherobank)	
Soběšice	GF Pherobank	GF Propher	GF Pherobank	GF Propher
Starý Lískovec	GF Pherobank	GF Propher	GF Pherobank	GF Propher
Kyjov	GF Pherobank	GF Propher	GF Pherobank	GF Propher
	PH Pherobank	PH Propher		



2: *Green and transparent delta traps from Propher and Pherobank*

The traps were suspended in May and remained in the areas until the end of September. All traps were marked to avoid confusion of the different pheromones during regular changes. Pheromones were changed after four weeks. The sticky boards were checked once a week and were changed as needed.

Identification

The determination was performed according to the morphology of genitalia (e.g. Robinson, 1976). The abdomens of adults were placed in test tubes with 10% KOH, where they were then boiled for 5 minutes. After cooking, the abdomens were rinsed with water and genitalia were dissected and placed in glycerol on a Petri dish. Subsequently, the determination was performed according to Razowski (2001). The determination of some specimens was revised by Z. Laštůvka.

RESULTS AND DISCUSSION

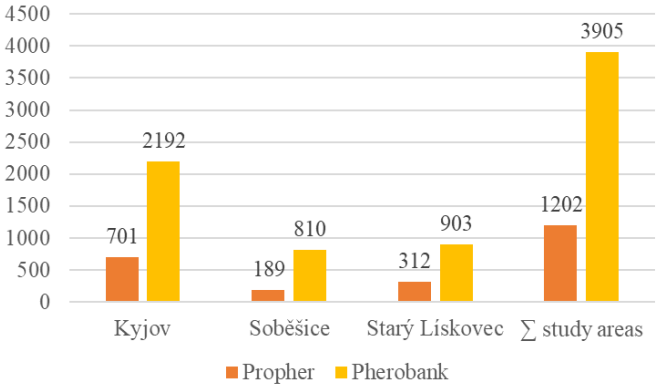
Grapholita funebrana Treitschke, 1835

Grapholita funebrana (GF) was detected in all localities. This finding was expected because *Grapholita funebrana* belongs to the widespread and abundant species and significant pests of stone fruits, especially plum trees. A total of 5107 adults of this species were identified (Fig. 3), with 999 adults captured in Soběšice, 1215 in Starý Lískovec and 2893 in Kyjov.

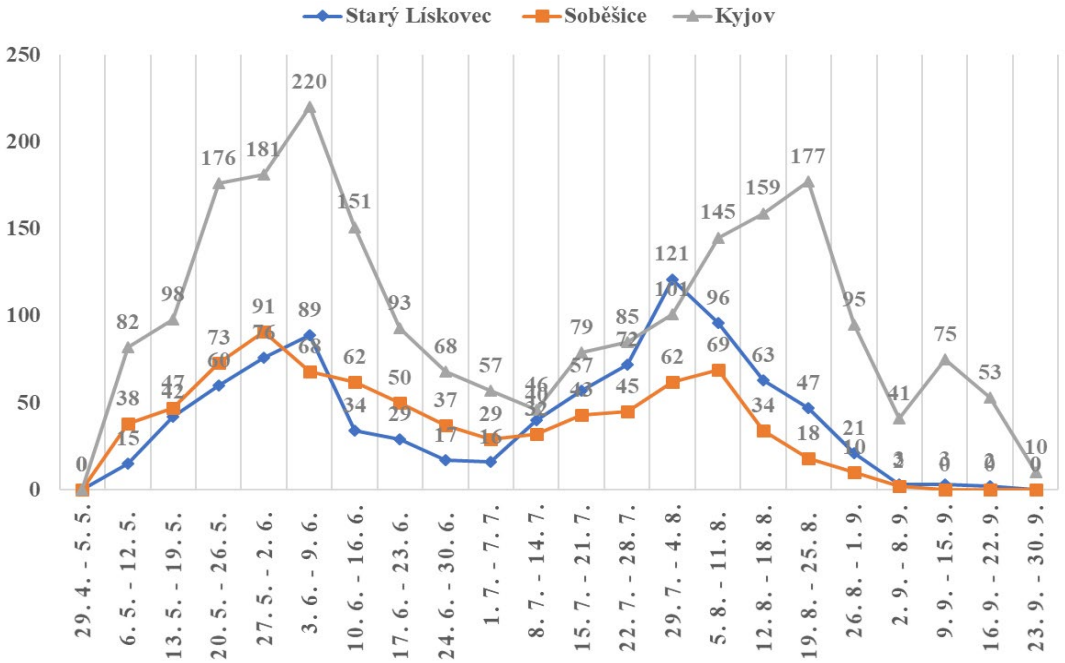
Grapholita funebrana flew more frequently on Pherobank pheromones, with a total of 3905 adults in the study areas (Fig. 3). For Propher pheromones, a total of 1202 adults of this species were recorded. Most *Grapholita funebrana* were captured in Kyjov using pheromones from Pherobank (2192 adults), and the lowest numbers were in Soběšice, using pheromones from Propher (189 adults). Flying into *Grapholita funebrana* pheromone traps in all study areas are shown in Figs. 4, 5. The graphs show two significant flight waves in all tested areas.

Pandemis heparana (Denis & Schiffermüller, 1775)

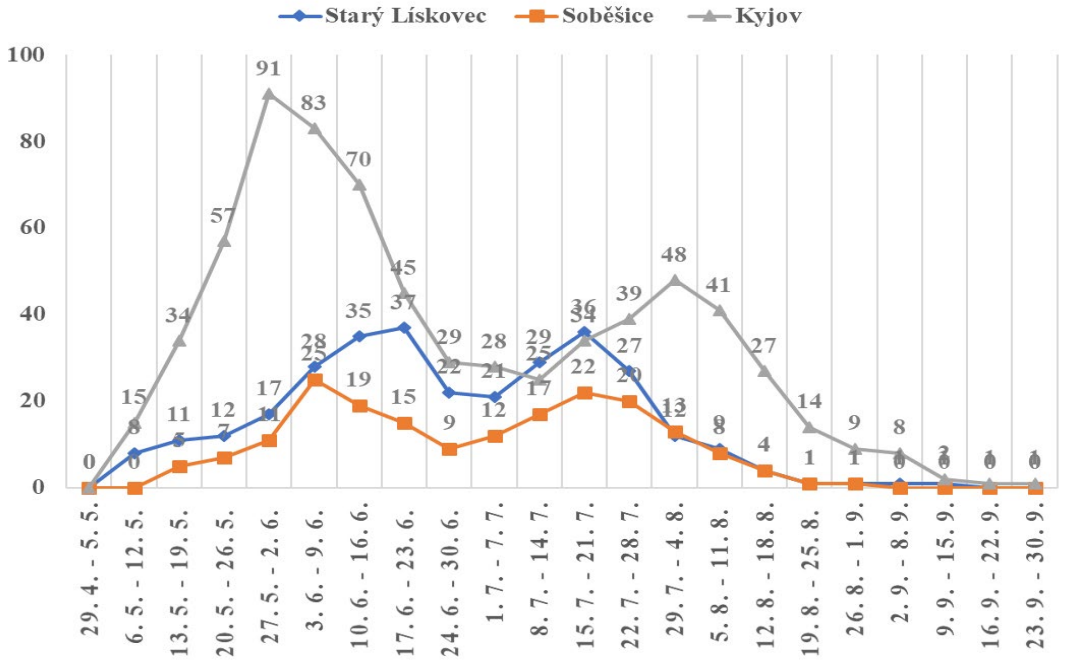
In 2019, *Pandemis heparana* was only recorded in Kyjov when using a pheromone from Pherobank. This species did not fly to the Propher pheromone. *Grapholita funebrana* flights to these pheromones were not recorded either. A total of 64 adults of *Pandemis heparana* were captured in Kyjov. *Pandemis heparana* was monitored in 2017 in the Arboretum of Mendel University in Brno, in the garden in Újezd u Černé Hory (Pražanová, 2018), in 2015 in the territory of the municipality of Ruda in the Vysočina region (Komínková, 2016) and in the territory of Eastern Moravia, near Zlín (Jakubíková, 2016), but always on pheromones from Propher because pheromones from Pherobank were not used. During these years, *Pandemis heparana* was not detected in any of the installed traps. The occurrence of *Pandemis heparana* in Kyjov was confirmed using a pheromone from Pherobank. In other areas, it was not possible to confirm the occurrence of the species. However, if the adults were not captured in 2017 and 2015, it could have been due to an inappropriate pheromone composition, which the observed species were not attracted to.



3: *Number of Grapholita funebrana males captured using Propher and Pherobank pheromones*



4: *Flight activity of Grapholita funebrana on Pherobank GF pheromone*



5: *Flight activity of Grapholita funebrana on Propher GF pheromone*

Non-target Species

A total of 2061 non-target specimens from the order Lepidoptera were recorded in the traps. A total of 668 adults of non-target species flew to Pherobank pheromones and 1393 adults of non-target species flew to Propher pheromones. The most important non-target species captured on the *Grapholita funebrana* pheromones was *Grapholita molesta*. A total of 1702 adults of this species flew to these pheromones. *Grapholita molesta,* as a non-target species, was recorded at all localities and always in a trap with the pheromone GF. The specificity of sex pheromones is given by the ratio of the individual components. *Grapholita funebrana* and *G. molesta* are related species and the composition of their pheromones can be highly similar and can only differ by a small number of particles, i.e. in their ratio. Therefore, it happens that they fly into each other's traps for 'their' pheromones. *Grapholita molesta* more often flew to

II: *Numbers of captured non-target species in Kyjov, Soběšice and Starý Lískovec*

Locality	Non-target species	*Pheromone*				
		Grapholita funebrana		*Pandemis heparana*		
		Pherobank	Propher	Pherobank	Propher	Σ
Kyjov	*Grapholita molesta*	317	575	0	0	892
	Cnephasia stephensiana	15	27	0	0	42
	Argyresthia trifasciata	19	36	0	0	55
	Noctua pronuba	0	0	5	31	36
	Yponomeuta malinellus	0	0	4	9	13
Soběšice	*Grapholita molesta*	35	62	0	0	97
	Cnephasia stephensiana	21	32	0	0	53
	Epiblema cirsiana	0	15	0	0	15
	Pammene suspectana	0	8	0	0	8
	Oegoconia novimundi	4	23	0	0	27
	Yponomeuta malinellus	2	7	0	0	9
Starý Lískovec	*Grapholita molesta*	216	497	0	0	713
	Cnephasia stephensiana	13	29	0	0	42
	Epiblema cirsiana	0	17	0	0	17
	Argyresthia trifasciata	17	25	0	0	42
	Σ	659	1353	9	40	**2061**

III: *Non-target species registered by various authors on the Grapholita funebrana pheromone*

Non-target species	Authors
Acleris holmiana (Linnaeus, 1758)	Velcheva, 2000
Acleris rhombana (Denis & Schiffermüller, 1775)	Velcheva, 2000
Acronicta psi (Linnaeus, 1758)	Jakubíková *et al*., 2016
Acronicta rumicis (Linnaeus, 1758)	Jakubíková *et al*., 2016
Agrotis segetum (Denis & Schiffermüller, 1775)	Hrudová, 2005
Agrotis clavis (Hufnagel, 1766)	Hrdý *et al*., 1979
Alcis repandata (Linnaeus, 1758)	Jakubíková *et al*., 2016
Anarsia lineatella (Zeller, 1839)	Hrdý *et al*., 1979
Apotomis infida (Heinrich, 1926)	Velcheva, 2000
Argyresthia trifasciata (Staudinger, 1871)	Pražanová, 2018
Celypha rosaceana (Schläger, 1847)	Jakubíková *et al*., 2016
Celypha striana (Denis & Schiffermüller, 1775)	Hrdý *et al.* 1979; Hrdý *et al.* 1993; Hrudová 2005; Jakubíková *et al*., 2016
Cnephasia communana (Herrich-Schäffer,1851)	Hluchý, 2011
Cnephasia genitalana (Pierce & Metcalfe, 1922)	Hrdý *et al*., 1993; Velcheva, 2000
Cnephasia pasiuana (Hübner, 1799)	Hluchý, 2011[1]
Cnephasia stephensiana (Doubleday, 1849)	Hrdý *et al.* 1993; Velcheva, 2000; Hluchý, 2011; Jakubíková *et al*., 2016; Pražanová 2018
Cydia pomonella (Linnaeus, 1758)	Hluchý, 2011

1 It was very probably *Cnephasia pumicana*, because Hluchý determined the *Cnephasia* species after Razowski (2001), which had not distinguished the taxa *C. pasiuana* and *C. pumicana*, and because *C. pumicana* is common and widespread species in the Czech Republic unlike the very rare *C. pasiuana* (J. Šumpich pers. comm.).

Non-target species	Authors
Enarmonia formosana (Scopoli, 1763)	Hrdý *et al*., 1979; Hrdý *et al*., 1993; Velcheva, 2000; Hluchý, 2011
Epiblema cirsiana (Zeller, 1843)	Jakubíková *et al*., 2016; Pražanová, 2018
Epiblema costipunctana (Hawort, 1811)	Hluchý, 2011
Epiblema sticticana (Fabricius, 1794)	Velcheva, 2000
Epiblema foenella (Linnaeus, 1758)	Hrdý *et al*., 1979; Velcheva, 2000
Epiblema hepaticana (Treitschke, 1835)	Velcheva, 2000
Epiblema junctana (Herrich-Schäffer, 1856)	Jakubíková *et al*., 2016
Epiblema mendiculana (Treitschke, 1835)	Velcheva, 2000
Epiblema scutulana (Denis & Schiffermüller, 1775)	Hrdý *et al*., 1979; Hrdý *et al*., 1993; Velcheva, 2000; Hrudová, 2005
Euxoa nigricans (Linnaeus, 1761)	Hrdý *et al*., 1979
Grapholita coronillana (Lienig & Zeller, 1846)	Hrudová, 2005
Grapholita janthinana (Duponchel, 1835)	Velcheva, 2000; Hluchý, 2011; Jakubíková *et al*., 2016
Grapholita molesta (Busck, 1916)	Hrdý *et al*., 1979; Velcheva, 2000; Hrudová, 2005; Hluchý, 2011; Jakubíková *et al*., 2016; Pražanová, 2018
Grapholita rosana (Danilevsky, 1968)?	Velcheva, 2000
Grapholita tenebrosana (Duponchel, 1834)	Hrdý *et al*., 1979; Hrdý *et al*., 1993; Velcheva, 2000; Hluchý, 2011
Hedya dimidiana (Clerck, 1759)	Hluchý, 2011
Hedya nubiferana (Haworth, 1811)	Velcheva, 2000
Hedya pruniana (Hübner, 1799)	Velcheva, 2000; Jakubíková *et al*., 2016
Hypena proboscidalis (Linnaeus, 1758)	Jakubíková *et al*., 2016
Hypena rostralis (Linnaeus, 1758)	Jakubíková *et al*., 2016
Mesoligia furuncula (Denis & Schiffermüller, 1775)	Hrdý *et al*. 1979; Jakubíková *et al*., 2016
Mesapamea secalella (Remm, 1983)	Jakubíková *et al*., 2016
Notocelia incarnatana (Hübner, 1800)	Jakubíková *et al*., 2016
Notocelia roborana (Hübner, 1796)	Hrudová, 2005
Notocelia rosaecolana (Doubleday, 1850)	Hrudová, 2005
Oegoconia novimundi (Busck, 1915)	Jakubíková *et al*., 2016; Pražanová, 2018
Pammene albuginana (Guenée, 1845)	Velcheva, 2000; Jakubíková *et al*., 2016
Pammene amygdalana (Duponchel, 1842)	Hrdý *et al*. 1997; Velcheva, 2000; Jakubíková *et al*., 2016
Pammene argyrana (Hübner, 1799)	Velcheva, 2000; Jakubíková *et al*., 2016
Pammene aurana (Fabricius, 1775)	Hrdý *et al*. 1979; Hrdý *et al*. 1997; Jakubíková *et al*., 2016
Pammene aurita (Razowski, 1991)	Hrdý *et al*., 1997
Pammene fasciana (Linnaeus, 1761)	Hrdý *et al*., 1993; Velcheva, 2000
Pammene gallicolana (Lienig & Zeller, 1846)	Velcheva, 2000; Hluchý, 2011; Jakubíková *et al*., 2016; Pražanová, 2018
Pammene giganteana (Peyerimhoff, 1863)	Velcheva, 2000; Hluchý, 2011
Pammene populana (Fabricius, 1787)	Velcheva, 2000
Pammene spiniana (Duponchel, 1843)	Mayer & McLaughlin in Hrdý *et al*., 1997; Velcheva, 2000; Jakubíková *et al*., 2016; Pražanová, 2018
Pammene splendidulana (Guenée, 1845)	Velcheva, 2000
Pammene suspectana (Lienig & Zeller, 1846)	Hrdý *et al*., 1979; Hrdý *et al*., 1997; Velcheva, 2000; Hrudová, 2005; Jakubíková *et al*., 2016; Pražanová, 2018
Recurvaria nanella (Denis & Schiffermüller, 1775)	Hrdý *et al*., 1979
Scrobipalpa atriplicella (Fischer von Röslerstamm, 1841)	Hrdý *et al*., 1979
Spilonota ocellana (Denis & Schiffermüller, 1775)	Hrudová, 2005

IV: *Non-target species registered by various authors on Pandemis heparana pheromone*

Non-target species	Authors
Agapeta zoegana (Linnaeus, 1767)	Jakubíková *et al*., 2016
Cacoecimorpha pronubana (Hübner, 1799)	Jakubíková *et al*., 2016
Cnephasia stephensiana (Doubleday, 1849)	Jakubíková *et al*., 2016
Crassa unitella (Hübner, 1796)	Pražanová, 2018
Dichelia histrionana (Frölich, 1828)	Jakubíková *et al*., 2016
Epiblema cirsiana (Zeller, 1843)	Jakubíková *et al*., 2016
Euspilapteryx auroguttella (Stephens, 1835)	Jakubíková *et al*., 2016
Gypsonoma minutana (Hübner, 1799)	Jakubíková *et al*., 2016
Hedya nubiferana (Haworth, 1811)	Jakubíková *et al*., 2016
Noctua fimbriata (Schreber, 1759)	Hrdý *et al*., 1993; Jakubíková *et al*., 2016
Noctua pronuba (Linnaeus, 1761)	Hrudová, 2005
Polia nebulosa (Hufnagel, 1766)	Jakubíková *et al*., 2016
Tortrix viridana (Linnaeus, 1758)	Pražanová, 2018
Yponomeuta malinellus (Zeller, 1838)	Pražanová, 2018
Zygaena ephialtes (Linnaeus, 1767)	Jakubíková *et al*., 2016

the pheromone from Propher (Tab. II). *Grapholita molesta* occurs mainly in warmer regions (Hrdý *et al.*, 1979a, 1994), which could be one of the reasons why this species was most abundantly recorded in Kyjov. Also, in Kyjov, there are mainly apricot and plum trees which are the main hosts of *G. molesta*. The flying of the following species on this pheromone was also recorded: *Cnephasia stephensiana* (Doubleday, 1849), *Epiblema cirsiana* (Zeller, 1843), *Pammene suspectana* (Lienig & Zeller, 1846), *Argyresthia trifasciata* (Staudinger, 1871), *Oegoconia novimundi* (Busck, 1915) and *Yponomeuta malinellus* (Zeller, 1838).

Adults of the species *Noctua pronuba* (Linnaeus, 1758) in the total number of 36 adults was recorded on *Pandemis heparana* pheromones from both companies. This species was also registered in traps with the *Pandemis heparana* pheromone by Hrdý *et al.* (1989) and Hrudová (2003). Furthermore, *Yponomeuta malinellus* was recorded on pheromones from both companies in the total number of 13 adults.

Various authors have already found a total of 58 non-target species flying on the *Grapholita funebrana* pheromone and 15 non-target species on the *Pandemis heparana* pheromone. The total spectrum of non-target species registered on pheromones for these two species is shown in Tab. III and IV.

CONCLUSION

The selectivity and efficiency of synthetic sex pheromones from Pherobank and Propher on fruit tree pests, *Grapholita funebrana* and *Pandemis heparana,* were tested, based on monitoring, with the following results:

1. Occurrence of *Grapholita funebrana* was confirmed in all studied localities, the highest number of captured individuals was in the orchard in Kyjov (2893 adults), and the lowest was in Soběšice (999 adults).
2. Occurrence of *Pandemis heparana* was shown in the locality of Kyjov, but only with a pheromone from Pherobank.
3. Pherobank pheromones proved to be more selective and effective than those from Propher during our experiment. More individuals of target species and fewer individuals of non-target species were captured on these pheromones than on pheromones from Propher.
4. Around 191 more specimens of non-target species flew on the pheromone from Propher than specimens of the target species.
5. A total of 2061 specimens from non-target moth species were captured.
6. The most abundant non-target species were *Grapholita molesta*, *Cnephasia stephensiana* and *Argyresthia trifasciata*.

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