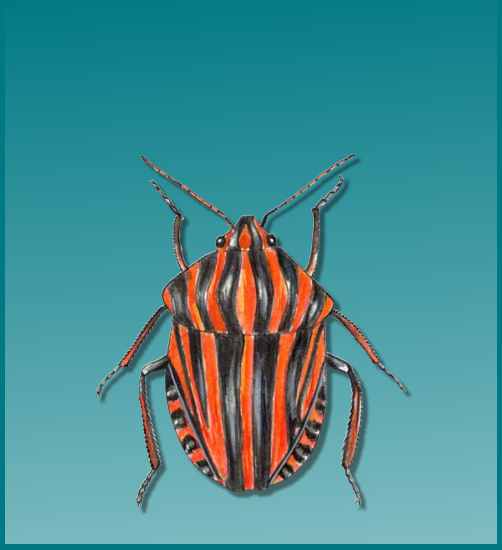

SELECTED ABSTRACTS & PAPERS
OF THE FIRST BALTIC INTERNATIONAL CONFERENCE

ON

FIELD ENTOMOLOGY AND FAUNISTICS

3–9 June 2014, Vilnius, Lithuania

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The Conference emphasizes the importance of faunistic research and provides selected or extended abstracts, short communications or full papers from 26 presentations by professors, scientific researchers, graduate, master or doctoral students from nine countries: Italy, Czech Republic, Poland, Lithuania, Latvia, Russia, Canada, USA, Ecuador.

Key words: aphidology, biodiversity, Bucculatricidae, Carabidae, Coleoptera, Cossidae, Crysomellidae, Curculionoidea, guava, *Hylobius*, Gracillariidae, fauna, faunistics, field methods, entomology, Kurtuvėnai Regional Park, leaf-mines, leaf-mining insects, Lepidoptera, Lepidoptera phylogeny, Lithuanian Entomological Society, micro-mounts, Nepticulidae, Tischeriidae, Tortricidae.

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Urgent need for increased faunistic research

Recent decades have been characterized by faunistics and systematics regaining their significance and now these disciplines are becoming an important area of biological research. One of the most fundamental challenges for mankind of the 21st century is to document the extent and distribution of global biodiversity as well as understand the ecological processes that generate and maintain it. Such information will be essential for informing and guiding efforts to safeguard the natural ecosystems that provide the Earth's life support systems. Without the baseline data of faunistic and taxonomic diversity providing means for the identification of the species in a region, no one can move forward in properly planning their conservation or their control in case of invasive species.

Fast development of modern research techniques, which flourished at the end of 20th century, slightly diminished interest in faunistic research. On the other hand, the negative impact on ecosystems, including threats from human activity that causes habitat destruction and modification in the face of the global biodiversity crisis and climate change, led to an urgent need for significant intensification of biodiversity studies.

The Conference emphasizes the importance of faunistic research that includes studies into the nature of insect fauna: from sampling, species identification and regional biodiversity inventory, evaluation of species abundance, documentation of described species (morphology incl. variability, bionomics incl. life cycles and habitats) and description of new taxa to taxonomic, phylogenetic, trophic, chorolological and other analyses of regional and global faunas.

The research postulated in the Conference involves a large-scale investigation of various groups of insects, which, in spite of their tremendous economic importance, constitute one of the world's least known faunas and for which there has been a disturbing decline of qualified specialists.

Professor Jonas Rimantas Stonis,
Conference Chairman

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The Conference brought together international academics
from the Baltic countries and Poland (speakers from other countries were also welcomed),
including professors and graduate, master or postgraduate (doctoral/PhD) students,
which presented methodological novelties and faunistic research in their respective fields.

The first aim of the Conference was to provide opportunities for academics
from various countries representing a range of disciplines in entomology to share their research
by means of the conference podium.

The Conference's second aim was to provide opportunities for academics to receive informal
in-depth feedback through discussions and enable them to establish contact with professionals
from other countries and institutions.

Number of given presentations:

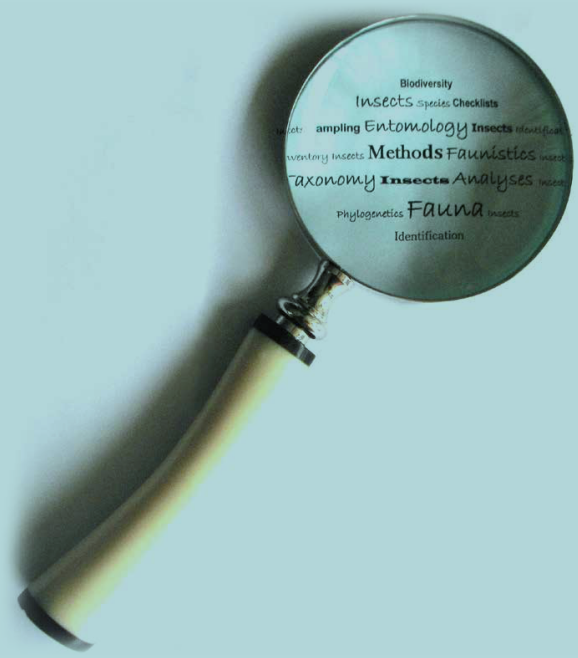
Italy – 2, Czech Republic – 1, Poland – 6, Lithuania – 15, Latvia – 6, Russia – 1, Canada – 2, USA – 4; Ecuador – 1.

Number of participants who provided presentations:

Italy – 2, Czech Republic – 2, Poland – 8, Lithuania – 18, Latvia – 8, Russia – 1, Canada – 4, USA – 3; Ecuador – 1.

SELECTED

ABSTRACTS and PAPERS



(PEER-REVIEWED)

CONTENTS

WHAT IS NEW AND MOST INTERESTING ABOUT THE NEPTICULIDAE OF THE CRIMEA AND LITHUANIA

Asta Navickaitė, Arūnas Diškus & Jonas Rimantas Stonis

Lithuanian University of Educational Sciences, Vilnius, Lithuania

INTRODUCTION

Due to the active destruction of landscapes as well as frequent fragmentation of habitats, global biodiversity is undergoing rapid decline. The increasing concern of the world's scientific community about the biodiversity crisis stimulated researchers to more actively inventorize the Earth's main biomes (Stonis, 2010; Navickaitė *et al*., 2011b).

The object of our research is one of the most primitive (and from this point of view, one of the most interesting) taxonomic groups of the Lepidoptera order (Nepticuloidea: Nepticulidae) comprising 850 species and 16 genera: *Pectinivalva*, *Roscidotoga*, *Simplimorpha*, *Enteucha*, *Mononeura*, *Areticulata*, *Stigmella*, *Bohemannia*, *Ectoedemia*, *Fomoria*, *Acalyptris*, *Parafomoria*, *Trifurcula*, *Glaucolepis*, *Etainia* and *Varius* (the classification of Nepticulidae follows Puplesis, 1994; Puplesis & Robinson, 2000, and Puplesis & Diškus, 2003). The majority of these genera are widely distributed throughout many continents; they include the world's smallest Microlepidoptera, which are characterized not only by their archaic morphology but also, as plant-miners, are greatly specialized. One of the most prominent characteristics of Nepticulidae, their mining within the green tissue of plants, presents an issue which is interesting and important for ecology (Stonis, 2010; Diškus & Stonis, 2012).

Because of stenophagy, sedentary lifestyle and a high rate of endemism, these small insects occur in almost all biomes (from tundra or deserts to tropical rainforests) and various terrestrial ecosystems and could serve as a perfect tool for characterizing the richness, origin and faunal relationships of biomes under investigation (Puplesis, 1994; Navickaitė *et al*., 2011a; Diškus & Stonis, 2012). However, research data concerning these insects, which is both of practical and theoretical importance, is insufficient. Prior to the investigation carried out by the first author and her colleagues, information on the fauna of Nepticulidae of the Crimea and Lithuania had been far from exhaustive. Climate change, intensive migration of the population and commercial projects pursuing economic benefits (in particular involving exotic territories) provide conditions for an incidental introduction of pest fauna (Diškus & Stonis, 2012). Because of

the life-style within assimilation tissues of leaves, buds, stems, young bark or fruits of plants, a number of Nepticulidae that we investigated could be considered as pests or potential pests; for that reason they are important from the economic point of view (Puplesis, 1994; Kuznetzov & Puplesis, 1994). It is considered that oligophagous endobiontic insects are capable adapt in new territories and establish trophic relationships with alien host-plants (Diškus & Stonis, 2012).

The investigation of life-cycles, trophic relationships or other biological characteristics of potential pests, as well as continuous cooperation with professionals of nature protection, could enable the preparation of effective measures preventing alien pests from infiltrating our fauna and also enable the implementation of a quarantine policy. The deficiency of investigation data, economical (practical) and theoretical (scientific) significance of the family Nepticulidae and increasing concern by the scientific community about the biodiversity crisis stimulated the studies of Nepticulidae of the Euro-Nemoral zone; the importance of such studies was also emphasized by the Convention on Biological Diversity of Rio de Janeiro.

MATERIALS

The first author A. Navickaitė, assisted by A. Diškus and other researchers (see Acknowledgements) conducted fieldwork over six years (2008–2013) and collected scientific material of Nepticulidae from different Lithuanian regions (Fig. 1). The integration of individual data (incl. Diškus *et al*., 2012) and data published by other researchers (e.g. Ivinskis, 2004; Ivinskis *et al*., 2012, etc.) offered the possibility for full-scale analysis of the Lithuanian Nepticulidae fauna. The collected and analysed material is stored in the collection of Biosystematics Research Group of the Lithuanian University of Educational Sciences (LEU).

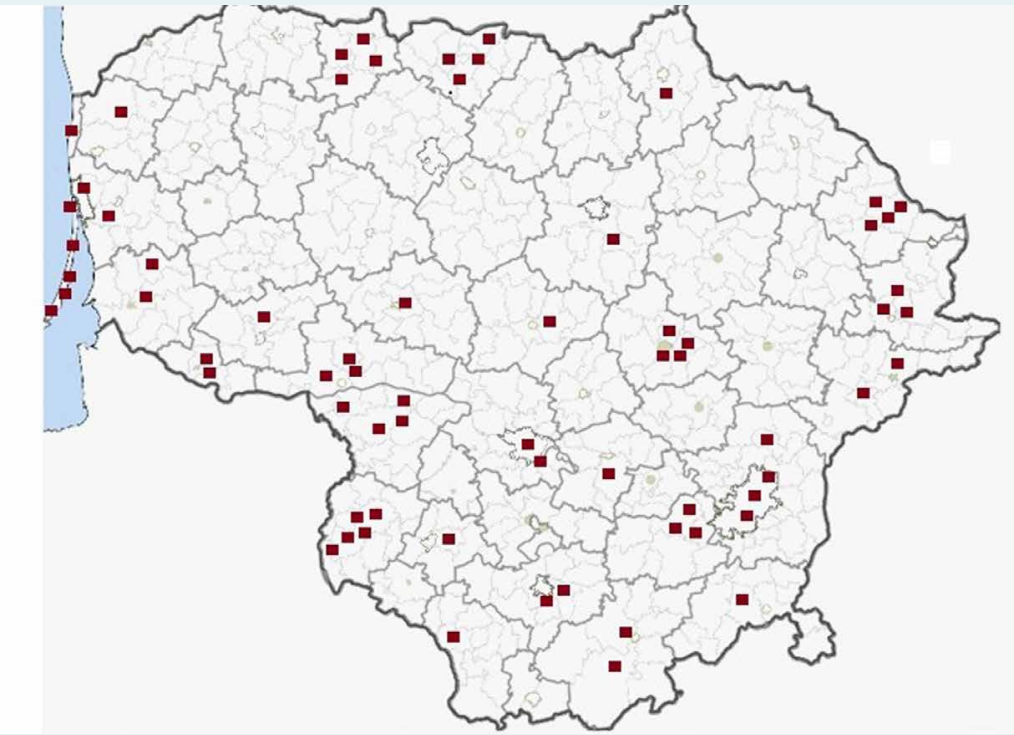


Figure 1. Localities of Nepticulidae investigations in Lithuania from which the data obtained served as a basis for the present study (after A. Navickaitė in Stonis *et al*., 2012a).

In 2011–2012, the first author A. Navickaitė, assisted by A. Diškus, J. R. Stonis, G. Varačinskas (LEU) and S. R. Hill from the UK carried out intensive long-term fieldwork in the Crimea: Karadag Nature Reserve (Fig. 2) and Yalta Forest Reserve, Angara Mountain Pass, Feodosia, Koktebel, Alushta and other localities. During the fieldwork, the authors and their assistants collected a large original scientific material. Also the authors, together with A. Remeikis and A. Rocienė (LEU), dissected and studied a sizeable amount of unidentified material collected in 1977–1989 in the Crimea by other researchers: S. Yu. Sinev (ZIN), Yu. I. Budashkin (KNURAS), I. Reznik (ZIN), and R. Puplesis (ZIN) (Stonis *et al*., 2013). Other, comparative material was collected during field trips to Naples (Campania, Italy, 2012) and Bergamo (Lombardy, Italy, 2013) (Fig. 2).

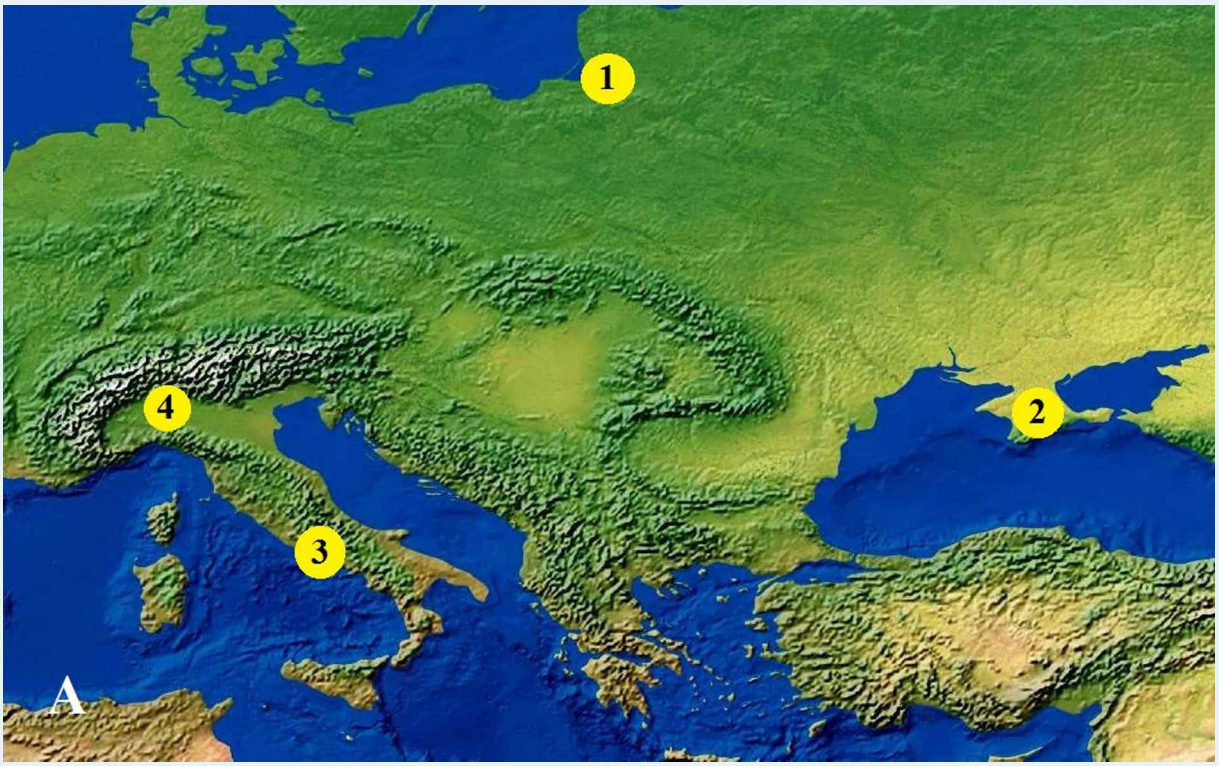


Figure 2. Localities where in 2008–2013 the first author A. Navickaitė, assisted by A. Diškus, J. R. Stonis, A. Remeikis and G. Varačinskas (LEU), collected the main material (1 – Lithuania; 2 – the Crimea) and comparative material (3, 4 – Italy).

REARING OF ADULTS FROM MINING LARVAE

Most of the treated species were reared from mining larvae using a standard method (Puplesis, 1994; Diškus & Stonis, 2012). Registration of the traces of larval activity (the mines or leaf-miners) was conducted by thorough inspection of damaged parts of host-plants or potential host-plants. Most of the Lithuanian Nepticulidae usually mine leaves, occassionally apple-tree/maple buds or maple samaras (e.g. *Etainia sericopeza*), or stems or young bark (e.g. *Ectoedemia atrifrontella*) (Puplesis, 1994; Puplesis, Diškus, 2003). For an evaluation of occurence of the species distributed in the Crimea and Lithuania, the 'Formula of Evaluation of Abundance of Leaf-miners' was followed (see Diškus & Stonis, 2012: 52–54). Species were evaluated in two ways: how widely they are distributed within the forested part of the Crimea; and how numerous (abundant) specimen samples were, including those attracted to light traps, in relation to the quantity of observed leaf-mines.

The following terminology for species mining abundance was used (Stonis *et al*., 2012b, Stonis *et al*., unpublished): 'Sporadic' was applied to species known from fewer than 4 leaf-mines in a locality of investigation; 'Not abundant' = known from 4–10 recorded leaf-mines; 'Abundant' = recorded from more than 10 but fewer than 40 leaf-mines; 'Very abundant' = species recorded from 40–100 leaf-mines; 'Extremely abundant' = recorded from more than 100 leaf-mines. Species with more numerous leaf-mines ('Epizootic') were not observed in the Crimea during the fieldwork of 2011 and 2012.

Following Stonis *et al.* (2012b) and Stonis *et al.* (unpublished), the terms 'Very widespread' or 'Widespread' were applied to species documented from numerous and disjunctive areas of the study region, including data from our observations on species traces (i.e. old/empty leaf-mines) in various localities during the fieldwork of 2011 and 2012, as well as unpublished records by R. Puplesis from the Crimea (1987–1988) and A. Diškus from Lithuania (1996–2003). 'Limited in distribution' or 'Highly limited in distribution' was applied to species collected (or leaf-mines observed) in very few localities; 'Solitary finding' designates species recorded from a single locality. Following Stonis *et al.* (2012b) and Stonis *et al.* (unpublished), the combination of these two evaluations (as given in the Table II.2 by Diškus & Stonis, 2012) determined which species should be regarded as 'very common', 'common', 'not rare', 'rare', or 'very rare'.

COLLECTION OF MATERIAL USING LIGHT TRAPS

This method is most relevant in countries like the Crimea with a hot climate when night temperatures are around +25°C – +28°C (Puplesis & Diškus, 2003). A sheet of white stiff cloth as a screen and ultraviolet spectrum bulbs (125 W and 250 W) were used for attracting insects. It was recommended that on windy nights with suitable temperature, the bulb should be hung lower in dense but low scrubs and the upper edge of the screen should be turned down by 90° to form a hood (Stonis & Remeikis, 2010) (Fig. 3C).

Nepticulidae specimens were collected using small glass test tubes (5 mm in diameter and 30–40 mm in depth) which were then plugged with a tight cotton wad, and, following Puplesis (1994) and Stonis *et al.* (unpublished), kept alive in a dark container with a few plant leaves added to preserve some moisture. It is best that the collected material is pinned and set (i.e., wings spread) outright or kept alive in a refrigerator at +10°C and prepared in the first half of the next day. Dead material (especially stored at higher temperatures and dry air conditions) looses elasticity in 2–4 hours and crumbles at pinning. For killing collected specimens, acetil acetate, chloroform or organophosphorus insecticides no longer were used, but each test tube with live specimen was placed individually in hot (just boiled) water for a one-two seconds. Some specimens were placed alive in individual sterile plastic test tubes with 70% alcohol and kept in a freezer for later molecular studies.

Figure 3. Long-term fieldwork in the Crimea: A, D – the Karadag Nature Reserve; B – leaf-mine collecting during the fieldwork in 2011; C – the screen turned down by 90° so as to form a hood (recommended and described by Stonis & Remeikis, 2010) during the fieldwork in 2009.

PREPARATION OF COLLECTED SPECIMENS

The reared under laboratory conditions or freshly collected specimens are pinned under a stereoscopic binocular microscope on a special elastic cushion using the finest 5–10 mm stainless minutien pins. The insect wings are fixed using narrow (1–1.2 mm wide and 8–10 mm long) transparent paper strips pinned with D1 and D2 minutien pins. The mounted material is left to dry for about 14 days. During fieldwork, a simpler technique for spreading wings was used: the wings of the fresh specimen were spread by air flow (blowing from the caudal end) and left to dry (there was no need to worry about the fixation or regularity

of wing setting). The correct wing setting of collected material is not always successful. It also depends on the correct pinning. For taxonomic analysis, this preparation stage can be dismissed (Puplesis & Diškus, 2003; Diškus & Stonis, 2012), however, when the wings of the examined specimen are spread it is easier to observe and describe the colour of the abdomen and arrangement of androconial scales on the hindwings and forewings; it is also easier to snap off the abdomen for genitalia preparation.

Under laboratory conditions, the specimens are mounted on small (1.5 mm wide and 7–10 mm long) white plastic strips and labelled. The labels contain information about the species, finding locality, habitat, date of finding, name of collector, information about the host-plant, fieldwork card number and, if applicable, and altitude above sea level; the labels of night-trapped adults may also contain the information about the light trap used. The collected material is stored in hermetically sealed boxes to prevent damage from pests, moisture and bright light. In regions of hot and humid climate the boxes also may be supplied with fungicide powder to prevent the from formation of mould.

In our study, the adults were measured using ocular micrometre and stereoscopic binocular microscope *MBS-10*. The length of the wingspan was measured from the end of the left wing cilia to the end of the right wing cilia. If the measured specimen is not straightened out the length of one of the forewings is indicated. The indicated length is multiplied by two and the thorax width is added. For depiction of the external coloured morphological patterns of adults Faber-Castell watercolour pencils can be used or specimens can be photographed using *Leica S6D* microscope and attached *DFC290* camera.

PREPARATION AND EXAMINATION OF MICRO-MOUNTS OF GENITALIA STRUCTURES

Techniques for genitalia preparation and protocols for description are outlined in Diškus & Stonis (2012) and Stonis *et al*., 2014. In our study, the genital micro-mounts were studied and photographed using a *Leica DM2500* microscope and *Leica DFC420* digital camera, respectively.

CHOROLOGICAL METHOD

The distribution ranges of all analysed species were thoroughly mapped. Taxa distinguished from the same or comparable distribution range were joined into groups which, in their turn, were named indicating the type of the range: Holarctic, Trans-Palaearctic, Euro-Siberian, West-Palaeartic, Euro-Mediterranean, Euro-Submediterranean, Sub-Mediterranean, Sub-Mediterranean-Mediterranean, Euro-Nemoral, and predominantly Sub-Baltic. The chorological analysis not only included congeneric species but also unrelated taxa. This type of species evaluation requires all available information about the species, including trophic relationships and other trophic specialization, distribution of host-plant and habitats. For the designation of European ecoregions we used the 'Map of the division of Europe in ecoregions' (by J. R. Stonis in Navickaitė *et al*., 2014: fig. 6), which is mostly based on recent research data on the Sub-Mediterranean by other authors (e.g., de Dios *et al*. 2009, Rueda *et al*. 2010) as well as our personal data (Fig. 4).

Figure 4. Division of Europe in ecoregions (provinces), where the Sub-Mediterranean ecoregion (province) can be treated as a transitional region between the whole nemoral, forested Europe (Euro-Boreal + Euro-Atlantic + Central European + Euro-Continental + Sub-Mediterranean) and the non-nemoral, Mediterranean ecoregion (after J. R. Stonis in Navickaitė *et al.*, 2014).

THE CRIMEAN NEPTICULIDAE FAUNA

The Crimean Nepticulidae within the contect of the European fauna. In total, 264 species of Nepticulidae belonging to 11 genera are known in the European fauna (Fig. 5).

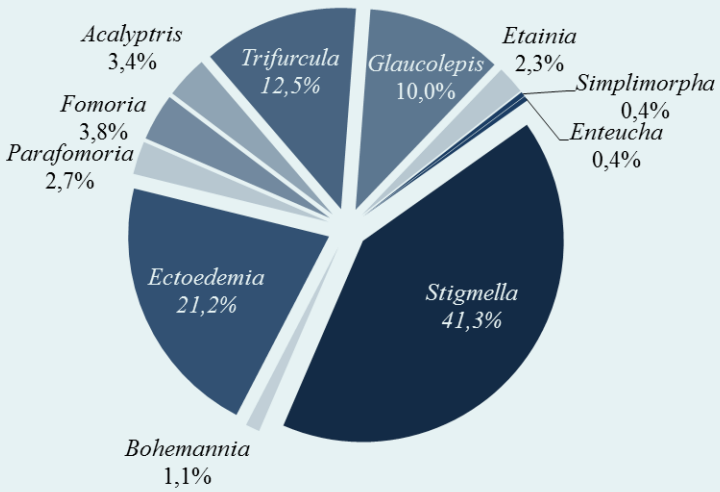


Figure 5. The revised taxonomic composition of the European Nepticulidae fauna.

Analysis of the European Nepticulidae fauna showed that trophic relationships had been established for 89% of the species (host-plants of 11% of European species remain unknown).

An analysis of host-plants revealed that the European Nepticulidae are trophically associated with 97 plant genera. The majority of Nepticulidae species mines on *Quercus* (42), *Betula* (11) and *Salix* (10). Yet 47% of plant genera are engaged by single mining Nepticulide species. Woody plants are dominant (66%) among the host-plants of the European pygmy moths whereas 34% of the known pygmy moths are trophically associated with herbaceous plants.

The majority of the pygmy moths of Europe mine plants of Rosaceae, Fagaceae, Fabaceae, Salicaeae and Betulaceae families. Rosacae is the dominant plant family with which 58 Nepticulidae species have trophic relationships; 17% of Nepticulidae species are trophically associated with Fagaceae family. However, 14 known host-plant families are mined only by one species of these leaf-miners. In total, we counted 31 host-plant families for the European Nepticulidae.

As shown in figure 4, the European Nemoral (forested) region includes the Euro-Boreal, Euro-Atlantic, Central European, Euro-Continental, and Sub-Mediterranean ecoregions. The European Nepticulidae fauna analysed in the current study was interpreted as 'Euro-Nemoral Nepticulidae fauna' (in spite that some Nepticulidae species mine woody plants and some other – the smaller part – mine grasses).

The Sub-Mediterranean ecoregion, on the basis of our studies conducted in the Crimea and Italy, is for the first represented as a transitory zone between the whole nemoral Europe and the Mediterranean ecoregion. As a rule, species (17) of the Sub-Mediterranean chorological group inhabit very limited areas. *Stigmella rhamnella*, *S. szoecsiella* and *Ectoedemia contorta,* which have trophic relationships either with *Rhamnus* (1 species) or with *Quercus* (2 species) host-plants, make an exception.

The fauna of the Euro-Atlantic province (ecoregion) comprises 123, Central European 141 and Euro-Mediterranean 164 Nepticulidae species. Meanwhile, 151 species of pygmy moths have been identified in the Sub-Mediterranean ecoregion.

The greatest number of the European Nepticulidae species is recorded in the Mediterranean province – 191 species. Yet the identified Nepticulidae fauna is unevenly distributed: some species occur in the area between the Iberian Peninsula and Greece or South-West Turkey (and Cyprus) whereas some of them are bound only to a certain part of the Mediterranean province. The number of Nepticulidae species identified in the western part of the Mediterranean province amounts to 109, in the central part 94 and in the eastern part 99.

From the taxonomical point of view, the unexpectedly high number of species identified in the Mediterranean ecoregion allows assuming that the distribution of some Nepticulidae genera is strongly restricted within the Mediterranean ecoregion as the number of species identified in this province accounts for 93% of the European fauna of *Glaucolepis* genus. A very strong bond to the Mediterranean province also is characteristic of *Acalyptris*, *Ectoedemia* and *Parafomoria* genera (respectively 89%, 86% and 85% of the total of the species of these genera identified in Europe). The largest Nepticulidae genus (*Stigmella*) represented in Europe by 109 species also is widely distributed in this province (73% of the European *Stigmella* fauna).

Based on chorological method for the first time applied for analysis of the European Nepticulidae fauna it was established that Nepticulidae species in this part of the world belong at least to 10 chorological groups: Euro-Nemoral *sensu lato* (incl. predominantly Sub-Baltic, see Navickaitė & Stonis, 2012), Euro-Submediterranean, Euro-Mediterranean, Sub-Mediterranean, Sub-Mediterranean–Mediterranean, West-Palaearctic, Euro-Siberian, Trans-Palaearctic, and Holarctic.

The largest groups in the European fauna are: Mediterranean (29%), Euro-Submediterranean (20%), and Euro-Mediterranean (12%); also many species belong to the Euro-Nemoral group (9%) (Fig. 6).

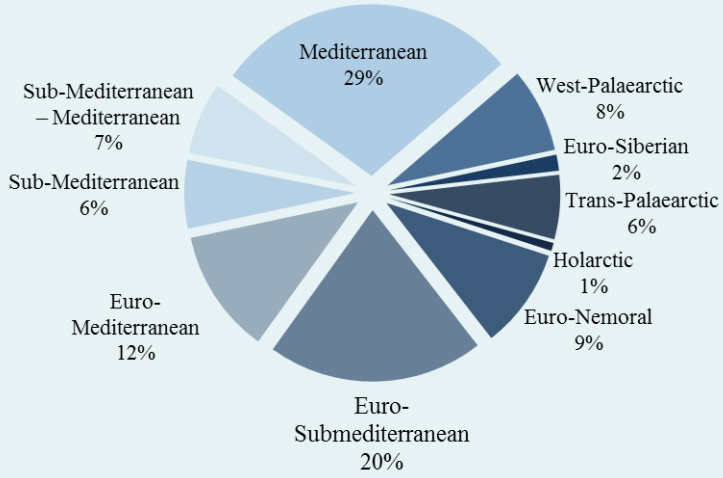


Figure 6. Chorological groups of the European Nepticulidae by size (relative percentage).

Among the 54 Nepticulidae species attributed to the Euro-Submediterranean chorological group, *Ectoedemia quinquella* and *Glaucolepis lituanica* are the most interesting ones. The latter has been recently published as a new species found in a few extremely remote and isolated European localities (including Lithuania) (Ivinskis *et al*., 2012). Presumably, this species should be considered as a relict rather than a species spreading from north to south due to the changing climate. Meanwhile, *E. quinquella* can serve as a typical example of a spreading species: the species is widely known in the Sub-Mediterranean ecoregion and, according to the data of our colleagues (van Nieukerken *et al*., 2010), has gradually spread in the Atlantic part of France, Benelux countries and, later, in the southern part of GB. The expansion of the distribution range of this species is possibly related to the climate change.

Taxonomy of Nepticulidae of the Crimea. The first material of Nepticulidae was collected in the Crimea in 1977; however, for a long time only a small number of attempts were reported to identify and publicize the fauna of this Lepidoptera family from the Crimea. In 2009–2010, under the 'Crimean Project', the authors identified 31 species of Nepticulidae, among which *Stigmella ulmiphaga*, *Ectoedemia rufifrontella* and Acalyptris platani were recorded for the first time from the Crimea; it was reported in our publication (Stonis & Remeikis, 2011; Stonis *et al*., 2013). Out of more than 600 examined specimens, only 3 were attributed to the *Trifurcula* genus: one to *T. subnitidella*, and two to *Trifurcula macedonica*, a new species within the fauna of the Crimea. *Stigmella szoecsiella*, *Ectoedemia albifasciella* and *E. pubescivora* were excluded

from the list of the Crimean species because of misidentification of these species or insufficient scope of previous research (Stonis *et al*., 2013).

The authors of the current paper, after having concluded fieldwork in Karadag, Yalta, Feodosia, Sudak, Alushta, Simferopol and other locations in 2011, succeeded in identifying 26 species of Nepticulidae which were new to the fauna of the Crimea (Navickaitė *et al*., 2014). The revised and updated taxonomic checklist of the Nepticulidae species of the Crimea includes comprehensive data about 20 species from the *Stigmella* genus, 1 species respectively from *Bohemannia*, *Ectoedemia* and *Fomoria* genera and 3 species from the *Trifurcula* genus, all of which are recorded for the first time for the fauna of the Crimea (i.e. 40% of the whole of the Crimean fauna) (Navickaitė *et al*., 2014). One species, *Ectoedemia spinosella*, was excluded from the list because of previous misidentifications having resulted from referring exclusively to leaf-mines (see van Nieukerken *et al*., 2004); our presumption is that *E. mahalebella* has been misidentified and mistaken as *E. spinosella* (Navickaitė *et al*., 2014).

At present the fauna of the Crimea includes 64 Nepticulidae species belonging to the *Simplimorpha* (1), *Stigmella* (41), *Bohemannia* (1), *Ectoedemia* (10), *Fomoria* (1), *Acalyptris* (1), *Trifurcula* (5), *Glaucolepis* (2) and *Etainia* (2) genera (Navickaitė *et al*., 2014). The *Bohemannia* and *Fomoria* genera were registered within the Crimean Nepticulidae fauna for the first time. *Trifurcula subnitidella* and *T. josefklimeschi* had been the only *Trifurcula* species in the Crimea. Additionally, we succeeded to document the distribution of the *T. silviae* and *T. eurema* in the Crimea. *T. macedonica* was identified during the study of the material collected in 1987. According to these data, 15% of Europe's species of the *Trifurcula* genus occur in the Crimean peninsula.

When analysing trophic relationships among Nepticulidae registered in the Karadag Nature Reserve and its surroundings, we identified that the majority of the newly identified species were related to the Rosaceae (35%) and Betulaceae (20%) host-plants.

We present *Trifurcula macedonica* and *Ectoedemia mahalebella* in the Crimean fauna without describing new subspecies, though the investigated material is of very distinctive nature.

Chorological analysis of Nepticulidae of the Crimea. The mapping and analysis of Nepticulidae distribution ranges taking into account the Crimean and general distribution showed that from the chorological point of view, Nepticulidae of the Crimea could be divided into 8 chorological groups. These groups could be aggregated into two larger distribution groups: the European (Euro-Submediterranean + Euro-Mediterranean + Sub-Mediterranean-Mediterranean + + Euro-Nemoral) and Palaearctic (West-Palaearctic + Euro-Siberian + Trans-Palaearctic) (Fig. 7).

There is a tendency that 72% of species from the Crimea belong to chorological groups that are more or less related to the Mediterranean ecoregion. It leads to a conclusion that these species could have originated in the South and later gradually spread all over the European continent.

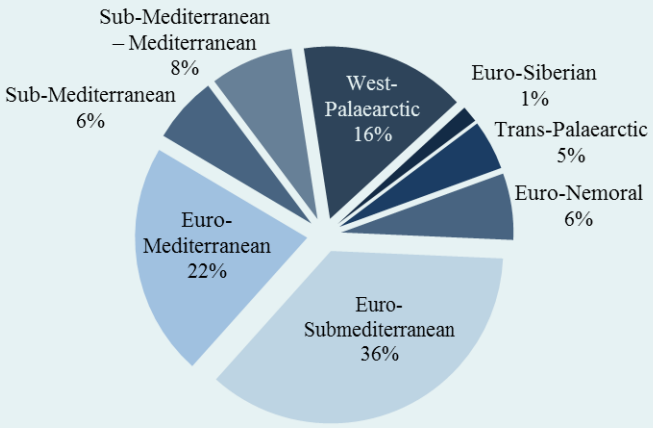


Figure 7. Chorological composition of the Crimean Nepticulidae fauna defined during the chorological analysis.

After having evaluated occurrence (data on geographical distribution and quantity/abundance, see Methods), we identified the common and rare species of the region. Rather a large number of species identified in the Crimea are characterized by wide distribution and moderately abundant mining (19%) or wide distribution and extremely abundant mining (17%). Among the Crimean fauna that has been analyzed, there are a number of species characterized by limited distribution and moderately abundant mining (12%), limited distribution and not abundant mining (12%) and local distribution and not abundant mining (12%). Common species can also be divided into common and very common; the latter are characterized by wide or very wide distribution and very abundant or abundant mining. Common species may be characterized by limited distribution if their mining has been identified as very abundant.

The common species identified within the Crimean fauna predominantly are of the Euro-Submediterranean chorological group (47%), whereas, contrary to our expectations, less numerous among the common species are those characterized by Sub-Mediterranean/Mediterranean ranges (18% of the common species of the Crimea).

The common Nepticulidae species of the Crimea are trophically associated with 13 plant genera, among which *Quercus*, *Sorbus*, *Crataegus* and *Prunus* are the most prolific (if estimated by the number of mining Nepticulidae species) (Fig. 8).

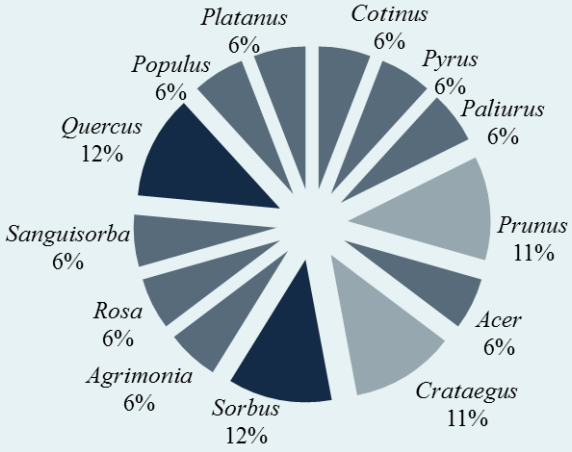


Figure 8. Identified trophic relationships of the common (common + very common) Nepticulidae species.

Rare species of the region are characterized by limited geographical distribution and not abundant or sporadic mining. However, in line with the applied methods, some of the widely distributed species were attributed to the rare category if their mining was sporadic; and, on the contrary, rare species may be characterized by abundant or very abundant mining if their geographical distribution has been identified as highly limited or based on solitary findings (according to Stonis *et al*., unpublished). Among the investigated Crimean fauna, there are species which are characterized by limited distribution and not abundant mining (5% of the entire fauna), solitary finding and not abundant mining (2%) and highly limited distribution and sporadic mining (2%). Rare species may also be divided into rare and very rare; the latter, according to Stonis *et al.* (unpublished), are characterized by only highly limited distribution or solitary finding and not abundant or sporadic mining.

The rare species of the Crimean fauna mainly belong to the Euro-Mediterranean chorological group; a number of rare species belong to the Euro-Submediterranean and Euro-Nemoral groups and the Sub-Mediterranean chorological group. As it could have been predicted, species which are characterized by wide ranges and Sub-Mediterranean/Mediterranean distribution are the fewest within the category of rare species.

Among the host-plants which are mined by rare species, the most prominent is the *Quercus* genus: about 1/5 of the total number of host-plants. The remaining rare species are associated with 14 other genera of host-plants (Fig. 9). To date, there are no known data about the *Trifurcula macedonica* host-plant.

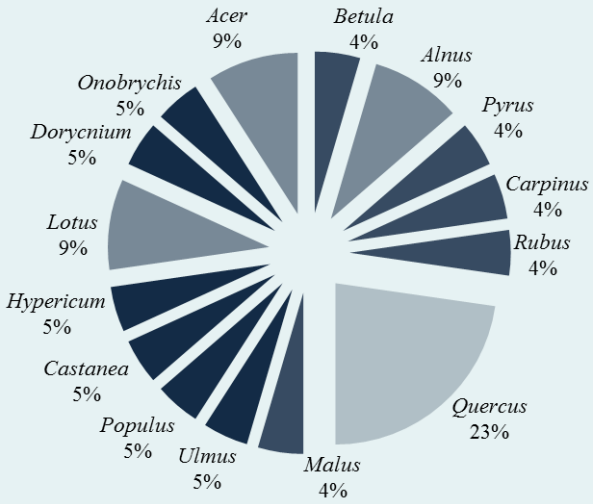


Figure 9. The identified trophical relationships among the rare (rare + very rare) Nepticulidae species of the Crimea.

Trophic analysis and features of the life cycle of the Crimean Nepticulidae. The majority of the Crimean Nepticulidae are related to the Rosaceae (18 species of Nepticulidae) and Fagaceae (12 species) plant families. It should be noted that as far as 54 species are adapted to mine woody plants and the remaining 10 species, herbaceous plants.

The analysis of the Crimean Nepticulidae showed that 7 species (11% of the identified fauna) mine cultivated plants: *Prunus spinosa*, *P. cerasifera*, *Malus domestica* and *Pyrus elaeagnifolia*.

During the investigation, we succeeded to record for the first time the host-plant of *Stigmella irregularis*, *Pyrus elaeagnifolia*, which widely occurs not only throughout the Karadag Reserve but also the whole of the mountainous Crimea.

During the present research, it has been observed that larval stage (and the whole life cycle) depends not only on the mined plant but also on the mining season, ambient temperature (sunshine or shade) and biological properties of Nepticulidae genus.

During our fieldwork, the mining seasonality of the Crimean species was analysed for the first time (Table 1).

The precise mining time was established for 39 (61%) known Crimean Nepticulidae species (most of adults of these species were reared). Meanwhile, such species as *Stigmella samiatella*, *S. atricapitella*, *Trifurcula silviae*, *Glaucolepis melanoptera*, *Ectoedemia atrifrontella* and *E. longicaudella* were recorded solely applying the light trap method. Thus, the seasonal cycles were established taking into consideration the flying time of adults and published literary data.

It can be maintained that almost 50% of Nepticulidae species found in Crimea have two generations in a year and about 30% have one generation. It has been reported that under favourable conditions some species may have even three generations in a year (e.g. *Simplimorpha promissa*, *Stigmella aceris*, and *Trifurcula eurema*). Comparison of the life cycles of Crimean species with the life cycles of the same species in other European countries show some mismatches which might be predetermined by the geographical position of the Crimean Peninsula and the favourable conditions of the coastal zone entailed by the Crimean mountains, which serve as a barrier for cold air masses.

Table 1. New revised data about mining time of Crimean Nepticulidae species. ◆ – reliably established (mines with mining larvae were collected); ● – established during fieldwork according to the empty mines); ○ – conjectural mining time of larvae (based on observations of old leaf-mines); I–III – month decades.

No.	Species	June			July			August			September			October		
		I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
1.	*Simplimorpha promissa*			●	●	●	◆	◆	◆	◆						
2.	*Stigmella confusella*					●	●									
3.	*Stigmella irregularis*					◆	◆	◆								
4.	*Stigmella freyella*				●	◆	◆									
5.	*Stigmella tiliae*				●	◆	◆									
6.	*Stigmella paliurella*		●	●				◆								
7.	*Stigmella microtheriella*				●	◆	◆									
8.	*Stigmella glutinosae*					●	○	◆								
9.	*Stigmella alnetella*		○	○		●	●	◆	◆							
10.	*Stigmella prunetorum*	●	●	●	●		◆									
11.	*Stigmella aceris*	●	●	○	●	◆	◆	◆								
12.	*Stigmella paradoxa*					◆	◆	◆	◆	◆						
13.	*Stigmella minusculella*				○	○	○	○	○			○	○	○		
14.	*Stigmella desperatella*				●	◆	◆	◆								

No.	Species	June			July			August			September			October		
		I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
15.	*Stigmella torminalis*						◆	◆								
16.	*Stigmella crataegella*			○	○	◆	◆									
17.	*Stigmella hahniella*			○	○		◆	◆								
18.	*Stigmella hybnerella*			○	○		○	○								
19.	*Stigmella catharticella*				●	◆	◆	◆								
20.	*Stigmella malella*				●	◆	◆	◆								
21.	*Stigmella rhamnella*				●	◆	◆	◆								
22.	*Stigmella viscerella*				●	●	◆									
23.	*Stigmella ulmivora*					○	●	◆								
24.	*Stigmella ulmiphaga*					○	●	◆								
25.	*Stigmella thuringiaca*				●	◆	◆									
26.	*Stigmella rolandi*			●	●	◆	◆	◆	◆							
27.	*Stigmella trimaculella*					●	◆									
28.	*Stigmella salicis*				○	●	◆									
29.	*Stigmella obliquella*					○	●	◆	◆							
30.	*Stigmella floslactella*				○	○					○	○				
31.	*Stigmella tityrella*			○	●	●	◆									
32.	*Stigmella carpinella*			○	●	◆	◆	◆			○	○	○			
33.	*Stigmella lemniscella*				●	●	◆									
34.	*Stigmella incognitella*				●	◆										
35.	*Stigmella perpygmaeella*			○	○						○	○				
36.	*Stigmella splendidissimella*					◆	◆									
37.	*Stigmella plagicolella*			○	●	◆	◆	◆	◆							
38.	*Stigmella atricapitella*					○	○					○	○	○		
39.	*Stigmella basiguttella*						●					○	○	○		
40.	*Stigmella dorsiguttella*			●	●			◆				○	○	○		
41.	*Stigmella samiatella*					○	○	○				○	○	○		
42.	*Stigmella roborella*					○	●	◆				○	○	○		
43.	*Bohemannia pulverosella*	○	○	●	●											
44.	*Ectoedemia atrifrontella*			○	○	○	○	○	○	○	○	○	○	○	○	○
45.	*Ectoedemia longicaudella*			○	○	○	○	○	○	○	○	○	○	○	○	○
46.	*Ectoedemia amani*								○	○	○	○	○	○	○	○
47.	*Ectoedemia similigena*									○	○	○	○	○	○	○
48.	*Ectoedemia turbidella*						○	○	○	○	○	○	○	○	○	○
49.	*Ectoedemia subbimaculella*											○	○	○	○	○
50.	*Ectoedemia rufifrontella*									○	○	○	○	○	○	○
51.	*Ectoedemia heringi*									○	○	○	○	○	○	○

No.	Species	June			July			August			September			October		
		I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
52.	*Ectoedemia contorta*									○	○	○	○			
53.	*Ectoedemia mahalebella*				●	◆	◆				○	○	○			
54.	*Fomoria septembrella*				○	○			○	○	○	○				
55.	*Acalyptris platani*			○	●	◆	◆			○	○	○				
56.	*Trifurcula subnitidella*									○	○	○	○	○		
57.	*Trifurcula josefklimeschi*						○	○	○	○						
58.	*Trifurcula silviae*							○	○	○						
59.	*Trifurcula eurema*					◆	◆			○	○	○				
60.	*Trifurcula macedonica*								○	○	○	○	○			
61.	*Glaucolepis melanoptera*									○	○	○	○			
62.	*Glaucolepis bleonella*										○	○	○			
63.	*Etainia sericopeza*				●	◆	◆									
64.	*Etainia louisella*					◆	◆									

THE LITHUANIAN NEPTICULIDAE FAUNA

Taxonomic composition of the Lithuanian Nepticulidae. Currently, 76 species of pygmy moths are known in the fauna of this country (for an annotated checklist containing new data about species distribution patterns, trophic specialization, host-plants, specified seasonal cycles, and occurrence, see Diškus *et al*., 2012; for an amazing addition to the Lithuanian fauna – *Glaucolepis lithuanica*, see Ivinskis *et al*., 2012). Most of the species belong to *Stigmella* (56) and *Ectoedemia* (13); the remaining species are divided among five other genera. Comparison of the taxonomic composition of the Lithuanian Nepticulidae fauna with the European one revealed no major differences or unique trends.

Chorological evaluation of the Lithuanian Nepticulidae fauna. Recent analysis of the Lithuanian Nepticulidae fauna indicated 8 chorological groups: the Holarctic, predominatly Sub-Baltic, Trans-Palaearctic, Euro-Mediterranean, Euro-Submediterranean, Euro-Siberian, West-Palaearctic and Euro-Nemoral (Fig. 10). The Lithuanian Nepticulidae species are distributed both in vast Holarctic and Palaearctic areas and in geographically restricted areas of Europe (Navickaitė & Stonis, 2012).

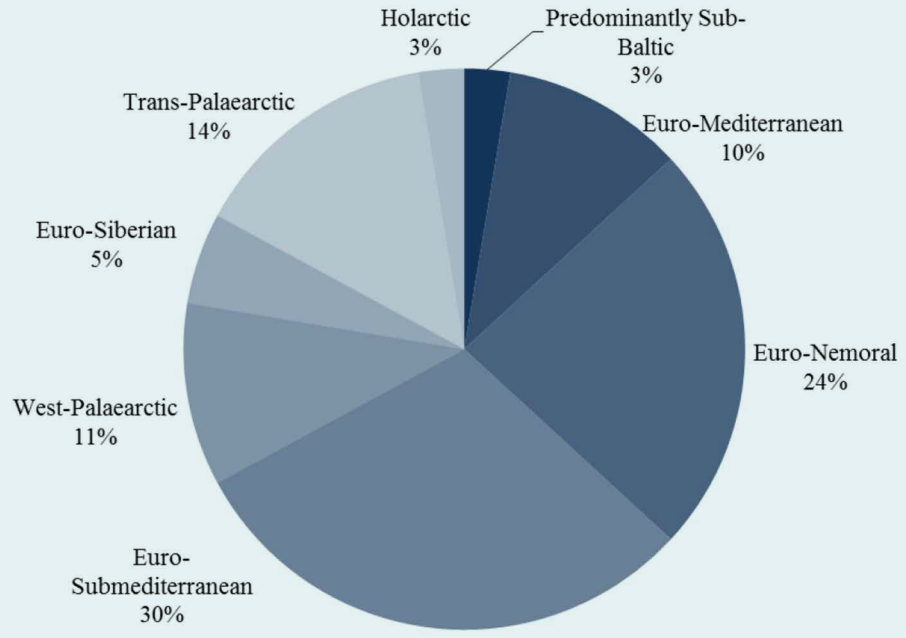


Figure 10. Chorological groups of the Lithuanian fauna of pygmy moth (updated).

The greatest number of pygmy moth species has been registered in the South-Eastern (63 species) and South-Western (67 species) regions of Lithuania. Mapping of all seventy six species recorded in the Lithuanian regions and their chorological grouping showed that the Curonian Spit region has unique species diversity (Navickaitė *et al*., 2011a; Ivinskis & Rimšaitė, 2013). As distinct from what had been expected, part of the pygmy moth fauna (from 26 to 31%) almost in every Lithuanian region is represented by Euro-Submediterranean distribution group (Navickaitė & Stonis, 2012). The best explored regions (the South-Eastern and South-Western) are predominated by Euro-Nemoral and Euro-Submediterranean species whereas the Coastal region stands out for abundance of species of Euro-Mediterranean group (Fig. 11).

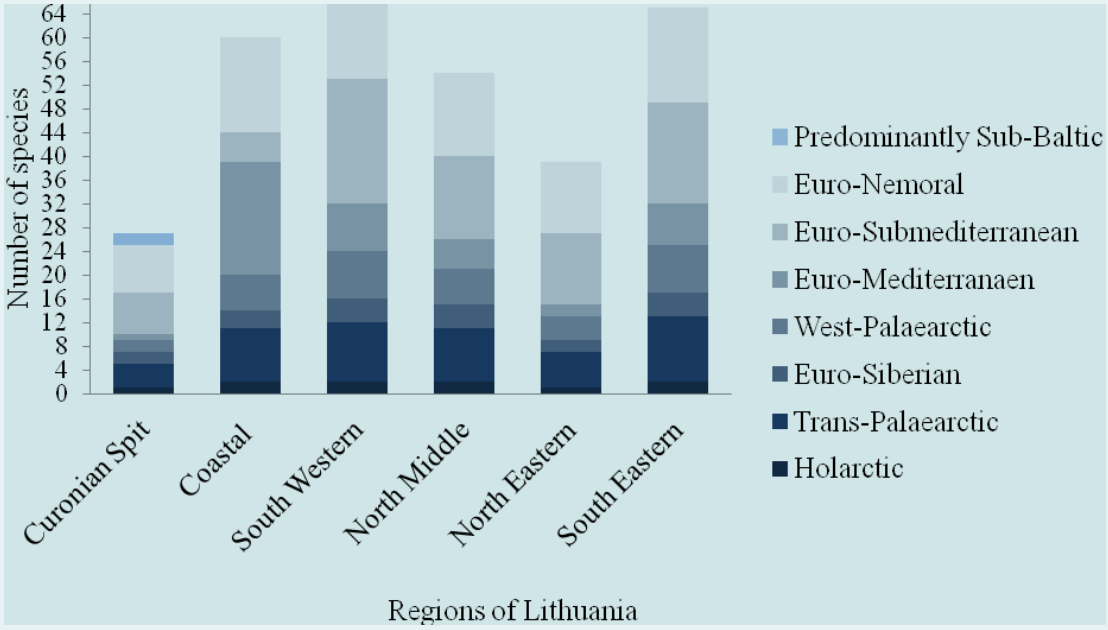


Figure 11. Chorological groups of Nepticulidae in the Lithuanian regions (After Navickaitė & Stonis, 2012).

Trophic relationships and seasonality of larval activity of the Lithuanian Nepticulidae. According to the newest data, the number of monophagous species amounts to 48. The strict oligophagous, who can mine plants of two or more species from one genus, are represented by 20 Nepticulidae species. This group of trophic specialisation prevails over the group of wide oligophagous (represented by 8 species). The almost all species of the latter group exclusively mine the plants from the Rosaceae family.

Among the Lithuanian Nepticulidae, only *Enteucha acetosae* has three generations per a year. The seasonality of larval activity in Lithuania was determined (Fig. 12).

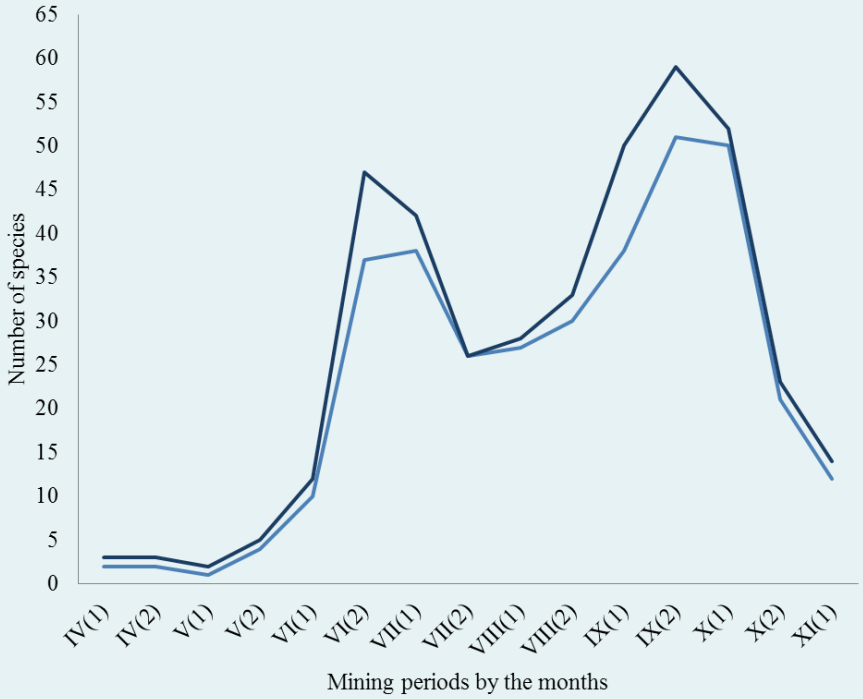


Figure 12. Larval activity of the Lithuanian Nepticulidae, with two activity peaks (darker, upper line exibit expected and calculated but not recorded peaks).

It has been determined that the Lithuanian Nepticulidae mine on host-plants from 35 genera and 15 families. Rosaceae, Salicaceae, Fagaceae and Betulaceae predominate; about 1/3 of the Lithuanian Nepticulidae is trophically associated with *Quercus*, *Betula* and *Malus*. Eleven species of the Lithuanian Nepticulidae mine fruit trees including 7 species from 3 genera (*Stigmella*, *Bohemannia* and *Ectoedemia*) which in different seasons mine the leaves of domestic apple tree (*Malus domestica*). Some Nepticulidae species (*Stigmella oxyacanthella*, *S. plagicolella* and *S. prunetorum*) can mine fruit trees of a few different plant species.

Occurrence of the Lithuanian Nepticulidae species. The evaluation of occurrence of species (common or rare) was followed by the method described in Stonis *et al.* (2012b) and Stonis *et al.* (unpublished). Among the total of Nepticulidae species recorded in Lithuania, 14 are rather widespread and abundantly mining (e.g. *Stigmella splendidissimella* and *Fomoria septembrella*). The mentioned category accounts for 1/5 of the known fauna. *Bohemannia pulverosella* is one of the 10 species which belong to the category of sparse distribution and abundant mining. They account for 13% of the Lithuanian Nepticulidae fauna. Groups of

highly limited distribution and very abundant mining (*Ectoedemia turbidella*), wide distribution but not abundant mining (*Stigmella floslactella*), and wide distribution and extremely abundant mining (*Ectoedemia argyropeza*) are represented only by single species each.

The Lithuanian Nepticulidae fauna is predominated by rare (about 40%) species. Meanwhile, it was established that 18 Lithuanian Nepticulidae species belong to common species: including 13 common (they account for 17% of the fauna) and 5 very common (about 7%) species. The latter are especially interesting since they can be regarded as potential pests.

In terms of biogeographical distribution of Nepticulidae, most of the common species (the sum of common and very common species) are characterized by Euro-Nemoral or Euro-Submediterranean distribution ranges (Fig. 13).

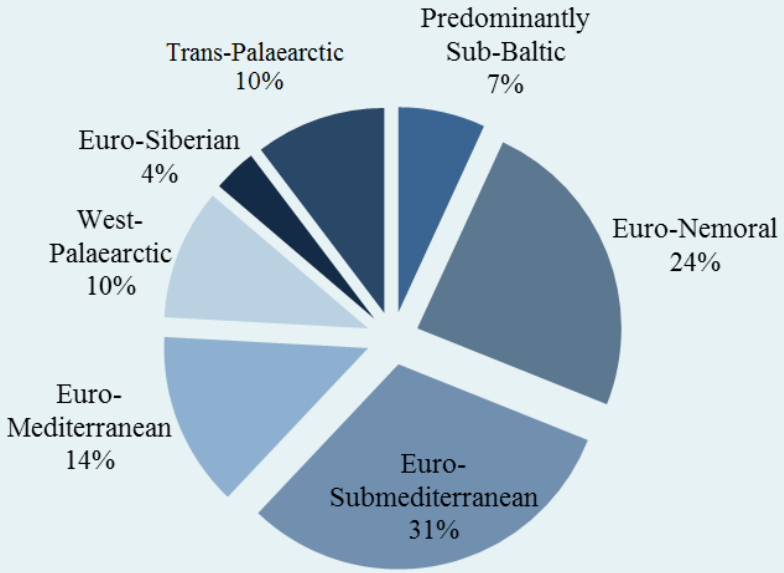


Figure 13. Belonging of the rare Lithuanian Nepticulidae species to different chorological groups.

Not abundant mining is characteristic of about half of the rare species (45%) of the Lithuanian Nepticulidae fauna: average abundance mining is characteristic of 38% of rare species and especially sporadic mining of 17% of the rare species. As distinct from the common species, the distribution of the rare species is highly limited (59%), based on solitary findings (34%) or sparse (7%). They are never widespread.

The rare species mainly mine on plants from *Ulmus*, *Fagus* and *Betula*. As distinct from the common species the rare species include miners trophically associated with host-plants belonging to *Salix*. Only two rare species – *Stigmella atricapitella* and *S. samiatella* (same as the common ones *S. ruficapitella* and *S. roborella*) mine leaves of *Quercus robur*.

CONCLUSIONS

1. Taking into consideration the recent taxonomic changes and the data on the newly described species it can be stated that currently the European Nepticulidae fauna comprises of 264 species which are trophically associated with 97, mostly woody (63%), host-plant genera and 34 plant families (mostly Rosaceae, Fagaceae and Fabaceae, in a lesser degree Betulaceae, Salicaceae, Lamiaceae, Cistaceae, Rhamnaceae,

Ulmaceae, Corylaceae, Apiaceae and Anacardiaceae). The trophic relationships of some European Nepticulidae (11%) are unknown.

2. Chorological analysis of the European fauna revealed that the Nepticulidae species of this region belong to 10 chorological groups: 29% Mediterranean, 20% Euro-Submediterranean, 12% Euro-Mediterranean, 9% Euro-Nemoral, 8% West-Palaearctic, 6% Sub-Mediterranean and Trans-Palaearctic, 2% Euro-Siberian, and 1% Holarctic. Analysis of the faunas of different European ecoregions showed that the greatest number (194) of Nepticulidae species is known from the Mediterranean ecoregion. *Simplimorpha* and *Glaucolepis* genera (93–100% of species) demonstrate an especially close links with the Mediterranean. The link of *Acalyptris, Ectoedemia* and *Parafomoria* to this region is somewhat weaker (85–89% of the 'European' species occur in the Mediterranean ecoregion).

3. The material collected during our intensive fieldwork and the material collected by other researchers helped to identify 64 species in the Crimean fauna (40% of this fauna was for the first time identified by the authors). The occurrence of a few species – *Stigmella szoecsiella, Ectoedemia albifasciella* and *E. pubescivora* – in the Crimea was not confirmed by reliable data. For this reason, these species were excluded from the list of fauna of the region.

4. Mapping of the Crimean Nepticulidae distribution ranges and chorological data analysis showed that about 72% of species discovered in the Crimea belong to the chorological groups which more or less are related with the Mediterranean ecoregion. Among the 8 chorological groups identified in the Crimean fauna, the species of the Euro-Submediterranean distribution range (36% of the known fauna of the peninsula) are dominant. Approximately one fifth of the species (22%) belongs to the Euro-Mediterranean chorological group and one sixth (16%) to the West-Palaearctic group. Meanwhile, the especially wide Euro-Siberian or Trans-Palaearctic ranges are characteristic only of 1% and 5% of species identified in the Crimea respectively.

5. Assessment of the occurrence of the species registered in the Crimean fauna allowed determining the common and rare species of the region; most of them are widespread in the forested part of the peninsula and characterized by abundant and very abundant mining. However, among the analysed Crimean fauna there are many species which are characterized by limited distribution and abundant mining or limited distribution and not abundant mining.

6. The majority of the common Crimean species mines *Quercus, Sorbus, Crataegus* and *Prunus* plants and mainly belong to the Euro-Submediterranean chorological group (about 47%). Meanwhile, as distinct from what had been expected, the least number of common species is characterized by the Sub-Mediterranean-Mediterranean distribution ranges.

7. Most of the rare species also mine on *Quercus* well as *Lotus, Alnus* and *Acer* and are characterized by Euro-Mediterranean (36%), Euro-Submediterranean and Euro-Nemoral (18% each) or Sub-Mediterranean (14%) distribution ranges. As could have been expected, the smallest number of rare species is characterized by wide distribution ranges or Sub-Mediterranean–Mediterranean distribution.

8. The data of trophic analysis showed that the majority of the Crimean Nepticulidae fauna is associated with the plants from the Rosaceae and Fagaceae (18 and 12 species respectively); about 11% of

the Crimean species are leaf-miners of cultivated plants (including *Stigmella irregularis* whose host-plant *Pyrus elaeagnifolia* was identified for the first time). According to the data of our fieldworks, the mining was reliably registered in the 1st decade of June to the 3rd decade of August (though it may continue to the 3rd decade of October). The peak of the larval activity is in July.

9. Based on the current data, 76 Nepticulidae species are known in the Lithuanian fauna. The majority of species were discovered in the South-Eastern (65 species) and South-Western (67 species) regions of the country.

10. From chorological point of view the Lithuanian Nepticulidae fauna is not homogeneous; it belongs to 8 chorological groups. The most abundant in the Lithuanian fauna are those of moderately limited European distribution: the Euro-Submediterranean (30%) and Euro-Nemoral (24%).

11. According to the available data, the species of the Euro-Submediterranean distribution constitute the major part of the Nepticulidae fauna (from 26% to 31%). Yet in the Coastal region, the number of such species is considerably lower (8%). The Coastal region is predominated by the species of the Euro-Mediterranean distribution (32%) which are less numerous in other Lithuanian regions including the Curonian Spit (they are especially few in the Curonian Spit region where they account for 4% of the regional fauna). From the chorological point of view, the Curonian Spit region is the most distinctive one among the Lithuania's regions. It is characterized by the species of the Sub-Baltic group which do not occur in other regions of the country. The Coastal region also is rather specific: the species of the Euro-Mediterranean group are occurring in greater abundance than anywhere else in Lithuania.

12. In Lithuania 15 families and 35 genera of host-plants were recorded. Most of the Lithuanian Nepticulidae is trophically associated with Rosaceae, Salicaceae, Fagaceae and Betulaceae families and about 33% of the fauna is associated with *Quercus, Betula* and *Malus* genera. The majority of the Lithuanian Nepticulidae species are trophically associated with woody plants (some of them are pest of cultivated/garden plants) and 17% of the fauna are miners of herbaceous plants.

13. The Lithuanian fauna is predominated by abundantly mining Nepticulidae (37 species or 49% of the total Lithuanian Nepticulidae fauna). It was determined that the most common in the Lithuanian Nepticulidae fauna are species of wide distribution and abundant mining (they account for more than one fifth of the total of known fauna). The smallest number is represented by species of highly limited distribution/very abundant mining or wide distribution/not abundant or sporadic mining (slightly over 1% each).

14. About 40% of the Lithuanian Nepticulidae species belong to the category of rare (rare and very rare) and 24% to the category of common species (17% of species are common and 7% very common). Nepticulidae both of common and rare species are characterized by the Euro-Nemoral and Euro-Submediterranean ranges (there are no significant chorological differences between the Lithuanian common and rare species). Yet as distinct from the common species, the rare and very rare species are characterized only by highly limited distribution (about 60% of the rare species) or almost solitary findings (34%) and, sometimes, sparse distribution (7%) yet never by wide or very wide distribution over the territory of the country.

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