New records of allochtonous, invasive and pest invertebrate species from the Republic of Macedonia

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Abstract
In this paper new data on allochtonous and invasive invertebrate species: Arion (Arion) cf. vulgaris Moquin-Tandon 1855, Cornu aspersum (O.F. Muller, 1774), Harmonia axyridis (Pallas, 1773), Acanthoscelides obtectus (Say, 1831), Trogoderma variabile Ballion, 1878, Stegobium paniceum (Linnaeus, 1758), Oxycarenus (s.str.) lavaterae (Fabricius, 1787), Corythucha ciliata (Say, 1832), Leptoglossus occidentalis Heidemann, 1910, Ceroplastes japonicus (Green, 1921), Pseudaulacaspis pentagona (Targioni Tozzetti, 1886) MacGillivray, 1921, Tuta absoluta (Meyrick, 1917) and Frankliniella occidentalis (Pergande, 1895) from Macedonia are presented. The study represents faunistic data synthesis from different parts of Macedonia, based on collecting efforts of several taxonomic experts. The results of the study help to outline the composition of non-native and invasive invertebrate fauna and to narrow gaps concerning the knowledge of their distribution and introduction in Macedonia.

Key words: allochtonous, invasive, pest invertebrate species, Macedonia.

Introduction
The globalization and worldwide trading especially in the last few decades have facilitated the distribution and introduction of non-native species. Most of the common reasons for introduction of alien species include: climate change, land use changes, forest alterations, trade, tourism and biological control of pests (Vander Zanden 2005). According to Roques (2010), 23% of terrestrial arthropods (mainly insects) represent non-native species and it is important to note here, that not all introduced species become invasive. According to Cuttelod et al. (2008) invasive alien species are alien species which become established in natural or semi-natural ecosystems or habitat, are an agent of change, and threaten native biological diversity.
It is widely accepted that only a small proportion of introduced species establish and only a small proportion of these species spread and become pests (Vander Zanden 2005), and these species are one of the most important causes of biodiversity loss.

Due to a lack of information and awareness, the issue of invasive species and their effects is often underestimated and adequate prevention and mitigation measures are lacking.

Table 1. Number of non-native species in Macedonia per order and family according to DAISIE database

| Group                  | No. alien species |
|------------------------|-------------------|
| Araneae, Acri          | 4                 |
| Coleoptera             | 16                |
| Anobiida               | 2                 |
| Anthicida              | 1                 |
| Chrysomelida           | 6                 |
| Cryptophagidae         | 1                 |
| Dermestidae            | 1                 |
| Latridiidae            | 2                 |
| Nitidulidae            | 2                 |
| Staphylinidae          | 1                 |
| Diptera                | 2                 |
| Cecidomyiidae          | 2                 |
| Hymenoptera            | 3                 |
| Encyrtidae             | 3                 |
| Lepidoptera            | 7                 |
| Arctiida               | 1                 |
| Coleophoridae          | 1                 |
| Gelechiidae            | 2                 |
| Gracillariidae         | 1                 |
| Saturniidae            | 1                 |
| Tortricidae            | 1                 |
| Orthoptera             | 1                 |
| Acrididae              | 1                 |
| Thysanoptera           | 1                 |
| Thripidae              | 1                 |
| Myriapoda              | 1                 |
| Total                  | 57                |

| Group                  | No. cryptogenic species |
|------------------------|-------------------------|
| Araneae, Acri          | 2                       |
| Blattodea              | 1                       |
| Blattidae              | 1                       |
| Coleoptera             | 6                       |
| Anobiida               | 5                       |
| Latridiidae            | 1                       |
| Hemiptera              | 4                       |
| Anthocoridae           | 1                       |
| Aphididae              | 3                       |
| Hymenoptera            | 1                       |
| Formicidae             | 1                       |
| Lepidoptera            | 3                       |
| Gracillariidae         | 1                       |
| Pyralidae/Crambidae    | 2                       |
| Psocoptera             | 7                       |
| Ectopsocidae           | 2                       |
| Liposcelididae         | 4                       |
| Trogiidae              | 1                       |
| Siphonaptera           | 1                       |
| Ceratophyllidae        | 1                       |
| Myriapoda              | /                       |
| Total                  | 25                      |
for Bulgaria, Albania and Macedonia is given by Tomov et al. (2009), and for Greece and the neighboring countries is presented in Avtizis et al. (2017).

An overview of the literature data concerning non-native and invasive invertebrates in Macedonia is presented by Hristovski et al. (2015), enlisting many allochtonous and invasive species which are sited in DAISIE database to. In fact, the only available checklist considering alien invasive species for Macedonia is provided by the DAISIE (Delivering Alien Invasive Species Inventories for Europe) information system (2016). Furthermore, available information about the presence of alien species in Europe can be found on the European Alien Species Information Network- EASIN (https://easin.jrc.ec.europa.eu/easin).

According the DAISIE database, the non-native arthropod fauna of Macedonia (Tab.1) includes 57 alien species: 4 Acari species, 1 species of Diplopoda, Oxidus gracilis (C.L. Koch 1847), and 52 species of Insecta, belonging to 7 orders and 22 families. The same database includes 25 cryptogenic species (2 Acari species and 23 species of Insecta belonging to 7 orders and 12 families).

It is obvious that Aphidids (Hemiptera) have the highest share of non-native insect species in Macedonia, and probably their introduction is mainly made by the import of horticulture and stored products.

Material and methods

The material includes museum and hand-collected specimens by several experts on separate field trips in different parts of the country, during the period 2011-2016.

Results and Discussion

In this paper new data of allochtonous and invasive invertebrate species from Macedonia are presented. The study comprises 13 species including 2 species of Gastropoda, 4 species of Coleoptera, 5 species of Hemiptera, 1 species of Lepidoptera and 1 species of Thysanoptera.

The list of species with short description about their origin and ecology is given below.

Arion (Arion) cf. vulgaris Moquin-Tandon 1855 (complex) (Gastropoda, Arionidae)

Records: Skopje, Kapishtec, park with grasses and Rubus, 270 m., N41.990642° E21.412814°, 19.10.2014, 21 specimens, leg. S. Hristovski; Skopie, Kapishtec, Park with grasses and Rubus, 270 m.a.s.l., 1 specimens laying eggs under stones, 21.02.2016, leg. N. Simov, S. Hristovski and I. Dedov; vill. Yanchishte, marsh, ruderal habitats, Alnus, N42.0521456° E21.1213413°, 17.09.2016, leg. L. Melovski.

Origin: South-Eastern Europe (Iberian Peninsula – Portugal, Spain, Andorra, South France).

Comments: A. cf. vulgaris is known being a pest from the past century (Godan 1983). Nowadays it is one of the most aggressive invasive gastropod species in and outside of Europe, causing damages of garden plants, stored productions, and saplings of deciduous forests (Proschwitz T. Von 1997; Rowson et al. 2014; Dedov et al. 2017). Furthermore Welter-Schultes (2012) reports that A. cf. vulgaris competes and replaces the close species Arion rufus (Linnaeus 1758), as well as A. cf. vulgaris can act as a vector for pathogenic Listeria spp. and L. monocytogenes (Gismervik et al. 2015). It is known that A. cf. vulgaris feeds on dead individuals of their own species as well as other invertebrate and vertebrate animals (Dedov, unpublished data). The subgenus and respectively species are not given in the list of Bank (2013) for Macedonia. Stankovic, Stojkoska & Norris (2006) published species Arion lusitanicus Mabile, 1868. The taxonomy and synonymy of the subgenus Arion are still not fully clear. Some authors (Wiktor 1983; Bank 2013) consider this species as a synonym of Arion (Arion) lusitanicus J. Mabille 1868, but contemporary studies indicate that we have (minimum) two different species (Castillejo 1997; Rowson et al. 2014).

Cornu aspersum (O.F. Muller, 1774) (Gastropoda, Helicidae)

Records: Skopje, Karposh vicinity, 20.07.2014, 20 specimens, leg. T. Mitev and S. Hristovski, det. I. Dedov.

Origin: Native distribution of Cornu aspersum covers Britain, Western Europe, and along borders of the Mediterranean and Black Seas (Burch 1960).

Comments: Cornu aspersum has calcareous shell 25–40 mm in diameter and 25–35 mm high, with four or five whorls. The shell is variable in color and shape, with specific pattern, generally is dark brown,
brownish golden, or chestnut with yellow stripes, flecks, or streaks (characteristically interrupted brown color bands). *C. aspersum* is a hermaphrodite, reproduction is usually sexual, although self-fertilisation rarely occurs. About two weeks after fertilization, the snail lays a batch of about 80 eggs into crevices in the topsoil or sheltered under stones. In a year it may lay six batches. The young snails take one to two years to reach maturity. *C. aspersum* inhabits sheltered places, quarries, graveyards, urban gardens and waste ground. It is also found in deciduous woodland in the U.K. (Kerney 1999).

*C. aspersum* is also a cosmopolitan invasive pest of a large range of agricultural crops in the Americas, SE Australia, New Zealand, South Africa and elevated areas (>1000 m) on many tropical and subtropical islands. It is a pest of specific crops in certain parts of the USA, it has emerged as a viticultural pest in South Africa and Australia (Barker 2002, Sanderson & Sirgel 2002). Fossils of *C. aspersum* have been found in the Mediterranean - Upper Pliocene strata in North Africa, as well as quaternary strata in southern France, Spain and Corsica. From there the species is penetrated in the synantropic parts of these areas, and was transported to the Mediterranean and neighboring coastal areas of the Atlantic. The expansion of the range of *C. aspersum* takes place in recent times, as the snail spreads worldwide by transport of fruits and vegetables, as well as the use of the species for cultivation. Probably the species penetrate in Macedonia with developing of snails-farming process.

*Harmonia axyridis* (Pallas, 1773) - Harlequin ladybird (Coleoptera, Coccinellidae)

**Record:** Shar Planina Mt., Golema Smreka, small peat bog in mountain pasture area, 2250 m.a.s.l., 22.07.2017, 1 specimen (f. conspicua), leg. S. Hristovski.

**Origin:** South-Eastern Asia (Belyakova & Reznik 2013).

**Comments:** This predaceous coccinellid was introduced into the USA from South-Eastern Asia as early as 1916 and since then it has been successfully used in many countries for the biological control of insect pests. Since 1990s the harlequin ladybird invaded natural ecosystems in USA. At present, *H. axyridis* occurs in almost many countries in Europe, North and South America, and Africa and now is considered to be an invasive species, which is having a) negative effect on native aphidophagous insects through direct competition and as a voracious, polyphagous predator, b) it also consumes soft fruit and is adversely affecting the wine and fruit growing industries and c) occurs at high densities in buildings during overwintering and is thus regarded as a human nuisance (Koch & Galvan 2008; Roy & Wajnberg 2008; Belyakova & Reznik 2013). In Europe it has spread very rapidly, particularly since 2002. It was also released in some Mediterranean countries (Portugal, Spain and Greece). It is predicted that the spread and increase within Europe will continue and that *H. axyridis* will become one of the most widely distributed coccinellids in the continent (Brown et al. 2008). This species is known from Macedonia from several localities: Dojran, Ohrid, Belčišta swamp, Skopje, Prilep, Kavadarc (Kulijer 2016).

*Acanthoscelides obtectus* (Say, 1831) - bean weevil (Coleoptera, Chrysomelidae)

**Record:** Herbal tea bags, Skopje, numerous specimens, March 2017.

**Origin:** The origin of *Acanthoscelides obtectus* is doubtful and rather unknown. The species may be of Mesoamerican (Central America) (Labeyrie 1990) or Andean origin (South America) (Alvarez et al. 2005).

**Comments:** It is cosmopolitan insect pest of leguminous seeds in the field and within stored products. The feeding of larval stages is of economic importance since as seed predator consumes parts of wild and cultivated bean, Phaseolus vulgaris L. causing damages. *Acanthoscelides obtectus* causes major economic losses in the Neotropical ecozone, as well as in the Palearctic, Afrotropical, and Indo-Malayan regions (Southgate 1978; Gepts 1998; Papa et al. 2006; Thakur 2012). This species co-disperse with the host which is an important strategy to expand its range over long distances. *A. obtectus* favors warmer climates, which limits its northern distribution. It is well known that major introduction of the species to Europe was made during the 19th century with grain shipments to Europe from where it subsequently spread throughout the world.
**Trogoderma variabile Ballion, 1878 - Warehouse beetle (Coleoptera, Dermestidae)**

**Record:** Herbal tea bags, Skopje, numerous larval specimens, November 2016.

**Origin:** *T. variabile* is cosmopolitan species (Háva 2015). This species is registered in all zoogeographical regions, including: South Africa, Central and North America, Middle East, Asia and Australia (Háva 2003; Stejskal et al. 2005), distributed mainly in the Holarctic Region (cf. Hagstrum & Subramanyam 2009; Háva 2015)
According to Nardi & Vomero (2017), in Europe, it was firstly recorded from Caucasus (Mroczkowski 1968) and since 1975 in other regions (cf. Šefrová & Laštůvka 2005; Denux & Zagatti 2010), and according EASIN (2018) the first introduction in Europe was in 1978 in UK (Denux & Zagatti 2010) primarily by trading (EASIN 2018). DAISIE database lists only the distribution in Czech Republic, Finland, Great Britain, Italy, Latvia and Sweden (DAISIE 2018). In recent literature (Nardi & Vomero 2017) the species presence is registered in other parts of Europe: Armenia, Belarus, Finland, Greece, Lithuania, South European Russia, Sweden, The Netherlands (Barševskis 2001; Hagstrum et al. 2013; Zhantiev 2013; Háva 2015) as well as Asia: Kyrgyzstan (Ovchinnikov 1996) and Syria (Pic 1908; Háva 2007).

Comments: *T. variabile* is a polyphagous pest. The adults do not feed, but the diet of larval stages is based on a dried high-protein material like legumes, cereals, milk powder and material from herbarium and zoological collections (Peacock 1993; Beal 2003; Hagstrum et al. 2013).

*Stegobium paniceum* (Linnaeus, 1758) - drugstore beetle (Coleoptera, Anobiidae)

**Record:** Herbal tea bags, Skopje, numerous larval specimens, July 2016.  
**Origin:** Australia and New Zealand (Tomov et al. 2009).  
**Comment:** Drugstore beetles have a worldwide distribution, but are more abundant in warmer regions or in heated structures in more temperate climates. The distribution includes Balkan countries: Albania, Macedonia, Bulgaria as well (Tomov et al. 2009). This species is not listed in the DAISIE database.  

*Stegobium paniceum* is also known as bread beetle or biscuit beetle, and it is often confused with the cigarette beetle and the common furniture beetle *Anobium punctatum*, which belongs to the same family and often attacks similar stored products. It is important pest of various organic materials such as dried herbs, spices, cereals, leather, museum collection etc. and is even known to bore through aluminum, tin and lead sheets. The life cycle of a drugstore beetle is dependent on the temperature (i.e. the lower the temperature the slower the process) and food source.

*Oxycarenus* (s.str.) *lavaterae* (Fabricius, 1787) – Lime seed bug (Hemiptera, Oxycarenidae)

**Record:** town of Prilep, center of the city, 655 m a.s.l., on *Tilia* sp., 41.346010°N 21.555139°E, 01.11.2018, many individuals, M. Langourov obs.  
**Origin:** Oxycarenus lavaterae is a west-mediterranean species, which during the last two decades of the 20th and first decade of 21st century, rapidly spread to the Northern and Eastern Europe (Rabitsch 2008, 2010). The species is trophically associated generally with *Tilia* sp., (Péricart 1999, Kment et al. 2006, Rabitsch 2008).  

The first records in neighboring regions on Balkan Peninsula were in Bulgaria (Kalushkov 2000; Simov et al. 2012). In the last two decades the species spread across almost all territory of the peninsula (Rabitsch 2010, Simov et al. 2012). Up to now its remains overlooked for Macedonia. This is the first record for the Macedonian fauna. The reference for Macedonia in Arslangündoğdu et al. (2018) is misidentification with the data for Montenegro (Rabitsch 2008, Velimirović et al. 1992).

*Corythucha ciliata* (Say, 1832) – Sycamore lace bug (Hemiptera, Tingidae)

**Records:** Vardar River Valley: town of Gevgelia, central part, 65 m a.s.l., on *Platanus orientalis*, 10.06.2013, 10♂, 15♀, leg. N. Simov; Gradsko Vill., 150 m a.s.l., on *Platanus orientalis*, 14.05.2014, 5♂, 5♀, leg. N. Simov; town of Veles, 170 m a.s.l., on *Platanus orientalis*, 14.v.2014, many individuals, leg. N. Simov, S. Hristovski, I. Dedov obs.; Demir Kapiya Vill., 105 m a.s.l., on *Platanus orientalis*, 09.07.2011, many individuals, M. Langourov obs.; town of Strumica., 230 m a.s.l., on *Platanus orientalis*, 14.07.2014, many individuals, M. Langourov obs.  
**Origin:** *C. ciliata* is an invasive alien species of North American origin (USA and Southern Canada) (Rabitsch 2008).
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After the first European record of *C. ciliata* in Italy (Servadei 1966), the species spread across almost all of Europe during the last five decades (Rabitsch 2010). The most preferred areas in the invaded regions are those with Submediterranean and Mediterranean climate (Rabitsch 2010). It is regarded as established in the Balkans from the second half of 20th century (Rabitsch 2008; Simov et al. 2012). Up to now its remains overlooked for the territory of the Macedonia. In summer of 2011, 2013 and spring 2014 it was recorded for the first time in Macedonia – Vardar Valley – Veles, Gradsko and Gevgelija.

In its native range *C. ciliata* is trophically associated with *Platanus occidentalis* and other sycamores (Coyle et al. 2005; Henry & Froeschner 1988). In Macedonia the main host for *C. ciliata* is *Platanus orientalis*. Practically, *C. ciliata* has been found in the whole range of Oriental plane in Macedonia – Vardar River Valley. In the neighboring countries the species is bivoltine (Simov et al. 2012). Threats of the mass growth and development of the Sycamore lace bug to the stability the tree populations of Oriental plane in Macedonia, has not yet been studied. The bugs’ feeding may weaken the plants vitality and support secondary infections by fungi and pathogens (Neal & Schaefer 2000; Rabitsch 2008).

**Leptoglossus occidentalis** Heidemann, 1910- western conifer seed bug (Hemiptera, Coreidae)

**Record**: Mariovski Kozjak Mt., above Vitolishte Vill., on *Pinus nigra*, 1140 m a.s.l., 41.169611° N 021.857722° E, 09.07.2012, 1♂1♀ 2 juv., leg. N. Simov.

**Origin**: *Leptoglossus occidentalis* is an invasive alien species of North American origin (Rabitsch 2008, 2010).

After one and half decade of its first record in Italy in 1999 (Bernardinelli & Zandigiacomo 2001) the species spread throughout almost all of Europe (Rabitsch 2008, 2010; Kment & Baňař 2008; Fent & Kment 2011; Werner 2011; Winkelmann & Bahr 2011) including Balkan countries: Slovenia – 2003, Croatia – 2004, Bulgaria – 2008, Serbia – 2006, Montenegro - 2008, Turkey – 2009, Greece - 2008, Bosnia and Herzegovina - 2014, Macedonia - 2015, Kosovo - 2015 (Rabitsch 2008, 2010; Fent & Kment 2011; Dautbašić and Mujezinović 2014; Kulijer 2016; Kulijer & Ibrahimi 2017).

The western conifer seed bug feeds on the young seeds and strobiles of various conifers from Pinacea and Cupressaceae families (Werner 2011), causing reduction of seed fertility (Connely & Schowalter 1991). It is classified as a pest in its native range (Mitchell 2000) and in Italy (Roversi et al. 2011). Furthermore, *L. occidentalis* can be considered a major threat for all European conifer forests as feeding strongly affects the germination capability of seeds (Lesieur et al. 2014).

The presence of western conifer seed bugs in isolated and very scarce populated region as Mariovski Kozjak and its good flight abilities are the reasons to regard this invasive alien species as well established in whole Macedonian territory.

**Ceroplastes japonicus** (Green, 1921) - Japanese wax scale (Hemiptera, Coccidae)

**Record**: Valandovo, on individual trees of persimmon (*Diospyros kaki* L., Ebanaceae), 2016, leg. S. Lazarevska.

**Origin**: Eastern Asia (China, Japan, Korea) (Ben-Dov et al. 2010).

**Comments**: This scale species is present in Europe since 1930 in France, Italy, Slovenia, Croatia, Bulgaria (Germain 2008; Pellizzari & Camporese 1994; Jančar et al. 1999; Masten-Milek at al. 2007; Pencheva 2007; Pencheva & Yovkova 2016). *C. japonicus* has been recorded in Macedonia since 2016 on persimmon trees in southern part of the country Marvinci, Balinci, Brajkovci close to Valandovo on individual persimmon trees, also in locality Nov Dojran, close to Dojran in persimmon orchards (Lazarevska et al. 2017).

*C. japonicus* is polyphagous species predominantly found on perennial plants and occasionally on annual hosts. According to Pellizzari & Camporese (1994) the most common host plants are *Citrus, Diospyros, Illex, Hedera*. Nowdays *C. japonicus* is reported on more than 100 plant species from 38 different families. The scale is a pest of soft and hardwood trees, fruit trees, citrus and ornamentals in urban environments (USDA-APHIS 2015). According to Xie et al. (2008) the scale is destructive pest in many forests, fruit orchards and ornamental plants in China. Forest of D. kaki and Ziziphus jujuba Mall. are so heavily damaged by this scale in north China that fruit loss is about 70%.
C. japonicus develops one generation per year. The oviposition begins in the middle of May and continues until the end of June. The pest reaches maturity in the beginning of September (Jančar et al. 1999). After mating males die, but fertilized females overwinter (Pellizzari & Camporese 1994).

Infestations of C. japonicus occur on foliage, stems and branches. This results in reduced vigor, but heavy infestations may result in chlorotic spotting, the premature shedding of leaves, wilting and the dieback of the stem. Honeydew, a sweet substance excreted by the scale insect, deposited on the leaves and fruits and serves as a medium for the growth of black sooty molds, which screen light from leaves and impair gas exchange and photosynthesis (Demirözer et al. 2004).

C. japonicus spreads mainly with plants for planting. Natural spread to very short distances is possible with neonate larvae in summer time. Overwintering as a young female and can survive outdoors at temperature several degrees below zero (Pellizzari & Camporese 1994).

**Pseudaulacaspis pentagona** (Targioni Tozzetti, 1886) MacGillivray, 1921 - mulberry scale (Hemiptera, Diaspididae)

**Record**: Gevgelija, on mulberry 1950/51, leg. Bekirov, 1958.

**Origin**: Eastern Asia (China and Japan) where is pest on Prunus and Morus (MacLeod 2007).

**Comments**: *P. pentagona* has spread widely to all warmer regions of the world. The scale was accidentally introduced to Italy in the nineteenth century and within Europe it now occurs in Azerbaijan, Bulgaria, France, Georgia, Germany, Greece, Hungary, Italy, Malta, Montenegro, Netherlands, Portugal, Russia, Serbia, Spain, Sweden, Switzerland, Turkey and Ukraine. In the past 20 years, it has spread northwards outdoors in Europe, perhaps because of the climate change. In colder countries e.g. Sweden, *P. pentagona* only lives in protected environments i.e. glasshouses (MacLeod 2007).

First report in Macedonia is on 4 ha mulberry trees in Gevgelia in 1953, but the author estimated that the appearance of the pest began in early the 50’s of twentieth century (Atanasov 1958).

*P. pentagona* is one of the most polyphagous scale, being recorded from well over 100 plant genera, including numerous crop and ornamental plants species. The Mulberry scale has between 1 to 4 generation per year, depending upon climate. In Macedonia it develops 3 generations (Atanasov 1958). It overwinters in cold winter countries as fertilized female and can survive temperature as low as -20°C. Oviposition starts during mid-May or earlier depending on the climate. Crawlers, the first larval instar, appear after 1-2 months and actively search for a suitable feeding site. The females have three larval instars and male five. The generation can be completed for 25-54 days during the summer or 80-90 days during the winter. Each female lays between 38-220 eggs (Atanasov 1959).

*P. pentagona* spreads mainly with plants for planting. Natural spread on very short distances is possible with neonate larvae in summer time before fixing on permanent place.

In the beginning of 1950’ of the twentieth century in Macedonia *P. pentagona* has caused severe damages to mulberry, but very soon in 1957/58 after introduction of its natural enemy *Prospaltela berlesei* How (Atanasov 1960) the pest has been put under control since to 2008-2009 when economically significant outbreaks occurred on peach in Rosoman, Kavadarcí (Postolovski & Lazarevska 2010).

**Tuta absoluta** (Meyrick, 1917) – Tomato leafminer (Lepidoptera, Gelechiidae)

**Record**: Gevgelija, Bogdanci, Valandovo, greenhouses with tomato, 2011, leg. M. Postolovski, S. Lazarevska, S. Bandzo.

**Origin**: South America (Peru, Brasil) (Garcia & Vercher 2010).

**Comments**: Pest of tomatoes of South American origin, which first appeared in Europe in Castellón (eastern Spain) in 2006. *Tuta absoluta* has expanded very quickly in the last three years (2007-2009) to most Mediterranean countries, as well as to many countries in central and north Europe (Garcia & Vercher 2010). In 2008 the pest was found in southern part of France in tomato crops (Germain et al. 2009). Also, the first appearance of the pest in Italy happened in the spring of 2008 in tomato crops in southern part of Sardinia and Sicily (Speranza & Sannino 2012). In 2009 the pest was distributed on the Balkan Peninsula on Crete, Peloponnese and Western Greece in tomato greenhouses and also in Bulgaria in field and greenhouses in southern part of the country (Harizanova et al. 2009). That year, the pest is also recorded in greenhouses in
Slovenia (Žežlića et al. 2011) and Croatia (Culjak et al. 2010). In 2010 *T. absoluta* is recorded in greenhouses with tomato and outdoor in coastal area of Montenegro (Hrnčić & Radonjić 2012) and Serbia (Tosevski et al. 2011).

First records of *T. absoluta* in Macedonia are in tomato greenhouses in the eastern part of the country in 2011 (Postolovski et al. 2011).

*T. absoluta* feeds almost exclusively on tomato (*Solanum lycopersicum* L.) but there is also one report that it eats other plant species from Solanaceae family (Garcia & Espul 1982).

Tomato leaf miner has high biotic potential and develops 12-15 generations per year in greenhouses. After its introduction into Europe, North Africa and the Middle East, *T. absoluta* has already caused extensive economic damage. Infestation of tomato plants occur throughout the entire crop cycle. Feeding damage is caused by all larval instars and throughout the whole plant. The larvae feed on the mesophyll tissue on the leaves, forming irregular leaf mines or extensive galleries in the stem, which affect the development of the plants. The larvae also attack fruit and the entryways are used by secondary pathogens, leading to fruit rot. The impact of the pest includes severe yield loss reaching 100%, increasing tomato prices, bans on the trade of tomato including seedlings, an increase in synthetic insecticide applications, disruption of integrated management programs of other tomato pests, and an increase in the cost of crop protection. In addition, the outbreak of this pest led to a significant augmentation of risks for growers, consumers and the environment associated with the blind use of chemicals (Zappalà et al. 2012).

*Frankliniella occidentalis* (Pergande, 1895) - Western Flower Trips (Thysanoptera, Thripidae)

**Record:** CABI/EPPO, 1988

**Origin:** Southwestern US (Waterhouse & Norris 1989).

**Comments:** *F. occidentalis* is native to Nort America. The western flower trips was first described in California in 1895, and since 1970s, it had invaded much of the word and became dominant population in most of the areas where it had been introduced (Kirk & Terry 2003).

The western flower thrips is widespread from sea level to sub-alpine altitudes. It is the most common thrips species. This thrips has spread to the Canary Islands, Europe, Hawaii, New Zealand, northern South America (Waterhouse & Norris 1989).

During the decades of 1970 and 1989 it spread to Europe and other countries in the world. In 1983 *F. occidentalis* was accidentally introduce in Netherland and later became main problem in field crops and orchards (Loomans 2003). In 1985 it was recorded in Danmark and Germany (CABI 2014), in 1987 the pest is recorded on chrysanthenum in Belgium (Clerco & Casteels 1992), in Czech Republic, Finland, France, Ireland, Italy, Poland (CABI 2014), in 1988 is recorded in Austria, Sicilia, Sardinia and Macedonia (CABI 2014). Today, this species is widespread in Macedonia in open field and greenhouses.

*F. occidentalis* is poor flier, but easily transported passively by the wind. It has been spread with international trade throughout subtropical and temperate regions of the world. In colder climates it is frequently a serious pest in greenhouses. The international spread of the western flower thrips occurred predominantly by the movement of horticultural material, such as cuttings, seedlings and potted plants. Within Europe, an outward spread from the original outbreak in the Netherlands is discernible. The speed of spread was 229±20km/year (Kirk & Terry 2003).

*F. occidentalis* is a polyphagous species with hosts in 65 families, including more than 250 species of vegetables and ornamental crops. Some examples of host plants are alfalfa, apricots, artichoke, carnations, chrysanthemum, corn, cotton, cucumber, eggplant, gerbera, gladiolus, grapefruit, grapes, impatiens, melons, nectarines, peaches, peanut, peas, pepper, plums, Spanish needle, strawberry, tomato, watermelon, and wild radish (CABI 2014).

Thrips cause both direct and indirect injury to crops. Direct damage occurs when the thrips cause injury by feeding or oviposition. *F. occidentalis* is prevalent in flowers, but it can also be found on crop foliage and fruit, which reduce photosynthetic capacity (Shipp et al. 2000) and cause fruit surface dimpling. Indirect damage refers primarily to the transmission of viruses (*Tomato spotted wilt virus* (TSWV), *Tomato chlorotic spot virus* (TSCV), *Impatiens necrotic spot virus* (INSV), and *Groundnut ring spot virus* (GRSV)). *F. occidentalis* is considered to be the predominant vector of TSWV worldwide, a serious virus for wide range of crop and non crop hosts and causes billions economic losses worldwide (Riley et al. 2011).
In warm regions or in greenhouses *F. occidentalis* develops 12-15 generation per year. Otherwise, adults and pupae will overwinter in sheltered places like under lumps of soil, tree bark, in grass and weeds, and only 1 or 2 generations may be completed. In spring, the adults migrate to flowering plants and start with oviposition. The female lays about 40-50 eggs, 1-2 per day. Each is inserted singly into the plant tissue.

**Conclusion**

It is highly important to follow the pathways of distribution and introduction of alien, invasive and pest species, to avoid vector-borne diseases and to prevent the negative impact and the habitat destruction on time. One of the steps to overcome this problem in Macedonia is to enrich the knowledge of the existing allochtonous fauna and to develop monitoring programs of their distribution. In general, the data regarding the presence and distribution of invasive species in Macedonia is far from satisfactory. The research contributes to enriching the knowledge of 11 invasive species, not registered in Macedonia before. Certainly, the list is not sufficient and further research on current topic is necessary with aim to enable the reconstruction of the distribution paths.

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