Preliminary data on the effect of semi-synthetic baits for Noctuidae (Lepidoptera) on the non-target Lepidoptera species

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SUMMARY

Noctuidae are one of the most important Lepidoptera groups containing dangerous pest species. Monitoring and detection of these pest species is routinely performed by traps baited with sex-pheromones. Baits that attract both males and females were developed for improved pest management. First the effectiveness of different synthetic compounds was evaluated. We also tested semi-synthetic baits that contained both synthetic and natural components (wine and beer). These were more attractive for moths considering species richness and abundance. Disadvantage of this increased effectiveness is that the traps catch more non target, rare and even protected species. In this study we analysed the effect of semi-synthetic baits developed for Noctuid moths containing wine on other non-target Lepidopterans. In the six sampling sites traps caught 17158 individuals of 183 Lepidoptera species. The number of Noctuidae species was 124, while their proportion was 84.4%. The traps caught 813 individuals of 9 protected and 20 valuable species, which was only 4.7% of all Lepidopterans. In contrast the mean proportion of 33 dangerous and potential pest species was 31.3% (5375 individuals). Number and abundance of both protected and pest species were affected by landscape structure. The risks of catching non-target species was higher in species rich natural and semi-natural landscape. In homogenous arable lands the number and proportion of valuable Lepidopterans was not significant.

Keywords: pest monitoring, food attractants, loss of biodiversity, semi-synthetic baits

INTRODUCTION

Noctuidae is one of the most important families of Lepidoptera because of several dangerous and economically important pest species. The monitoring of these pests, which is an important part of the IPM (Integrated Pest Management) strategy against them, is generally performed by different trapping methods. In the last decades, widely used sex pheromone-baited traps have replaced the light traps used before. These baited traps can easily be used and are very effective and species specific, but lure only male moths. However, data of females are more valuable for pest control decisions, so the development of female catching baits have been ongoing since the 1970’s (Creighton et al., 1973; Cantelo and Jacobson, 1979; Landolt, 2000; Landolt and Alfaro, 2001; Tóth et al., 2010). The effectiveness of several synthetic compounds (e.g. phenylacetaldehyde, isoamyl-alcohol and isobutanol in combination with acetic acid) were proved to be effective for Noctuid moths. The effectiveness of these synthetic baits can be increased with wine and beer as natural additives. These ‘semi-synthetic’ baits lure more species and more individuals than the synthetic ones (Nagy et al., 2014; Tóth et al., 2015). These synthetic and semi-synthetic baits are more general attractants than species specific pheromones. Using these traps, several important pest species can be monitored in the same time minimizing sampling effort (Tóth et al., 2010). The remarkable disadvantage of the lack of specificity is the risk of catching non-target and even rare or protected species. In some cases, even the more specific traps baited with sex pheromone can also catch non target species (Olenici et al., 2007), but the probability of non-target catches might be much higher in case of traps baited with feeding attractants.

In the present study, the effect of semi-synthetic baits, consisting of isoamyl alcohol, acetic acid and wine, was analysed on the non-pest, non-target Lepidoptera species. We used data from different studies, which aimed to develop ‘bisex’ (attractive for both males and females) baits or faunistic analysis of natural and semi-natural habitats. Our goal was to determine the amount of the non-target effect and provide a basis for further investigations.
MATERIAL AND METHODS

In the present analysis we used data of different studies on semi-synthetic baits for trapping Noctuid pest species. The sampling was carried out in six locations in East and Northeast Hungary (5 sites) and West Ukraine (1 site) during 2013-2014. Four of the sampling sites (Forró, Balmazújváros, Debrecen-Ondód, Hernádnémeti) were located in mostly agricultural landscape surrounded by intensively used arable lands while the others (Nagycsere and Nagydobrony) were surrounded with more diverse extensively used landscapes (Figure 1, Table 1).

Figure 1: Location of the sampling sites and linear transects of the traps in the six studied sites in 2013-2014 (Source: GoogleEarth).
Noctuidae moths (Hadeninae and Acronictinae subfamilies, which cumulative ratio was 80.4% (11653 individuals) among sampled sites. The baits showed much higher effectiveness in case of species belonging to Xyleninae, Noctuinae, moths was 14487 that was the 84.4% of the identified Lepidopterans and their ratio varied between 70.2 -95.5 by ecosystems than in the most diverse extensively used landscapes (67.2 -72.5%). The total number of Noctuid ratio of Noctuidae species among all sampled Lepidoptera was higher (82.9 -90.6%) in the less diverse agro-sites 126 Noctuidae species of 17 subfamilies were sampled, which were 68.9% of all sampled Lepidoptera. The

Table 2

Hepialidae only one specimen was caught that also could not be identified at species level (see Appendix 1). The 2.7 % (n=484) of the specimens could be identified only at the family level. In case of characterized with total and mean number of species and individuals in case of groups, families and species. The

Table 1

Sampling area | N   | E     | Start         | Finish          |
-------------|-----|-------|---------------|-----------------|
Forró        | 47° 19.770' | 21° 3.773' | 1st July 2013 | 1st November 2013 |
Debrecen-Ondód | 47° 32.031' | 21° 31.053' | 2nd July 2013 | 2nd November 2013 |
Nagydobrony  | 48° 25.619' | 22° 25.128' | 20th July 2014 | 19th October 2014 |
Nagycsere    | 47° 31.847' | 21° 46.910' | 17th July 2014 | 12th November 2014 |
Hernádnémeti | 48° 9.595' | 21° 2.991' | 2nd July 2014 | 16th November 2014 |
Balmazújváros | 47° 36.202' | 21° 26.352' | 8th July 2014 | 22nd November 2014 |

In Forró, Ondód, Hernádnémeti and Balmazújváros the effect of natural compounds (wine and beer) and their extracts on the efficiency of synthetic lures was tested. In Nagycsere the Noctuidae fauna of a semi-natural landscape, while in Nagydobrony the fauna of the protected Nagydobrony Game Reserve was studied using synthetic and semi-synthetic baits for Noctuid species. We use the data collected by semi-synthetic baits contain mixture of isoamyl alcohol, acetic acid and red wine (1:1:1, 3 ml), which was used in all of the six studies. Polypropylene tubes with 4 ml capacity were used as dispensers (Tóth et al., 2015). The mixture was administered on dental rolls inside the tubes. The lure could evaporate across a small opening with 4 mm in diameter, which was opened when setting out in the field. The trapped moths were killed by an insecticide strip.

During the studies CSALOMON® VarL+ traps were used in five (Balmazújváros, Ondód, Hernádnémeti and Forró) or four (Nagycsere, Nagycsere) repetitions. The traps were placed in the sites on trees situated in the edge of the sites in 1.8-2 m height. The distance between the traps was 40-100 m depending on the design of the given study. The sampling periods of Noctuid moths in the six sampling sites studied in 2013-2014

RESULTS AND DISCUSSION

In the six sampling sites the traps caught 17642 Lepidoptera that belonged to 184 species and nine families (see Appendix 1). The 2.7 % (n=484) of the specimens could be identified only at the family level. In case of Hepialidae only one specimen was caught that also could not be identified at species level (Table 2). Beyond that 843 individuals of Vespidae species (Vespa crabro, V. germanica and Polistes sp.) and 11 honey-bees (Apis mellifera) were sampled.

The most species rich sites were Nagycsere (128) and Nagydobrony (91), which can be characterised by most diverse landscape structure than the others, where the species number ranged between 57 and 70. The mean number of species per trap was higher in Nagycsere (71.3±7.1) while in Ondód a trap lured only 33.2 (±5.5) species on the average. The abundance of Lepidoptera generally was higher in the less diverse arable lands. The number of individuals per trap was the highest in Balmazújváros (1162±127.1), however the abundance was relatively high also in the species rich Nagycsere (640.8±95.3) (Table 2).

The semi-synthetic bait used in these samplings was developed to monitor noctuid pest species. In the six sites 126 Noctuidae species of 17 subfamilies were sampled, which were 68.9% of all sampled Lepidoptera. The ratio of Noctuidae species among all sampled Lepidoptera was higher (82.9-90.6%) in the less diverse agro-ecosystems than in the most diverse extensively used landscapes (67.2-72.5%). The total number of Noctuid moths was 14487 that was the 84.4% of the identified Lepidoptera and their ratio varied between 70.2-95.5 by sites. The baits showed much higher effectiveness in case of species belonging to Xyleninae, Noctuinae, Hadeninae and Acronictinae subfamilies, which cumulative ratio was 80.4% (11653 individuals) among sampled Noctuidae moths (Table 2).
The characteristic variables of samples taken in the six studied sites in 2013-2014. N: number of individuals, Ntrap: mean number of individuals per trap [individuals/trap], S: number of species, Strap: mean number of species by trap [species/trap], SD: standard deviation

| Number of individuals | Forró | Ondód | Hernánméneti | Balmazujváros |
|-----------------------|-------|-------|--------------|---------------|
|                       | N     | Ntrap | ±SD          | N             | Ntrap | ±SD          | N         | Ntrap | ±SD          | N         | Ntrap | ±SD          |
| Heptalidae             | 0     | 0.00  | 0.00         | 0             | 0.00  | 0.00         | 0         | 0.00  | 0.00         | 0         | 0.00  | 0.00         |
| Pyralidae              | 77    | 15.4  | 9.2          | 245           | 49.0  | 24.7         | 756       | 151.2 | 31.8         | 124       | 24.8  | 8.3          |
| Nymphalidae            | 0     | 0.00  | 0.00         | 0             | 0.00  | 0.00         | 33        | 6.6   | 4.2          | 370       | 74.0   | 20.6         |
| Sphingidae             | 0     | 0.00  | 0.00         | 0             | 0.00  | 0.00         | 0         | 0.00  | 0.00         | 0         | 0.00  | 0.00         |
| Geometridae            | 0     | 0.00  | 0.00         | 0             | 0.00  | 0.00         | 0         | 0.00  | 0.00         | 0         | 0.00  | 0.00         |
| Thyatiridae            | 0     | 0.00  | 0.00         | 2             | 0.4   | 0.9          | 33        | 6.6   | 4.2          | 370       | 74.0   | 20.6         |
| Nolidae                | 0     | 0.00  | 0.00         | 0             | 0.00  | 0.00         | 0         | 0.00  | 0.00         | 0         | 0.00  | 0.00         |
| Erebidida              | 53    | 10.6  | 4.4          | 37            | 7.4   | 2.4          | 104       | 20.8  | 15.0         | 19        | 3.8   | 2.2          |
| Noctuidae              | 2791  | 558.2 | 137.6        | 646           | 129.2 | 35.2         | 2458      | 491.6 | 52.2         | 5297      | 1059.4 | 122.7        |
| Xyleniinae             | 991   | 198.2 | 50.4         | 363           | 72.6  | 23.9         | 896       | 179.2 | 23.8         | 3287      | 657.4  | 70.4         |
| Noctuidae              | 103   | 20.6  | 4.3          | 43            | 8.6   | 3.8          | 429       | 85.8  | 12.1         | 1262      | 252.4  | 47.7         |
| Hadeninae              | 912   | 182.4 | 48.6         | 72            | 14.4  | 1.8          | 563       | 112.6 | 23.3         | 191       | 38.2   | 5.7          |
| Other Noctuidae subfam.| 537   | 107.4 | 23.0         | 94            | 18.8  | 13.0         | 447       | 89.4  | 19.5         | 421       | 84.2   | 19.5         |
| non identified Lepidoptera* | 140  | 28.0  | 14.7         | 12            | 2.4   | 2.2          | 2         | 0.4   | 0.5          | 0         | 0.0    | 0.0          |
| identified Lepidoptera | 2921  | 584.2 | 140.9        | 930           | 186.0 | 58.8         | 3351      | 670.2 | 61.3         | 5810      | 1162.0 | 127.1        |

| Number of species | S | Strap | ±SD | S | Strap | ±SD | S | Strap | ±SD | S | Strap | ±SD |
|-------------------|---|-------|-----|---|-------|-----|---|-------|-----|---|-------|-----|
| Lepidoptera species number | 64 | 48.4  | 3.4  | 59 | 33.2  | 5.4  | 70 | 56.7  | 2.2  | 57 | 44.6  | 3.4 |
| Xyleniinae        | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00 |
| Pyralidae         | 2 | 1.2   | 0.4   | 3 | 2.2   | 0.4   | 3 | 2.8   | 0.4   | 3 | 2.8   | 0.4 |
| Nymphalidae       | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00 |
| Sphingidae        | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00 |
| Geometridae       | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00 |
| Thyatiridae       | 0 | 0.00  | 0.00  | 1 | 0.2   | 0.4   | 3 | 1.8   | 0.4   | 3 | 1.8   | 0.4 |
| Nolidae           | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00  | 0 | 0.00  | 0.00 |
| Erebidida         | 4 | 3.2   | 0.4   | 6 | 3.0   | 1.2   | 6 | 4.2   | 1.3   | 3 | 1.6   | 0.5 |
| Noctuidae         | 58 | 44.0  | 3.4   | 49 | 27.8  | 4.5   | 58 | 48.8  | 1.8   | 48 | 38.4  | 3.2 |
| Xyleniinae        | 28 | 19.0  | 3.1   | 24 | 14.2  | 2.9   | 27 | 21.6  | 1.1   | 25 | 20.0  | 1.4 |
| Noctuidae         | 8 | 7.2   | 0.4   | 8 | 5.0   | 1.0   | 10 | 10.0  | 0.0   | 10 | 7.8   | 1.1 |
| Hadeninae         | 11 | 10.4  | 0.9   | 9 | 4.4   | 0.9   | 12 | 9.6   | 0.5   | 8 | 6.2   | 1.1 |
| Other Noctuidae subfam. | 17 | 7.4   | 1.1   | 8 | 4.2   | 0.4   | 9 | 7.6   | 1.5   | 5 | 4.4   | 0.9 |
| Nagydobrony       | 91 | 57.0  | 5.4   | 128 | 71.3  | 7.1   | 183 | 51.1  | 12.6  | 61.5 | 12.6  | 12.6 |
| Nagysere          | 1 | 0.3   | 0.5   | 0 | 0.0   | 0.0   | 1 | 0.04  | 0.19  |
| Total              | 92 | 57.3  | 5.4   | 51 | 71.8  | 7.1   | 184 | 51.2  | 12.6  | 61.7 | 12.6  | 12.6 |

*Individuals identified only in family level.

In Forró all the five most abundant species, in Ondód, Hernánméneti and Balmazujváros four, while Nagysere and Nagydobrony three of them were Noctuid moths. Beyond them the bats lured high number of Hypsopygia costalis (Pyralidae), Pelosia muscera (Erebidae) and two Thyatiridae species (Tethea ocularis and Thyatia batis). The most abundant species of the sites are mostly occurred in all sites, but the locally dominant
Pelosia muscerda, Cirrhia icterica and Cranioptera ligustri occurred only in two sites with higher habitat diversity (Nagycsere and Nagydrbony). The common and polyphagous Agrochola circellaris, Mythimna albipuncta, Xestia xanthographa and Acronicta rumicis were dominant in three sites. The also widely distributed Cirrhia ocellaris, Hypsopygia costalis, Allophyes oyacanthae, Trachea atriplicis, Tethea ocularis and Agrotis segetum reached high relative frequencies in two whereas the others only in one site (Table 3). Most of these species feed on tree canopy and only 6 of them can be regarded as real or potential pest species. Among them only Agrotis segetum, which can cause significant damage in most crops and even in horticulture, is a harmful pest.

Table 3
Five most abundant species of the studied sites with their relative frequencies [RF%] and number of occupied sites. The species are ordered decreasingly by their summarised RF%.

| Species                        | Forró | Hernádnémeti | Balmazújváros | Nagydobrony | Nagycsere | Sum | site (n=6) |
|--------------------------------|-------|--------------|---------------|-------------|-----------|-----|-----------|
| *Agrochola circellaris*        | 28.48 | 5.222        | 19.21         | 11.51       | 9.58      | 6   | 6         |
| *Hypsopygia costalis*          | 24.84 | 4.775        | 11.93         | 7.06        | 6         | 6   | 6         |
| *Allophyes oyacanthae*         | 10.58 | 17.62        | 4.59          | 6           |           |     |           |
| *Trachea atriplicis*           | 13.45 | 12.57        | 4.14          | 6           |           |     |           |
| *Mythimna albipuncta*          | 12.26 | 4.731        | 5.103         | 3.99        | 6         |     |           |
| *Acronicta rumicis*            | 5.067 | 6.882        | 6.625         | 3.22        | 6         |     |           |
| *Tethea ocularis*              | 5.923 | 5.269        | 6.299         | 4.955       | 2.88      | 3   |           |
| *Agrotis segetum*              | 5.146 | 5.146        | 5.559         | 1.29        | 5         |     |           |
| *Acronicta megacephala*        | 5.146 | 1.89         | 6             | 1.68        | 2         |     |           |
| *Pelosia muscerda*             | 16.36 | 6.087        | 1.29          | 6           |           |     |           |
| *Acrochola helvola*            | 4.487 | 0.80         | 1.68          | 4           |           |     |           |
| *Cirrhia icterita*             | 3.348 | 0.31         | 0.74          | 2           |           |     |           |

* pest species

The number of harmful and potentially significant pest species was 32 in the samples. Most of them (20) belong to the Noctuidae family and there were 5 Erebidae, 2 Geometridae, 3 Pyralidae and 2 Thytiridae species. The mean number of pest species per trap was lower in Debrecen-Ondód (12.0±2.0) while this value reached the maximum in Hernádnémeti (17.6±1.1). The total number of pests was 5373 which was 31.3% of all Lepidoptera samples. The ratio of the pest species was higher in the agricultural sites then in the most diverse ones. The mean proportion of Noctuiidae was 74.6(±18.2).% and the Pyralidae was 18.1(±19.1)% while the other three family played a minor role. Baits lured the most individuals of Hypsopygia costalis, Agrochola circellaris, Acronicta rumicis, Agrotis segetum and Noctua pronuba. Most of them occurred at all of the studied sites, but the Hypsopygia costalis was caught only the agricultural sites. In Balmazújváros high abundance of Agrochola circellaris and Acronicta megacephala was caused by nearby poplar plantation. These plantations can be a source of these pests. Considerable part of the pest species could be found with low abundance and 8 of them occurred only in the two more diverse species rich sites (Table 4).

The traps caught 34 individuals of seven protected Noctuidae, one Erebidae and one Nymphalidae species in all of the six sampling sites. Six of them and 19 other species are interesting and valuable in faunistical aspect. They mostly belong to the Noctuidae family however there were two Erebidae and two Geometridae species. During the studies totally 411 individuals of these valuable species were sampled, which is 2.4% of the Lepidoptera identified at species level while the ratio of the protected Lepidoptera was only 0.2%. In Balmazújváros protected species were not sampled and only one valuable species could be found, however the number of protected species was also low both in the species rich Nagycsere and Nagydrbony. The number of faunistically interesting and protected species was much lower in the agricultural sites (max. 7 species) than in the two semi natural ones (14 and 15 species). The number of valuable species was the highest in Nagycsere where 4 protected and 11 faunistically interesting species were trapped. The ratio of valuable individuals differed between 2.9-4.5% by sites, but the ratio of protected species was lower than 1% in each site (Table 5).
Semi-synthetic baits used in this study attract a large amount of Noctuid moths. Both the species number and abundance were high in each sampling sites, although they depend on the landscape structure. High landscape diversity results in higher species richness but in case of abundance it does not cause differences. The bait also lured Vespidae species with relatively high abundance, but did not attract honey-bees. Most of the sampled Lepidopterans belonged to the Noctuidae family (totally 124 species). Among them the species of Noctuidae, Erebidae and Geometridae families was the highest. Among the most abundant species there were six pests: *Agrochola circellaris*, *Hypsopygia costalis*, *Acronicta rumicis*, *Agritis segetum*, *Acronicta megacephala* and *Thyatiria batis*. The dominant species of arable land and more diverse sites were different. The total number of pest species was 32. Most of them (20) were noctuid moths containing such harmful ones as *Agritis segetum*, *Agritis exclamationis*, *Agritis ipsilon*, *Lacanobia oleracea* etc. The summarised proportion of these species was 31.3\% among all identified Lepidopterans. Considering their economic importance the majority of the caught Lepidopterans were indifferent. Both number and abundance of protected and valuable species was low, however the risk of catching valuable and non-target species was higher in the natural and semi natural sites. The traps caught totally 411 individuals of 28 protected and/or faunistically interesting species, which was a very little part (2.4\%) of all sampled Lepidopterans.

On the basis of these preliminary results the use of the tested semi-synthetic bait does not endanger the populations of non-target Lepidopterans. For more detailed results we should carry out further studies and should analyse these and other ongoing studies together.

### Table 4

| Family          | Forró | Ondód | Hernád-németi | Balma-zújváros | Nagy-dobrony | Nagy-csere | Sum |
|-----------------|-------|-------|---------------|----------------|-------------|------------|-----|
| Noctuidae       | 61    | 181   | 160           | 693            | 12          | 104        | 121 |
| Pyralidae       | 76    | 231   | 688           | 44             | 0           | 0          | 103 |
| Noctuidae       | 148   | 64    | 222           | 68             | 16          | 34         | 552 |
| Noctuidae       | 173   | 49    | 88            | 99             | 25          | 46         | 480 |
| Noctuidae       | 29    | 29    | 102           | 95             | 17          | 103        | 375 |
| Noctuidae       | 1     | 2     | 9             | 299            | 3           | 11         | 325 |
| Noctuidae       | 70    | 7     | 69            | 17             | 21          | 13         | 197 |
| Noctuidae       | 40    | 1     | 10            | 1              | 32          | 48         | 132 |
| Noctuidae       | 38    | 1     | 53            | 23             | 11          | 3          | 129 |
| Noctuidae       | 0     | 0     | 20            | 2              | 88          | 17         | 127 |
| Pyralidae       | 0     | 0     | 3             | 50             | 7           | 0          | 124 |
| Noctuidae       | 26    | 24    | 25            | 36             | 0           | 11         | 122 |
| Noctuidae       | 14    | 0     | 2             | 8              | 12          | 68         | 104 |
| Noctuidae       | 11    | 4     | 48            | 16             | 7           | 13         | 99  |
| Noctuidae       | 81    | 1     | 4             | 0              | 1           | 3          | 90  |
| Noctuidae       | 38    | 7     | 28            | 6              | 0           | 0          | 79  |
| Pyralidae       | 1     | 11    | 18            | 9              | 0           | 0          | 39  |
| Thyatiridae     | 0     | 2     | 12            | 2              | 14          | 1          | 31  |
| Noctuidae       | 9     | 1     | 13            | 1              | 0           | 0          | 24  |
| Noctuidae       | 0     | 0     | 0             | 0              | 1           | 22         | 23  |
| Noctuidae       | 9     | 8     | 2             | 0              | 0           | 0          | 19  |
| Erebididae      | 15    | 1     | 0             | 0              | 0           | 0          | 16  |
| Noctuidae       | 4     | 1     | 0             | 0              | 5           | 4          | 14  |
| Erebididae      | 0     | 1     | 0             | 0              | 11          | 0          | 12  |
| Erebididae      | 0     | 0     | 0             | 0              | 0           | 3          | 3   |
| Erebididae      | 0     | 0     | 0             | 0              | 0           | 1          | 1   |
| Erebididae      | 0     | 0     | 0             | 0              | 0           | 1          | 1   |
| Erebididae      | 0     | 0     | 0             | 0              | 0           | 1          | 1   |
| Erebididae      | 0     | 0     | 0             | 0              | 0           | 1          | 1   |
| Erebididae      | 0     | 0     | 0             | 0              | 0           | 1          | 1   |
| Erebididae      | 0     | 0     | 0             | 0              | 0           | 1          | 1   |
| Total number of pests | 844   | 629   | 1623          | 1490           | 276         | 511        | 5373 |
| Ratio of pests among all Lepidoptera (%) | 28.9 | 67.6 | 48.4 | 25.6 | 17.5 | 20.0 | 31.3 |
| Total number of identified Lepidoptera | 2921 | 930  | 3351 | 5810 | 1583 | 2563 | 17158 |
Table 5

List of the protected and faunistically interesting species caught in the six sampling sites in 2013-2014 with their number of individuals and ratio among all sampled Lepidoptera and taxonomy. P: protected, F: faunistically interesting

| Prot. | Family | Forró | Ondód | Hernád- néméti | Balmaz- újváros | Nagy- dobony | Nagy- csere | Sum |
|-------|--------|-------|-------|---------------|---------------|-------------|-------------|-----|
| P/F   | Noctuidae | Meganeaphria bimaculosa | 2 | 0 | 0 | 0 | 0 | 2 |
| P/F   | Noctuidae | Energia paleacea | 0 | 0 | 0 | 2 | 3 | 5 |
| P/F   | Noctuidae | Lithophane semibrunea | 0 | 1 | 1 | 0 | 2 | 4 |
| P/F   | Noctuidae | Marmora maura | 0 | 0 | 0 | 0 | 3 | 0 |
| P/F   | Noctuidae | Orbona fragariae | 4 | 0 | 0 | 0 | 0 | 1 |
| P/F   | Erebidae | Staurophora celsia | 0 | 0 | 0 | 0 | 0 | 9 |
| P     | Erebidae | Catocala fraxini | 0 | 0 | 0 | 1 | 1 | 2 |
| P     | Noctuidae | Cataphe aichymiata | 0 | 1 | 0 | 0 | 0 | 1 |
| P     | Nymphalidae | Apatura ilia | 0 | 0 | 0 | 0 | 2 | 0 |
| F     | Erebidae | Catocala hynemaeca | 0 | 1 | 75 | 0 | 0 | 76 |
| F     | Erebidae | Herminia tenax | 0 | 0 | 0 | 0 | 1 | 1 |
| F     | Geometridae | Eupha unangulata | 0 | 0 | 0 | 2 | 0 | 2 |
| F     | Geometridae | Idaea muricata | 0 | 0 | 0 | 0 | 14 | 14 |
| F     | Noctuidae | Eucarta amethystina | 0 | 0 | 0 | 0 | 2 | 0 |
| F     | Noctuidae | Eucarta virgo | 22 | 0 | 0 | 14 | 1 | 37 |
| F     | Noctuidae | Diarsia rubi | 0 | 0 | 0 | 0 | 5 | 5 |
| F     | Noctuidae | Euxoa segnilla | 0 | 0 | 0 | 2 | 7 | 9 |
| F     | Noctuidae | Xestia castanea | 0 | 0 | 0 | 2 | 0 | 2 |
| F     | Noctuidae | Xestia seestriata | 0 | 0 | 0 | 0 | 2 | 4 |
| F     | Noctuidae | Agrochola humilis | 3 | 3 | 2 | 0 | 8 | 16 |
| F     | Noctuidae | Agrochola laevis | 3 | 9 | 2 | 0 | 34 | 48 |
| F     | Noctuidae | Agrochola lota | 0 | 0 | 1 | 0 | 33 | 34 |
| F     | Noctuidae | Athemia centrago | 0 | 0 | 0 | 0 | 4 | 4 |
| F     | Noctuidae | Blepharita satura | 0 | 0 | 0 | 0 | 1 | 1 |
| F     | Noctuidae | Dryobotodes eremita | 45 | 7 | 14 | 0 | 0 | 66 |
| F     | Noctuidae | Helotropha leucostigma | 0 | 0 | 0 | 0 | 1 | 1 |
| F     | Noctuidae | Tilacea citrus | 0 | 0 | 0 | 0 | 1 | 1 |
| F     | Noctuidae | Xylena essolea | 5 | 3 | 20 | 14 | 0 | 54 |

Number of valuable species: 7, 7, 7, 1, 14, 15, 28
Number of protected species: 1, 2, 2, 1, 0, 5, 4, 9
Number of valuable individuals: 84, 25, 115, 14, 71, 102, 411
Number of protected individuals: 6, 2, 1, 0, 9, 16, 34
Ratio of valuable individuals: 2.88, 2.69, 3.43, 0.24, 4.49, 3.98, 2.40
Ratio of protected individuals: 0.21, 0.22, 0.03, 0.00, 0.57, 0.62, 0.20
Total number of identified Lepidoptera: 2921, 930, 3351, 5810, 1583, 2563, 17158

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Appendix 1

List of the sampled Lepidoptera species with their taxonomy and conservational status. Pest species are signed with asterix (*). P: protected, F: faunistically interesting

| Family         | Subfamily | Species                                                                 |
|----------------|-----------|--------------------------------------------------------------------------|
| Hepialidae     |           | one unidentified species                                                 |
| * Pyralidae    | Pyralinae | H ypopygota costalis (Fabricius 1775)                                    |
| * Pyralidae    | Pyralinae | Pyralis farinalis (Linnaeus, 1758)                                       |
| * Pyralidae    | Pyraustinae | O strinia nabialis (Hübner, 1796)                                        |
| P Nymphalidae  | Aputarinae | Aputura ila ([Denis & Schiff ermüller], 1775)                            |
| Nymphalidae    | Nymphalinae | Araschnia levana (Linnaeus, 1758)                                       |
| Nymphalidae    | Nymphalinae | Nymphalis c-album (Linnaeus, 1758)                                       |
| Nymphalidae    | Satyrinae  | M inos dryas (Scopoli, 1763)                                             |
| Nymphalidae    | Satyrinae  | Pararge aegeria tircis (Godart, 1821)                                    |
| Sphingidae     | Macroglossinae | D eltephila porcellus (Linnaeus, 1758)                              |
| Geometridae    | Ennominae | A peira syringaria (Linnaeus, 1758)                                      |
| Geometridae    | Ennominae | Cabera exanthemata (Scopoli, 1763)                                       |
| * Geometridae  | Ennominae | E ctopis crepusciliaria ([Denis et Schiffermüller], 1775)               |
| Geometridae    | Ennominae | Ematurga atomaria (Linnaeus, 1758)                                       |
| Geometridae    | Ennominae | Hypomecis punctinalis (Scopoli, 1763)                                    |
| Geometridae    | Ennominae | Hypomecis roboraria ([Denis & Schiffermüller], 1775)                    |
| Geometridae    | Ennominae | Ligidia adustata ([Denis & Schiffermüller], 1775)                       |
| Geometridae    | Ennominae | Macaria notata (Linnaeus, 1758)                                          |
| * Geometridae  | Ennominae | Peribatodes rhomboidaria ([Denis & Schiffermüller], 1775)               |
| Geometridae    | Larentinae | Cosmorhoe ocellata (Linnaeus, 1758)                                      |
| Geometridae    | Larentinae | Episrita autumnata (Borkhausen, 1794)                                    |
| F Geometridae  | Larentinae | Eupha unangulata (Haworth, 1809)                                         |
| Geometridae    | Sterrhinae | Idaea aversata (Linnaeus, 1758)                                          |
| F Geometridae  | Sterrhinae | Idaea marica (Hufnagel, 1787)                                            |
| * Thyatiridae  | Thyatirinae | H abroxyme pyrithoides (Hufnagel, 1766)                                  |
| Thyatiridae    | Thyatirinae | Tethe a ocularis (Linnaeus, 1758)                                        |
| Thyatiridae    | Thyatirinae | Tethe a or ([Denis et Schiffermüller], 1775)                            |
| * Thyatiridae  | Thyatirinae | The tira haitis (Linnaeus, 1758)                                         |
| Nolidae        | Nolinae   | N oha crassatula (Hübner, 1793)                                          |
| Nolidae        | Nolinae   | Nycteola degenerana (Hübner, 1799)                                       |
| * Erebidae     | Arctinae  | Phragmatobia fuliginosa (Linnaeus, 1758)                                 |
| Erebidae       | Aventinae | Trisateles emortalis ([Denis & Schiff ermüller], 1775)                  |
| * Erebidae     | Calpinae  | Sciloapteryx labiris (Linnaeus, 1758)                                    |
| Erebidae       | Catocalinae | Catocala electa (Vieweg, 1790)                                          |
| Erebidae       | Catocalinae | Catocala elocata (Esper, 1788)                                          |
| P Erebidae     | Catocalinae | Catocala fraxini (Linnaeus, 1758)                                       |
| Erebidae       | Catocalinae | Catocala fulminea (Scopoli, 1763)                                       |
| F Erebidae     | Catocalinae | Catocala hymenaea ([Denis & Schiff ermüller], 1775)                     |
| Erebidae       | Catocalinae | Catocala mappa (Linnaeus, 1758)                                         |
| Erebidae       | Catocalinae | Catocala promissa (Denis & Schiffermüller, 1775)                        |
| Erebidae       | Catocalinae | Catocala sponsa (Linnaeus, 1767)                                         |
| Erebidae       | Catocalinae | Dysgonia algira (Linnaeus, 1767)                                         |
| * Erebidae     | Catocalinae | Euclidia glyptica (Linnaeus, 1758)                                       |
| Erebidae       | Catocalinae | Lygephila cracciae ([Denis & Schiff ermüller], 1775)                    |
| Erebidae       | Catocalinae | Lygephila pastinum (Treitschke, 1826)                                    |
| Erebidae       | Eustrotinae | Protodeltote pygarga (Hufnagel, 1766)                                   |
| Erebidae       | Herminiinae | Herminia grinialis ([Denis & Schiff ermüller], 1775)                    |
| Erebidae       | Herminiinae | Herminia tarsispennalis (Treitschke, 1835)                                |
| F Erebidae     | Herminiinae | Herminia lemnalis (Rebel, 1899)                                         |
| Erebidae       | Hyponinae | Hyponia proboscis (Linnaeus, 1758)                                       |
| Erebidae       | Hyponinae | Hyponia rostralis (Linnaeus, 1758)                                       |
| Erebidae       | Lithosinae | Eilema griseola (Hübner, 1803)                                           |
| Erebidae       | Lithosinae | Lithosia quadra (Linnaeus, 1758)                                         |
| Erebidae       | Lithosinae | Pelsia muscera (Hufnagel, 1766)                                          |
| Erebidae       | Lithosinae | Wiria sororculus (Hufnagel, 1766)                                        |
| * Erebidae     | Lymantrinae | Lymantria dispar (Linnaeus, 1758)                                        |
| * Erebidae     | Lymantrinae | Lymantria monacha (Linnaeus, 1758)                                       |
| Family       | Subfamily | Species                                                                 |
|--------------|-----------|-------------------------------------------------------------------------|
| Noctuidae    | Acontiinae| *Aedea leucomalas* (Linnaeus, 1758)                                      |
| Noctuidae    | Acroacininae| *Acronicta auricula* ([Denis & Schiff errmüller], 1775)                  |
| Noctuidae    | Acrocininae| *Acronicta euphorbiae* ([Denis & Schiff errmüller], 1775)               |
| Noctuidae    | Acrocininae| *Acronicta megacephala* ([Denis & Schiff errmüller], 1775)              |
| *Noctuidae   | Acrocininae| *Acronicta psi* (Linnaeus, 1758)                                         |
| *Noctuidae   | Acrocininae| *Acronicta rumicis* (Linnaeus, 1758)                                     |
| Noctuidae    | Acrocininae| *Cramiophora ligustris* ([Denis & Schiffermüller], 1775)                |
| Noctuidae    | Acrocininae| *Moma alpium* (Osebeck, 1778)                                           |
| Noctuidae    | Amphipyrinae| *Amphiptyra berbera svensoni* (Fletcher, 1968)                          |
| Noctuidae    | Amphipyrinae| *Amphiptyra livida* ([Denis & Schiff errmüller], 1775)                  |
| Noctuidae    | Amphipyrinae| *Amphiptyra pyraumed* (Linnaeus, 1758)                                  |
| Noctuidae    | Amphipyrinae| *Amphiptyra tragocephus* (Clerck, 1759)                                 |
| Noctuidae    | Bryophilinae| *Cycasia alga* (Fabricius, 1775)                                        |
| *Noctuidae   | Cotochilinae| *Catathela alenschista* ([Denis & Schiff errmüller], 1775)              |
| *Noctuidae   | Condicinae| *Eucarta amethystina* (Hübner, 1803)                                     |
| *Noctuidae   | Condicinae| *Eucarta virgo* (Treitschke, 1825)                                       |
| *Noctuidae   | Cyrtptinae| *Gloia alga* (Esper, 1789)                                              |
| Noctuidae    | Ctenuchinae| *Amata phegea* (Linnaeus, 1758)                                          |
| Noctuidae    | Hadeniinae| *Hada plebeja* (Linnaeus, 1761)                                         |
| *Noctuidae   | Hadeniinae| *Hadula trifoli* (Hufnagel, 1766)                                        |
| Noctuidae    | Hadeniinae| *Lacanobia contigua* ([Denis & Schiff errmüller], 1775)                 |
| *Noctuidae   | Hadeniinae| *Lacanobia oleracea* (Linnaeus, 1758)                                   |
| Noctuidae    | Hadeniinae| *Lacanobia suasa* ([Denis & Schiffermüller], 1775)                      |
| Noctuidae    | Hadeniinae| *Lacanobia thallassina* (Hufnagel, 1766)                                 |
| Noctuidae    | Hadeniinae| *Lacanobia w-latinum* (Hufnagel, 1766)                                  |
| Noctuidae    | Hadeniinae| *Leucania obsolata* (Hübner 1803)                                       |
| *Noctuidae   | Hadeniinae| *Mamestrina brassicae* (Linnaeus, 1758)                                 |
| Noctuidae    | Hadeniinae| *Mythimna (Mythimna) pallens* (Linnaeus, 1758)                          |
| Noctuidae    | Hadeniinae| *Mythimna albipuncta* ([Denis et Schiffermüller], 1775)                |
| Noctuidae    | Hadeniinae| *Mythimna farrago* (Fabricius, 1787)                                     |
| Noctuidae    | Hadeniinae| *Mythimna l-album* (Linnaeus, 1767)                                      |
| Noctuidae    | Hadeniinae| *Mythimna turca* (Linnaeus, 1761)                                        |
| Noctuidae    | Hadeniinae| *Mythimna vitellina* (Hübner, 1808)                                     |
| Noctuidae    | Hadeniinae| *Thorema cespitis* ([Denis & Schiffermüller], 1775)                    |
| *Noctuidae   | Hadeniinae| *Heliostethina* *Heliocerus armeria* (Hübner, 1808)                    |
| Noctuidae    | Hadeniinae| *Pyrrha umbra* (Hufnagel, 1766)                                         |
| *Noctuidae   | Noctuiinae| *Agrotis exclamationis* (Linnaeus, 1758)                                 |
| *Noctuidae   | Noctuiinae| *Agrotis ipsilon* (Hufnagel, 1766)                                      |
| *Noctuidae   | Noctuiinae| *Agrotis segetum* ([Denis et Schiffermüller], 1775)                    |
| Noctuidae    | Noctuiinae| *Asyly laborum* (Linnaeus, 1761)                                         |
| F Noctuidae  | Noctuiinae| *Diarsia rubi* (Vieweg, 1790)                                           |
| F Noctuidae  | Noctuiinae| *Euxoa septilis* (Duponchel, 1837)                                       |
| Noctuidae    | Noctuiinae| *Metagonorisma depuncta* (Linnaeus, 1761)                                |
| Noctuidae    | Noctuiinae| *Noctua fenestra* (Schreber, 1759)                                      |
| Noctuidae    | Noctuiinae| *Noctua interjecta* Hübner, 1803                                        |
| Noctuidae    | Noctuiinae| *Noctua interposita* (Hübner, 1790)                                     |
| Noctuidae    | Noctuiinae| *Noctua jane* (Borkhausen, 1972)                                        |
| Noctuidae    | Noctuiinae| *Noctua janina* ([Denis & Schiffermüller], 1775)                       |
| Noctuidae    | Noctuiinae| *Noctua orbina* (Hufnagel, 1766)                                        |
| *Noctuidae   | Noctuiinae| *Noctua prunina* (Linnaeus, 1758)                                       |
| Noctuidae    | Noctuiinae| *Ochropus plecta* (Linnaeus, 1761)                                       |
| Noctuidae    | Noctuiinae| *Xestiya varia* ([Denis & Schiffermüller], 1775)                       |
| F Noctuidae  | Noctuiinae| *Xestiya castanea* (Esper, 1798)                                         |
| *Noctuidae   | Noctuiinae| *Xestiya c-nigrum* (Linnaeus, 1758)                                      |
| F Noctuidae  | Noctuiinae| *Xestiya sextipigata* (Haworth, 1809)                                   |
| *Noctuidae   | Noctuiinae| *Xestiya sanforgrapha* ([Denis & Schiff errmüller], 1775)               |
| Noctuidae    | Oncocemiinae| *Calophasia lunula* (Hufnagel, 1766)                                    |
| *Noctuidae   | Pantheinae| *Colocasia coryli* (Linnaeus, 1758)                                      |
| *Noctuidae   | Plusiinae| *Autographa gamma* (Linnaeus, 1758)                                      |
| *Noctuidae   | Plusiinae| *Maculaniwpga confusa* (Stephens, 1850)                                 |
| Noctuidae    | Psaphidinae| *Alliophyodes australasii* (Linnaeus, 1758)                             |
| P/F Noctuidae| Psaphidinae| *Meganephria bimaculosa* (Linnaeus, 1767)                               |
| Noctuidae    | Rivulinae| *Rivula sericealis* (Scopoli, 1763)                                     |
| *Noctuidae   | Xyleniinae| *Actinotia polyodon* (Clerck, 1759)                                     |
| *Noctuidae   | Xyleniinae| *Agrochola cirsellaris* (Hufnagel, 1766)                                |
| Noctuidae    | Xyleniinae| *Agrochola helvola* (Linnaeus, 1758)                                    |
| F Noctuidae  | Xyleniinae| *Agrochola humila* ([Denis & Schiff errmüller], 1775)                   |
| F Noctuidae  | Xyleniinae| *Agrochola laevi* (Hübner, 1803)                                        |
| Noctuidae    | Xyleniinae| *Agrochola littora* (Linnaeus, 1758)                                    |
| F Noctuidae  | Xyleniinae| *Agrochola lata* (Clerck, 1759)                                         |
| Noctuidae    | Xyleniinae| *Agrochola lechynnis* ([Denis & Schiffermüller], 1775)                  |
| Noctuidae    | Xyleniinae| *Agrochola macilenta* (Hübner, 1803)                                   |
| Noctuidae    | Xyleniinae| *Agrochola nitida* ([Denis et Schiffermüller], 1775)                   |
Continuation of Appendix 1.

| Family       | Subfamily       | Species                                                                 |
|--------------|-----------------|-------------------------------------------------------------------------|
| Noctuidae    | Xyleninae       | *Ammosoma caecimacula* ([Denis & Schiff ermüller], 1775)               |
| Noctuidae    | Xyleninae       | *Apamea anceps* ([Denis & Schiff ermüller], 1775)                      |
| Noctuidae    | Xyleninae       | *Apamea lioxyta* ([Denis & Schiff ermüller], 1775)                     |
| Noctuidae    | Xyleninae       | *Apamea monoglypha* (Hufnagel, 1766)                                    |
| Noctuidae    | Xyleninae       | *Aporophyla lutentia* ([Denis & Schiff ermüller], 1775)                |
| F Noctuidae  | Xyleninae       | *Acethmia centrago* (Haworth, 1809)                                    |
| Noctuidae    | Xyleninae       | *Athetis furvula* (Hübner, 1808)                                       |
| Noctuidae    | Xyleninae       | *Athetis gloteosa* (Treitschke, 1835)                                   |
| F Noctuidae  | Xyleninae       | *Blepharita satura* ([Denis & Schiff ermüller], 1775)                  |
| F Noctuidae  | Xyleninae       | *Brachylonia viminalis* (Fabricius, 1777)                               |
| Noctuidae    | Xyleninae       | *Caradrina clavipalpis* (Scopoli, 1763)                                 |
| Noctuidae    | Xyleninae       | *Caradrina kadeni Freyer, 1836                                          |
| Noctuidae    | Xyleninae       | *Caradrina morpheus* (Hufnagel, 1766)                                   |
| Noctuidae    | Xyleninae       | *Cirrhia gilvago* ([Denis & Schiff ermüller], 1775)                    |
| Noctuidae    | Xyleninae       | *Cirrhia icteritia* (Hufnagel, 1766)                                   |
| Noctuidae    | Xyleninae       | *Cirrhia ocellaris* (Borkhausen, 1792)                                  |
| Noctuidae    | Xyleninae       | *Conistra erythrocephala* ([Denis & Schiff ermüller], 1775)            |
| Noctuidae    | Xyleninae       | *Conistra ligula* (Esper, 1791)                                         |
| Noctuidae    | Xyleninae       | *Conistra rhodogosia* (Scopoli, 1763)                                   |
| * F Noctuidae| Xyleninae       | *Conistra vaccini* (Linnaeus, 1761)                                     |
| Noctuidae    | Xyleninae       | *Conistra veronicae* (Hübner, 1813)                                    |
| Noctuidae    | Xyleninae       | *Cosmia affinis* (Linnaeus, 1767)                                       |
| F Noctuidae  | Xyleninae       | *Cosmia trapezina* (Linnaeus, 1758)                                     |
| Noctuidae    | Xyleninae       | *Dryobotodes eremita* (Fabricius, 1775)                                 |
| Noctuidae    | Xyleninae       | *Dypterygia scabriuscula* (Linnaeus, 1758)                              |
| P/F Noctuidae| Xyleninae       | *Enargia paleacea* (Esper, 1788)                                        |
| Noctuidae    | Xyleninae       | *Euplexia lucipara* (Linnaeus, 1758)                                    |
| Noctuidae    | Xyleninae       | *Eupserlia transversa* (Hufnagel, 1766)                                 |
| Noctuidae    | Xyleninae       | *Griposia aprilina* (Linnaeus, 1758)                                   |
| F Noctuidae  | Xyleninae       | *Helotropha leucostigma* (Hübner, [1808])                              |
| Noctuidae    | Xyleninae       | *Hoplodrina ambigua* ([Denis & Schiff ermüller, 1775])                 |
| Noctuidae    | Xyleninae       | *Hoplodrina blanda* ([Denis & Schiff ermüller, 1775])                  |
| P/F Noctuidae| Xyleninae       | *Lithophane ornithopus* (Hufnagel, 1766)                                |
| Noctuidae    | Xyleninae       | *Lithophane semibrunnea* (Haworth, 1809)                                |
| Noctuidae    | Xyleninae       | *Mesapamea secalis Remm, 1983                                          |
| Noctuidae    | Xyleninae       | *Mesapamea secalis* (Linnaeus, 1758)                                   |
| Noctuidae    | Xyleninae       | *Mesogona acetosellae* ([Denis & Schiff ermüller], 1775)               |
| Noctuidae    | Xyleninae       | *Mesoligia furuncula* ([Denis & Schiff ermüller], 1775)                |
| P/F Noctuidae| Xyleninae       | *Mormo maura* (Linnaeus, 1758)                                          |
| Noctuidae    | Xyleninae       | *Oligia latruncula* ([Denis & Schiff ermüller], 1775)                  |
| Noctuidae    | Xyleninae       | *Oligia strigilis* (Linnaeus, 1758)                                     |
| P/F Noctuidae| Xyleninae       | *Orbona fragariae* (Vieweg, 1790)                                       |
| Noctuidae    | Xyleninae       | *Parastichitis suspicata* (Hübner, 1817)                                |
| * F Noctuidae| Xyleninae       | *Philogophora meticulosa* (Linnaeus, 1758)                              |
| Noctuidae    | Xyleninae       | *Pseudoastritia candidula* ([Denis et Schiff ermüller], 1775)           |
| Noctuidae    | Xyleninae       | *Ruina ferruginea* (Esper, 1785)                                        |
| P/F Noctuidae| Xyleninae       | *Sauraphora celsia* (Linnaeus, 1758)                                    |
| Noctuidae    | Xyleninae       | *Thalpophila matura* (Hufnagel, 1766)                                   |
| Noctuidae    | Xyleninae       | *Tilacea anrago* (Denis & Schiff ermüller, 1775)                        |
| F Noctuidae  | Xyleninae       | *Tilacea citrago* (Linnaeus, 1758)                                      |
| Noctuidae    | Xyleninae       | *Trachea amplipectis* (Linnaeus, 1758)                                  |
| Noctuidae    | Xyleninae       | *Xanthia gilvago* ([Denis & Schiff ermüller], 1775)                    |
| Noctuidae    | Xyleninae       | *Xanthia icteritia* (Hufnagel, 1766)                                    |
| Noctuidae    | Xyleninae       | *Xanthia ocellaris* (Borkhausen, 1792)                                  |
| Noctuidae    | Xyleninae       | *Xanthia togata* (Esper, 1788)                                          |
| F Noctuidae  | Xyleninae       | *Xylena exsoleta* (Linnaeus, 1758)                                      |