NAT. CROAT. | VOL. 28 | No 2 | 345-358 | ZAGREB | December 31, 2019

original scientific paper / izvorni znanstveni rad

DOI 10.20302/NC.2019.28.24

CONTRIBUTION TO THE KNOWLEDGE OF BUTTERFLY AND MOTH FAUNA (INSECTA: LEPIDOPTERA) OF GORNJE PLAVNICE, BJELOVAR, CROATIA – RESULT OF A ONE YEAR PHOTOGRAPHIC STUDY

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Veljković, M.: Contribution to the knowledge of butterfly and moth fauna (Insecta: Lepidoptera) of Gornje Plavnice, Bjelovar, Croatia – result of a one year photographic study. Nat. Croat., Vol. 28, No. 2., 345-358, Zagreb, 2019.

This paper gives a list of 100 species from 14 families of Lepidoptera found in Gornje Plavnice near Bjelovar, Croatia in the period from 14 April 2017 to 1 September 2017. This photographic research, conducted mainly in meadows, fallow land, forest edges and backyards in the study area, presents a contribution to the knowledge of butterfly and moth fauna of the Bjelovar-Bilogora area as well as of Croatia as a whole.

Key words: Lepidoptera, fauna, Gornje Plavnice, Bjelovar-Bilogora area

Veljković, M.: Prilog poznavanju faune danjih i noćnih leptira (Insecta: Lepidoptera) u Gornjim Plavnicama, Bjelovar (Hrvatska) – rezultat jednogodišnjeg fotografskog istraživanja. Nat. Croat., Vol. 28, No. 2., 345-358, Zagreb, 2019.

Rad donosi popis 100 vrsta leptira iz 14 porodica, zabilježenih u Gornjim Plavnicama blizu grada Bjelovara, Hrvatska, od 14. travnja 2017. do 1. rujna 2017. godine. Ovo istraživanje, temeljeno na fotografijama, uglavnom se provodilo na području livada, neobrađenih poljoprivrednih površina, rubova šuma i dvorišta na području istraživanja te predstavlja doprinos poznavanju faune danjih i noćnih leptira Bjelovarsko-bilogorskog područja i Hrvatske.

Ključne riječi: Lepidoptera, fauna, Gornje Plavnice, Bjelovarsko-bilogorsko područje

INTRODUCTION

One hundred and ninety seven butterfly species have been recorded in Croatia (Šašić *et al.*, 2015) but around 3,000 moth (Kučinić & Plavac, 2009). Although more numerous, moths are little represented in the literature in Croatia, while for butterfly fauna there is much more published information, as well as the first checklist of Croatian butterflies (Šašić & Mihoci, 2011) and a Red Book of Butterflies of Croatia (Šašić *et al.*, 2015). However, there have been some improvements, through newly published data about moths in Croatia such as the first checklist of the Arctiinae subfamily (Kučinić *et al.*, 2014), the moth fauna of Motovun forest (Koren *et al.*, 2015), of Lonjsko polje (Koren *et al.*, 2017), the surroundings of the Bednja River, Varaždin County (Koren, 2018). However, for some areas in Croatia, fauna of neither butterflies nor moths is sufficiently studied; one such area is that of in the Bjelovar-Bilogora area, within Bjelovar-Bilogora County. About butterfly fauna there are only a few papers (e.g. Grubišić *et al.*, 2006; Mihoci *et al.*, 2007; Fištrek, 2018), while data about moth fauna in Bjelovar-Bilogora area are scarce.

High quality digital photographs not only give an opportunity for less invasive research into butterfly diversity, not involving the killing of observed individuals, (Koren & Letić, 2014) but also enables the study and documentation of an unfamiliar or even rare species a long time after field research (Quinn & Klym, 2009). Moreover, according to Quinn & Klym (2009), photographs can reveal shapes, patterns and even behavior not noticed during field work. Furthermore, photographs with the correct coordinates, locality name, date and observer, create valuable data (Koren & Letić, 2014). According to Winterton *et al*. (2012), due to the sharing of such photographs in online image databases, species new for science have been discovered; the base for their recognition as new for science by professional taxonomists and formal descriptions has been created. In the time of global climate change and rapid biodiversity loss, social media and web platforms about butterflies and moths can be a good base for further research, like eButterfly, a web-platform in North America where butterfly enthusiasts create a globally accessible database of butterfly observations (Prudic *et al*., 2017). There are similar web-platforms in different parts of the world (Butterflies of India, Moths and Butterflies of Europe and North Africa, UK Moths, Lepiforum e. V., Leptiri.net (Croatia), Observado, iNaturalist in Europe. However, according to Koren & Letić (2014), for correct identification, considerable knowledge on the local butterfly fauna is needed as well as butterfly identification guides (Lafranchis, 2004; Tolman & Lewington, 2008). Also, for some species, especially moths, photographs are not enough for correct identification, and genitalia analysis is needed. For instance, in this study some moth families like Gelechiidae and Pterophoridae, in agreement with Dr. Koren, were excluded from the species list because their identification only from photographs and without genitalia analysis would not be reliable. For identification of both butterfly and moth species that cannot be properly identified only from the field observations and digital photographs or for confirmation of correct identification, some methods like genitalia analysis (e.g. Mrnjavčić Vojvoda *et al*., 2014; Kučinić *et al*., 2014; Koren, 2018, etc.) and, recently, the DNA bar-coding approach (e.g. Hajibabaei *et al*., 2006; Jin *et al*., 2018) are used. In some genera, species are very similar, which complicates their determination, as in numerous members of the genus *Catocala*, where maculation, genitalia and barcodes may not be enough for correct species identification, so study of host plants and larvae also should be conducted (https://mothphotographersgroup.msstate.edu). Still, the majority of butterfly species occurring in Croatia can be correctly identified from the photographs by the entomologists (Koren & Letić, 2014). Moreover, according to Patterson (2012) a large number of moths can be identified in this way. However, there is no available data about research into moths in Croatia based on the digital photographs.

Usage of digital photography in butterfly and moth research is getting more attention with the development of this technology, so many authors use digital photography together with other methods (e.g. Basset *et al*., 2000; Rice & White, 2015), while others like Medhi *et al*. (2018) studied butterfly diversity in India

on the basis of digital photography and observations. Sourakov (2018) utilized digital photographs and observations in research into mass aggregations of *Idia* moths (Lepidoptera: Erebidae) in Florida. Some authors go further, like Remboski *et al*. (2018), with the use of digital image processing and machine learning techniques for identification of fruit flies, or like Suetsugu & Hayamizu (2014) with the use of interval photography with a digital camera to show moth visitors of the *Platanthera* orchids. In Croatia there have also been some improvements, at least in using digital photography in butterfly research; Koren & Letić (2014) conducted the first photographic survey of butterfly diversity in Croatia, based on identification from the photographs, while recent studies mostly use photographs in addition to other methods (Koren *et al*., 2017; Fištrek, 2018).

The aim of this preliminary photographic research project, based on the identification of specimens from photographs taken in the surveyed area, is to make a contribution to the knowledge of the butterfly and moth fauna of this previously under-surveyed area and about possible threats to their biodiversity.

MATERIAL AND METHODS

Study area

Bjelovar-Bilogora County has an area of 2.652 km^2, which is 3.03% of the total area of Croatia. The county has a few cities (Bjelovar, Daruvar, Čazma, Garešnica and Grubišno Polje) and a large number of villages and settlements. It is situated in the central part of continental Croatia and has four characteristic geographic units: Bilogora (north and northeast), bordering the mass of Papuk and Ravna Gora (east), Moslavačka gora (southwest) and the valleys of the Česma and Ilova (west, central and south) (http://www.bbz.hr). Bilogora is a low, broad mountain in northern Croatia, which stretches along the southwestern edge of Podravina from the northwest to the southeastern part, in a length of about 80 km. The highest peak is called Stankov vrh (309 m). The entire surface is covered with a herbal mantle (Poljak, 2001). The lower slopes are under vineyards, orchards and corn fields, while above them continue forests, predominantly deciduous. It is part of the lowland oak forests region, with complexes of sessile oak(*Quercus petraea* (Matt.) Liebl.) and hornbeam (*Carpinus betulus* L.). Common oak (*Quercus robur* L.) can also be found there as well as beech, *Fagus sylvatica* L. on the north slopes (Poljak, 2001). The study area in this paper comprises the edge parts of the Bilogora and the northern surroundings of the city of Bjelovar. Gornje Plavnice is a village in close vicinity (north side) of the city of Bjelovar, traditionally an agricultural part of Croatia covered with agricultural fields, meadows and deciduous forests, like the most of Bjelovar – Bilogora area. Most of the surveyed area consists of agricultural land covered with crops like corn, wheat, barley, oil seed rape, etc. with only a few fallow parcels. The area is fragmented into many smaller parcels with mentioned crops but also with gardens, meadows, and fallow land near each other.

Butterfly and moth photographic survey

The research was performed from 14 April 2017 to 1 September 2017, on an area of 387,000 m^2, situated in Gornje Plavnice near Bjelovar, in the continental part of Croatia (see Fig. 1), where specimens of butterflies and moths were observed and photographed. Moths were photographed resting on house walls below the external house light during night. The habitats present in this area include wet and mesophilous meadows, forest edges, glades, agricultural land, fallow land, backyards, orchards and gardens. Butterflies and moths were photographed by the author. Butterflies were identified using Tolman & Lewington (2008) while identification of moth species was done according to Fibiger (1993), Leraut (2009; 2014), Nowacki (1998), Manley (2008) and Waring *et al*. (2003). Also, a professional butterflies and moths website (www.lepiforum.de) was used. Furthermore, identification of both moth and butterfly species was revised by Dr. Toni Koren from the Hyla Association, Zagreb. Systematics follows Van Nieukerken *et al*. (2011). All collected photographs of butterflies and moths are kept in the author's private collection. Plant species were identified using Domac (2002) and Nikolić (2018) (Flora Croatica Database).

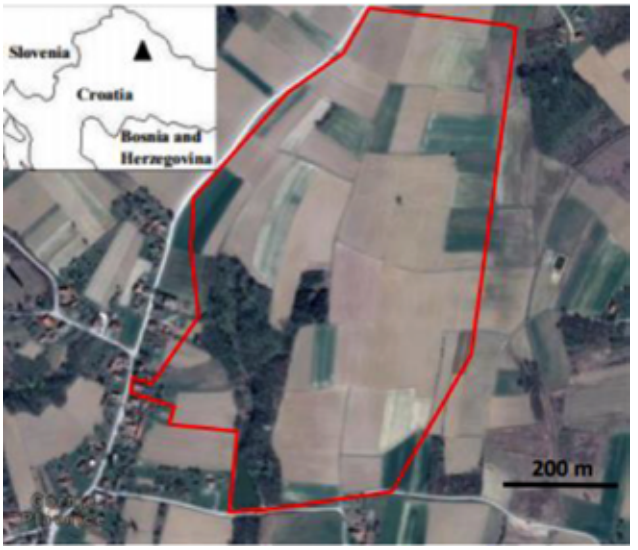

Fig 1. Location of the study area in Gornje Plavnice near Bjelovar, Croatia.

RESULTS AND DISCUSSION

Although the overall number of photographs taken during the research reached around 3,200, many of them were not enough clear for proper identification. Consequently, on the base of a total number of 2,030 high quality photographs, 100 species from 14 Lepidoptera families were identified. From the whole number, 36 species were butterfly species and three of them are listed in the Red Book of Butterflies of Croatia (Šašić *et al*., 2015): *Apatura ilia*, *Lycaena dispar* and *Papilio machaon* as Near Threatened (NT). Most recorded butterfly species belong to the

families Nymphalidae (16) and Lycaenidae (8). In this research, the most common moths were geometrid moths (Geometridae) with 23 species and noctuid moths (Noctuidae) with 17 species. Species from other families were less found and contained 1-7 species. The list of butterfly and moth species is presented in Tab. 1.

Usually, meadows in this area are mowed two to three times every year in order to produce hay for livestock feeding and the vegetation mostly consists of species from the family Poaceae and Fabaceae as well as of other plant families like Apiaceae, Asteraceae, Ericaceae, Rubiaceae and Lamiaceae. Most of the surrounding arable fields in the study area are fertilized with mineral fertilizers and treated, a few times during the season, with herbicides and pesticides, which have a bad effect on insects. As the meadows are mainly near such agriculture land, their flora and fauna are also affected by chemicals because of airborne transmission. Meadows occupy a much smaller part of the study area than agricultural land because of agricultural intensification and reduced production of hay for livestock feeding. Furthermore, in July and August 2017, seismic investigation of oil and gas reserves in this area was conducted and many meadows were invaded by heavy machines, whereas on some meadows new boreholes are planned. All these factors could affect butterfly and moth biodiversity as most of them were found on mesophilous and wet meadows (30 of 36 butterfly species and 19 of 64 moth species), but further research about their populations should be conducted. The most frequently found butterfly species on the meadows in the study area were *Polyommatus icarus, Coenonympha pamphilus, Pieris rapae* and *Lycaena phlaeas.* The least frequent species are *Iphiclides podalirius, Erynnis tages, Pyrgus malvae*, *Pyrgus armoricanus* and *Thymelicus sylvestris*. Some flower generalist species like *P. icarus, C. pamphilus* and *Maniola jurtina* (Wallis De Vries *et al*., 2012) occurred on the flowers of different plant species. *P. icarus* was attracted by the flower of *Trifolium pratense* L., *Trifolium repens* L. as well as by flowers of *Convolvulus arvensis* L., *Centaurea* sp.and *Erigeron annuus* (L.) Pers. *P. icarus*, also photographed on its host plant *Lotus corniculatus* L., according to Janz *et al.* (2005) has strategy for host plant searching that allows the usage of the same host plant individual for both oviposition and adult nutrition. Being a favored plant for both adult nutrition and food for larvae, *L. corniculatus* enables *P. icarus* females to search for only one resource to complete both tasks (Janz *et al*., 2005). Some flower specialist butterfly species, like a copulating pair of *E. tages* (Wallis De Vries *et al*., 2012), occurred near their main larval food plant, *Lotus corniculatus* L. (Gutiérrez *et al*., 2001). Furthermore, *Cyaniris semiargus,* an indicator species of unmanaged sites like abandoned grasslands and *Cupido argiades,* an indicator species of alluvial meadows (Trappe *et al*., 2017), were photographed on the flower of *Trifolium pratense* L. Flowers of the plants from the genus *Centaurea* attracted many butterfly species like *T. sylvestris*, *Lasiommata megera*, *C. pamphilus*, *Melitaea athalia*, *Aglais io*, *M.jurtina*, *Melanargia galathea*, *Araschnia levana*, while *C. pamphilus* and *C. argiades* were found also on the flower and leaf of a plant from the genus *Plantago,* near a backyard in the study area. One specimen of *L. dispar* was photographed, on a newly sown meadow, on the leaf of *Sorghum halepense*

(L.) Pers. (see Fig. 2). This corresponds to the finding of Trappe *et al*. (2017) where *L. dispar* occurred on semi-natural grasslands. The nearest finding of this species in Bjelovar-Bilogora is the finding of *L. dispar* in Grubišnopoljska Bilogora (Mihoci *et al*., 2007). *Pieris napi*, a species that favors more humid meadows and forested areas (Friberg *et al*., 2015), was attracted by the flower of the *Centaurea* sp. Flowers of some invasive plant species like *Erigeron annuus* (L.) Pers. attracted *P. armoricanus, C. glycerion, C. pamphilus, L. phlaeas, M. jurtina, M. athalia, Neptis sappho,* while *Issoria lathonia* was found on the flower of the *Solidago canadensis* L.

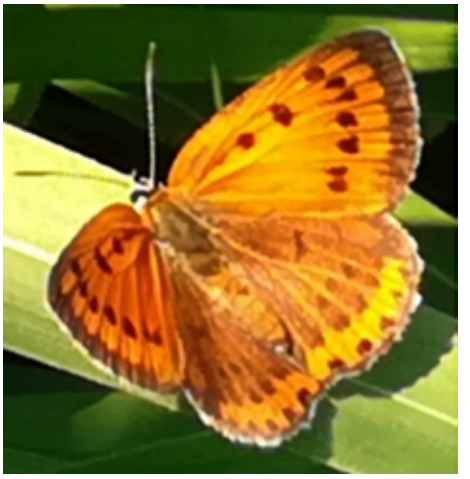

Fig. 2. *Lycaena dispar* (Haworth, 1802) in the study area near Bjelovar, Croatia.

Moth species like *Cydia pomonella, Celypha striana, Oncocera semirubella, Pyrausta purpuralis, Nomophila noctuella, Chiasmia clathrata, Selenia lunularia, Ematurga atomaria, Idaea ochrata, Polypogon tentacularia, Euclidia glyphica, Deltote bankiana,* found on the meadows in the study area, mainly appeared on the leaves of the plants from the family Poaceae. *Acontia trabealis* was photographed on the leaves of *Convolvulus arvensis* L., *A. trabealis* the main food plant (Koren *et al*., 2015), whereas *Acontia lucida* was found on the flower of the *Centaurea* sp. *Tyta luctuosa* was found resting on a leaf of *Achillea millefolium* L., close to the part inhabited with *Convolvulus arvensis* L. and species of the genus *Plantago,* used for the feeding of *T. luctuosa* caterpillars (Koren & Gomboc, 2017). *T. luctuosa*, according to Rosenthal *et al*. (1988) and Tóth *et al*. (2004), has potential value as a biological control agent for *C. arvensis*, which can be potentially useful for reducing the usage of herbicides, used in the study area. *E. atomaria* was found on the leaves of *Trifolium* sp., used as food plant for caterpillars of this species (Koren & Gomboc, 2017) and, like *P. tentacularia* and *Heliothis viriplaca,* on the flower of the invasive species *Erigeron annuus* (L.) Pers. Meadows in the study area are also inhabited by *Mentha sp.*, one of the host plants of *Scopula ornata* (found near the house light), as well as by plants from the genus *Galium, Stellaria* and *Campanula*, host plants of another species of Geometer moths, *Xanthorhoe ferrugata*, recorded near the house light (Koren *et al*., 2015).

Fallow land in the study area was mostly agricultural land that had not been cultivated for a few years. Although mostly plants from the family Poaceae inhabit such land, nowadays some invasive alien species such as *Ambrosia artemisiifolia* L. and *Solidago canadensis* L. occur there. In parts closer to the wood edge, young trees of *Juglans nigra* L. and even *Robinia pseudoacacia* L. occur. *A. levana* occurred on a flower of *Solidago canadensis* L. and on a flower of *Daucus carota* L. ssp. *carota,* whereas *Melitaea phoebe* was sitting on the leaf of the host plant *Cirsium arvense* (L.) Scop., and on a young tree of *Juglans nigra* L., near the area where another *M. phoebe*

host plant, *Cirsium vulgare* (Savi) Ten. grows (Tóth *et al*., 2015). *N. sappho*and *M. athalia* occured on the leaf of *Ambrosia artemisiifolia* L. Mosaic of fallow land and meadows, mown occasionally in the study area, presents an important habitat for the survival of *Rhyparia purpurata*, a rare species in Croatia (Koren & Gomboc, 2017). In this study, a specimen of *R. purpurata* was found near the forest edge, on a leaf of *Achillea millefolium* L. and close to *R. purpurata* caterpillar food plants from the genus *Cirsium*, *Galium*, *Rubus* and *Trifolium* (Koren & Gomboc, 2017).

Although agricultural land has much lower biodiversity, some butterfly and moth species were found there. *Aglais io* was found sitting on the ground near the edge of the agricultural land covered with *Zea mays* L. Some part of the study area is under the crop *Brassica napus* L. Although it demands pesticide and herbicide treatments during the flowering period, this crop attracts insects like bees and butterflies. *Pieris rapae* was found on the leaf of *Urtica dioica* L., on the forest edge and on the meadow plant from the genus *Lamium*, close to a field with oil seed rape (*Brassica napus* L.) and near the garden with *P. rapae* host plants, *Brassica oleracea* L. (Friberg *et al*., 2015). *Pieris rapae* is often found in cultivated *Brassica* fields (Friberg *et al*., 2015); in the study area such fields are usually treated with pesticides two-three times a year, which constitues a threat for their population. An individual from a moth species from the family Erebidae, *Polypogon tentacularia,* was photographed while sitting on a leaf of *Zea mays*L., near fallow land inhabited by the *P. tentacularia* host plant from the genus *Solidago*, *Solidago canadensis* L. (Koren *et al*., 2015), while *Autographa gamma* was photographed on the leaf of *Sorghum halepense* (L.) Pers. Although the study area includes some parcels with intensive agriculture, some parcels sown with *Triticum aestivum* L. are not treated with herbicides and pesticides, and so create a habitat for *Matricaria* sp. inside the crop field and *Urtica dioica* L. on its edges, which are host plants of *Macdunnoughia confusa*, found near the light (Koren *et al*., 2015).

Gardens in the study area attracted some species like *Macroglossum stellatarum*, photographed on a flower of *Zinnia elegans* Jacq. Besides vegetables and flowers, gardens in the study area also contain plant species like *Chenopodium album*L., *Rumex* sp., genus *Polygonum*, *Trachea atriplicis* caterpillar food plants (Koren & Gomboc, 2017). Mentioned moth species was found on a wall below the house outside light. As in some gardens, mostly those planted with vegetables, pesticides and herbicides are used, the larvae of butterflies and moths as well as adult species could be affected.

As orchards and backyards are usually planted with indigenous fruit cultivars, which mostly do not demand treatment with pesticides, many butterfly and moth species were found there. *Celastrina argiolus* and *Brenthis daphne* were photographed on the leaf of *Rubus idaeus* L., planted between a small meadow and a garden. *Apatura ilia* was found sitting on gloves on a house terrace and while flying along the forest edge. Also, this species occurred on the leaf of *Pyrus communis* 'Williams' in a backyard with fruit trees and livestock dung, probably attracted by the honey dew and dung that it uses for food (Šašić *et al*., 2015). *Polygonia c-album* was photographed while sitting on the leaves of *Rubus idaeus* L. and on a branch of *Prunus domestica* L., while *Araschnia levana* was found on

the leaves of *Rubus idaeus* L. A young tree of *Prunus domestica* L., in the backyard, attracted *Pararge aegeria*. *Cydia pomonella*, common in old extensive orchards and gardens with lower impacts of pesticides (Koren & Gomboc, 2017), was found on the leaf of a plant species from the genus *Malus.* Fruits of this genus as well as of *Prunus domestica* L., *Prunus persica* (L.) Batsch, genus *Pyrus*, *Juglans*, *Cydonia*, all present in orchards and backyards of the study area, are all used by *C. pomonella* larvae for feeding (Koren & Gomboc, 2017). *Diasemia reticularis* was found sitting on the leaf of *Rubus idaeus* L., which grows between an orchard and garden. The study area is rich in bark lichens on branches of the trees in orchards, backyards and forests, forage for the overwintering larvae of *Laspeyria flexula* (Macdonald & Feber, 2015), found near the light.

The forest edge presents an important habitat for different species. *Issoria lathonia* was found sitting on the leaf of *Corylus avellana* L. while *Papilio machaon* was found during its flight from the forest to the area of backyards and orchards, where it was also observed. The area where this species was found is rich in plants from the family Apiaceae like *Daucus carota* L. ssp. *carota*, *Petroselinum crispum* (Mill.) A. W. Hill, *Foeniculum vulgare* Mill., some of *P. machaon* host plants (Trappe *et al*., 2017). Many butterfly species are not camera shy and they can be fully contained within the camera's field (Quinn & Klym, 2009). However, some butterfly species move rapidly like the genus *Colias*, Hesperiidae genera like *Spialia* and *Pyrgus*, so it is not easy to record them with digital photography (Koren & Letić, 2014). *P. machaon* belongs to the group of the best flyers among butterflies (Šašić *et al*., 2015) and it was quite tough to photograph specimens of them in the field, so the video was taken and then observed and transformed into photographs for identification. The genus *Quercus* occurs on the forest edge in the study area, while the genus *Salix* inhabits the stream below the forest slopes *(Macaria alternata* and *Lomographa temerata* host plants) as well as *Alnus* (in the part between the forest and the pond), another host plant of *Macaria alternata* (Waring *et al*., 2003; Koren *et al*., 2015), so their occurrence near a house light in this study reflects the existence of their preferred habitats. *Perizoma alchemillata* was found near the exterior house light, close to the forest edge where *P. alchemillata* host plants from the family Lamiaceae and *Galeopsis* sp. (Gathmann *et al*., 2006) grow. One of the *Polypogon tentacularia* host plants, *Solidago canadensis* L., inhabits the slope between the forest and meadow, while plants from the genus *Hieracium,* and *Taraxacum officinale* Weber, also *P. tentacularia* host plants (Koren *et al*., 2015) inhabit meadow near the slope. The main threats for forest edges is presented by the mowing of lower plants and shrubs for the sake of the maintenance of agricultural land and meadows, which usually almost reach the forest edges.

Forests in and around the study area are deciduous, containing species of the genera *Quercus, Carpinus, Fagus, Acer* but also from the genera *Alnus* and *Salix* in the lower parts of the terrain, closer to the pond and stream which stretches alongside the forest in the study area. *Apoda limacodes*, the only representative of the family Limacodidae found in this study, was photographed on the wall beyond the exterior house light and caterpillars of this species feed on the leaves

of tree species of *Quercus, Carpinus, Fagus* and *Acer* (Koren & Gomboc, 2017). Another species attracted to the light is *Endotricha flammealis* and caterpillars of this species feed on plants from the genus *Quercus*, present in the deciduous forest within the surveyed area, plants from the genus *Salix*, inhabiting the stream, which stretches along this forest as well as on plants from the genus *Lotus* (Koren & Gomboc, 2017), on the meadow in the study area. Larvae of the adult *Selenia lunularia*, found in a backyard inhabited by the *S. lunularia* host plant, *Prunus* sp., also can use *Quercus* sp. from the deciduous forest in the study area, as a host plant (Koren *et al.*, 2015). Some of the host plants of the *Idaea rusticata*, found near the house light, are *Clematis vitalba* L., which inhabits the forest in the study area where it hangs from the trees more exposed to light, and *Hedera helix* L. (Waring *et al.*, 2003), present both in forests and backyards in the study area. Adult *Lomaspilis marginata* was found near the house light close to the stream in the study area, inhabited with host plant of this species, *Salix* sp. (Waring *et al.*, 2003), while another host plant of *L. marginata*, *Populus nigra* L., grows near the road along the edge of the study area (Noble, 1975). *Melanchra persicariae*, found near the light, uses a lot of different host plants from *Urtica dioica* L., *Convolvulus arvensis* L., *Corylus avellana* L. (Waring *et al.*, 2003), *Sambucus nigra* L. (Noble, 1975) to *Larix decidua* Mill., from the family Pinaceaea (Heath & Emmet, 1979). Although not included in the surveyed area, forest of *Larix decidua* Mill. is in the close vicinity of the study area and constitutes a preferred habitat for this species, together with the mentioned plant species. Forests in the study area are still quite well maintained but, nowadays, many forest parts in the near surrounding of the study area and even wider Bjelovar-Bilogora area are destroyed because of clearcut logging, bad management and absence of proper afforestation. On such woodland areas, invasive plant species like *Robinia pseudoacacia* L. become dominant. Moreover, new boreholes are opened in some forests near the study area and the light they emit during the night probably affects the physiological characteristics of the forest trees. More research should be conducted in order to gain better understanding how the mentioned threats affect host plants as well as butterfly and moth biodiversity and survival.

The results of this research have a preliminary character so they should be a starting point for further research. Surveys of the butterfly and moth fauna of Bjelovar-Bilogora are needed to gain more recent knowledge about their biodiversity and the stability of their populations under different threats, especially for butterflies, such as agricultural intensification, abandonment of traditional agriculture, climate change (including droughts), change of woodland management (Van Swaay, 2010), oil boreholes and seismic investigation of oil and gas reserves.

ACKNOWLEDGEMENTS

I would like to thank to Dr. Toni Koren (Hyla Association, Zagreb) for revision of butterfly and moth identification in this study.

Received October 16, 2017

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Tab. 1. Systematic list of butterfly and moth species found in Gornje Plavnice (Bjelovar) with observation dates.

Species	Observation date in 2017
Fam. Tortricidae:	
1. Agapeta zoegana (Linnaeus, 1767)	11.8., 19.8.2017
2. Celypha striana ([Denis & Schiffermüller], 1775)	31.7.2017
3. Grapholita compositella (Fabricius, 1775)	13.8.2017
4. Cydia pomonella (Linnaeus, 1758)	24.7.2017
Fam. Limacodidae:	
5. Apoda limacodes (Hufnagel, 1766)	21.7.2017
Fam. Papilionidae:	
6. Iphiclides podalirius (Linnaeus, 1758)	1.7.2017
7. Papilio machaon (Linnaeus, 1758)	11.8.2017
Fam. Hesperiidae:	
8. Erynnis tages (Linnaeus, 1758)	4.7.2017
9. Carcharodus alceae (Esper, 1780)	16.7., 29.7.2017
10. Pyrgus malvae (Linnaeus, 1758)	27.4.2017
11. Pyrgus armoricanus (Oberthür, 1910)	19.7.2017
12. Thymelicus lineola (Ochsenheimer, 1808)	22.6.2017
13. Thymelicus sylvestris (Poda, 1761)	4.6.2017
14. Ochlodes sylvanus (Esper, 1777)	28.7.2017
Fam. Pieridae:	
15. Pieris rapae (Linnaeus, 1758)	24.6., 3.8., 8.8., 15.8., 23.8.2017
16. Pieris napi (Linnaeus, 1758)	26.6., 8.7.2017
17. Colias crocea (Geoffroy, 1785)	3.8.2017

Fam. Lycaenidae:	
18. Lycaena phlaeas (Linnaeus, 1761)	1.7., 8.7., 18.7., 8.8.2017
19. Lycaena dispar (Haworth, 1802)	6.6., 13.8.2017
20. Lycaena tityrus (Poda, 1761)	17.7., 28.7., 29.7., 31.7.2017
21. Cupido argiades (Pallas, 1771)	15.7., 22.7., 8.8.2017
22. Cupido alcetas (Hoffmannsegg, 1804)	27.4.2017
23. Celastrina argiolus (Linnaeus, 1758)	1.7.2017
24. Cyaniris semiargus (Rottemburg, 1775)	17.7.2017
25. Polyommatus icarus (Rottemburg, 1775)	27.6., 1.7., 4.7., 8.7., 16.7., 8.8.2017
Fam. Nymphalidae:	
26. Pararge aegeria (Linnaeus, 1758)	14.4., 26.6.2017
27. Lasiommata megera (Linnaeus, 1767)	4.7., 15.7.2017
28. Coenonympha glycerion (Borkhausen, 1788)	16.7., 19.7., 28.7., 29.7.2017
29. Coenonympha pamphilus (Linnaeus, 1758)	27.4., 30.4., 30.6., 8.7., 16.7., 25.7., 27.7.2017
30. Maniola jurtina (Linnaeus, 1758)	24.6., 26.6., 1.7., 8.7., 21.7., 8.8. 2017
31. Melanargia galathea (Linnaeus, 1758)	19.6., 24.6., 26.6., 6.7.2017
32. Issoria lathonia (Linnaeus, 1758)	29.7.2017
33. Brenthis daphne (Bergsträsser, 1780)	26.6.2017
34. Neptis sappho (Pallas, 1771)	26.7.2017
35. Apatura ilia ([Denis & Schiffermüller], 1775)	19.7., 4.8., 8.8.2017
36. Aglais io (Linnaeus, 1758)	17.4., 18.6.2017
37. Vanessa atalanta (Linnaeus, 1758)	15.8.2017
38. Polygonia c-album (Linnaeus, 1758)	6.7., 8.7., 12.7., 26.7.2017
39. Araschnia levana (Linnaeus, 1758)	17.4., 21.7., 24.7., 28.7., 31.7.2017
40. Melitaea phoebe ([Denis & Schiffermüller], 1775)	20.7., 21.7., 25.7.2017
41. Melitaea athalia (Rottemburg, 1775)	27.4., 1.5., 26.6., 16.7., 27.7., 28.7.2017
Fam. Pyralidae:	
42. Synaphe punctalis (Fabricius, 1775)	17.7.2017
43. Endotricha flammealis ([Denis & Schiffermüller], 1775)	17.7., 21.7.2017
44. Oncocera semirubella (Scopoli, 1763)	16.7.2017
45. Homoeosoma sinuella (Fabricius, 1794)	13.7., 3.8.2017
Fam. Crambidae:	
46. Elophila nymphaeata (Linnaeus, 1758)	21.7.2017
47. Pyrausta purpuralis (Linnaeus, 1758)	26.7., 31.7.2017
48. Sitochroa verticalis (Linnaeus, 1758)	29.7.2017
49. Ostrinia nubilalis (Hübner, 1796)	23.7., 28.7., 6.8.2017
50. Pleuroptya ruralis (Scopoli, 1763)	17.7., 18.7.2017
51. Diasemia reticularis (Linnaeus, 1761)	1.7.2017
52. Nomophila noctuella ([Denis & Schiffermüller], 1775)	22.6., 21.7.2017
Fam. Sphingidae:	
53. Macroglossum stellatarum (Linnaeus, 1758)	16.7.2017
54. Deilephila porcellus (Linnaeus, 1758)	3.8.2017
Fam. Geometridae:	
55. Lomaspilis marginata (Linnaeus, 1758)	23.7.2017
56. Macaria alternata ([Denis & Schiffermüller], 1775)	15.7.2017
57. Chiasmia clathrata (Linnaeus, 1758)	27.4.2017
58. Selenia lunularia (Hübner, 1788)	22.6.2017
59. Lomographa temerata ([Denis & Schiffermüller], 1775)	23.7.2017
60. Campaea margaritaria (Linnaeus, 1761)	31.8.2017
61. Ematurga atomaria (Linnaeus, 1758)	17.4. ,16.7., 6.8.2017
62. Chlorissa cloraria (Hübner, 1813)	24.8.2017

Fam. Geometridae:	
63. Idaea ochrata (Scopoli, 1763)	8.7.2017
64. Idaea rusticata ([Denis & Schiffermüller], 1775)	25.7.2017
65. Idaea dimidiata (Hufnagel, 1767)	4.8.2017
66. Idaea aversata (Linnaeus, 1758)	1.9.2017
67. Idaea degeneraria (Hübner, 1799)	20.7.2017
68. Scopula immorata (Linnaeus, 1758)	8.7.2017
69. Scopula virgulata ([Denis & Schiffermüller], 1775)	29.7.2017
70. Scopula ornata (Scopoli, 1763)	24.8.2017
71. Timandra comae (Schmidt, 1931)	13.7., 21.7.2017
72. Cyclophora annularia (Fabricius, 1775)	4.8.2017
73. Xanthorhoe ferrugata (Clerck, 1759)	25.8.2017
74. Catarhoe cuculata (Hufnagel, 1767)	23.7., 11.8.2017
75. Camptogramma bilineata (Linnaeus, 1758)	25.8, 26.8.2017
76. Pelurga comitata (Linnaeus, 1758)	19.8.2017
77. Perizoma alchemillata (Linnaeus, 1758)	18.7.,11.8.2017
Fam. Notodontidae:	
78. Clostera pigra (Hufnagel, 1766)	24.8.2017
Fam. Erebidae:	
79. Phragmatobia fuliginosa (Linnaeus, 1758)	19.8.2017
80. Rhyparia purpurata (Linnaeus, 1758)	4.6.2017
81. Polypogon tentacularia (Linnaeus, 1758)	16.7., 20.7.2017
82. Laspeyria flexula ([Denis & Schiffermüller], 1775)	1.9.2017
83. Euclidia glyphica (Linnaeus, 1758)	18.5.2017
Fam. Noctuidae:	
84. Macdunnoughia confusa (Stephens, 1850)	24.8.2017
85. Autographa gamma (Linnaeus, 1758)	26.6., 27.7.2017
86. Deltote bankiana (Fabricius, 1775)	1.5., 13.7.2017
87. Acontia trabealis (Scopoli, 1763)	27.4., 1.5., 1.7., 18.7.2017.
88. Acontia lucida (Hufnagel, 1766)	6.7.2017
89. Aedia funesta (Esper, 1786)	30.6., 10.7.2017
90. Tyta luctuosa ([Denis & Schiffermüller], 1775)	16.7.2017
91. Heliothis viriplaca (Hufnagel, 1766)	28.7.2017
92. Nyctobrya muralis (Forster, 1771)	17.8.2017
93. Pseudeustrotia candidula ([Denis & Schiffermüller], 1775)	16.7.2017
94. Hoplodrina ambigua ([Denis & Schiffermüller], 1775)	19.8.2017
95. Trachea atriplicis (Linnaeus, 1758)	10.7.2017
96. Melanchra persicariae (Linnaeus, 1761)	23.7.2017
97. Conisania luteago ([Denis & Schiffermüller], 1775)	6.7.2017
98. Agrotis exclamationis (Linnaeus, 1758)	15.7., 16.7., 21.7.2017
99. Axylia putris (Linnaeus, 1761)	18.7.2017
100. Xestia c-nigrum (Linnaeus, 1758)	23.7.2017