

A Review of New Alien Arthropod Pests and their Impact on Agriculture Crops in Montenegro

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Abstract: An overview of some new alien arthropod pests recorded in the last decade on agricultural crops in Montenegro is presented. Fifteen species were found in the period 2006-2016. The newly recorded species are (in chronological order): *Polyphagotarsonemus latus*, *Liriomyza bryoniae*, *Aphis illinoisensis*, *Scaphoideus titanus*, *Frankliniella occidentalis*, *Luperomorpha xanthodera*, *Tetranychus cinnabarinus*, *Tuta absoluta*, *Bemisia tabaci*, *Liriomyza trifolii*, *Aleuroclava aucubae*, *Drosophila suzukii*, *Aleurocanthus spiniferus*, *Rhagoletis cingulata*, and *Phthorimea operculella*. All species are considered established, with the exception of *L. trifolii*, *L. xanthodera*, *A. aucubae*, *R. cingulata*, and *Ph. operculella*. The spreading of the new alien species and their potential phytosanitary and environmental impact are discussed.

Key words: Alien species, vegetables, fruits, detection, spreading

Introduction

The introduction of alien species as a dynamic process results in detection of new species in many countries yearly. Alien species can be introduced both accidentally and intentionally. Many introductions are unintentionally coming into countries with other goods. Increased mobility and human interactions have been key drivers in the spread of alien species worldwide (CHENJE & MOHAMED-KATERERE 2006). The invasive alien species introduced and/or spread outside their natural ranges affect local biodiversity in almost all types of ecosystems on earth and thus are regarded as one of the greatest threats to the biodiversity (CBD 2009).

Montenegro is located in southeastern Europe, on the Balkan Peninsula. It has a coast on the Adriatic Sea, and borders Croatia, Bosnia and Herzegovina, Serbia, and Albania. The terrain in Montenegro ranges from high mountains in the northern part, through karst segment in central and western part, to a narrow coastal plain. The climate varies from Mediterranean to subcontinental and continental. With its various relief and climate, the country

is notable for its diverse agricultural production provided mainly by small-scale farming units. These include: fruit growing (citrus and continental fruits), viticulture, olive growing, crop production (potato, maize, wheat, barley, alfalfa and clover), and vegetable production (both in protected area and in open field) (ANONYMOUS 2015). The trade in plant material is also intensive in Montenegro. All these factors create favourable conditions for the interception, introduction and establishment of new alien species.

In this paper we focus on the alien arthropod pests recorded in the last decade on agricultural crops in Montenegro.

Materials and Methods

Visual inspections of the vegetable and fruit crops were made by the authors, who were authorised to do the field inspections by the Phytosanitary Directorate of Montenegro, Ministry of Agriculture and Rural Development. The majority of new alien

species were directly found *in situ*, either in the open field or in greenhouses, and then sampled for further identification. Other species were recorded in samples provided by the Phytosanitary Inspectorates.

Different types of traps: pheromone, lure attractants, yellow and blue sticky traps, as well as sweep nets were used for detection of the presence and spreading of pests. The collected specimens were preserved in 70% ethanol for subsequent identification. Samples of the infested plants were taken as well. All samples of insects and mites were processed according to the standard entomological procedures for morphological diagnostics. In most cases, photographs of living specimens and damages from them were taken.

Results and Discussion

Fifteen alien phytophagous species were found in the period 2006-2016. The collection sites are presented in Fig. 1.

The newly recorded species for Montenegro follow in chronological order:

The broad mite, *Polyphagotarsonemus latus* (Banks, 1904) (Acari, Tarsonemidae)

The species is highly polyphagous and capable of attacking more than 60 botanical families (PETANOVIĆ 2004). In the tropical area, it is common in the field, while in the temperate regions is present in greenhouses, on numerous agricultural crops, ornamentals and wild plants (JEPPSON et al. 1975).

The pest was first detected in 2006 on sweet pepper in several greenhouses near Podgorica. *P. latus* showed very restricted spreading in the following three years and was recorded only in two other greenhouses: on sweet pepper in Danilovgrad locality and in nursery of citrus plants in Đenovići locality (HRNČIĆ & RADONJIĆ 2010, RADONJIĆ & HRNČIĆ 2010). On the visual inspections, various symptoms of infestation were registered. On sweet peppers the terminal buds showed signs of drying; the leaves were curled, yellowed, sometimes bronzed; flowers also dried up and usually dropped off; the newly formed fruits were severely deformed and bronzed. On infested citrus the leaves were light green and rough, narrowed, crinkled and distorted, with margins curled downward or being only half-developed; the internodes were shorter than normal. After 2012, *P. latus* was not detected at any new locality, while at those where was found in previous years, the damages were scarce, and in some years even not registered at all. Therefore, it is still questionable whether the pest may be considered



Fig. 1. Main collection sites in Montenegro. Geographical name of area/ locality as indicated on the map: A – Area of Zeta, B – Area of Bjelopavlići, C – Area of Skadar Lake, D – Area of Boka Kotor Bay, 1 – Podgorica 2 – Danilovgrad, 3 – Đenovići, 4 – Radanovići, 5 – Nudo, 6 – Ulcinj, 7 – Bar, 8 – Herceg Novi, 9 – Lastva Grbaljska, 10 – Kumbor, 11 – Baošići, 12 – Tivat, 13 – Kolašin, 14 – Bijelo Polje, 15 – Nikšić, 16 – Perast, 17 – Bigova

established in a very restricted area in the southern part of Montenegro.

The agromyzid leaf miner, *Liriomyza bryoniae* (Kaltenbach, 1858) (Diptera, Agromyzidae)

The species probably originates in southern Europe, but has now spread into many other parts of the EPPO (European and Mediterranean Plant Protection Organization) region, where crops are grown indoors. It is a highly polyphagous and a major pest on crops of Asteraceae, Brassicaceae, Cucurbitaceae and Solanaceae in greenhouses. In the warmer parts of the EPPO region, it is also found in the field (CABI/ EPPO 1991).

The presence of *L. bryoniae* was formally confirmed in 2006 from infested leaves of tomato collected in the open field in Radanovići locality (RADONJIĆ & HRNČIĆ 2011). In the following years, the pest showed high rate of spreading and now is widely distributed on vegetables, both in greenhouses and the open field in southern Montenegro (along the seacoast and in areas of Zeta and Bjelopavlići). The species was registered on cucumber and

mangold as well. We found the typical symptoms of irregular twisting continuous mines on the upper surface of the leaves. In cases of severe infestations the entire leaves were mined. Apart from being visually detected on the infested plants, the adults were also captured on yellow sticky traps placed in greenhouses. *L. bryoniae* is considered established in the southern part of Montenegro, although it has not apparently caused serious damages.

The grapevine aphid, *Aphis illinoisensis* (Shimer, 1866) (Hemiptera, Sternorrhyncha, Aphididae)

Aphis ilinoisensis is a North American species. In the Mediterranean region, it was first found in Turkey in 2002 (REMAUDIÈRE et al. 2003), and on the island of Crete, Greece, in 2005 (TSITSIPIS et al. 2005).

The species was found for the first time in 2007 on young terminal shoots in one grapevine nursery near Podgorica locality (HRNČIĆ et al. 2008, PETROVIĆ-OBRAĐOVIĆ et al. 2010). Visual inspections in 2008 showed gradual spreading of *A. ilinoisensis* in vineyards close to the site of the first detection and in a few vineyards at the Đenovići locality. In the following years, the species was detected at many localities in vine-growing regions of Montenegro. The visual inspections showed that the pest prefers leaves on young terminal shoots and the lower side of leaves. More abundant populations were found where no regular cutting of shoots was made, especially after mid-July. There have been no signs of presence of this aphid on grape bunches in Montenegrin vineyards so far. It is considered established in many vine-growing areas, although not registered as an abundant and serious pest.

The American grapevine leafhopper, *Scaphoideus titanus* (Ball, 1932) (Hemiptera, Auchenorrhyncha, Cicadellidae)

The species is native to North America and its first occurrence in Europe was reported from France (BONFILS & SCHVESTER 1960). In countries neighbouring to Montenegro, it was detected in Serbia (MAGUD & TOŠEVSKI 2004), Croatia (BUDINŠČAK et al. 2005), and Bosnia and Herzegovina (DELIĆ et al. 2007).

In the Montenegrin vineyards, the presence of *S. titanus* was first recorded on yellow sticky traps in 2008 in the area of Zeta (RADONJIĆ et al. 2008). In 2009 and 2010, the species spread to new localities mainly adjacent to the site of the first detection, with the exception of the Nudo locality at around 100 km westwards (RADONJIĆ et al. 2012). The regular monitoring of the pest included the detection of first and second instar nymphs on the lower side

of the oldest grapevine leaves, as well as of adults captured in sweep nets and on yellow sticky traps. Overwintering eggs were also found beneath the bark of the 2-3-year old shoots in the inspected vineyards (RADONJIĆ et al. 2013). After 2011, the pest was not found at any new locality, and its population density slightly decreased and was ranked as low in all localities where its presence was confirmed. The species can be considered established in a restricted vine-growing area in Montenegro.

Scaphoideus titanus is the main vector of 'Flavescence dorée' (FD) phytoplasma that is one of the most destructive phytoplasma diseases of grapevine. The presence of FD phytoplasma has not been detected in Montenegro so far.

The western flower thrips, *Frankliniella occidentalis* (Pergande, 1895) (Thysanoptera, Thripidae)

The species is indigenous to North America from where began to spread internationally since 1980 and by now it has been reported from countries of all continents. In Europe, it is generally found only on greenhouse crops (EPPO/ CABI 1997b).

In 2008, *F. occidentalis* was first detected on the flowers and leaves of cucumbers, as well as on blue sticky traps, at a greenhouse in the area of Zeta (HRNČIĆ et al. 2009). In the next few months, the species spread rapidly in greenhouses within the areas of Zeta and Bjelopavlići, which are considered the main vegetable production areas in Montenegro. The pest was also found on greenhouse sweet pepper and mangold. In 2009, the spreading of *F. occidentalis* was registered in greenhouses within the localities Radanovići, Ulcinj and Bar (RADONJIĆ & HRNČIĆ 2011). We detected the species on the above-mentioned host plants and on aubergine and beans as well. At the end of July 2009, *F. occidentalis* was first found outdoors, in flowers of the weeds *Inula britannica* L., *Picris hieracioides* L., and *Cichorium intybus* L., near the inspected greenhouses in the Ulcinj and Bar localities (RADONJIĆ & HRNČIĆ 2011). The inspection of greenhouses in the following years confirmed the presence of the species in all aforesaid host plants and localities. The most common symptoms of the infestation were the discolouration of the upper leaf surface in cucumbers, mangolds, beans and aubergines, followed by silverying and appearance of feeding scars on the underside of leaves. Discolouration and scarring of flowers and petals were particularly noticed in sweet pepper and cucumber. The most conspicuous consequences of infestations were found on sweet pepper fruits, although these damages are mostly aesthetical and

lead to downgrading. However, *F. occidentalis* is more important as a vector of *Tomato spotted wilt virus* (TSWV) on sweet pepper in Montenegro (ZINDOVIĆ et al. 2011, 2014). This virus is regarded as one of the most aggressive and polyphagous viruses in plant-growing. *F. occidentalis* is considered established in Montenegro.

The flea beetle, *Luperomorpha xanthodera* (Fairmaire, 1888) (Coleoptera, Chrysomelidae, Alticinae)

Luperomorpha xanthodera is a polyphagous species which originates in China. It was first recorded in Europe on ornamental flowers for Britain in 2004, for Italy in 2007, for the Netherlands in 2009, and for Poland in 2012 (DEL BENE & CONTI 2009, KOZŁOWSKI & LEGUTOWSKA 2014).

The species was first recorded in 2009 in a greenhouse near Podgorica locality on several citrus species: mandarin, oranges, lemon, grapefruit, as well on *Fortunella* sp., strawberries and some ornamentals (RADONJIĆ & HRNČIĆ 2009). Adults predominately feed on flowers of citrus and strawberry and in a lesser extent on leaves. In the following years, its spreading from the site of the first detection was not confirmed. The only exception was the finding of the species on *Rosa* sp. at a nursery in Đenovići locality, in 2010. Since 2012, *L. xanthodera* has not been found in any of these or other new localities. Its establishment could not be confirmed in Montenegro so far.

The carmine spider mite, *Tetranychus cinnabarinus* (Boisduval, 1867) (Acari, Tetranychidae)

This species has subtropical origin and worldwide distribution. It is widespread in subtropical areas of the world and common in greenhouses throughout the temperate countries. The species attacks both vegetables (in particular, tomatoes, cucumbers, and aubergines) and ornamentals (carnation, gerbera) in glasshouses (ZHANG 2003, PETANOVIĆ 2004).

In 2009, *T. cinnabarinus* was first detected on tomato at greenhouses in the areas of Zeta and Bjelopavlići (RADONJIĆ & HRNČIĆ 2011). During 2010, its presence was confirmed for the same areas (RADONJIĆ & HRNČIĆ 2012). In addition, the species was found on tomato at greenhouses at Bar locality. In 2011 and 2012, its spreading was confirmed by the new findings at greenhouses in the localities Radanovići and Ulcinj, where aubergine and beans were also recorded as host plants. Visual inspections showed that adults and nymphs feed primarily on the undersides of the leaves, which causes prematurely

chlorosis and symptoms resembling withering. The heavily infested leaves may fall off. The pest produces visible silk webbing and the severely infested plants may be completely covered with it. It was also observed that conspicuous clusters of *T. cinnabarinus* are formed on the top of such plants. In cases of severe infestations complete drying of plants were detected. During the hottest months, from the end of July and August, the presence of the species was confirmed in tomato in the open field. *T. cinnabarinus* is considered established in the southern part of Montenegro and particularly damaging to the tomato production.

The South American tomato moth, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera, Gelechiidae)

Tuta absoluta originates in South America, and was first detected in Europe (Spain) in 2006 (EPPO/OEPP 2008).

The species was first detected in 2010 on tomatoes at greenhouses in the localities Radanovići, Ulcinj, Bar and Herceg Novi, both on the infested plants and on the pheromone traps (HRNČIĆ & RADONJIĆ 2011). Soon after the first detection it rapidly spread into the main vegetable producing areas of Zeta and Bjelopavlići. In Radanovići and Herceg Novi, it also attacked aubergines. In the years 2011-2014 the pest was continuously monitored in areas where tomatoes are primarily produced. Pheromone traps, in the greenhouses and in the open field, were used as an addition to the visual inspections. Adults were captured both indoors and outdoors (HRNČIĆ & RADONJIĆ 2012). Typical symptoms of infestation on leaves were the conspicuous, irregular mines and galleries formed by larvae. The mines and galleries later became necrotic. Fruits may be attacked as soon as they are formed or later, during the development and even in a mature state. The infested fruits could be invaded by secondary pathogens, which lead to decay. Damages were recorded only on leaves in aubergines. The continuous monitoring for five years confirmed that *T. absoluta* is widely distributed and predominantly present in greenhouses where tomato are produced. The species is also present in the open field, particularly, during the hottest summer months. It is considered established in Montenegro.

The tobacco whitefly, *Bemisia tabaci* (Gennadius, 1889) (Hemiptera, Sternorrhyncha, Aleyrodidae)

The evolutionary affiliations of the *Bemisia* taxa suggest that *B. tabaci* may have originated in tropical Africa, although some evidence suggests that may be native to India or Pakistan. *B. tabaci* was

described in 1889 as a tobacco pest in Greece. It is a pest in the greenhouses and open fields, which adapts easily to new host plants and geographical regions (OLIVEIRA et al. 2001).

Although *B. tabaci* was first recorded on *Hybiscus* sp. in Podgorica in 2008, its first detection on vegetables was on melon in an open field near Ulcinj locality in 2011 (HRNČIĆ et al. 2012). In 2012-2013, the species spread mostly in the open fields along the seacoast and was found on melon, cucumber, aubergine, watermelon, sweet pepper, tomato, and zucchini in the localities Bar and Lastva Grbaljska (HRNČIĆ et al. 2014). In 2014-2015, it was found in the area of Zeta, only on melon and zucchini. The complete life cycle of this pest was confirmed in all of these plants. Visual inspections of the infested hosts showed that population starts building up from July. Colonies are developed primarily on the underside of leaves. Adults and larvae cause direct and indirect damages by feeding. Indirect damages appeared to be more serious, because of huge excretion of honeydew on the leaf surface. Consequently, sooty mold fungi that use honey dew as a substrate colonise the infested surfaces. Although population size is considered low, the presence of *B. tabaci* has been confirmed every year since the first record in Montenegro. The species could be considered established. It has not been found to transmit any viruses on vegetables in Montenegro so far.

The American serpentine leafminer, *Liriomyza trifolii* (Burgess, 1880) (Diptera, Agromyzidae)

The species originates in North America and has started to spread to other parts of the world since the 1960s. (EPPO/ CABI 1997c).

In 2012, *L. trifolii* was first detected on zucchini at a greenhouse in Bar locality. Linear, narrow mines, of serpentine or irregular shape were noticed on leaves. In some cases blotch forms were found at the end of the mine. In 2013 and 2014, no further detection of the pest was confirmed. *L. trifolii* is considered not established in Montenegro so far.

Aucuba whitefly, *Aleuroclava aucubae* (Kuwana, 1911) (Hemiptera, Sternorrhyncha, Aleyrodidae)

This species is native to the East Palaearctic (Japan, Taiwan and China) and has been introduced to the USA (California) (EVANS 2008), northern Italy in 2006 (PELLIZZARI & ŠIMALA 2007 – misidentified as *Aleuroclava guyavae* (Takahashi), Slovenia (SELJAK 2012) and Croatia in 2013 (ŠIMALA et al. 2015).

The first record of the species was on citrus nursery plants at greenhouses near Podgorica locality

in 2012 (RADONJIĆ et al. 2014). Elliptical, deep black pupae, with characteristically ornamented surface on the underside of leaves were noticed. Presence was sparse. In the following years no further findings were registered. The pest is not considered established in Montenegro.

Aleuroclava aucubae is a polyphagous insect known to occur on plants from more than 15 plant families. According to the present knowledge, this species does not cause apparent damages to cultivated plants. However, it might become a minor pest for citrus production in the Mediterranean countries (PELLIZZARI & ŠIMALA 2007, SELJAK 2012).

The spotted-wing drosophila, *Drosophila suzukii* (Matsumura, 1931) (Diptera, Drosophilidae)

Drosophila suzukii is highly polyphagous and attacks a wide range of fruit crops and an increasing number of wild fruits. It is an endemic to South-East Asia which recently invaded the Western countries (CINI et al. 2012, CABI 2016a).

The species was first recorded in 2013, in citrus orchards at localities Đenovići, Ulcinj, Bar, Kumbor, Baošići, and Tivat. The specimens were captured in Tephri traps baited with the three-component synthetic dry food attractant (ammonium acetate, trimethylamine hydrochloride, and putrescine), which is regularly used as an attractant for monitoring of *Ceratitis capitata* Wiedemann in Montenegro (RADONJIĆ & HRNČIĆ 2015).

In the same year, the pest was found in the areas of Skadar Lake and Podgorica, in Tephri traps within mixed fruit orchards, as well as at fruit markets in Podgorica. In the period 2014-2016, *D. suzukii* was spread in the northern part of Montenegro and detected in the localities Kolašin, Bijelo Polje, and Nikšić, in Tephri traps placed in raspberry orchards. Both sexes were captured in the traps. The pest is considered established in Montenegro.

The orange spiny whitefly, *Aleurocanthus spiniferus* (Quaintance, 1903) (Hemiptera, Sternorrhyncha, Aleyrodidae)

The species originated in Southeast Asia and has spread widely in tropical and subtropical Asia, into Africa and the Pacific Islands (EPPO/ CABI 1997a). It was first detected in Europe in 2008 in Italy (PORCELLI 2008), and in 2012 in Croatia (ŠIMALA & MASTEN MILEK 2013).

In 2013, *A. spiniferus* was first detected in citrus orchards in the localities Herceg Novi, Kumbor and Baošići (RADONJIĆ et al. 2014). In 2014, the species was found in Bar, in 2016 in Perast, and in January 2017 in Tivat, in citrus orchards as well. All those

localities are on the seacoast within the area of Boka Kotor Bay. During visual inspections of citrus orchards, adults, nymphs and eggs were found as dense colonies on the undersurface of leaves. The excretion of huge amounts of honeydew which coats leaves and fruits, creates favourable conditions for the development of a heavy sooty mould fungus on the infested plants, which become blackened. The heavily infested citrus plants were almost completely black in appearance, and severe defoliation was noticed as well. The repeated severe infestations also led to stunted growth and ceased blooming and fruit production. The presence of this species was detected on grapevine and some ornamental plants as well. The pest is considered abundant and established in the localities within the area of Boka Kotor Bay.

The eastern cherry fruit fly, *Rhagoletis cingulata* (Loew, 1862) (Diptera, Tephritidae)

Rhagoletis cingulata is an eastern North American species. It is an important quarantine pest for temperate regions and is listed on EPPO A2 list as a severe pest of cherries (CABI 2016b).

In 2013, *R. cingulata* was first detected in cherry orchard in Lastva Grbaljska locality. Only one specimen (male) was captured in a McPhail trap baited with ammonium acetate (RADONJIĆ 2013). In 2014 and 2015 McPhail traps were set up at four additional localities on the seacoast: Ulcinj, Bar, Baošići, and Bigova. Except in 2014, when several specimens were captured again in Lastva Grbaljska, monitoring in the following years has showed no further detection at any of the inspected localities. The pest is considered not established in Montenegro so far.

The potato tuber moth, *Phthorimea operculella* (Zeller, 1873) (Lepidoptera, Gelechiidae)

Phthorimea operculella is a cosmopolitan pest, especially in warm temperate and tropical regions where host plants are grown (CABI 2015).

In 2015, the presence of *Ph. operculella* was confirmed in five samples of imported potato tubers sent by the Phytosanitary Inspectorates. As a result of the larval boring, long or short irregular mines, filled with frass, were registered in the infested tubers. Larvae and pupae were also found in the

infested tubers and, after eclosion of the adults, the identity of the species was definitely confirmed. No further detections of the pest were made in the samples of domestic and imported potato, formally delivered to us in 2016. This pest is not established in Montenegro and the findings from 2015 could be considered an interception.

Conclusions

As a result of the ten-year monitoring of pests that attack agricultural crops in Montenegro, 15 new alien species were found. Among them, *F. occidentalis*, *L. bryoniae*, *A. illinoisensis*, *T. absoluta*, and *D. suzukii* have showed the highest rate of spread and successful establishment in a wide area since their first detection. At the same time, *S. titanus*, *T. cinnabarrinus*, *B. tabaci*, and *A. spiniferus* were also successfully established, but in restricted areas. The remaining species are considered casual in Montenegro so far.

In the economic sense, under the current situation, the most important pests are: *F. occidentalis* because of direct and indirect damages which it have already caused, and *A. spiniferus* because of a high population pressure and negative consequences on citrus production in the area of establishment. *S. titanus* and *B. tabaci* are regarded as potentially very dangerous, considering their activity as virus vectors. The same is valid for *D. suzukii* because of its high rate of spread and many available host plants (cultivated and wild). In respect of *T. absoluta*, our conclusion is that after the serious damages caused by this species after its first detection, the impact on tomato production was lower in the following years.

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