Trophic Connections of Leafroller Moths (Lepidoptera: Tortricidae) and Oaks in Sofia Region, Bulgaria

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Abstract
The trophic connections of leafeating tortricids (Lepidoptera: Tortricidae) and the oaks were studied in the Sofia region of West Bulgaria. Biological material – larvae and pupae, 5200 in number, was collected in April-May 2011-2013 at 17 sampling sites. Fifteen tortricids have been identified, 7 oak species and 57 trophic connections between them, 31 of which new for Bulgaria. A complete up-to-date list of trophic connections of leafeating trotricids with Quercus spp. reported in Bulgarian publications is provided.

Key words: phyllophages, leafeaters, Quercus, up-to-date list, insect-plant interactions, pests.

Introduction
The Tortricidae family (the leafroller moths) ranks among the first in the order Lepidoptera by species richness with about 11 365 species described, about 100 of which are considered pests in agriculture and forestry (Gilligan et al. 2018). Forestry pests of the family are phyllophages (leafeaters). Especially the green oak tortix Tortrix viridana (Linnaeus, 1758) has a wide range of hosts of the genus Quercus (Du Merle 1999) and is one of the most important defoliators causing economically significant damage to deciduous forests in Europe, Asia Minor and North Africa (Kalapanida-Kantartzi & Glavendekić 2002).

In Bulgaria, 45 species of leafroller moths have been found to damage various organs of oak (Ganchev 1990). Two leaf-eaters – T. viridana and Archips xylosteana (Linnaeus, 1758) are widespread and cause economically significant damage to the oak forests in the country (Zlatanov 1968; Ganchev 1978, Tsankov et al. 1997). In recent decades, the “complex of leafroller moths” ranks as the second economically most important group of pests in the deciduous forests of the country after Lymantria dispar (Linnaeus, 1758) (Zaemdzhikova & Balov 2011; Zaemdzhikova et al. 2019).

The leafroller moths are an essential and permanent element of the insect complex in oak forests. Despite their economic importance, the picture of their trophic connections with the oaks is fragmentary, as previous studies have very often recorded leafroller species without specifying the oak species (Atia 1978a, b; Ganchev 1978; 1990). This necessitates further studies on this group of pests.
Table 1. Phyllophagous species of the Tortricidae family recorded on *Quercus* spp. in Bulgaria (according to published research).

| Tortricidae spp.       | Quercus spp.                          | Locality                                           | Source                      |
|------------------------|---------------------------------------|----------------------------------------------------|-----------------------------|
| Aleimma loeflingiana   | *Q. pubescens*                        | Kresna Gorge                                       | Zlatkov 2011¹               |
| Anacampsis timidella   | *Q. frainetto, Q. cerasis, Q. robur,* |                                                    |                             |
|                        | *Q. pubescens, Q. stranjensis*        |                                                    |                             |
| Ancylis mitterbacheriana| *Quercus* spp.                        |                                                    | Ganchev 1978⁸; Ganchev 1990 |
| Ancylis apupana        | *Quercus* spp.                        |                                                    | Ganchev 1990⁹               |
| Archips crataegana     | *Q. petraea, Q. frainetto, Q. cerasis*| Bozhuritsa area (near Vidin) Vakarel Vill. (Sredna Gora Mt.) | Atia 1978a¹; Ganchev 1978⁸; Ganchev 1990 |
| Archips podana         | *Quercus* spp.                        | in the vicinity of: Sofia, Kliusra, Asenovgrad, Plovdiv, Burgas, Sliven | Atia 1978a¹; Ganchev 1978⁸; Ganchev 1990 |
| Archips rosana         | *Q. petraea, Q. robur, Q. frainetto, Q. cerasis, Q. stranjensis (=Quercus hartriwissiana)* | Strandza Mt. | Zlatanov 1968*               |
| Archips xylostena      | *Q. petraea, Q. frainetto, Q. cerasis, Q. stranjensis, Q. pubescens, Q. stranjensis* | Vakarel Vill. (Sredna Gora Mt.), in the vicinity of Vidin | Tsankov et al. 1997         |
|                        | *Q. petraea, Q. frainetto, Q. cerasis* |                                                    |                             |
| Argyrotaenia ljungiana | *Quercus* spp.                        | Borisova gradina (Sofia) Stara Planina Mt.         | Zlatanov 1956; Zashev 1956   |
| Choristoneura hebenstreitella | *Quercus* spp.                        | Stara Planina Mt.                                  | Zashev 1957; Boykov 1961; Daskalova 1980 |
| Eudemis profundana     | *Q. robur*                            | Antimovo Vill., Plovdiv Vill. (close to Burgas), Topolchane Vill. (close to Sliven) in the vicinity of: Sofia, Vratsa, Kliusra, Asenovgrad | Zlatanov 1968               |
|                        | *Quercus* spp.                        | Strainzha Mt.                                      |                             |
|                        | *Q. rubra*                            |                                                    |                             |
|                        | *Q. rubra*                            |                                                    |                             |
|                        | *Quercus* spp.                        |                                                    |                             |
|                        | *Q. rubra*                            |                                                    |                             |
|                        | *Quercus* spp.                        |                                                    |                             |
|                        | *Q. rubra*                            |                                                    |                             |
| Argyrotaenia ljungiana | *Quercus* spp.                        | Eastern Stara Planina Mt.                          | Atia 1978a¹; Ganchev 1978⁸; Ganchev 1990 |
| Choristoneura hebenstreitella | *Quercus* spp.                        |                                                    |                             |
| Eudemis profundana     | *Q. robur*                            | Sofia                                             | Balevski & Georgiev 1998; Georgiev & Kolarov, 1999 |

⁸ Dr. I. Atia, 1978; ⁹ Dr. I. Ganchev, 1990; ¹ Dr. V. Zlatkov, 2011; ² Dr. V. Zapryanov, 1983; ³ Dr. G. Chorbadzhiev, 1992; ⁴ Dr. K. Balevski & Dr. G. Georgiev, 1998; ⁵ Dr. D. Zlatanov, 1996; ⁶ Dr. Z. Stefanov, 1956; ⁷ Dr. Ch. Zashev, 1957; ⁸ Dr. H. Boykov, 1961; ⁹ Dr. C. Daskalova, 1980; ¹⁰ Dr. S. Balevski & Dr. I. Georgiev, 1999.
| Species                        | Hosts                  | Reference                     |
|-------------------------------|------------------------|-------------------------------|
| *Gypsonoma dealbana* °(Frölich, 1828) | *Quercus* spp.         | Ganchev 1990°                  |
| *Hedya nubiferana* (Haworth, 1811) | *Quercus* spp.         | Atia 1978a¹; Ganchev 1978°; Ganchev 1990 |
| *Notocelia roborana* °        | *Quercus* spp.         | Ganchev 1990°                  |
| *Pandemis cerasana* (Hübner, 1786) | *Q. petraea*, *Q. frainetto*, *Q. cerris* | Vakarel Vill. Tsankov *et al.* 1997 |
| *Pandemis corylana* °(Fabricius, 1794) | *Q. petraea*, *Q. frainetto*, *Q. cerris* | Sofia Region Zaemdzhikova 2014° |
| *Pandemis damaeana* (Tretishe, 1835) | *Quercus* spp.         | Ganchev 1990°                  |
| *Pandemis heparana* ((Denis & Schiffermüller), 1775) | *Quercus* spp.         | Eastern Stara Planina Mt. Keremidchiev 1965° |
| *Psycholoma lecheana* (Linnaeus, 1758) | *Q. petraea*, *Q. robur*, *Q. frainetto*, *Q. cerris*, *Q. stranjensis* | Strandzha Mt. Zlatanov 1968° |
| *Ptycholoma lecheana* °(Linnaeus, 1758) | *Quercus* spp.         | Atia 1978a°; Ganchev 1978; Ganchev 1990 |
| *Syriconis lacunana* °        | *Quercus* spp.         | Ganchev 1978°                  |
| *Tortricodes alternella* °    | *Q. petraea*, *Q. frainetto*, *Q. cerris*, *Q. robur* | Zlatanov 1971¹; Ganchev 1978; Ganchev 1990 |
| *Tortrix viridana* Linnaeus, 1758 | *Q. petraea*, *Q. frainetto*, *Q. serris*, *Q. pubescens*, *Q. robur*, *Q. stranjensis*, *Q. cerris*, *Q. rubra* | Vidin (place Bozhuritsa, Kotenovtsi Vill., Tiyanovtsi vVill.), Samokov (Gutsal Vill.), Plovdiv (Krustevich Vill.) and Vakarel Vill. Tsankov *et al.* 1997 |
| *Zeiraphera isertana* ° (Fabricius, 1794) | *Q. robur*, *Q. petraea*, *Q. stranjensis* | Strandzha Mt. Zlatanov 1968 |

° not found in our sample
¹ first publication in Bulgaria

Zaemdzhikova 2014

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A list of previously known trophic connections of leaf-eating species from the family Tortricidae and *Quercus* spp., summarizing available Bulgarian publications, is presented in Table 1, which includes 25 tortricids and 51 trophic connections. The oldest publication is the record of *Archips xylosteana* in Stara Planina Mt. by Chorbadzhiev (1929), unfortunately made without specifying the oak species. The most numerous records are on *A. xylosteana* (13) and *T. viridana* (11). These two species are also the only ones found in early Bulgarian publications dating from before 1960. The most numerous records, in fact the majority, of trophic relationships with specific oak species were made in the 1970s by Zlatanov (27), followed by the Tsankov in the 1990s (6).

Oak forests cover 1,404,000 ha in Bulgaria (EFA 2018). They are the main vegetation (50%) in the lowland and foothills belt, which covers the altitudes from 0 to 1000-1200 m. a.s.l. ("belt of oaks"). Bulgarian oak forests are dominated by *Quercus petraea* Liebl., *Q. frainetto* Ten., *Q. cerasis* L. and *Q. pubescens* Willd. (98% of their area). The remaining 2% are distributed among 5 relatively rare species: *Q. robur* L., *Q. rubra* L., *Q. hartwissiana* Steven, *Quercus suber* L. and *Q. coccifera* L. Rare among the rare are the relict species *Q. hartwissiana* and the maquis species *Q. coccifera*.

Although rare now, *Q. robur* has historically dominated the plains. It is still ubiquitous there, but because of anthropogenic pressure, it has survived throughout its former wide range as isolated small forests and single trees (Markoff et al. 2017). Nevertheless, it retains its ecological significance, at least because its restoration is one of the measures for adaptation of forests to climate change (Raev et al. 2011). *Q. hartwissiana* (= *Q. stranjensis*) is a relict species represented by small areas in the Strandja Mountains in Bulgaria. *Q. rubra* is a known American species. It is interesting as an example of the adaptation of torticids to exotic species. The evergreen Mediterranean oaks *Q. suber* and *Q. coccifera* are represented by small areas in southwestern Bulgaria and are little known. *Q. coccifera* forms natural forests on xerothermic habitats. *Q. suber* plantations are grown for cork production. They are interesting as a vanguard of Mediterranean vegetation, which is expected to extend its range to the north (Raev et al. 2011).

The purpose of this work is to investigate the trophic connections of phyllophagous Tortricidae with the oaks in the Sofia region.

**Material and methods**

The study was conducted in April-June 2011-2013 in the oak forests in the Sofia region. Biological material (larvae and pupae) was collected from 17 sampling sites in the mountains Vitosha, Lyulin, Western Stara Planina and Ihtimanska Sredna Gora, which surround Sofia valley, as well as in the Sofia valley itself (Table 2 and Fig. 1).

**Figure 1.** Location of sampling sites.
| №  | Locality                              | Altitude, m. | Coordinates                | Quercus spp.        |
|----|---------------------------------------|--------------|----------------------------|---------------------|
|    |                                        |              | N 42° 37' 20" E 23° 13' 30" | Q. petraea          |
| 1  | Muzey na sovite area                  | 1265         |                            | Q. petraea          |
| 2  | Tihiya kut area                       | 1055         | N 42° 38' 18" E 23° 13' 05"| Q. petraea          |
| 3  | Bosnek Vill.                          | 950          | N 42° 30' 27" E 23° 09' 17"| Q. petraea          |
| 4  | Byalata voda area                     | 985          | N 42° 38' 29" E 23°13' 49" | Q. petraea          |
| 5  | above Dragalevtsi Monastery “Uspenie Bogorodichno” | 895  | N 42° 37' 20" E 23° 18' 19" | Q. rubra            |
| 6  | above residential area ”Dragalevtsi”   | 865          | N 42° 37' 17" E 23° 18' 31"| Q. cerris           |
| 7  | Rudartsi Vill.                        | 850          | N 42° 34' 54" E 23° 08' 59"| Q. petraea          |
| 8  | above residential area ”Knyazhevo”     | 750          | N 42° 39' 14" E 23'14' 33" | Q. petraea          |
|    |                                        |              | N 42° 37' 24" E 23°12' 18" | Q. petraea          |
| 9  | Manastirski livadi area               | 920          | N 42° 39' 19" E 23° 11' 28"| Q. petraea          |
| 10 |                                        | 900          | N 42° 39' 26" E 23° 12' 19"| Q. frainetto        |
| 11 |                                        | 890          | N 42° 39' 24" E 23° 12' 18"| Q. petraea          |
|    |                                        |              | N 42° 39' 24" E 23° 12' 18"| Q. cerris           |
| 12 | “St. Georgi” Monastery                | 865          | N 42° 48' 17" E 23° 30' 28"| Q. frainetto        |
| 13 | “St. Nikolay Mirlikiysi” Monastery    | 860          | N 42° 47' 51" E 23° 31' 32"| Q. petraea          |
|    |                                        |              | N 42° 47' 51" E 23° 31' 32"| Q. cerris           |
| 14 | German Vill.                          | 670          | N 42° 35' 54" E 23° 26' 07"| Q. petraea          |
| 15 | Vakarel Vill.                         | 970          | N 42° 39' 13" E 23° 39' 50"| Q. petraea          |
|    |                                        |              | N 42° 39' 13" E 23° 39' 50"| Q. cerris           |
|    |                                        |              | N 42° 39' 13" E 23° 39' 50"| Q. frainetto        |
| 16 | Borisova gradina park                 | 605          | N 42° 40' 35" E 23° 20' 33"| Q. rubra            |
| 17 | Forest Research Institute – Arboretum | 645         | N 42° 37' 49" E 23° 21' 13"| Q. robur            |

For each specimen taken, the hoste species was identified and recorded on the spot. The biological material was transported to the entomological laboratory of the Forest Research Institute where it was reared at room temperatures (18-20 °C). Bringing up of larvae and pupae was performed according to the commonly used methodology applied to all Microlepidoptera (Swatschek 1958; Buszko & Palka 2006).
During the period, 4522 larvae and 678 pupae of tortrix moths were collected. From the collected larvae, 630 died before they could pupate. In the result, 4570 pupae were investigated. Adults were identified following the keys of Razowski (2002; 2003; 2008) and Kuznetsov (1978). Identification of pupae was done following Kuslickij & Narol'skii (1986).

The sampling sites are located at altitudes from 600 up to 1300 m a.s.l., which is the upper half of the oaks belt in Bulgaria. Seven oak species were found - all known but the two evergreen. The sampling sites are dominated by *Quercus petraea*, *Q. frainetto* and *Q. cerris*, followed at a considerable distance by *Q. pubescens*. Their shares proved similar to their shares in the whole country, with easy to explain deviations (Fig. 2). The share of *Q. petraea* in the sample is higher than its national average because it is the dominant oak species at altitudes over 600 m a.s.l. in Bulgaria. On the contrary, the shares of *Q. frainetto* and *Q. pubescens* that gravitate to the lower places are smaller. The share of *Q. cerris* which is ubiquitous in the oak belt equals its country-wide average. *Q. pubescens*, which is less common than the other three, is also the less common in the sample.

![Figure 2. Shares of the oak species in the sample and in the whole country.](image)

The small shares of *Quercus robur* L., *Q. rubra* L. and *Q. hartwissiana* in the sample are nevertheless much larger than their country-wide average. Because they are of considerable interest for biology and ecology, at least one forest stand of each was searched for and investigated. With the exception of 4 such sites, the others were selected as typical representatives of the locality and reflect the natural tree species composition of the region. Unfortunately, *Quercus suber* and *Q. coccifera* do not occur in the study area and were not studied.

**Results**

**General.** The trophic connections found are presented in Table 3, which is the main result of the present study. From our findings (Table 3) and literature sources (Table 1), a complete up-to-date list of trophic connections of leaf-eating tortricids with oaks recorded in Bulgaria was compiled (Table 4). Recapitulation parameters are given in Table 5.
Table 3. Phyllophagous Tortricidae species identified on *Quercus* spp. in biological material collected.

| Tortricidae spp. | *Q. cerris* L. | *Q. petraea* Liebl. | *Q. robur* L. | *Q. frainetto* Ten. | *Q. hartwissiana* Steven | *Q. rubra* L. | *Q. pubescens* Willd. |
|------------------|----------------|---------------------|--------------|-------------------|------------------------|--------------|---------------------|
|                  | Sampling sites |                     |              |                   |                        |              |                     |
| *Aleimma loeflingiana* | 2, 3, 6*   | 3, 4, 14*          | 17*          |                   |                        |              | 3B                  |
| *Archips crataegana*    | 3, 7, 8, 9, 11T | 2, 3, 4, 9, 11, 13, 14T | 17*          | 7, 10, 12T        | 17*                    | 5, 16*       |
| *Archips podana* **    | 4, 14*      | 17*                | 7*           | 17*               | 5, 16*                 |
| *Archips rosana*       | Z           | 9, 11Z             | 17Z          | 10Z               | Z                      | 5, 16*       | Z                   |
| *Archips xylostelana*  | 2, 3, 7, 8, 9, 11, 13, 14Z | 1, 2, 3, 4, 7, 8, 9, 11, 13, 14, 15Z | 17SZ         | 7, 9, 10, 12Z      | 17Z                    | 5, 16SZ      | Z                   |
| *Choristoneura hebenstreitella* ** | 3, 4, 14* |                      |              |                   |                        |              |                     |
| *Eudemis profundana*   | 2, 3, 9, 11* | 1, 2, 3, 4, 7, 9, 11* | 17BG         | 7, 9, 10, 12*     | 16*                    | 3*           |
| *Hedya nubiferana* **  | 14*         |                     |              |                   |                        |              |                     |
| *Pandemis cerasana*    | 3, 9, 6T    | 2, 3, 4, 9, 11, 14T | 17T          |                   |                        | 5, 16*       |
| *Pandemis dumetana**   | 16*         |                     |              |                   |                        |              |                     |
| *Pandemis heparana**   | 9, 8*       | 3*                 |              |                   |                        |              |                     |
| *Ptycholoma lecheana*  | 14Z         | Z                   | 17Z          | Z                 | Z                      | Z            | Z                   |
| *Spilonota ocellana**  | 2, 3, 11, 14* | 17*               | 10*          |                   |                        | 16*          |
| *Tortrix viridana*     | 2, 7, 8, 9Z | 3, 4, 7, 8, 9, 11, 13, 14Z | 17Z         | 7, 9, 10Z         | 17Z                    | 5, 16Z       | 3Z                  |
| *Zeiraphera isertana*  | 2, 3*       | 1, 2, 3, 4, 9, 11Z | Z            | 9*                | Z                      | 16*          |

*New trophic connection for Bulgaria; **All listed trophic connections are new for Bulgaria
T first recorded by Tsankov, Z – Zlatanov, SZ – Stefanov-Zashev, BG – Balevski-Georgiev, B – Boyan Zlatkov
### Table 4. Trophic connections of the phyllophagous (leaf-eating) species of the Tortricidae family with the *Quercus* spp. in Bulgaria.

| Tortricidae spp. | *Q. cerris* | *Q. petraea* | *Q. robur* | *Q. frainetto* | *Q. hartwissiana* | *Q. rubra* | *Q. pubescens* |
|------------------|-------------|--------------|------------|----------------|-------------------|------------|---------------|
| *Acleris variegana* | *(C)*       | *           | *          | *(C)            |       |           |               |
| *Aleimma loeflingiana* | *           | *           | *          | *(C)*           |       |           |               |
| *Anacampsis timidella* | *(C)*      | *(C)*       | *(C)*      | *(C)*           | *(C)*  |           |               |
| *Ancylis mitterbacheriana* | *(C)*     | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Ancylis upupana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Archips crataegana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Archips podana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Archips rosana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Archips xylosteana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Argyrotaenia ljiungiana* | *(C)*     | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Choristoneura hebenstreitella* | *(C)* | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Eudemis profundana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Gypsonoma dealbana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Hedya nubiferana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Notocelia roborana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Pandemis cerasana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Pandemis corylana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Pandemis dumetana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Pandemis heparana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Psycholoma lecheana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Spilonota ocellana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Syricoris lacunana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Tortricodes alternella* | *(C)*     | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Tortrix viridana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |
| *Zeiraphera isertana* | *(C)*       | *(C)*       | *(C)*      | *(C)*           | *(C)*  | *(C)*     | *(C)*         |

* *trophic connections recorded by us in Sofia region
(C) country-wide trophic connections recorded in other Bulgarian publications
### Table 5a. Recapitulation by insect species.

| Trotricidae spp. | Frequency of the species in sampling sites | New connections for Bulgaria | Confirmed known connections | Known connections not observed | Total of connections evidenced in Bulgaria | Publications in Bulgaria |
|------------------|-------------------------------------------|------------------------------|-----------------------------|-------------------------------|------------------------------------------|--------------------------|
|                  | Species found by us in Sofia region sample |                              |                             |                               |                                          |                          |
|                  | Numbers                                     |                              |                             |                               |                                          |                          |
| Aleimma loeflingiana | 6                                          | 3                            | 1                           | 4                             | 1                                        |                          |
| Archips crataegana | 14 <sup>m</sup>                             | 3                            | 5                           | 1                             | 6 <sup>m</sup>                           | 5                        |
| Archips podana ** | 6                                          | 5 <sup>M</sup>               | 3                           | 5                             |                                          |                          |
| Archips rosana    | 6                                          | 3                            | 7 <sup>M</sup>              | 5                             |                                          |                          |
| Archips xylostaeana<sup>7</sup> | 16 <sup>M</sup>                             | 6 <sup>m</sup>               | 1                           | 7 <sup>M</sup>                | 13 <sup>M</sup>                         |                          |
| Choristoneura hebenstreitella ** | 3                                          | 1                            | 1                           | 3                             |                                          |                          |
| Eudemis profundana | 11                                          | 5 <sup>M</sup>               | 1                           | 6 <sup>m</sup>                | 5                                        |                          |
| Hedya nubiferana ** | 1                                          | 1                            | 1                           | 3                             |                                          |                          |
| Pandemis cerasana | 10                                          | 2                            | 2                           | 1                             | 5                                        | 2                        |
| Pandemis dumetana ** | 1                                          | 1                            | 1                           | 1                             |                                          |                          |
| Pandemis heparana ** | 3                                          | 2                            | 2                           | 1                             | 3                                        |                          |
| Psycholoma lecheana<sup>7</sup> | 2                                          | 2                            | 5 <sup>M</sup>              | 7 <sup>M</sup>                | 3                                        |                          |
| Spilonota ocellana ** | 7                                          | 4 <sup>m</sup>               | 4                           | 3                             |                                          |                          |
| Tortrix viridana<sup>7</sup> | 13 <sup>m</sup>                             | 7 <sup>M</sup>               | 7 <sup>M</sup>              | 11 <sup>m</sup>               |                                          |                          |
| Zeiraphera isertana | 7                                          | 3                            | 1                           | 2                             | 6 <sup>m</sup>                           | 2                        |
| **Total for sample results** | 31                                          | 26                           | 12                          | 69                             |                                          |                          |
| Species known in Bulgaria but not found by us in Sofia region sample | 1                                          | 5                            | 1                           | 1                             |                                          |                          |

**all connections new for Bulgaria**

<sup>M</sup> maximum value

<sup>m</sup> next maximal value

<sup>N</sup> no new connections were observed

<sup>F</sup> first scientific records (before 1960)

<sup>F</sup> found with all seven oak species

The number of 15 Tantlmeicidae species were found feeding on the leaves of 7 oak species (Table 3). All 15 torticids identified are among the known 25 species, listed in Table 1. The remaining 10 were not found in the material collected. These are well-known species in Bulgaria (Zlatkov 2011), which appear to be rarely found on oak. Lists of the 15 found and the 10 not found species can be seen in Table 5a.
The total of 57 trophic connections were established in our sampling data, 31 of which were new for Bulgaria (Table 3 and Table 5a). Finally, the total of 82 trophic connections of leafeating torticids with oak species have been established in Bulgaria, of them 31 are new records for Bulgaria made in this study, 26 are connections known from other Bulgarian publications and confirmed by us and 25 are known trophic connections not observed by us in the study area. Of the latter, 13 involve tortricids that were not found in our biological material, in the remaining 12 cases, the insect was found, but not the connection (Table 4 and Table 5a).

Table 5b. Recapitulation by tree species.

| Quercus spp. | Frequence in sampling sites | New connections for Bulgaria | Confirmed known connections | Known connections not observed | Total of connections evidenced in Bulgaria |
|--------------|----------------------------|----------------------------|-----------------------------|--------------------------------|------------------------------------------|
| Q. cerris    | 9                          | 5                          | 5                           | 4                              | 14                                       |
| Q. petraea   | 11                         | 6                          | 6                           | 3                              | 15                                       |
| Q. robur     | 1                          | 5                          | 5                           | 3                              | 13                                       |
| Q. frainetto | 4                          | 4                          | 4                           | 5                              | 13                                       |
| Q. hartwissiana | 1                      | 2                          | 2                           | 4                              | 8                                        |
| Q. rubra     | 2                          | 8                          | 2                           | 2                              | 12                                       |
| Q. pubescens | 1                          | 1                          | 2                           | 4                              | 7                                        |
| **Total**    | **31**                     | **26**                     | **25**                      | **82**                         |                                          |

It is worth mentioning that despite the significant volume of biological material, this study did not find a new for Bulgaria phyllophagous tortricid damaging the oaks. Such was found the following year – *Pandemis corylana* (Fabricius, 1794) – in a much more limited study in the Sofia region (Zaedzhekova 2014). This is a species well known in the country (Zlatkov 2011) but not recorded by then to feed on any oak species.

**New records.** For 6 species: *Archips podana* (Scopoli 1763), *Choristoneura hebenstreitella* (Müller, 1764), *Pandemis dumetana* (Treitschke, 1835), *Pandemis heparana* ([Denis & Schiffermuller], 1775), *Spilonota ocellana* ([Denis & Schiffermüller], 1775) and *Hedya nubiferana* (Haworth, 1811), all connections established were new for Bulgaria (Table 5a). All these 6 leafrollers are relatively rare. The most numerous new connections were found for *Eudemis profundana* ([Denis & Schiffermüller], 1775) and *A. podana* – 5 for each. No new connections were found for the most common species of *T. viridana* and *A. xylosteana*. and also for *Ptycholoma lecheana* (Linnaeus 1758). This was a foreseeable result because these species had already been reported on all oak species.

**Unobserved connections.** The most numerous unobserved known connections – 5, had *P. lecheana*. This species was found at 2 of our sampling sites only, although it is known with trophic connections with all oak species. Same number of unobserved known connections have *Anacampsis timidella* (Wocke, 1887) and *Tortricodes alternella* ([Denis & Schiffermuller], 1775) that did not surface in our material (Table 5a).

**Occurrence.** In the sample, *A. xylosteana* was most commonly encountered (16 sites), followed by *A. crataegana* (14), *T. viridana* (13) and *E. profundana* (11). This was expected for *T. viridana* and *A. xylosteana*, which are known to be the country's most common leafroller moth species. Surprisingly close to them were *A. crataegana* and *E. profundana*, which are far from being as common as them (Table 5a).
**Host ranges.** Four leafroller species – *A. rosana* (Linnaeus, 1758), *A. xylosteana*, *T. viridana* and *P. lecheana* have trophic connections with all oak species. Further three – *E. profundana*, *Archips crataegana* (Hübner, 1799) and *Zeiraphera isertana* (Fabricius, 1794) have connections with all but one (Table 5a).

**Entomofauna.** The most numerous connections with leafroller moths have *Q. petraea* (15 species), followed tightly by *Q. cerris* (14 species), *Q. robur* and *Q. frainetto* (13 species), and *Q. rubra* (12 species). Interestingly, the North American species *Q. rubra* shows the same spectrum of trophic connections as the native oaks (Table 5b).

**Discussion**

All identified leafroller species are known as oak pests in Bulgaria (Atia 1978a; Ganchev 1990; Zlatanov 1968; Keremidchiev 1965; Zaemdzhikova & Balov 2011; Zaemdzhikova 2014). In any case, all the specimens we examined were taken from living vital trees, which is natural for leafeaters. The damage and costs caused in Bulgaria by the Torticidae species are extensively documented and hence the status of economically significant pests is undoubted for the most common species *T. viridana* and *A. xylosteana*. Less widespread species may require specialized studies.

Although the scientific interest in torticids in oak forests dates back to the 1920s, the present study provides a lot of new data of trophic connections of torticids and oaks: 31 of the observed connections are new to Bulgaria, which increased by 60% the number of records made, from 51 to 82. The large number of new for Bulgaria connections is due to the fact that many older authors did not determine accurately the species of oak on which the particular insect was found. As our sampling sites are representative of the upper half of the oak habitat in Bulgaria, a new study in the plain forests at altitudes from 0 to 600 m a.s.l. is obviously needed to complete the picture of the connections. In addition, The evergreen Mediterranean oaks remain completely unexplored in Bulgaria. Although represented by insignificant areas, they are very interesting in that they are located on the northern border of their range.

The present study focuses on the trophic connections of the leafeating leafroller moths with the oak species. A complete study of the food web of leafrollers and oaks requires a variety of additional studies. Despite of their economic importance, little is known about the population sizes of the individual leafroller species in Bulgaria, their trophic specialization and their spatial distribution. In the professional records, they are referred to as the complex of "Tortricidae-Geometridae". However, the knowledge of trophic specialization can be useful for planning forest protection activities. Knowledge of species composition and population sizes of Tortricidae species will allow to monitor the dynamics in their world, which in turn will allow to detect presumable impact of climate change. Scientific publications on these issues are scarce and controversial. E.g., it is well known that the leafroller moths are more or less associated with certain groups of plants, but generally have low trophic specialization (Razowski 2008). According to Staley & Zhechev (1997), leafroller moths have no preference for any oak species. Controversly, Keremidchiev (1965), Zlatanov (1968; 1971) and Ovcharov et al. (2000 a, b) reported leafroller moths preference for sessile oak (*Q. petraea*), with frainetto oak their occurrence decreased and reached a minimum in cerris oak. This opinion has not been obtained through nutritional experiments that would be decisive, and perhaps confuses preference with attacks number. In our results, most attacks are observed in sessile oak *Q. petraea*, too, but this may be due to the simple fact that it is the most frequent in our sample.

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