

Notes on occurrence of moths (*Lepidoptera*, *Heterocera*) in Ksany village in the commune of Opatowiec of the Świętokrzyskie Province

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Article history

Received: 25 May 2020

Received in revised form:
22 June 2020

Accepted: 17 September 2020

Available: 29 September 2020

Abstract

On selected days from July to September 2017, the butterfly species with twilight and nocturnal activity in the village of Ksany in agriculturally and little anthropogenically transferred land were studied. Catching was done in the evening and night hours, using a method of the vividly attracting to the light. Flying moths were photographed on-site for later determination. A total of 13 catches were carried out with an average at intervals of 1–2 weeks. Over 60 moths species were determined, mostly belonging to the families *Geometridae* and *Erebidae*. When analyzing the results of catches, basic weather parameters such as temperature, air pressure and moon phase were taken into account.

Keywords: moths, nocturnal butterflies, *Heterocera*, *Geometridae*, *Erebidae*, rapid inventory

Introduction

The butterflies (Lepidoptera and moths) are one of the best known among all groups of insects. Among more than 160 thousands species occurring worldwide, there are 3258 butterfly species described only in Poland and belonging to 69 families. Butterflies with the night activity called usually the moths belong to 164 families, while those with daily activity count only 6 families. However, despite this facts night butterflies are much less known than those which are active during the day [1]. The basis for the division of the whole group of butterflies into day and night species was the difference in the construction of the antennae. The diurnal species with the exception of the family *Hedylidae*, have thin antennae with a small balls or clubs at their end. In turn antennae of the moth are usually feathery with no ball on the end. Using this feature the group with “club-antennae” is called Rhopalocera and most of daily active butterflies were assigned to this group. To the *Heterocera* group belong nocturnal butterflies with a varied-antennae structure [2]. It is now widely known that this division, as well as the division into smaller (*Microlepidoptera*) and larger butterflies (*Macrolepidoptera*) does not correspond to modern views on phylogeny of butterflies, but it is often used for practical reasons [2].

Some of the butterflies attributed to the *Heterocera* group lead a daily lifestyle, and the activity of certain species of day butterflies at dusk or at night is also observed. Morphological differences between individual families of butterflies are often visible at a glance. Those with nocturnal activity are characterized by thick body, covered with bristles, apparently larger scales on the wings, a variety of tentacles, for example pinnate or crested. They rest with wings folded roof or sideways, and their coloration is usually masking, although there are also some brightly colored species. In contrary, diurnal butterflies usually have a slender body, tentacles ending in a club form and colorful upper side of the wings. During rest they put their wings vertically above the body. Moths play important roles in many ecosystems as pollinators, herbivores, and prey for a wide range of species such as night birds and bats [3, 4]. The distribution and ecology of moths are well known in comparison to many other invertebrates [5]. In recent decades, declines of moth populations have been observed in European countries. For instance in Great Britain the abundance of macro-moths decreased by 28% between 1968 and 2007 [5] and similar negative trends have been noticed in Sweden [6] and the Netherlands [7]. Such declines are expected to have cascading effects at both higher (bats, birds) and lower (plants) trophic levels as moths play the keystone role in many ecosystems [4, 8].

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There are many methods for observing and catching night butterflies, and one of the most well-known and commonly used is attracting them to the artificial light. For this purpose, a white screen and incandescent mercury bulbs (MIX), mercury vapor lamps (LRF), UV lamps or self-fishing lamps are usually used. Light traps can be designed in various ways and operated using different light sources; both of these modifications are known to affect trap performance [9, 10]. Nowadays, also important modifications and improvements in traps were introduced as for example dedicated UV LED lamps with emitted electromagnetic spectrum wave length corresponding to the peak sensitivity in most Lepidoptera eye receptors for ultraviolet, blue and green [11]. Moreover the works of Infusino and collaborators [12] clearly shows the greater effectiveness of this light source in catching some moths genera in comparison to those caught by mercury vapour lamp traps. However, not only kind of light source but also weather factors, such as temperature and rainfall can influence catch size [13, 14]. Because of many different factors which influenced trap efficiency the quantitative results are problematic and may restrict the value of monitoring data by complicating attempts to assess trends and compare results across studies and regions [15].

In this study we used light traps in an agricultural landscape of Ksany village which is a countryside in Świętokrzyskie province to make a catches of nocturnal butterflies. During the catching the basic weather parameters such as temperature, air pressure and moon phase were collected to assess their relationship with the activity and number of flying moths. Based on the outcome of these observations, we added some observations about moths occurrence and diversity of the studied station.

Materials and methods

In total, 13 catchings of moths were conducted on selected days from the 14 July to the 2 September 2017 and repeated for one month from the 12 May to 9 June 2018. The catching stand was located in the Koszycko-Opatowiec area of the protected landscape, directly near the ecological corridor running from the South to the North. The nearest East Mountains park is located about 11 km from the catchment site, and two Natura 2000 protected areas are only around 3.5 km away. These are the areas of Dolina Nidy (PLB 260001) and Ostoja Nidziańska (PLH 260003). The station of catches was in typically agricultural

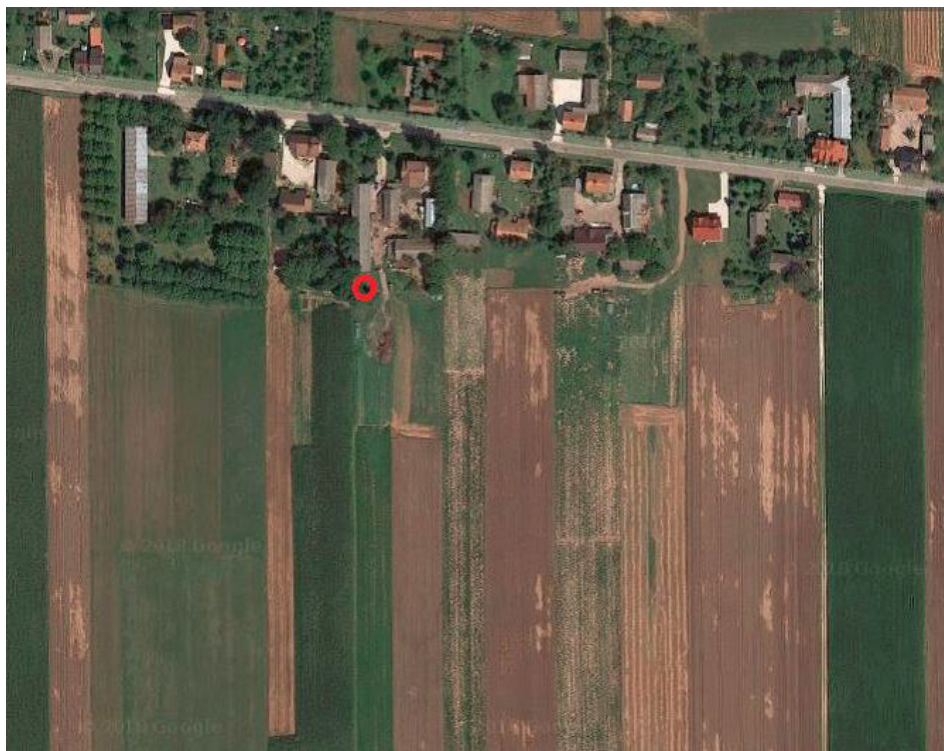


Figure 1. An aerial view of the area of the study with marked place of the screen location

Source: geoserwis.gos.gov.pl.

landscape, subjected by anthropopressure as the fields cultivation, houses and farm buildings (Fig. 1). The trap was on farmland (50°16'31.5"N 20°41'22.8"E) near outbuildings and shelters (Fig. 2) however, in surroundings there were also some orchards and a bit further meadows and forests.



Figure 2. Station where the trap for catching moths was placed

neutral white light with a light color of 400 K and a luminous flux of 6700 lm were used. During the catching, the position of screen was sometimes changed, in order to find the most optimal arrangement. A screen was placed in two ways – on the ground, or hanging vertically as cylindrical tube with a light bulb in the middle. In both cases the light source was in distance of about 50 cm from the screen surface. Incoming and landing on the screen moths were photographed for documentation and later species determination which was done using the keys [1, 2, 16, 17, 18] and web pages dedicated to butterflies e.g. [19]. The nocturnal activity of moth was estimated as general number of all specimens coming to the screen on a five-point scale where 1 (very low) means only single moths and 5 (very large) dozen of them in a unit of time. During the catching, values of mean air temperature, air pressure as well as wind direction and speed were collected from dedicated web page [20]. The phase of moon at night of sampling was noted according to the moon calendar on the website [21].

The catching was done after sunset during evening and night usually between 9:00 p.m. and 1:00 a.m. For catching of the moths a live method was used, consisting in trap with white cotton screen 2 m high and 1,5 m width and attracting light. As a source of light the mercury LRF bulb of 125 W (POLAMP),

Results and Discussion

In this study catching and observation methodology was pro-ecological and consistent with the principles of nature protection. In total, during all of the catches almost 60 different forms of nocturnal butterflies were photographed and 46 of them were determined to the species level (Tab. 1). The caught individuals belonged to 12 families. Some of the representatives are shown on the figures 3, 4, and 5. The most abundant was geometer moths belonging to the family *Geometridae*, from which 11 species were recognized. Next the most abundant in species family was *Erebidae* (10 species) followed by *Noctuidae* (8 species) and *Sphingidae* (5 species). The families *Crambidae*, *Drepanidae*, *Notodontidae* and *Pterophoridae* were represented by 2 species each while the families *Lasiocampidae*, *Nolidae*, *Pyralidae*, and *Cossidae* were confirmed only with one representative respectively. The largest number of observed butterflies were the black arches [*Lymantria* (*Lymantria*) *monacha* (Linnaeus, 1758)] and white ermine [*Spilosoma* (*Spilosoma*) *lubricipeda* (Linnaeus, 1758)] from the *Erebidae* family (Tab. 1, Fig. 3).

Table 1. List of nocturnal butterflies determined to the species level during catches with number of specimens observed and month of occurrence

No.	Family	Species	Number of specimens	Month
1	<i>Cossidae</i> Trociniarkowate	<i>Cossus cossus</i> (Linnaeus, 1758) Trociniarka czerwica	2	VIII
2	<i>Crambidae</i> Wachlarzykowate	<i>Anania hortulata</i> (Linnaeus, 1758), Przezierka pokrzywianka	> 10	VI, VII, VIII
3	<i>Crambidae</i> Wachlarzykowate	<i>Patania ruralis</i> (Scopoli, 1763) Boczanka brązowianka	> 5	VII, VIII
4	<i>Drepanidae</i> Wycinkowate	<i>Habrosyne pyritoides</i> (Hufnagel, 1766) Pluszówka agatka	1	VI
5	<i>Drepanidae</i> Wycinkowate	<i>Thyatira batis</i> (Linnaeus, 1758) Płamówka malinówka	3	VII
6	<i>Erebidae</i> Mrocznicowate	<i>Arctia caja</i> (Linnaeus, 1758) Niedźwiedziówka kaja	1	VIII
7	<i>Erebidae</i> Mrocznicowate	<i>Catocala fulminea</i> (Scopoli, 1763) Wstęgówka śliwica	1	VII
8	<i>Erebidae</i> Mrocznicowate	<i>Laspeyria flexula</i> (Denis & Schiffmüller, 1775)	3	VI, VII
9	<i>Erebidae</i> Mrocznicowate	<i>Lymantria (Porthetria) dispar</i> (Linnaeus, 1758) Brudnica nieparka	> 10	VII, VIII
10	<i>Erebidae</i> Mrocznicowate	<i>Lymantria (Lymantria) monacha</i> (Linnaeus, 1758) Brudnica mniszka	> 20	VII, VIII, IX
11	<i>Erebidae</i> Mrocznicowate	<i>Paracolax tristalis</i> (Fabricius, 1794)	4	VI, VII
12	<i>Erebidae</i> Mrocznicowate	<i>Phragmatobia fuliginosa</i> (Linnaeus, 1758) Sadzanka rumienica	> 10	V, VII, VIII
13	<i>Erebidae</i> Mrocznicowate	<i>Spilosoma lubricipeda</i> (Linnaeus, 1758) Szewnica miętówka	> 5	VII, VIII
14	<i>Erebidae</i> Mrocznicowate	<i>Spilosoma urticae</i> (Esper, 1789) Szewnica pokrzywówka	> 20	V, VI, VII, VIII
15	<i>Erebidae</i> Mrocznicowate	<i>Hypena proboscidalis</i> (Linnaeus, 1758) Rozszczepka śnicianka	> 5	VII, VIII
16	<i>Geometridae</i> Miernikowcowate	<i>Biston betularia</i> (Linnaeus, 1758) Krępak nabrzozak	> 5	VII
17	<i>Geometridae</i> Miernikowcowate	<i>Camptogramma bilineata</i> (Linnaeus, 1758) Paśnik goździeniak	2	VII
18	<i>Geometridae</i> Miernikowcowate	<i>Campaea honoraria</i> (Denis & Schiffmüller, 1775) Ostrołot dębowskiak	1	VIII
19	<i>Geometridae</i> Miernikowcowate	<i>Comibaena bajularia</i> (Denis & Schiffmüller, 1775) Miernik plamiak	1	VI
20	<i>Geometridae</i> Miernikowcowate	<i>Ennomos erosaria</i> (Denis & Schiffmüller, 1775) Latalec gruszek	2	VI, VIII
21	<i>Geometridae</i> Miernikowcowate	<i>Ennomos fuscantaria</i> (Haworth, 1809) Latalec najesioniak	1	VII
22	<i>Geometridae</i> Miernikowcowate	<i>Epirrhoe alternata</i> (Müller, 1764) Paśnik zmiennik	> 5	VI, VII, VIII
23	<i>Geometridae</i> Miernikowcowate	<i>Eupithecia centaureata</i> (Denis & Schiffmüller, 1775) Grotnik chabrowiak	1	VI
24	<i>Geometridae</i> Miernikowcowate	<i>Hemithea aestivaria</i> (Hübner, 1789) Miernik kreskowiak	1	VIII

No.	Family	Species	Number of specimens	Month
25	<i>Geometridae</i> Miernikowcowate	<i>Hypomecis roboraria</i> (Denis & Schiffermüller, 1775) Przylepek nadębek	> 5	V, VI, VII
26	<i>Geometridae</i> Miernikowcowate	<i>Lomaspilis marginata</i> (Linnaeus, 1758) Plamiec nabuczak	> 5	VI, VIII
27	<i>Lasiocampidae</i> Barczatkowate	<i>Odonestis pruni</i> (Linnaeus, 1758) Barczatka sliwienica	> 10	VI, VII
28	<i>Noctuidae</i> Sówkowate	<i>Acronicta (Viminia) rumicis</i> (Linnaeus, 1758) Wieczernica szczawiówka	> 10	V, VII, VIII, IX
29	<i>Noctuidae</i> Sówkowate	<i>Acontia (Emmelia) trabealis</i> (Scopoli, 1763) Polnica szachownicza	3	VI, VIII
30	<i>Noctuidae</i> Sówkowate	<i>Diachrysia chrysis</i> (Linnaeus, 1758) Błyszczka spizówka	> 10	V, VI, VII, VIII, IX
31	<i>Noctuidae</i> Sówkowate	<i>Diachrysia stenochrysis</i> (Warren, 1913)	> 5	V, VIII, IX
32	<i>Noctuidae</i> Sówkowate	<i>Mythimna (Mythimna) pallens</i> (Linnaeus, 1758) Mokradlica	> 5	VII, VIII, IX
33	<i>Noctuidae</i> Sówkowate	<i>Noctua fimbriata</i> (Schreber, 1759) Rolnica aksamitka	1	VI
34	<i>Noctuidae</i> Sówkowate	<i>Plusia festucae</i> (Linnaeus, 1758) Złocica kostrzewica	1	VII
35	<i>Noctuidae</i> Sówkowate	<i>Trachea atriplicis</i> (Linnaeus, 1758) Agatówka łobodnica	3	VIII, IX
36	<i>Nolidae</i> Rozeliowate	<i>Pseudoips prasinana</i> (Linnaeus, 1758) Zielonka ukośnica	1	VIII
37	<i>Notodontidae</i> Garbatkowate	<i>Cerura (Apocerura) erminea</i> (Esper, 1783) Widłogonka gronostajka	1	V
38	<i>Notodontidae</i> Garbatkowate	<i>Notodonta tritophus</i> (Denis & Schiffermüller, 1775)	1	VI
39	<i>Pterophoridae</i> Piórolotkowate	<i>Oxyptilus pilosellae</i> (Zeller, 1841)	1	VIII
40	<i>Pterophoridae</i> Piórolotkowate	<i>Emmelina monodactyla</i> (Linnaeus, 1758) Piórolotek zwyczajny	> 10	VI, VII, VIII, IX
41	<i>Pyralidae</i> Omacnicowate	<i>Hypsopygia costalis</i> (Fabricius, 1775)	1	VIII
42	<i>Sphingidae</i> Zawisakowate	<i>Deilephila elpenor</i> (Linnaeus, 1758) Zmrocznik gładysz	> 10	V, VI, VII
43	<i>Sphingidae</i> Zawisakowate	<i>Deilephila porcellus</i> (Linnaeus, 1758) Zmrocznik pazik	> 15	V, VI, VII
44	<i>Sphingidae</i> Zawisakowate	<i>Laothoe populi</i> (Linnaeus, 1758) Nastroz topolowiec	2	VIII
45	<i>Sphingidae</i> Zawisakowate	<i>Sphinx ligustri</i> (Linnaeus, 1758) Zawisak tawulec	2	VI
46	<i>Sphingidae</i> Zawisakowate	<i>Sphinx pinastri</i> (Linnaeus, 1758) Zawisak borowiec	1	VII

When compared with other studies, the number of noticed moths species was moderate. For example Nowacki and Pałka [22] in the ecosystems of the Nowa Dęba Training Area in the years 1999–2013 found 273 species of noctuid moths from the families Nolidae, Erebidae and Noctuidae which constituted about 55% of the Polish Noctuidae. However, smaller number of species in our study can be a result of the used

method, shorter time of trapping and other different reasons as for example different landscape which was certainly more influenced by anthropomorphic changes and light pollution.














The most interesting butterflies that have been observed were the goat moth [*Cossus cossus*, (Linnaeus, 1758)], which is one of the largest indigenous which adults reach the size 59–96 mm (Fig. 5.5), the lesser puss moth [*Cerura (Apocerura) erminea*

(Esper, 1783)] (Fig. 5.7), which is quite rare and noted only on several sites in Poland. This observation leads us to the conclusion that the study area which is in ecological corridor between different ecosystems of South Poland plays an important role for the moth biodiversity which was noticed in the early 20th century in the Sandomierz Basin by Karpowicz [23] and Kulesza [24] who gave a list of 302 species which were mostly confirmed by Bielewicz [25, 26] and Nowacki and Pałka in 2015 [22].

The largest number of moths lured to the light during single catching was observed at night 9/10 June 2018 (Tab. 2). That night was reported with high air temperature reaching 21°C and low wind speed reached mean 6 km/h. At that night the moon was in the last quarter of lunar period (Tab. 2). The weather conditions were very similar to those at night from 4 to 5 July 2017, where also the high density and big activity of the night butterflies was observed. In contrary the smallest numbers of moths arriving to the light trap were recorded at nights on 14/15

and 25/26 August 2017, as well as on 2/3 September 2017 (Tab. 2). At that time of catching, the air temperature was quite low and reached on average 14°C, 16°C and 12°C respectively. The atmospheric pressure was between 1018 and 1025 hPa, and the average wind speed was 10 km/h. It is well known that the diversity of species noticed in station during field studies is strongly related to the number of samples taken and the sampling effort [27]. Explicit calculation of the rarefaction diversity measurement and the determination of sufficient sample size is necessary [28]. We are aware of the limitations of our study and because of this our results can only be treated as faunistic notes. Similarly quantitative data can be only assumed because of used pro-ecological method of catching which gave no possibility to count reliably abundance data. This could be solved in future studies by using other trap method or by involving several team members to count and observe trap screen simultaneously at the same time.

Table 2. Comparison of moth nocturnal activity, moon phases and weather conditions during all catches

No.	Night	Density and activity ¹	Moon phase	Weather parameters		
				Mean temperature (°C)	Air pressure (hPa)	Mean wind speed (km/h)
1	14/15.07.2017	2		15	1015	7
2	29/30.07.2017	2		16	1018	10
3	4/5.08.2017	4		21	1012	5
4	5/6.08.2017	3		18	1015	7
5	14/15.08.2017	1		14	1025	10
6	18/19.08.2017	3		20	1015	11
7	19/20.08.2017	2		18	1020	4
8	25/26.08.2017	1		16	1018	8
9	1/2.09.2017	2		17	1012	7
10	2/3.09.2017	1		12	1018	9
11	12/13.05.2018	3		16	1022	5
12	25/26.05.2018	3		16	1010	4
13	9/10.06.2018	5		21	1012	6

¹ Moth density: 1—very low; 2—low; 3—medium; 4—large; 5—very large.

Not only kind of trap but also weather conditions such as temperature and rain can influence catch size [13, 14]. The warmer the night was the higher number of moths was caught [14] while the high humidity negatively affected moth abundance [29]. Our light trapping sessions were conducted in rather good weather conditions, however results of catches can be influenced by the moths susceptibility to the light, light range of the bulb which could be lower because of light pollution in village as well as a moon phase which during catching was mostly waxing or waning moon quarter but not new or full moon.

Conclusions

Moths are the richest in species group of *Lepidoptera*, however the diurnal butterflies are the most known. During catches in Ksany village 60 different morphotypes of moths were found from which 44 were identified to the species level. The moths activity depends on many factors among which weather conditions especially temperature played an important role. More detailed studies are needed in order to gather more precise information about diversity and abundance of nocturnal butterflies.

Acknowledgments

We would like to thank the anonymous reviewer for valuable comments on earlier version of the manuscript and Ms Agata Fyda for help with editing of the text. This research was funded by own funds of Department of Environmental Protection of the University of Applied Sciences in Tarnow.

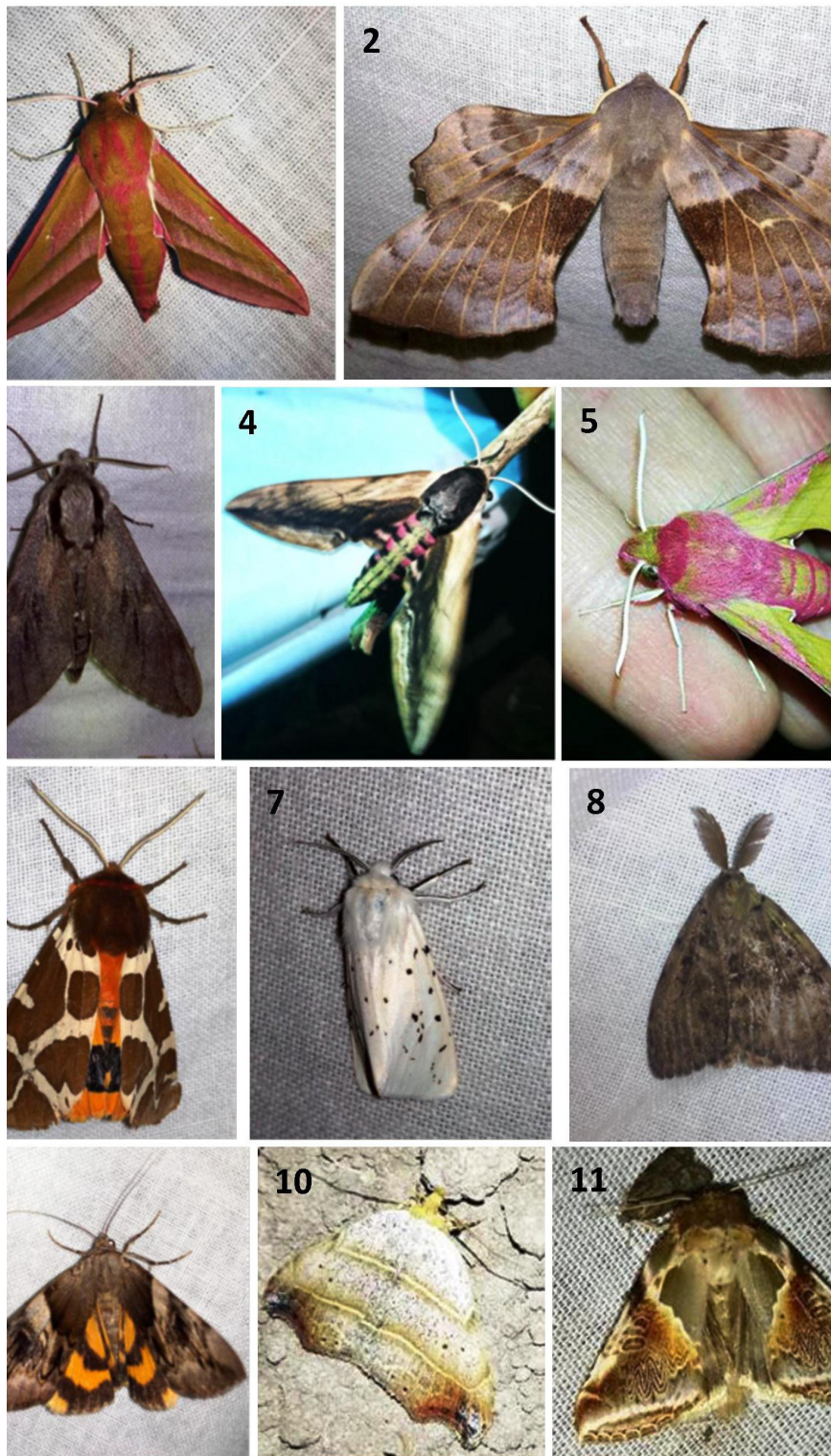
Author Contributions

Conceptualization, Janusz Fyda and Klaudia Konop; methodology, Janusz Fyda and Klaudia Konop; software, Klaudia Konop; validation, Klaudia Konop and Janusz Fyda; formal analysis, Klaudia Konop and Janusz Fyda; investigation, Klaudia Konop; resources, Klaudia Konop; data curation, Klaudia Konop; writing—original draft preparation, Klaudia Konop; writing—review and editing, Janusz Fyda; visualization, Klaudia Konop and Janusz Fyda; supervision, Klaudia Konop; project administration, Klaudia Konop and Janusz Fyda; funding acquisition, Klaudia Konop and Janusz Fyda.

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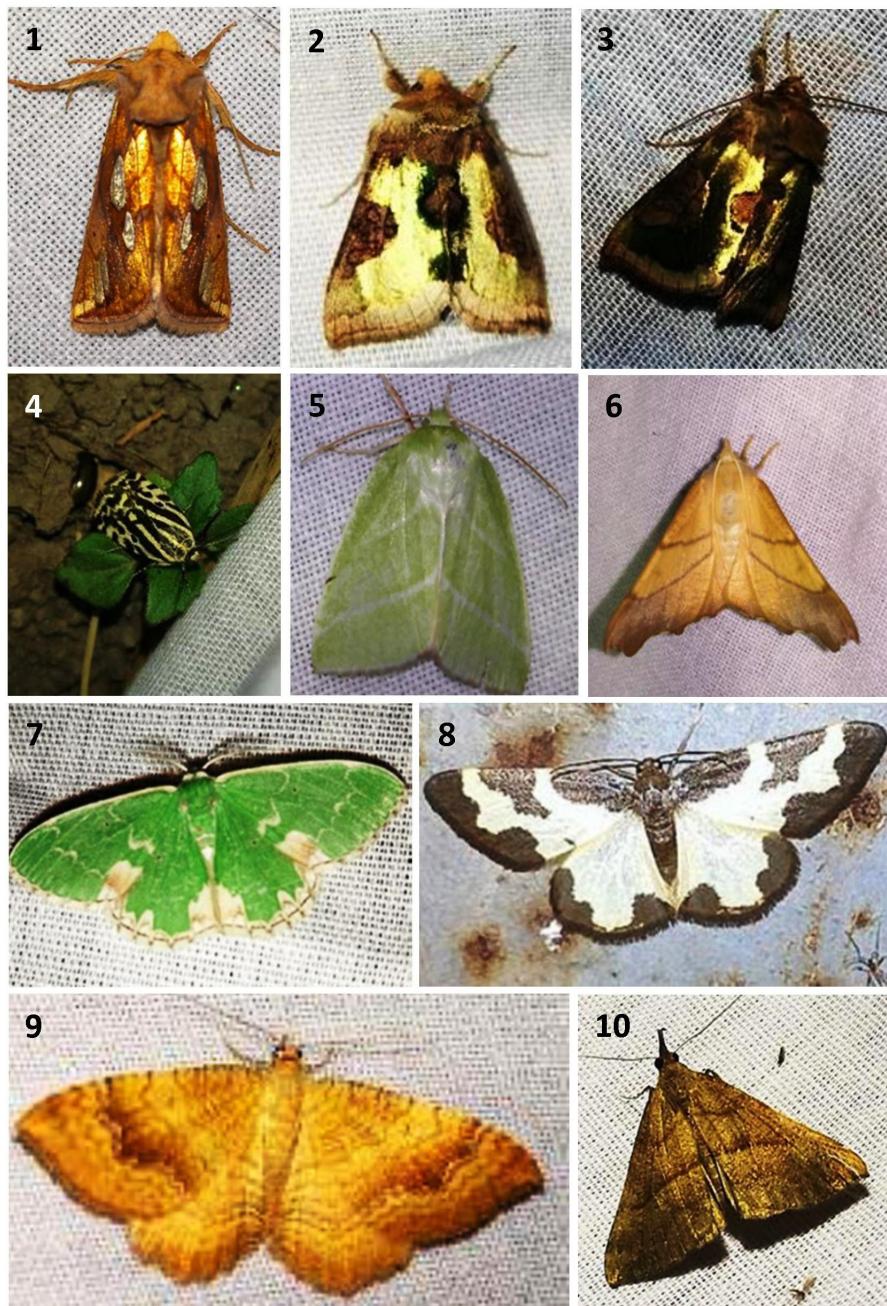
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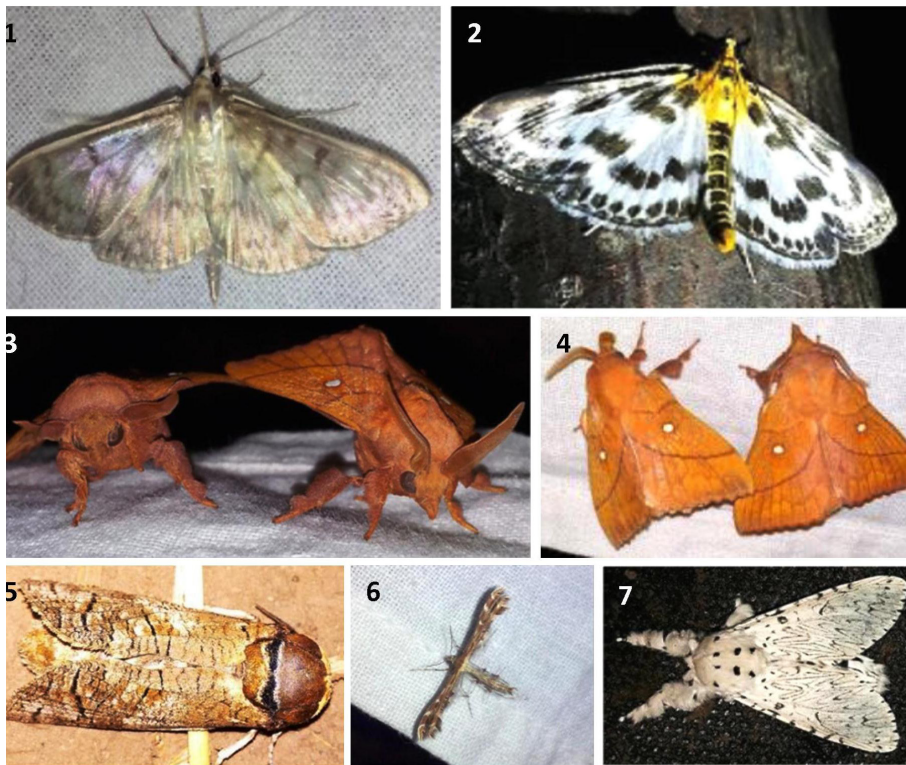
Note: Family *Sphingidae*: 1—*Deilephila elpenor* (Linnaeus, 1758); 2—*Laothoe populi* (Linnaeus, 1758); 3—*Sphinx pinastri* (Linnaeus, 1758); 4—*Sphinx ligustri* (Linnaeus, 1758); 5—*Deilephila porcellus* (Linnaeus, 1758). Family *Erebidae*: 6—*Arctia caja* (Linnaeus, 1758); 7—*Spilosoma lubricipeda* (Linnaeus, 1758); 8—*Lynantria (Porthetria) dispar* (Linnaeus, 1758); 9—*Catocala fulminea* (Scopoli, 1763); 10—*Laspeyria flexula* (Denis & Schiffemüller, 1775). Family *Drepanidae*: 11—*Habrosyne pyritoides* (Hufnagel, 1766).

Figure 3. Some of specimens representing families of the moths on studying area



Note: Family *Noctuidae*: 1—*Plusia festucae* (Linnaeus, 1758); 2–3—*Diachrysis chrysitis* (Linnaeus, 1758); 4—*Acontia (Emmelia) trabealis* (Scopoli, 1763). Family *Geometridae*: 5—*Pseudoips prasinana* (Linnaeus, 1758); 6—*Ennomos fuscantaria* (Haworth, 1809); 7—*Comibaena bajularia* (Denis & Schiffermüller, 1775); 8—*Lomaspilis marginata* (Linnaeus, 1758); 9—*Camptogramma bilineata* (Linnaeus, 1758); 10—*Hypena proboscidalis* (Linnaeus, 1758).

Figure 4. Some of specimens representing families of the moths on studying area



Note: Family *Crambidae*: 1—*Patania ruralis* (Scopoli, 1763); 2—*Anania hortulata* (Linnaeus, 1758). Family *Lasiocampidae*: 3–4—*Odonestis pruni* (Linnaeus, 1758). Family *Cossidae*: 5—*Cossus cossus* (Linnaeus, 1758). Family *Pterophoroidea*: 6—*Oxyptilus pilosellae* (Zeller, 1841). Family *Notodontidae*: 7—*Cerura (Apocerura) erminea* (Esper, 1783).

Figure 5. Some of specimens representing families of the moths on studying area